Gorgon Gas Development
Barrow Island Nature Reserve

Chevron Australia

Report and recommendations
of the Environmental Protection Authority

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Environmental Impact Assessment Process Timelines

Date	Progress stages	Time (weeks)
19/11/03	**Level of Assessment set (following any appeals upheld)**	**-**
12/09/05	**Proponent Document Released for Public Comment**	**94**
24/10/05	**Additional Proponent Document Released for Public Comment**	**6**
3/01/06	**Public Comment Period Closed**	**9**
13/03/06	**Final Proponent Response to the Issues Raised**	**9**
19/05/06	**Final EIS/Response to Submissions Released by Proponent**	**9**
6/06/06	**EPA Report to the Minister for the Environment**	**3**

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Summary and recommendations

Chevron Australia Pty Ltd, as operator for the Gorgon Joint Venturers, proposes to extract, pipe, liquefy and export 10 million tonnes per annum of natural gas from the Greater Gorgon and Jansz gas fields using facilities offshore and on Barrow Island, Western Australia. The proposal also includes provision for a domestic gas plant and the potential for the injection underground of carbon dioxide extracted from the reservoir gas, and associated infrastructure.

Previous in-principle decision on use of Barrow Island for Gorgon development

Barrow Island is a class A nature reserve, gazetted in 1910 and recognised for its very high conservation values. The waters around Barrow Island are also recognised for their conservation values, with parts included in marine conservation reserves, including a marine park.

The Environmental Protection Authority (EPA) has previously provided strategic advice on a conceptual proposal from an environmental perspective under Section 16(e) of the *Environmental Protection Act 1986*. The Conservation Commission provided advice on nature conservation matters and the Department of Industry and Resources (DoIR) advised on the strategic, economic and social aspects of the proposal.

The EPA noted the very high environmental and unique conservation values of Barrow Island, which are reflected in its status as a class A nature reserve. The EPA concluded in its advice to Government at that time "*Having weighed the environmental values, the limited available data about risks, and the current level of knowledge on their management, the EPA is of the view that the proponent has failed to demonstrate that establishing a gas processing complex on Barrow Island could achieve an acceptably low level of risk to Barrow Island's outstanding environment and unique conservation values.*" Among other things in that report the EPA recommended the proponent be required to demonstrate that risk standards could be met, with a 'very high level of confidence'. It went on to state that, should the Government decide to allow the proposal to proceed, two overarching principles were required to underpin any development on Barrow Island;

- the class A nature reserve status of Barrow Island should have primacy; and
- environmental and conservation values of the island should not be compromised.

Those recommendations form useful tests for the proposal now before the EPA for formal assessment.

Having considered the advice received on environmental, economic, social and strategic issues, in September 2003 the Western Australian Government provided in-principle agreement to the joint venturers for restricted access to Barrow Island nature reserve for gas processing facilities, as a foundation for the development of the Gorgon gas fields. That decision required special conditions including:

- formal environmental impact assessment demonstrating that environmental factors can be managed without unacceptable impact on conservation values; and
- development of standards for acceptable management of risk to conservation values and a clear demonstration that they can be met with a very high level of confidence.

The *Barrow Island Act 2003* and Agreement became the enabling legislation for the proposal. The *Barrow Island Act 2003* requires compliance in all respects with the *Environmental Protection Act 1986.* The *Barrow Island Act 2003* also requires that grant of leases, licences and easements necessary for the proposal to proceed on Barrow Island cannot occur unless a decision is made that the proposal may be implemented under the Environmental Protection Act.

In accordance with the Government's in-principle decision, the proponent referred the proposal for formal environmental impact assessment under the *Environmental Protection Act 1986.* The proposal is also being assessed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

This report of the EPA

Formal environmental impact assessment has now been undertaken under Part IV of the *Environmental Protection Act 1986.* This report provides the Environmental Protection Authority's advice and recommendations to the Minister for the Environment on that assessment, including the key environmental factors relevant to the proposal, as required by Section 44 of the *Environmental Protection Act 1986*. In addition, the EPA may make recommendations as it sees fit.

The EPA makes independent environmental recommendations and it is then the role of the Minister for the Environment to decide if a proposal may be implemented. The EPA is also required to have regard for the principles set out in section 4A of the *Environmental Protection Act 1986.*

Relevant environmental factors and principles

The EPA decided that the following key environmental factors relevant to the proposal required detailed evaluation in this report:

(a) Terrestrial flora, fauna and vegetation communities;

(b) Subterranean fauna;

(c) Introduced non-indigenous organisms;

(d) Marine biota, particularly flatback turtles and benthic primary producers;

(e) Greenhouse gas injection and emissions;

(f) Light, noise and vibration, particularly as they affect turtles

(g) Air quality; and

(h) Groundwater as it affects subterranean fauna.

There were a number of other factors which were relevant to the proposal, but the EPA is of the view that the information set out in Appendix 3 provides sufficient evaluation. These other factors included:

(i) Soil and landform;

(j) Surface water;

(k) Liquid and solid waste disposal;

(l) Hazards and spills;

(m) Cultural heritage; and

(n) Public safety.

The following principles were considered by the EPA in relation to the proposal:

(a) The principle of conservation of biological diversity and ecological integrity;

(b) The precautionary principle;

(c) The principle of intergenerational equity; and

(d) The principle of minimisation of waste.

Key assessment findings

The EPA has considered the proponent's Environmental Review and Management Programme report and supporting documentation, public and government agency submissions, advice from specialist technical experts and the proponent's response to submissions in undertaking its assessment. The EPA recognises that the proponent has undertaken a substantial and extensive review.

There are a number of key issues related to this proposal that required careful consideration by the EPA. The proposal is unusual in that a major industrial complex is being proposed for a class A nature reserve with very important conservation values represented nowhere else in the world. There have been few, if any, proposals of this magnitude and significance considered before for a site of such sensitivity in Western Australia.

Outlined below are the key environmental factors considered by the EPA regarding the environmental manageability and acceptability of the proposal.

Turtles and other marine fauna

Marine fauna, a number of which are listed species, comprise an important component of the conservation values of the waters around Barrow Island. The marine habitats around Barrow Island support year-round foraging populations of marine turtles. Of the six species of sea turtles found in Western Australia, five are found in the Montebello/Barrow Islands Marine Conservation Reserves (MCR). Barrow Island and adjacent marine areas provide essential habitat for a wide range of the life history stages for marine turtles.

The very large nesting population of green turtles on the western beaches of Barrow Island is internationally significant. North Whites Beach supports only a trivial

amount of nesting and is thus a better option than Flacourt Bay for the feed gas pipeline shore crossing.

Flatback turtles are listed as 'fauna that is rare or likely to become extinct' under the *Wildlife Conservation Act 1950*. The nesting population on Barrow Island is a major part of the Pilbara genetic stock. Flatbacks nest preferentially on the lower energy east coast beaches of Barrow Island. Terminal Beach and Bivalve Beach, either side of the proposed causeway to the materials off-loading facility (MOF) and jetty, are two of the most important on Barrow Island for nesting by flatbacks.

About one third of the Pilbara flatback turtles are thought to nest within the project area. This Barrow Island population is an internationally significant rookery of very high conservation significance at the global scale. Indications are that 70% (~500 females annually) of flatback turtle nesting on Barrow Island occurs on the mid-east coast beaches, immediately to the north and south of Town Point where most of the Gorgon proposal infrastructure would be located.

Both the green and flatback turtle stocks in the Barrow Island region are already subjected to a range of negative impacts from human activities within their nesting, migratory and foraging ranges. Any reduction in population dynamics of these species at Barrow Island as a result of the Gorgon proposal will further reduce the long term survival prospects for these species in Western Australia.

A key risk to these turtles, is the effect of artificial lights on nesting behaviour by adults and on orientation by new hatchlings. Individual lights can disorient hatchling turtles up to a few hundreds of metres. The diffuse glow from light sources can cause disorientation on hatchlings up to 4.4km from the light source.

The Gorgon proposal infrastructure, has the potential to significantly alter the light horizon behind and over the most important flatback turtle nesting beaches in Western Australia. The MOF and jetty have the potential to extend these altered light horizons over 4km out to sea. Both direct lighting and glow are likely to reduce breeding success and recruitment, with serious long term impacts on population size.

Once at sea, hatchlings are very likely to be attracted to and entrapped by lights on the jetty and ships loading at sea or working in the vicinity. When trapped, the hatchlings become easy targets for predators.

The proponent has undertaken work to identify how lights could be minimised and commitments by the proponent to minimise lighting at the detailed design stage are appropriate, but lights on the plant, support facilities, jetty and on LNG tankers would still be required. It is clear from the ERMP that the Gorgon facilities on shore and on the causeway and jetty will not be dark and hence will not maintain the natural dark horizon that helps cue turtles to nest on the adjacent beaches.

The proponent has identified a number of useful approaches to reduce light intensity and spillage. While the ERMP implies significant reductions in lighting effects over a conventional regime, it gives no assurance that the reduction achieved will keep changes to the light horizons at a level that is not disruptive to nesting turtles and at a level that does not increase hatchling mortality.

The size of the nesting population of flatback turtles on the mid-east coast beaches of Barrow Island will decline substantially over the next few decades. Increased mortality of hatchlings will occur through increased predation and losses to disorientation.

It is not certain what impact the causeway would have on the beach profiles on either side. Beach profile is one of the criteria which governs the suitability of a beach for nesting. The EPA is therefore unable to conclude that the presence of the causeway and MOR is environmentally acceptable in terms of potential impacts on longshore drift and the maintenance of important turtle nesting beaches on either side of the structures.

Direct impacts, from intake by the dredge and boat strike are likely. A large proportion of turtles killed by boat strike or propeller damage are associated with dredged shipping channels. Suction dredges kill turtles during dredging operations in other locations. Deaths of turtles can be expected off the east coast of Barrow Island.

Laying of pipelines and shore crossings at North Whites Beach would cause short term localised disturbance but this is not expected to have significant effects at a population level on green turtles. The effects of laying the DOMGAS line and optic fibre cable on turtles are unknown.

Prolonged elevated levels of turbidity and sedimentation are likely to reduce the availability of food for turtles in the area. Dredging will cause a direct reduction in available foraging grounds available for green, hawksbill, loggerhead and flatback turtles, but only in the order of tens of individuals. Indirect effects of turbidity and sedimentation could be expected to have a wider effect on food sources for possibly a few years after dredging.

When mortality increases by as little as a few percent above natural rates at any life history stage and continues over a turtle generation of a few decades, a marine turtle population will decline significantly. Consistent annual losses from a population of 5-10% of a life history stage above natural mortality levels can be expected to cause serious population declines within one generation and reduce populations towards extinction within about 100 years.

Even small annual reductions in breeding success and recruitment over the 60+ year life of the Gorgon proposal are likely to lead to serious declines in the flatback turtle population, possibly leading towards local extinction. There is a reasonable probability that the combined continuing impact over the 60+ year life of the Gorgon proposal as it is currently planned will threaten the viability of the most important flatback turtle rookery in Western Australia. This impact will only be apparent when the next generation of turtles return to breed in several decades time.

Due to the limited level of knowledge, multiple threats, probability of impacts, potentially high consequences and low level of certainty about how any impact could be effectively managed, the EPA does not consider that the risk of significant environmental impacts to the flatback turtle population can be judged to be acceptably low. The EPA concludes that the likely impacts on flatback turtles from the project as proposed are environmentally unacceptable.

Marine ecosystem and dredging

The assessment has shown that the marine environment around Barrow Island will generally be more extensively affected, and more difficult to protect from the effects of the proposal, than the terrestrial environment. It has also become evident to the EPA that there is considerable uncertainty surrounding the prediction of marine environmental impacts associated with this proposal.

Key marine aspects of the proposal involve approximately 7.6 million cubic metres of dredging for construction of port facilities, reclamation, pipeline and optic fibre cable laying, and dredge spoil disposal off the east coast of Barrow Island, and horizontal directional drilling (HDD) and pipeline laying off the west coast.

While the area of new clearing on Barrow Island would be limited to 300ha, 1650ha would be directly affected by the construction of infrastructure on the seabed. Key marine aspects of the proposal are predicted to disturb a total of about 10,900ha of the seabed at the completion of construction, primarily by the effects of turbidity and sedimentation generated by dredging. The predicted zone of influence within which elevated turbidity could occur at some time during construction encompasses an area of approximately 150,000ha. The scale of these predicted temporary and permanent impacts is significant and unprecedented in Western Australia. The EPA has not been provided with sufficient certainty that the risk of flow-on ecological effects of these impacts is acceptably low, that habitats will fully recover to the pre-impacted state or that recovery will occur in the time anticipated by the proponent.

While the proponent has undertaken extensive simulation modelling to predict the potential impacts of dredging, there is considerable uncertainty around what would be the actual zone and degree of impact to the marine environment and the time-scales and extent of recovery from that impact. In its assessment, the proponent has assumed that the fine sediments generated during dredging at Barrow Island would be similar to those produced during the dredging which occurred at Geraldton port a few years ago. Turbidity from the Geraldton port dredging program proved to be particularly difficult to manage because of the hardness of the rock encountered and the associated production of very fine particles. These factors generated a persistent turbidity plume which extended tens of kilometres along the coast north of the dredge site and caused significant reductions in seagrass health and cover around the dredged areas.

Based on current geo-technical work, rock at Barrow Island is considered to be almost twice as hard as the rock encountered at Geraldton. While the proponent has indicated that this should result in less fines generation as the rock may chip more easily, the actual amount of fines generated would not be known with any certainty until dredging commenced and monitoring occurred. Uncertainty also remains on the marine habitats that would be affected and the flow-on ecological consequences. While the proponent has used the available public information about habitats and undertaken some additional surveys, the extent of the area involved means that it is not clear just how much coral habitat, for example, is within the zone of influence of the proposal and how important that habitat is for overall ecosystem structure and function.

A number of computer simulations have been run by the proponent to predict the possible effects of horizontal directional drilling, dredging and dredge spoil disposal. Overall, the results indicate that turbidity plumes from these activities would be extensive and their temporary and permanent impacts on marine habitats would extend well beyond, and in some cases be spatially disconnected from, the development area.

Part of the marine area around Barrow Island is included in the Montebello/Barrow Islands Marine Conservation Reserves. A large area on the east coast of the island is designated as a port area and has been excluded from the Marine Conservation Reserves. While it has been excluded, the port area includes significant marine environmental values that are equivalent to those within the Reserves.

The proponent predicts that while a proportion of impacted benthic habitats in the zone of influence is likely to recover over a period of between 2 – 30 years following the completion of turbidity generating activities, considerable areas of benthic habitat are predicted to be permanently lost. These losses have been evaluated by the proponent broadly in the context of the EPA's Guidance Statement No.29 (*Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment*). The predicted permanent loss of coral habitat exceeds the EPA's cumulative loss threshold of 10% for designated development areas in two management units based around the inner operational areas associated with the proposed marine facilities at Barrow Island.

The proponent has also evaluated loss of benthic primary producer habitats in other designated management units within broader areas of the Barrow Island port against the 10% cumulative loss threshold. The EPA considers the outer parts of the port area at Barrow Island to be far greater in extent than intended for the application of the 10% cumulative loss threshold in Guidance Statement No. 29, and that the predicted loss and damage to the ecologically important benthic primary producer communities in these outer areas of the port is significant in view of the marine values there.

The proponent has proposed a three tiered management regime to deal with adverse impacts from dredging. The EPA appreciates that controlling dredge plumes in a dynamic environment is not a precise exercise. The EPA has not, however, been convinced that the approach to monitoring or the level of management proposed adequately addresses the residual environmental risks that arise due to the suite of uncertainties outlined above. Moreover, the EPA is concerned that the proposed management approach may not allow the proponent to respond decisively and early enough to ensure that unacceptable, and potentially irreversible, impacts do not occur to particularly important coral communities on the Lowendal shelf and at Batman and Dugong reefs. These important areas of reef are within a few kilometres of the predicted impact zones and the actual extents of those impact zones have considerable uncertainty about them.

The EPA considers that, even with best endeavours, the likely impacts of the dredging and infrastructure currently proposed would be environmentally unacceptable. The EPA thus considers that the proposed scale of dredging and marine infrastructure development should not be approved.

Introduced non-indigenous species

A number of mammals listed as threatened under the *Wildlife Conservation Act 1950*, are now confined to Barrow Island and a few other islands or have restricted distributions elsewhere. These include the Barrow Island Spectacled Hare-wallaby, Barrow Island Euro, Barrow Island Mouse, Golden Bandicoot, Boodie and the Black Flanked Rock Wallaby. Several of these or their close relatives were formerly abundant on the mainland. These include the Spectacled Hare-wallaby, Golden Bandicoot and Boodie. A major reason for their decline on the mainland was the introduction of non-indigenous species (NIS), particularly predators. The introduction and establishment of non-indigenous species as a result of the proposal represents a major threat to the terrestrial conservation values of Barrow Island nature reserve.

A gas processing complex requires many times more equipment, personnel and transport movements than the oil operation on Barrow Island has in the past. Major construction activity would require thousands of workers on short term contracts managed by many sub-contractors. Managing quarantine awareness and compliance with such a workforce is fundamentally different from doing so with the long term, small scale and dedicated workforce that operates the oil asset. The EPA is not aware of any examples where such a task has been successfully demonstrated.

The EPA considers that maintaining strict quarantine under the proposed circumstances would be much riskier than under the current conditions. Accordingly, the standards for protection would need to be high, well resourced and rigorously applied over the 60+ year life of the proposal. The proposal would also involve extensive construction and operations in the marine environment around Barrow Island that the existing operations have not required.

The proponent has undertaken rigorous and extensive desktop assessment on the introduction of non-indigenous species and quarantine management procedures available to reduce introduction risks and is to be commended for that work.

The EPA notes and strongly supports the proponent's adoption of the EPA's recommendation that there should be a "zero tolerance of invasions target" for Barrow Island. The EPA recommended that the proponent demonstrate that an "acceptably low" level of risk could be achieved and commends the proponent's acknowledgement of this requirement. Such a standard is vital to ensure the survival of terrestrial species found nowhere else in the world.

The proponent has engaged in a transparent and rigorous process involving experts and community members to define acceptable risk standards for the establishment of non-indigenous species on Barrow Island, as recommended by the EPA. The process was open to all and included representatives from the Conservation Council of Western Australia and the Conservation Commission.

Four steps affecting the establishment of an introduced species on Barrow Island were examined. Those steps were introduction, survival, detection and eradication. The process determined that participants accepted three risk scenarios, with a strong preference for a scenario where the risk of introduction was at the lowest level of 1, on a scale from 1 to 10, qualitatively described as "extremely remote, highly

unlikely". The expert and community process determined that scores up to 3 ("slight chance") for introduction would only be acceptable in the other two scenarios if scores of 1 could be achieved for at least one of the other three steps (survival, detection or eradication).

The proponent has involved credible experts in a significant body of work undertaking detailed desktop reviews of the qualitative risks of introducing non-indigenous species to the nature reserve. The proponent has provided the EPA with qualitative risk assessments for 16 introduction pathways identified for the proposal.

Those analyses show that qualitative residual risk scores for introduction, assuming successful application of all available quarantine barriers, range from a score of 1 (acceptable to the experts and community) to scores of 2 or 3 (not acceptable). Application of quarantine barriers reduces the risk of introductions but residual risk remains. When considering two of the critical pathways, experts advised the proponent that the risk of introduction was 'low' (scores ranged from 1 to 3) but introduction risk scores could not be further reduced to meet a uniform standard of 1, as required by the community and expert process. This is understood to mean that no additional practical barriers could be envisaged that would improve the results.

The EPA notes that in only 10 of the 42 cases assessed did the level of introduction risk clearly achieve a score of 1 found acceptable during the expert and community standards setting process. These scores assume that all risk treatments recommended by the experts are adopted. If those recommendations are not adopted, there is a clear score of 1 in only 3 cases and scores range up to 5 in one case.

No data have been provided so far by the proponent about the effectiveness and certainty of control at the survival, detection or eradication steps. These data are critical to demonstrate establishment could be avoided if introduction scores remain above 1. This means that the standards set by the expert and community process have not been met in a large majority of cases and are incapable of being met on the current information available. Where introduction scores are greater than 1, the standards require at least one other step to be scored at 1. None of the other steps has been scored and the proponent advised the EPA that it is not considered practical to do so.

The EPA considers that the community and expert view that only the lowest level of risk is acceptable in a class A nature reserve is appropriate for such an important conservation asset. The EPA further considers that risks would need to be at the 'extremely remote, highly unlikely' level to be acceptably low. While the proponent considers that its analysis of risk is conservative, the EPA is mindful of the very high significance of Barrow Island and thus the critical consequences if quarantine fails.

The EPA is also aware that failures are more likely with a large, short term workforce and where a complex operation relies on absolute human vigilance over decades. A well run quarantine system would be run on similar lines to an excellent safety system. Despite clear commitment, vast resources and constant effort applied to existing safety systems in many industries, injuries and even deaths still occur in the long run. Data on the rates of failure of well run quarantine systems are outlined in Section 4.3.

The EPA notes that the assessed scores rely on all practical quarantine barriers being applied, and that there are no other practical barriers that experts could envisage. The EPA also notes that those barriers need to operate successfully 24 hours per day, 365 days a year for the 60+ year life of the project to achieve the assessed outcome and that in a majority of cases the assessed scores do not reach the standard set by the expert and community process.

The EPA sought expert advice from Professor Richard Hobbs of Murdoch University on the likelihood of conservation values on Barrow Island being sustained if the Gorgon proposal was to proceed. Professor Hobbs advised that:

"The proposed Quarantine Management System rightly concentrates on pre-border measures to reduce the likelihood of invasion, but the proponents have not adequately established that this system will be effective, and have provided little detail on measures to detect and eradicate successful incursions. Lessons from other parts of the world, including many islands, indicate that invasive species can have devastating effects on island biota and ecosystems. Hence it is not possible to conclude that the conservation values of Barrow Island will be sustained if the Gorgon proposal was to proceed in its current form".

The EPA considers that the residual risk of the introduction of non-indigenous species to Barrow Island Nature Reserve is environmentally unacceptable as the risk has not been demonstrated to be acceptably low and no feasible additional quarantine barriers or other control conditions have been proposed to achieve an environmentally acceptable outcome.

Subterranean fauna and fauna restricted to the development footprint

Based on surveys to date, up to seven subterranean taxa have been found beneath the plant site and nowhere else so far. As the construction camp has also been relocated west of the existing accommodation on Barrow Island, it is not certain that this area has been adequately sampled for subterranean taxa yet. Two taxa of terrestrial invertebrates (a scorpion and a pseudo-scorpion) have also only been found within the development footprint so far.

If any of these taxa actually occur only on or below the development site, then it is almost certain that they would become extinct when the site is cleared and developed. The terrestrial taxa would be lost because their habitat would be removed by clearing. The subterranean taxa would have to be regarded as lost because cutting and filling would destroy much of the troglobitic habitat, construction would impede the infiltration of rainfall and associated nutrients on which stygofauna depend and operations are likely to lead eventually to the infiltration of spilt hydrocarbons.

The proponent is currently carrying out further surveys on the distribution of subterranean fauna and terrestrial fauna restricted to the proposal footprint, to assess whether those species occur elsewhere on the island outside the development area. The proponent considers that, based on the island's geology, it is likely that the subterranean species are more widely dispersed but this has not yet been demonstrated.

Other potential risks to subterranean fauna include:-

- draw-down of the aquifers on which they depend, if abstraction of water for desalination affects those aquifers; and
- leakage of injected wastes or carbon dioxide into the zones where those biota live.

With the current level of knowledge, the EPA can only conclude that there is a finite risk that these taxa would be lost and that such an outcome would be unacceptable. Accordingly, the EPA concludes, on the current evidence, that clearing of the sites where these taxa occur is environmentally unacceptable.

Greenhouse gases

Greenhouse gases would be emitted by the project principally through venting of carbon dioxide (CO_2) removed from the reservoir feed gas prior to processing, and from combustion sources used to supply energy for gas processing. Greenhouse gas emissions are a major contributor to climate change. It is predicted the project would emit about 4 million tonnes of greenhouse gases annually, comprising about 0.7 million tonnes per annum (MTPA) from reservoir CO_2 vented, and about 3.3MTPA from combustion sources for gas processing. This would add about 6% to Western Australia's greenhouse gas emissions, or 1% to Australia's emissions. Australia represents around 1% of global greenhouse gas emissions.

A total of about 3.4MTPA of CO_2 would be removed from the reservoir feed gas prior to processing. The proposal includes a plan to inject at least 2.7MTPA (80%) of this back into the subsurface, more than 2000 metres below Barrow Island (up to 0.7MTPA (20%) may need to vented to the atmosphere due to operational reasons such as maintenance and repair). The proponent has carried out extensive investigations of the potential to dispose of reservoir CO_2 by injection. This has included assessment of potential CO_2 injection sites, subsurface geology and stratigraphy, injectivity and capacity of formations to store the CO_2, and likely CO_2 behaviour and movement in the subsurface.

The proponent is still carrying out further investigations on the feasibility and costs of CO_2 injection, and is currently drilling a well to test the injectivity of the Dupuy Formation. The proponent has committed to progressing a scheme to inject about 80% of the reservoir CO_2 unless it is "technically infeasible or cost prohibitive". The current drilling and testing will provide further information to assess feasibility and cost. The proponent has indicated that if it is technically infeasible or cost prohibitive to inject the proposed volume of CO_2, then it would liaise with Government with the intent of maximising the injection of CO_2 within the commercial constraints of the project.

One of the benefits identified by the proponent in locating the gas processing facilities at Barrow Island was the potential to inject CO_2 back into the subsurface to reduce overall greenhouse gas emissions from the project. If injection did not occur, then the chief environmental benefit of locating this project on Barrow Island would be lost.

The proponent has adopted a number of significant efficiency improvements to minimise greenhouse gas emissions associated with the gas processing, including:

- use of sub-sea technology rather than platform-based offshore gas processing;
- improvements in LNG process technology; and
- improved waste heat recovery on the gas turbines resulting in a significant reduction in the use of supplementary boilers and heaters.

Based on benchmarking undertaken by the proponent, this would make the overall greenhouse gas efficiency of the project, in terms of tonnes of greenhouse gases emitted per tonne of LNG produced, comparable with North West Shelf Train 4 and 5 expansion, and other LNG developments in similar environments around the world, provided the injection scheme was implemented. The proponent has also identified potential areas for additional improvements in the future which would further improve the overall greenhouse gas efficiency of the project.

The EPA considers the project would be environmentally unacceptable if it did not include a scheme designed to inject a high percentage of the reservoir CO_2, or implement alternative measures to abate the equivalent amount of reservoir CO_2 vented to the atmosphere.

Conclusion

Having considered the proponent's Environmental Review and Management Programme report and supplementary information, public and government agency submissions, separate expert advice and the proponent's response to submissions, the EPA has concluded that the overall impacts of the proposal would be environmentally unacceptable. While the proponent has identified measures through the environmental assessment to reduce impacts and risks to the key terrestrial and marine environmental values, it is the EPA's judgment that the extent of predicted impacts and degree of residual uncertainty and risks posed by the proposal remain unacceptably high. The key areas where significant impacts or risk of impacts remain are:

- risk of impacts to flatback turtle populations;
- impacts on the marine ecosystem from dredging;
- risk of introduction of non-indigenous species; and
- potential loss of subterranean and short range endemic invertebrate fauna species.

The proponent has not been able to demonstrate to the EPA that the sensitive conservation and environmental values could be maintained with a high degree of certainty, nor that the risks to those values would be acceptably low in the long term.

Based on the assessment, the EPA does not believe that the proposal could be made environmentally acceptable. Accordingly, the EPA recommends that, from an environmental point of view, the proposal should not be permitted to proceed as proposed.

Other advice

The EPA has some recommendations that have come out of its assessment that are relevant to existing circumstances on and around Barrow Island.

Size of Barrow Island Port

The EPA considers that a process to rationalise the Barrow Island port area to the smallest possible size to allow safe shipping operations should be implemented by the Government as a priority. The EPA understands that the Government has already made a decision to examine this issue and supports its early implementation.

Governance of current operations

The EPA notes that Chevron Australia acts as operator for the oil field that continues on Barrow Island nature reserve today. A number of contractors service that oil field and Barrow Island is also used as a transit point to support other offshore operations. The oil field operations are regulated under the terms of lease L1H granted pursuant to the *Petroleum Act 1936 and 1967*. The majority of development on the lease predates the *Environmental Protection Act 1986* and current operations on Barrow Island have not been subject to environmental impact assessment or conditions imposed by the Minister for the Environment. Pollution control aspects of these operations are subject to regulation under Part V of the *Environmental Protection Act 1986*. Regardless of any decision by Government about the Gorgon proposal, these existing operations require additional, up to date environmental conditions, with direct professional oversight by conservation authorities, to ensure the conservation values of the nature reserve are maintained in the long term.

The EPA considers that sufficient agency resources and governance arrangements should be put in place to properly manage existing operations on Barrow Island. These arrangements should pay particular attention to the need to manage multiple responsible entities and ensure that responsibilities are not avoided because it may be unclear who is responsible for a particular incident. For example, if an introduced species arrived on Barrow Island, it would be critical that it was rapidly contained and dealt with, regardless of who was responsible for its introduction. To protect the conservation values of the island and its surroundings, it would be vital that the issue was effectively dealt with, without delays caused by deciding who was responsible or who would pay.

The Conservation Commission is the vesting authority for Barrow Island Nature Reserve. Operational responsibility for the management of actions on nature reserves rests with the Department of Conservation and Land Management.

The EPA considers that significantly upgraded environmental regulatory control is required on Barrow Island, including the capacity for the Department of Conservation and Land Management to better regulate relevant parts of the activities and manage the conservation values of Barrow Island.

The EPA notes that lease L1H is due for renewal in February 2009 and recommends that approaches to include upgraded regulatory control of conservation and

environmental matters be examined with a view to including such controls in the lease conditions.

Decision on the Gorgon proposal

The EPA recognises that the Government has previously provided in-principle agreement to the Joint Venturers for restricted access to Barrow Island for gas processing facilities, as a foundation for the development of the Gorgon area gas fields, subject to this environmental impact assessment and other statutory approvals. The EPA also recognises that the Government's decision regarding the current proposal will be based on consideration of social, economic, and strategic issues, as well as environmental matters.

Because the EPA does not consider that its environmental objectives could be met, it has not included recommended environmental conditions for the management of the proposal in this report. If, however, Government was to decide that the proposal may proceed for other than environmental reasons, a set of strict conditions and governance arrangements would be required, along with implementation of the proponent's commitments. A draft framework to guide the necessary content of a possible set of environmental conditions is included in Appendix 4.

Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on the relevant environmental factors and principles the EPA considered relevant to the proposal, as set out in Section 4.
2. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objectives and is considered environmentally unacceptable, particularly with regard to the risk of impacts to flatback turtle populations, impacts on the marine ecosystem from dredging, risk of introduction of non-indigenous species and potential loss of subterranean and short range endemic invertebrate fauna species.
3. The EPA therefore recommends that, from an environmental point of view, the proposal should not be permitted to proceed as proposed at Barrow Island.
4. That the Minister notes the EPA's other advice presented in Section 6 and Appendix 4 outlining essential environmental requirements that the EPA considers would need to be applied to the proposal, should the Government decide for other than environmental reasons that the proposal may be implemented.

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4. Gorgon Gas Development and boundaries of Montebello/Barrow Islands Marine Conservation Reserves. Note semi-circular area of Barrow Island Port.
5. North Whites Beach feed gas pipeline route and process facility location at Town Point.

Appendices

1. List of submitters
2. References
3. Summary of identification of relevant environmental factors
4. Possible draft framework for environmental conditions
5. Summary of submissions and proponent's response to submissions (on Disk 1)
6. Residual risk tables
7. Report by Dr Keith Hayes et al, CSIRO (on Disk 2)
8. Proponent response to report by Dr Hayes et al, CSIRO (on Disk 2)
9. Letter from Dr Keith Hayes, CSIRO (on Disk 2)
10. Report by Professor Richard Hobbs, Murdoch University (on Disk 2)
11. Proponent response to report by Professor Hobbs, Murdoch University (on Disk 2)
12. Report by Dr Colin Limpus, Queensland EPA (on Disk 2)

1. Introduction and background

This report provides the advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment on the environmental factors and principles relevant to the proposal by Chevron Australia to develop the Greater Gorgon gas fields (Figure 1). The proposal includes a 10 million tonne per annum liquefied natural gas processing complex, a 300 terajoule per day domestic gas plant, a carbon dioxide injection plant and associated infrastructure on Barrow Island nature reserve (Figure 2). The proposal also involves some 7.6 million cubic meters of dredging and other ancillary works which would result in the direct disturbance of about 1390ha of seabed habitat adjacent to Barrow Island and its surrounding marine management area (Figure 3).

The EPA, in its Bulletin 1101 (EPA, 2003), advised against locating a gas processing complex on Barrow Island nature reserve as a matter of principle and because it was not convinced, based on the information then available, that the important conservation and environmental values of Barrow Island could be adequately protected. That report formed part of an environmental, social and economic (ESE) review of the Gorgon development by Government in 2003. That review led to an in-principle decision by Government for restricted access to Barrow Island class A nature reserve for gas processing facilities, as a foundation for the development of the Gorgon gas fields. That decision required special conditions, including;

- net conservation benefits; and
- environmental, social, economic and strategic conditions.

The *Barrow Island Act 2003* set out the terms of access to the island, including the need to comply with all other statutes, including all provisions of the *Environmental Protection Act 1986*.

Barrow Island is approximately 23,600ha in area. It has been recognised, in statute and by the community, for its high conservation values for over ninety-five years. It has been classified as a class A nature reserve to reflect its status as a jewel in the crown of the conservation estate and to protect its environmental values. The waters around Barrow Island in part have recently been gazetted as part of Montebello/Barrow Islands Marine Conservation Reserves.

The internationally recognised environmental values of Barrow Island are its unique combination of taxa and communities and its island status. Of the known taxa on Barrow Island, there are at least 24 terrestrial taxa that occur nowhere else and another 5 that are restricted in their distribution. The high density and diversity of species are largely due to Barrow Island being naturally quarantined from invasive species because it is an island and legislatively protected by its statutory status.

Barrow Island currently supports an oil production operation with a workforce of 150-200 people. This operation has been in place since the 1960s. Production is declining but is expected to continue for 15-20 years more. The proponent advises that to date some 1222ha (5.2% of the island) have been disturbed by oil operations.

The Gorgon proposal was referred to the EPA for formal environmental impact assessment on 19 November, 2003. The proposal is also a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act.* As such it is also being assessed by the Commonwealth, in parallel with the EPA's assessment.

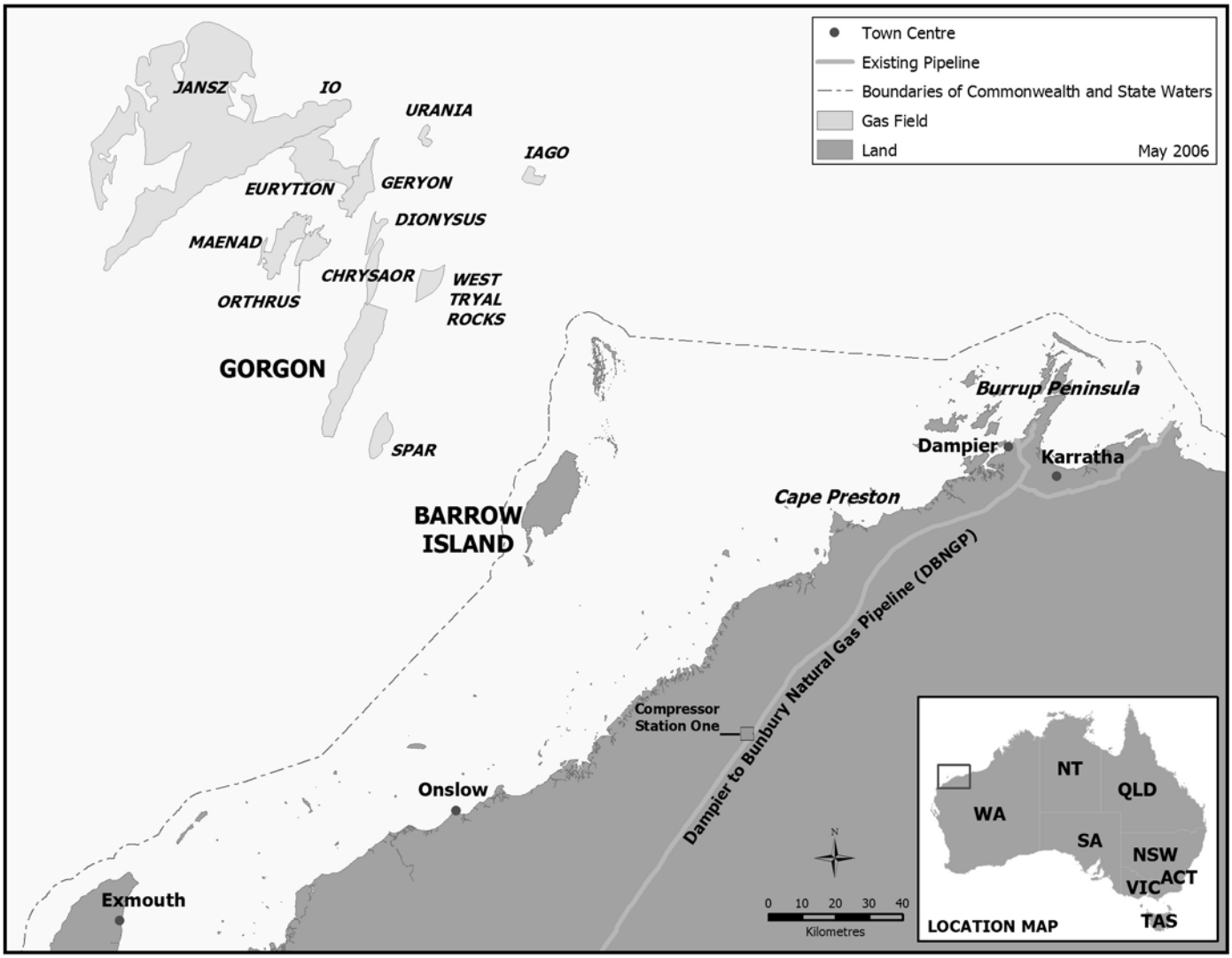

Figure 1: Location of Barrow Island nature reserve and Greater Gorgon and Jansz gasfields.

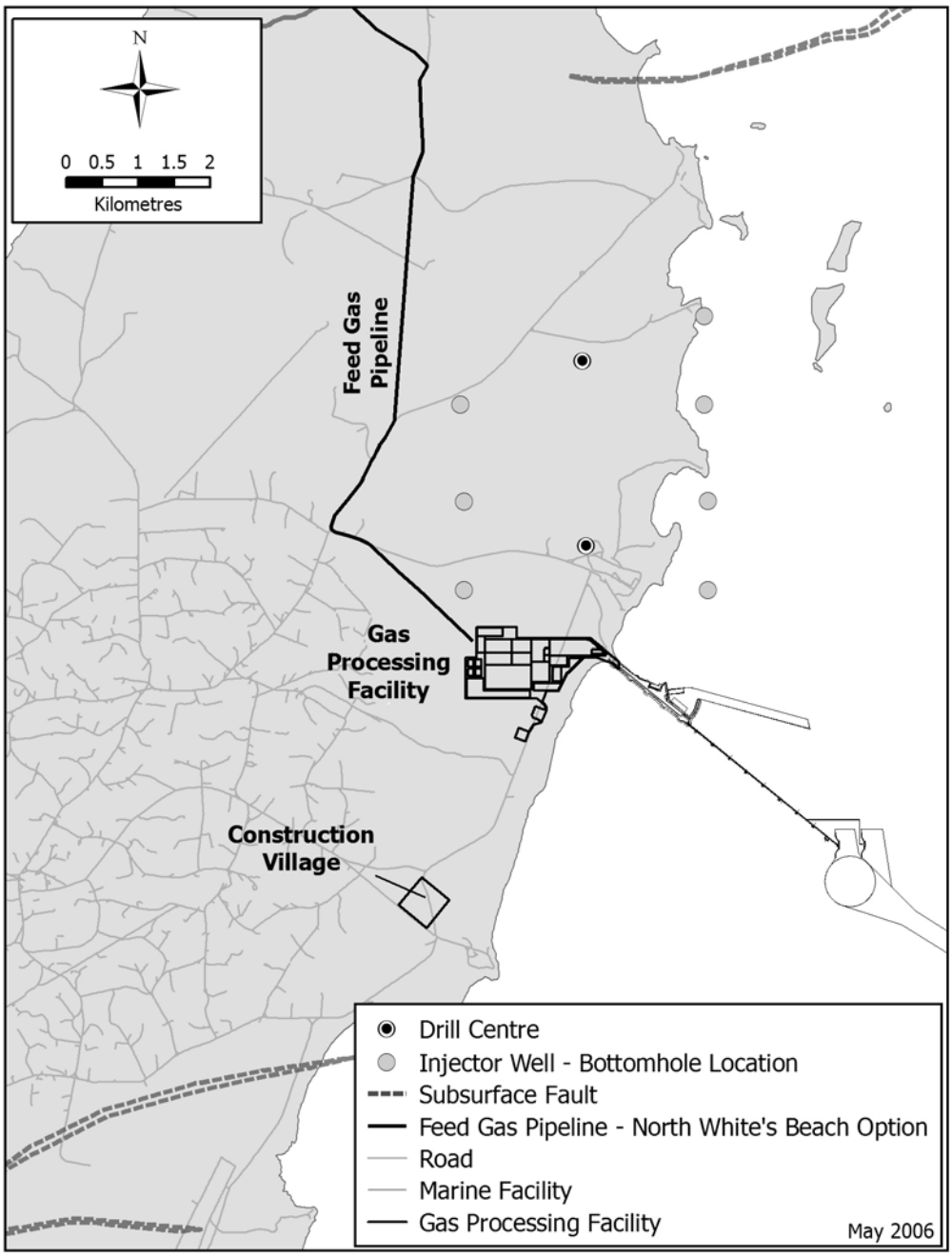

Figure 2: Schematic layout of Gorgon Gas Development on Barrow Island nature reserve.

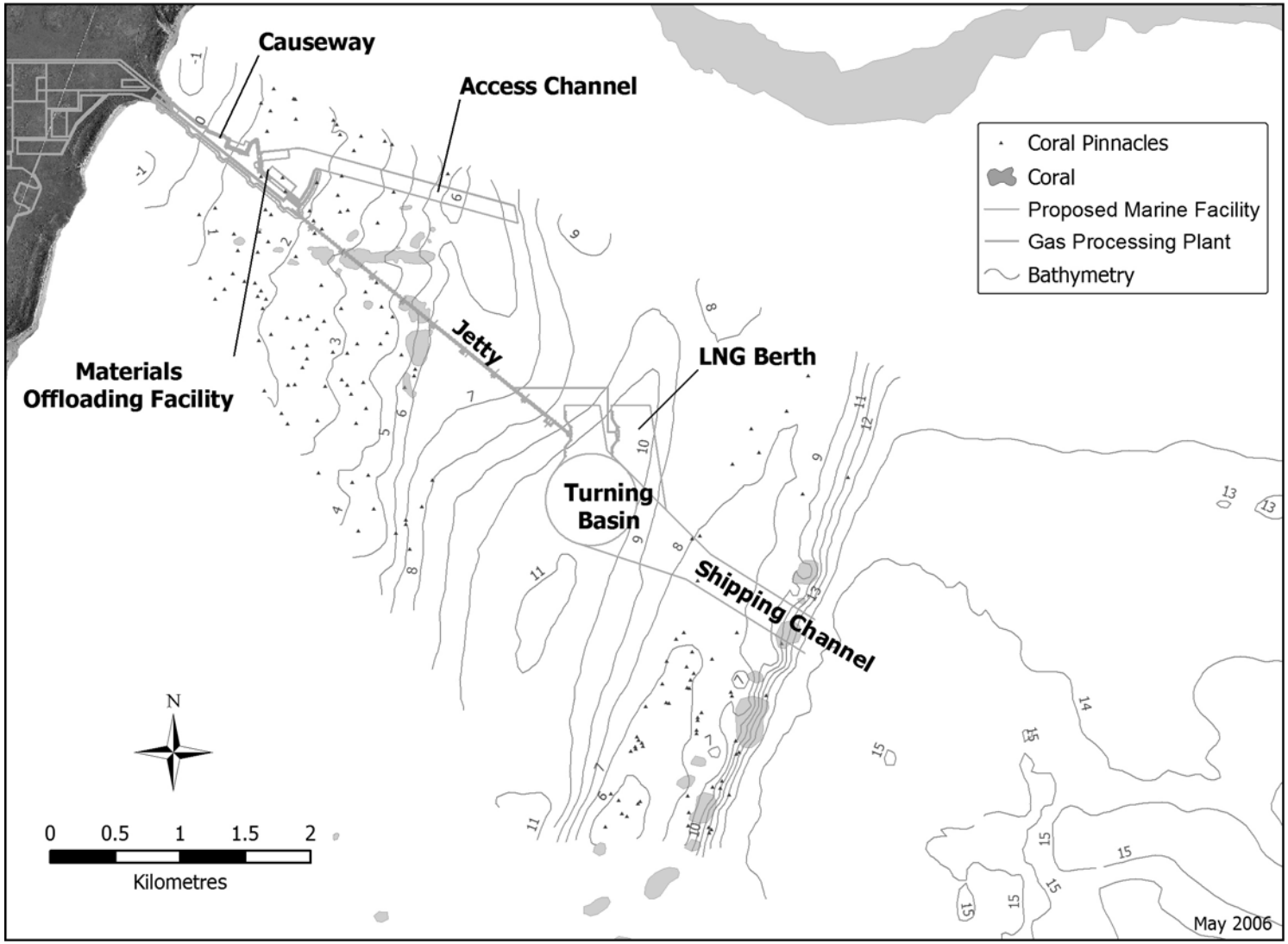

Figure 3: Schematic layout of marine facilities off Town Point, Barrow Island showing partial distribution of corals.

Work undertaken by the proponent during the ERMP process has advanced knowledge of the values of Barrow Island and indicates that there is still much to learn. Survey work undertaken since the time of the ESE has discovered (Table 1) additional plant and animal species (including a number of un-described taxa), and additional introduced species have been detected (Chevron, 2005a). Ongoing research on turtles has tracked female flatbacks for the first time and made a start on understanding their response to lights. We still do not know where juvenile flatbacks live. Some intensive desktop work has detailed the extent and complexity of the quarantine task required to prevent introductions of non-indigenous species and accomplished detailed simulations of the extensive area likely to be affected by dredging.

Further details of the proposal are presented in Section 2 of this report. Section 3 outlines the context of the report and Section 4 discusses the environmental factors and principles relevant to the proposal. Section 5 presents the EPA's conclusions, Section 6 provides other advice by the EPA, and Section 7, the EPA's recommendations.

A summary of submissions and the proponent's response to submissions is included on a compact disc inside the back cover of this report. It is included as a matter of information only and does not form part of the EPA's report and recommendations. Issues arising from this process, and which have been taken into account by the EPA, appear in the report itself.

Table 1. Increases in known flora and fauna on and around Barrow Island as a result of work performed for the Gorgon Gas Development ERMP.

FLORA		
New records for Barrow Island 2006	• *Tribulus hirsutus* • *Evolvulus alsinoides* var. *villosicalys* • *Ptilotus fusiformis* var. *fusiformis* • *Setaria verticillata* • *Tephrosia clementii* • *Eriachne flaccida* • *Leptopus decaisnei* • *Phyllanthus erwinii* • *Eriachne helmsii* • *Polycarpaea corymbosa*	
STYGOFAUNA		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Total species	24 species[1]	Over 20 described taxa[2] • Including 2 new species of anchialine hadziid amphipods and 5 species restricted to the development site. Plus a number of undescribed taxa[3]

[1] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow Island,* page 110.
[2] Chevron (Sept 2005) *Draft EIS/*ERMP, page 249.
[3] Biota (Oct 2005) *Subterranean Fauna Survey*, page 32.

TROGLOFAUNA		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Total species	4 species[1]	Over 10 taxa[4] • Including a new troglobitic spiroboloid millipede (*Speleostrophus nesiotes*), a new dipluran (*Japygida* sp. 1), a new undescribed archaeognathan, and a new undescribed symphylan. • Including 2 species restricted to the development site
TERRESTRIAL INVERTEBRATE FAUNA		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Total species	6 species[1] (5 land snails, 1 scorpion)	108 species[5] (10 mites, 74 spiders, 7 pseudoscorpions, 3 scorpions, 7 centipedes, 3 isopods, 4 land snails) • Including 57 undescribed species and 10 species endemic to Barrow Island
MARINE VERTEBRATE FAUNA		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Total whale species in the vicinity of Barrow Island listed under State or Federal Acts	7 species[6]	29 species[7]
Total shark species in the vicinity of Barrow Island listed under State or Federal Acts	2 species[8]	3 species[7]
Total dolphin species in the vicinity of Barrow Island listed under State or Federal Acts	0 species[9]	14 species[7]
Total dugong species in the vicinity of Barrow Island listed under State or Federal Acts	1 species[9]	1 species[7]
Total marine turtle species in the vicinity of Barrow Island listed under State or Federal Acts	5 species[8]	6 species[7]

[4] Biota (Oct 2005) *Subterranean Fauna Survey*, page 25-28.

[5] Biota (April 2005) *Barrow Island Short Range Endemics and Other Terrestrial Invertebrates*.

[6] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow* Island, page 86.

[7] BBG (April 2005) *Gorgon Development on Barrow Island Protected Marine Species*, Table 5-1.

[8] EPA (July 2003) *Environmental Advice on the Principle of Locating a Gas Processing Complex on Barrow Island Nature Reserve* Section 16E Report, page 45.

[9] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow* Island, page 88.

REPTILES AND AMPHIBIANS		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Restricted or significant reptile species	2 species[10]	2 species[11] Plus 1 new record for Barrow Island[12]
Total amphibian species	1 species[13]	1 species[14]
BIRDS		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Land birds endemic to Barrow Island	1 species[15]	1 species[16] Plus 4 new records for Barrow Island; Great egret *(Ardea (Egretta) alba)*, Little pied cormorant (*Phalacrocorax melanoleucos*), Little black cormorant (*Phalacrocorax sulcirostris)* and Oriental cuckoo (*Cuculus saturatus)*
Total species of seabirds	53[17] Including 21 migratory species and 6 resident species	67 species[18] Including 25 migratory species and 20 resident species
MAMMALS		
	EPA Section 16E Report 2003	**Gorgon Development 2006**
Restricted or significant species	10 species[19] Including 6 species listed under State or Federal Acts	10 species[20] Including 6 species listed under State or Federal Acts

[10] EPA (July 2003) *Environmental Advice on the Principle of Locating a Gas Processing Complex on Barrow Island Nature Reserve* Section 16E Report, page 47.
[11] Chevron (Sept 2005) *Draft EIS*/ERMP, page 242.
[12] Bamford, Biota and BBG (April 2005) *Gorgon Development on Barrow Island Mammals and Reptiles*, page 14.
[13] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow* Island, page 109.
[14] Chevron (Sept 2005) *Draft EIS*/ERMP, page 243.
[15] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow* Island, page 108.
[16] Chevron (Sept 2005) *Draft EIS*/ERMP, page 234.
[17] Chevron (Feb 2003) *ESE Review of the Gorgon Gas Development on Barrow* Island, page 90.
[18] Chevron (Sept 2005) *Draft EIS*/ERMP, page 266.
[19] EPA (July 2003) *Environmental Advice on the Principle of Locating a Gas Processing Complex on Barrow Island Nature Reserve* Section 16E Report, page 46.
[20] Chevron (Sept 2005) *Draft EIS*/ERMP, page 241.

2. The proposal

The main characteristics of the current proposal are summarised in Table 2 below. A detailed description of the proposal is provided in Section 6 of the Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development (Chevron, 2005a). That document serves as the Environmental Review and Management Programme (ERMP) for the Western Australian assessment process as well as the draft Environmental Impact Statement (draft EIS) for the purposes of the Commonwealth assessment process.

Since the time of the in-principle consideration of a gas processing complex on Barrow Island in 2003, the proposed plant has been increased in size from 5 million tonnes per annum to 10 million tonnes per annum, additional gas resources comprising the Jansz and other fields in the Greater Gorgon area have been included and the project life has been extended from 30 years to 60 years. These elements are described in the ERMP.

Since the ERMP was released in September 2005, further changes to the proposal have been made. The characteristics set out in the ERMP are included for completeness but where details have been changed those changes, as advised by the proponent, are listed in Table 2 below. A further document, titled the Additional Information Package (AIP) was released by the proponent in October 2005 (Chevron, 2005b). Additional detail has also continued to be provided by the proponent to the EPA, up to at least 21 April, 2006 (for example, EPA Briefing Papers 1 to 4 – Chevron, 2006a-d).

The proponent has also released a Final EIS/ Response to Submissions on the ERMP, as required by the Commonwealth and State assessment processes (Chevron, 2006e). That document contains responses to the submissions made by members of the public under both the State and Commonwealth processes, as well as modifications to the proposal and additional modelling of dredging impacts.

Table 2: Summary of key proposal characteristics

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
Project timeline	Commence construction	Late 2006	No change
	First shipment of LNG	Mid 2010	No change
	Development life	60 years	No change
Size of recoverable resource	Gorgon field	0.27 Tm^3 (9.6 Tcf) (technically proven and certified)	No change
Leases	Gorgon field	WA-2-R; WA-3R	No change
Typical gas composition	Gorgon field	CO_2 = 14 to 15% N_2 = 2 to 3% Hydrocarbon = remainder	No change

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
	Jansz field	CO_2 = < 1% N_2 = 2% Hydrocarbon = remainder	No change
Wells	Design	Subsea	No change
	Location	Gorgon gas field	No change
	Number	18 to 25	No change
Feed gas pipeline	Total length	~ 84km	No change
	Length offshore	~ 70km	No change
	Length in state waters	5.6km (i.e. 3 nautical miles), 60ha	No change
	Indicative route offshore	North White's Beach route	No change
	Length onshore (Barrow Island)	~ 14km	No change
	Design onshore	Above ground on pipe supports	Buried (~ 1000mm cover)
	Construction easement (onshore)	~ 42ha	No change
	Shore crossing	North White's Beach. Flacourt Bay fallback	North White's Beach
	Route onshore	Refer to Draft EIS/ERMP Figure 8.13 Page 233	See Figure 5
Domestic gas pipeline	Length offshore	~ 70km, 70 ha	No change
	Length onshore (mainland)	~ 30km	30 to 40km. Studies are ongoing to determine the environmentally preferred mainland shore crossing location
	Construction easement (mainland)	~ 90ha	90 to 120ha
	Offshore route	Essentially direct line	No change
	Shore crossing	Immediately to the south of the existing Apache Energy Sales Gas Pipeline	Studies are ongoing to determine the environmentally preferred mainland shore crossing location
	Mainland route	Immediately to the south of, and running parallel to, the existing Apache Energy Sales Gas Pipeline	Studies are ongoing to determine the environmentally preferred combination of mainland shore crossing location and onshore pipeline route
CO_2 injection pipeline	Length	< 5km	No change
	Easement	< 6ha	No change
CO2 wells	Number of drill centres	2	No change
	Number of wells	6-8	No change

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
Gas processing facility	Location	Town Point	No change
	Number of LNG trains	2	No change
	Size of LNG trains	5 Mtpa nominal	No change
	Indicative plant layout	Trains 1 and 2 built on south side	Trains 1 and 2 built on north side
	LNG tank size	~ 135,000 to 155,000 m^3 net each	~ 135,000 to 165,000 m^3 net each
	Energy optimisation	Boilers required	Boilers deleted, but direct fired heaters required for startup and rare operational scenarios
		DLN on compression turbines (4 x 80 MW)	No change
		DLN on power generation turbines (3 x 116 MW)	Conventional 4 x 116 MW for reliability of supply
	NOx emissions	4,430 tpa	6,100 tpa, ground level concentrations reduced due to improved dispersion
	Flare design	Elevated flare (150m)	Ground flare for main plant flare. Elevated flare in storage and loading area (rarely used)
	Domestic gas production rate	300 TJ/day	No change
	Condensate production rate	2,000 m^3/day hydrocarbon condensate	No change
	Condensate tank size	2 x 35,000 m^3	2 x 60,000 m^3
	Condensate load-out concept	Via existing WA Oil loading line or new subsea line or new dedicated line installed on the proposed jetty	Via a new dedicated line installed on the proposed jetty
Construction village	Location	Four options still being investigated. Base Case immediately south of Gas Processing Facility	2.6km south of Gas Processing Facility
	Schedule	Pioneer Camp proposed	Pioneer Camp concept discarded

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
Administration and operations complex	Composition	Operations centre located within gas processing facility. Administration complex to comprise: 1. Administration buildings 2. Maintenance centre 3. Canteen 4. Fire station 5. Medical clinic 6. Laboratory 7. Mobile equipment storage 8. Substation	Operations centre located within administration complex outside plant boundary
	Location	Near the gas processing facility	No change
Utilities area (construction)	Location	Near the construction village or near the gas processing facility	Near the gas processing facility
Roads	Designated for upgrade	Upgrades of key roads would involve grading, sealing, widening and straightening as appropriate	Upgrade to roads: WAPET landing to Town Point Town Point to the airport (via construction village) Feed gas pipeline route
Water supply	Source	Exploratory wells as base case. Options being considered are deep well (i.e. CO_2 data well) and seawater intake	No change (awaiting hydrogeological survey results). Should sea water intake be required sensitive features on the east coast would be avoided
	Location	Exploratory wells (as base case) covered by investigatory works	No change
	Volume	~ 4,500 m^3/day raw water supply	~ 5,150 m^3/day raw water supply
Waste water treatment		Tiered system to enable separate treatment (if any) Separate treatment of grey and black water to enable reuse	Tiered system – no change Combined black/grey water treatment
Waste water disposal		Injection (deep) of surplus treated effluent	No change to base case. Ocean outfall of treated stream under review as fallback
		Injection (deep) of reverse osmosis brine as base case, ocean outfall an option	No change. Ocean outfall of treated stream under review as fallback

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
		Injection (deep) of contaminated streams such as storm water as base case	No change. Ocean outfall of treated stream under review as fallback
Power generation and supply (construction phase)		Located in the utilities area. Investigate connection to existing supply	No change
Utilities corridors	Location	Between utilities area, construction village and gas processing facility	No change
Airport	Modifications	Extension, but may require realignment	Extension of existing runway to the south. No realignment
Air emissions	Volume of greenhouse gases (with CO_2 injection)	4.0 million tonnes of CO_2e per annum	No change
	Total SOx	0.15 tpa	No change
	Total particulates (PM10)	241 tpa	No change (expect lower with ground flare)
Port facilities	Causeway design	Solid	No change
	Causeway length	~ 800m	No change
	MOF design	Solid	No change
	MOF length	~ 325m	520m
	MOF access	Constructed channel 1.3km long x 120m wide, dredged to 6.5m relative to chart datum	~ 1.6km long
	LNG jetty design	Open pile structure	No change
	LNG jetty length	3.1km	~ 2.7km
	Turning basin and access channel design	Turning basin 1 x 900m circle, channel 300m wide minimum	No Change. Options still being investigated
	Turning basin and access channel depth	Dredged to 14m relative to chart datum	No change. Options still being investigated
	Barge landing	Use WAPET landing, as the MOF would not be available	Upgrade WAPET landing
Dredging	MOF volume	0.8 Mm^3	1.1 Mm^3
	MOF dredging programme duration	~ 21 weeks	No change
	LNG turning basin and access channel	7.0 Mm^3 (single berth)	6.5 Mm^3 (dual berth). Options still being investigated
	LNG turning basin and access channel programme duration	~ 45 weeks	~ 42 weeks
Dredge spoil ground	Location	Closest point approx 10km from the east coast of Barrow Island	No change

Element	Description	Original proposal (as per Draft EIS/ERMP)	Updated proposal
Marine footprint	Area	1,500ha	1,385ha
Optical fibre cable	Route	Barrow Island to Onslow or Peedamulla, 130ha	No change. Use MOF at Barrow Island
Shipping	LNG export shipments	~ 3 per week	No change
	LNG ship size	Design to allow 215,000 m^3 ship	No change
	Condensate export shipments	~ 1 per month	~ 1 per 2 months
	Condensate parcel size	~ 300,000 barrels or 50,000 m^3	600,000 barrels or 100,000 m^3 (i.e. standard tanker size)
Workforce	Number of personnel on Barrow Island at peak	~ 3,300	No change
	Total number of operations personnel	600	No change
	Number of operations personnel on Barrow Island	150 to 200	No change
	Number of operations personnel on rotation (off the island)	150 to 200	No change
	Number of operations personnel in Perth office	200 to 300	No change
Development investment	Total investment	~ $11 billion	No change

Legend

~ approximately
< less than

mm – millimetre
m – metre
km – kilometre
ha– hectare
m^3 – cubic metre
Mm^3 – Million cubic metres
Tm^3 – Trillion cubic metres
tpa – tonnes per annum
Mtpa – Million tonnes per annum
TJ/day – Terajoules per day
Tcf – Trillion cubic feet

LNG – Liquefied Natural Gas
MW – Megawatt
DLN – Dry, Low NOx (burners)
MOF – Materials Offloading Facility
CO_2 – Carbon Dioxide
SOx – Sulphur Oxides
N_2 – Nitrogen
NOx – Oxides of Nitrogen
WAPET – West Australian Petroleum Pty Ltd

3. Context for the assessment

Barrow Island is a class A nature reserve, gazetted in 1910 and recognised for its very high conservation values. The waters around Barrow Island are also recognised for their conservation values, with parts included in a marine conservation reserve.

In 2001, the proponent sought advice from Government on the possibility of locating a gas processing complex on Barrow Island. Part of the case for using Barrow Island was the opportunity to inject carbon dioxide, removed from the reservoir gas, beneath the island.

Previous in-principle decision on use of Barrow Island for Gorgon development

In November 2001 the proponent was advised that the WA Government was prepared to consider the restricted use of Barrow Island for the initial development of the Gorgon area gas fields, after all relevant environmental, social, economic and strategic issues had been examined, and provided that the proposed development would yield net benefits for conservation.

A process was put in place to provide separate environmental, social, economic and strategic advice (the ESE process) to ensure that Government had the best available information to make an in-principle decision about access to Barrow Island and to ensure that all interested parties had an opportunity to provide input to the Government's deliberations.

The Environmental Protection Authority provided strategic advice on a conceptual proposal from an environmental perspective under Section 16(e) of the *Environmental Protection Act 1986*. The Conservation Commission provided advice on nature conservation matters and the Department of Industry and Resources (DoIR) advised on the strategic, economic and social aspects of the proposal.

The EPA noted the very high environmental and unique conservation values of Barrow Island, which are reflected in its status as a class A nature reserve. The EPA concluded in its advice to Government at that time:

"Having weighed the environmental values, the limited available data about risks, and the current level of knowledge on their management, the EPA is of the view that the proponent has failed to demonstrate that establishing a gas processing complex on Barrow Island could achieve an acceptably low level of risk to Barrow Island's outstanding environment and unique conservation values."

Among other things in that report the EPA recommended the proponent be required to demonstrate that risk standards could be met, with a 'very high level of confidence'. It went on to state that, should the Government decide to allow the proposal to proceed, two overarching principles were required to underpin any development on Barrow Island;

- the class A nature reserve status of Barrow Island should have primacy; and
- environmental and conservation values of the island should not be compromised.

Those recommendations form useful tests for the proposal now before the EPA for formal assessment.

Having considered the advice received on environmental, economic, social and strategic issues, in September 2003 the Western Australian Government provided in-principle agreement to the joint venturers for restricted access to Barrow Island nature reserve for gas processing facilities as a foundation for the development of the Gorgon gas fields. That decision required special conditions including;

- formal environmental impact assessment demonstrating that environmental factors can be managed without unacceptable impact on conservation values; and

- development of standards for acceptable management of risk to conservation values and a clear demonstration that they can be met with a very high level of confidence.

The subsequent *Barrow Island Act 2003* and Agreement became the enabling legislation for the proposal. The *Barrow Island Act 2003* requires compliance with the *Environmental Protection Act 1986.* The *Barrow Island Act 2003* also requires that grant of leases, licences and easements necessary for the proposal to proceed on Barrow Island cannot occur unless a decision is made that the proposal may be implemented under the Environmental Protection Act.

In accordance with the Government's in-principle decision, the proponent referred the proposal for formal environmental impact assessment under the *Environmental Protection Act 1986.* The proposal is also being assessed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*

This report of the EPA

Formal environmental impact assessment has now been undertaken under Part IV of the *Environmental Protection Act 1986.* This report provides the Environmental Protection Authority's advice and recommendations to the Minister for the Environment on that assessment, including the key environmental factors relevant to the proposal, as required by Section 44 of the *Environmental Protection Act 1986*. In addition, the EPA may make recommendations as it sees fit.

The EPA makes independent environmental recommendations and it is then the role of the Minister for the Environment to decide if a proposal may be implemented. The EPA is also required to have regard for the principles set out in section 4A of the *Environmental Protection Act 1986.*

4. Key environmental factors and principles

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on what the Authority considers to be the key environmental factors identified in the course of the assessment and the Authority's recommendations as to whether or not the proposal may be implemented. If the Authority recommends that implementation be allowed it must set out the conditions and procedures, if any, to which implementation should be subject. In addition, the EPA may include other information, advice and recommendations as it thinks fit.

The identification process for the key factors selected for detailed evaluation in this report is summarised in Appendix 3. The reader is referred to Appendix 3 for the evaluation of factors not discussed below. A number of these factors, such as soil and landform, surface water, liquid and solid waste disposal, hazards and spills, cultural heritage and public safety are relevant to the proposal, but the EPA is of the view that the information set out in Appendix 3 provides sufficient evaluation.

It is the EPA's opinion that the following key environmental factors relevant to the proposal required detailed evaluation in this report:

Terrestrial flora, fauna and vegetation communities;

(a) Subterranean fauna;

(b) Introduced non-indigenous organisms;

(c) Marine biota, particularly flatback turtles and benthic primary producers;

(d) Greenhouse gas injection and emissions;

(e) Light, noise and vibration, particularly as they affect turtles;

(f) Air quality; and

(g) Groundwater as it affects subterranean fauna.

The above key factors were identified from the EPA's consideration and review of all environmental factors generated from the ERMP document and the submissions received, in conjunction with the proposal characteristics.

Details on the key environmental factors and their assessment are contained in Sections 4.1 – 4.6. The description of each factor shows why it is key to the proposal and how it would be affected by the proposal. The assessment of each factor is where the EPA decides whether or not a proposal meets the environmental objective set for that factor.

In preparing this report and recommendations, the EPA has had regard for the object and principles contained in Section 4A of the *Environmental Protection Act (1986).* Appendix 3 contains a summary of the EPA's consideration of the principles.

The following principles were considered by the EPA in relation to the proposal:

(a) The principle of conservation of biological diversity and ecological integrity;

(b) The precautionary principle;

(c) The principle of intergenerational equity; and

(d) The principle of minimisation of waste.

The EPA notes that this proposal has a number of environmental risks where the amount of data available or able to be supplied by the proponent is limited. Consequently environmental risks are not well understood or management precendents are not well established. Four such issues are marine turtles, dredging the introduction of non-indigenous species and subterranean fauna.

Because there are limited data available about the likely impacts and limited precedents for managing these issues, the EPA has requested the proponent to make commitments to the outcomes that would be achieved in terms of environmental management and control. For example, if insufficient data exist to demonstrate the level of lighting that would ensure that turtle reproduction was not significantly compromised, then a commitment which deals with the consequence, despite this lack of data, could be made. Such a commitment might be to ensure that the percentage of hatchlings that reached the water's edge was at least 99%, say, of those hatching from the nest.

In its advice on the principle of locating a gas processing complex on Barrow Island (EPA, 2003), the EPA made the following statement:

"Having weighed the environmental values, the limited available data about risks, and the current level of knowledge on their management, the EPA is of the view that the proponent has failed to demonstrate that establishing a gas processing complex on Barrow Island could achieve an acceptably low level of risk to Barrow Island's outstanding environment and unique conservation values."

The ERPM is thus the vehicle for the proponent to demonstrate that there is sufficient data available, and adequate management actions in place, to enable the EPA to decide if the proposal is environmentally acceptable.

The proponent has adopted a risk based approach to this assessment (see chapter 9 of the ERMP). In this approach, the risk was evaluated based on familiar management practices and then additional management options were considered to reduce the risks. The residual risks were those remaining once preferred management options had been adopted. The proponent created tables including residual risks to the environment from each stressor relevant to the proposal (eg. Tables 10-13 and 10-14 in the ERMP). The residual risks are rated on a three point scale as low, medium or high. This approach has been taken to all issues except quarantine, where a more sophisticated ten point scale of risk ratings has been used. The issue of introduction of non-indigenous species has been assessed separately in Section 4.3 below and is not included below.

Those residual risks have been analysed by the EPA and the results summarised in Table 3 below. The full table of analyses is contained in Appendix 6 This analysis has taken a precautionary approach whereby the most conservative level has been allocated in cases where the risk was listed as an interval by the proponent. For example, a risk listed by the proponent as low-medium has been allocated as medium in Table 3 and Appendix 6.

The conclusions by the EPA below are reached using the base data supplied by the proponent. It should be noted that risk rating is ultimately a subjective process and the EPA may not have reached the same view as the proponent on any particular activity. For example, the proponent has scored the residual risk from lighting on turtles as 'low' (Chevron, 2006c). The EPA considers that there is insufficient data on lights and glow or knowledge of turtle biology to come to the view that a 'low' residual risk is warranted for this issue with high uncertainty and potentially high consequences. Nonetheless, the proponent's scores are reflected in Table 3 for consistency in this analysis.

It is important to recognise that a rating of low for oil leaks is not necessarily mathematically equivalent to a rating of low for clearing. Ratings are, however, a useful way of gaining a qualitative feel for the level of risk from a particular stressor to a particular environmental factor and the EPA found the proponent's approach helpful.

Table 3. Residual risk from activities during construction and operations

	Residual risk		
	Low	Medium	High
Percentage of activities during construction	46	49	5
Percentage of activities during operations	69	29	2

Table 3 demonstrates that during construction, 46% of the activities were assessed by the proponent as having a residual risk rated as 'low', 49% had a residual risk rated as 'medium' and 5% had a residual risk rated as 'high'. Some 54% of all construction activities included in this assessment thus had a residual risk of medium or high. For operations, 31% of activities had a residual risk of medium or high. The EPA finds that this is a useful summary of the array of interactions between environmental factors and the stressors on them. It demonstrates that a large fraction of those environmental factors would be subject to a residual risk of medium or high if the proposal were to proceed.

Overall, the EPA considers that risk ratings of medium (noting that these are the proponent's ratings) for a large fraction of the environmental factors affected by the proposal demonstrates that there are a number of issues which have an unacceptably high level of residual risk for an area with unique conservation values in a class A nature reserve. Detailed assessment of the key environmental factors appears in the sections below.

4.1 Turtles and other marine fauna

Description

Marine fauna, a number of which are listed species, comprise an important component of the conservation values of the waters around Barrow Island. The marine habitats around Barrow Island support year-round foraging populations of marine turtles (Prince, 2001). Of the six species of sea turtles found in Western Australia, five are found in the Montebello-Barrow Islands MCR. Barrow Island and adjacent marine areas provide essential habitat for a wide range of the life history stages for marine turtles (Limpus, 2006).

The very large nesting population of green turtles on the western beaches of Barrow Island is a major part of the Northwest Shelf genetic stock (Moritz et al., 2002) and is internationally significant as one of the few very large green turtle breeding populations remaining globally (Hirth, 1997). North Whites Beach supports only a trivial amount of nesting.

Flatback turtles are wholly endemic to Australian waters and are listed as 'fauna that is rare or likely to become extinct' under the *Wildlife Conservation Act 1950*. The nesting population on Barrow Island is a major part of the Pilbara genetic stock. This

summer breeding Pilbara stock effectively will not interbreed with the neighbouring winter breeding stock that breeds in Bonaparte Gulf and Arnhem Land (Limpus, 2006).

Flatbacks nest preferentially on the lower energy east coast beaches of Barrow Island. Terminal Beach and Bivalve Beach, either side of the proposed causeway to the MOF and jetty, are two of the most important on Barrow Island for nesting by flatbacks (Table 4). Their listed status, under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999,* means that the Commonwealth government is required to produce and implement a recovery plan for this species and a Commonwealth agency must not take any action that contravenes a recovery plan or threat abatement plan.

Table 4. Flatback turtle average nesting density - east coast of Barrow Island (nests/night/km)

	Beach				
Year	Terminal	Bivalve	Yacht Club N	Bed	Junction
2003/2004	30	49	37	-	-
2004/2005	30	40	26	1	7

Source: Chevron 2005a

About one third of the Pilbara flatback turtles are thought to nest within the project area. This Barrow Island population is one of the few documented large nesting aggregations for this species, which makes it an internationally significant rookery of very high conservation significance at the global scale. The dense beds of sea pens off the east coast of Barrow Island will support foraging flatback turtles (Limpus, 2006).

Knowledge about flatback behaviour is limited. The recent work supported by the proponent indicates that these turtles may be resident for extended periods in the waters between Barrow Island and the mainland. Indications are that 70% (~500 females annually) of flatback turtle nesting on Barrow Island occurs on the mid-east coast beaches, immediately to the north and south of Town Point where most of the Gorgon proposal infrastructure would be located.

With approximately 500 nesting flatback females on these beaches laying on average three egg clutches a season, nesting turtles could spend from 1500 to 4500 turtle days, which equates to approximately 35-75 female turtles per day, in the vicinity of dredging operations during the course of a single six week nesting season. Long lived individuals can be expected to breed for more than ten seasons spanning about 30 years of breeding life (Limpus, 2006).

Both the green and flatback turtle stocks in the Barrow Island region are already subject to a range of negative impacts from human activities within their nesting, migratory and foraging ranges. Any reduction in population dynamics of these species at Barrow Island as a result of the Gorgon proposal will further reduce the long term survival prospects for these species in Western Australia (Limpus, 2006). Alternatively, any enhancement of population performance that could be achieved through this proposal will increase their survival prospects.

Submissions

Submissions on this factor included the following:

- The proposed location of the gas processing facility at Town Point is within a significant rookery for flatback turtles, and is likely to disturb their nesting patterns during construction and operation. The project would require significant light emissions, and the ERMP and subsequent information does not demonstrate that the impacts of light to turtles on the east and west coasts would be fully mitigated.
- The data available on dugong distribution and abundance in Barrow Island coastal waters are not conclusive. Targeted surveys to obtain more reliable data on the likelihood of impacts on dugongs should be undertaken.
- Physical disturbance to turtle nesting beaches during construction must be minimised, with activities avoided during the nesting season. A programme of monitoring turtle activity at affected beaches before, during and after construction work should be implemented, as well as a programme to mitigate any detrimental impacts on turtle nesting from beach disturbance.
- Infrastructure and facilities should be moved inland to minimise impacts of light emissions on the coast.
- The risk assessment for impacts of light emissions on turtles should be revised to adopt a precautionary approach given that the long-term impacts of light emissions from the development are unknown.
- A monitoring and management plan for light (including risk to biodiversity) should be prepared.
- A monitoring and management programme should be developed to detect whether noise and vibration have a detrimental impact on fauna, and avoidance and/or mitigatory measures should be developed in the event that impacts are detected.
- The impacts from dredging on marine benthic habitat, which are utilised by listed threatened and migratory species, are very large. There is uncertainty about recovery potential and flow-on effects that may affect habitat structure and food webs.
- Barrow Island and all the waters within a 20 kilometre radius are listed as habitat critical to the survival of green turtles in the Commonwealth Recovery Plan for Marine Turtles in Australia.
- The EIS/ERMP acknowledges that there would be adverse impacts on turtles from dredging and light emissions. However, these impacts are not resolved or adequately mitigated.
- Construction work near turtle nesting beaches at night during peak nesting seasons should be avoided, non-essential lighting should be eliminated.
- The ERMP acknowledges the threats to the sea turtles, but does not provide any guarantee that the impact of the development, on the east coast and the west coast, would be mitigated successfully.

- The Dredging and Spoil Disposal Management Plan should be prepared before development, as the impacts of dredging on the turtle populations could be significant and unavoidable.
- The risk to flatback turtles is critical and almost certain for the populations nesting on the beaches to the north and south of Town Point.
- A precautionary approach must be taken due to the uncertainty regarding the use of the beaches by the turtles and the effectiveness of dredge modifications.
- Increased lighting would attract gulls and terns to forage in the area, and increase their predation of turtle hatchlings.

Assessment

The EPA's environmental objective for this factor is to maintain the abundance, diversity, geographic distribution and productivity of marine fauna at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

A key risk to these turtles, is the effect of artificial lights, (and possibly noise and vibration) on nesting behaviour by adults and on orientation by new hatchlings. Individual lights can disorient hatchling turtles up to a few hundred metres (Chevron, 2005a). The diffuse glow from light sources can cause disorientation on hatchlings up to 4.8km from the light source (Limpus, 2006).

The Gorgon proposal infrastructure, including the plant, flare, MOF, support facilities, roads , airport and construction village have the potential to drastically alter the light horizon behind and over some of the most important flatback turtle nesting beaches in Western Australia. The MOF and jetty have the potential to extend these altered light horizons over 4km out to sea. Both direct lighting and glow are likely to reduce breeding success and recruitment, with serious long term impacts on population size.

Once at sea, hatchlings are very likely to be attracted to and entrapped by lights on the jetty and ships loading at sea or working in the vicinity. When trapped, the hatchlings become easy targets for predators.

The proponent has undertaken work to identify how lights could be minimised and commitments by the proponent to minimise lighting at the detailed design stage are appropriate. Changes have been made to the main flare by placing it at ground level on the inland side of the plant. This change would assist in screening the flare from the beaches but glow reflected off the cloud base or even haze in the air will still be problematic and may even be exaggerated by an open ground flare. Lights on the plant, support facilities, jetty and on LNG tankers would still be required. It is clear from the ERMP that the Gorgon facilities on shore and on the causeway and jetty will not be dark and hence will not maintain the natural dark horizon that helps cue turtles to nest on the adjacent beaches (Limpus, 2006).

There are no definitive data to show that the minimum level of lighting required for operational and safety reasons is low enough to avoid adverse affects from both direct lighting and glow on turtle breeding success and recruitment. The proponent has

identified a number of useful approaches to reduce light intensity and spillage. While the ERMP implies dramatic reductions in lighting effects over a conventional regime, it gives no assurance that the reduction achieved will keep changes to the light horizons at a level that is not disruptive to nesting turtles and at a level that does not increase hatchling mortality (Limpus, 2006)

The proponent indicates that up to 50% of turtles at the two beaches either side of the causeway could be affected by lighting from the project (Chevron, 2005a). Over water light sources several kilometres offshore on the jetty and ships could also affect hatchlings coming off beaches more distant from Town Point. Increased mortality of hatchlings will occur through increased predation and losses to disorientation (Limpus, 2006). The size of the nesting population of flatback turtles on the mid-east coast beaches of Barrow Island will decline substantially over the next few decades. Increased mortality of hatchlings will occur through increased predation and losses to disorientation (Limpus, 2006)

There is also limited information specifically addressing the issue of whether or not the construction of a causeway would deleteriously affect the accumulation of sand on the adjacent nesting beaches. Beach profile is one of the criteria which governs the suitability of a beach for nesting. The proponent has provided a report (MetOcean Engineers, 2005) on some modelling of siltation in the dredged channel under cyclonic conditions, which makes some conflicting comments on effects on the adjacent beaches. On the one hand cyclonic swells are not considered likely to significantly affect sand accumulations but the report also warns that the model scale may be too coarse to reflect changes there. Expert advice suggests modelling to date has not been configured to answer questions concerning the effect of engineering works on shore geometry. It is thus not certain what impact the causeway would have on the beach profile. The EPA is therefore unable to conclude that the presence of the causeway and MOF is environmentally acceptable in terms of potential impacts on longshore drift and the maintenance of important turtle nesting beaches on either side of the structures.

If nesting turtles are deterred from nesting on the optimum beaches, changing distribution of nesting beaches is likely to affect nest temperatures and hence sex ratios (Limpus, 2006). Data from flatback rookeries elsewhere (Limpus, 2004) indicated that some nesting populations can be biased towards one sex. It is likely that the turtles hatching on Barrow Island may comprise a high proportion of males because nests are likely to be cooler there, due to oceanic influences, than on the mainland. If this is so, any reduction in breeding success on Barrow Island may be magnified by longer term imbalances in the sex ratio of adults. While this scenario is speculative because no data are available, it is consistent with known outcomes from other populations and highlights the level of uncertainty surrounding the effect that adverse impacts on the breeding success of flatbacks would have.

Direct impacts, from intake by the dredge and boat strike are likely. Turtles will use the edges of dredged channels as resting areas, leading to a likely increase in the density of turtles in the vicinity of the channels (Limpus, 2006). Large ships' propellers suck in turtles resulting in injury and death. A large proportion of turtles killed by boat strike or propeller damage are associated with dredged shipping channels. Suction dredges kill turtles during dredging operations in other locations

(Greenland, et al. 2004). Deaths of turtles can be expected off the east coast of Barrow Island because of the large flatback nesting population and the potential for foraging populations of green, hawksbill, loggerhead and flatback turtles there. No estimate of the extent of annual mortality likely as a result of the Gorgon proposal is available.

Equipment such as pile drivers or vibratory hammers for jetty construction, seismic sources and possible blasting for channel construction are likely to generate significant percussion locally and underwater sound pulses that may travel many kilometres. The significance of impacts of noise and percussion on marine life including turtles, dugongs, cetaceans and fishes will vary according to species, distance from source, timing and management measures put in place. Even with the proposed management measures, impacts will be unavoidable and there is significant residual risk to flatback turtles and other species from noise and vibration from underwater sources.

Laying of pipelines and shore crossings at North Whites Beach would cause short term localised disturbance but this is not expected to have significant effects at a population level on green turtles. The effects of laying the DOMGAS line and optic fibre cable on turtles are unknown.

Prolonged elevated levels of turbidity and sedimentation are likely to reduce the availability of food for green, flatback and other marine turtles in the area. These turtles feed on a range of benthic species, all of which may be significantly impacted by the proposed dredging programme. Dredging will cause a direct reduction in foraging grounds for green, hawksbill, loggerhead and flatback turtles, but should only remove the capacity to support in the order of tens of individuals (Limpus, 2006). Indirect effects of turbidity and sedimentation can be expected to have a wider effect on food sources for possibly a few years after dredging (Preen and Marsh, 1995).

When mortality increases by as little as a few percent above natural rates at any life history stage and continues over a turtle generation of a few decades, a marine turtle population will decline significantly. Consistent annual losses from a population of 5-10% of a life history stage above natural mortality levels can be expected to cause serious population declines within one generation and reduce populations towards extinction within about 100 years. If anthropogenic mortality factors are removed, recovery of the population will be slow. No population level modelling data are available for flatback turtles. Data for green turtles, however, show that the decline caused by loss of a few percent of adults from a population over 50 years can be expected to require about 150 years for the population to recover after the mortality factor is removed (Limpus, 2006).

Even small annual reductions in breeding success and recruitment over the 60+ year life of the Gorgon proposal are likely to lead to serious declines in the flatback turtle population, possibly leading towards local extinction. Any recovery would be likely to take well over 100 years. Based on expert advice, there is a reasonable probability that the combined continuing impact over the 60+ year life of the Gorgon proposal, as it is currently planned, will threaten the viability of the most important flatback turtle rookery in Western Australia. This impact will only be apparent when the next generation of turtles returns to breed in several decades time (Limpus, 2006).

Other marine species including dugong, other turtle species, whale sharks and whales are also listed fauna. Apart from dugong, these species are likely to be more prevalent on the west coast of Barrow Island. HDD, pipe laying operations and the discharge of hydro-test water containing chemicals are credible threats to species on the west coast. North Whites Beach supports only a trivial amount of green turtle nesting and is thus a better option for the feed gas pipeline shore crossing than Flacourt Bay. Threats to dugong and other marine mammals on the east side of Barrow Island include direct impacts as well as the effects of repeated seismic activity used to track injected carbon dioxide. Available data suggests dugong numbers are probably low but information on the potential impacts on this species of the various stressors imposed by the proposal is sparse. Seismic activity at sea is routine in this area and management actions are routinely applied to limit the potential for significant impacts in these cases.

Summary

Having particular regard to the:

- size and significance of the Barrow Island flatback turtle population;
- dependence of a large fraction of that population on the nesting beaches immediately north and south of the proposed causeway;
- likely impact of lights and glow on deterring females from the important nesting beaches either side of the causeway;
- likely increase in hatchling mortality as a result of increased predation under lights on the jetty and ships;
- likely deaths caused by boat strike, propeller cuts and intake by dredges;
- potential reductions in food resources for foraging turtles;
- low level of certainty about whether lighting in particular and other impacts in general could be effectively managed; and
- reasonable probability that the combined continuing impact over the life of the proposal will threaten the viability of the most important flatback turtle rookery in Western Australia;

the EPA does not consider that the risk of significant environmental impacts to the flatback turtle population can be judged to be acceptably low. The EPA concludes that the likely impacts on flatback turtles from the project as proposed are environmentally unacceptable.

4.2 Marine ecosystem and dredging

Description

The marine ecosystem surrounding Barrow Island has diverse values which have been recognised by the creation of the Montebello/Barrow Islands Marine Conservation Reserves (CALM, 2004). A large area on the east side of Barrow Island has been zoned (Figure 4) for the Port of Barrow Island. Similar values to those within the marine reserves exist within the Port boundary. Dredging is potentially the largest disturbance within the marine environment and is the focus of this section. There are

also other infrastructure components such as pipelines, cables, a causeway, a MOF and a jetty which will also disturb the marine environment in the short and long term.

Key environmental values

Marine areas around Barrow Island have been included in the Montebello/Barrow Islands Marine Conservation Reserves (MCR). The Indicative Management Plan for the Montebello/Barrow Islands MCR (CALM, 2004) sets out management targets for the ecological and social values of the MCR. The high marine biodiversity of the Montebello-Barrow Islands marine environment is a fundamental value of the area. This biodiversity arises from the diverse mix of habitats and oceanographic conditions which occur in the area. Important marine habitats in the MCR include low lying islands, channels, extensive sandy and rocky intertidal areas, sub-tidal limestone platforms and reefs, barrier and fringing coral reefs and sandy seabed. Limestone reef areas have extensive meadows of macro-algae such as *Sargassum* which, along with corals and coral communities, are among the area's most important benthic primary producer habitats (BPPH). The area's biological productivity reflects the strong linkages between these habitats and juvenile and adult fish and other marine fauna such as sea turtles, which may utilise different habitats at different times in their lives.

Guidance in the Indicative Management Plan for the Montebellos/Barrow Islands Marine Conservation Reserves about ecological values forms part of the framework within which the EPA has considered the marine environmental effects of this proposal.

A large port area (~28,600ha), created under the *Shipping and Pilotage Act 1967,* is situated off the east coast of Barrow Island. This area was deleted from the proposed MCR during the consultation process prior to the gazettal of the reserve boundaries. During this assessment, it has become apparent to the EPA that the waters of the Barrow Island port, including areas in the vicinity of the proposal, support many of the significant environmental values identified for the Montebello/Barrow Islands MCR. By way of specific examples, there are significant flatback turtle nesting areas close to proposed infrastructure on the east coast of Barrow Island and dense thickets of *Acropora* corals occur nearby on the south-western edge of the Lowendal Shelf. Other important values identified in the port area include benthic primary producer habitats (coral bombora, coral reef communities, mixed macroalgal and coral communities, limestone pavement habitats, soft bottom habitats and the high relief limestone reef running south from the Lowendal Shelf.

The EPA's objective with respect to the marine environment of the Barrow Island port and surrounding State marine waters is to protect the structure and functions of the ecosystem such that ecological integrity and biodiversity values are maintained at a level commensurate with the importance of the area.

Major marine elements of the proposal

The proposal includes a feed gas pipeline to Barrow Island and port and marine facilities off Town Point within the Barrow Island Port area (Figures 4 and 5). A solid fill causeway and materials off-loading facility and associated approach channel, an LNG jetty, loading terminals, berth pockets, a turning basin and an approach channel

for LNG and condensate tankers are the main port and maritime components of the proposal on the east coast of Barrow Island. A pipeline to supply domestic gas (DOMGAS) to the mainland and a fibre optic cable to the mainland would also be required. In all, the proponent's data indicate that 1650ha would be directly affected by the construction of infrastructure on the seabed.

Development of ship access channels, berth pockets and turning basins for the MOF and LNG export facilities would require dredging of approximately 7.6 Million cubic meters (Mm^3) of marine sediments and rock. Of this total amount, approximately 1.1 Mm^3 of sediment and rock would be dredged to create an access channel and berth pockets for the MOF. Material dredged for the MOF access channel would be used for reclamation of the causeway and MOF. The remaining 6.5 Mm^3 of dredging would be required to develop the proposed shipping channel for LNG export. The proponent anticipates that approximately 40% of material dredged for the LNG export facilities would be unconsolidated sandy sediment with the remainder being high strength rock. Dredged material that is not pumped directly to land or reclamation areas for the causeway and MOF is proposed to be dumped at sea within a 900ha spoil ground located south east of Barrow Island. The proponent's prediction is that dredging and dredge spoil disposal would take 66 weeks.

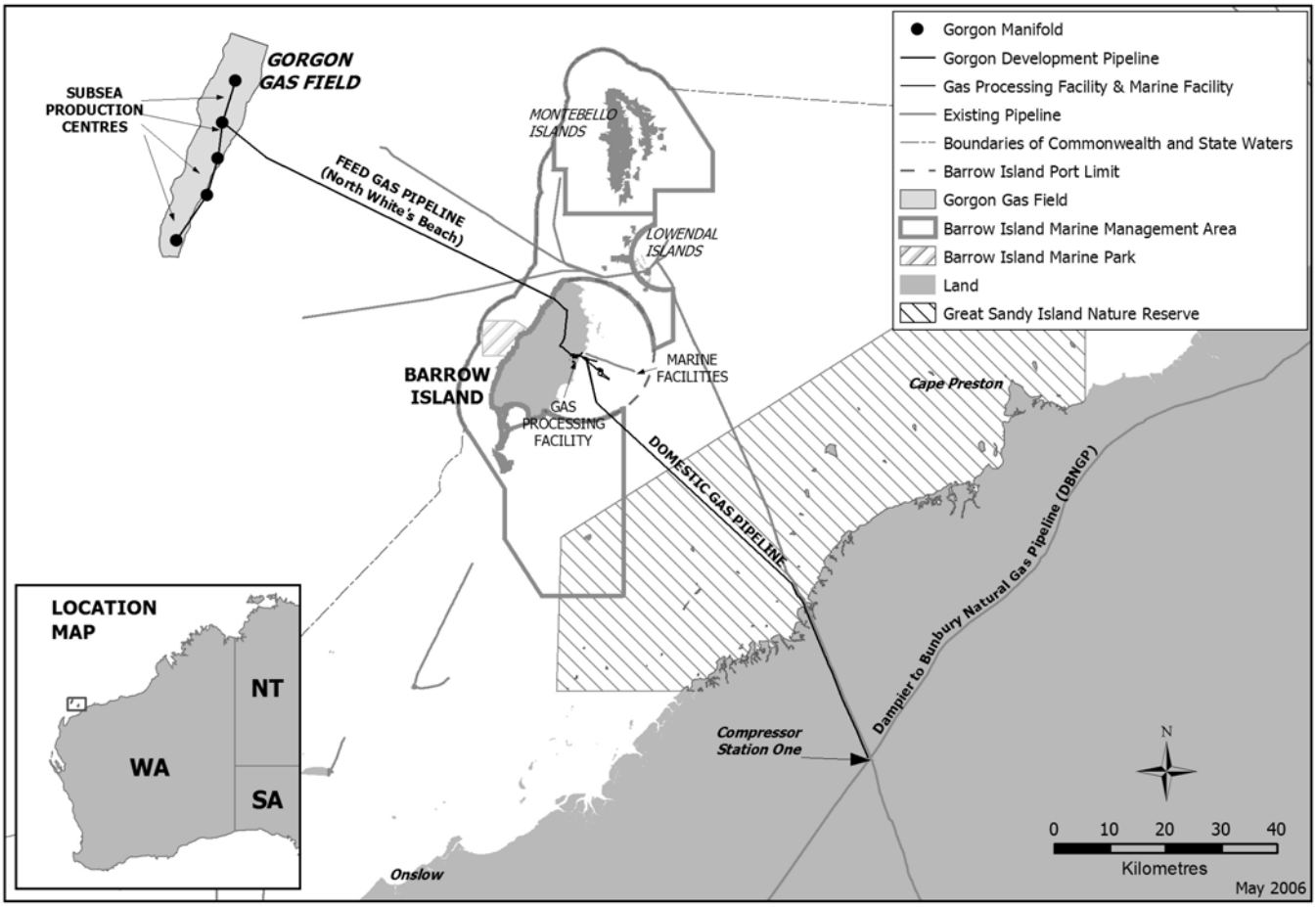

Figure 4: ***Gorgon Gas Development and boundaries of Montebello/Barrow Islands Marine Conservation Reserves. Note semi-circular area of Barrow Island Port.***

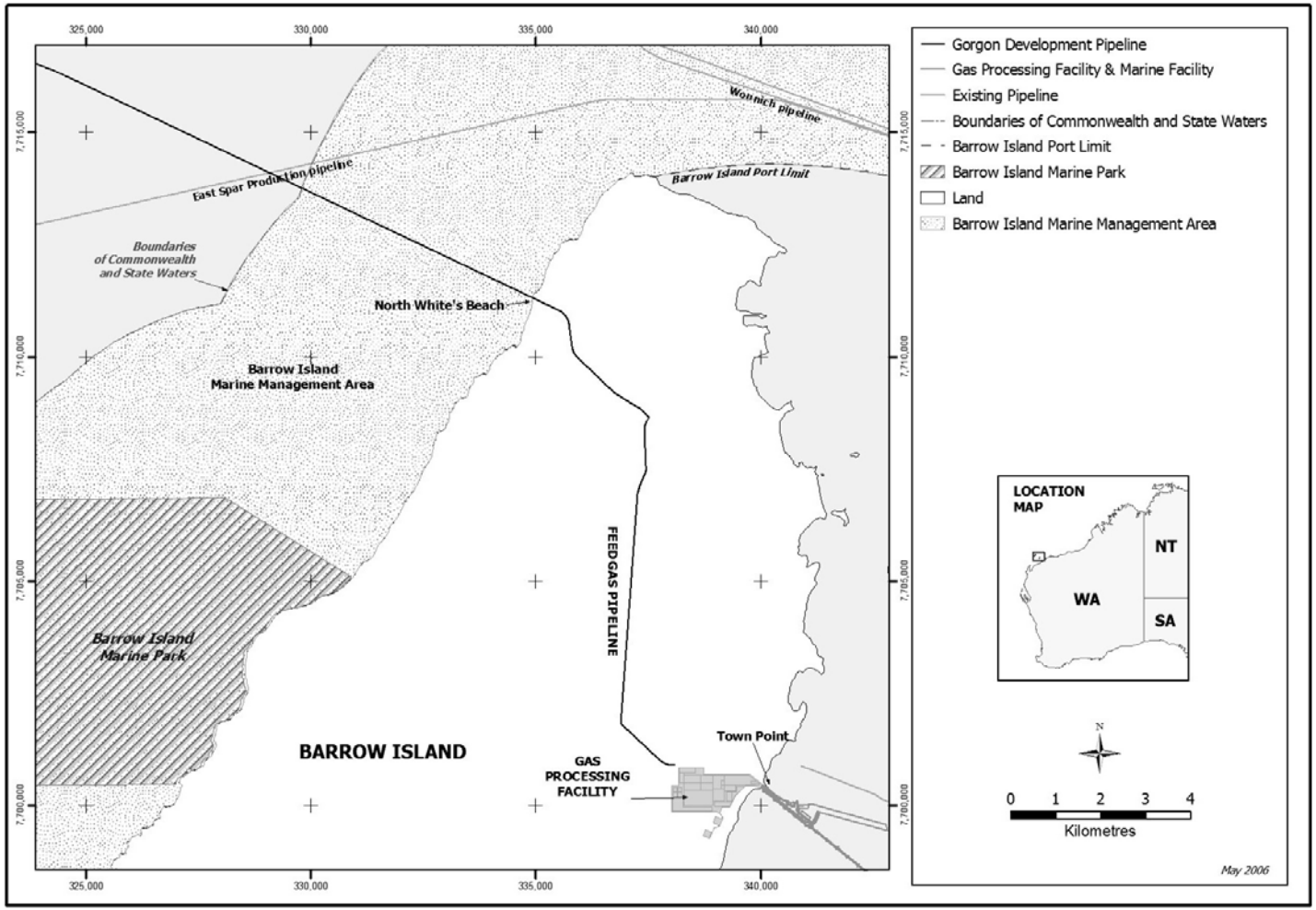

Figure 5: North Whites Beach feed gas pipeline route and process facility location at Town Point.

A 2.7km-long open trestle LNG jetty is proposed to extend from the end of the 1.5km long solid fill causeway and MOF, which extend eastward off Town Point. The LNG jetty terminates at its eastern end at LNG loading wharfs. The proponent's best estimate is that the LNG jetty would need to be supported by approximately 200 steel pylons, each driven into the seabed using drilling and pile-driving. Since the release of the ERMP the configuration and dimensions of proposed port and maritime facilities have changed (Table 2) and the proponent has advised the EPA that it is possible the proposal will undergo further changes as design progresses. An indicative layout of the port and maritime facilities is shown in Figure 3.

In addition to the port and maritime facilities off the east coast of Barrow Island, the proposal includes a domestic gas pipeline to supply Gorgon gas to the Western Australian market and an optic fibre cable for telecommunications between Barrow Island and the mainland. The current proposal is for both of these infrastructure components to traverse the seabed within the port area before crossing to the mainland.

The DOMGAS pipeline is approximately 460mm in diameter and is proposed to be placed within a corridor some 30m wide. It crosses the mainland shore adjacent, parallel to, and 50m south of, the existing Apache domestic gas pipeline between Onslow and Dampier. The optic fibre cable is approximately 50mm in diameter and is proposed to be laid within a 10m wide corridor which extends from the east coast of Barrow Island to a shore landing site near Onslow. The DOMGAS pipeline and optic fibre cable routes have not been finalised or surveyed. Together with the feed gas pipeline in State waters, these elements would disturb 260ha of seabed, based on information supplied by the proponent.

On the west coast of Barrow Island, feed gas pipelines and associated facilities such as control umbilical bundles traverse State marine waters, including part of the Montebello/Barrow Islands Marine Management Area, before crossing the shore at North White's Beach and traversing the island to the proposed LNG processing facilities at Town Point. It is proposed that the shoreline crossing for the feed gas pipeline and associated facilities would be developed using horizontal directional drilling (HDD) techniques.

Environmental issues associated with dredging, reclamation and sea dumping

Dredging for the construction of proposed port and maritime facilities off the east coast of Barrow Island is predicted to cause impacts on benthic primary producer habitats and water quality that are considerably larger than those of the direct footprint areas alone. In view of this, the EPA has given considerable attention to appraising the proponent's impact predictions and evaluation of the potential ecological consequences of the dredging impacts.

For the purpose of this assessment, the environmental impacts of dredging-related activities have been grouped into direct losses and indirect effects on marine ecological communities and their habitats. Permanent loss of benthic habitat occurs if habitat is overtopped by proposed infrastructure (e.g. causeway, MOF, off-shore spoil ground) or if it is excavated (e.g. dredging the LNG shipping channel, ship turning basin).

Although the proponent has provided information to the EPA that sets out the footprint areas of each marine component of the proposal the proposal is still in early stages of detailed design and hence there is uncertainty about exactly how the infrastructure would be configured, where the various components would be located and what benthic habitats would be affected.

Indirect effects of dredging, reclamation and spoil disposal on BPPH and marine ecosystems are driven primarily by two effects. Firstly, the generation of fine sediment particles called 'fines' causes turbidity adversely affecting the quality and quantity of light reaching benthic organisms. Secondly, elevated rates of sediment deposition smothers biota and changes physical characteristics of the substrate. The amount and physical characteristics of fines liberated to the water column is determined by factors including the type of substrate being dredged (e.g. sediment or rock) and the dredging methods employed. In general for this proposal, trailer hopper suction dredges (THSD) would dredge unconsolidated sediment while hard rock would be removed using cutter suction dredges (CSD) respectively.

Fines can be liberated near the seabed due to the disturbance of bulk sediment by drag heads of THSDs as they traverse a dredge area. Similarly, the grinding action of the cutter head on a cutter suction dredge (CSD) working on hard rock can result in near-bottom generation and release of very fine particles known as 'rock flour'. Rock flour generation was a serious environmental problem identified during cutter suction dredging of hard rock for the Geraldton Port Enhancement Project. The EPA notes that the proponent's most recent geo-technical information from Barrow Island indicates that rock to be dredged is nearly twice as hard as that recently dredged in Geraldton. In all, a total of approximately 5 Mm^3 of this harder material would be expected to be encountered if dredging occurred off Barrow Island.

A third mechanism causing fines liberation is when dredged material from either a THSD or CSD is discharged into hoppers or barges, which are then allowed to overflow. When dredged material is lifted off the seabed, it is mostly water with a relatively small proportion of sediment and rock. Because of this, barges and hoppers are often allowed to overflow large volumes of fines-laden water for considerable periods of time (e.g. 50 – 60 minutes) before they contain predominantly sediment and rocks. Once full of sediment and rock, barges transport this material to the spoil ground where the load is dumped. Overflow, particularly from the CSD operation, is a major source of fines liberated to the water column. Finally, fines are sometimes liberated during the dewatering of reclamation areas which are constructed using dredged material, but the amount should be relatively small. This is because well designed reclamation areas provide for the retention and settlement of fines within the reclamation area before excess water is discharged.

Turbidity and elevated sediment deposition affect benthic primary producers and their habitats in different ways. Turbidity causes deterioration in water clarity, which in turn, affects the quality and quantity of light that reaches the seabed for photosynthesis. Effects of reduced light on benthic primary producers can range from sub-lethal effects (e.g. reduced reproductive fitness, coral bleaching, reduced seagrass density) to mortality. As the ecological impacts of dredge-related turbidity are caused by light reduction, impacts will be related to the light attenuating properties of the fines as well as the amount of fines in the water column (i.e. total suspended

solids). For example, it would be expected that a certain mass of very fine sediment particles (e.g. <75 µm) in the water column would have greater light attenuating properties than a similar mass of coarse sand sized particles.

Sediments liberated to the water column eventually settle on the seabed. The distance the particles travel and the rates at which they settle is dependent on factors including the size and density of sediment particles, direction and speed of water currents, roughness of the seabed and waves. Settled material can also be resuspended and redistributed by waves and currents. The extent and severity of ecological impacts due to the deposition of dredge-related sediments is determined by factors such as the physical characteristics of sediment deposited, rate of deposition and the location of habitats and sensitivity of those habitats and associated biota to sediment.

In order to establish a distribution and abundance of marine habitats potentially affected by dredge-related turbidity and sediment deposition, the proponent compiled existing benthic habitat data and undertook additional survey work to produce a benthic habitat map for areas around Barrow Island and Lowendal Shelf. During the assessment discrepancies between different benthic habitat data sets have been identified. Furthermore, the most recent benthic habitat data supplied in mid-May 2006 indicate that coral communities are more widespread and abundant in the immediate vicinity of the proposed infrastructure than shown on maps in the ERMP. Uncertainties about the actual distribution and abundance of benthic habitats within the predicted zone of influence of dredging carry uncertainty through into the predictions of both direct losses and indirect effects.

The proponent's approach to predicting indirect impacts

The proponent has predicted the extent and severity of indirect environmental impacts of proposed dredging and spoil disposal in the ERMP and supporting documents (including Part C of the Response to Submissions – Chevron, 2006e) by applying a numerical modelling approach, which is summarised as follows.

A hydrodynamic model has been used to simulate the direction and speed of water currents in the vicinity of Barrow Island. The hydrodynamic model is coupled to a transport model which predicts the fate of sediment particles less than 150µm in size that would be liberated to the water column from the CSD head, barge overflow and discharge of fines from the MOF reclamation. Particles greater than 150µm are not considered in the modelling as it is assumed these particles would settle close to the dredge site. Sediment grain size data used in the modelling was from experience and samples from the dredging of the Geraldton Port in 2002/03. The modelling predicts the extent and intensity of turbidity plumes and sediment deposition associated with dredging and spoil disposal.

The proponent has proposed acceptability thresholds for turbidity (as concentration of total suspended solids) and sediment deposition (rate of sediment deposition per unit area per day) for two coral taxa using information gathered from a review of scientific literature. The turbidity and sediment deposition thresholds used in the modelling presented in the ERMP were assumed by the proponent to represent levels that, if exceeded for a number of consecutive days, would cause mortality or sublethal effects on corals. The two coral taxa selected were *Acropora* and *Porites.* Acroporid corals

were selected to represent fast growing, branching corals which are relatively susceptible to elevated turbidity and sediment deposition. *Porites* corals on the other hand are slow growing and generally have a 'massive' habit. *Porites* corals can form large bombora which, depending on their size, can be up to several hundred years old. These corals have been assumed to be an indicator taxa for biota that are relatively resilient to elevated turbidity and sediment deposition. Thresholds have not been developed for other groups or species of coral or for other benthic biota that require light for photosynthesis (e.g. benthic macro-algae) or may otherwise be susceptible to smothering by sediment (e.g. filter-feeders).

Outputs of the sediment transport modelling were compared to the proposed turbidity and sedimentation thresholds for corals to predict boundaries of zones of influence and effect, which were then superimposed onto the habitat map. Finally, the proponent made judgements about the recovery potential of impacted benthic biota and their habitats. Benthic habitats were considered by the proponent to be permanently lost if they were not predicted to recover within 30 years.

Environmental impacts of dredging and spoil disposal were predicted in the ERMP using the modelling approach outlined above. The ERMP acknowledged key gaps in the process applied to predict impacts. Gaps were addressed in part in the Additional Information Package (AIP) that was supplied on October 2005. Validation of models is required to enable comparison of modelled predictions against actual measurements from the field. Limited validation of the hydrodynamic modelling was described in the AIP. Other key gaps were a lack of information about the sensitivity of predictions to various meteorological conditions and uncertainty about how predicted impacts may change if turbidity and sediment deposition thresholds for corals took account of cumulative pressure (i.e. threshold levels are based on the sum of exposure to turbidity and sediment deposition rather than consecutive days of exposure). This gap was not addressed in the AIP. Rather, the proponent provided new predictions to the EPA in a document titled *Gorgon Development on Barrow Island: Technical Report on the Outcomes of Additional Modelling to Inform Impact Prediction* which was received in March 2006. The proponent refers to this document as Part C, released publicly in May 2006 as part of the Response to Submissions (Chevron, 2006e).

A number of modelled scenarios have been run by the proponent to simulate the possible effects of dredging and provide some insight into the sensitivity of the modelling approach to various assumptions and sources of uncertainty. These simulations are presented in Part C of the Response to Submissions (Chevron, 2006e).

Submissions

The following points were made in submissions on this factor:

- The proposed construction of a solid causeway is likely to have greater impacts on natural sedimentation processes than an open structure.
- Information should be provided on the methods used for estimating cumulative impacts of plumes on the marine environment, in order for

a detailed assessment to be made on the cumulative loss of benthic primary producers (BPPs) and their habitats.

- High resolution benthic habitat mapping in areas potentially affected by the plumes should be undertaken.
- Greater technical justification is required for the assumptions that there would be full recovery of macroalgal and macroalgal/scattered coral BPP habitats, and the temporary or permanent loss of BPP habitat would not effect overall ecosystem integrity.
- There are uncertainties associated with the hydrodynamic modelling, transport modelling and prediction of ecological impacts, in the marine environmental impact prediction for dredging and spoil dumping.
- The assumption that hard corals are a suitable surrogate for predicting the response of other critical coral reef communities, algal reef or seagrass communities to turbidity and sedimentation should be justified.
- Caution needs to be exercised when making assumptions about the capacity of BPP habitats to recover from significant impact over generalised time frames (30 years in the ERMP) due to the uncertainty about recovery potential, recovery trajectories and consequences of flow-on effects for food webs that may be associated with changes in habitat structure and function over time.
- The timeframes for implementing responses [during dredging] to exceedances of various criteria should be clarified.
- The development should be consistent with the objectives of the Montebello/Barrow Islands Marine Conservation Reserves. The ERMP does not contain adequate evaluation of the impacts of the proposal against the targets for ecological and social values in the Management Plan for the Marine Conservation Reserves.
- The proposal should be amended to reduce the dredge plume impact to the marine environment to meet, as a minimum, the EPA Guidance Statement No 29 and targets set for the Marine Conservation Reserve. Alternatively, greater consideration should be given to other development options and to different dredging operations that may increase the size of aggregate and reduce the extent of the plume.
- The management strategies for dredging during coral spawning periods need to be clarified.
- Baseline marine biodiversity studies and long-term monitoring strategies need to be developed to supplement and improve the existing limited information base.
- Before construction begins, a study of currents and their potential impacts should be undertaken.
- The proponent has not committed to a stringent enough monitoring and intervention strategy for dredging. Would there be a process in place whereby the dredging would stop immediately should unacceptable impacts be observed? Who would oversee this process, and what would be done?

- Physical disturbance from the construction of the causeway, jetty, access channels and dumping grounds would have an almost certain major impact on BPPs and shallow benthic and coastal communities.

Assessment

Dredging

A key issue for the EPA has been to assess the level of confidence that could be placed on predictions of impact. In essence, the EPA's assessment has found that each modelled scenario in Part C of the Response to Submissions produces different impact predictions and predictions differ from those presented in the ERMP. Overall, the results indicate that turbidity plumes from dredging and spoil disposal off the east coast of Barrow Island would be extensive and their impacts on BPPH could range over wide areas, some of which would be discontinuous with the proposed infrastructure footprints. Depending on the actual weather and ocean conditions, the equipment used and the characteristics of fines produced by dredging, the zone of influence within which increased turbidity may be above background conditions (~2mg/L or greater) at some time encompasses an area of up to ~150,000 ha. Based on the most recent assessment of impacts, it is predicted that the total area of benthic habitats seriously damaged immediately following completion of drilling, dredging and dumping would be about 10,600 ha. The proponent predicts that a proportion of benthic habitats in this 10,600ha area would be likely to recover over a period of 5 – 30 years following the completion of turbidity generating activities. If full recovery occurred, it would leave an area of permanent loss of marine habitats of about 1,390 ha, based on data supplied by the proponent. The scale of these predicted temporary and permanent impacts is significant and unprecedented. The predicted areas of impacts are shown in Table 5.

Table 5. Predicted dredging and horizontal directional drilling impacts within the 150,000ha zone of influence for the 'most-likely' impact scenario.

Habitat Type	**Temporary* Loss**	**Permanent Loss**
	ha	**ha**
Intertidal Reef – macroalgal dominated	329	5
Subtidal Reef – macroalgae and scattered corals	3,073	130
Subtidal Reef/sand – scattered seagrass	7,078	1,121
Coral communities	166	129
Total	**10,647**	**1,385**

**Temporary = Recovery assumed <30 years*

Is has become apparent that there is uncertainty associated with most individual steps of the impact prediction process and that this uncertainty is propagated throughout the chain of processes applied by the proponent to predict impacts. While the EPA notes that the modelling used is sophisticated and represents an improvement on similar predictive tools used in the past, given the fundamental importance of the hydrodynamic model for impact predictions its validation with field data from around

Barrow Island has been limited. Furthermore, uncertainty that is beyond the proponent's ability to fully capture, relates to the meteorological and oceanographic conditions that would be experienced when dredging actually occurred (i.e. it is impossible to forecast exact conditions). For example, the modelling predicts that the location, aerial extent and severity of impact vary with possible dredging start times and with different meteorological conditions.

Other aspects of uncertainty relate to a lack of fundamental understanding of the cause-effect pathways between turbidity generated by dredging and the impacts on marine habitats, biota and ecological processes. Robust relationships between suspended solid concentrations and water clarity (i.e. light attenuation coefficient), which is a key determinant of the health of photosynthetic benthic organisms and the communities they form, have not been established to inform this assessment. Little is presently known about the natural variation in turbidity and sediment deposition rates in the waters around Barrow Island and how natural levels and patterns could be affected by fines generated by dredging. These fundamental knowledge gaps mean that the EPA's confidence in the ability of the proposed turbidity and sedimentation thresholds proposed by the proponent to protect corals, and the resulting simulations of impacts, is limited at best. Examples of the sources of technical uncertainty identified during this assessment are summarised in Table 6 below.

Table 6. Basis of the proponent's predictions and associated source of uncertainty.

Basis of Predictions	**Sources of Uncertainty**
Generation of 'fines'	• Characteristics of material (e.g. particle sizes, settling rates, light attenuating properties) • Fines production rate (e.g. how much per unit volume, or mass of dredged material, 5%, 10%) • Type of dredging equipment
Oceanography	Natural variation and representation of: • Tides • Winds • Waves • Bathymetry
Transport of 'fines'	• Behaviour of particles in the water column (e.g. settling rates, assumptions about settlement and re-suspension of sediments and what is predicted to be 'lost' to the open ocean) • Source representation (e.g. proportion of fines liberated from cutter head vs. overflow)
Deposition/re-suspension of fines	• Representation of re-suspension and deposition algorithms in the model (e.g. appears particles <75μm do not settle in the model) • Representation of wave forcing and its influence on sediment deposition and re-suspension
Location and description of habitat types	• Surety (e.g. proportion of zone of influence surveyed/resolution of surveys) • Habitat classification process (e.g. control rules for clumping of habitat types) • Changing baseline (e.g. new data indicates more coral that originally shown)
Coral impact criteria for sedimentation and turbidity	• Intensity and duration (e.g. transferability of results from the literature to dredging scenarios) • Application of coral criteria to different habitat classifications • Consecutive vs. cumulative criteria

Basis of Predictions	Sources of Uncertainty
	• Effects of chronic repetitive stress (i.e. over 66 weeks) • Relationships between sediments in the water column and water clarity and sediment deposition
Extent of impact at completion of dredging	• Location, spatial extent and severity (e.g. ERMP predicted impacts on the Lowendal Shelf. Little impact predicted by revised modelling) • Potential for flow-on ecosystem effects (i.e. potential consequences of losses for non-coral biota) • Representation of sedimentation impacts (e.g. no sediment load off Shark beach, but persistent chronic high turbidity)
Time course and extent of recovery	• Assumptions about recovery (e.g. how much, how long) • Recruitment • Potential flow-on ecosystem effects
Dredging scenarios	• Each scenario has different impacts (e.g. effect of different start times, different dredges, degree of overflow)

The EPA is concerned that the treatment of fines generation in the most recent modelling may not represent actual performance during dredging and spoil disposal. The modelling presented in Part C assumes that for cutter suction dredging, 40% of fines are produced at the cutter head, 40% from overflow and 20% is transported to the spoil ground and dumped. In contrast, the modelling in the ERMP assumed a 50:50 split in fined generation between the cutter head and overflow. These differences illustrate that the relative amount of fines liberated from the dredge cutter, overflow and spoil disposal are assumptions only and may bear little relationship to what actually occurs.

The proponent has evaluated loss of benthic primary producer habitats by broadly applying guidance offered in EPA Guidance Statement No. 29 (EPA, 2004). The loss estimates are based on model outputs, assumptions about recovery and a benthic habitat map. While the proponent has used the available public information about benthic habitats and undertaken additional survey work, the extent of the area involved and a lack of clarity about the decision rules applied in the mapping process to delineate habitats means that there is uncertainty about just how much coral habitat, for example, is within the zone of influence of the proposal. Nevertheless, the proponent has estimated the extent of temporary and permanent losses of each BPPH due to infrastructure and indirect effects in management units defined in the Barrow Island port area using the best information available to it at the time the ERMP and Part C were published. The losses are considered within management units of approximately 5000ha as required by Guidance Statement No. 29. They are only considered against the cumulative loss thresholds set out in Guidance Statement No. 29 if they are considered to be permanent. Loss of benthic primary producer habitat is considered to be permanent by the proponent if recovery is predicted to take greater than 30 years after completion of construction.

Predicted permanent losses of coral habitat exceed the EPA's 10% cumulative loss threshold for inner port management units 4 and 8 on Figure 18 in the Response to Submissions (Chevron, 2006e). The proponent has also applied the loss limit of 10% to units 5, 6, 7 and 9, presumably because these units are within the broader port area. The EPA notes, however, that this cumulative loss threshold is designed to apply to management units within 'inner port' areas only. It is the EPA's view that a lower

cumulative loss threshold should apply in management units outside the inner operational areas of ports.

The EPA understands that Government has agreed that a process for the rationalisation of the port limits at Barrow Island should occur in recognition of the important ecological values within the port limits (e.g. *Acropora* thickets on the south western Lowendal Shelf) and the connectivity of port areas with the waters surrounding the island which are included in the Montebello/Barrow Islands MCR.

The proponent defines temporary losses of BPPH as those predicted to recover within 30 years following the completion of construction. In view of the extent of the anticipated and predicted scale of impacts and the uncertainties surrounding impact prediction and recovery potential, the residual risk that these issues present must be considered by the EPA. Adding the temporary losses to the permanent losses provides an indication of the potential extent of impact immediately following completion of dredging, spoil disposal and horizontal directional drilling (HDD). Using the proponent's data it has been estimated that approximately 10,647ha of seabed could be severely impacted immediately following completion of dredging, spoil disposal and HDD.

In almost all cases the area of these impacts significantly exceed the EPA's cumulative loss thresholds. For example, the most recent modelling predicts that approximately 1951ha of sub-tidal limestone reef with macro-algae and scattered corals east of Shark Point (south of Town Point on the east coast of Barrow Island) would suffer high impacts, and recover fully some time between 2-5 years and 30 years after dredging. The EPA is concerned with the loss of biodiversity and productivity in these areas during the period of recovery.

The timescales of recovery may extend over one or more life times of biota that depend on ecosystem services provided by benthic habitats off the east coast of Barrow Island. Furthermore, depending on the trajectory of recovery, it is possible that high levels of impact on habitats that support relatively long-lived biota such as corals may result in an altered habitat in 30 years time which lacks the longer lived components. Alternatively, the contribution by those components to habitat structure and function could be significantly altered relative to the current situation. The potential for flow-on ecological effects of impacts at this scale are virtually unknown.

The structure, functions and diversity of natural benthic communities are controlled by ecological processes such as growth, mortality and recruitment. Protecting existing adults populations of benthic biota from the effects of anthropogenic pressures is important for maintaining natural growth and mortality processes which drive natural community structure. There is also a need to ensure that critical biological processes, such as reproduction, are not interrupted. In corals, recruitment of new individuals to populations and communities is dependent on egg and sperm production (gametogenesis), spawning, fertilisation, larval development and competency, settlement success and early post settlement survival. Turbidity and sediment deposition are known to have significant adverse affects on each of these reproductive stages in corals.

Management of dredging impacts has proved to be problematic during recent operations at Geraldton and Dampier. Fine sediments which were liberated to the

water column by those dredging operations caused significant and potentially long-term impacts on seagrasses (CSIRO 2005) and corals (Blakeway, 2005, Stoddart and Anstee, 2005) respectively and during dredging at Geraldton a persistent, intense and extensive turbidity plume was observed on satellite imagery extending some tens of kilometres north from the dredge site. Field observations and remote sensing data (LandSat) compiled shortly after the completion of dredging indicated that the aerial cover of seagrass at sites up to 3km from the dredged channel had been reduced by around 40% (CSIRO, 2005). There is a trend of seagrass recovery since the dredging in 2002/03 at Geraldton but longer term monitoring is required to confirm this, as climax seagrass species are slow growing.

The most recent information provided by the proponent is that the rock to be dredged at Barrow Island is about twice as strong as that at Geraldton. Similar turbidity and sedimentation issues to those at Geraldton could be anticipated. Alternatively, the proponent considers that the presence of stronger rock at Barrow Island may reduce turbidity. The actual outcome would not be known until dredging commenced. Accordingly, the EPA has taken a precautionary approach to this issue.

The dredging methodology proposed here is a combination of the methods used in Geraldton and Dampier. Specifically, the proposal is to remove unconsolidated sediments using trailer suction hopper dredges (TSHD) and to use a large cutter suction dredge (CSD) to remove the harder cemented sediment and rock. Fine sediments are liberated to the water column using both of these methods, however grinding and breaking of rock and overflow from cutter suction dredging are expected to be the most significant sources of fines for this proposal.

Managing the impacts of dredging is a world-wide problem. There are, however, existing regulatory approaches (e.g. restricted or no overflow) and existing and emerging technological innovations (e.g. environmental valve and 'green pipe' systems) that are being implemented by jurisdictions around the world where there is a requirement to protect sensitive habitats (e.g. coral reefs, seagrass meadows) and other social and economic uses of the marine environment (e.g. aquaculture) from the effects of dredging. From information provided by the proponent about the proposed base case for dredging (e.g. full overflow) and data collected during dredging in Geraldton (GEMS, 2003), the EPA estimates that about 1,500 tonnes of particles less than 75 µm in size would be liberated to the environment each day during the proposed dredging. This equates to approximately 675,000 tonnes of particles less than 75 µm in size produced over the 66 week dredging campaign.

The proponent has proposed a monitoring and management programme to deal with dredging and spoil disposal. The programme has three tiers of management response where management is triggered if turbidity (as total suspended solids), sediment deposition, coral bleaching or coral mortality criteria are exceeded. In essence the three tiers of management are:

- Tier 1: advise, predict duration of stress, review management and work practices, alert dredging contractor, intensify monitoring, begin coral monitoring;
- Tier 2: implement additional monitoring to test water quality and coral health relationships, modify dredging and spoil disposal activities to reduce impact; and

- Tier 3: cease dredging.

The EPA appreciates that controlling dredge plumes in a dynamic environment is not a precise exercise. The EPA has not been convinced, however, that the approach to monitoring or the degree and speed of management responses proposed would properly protect the environmental values outlined above. In the absence of a relationship between light and turbidity, total suspended solids as a robust early warning indicator for environmental monitoring is not adequate.

Furthermore, the EPA notes that under the proposed monitoring and management framework, it could take up to 22 days before a Tier 2 management response is mounted in moderate impact areas and further time to determine whether coral mortality would trigger the need to cease dredging (Tier 3 management; Chevron, 2005a). There is also uncertainty about what the re-start criteria for dredging would be, and how long it would take to determine, after dredging had been suspended based on coral mortality. It would be desirable from an environmental protection perspective if the criteria for coral health were based on sub-lethal indicators of stress (i.e. coral bleaching). This measure would also provide surety to the proponent with respect to the re-start criterion for dredging if it is suspended. Once stresses are released, coral bleaching reverses in a matter of a few days and is a clear indicator of a return to health.

In summary, the EPA is concerned that the proposed management approach would not allow the proponent to respond decisively and early enough to ensure that unacceptable impacts do not occur, including to particularly important concentrations of coral habitat on the Lowendal shelf and at Batman and Dugong reefs. These structures are within a few kilometres of the predicted impact zones and the actual extents of those impact zones have considerable uncertainty about them.

The EPA is of the view that, even with best endeavours, the level of uncertainly surrounding the prediction of impacts associated with dredging, reclamation and spoil disposal remains high. The EPA is also concerned that the management measures proposed do not represent best practice for dredging in sensitive environments. The EPA is not convinced that dredging as proposed can be implemented and managed in a manner that would prevent unacceptable environmental impacts from occurring. The EPA thus considers that the proposed scale of dredging impacts should not be approved.

Drilling and blasting

There are other marine environmental issues associated with the proposal which warrant consideration. These issues relate to the possibility of marine blasting, management of hydrostatic test (hydrotest) water from the domestic gas pipeline, jetty construction, installation of pipelines/cables, waste discharges and seismic data acquisition.

The ERMP pointed to the possibility that marine blasting may form part of the proposal associated with development of ship access channels. Noise and pressure waves generated by marine blasting have the potential to disturb, injure or kill marine fauna, including important listed species. The EPA notes that the proponent's

responses to submissions on marine blasting lack certainty. For example, while the proponent states that "indications from geo-technical investigation, laboratory testing and discussions with dredge contractors suggest that there is no need to do any drilling and blasting", the responses to submissions also set out some proposed monitoring and management protocols for marine blasting (e.g. use of warning shots prior to marine blasting, a marine mammal observation programme, consideration of physical removal of turtles, possible suspension of blasting during turtle breeding season). This lack of certainty means it is not possible for the EPA to properly evaluate the exposure of marine biota to risks from marine blasting or the likely effectiveness of the indicative measures which the proponent has outlined to address risk. Accordingly, the EPA has reached a view that it has not been provided with sufficient information about possible marine blasting or the residual environmental risks it presents to be confident that blasting at this site could be managed in an environmentally acceptable manner.

Drilling in the marine environment has potential to cause direct and indirect impacts on benthic habitats and communities. Horizontal directional drilling is proposed for developing the shoreline crossing for the feed gas pipelines on the west coast of Barrow Island (and possibly for the DOMGAS shore crossing on the mainland) and as part of the LNG jetty construction. Direct loss of habitats and communities may arise from smothering due to the deposition of cuttings and drilling mud/fluids on the seabed. Indirect effects could result from turbidity and potential toxicity, with the extent and severity of effects influenced, at least in part, by the type of drilling mud/fluids used. For example, the proponent has predicted impacts associated with the use of a polymer drilling fluid and a bentonite-based fluid for HDD on the west coast.

The EPA notes that the predicted extent and severity of impacts associated with the polymer drilling fluid are significantly less than if bentonite fluid is modelled. Other determinants of potential impacts from drilling are likely to include the extent to which the activity is managed to achieve no discharge of mud/fluids and cuttings, the physical properties of any released cuttings and mud/fluids, inherent susceptibility of biotic receptors to discharged cuttings/mud/fluids, the dispersion of these materials by natural water currents and the persistence of deposited materials on affected benthic habitats and communities. Direct losses of benthic primary producer habitats associated with construction and presence of the proposed LNG jetty have been included in estimates of cumulative loss for management units 4 and 8 and this is appropriate. However, quantitative predictions of production, dispersion and settlement of discharged drill cuttings and mud/fluid, and their potential indirect effects on habitats and associated biota were not supplied for drilling activity associated the construction of the proposed LNG jetty.

Noise and vibration associated with pile driving has the potential to disturb marine fauna. The ecological consequences of disturbance due to noise and vibration are difficult to predict. Loud, percussive shocks can deter or even kill marine fauna and could have significant effect if they occurred over an extended period through the flatback turtle aggregation and nesting period, for example.

Pipe and cable laying

The DOMGAS gas pipeline and the optic fibre cable are proposed to be installed using offshore pipe lay vessels. Typically these vessels use a wide spread anchor array to position and move the vessel forward while laying the pipe. The anchor lines can be many hundreds of metres long and are tightened or slackened to manoeuvre the vessel. The steel anchor lines are in contact with the seabed, sometimes for significant distances, causing shear on the seabed as the angles between the vessel and anchors change. After moving forward a certain distance, service vessels retrieve the anchors and redeploy them forward to allow the process to be repeated. The proposed pipeline and optic fibre cable routes shown in the ERMP traverse areas of sub-tidal reef that support coral and macro-algal communities as well as soft bottom habitats. The adverse impact of this activity on benthic communities in relatively shallow water and where bathymetry is complex can be significant.

To minimise the damage caused by anchors, best practice would involve the use of vessels with dynamic positioning technology instead of anchors. Nevertheless, seabed scour from thrusters used to position these types of vessels is an issue that will need to be considered, particularly if vessels operate in shallow water. The proponent has advised the EPA that 70ha and 130ha of marine habitats would be disturbed due to 30m and 10m wide corridors for the DOMGAS pipeline and optic fibre cable respectively.

The EPA notes that the proponent currently assumes that the diameters of the DOMGAS pipeline and optic fibre cable would be approximately 460mm and 50mm respectively. In view of the size of these components, the footprints of the DOMGAS pipeline and optic fibre cable routes should be reduced and rationalised. As detailed marine habitat surveys have yet to be undertaken for the proposed routes and because the proposal is still in the early stages of design, the proponent has not demonstrated that all reasonable and practicable measures have been taken to:

- select routes that avoid and minimise impacts on the different benthic primary producer habitats to ensure losses and disturbance is within acceptable levels;
- reduce and rationalise the widths of proposed easements to be more commensurate with the small size of the pipeline and optic fibre cable; and
- avoid impacts associated with proposed installation methods (e.g. anchoring).

Marine waste discharges

The proposal will generate several waste streams. Deep well injection is the proponent's base case option for management of waste streams from the proposal including LNG plant hydrotest water, LNG process water, hyper-saline desalination waste, treated domestic wastewater and some stormwater. Nevertheless, throughout the assessment, the proponent has retained ocean discharge as a fallback option. Limited information has been supplied by the proponent to the EPA about the possible concentrations and loads of contaminants in the wastes and their individual and cumulative ecological effects on the marine environment are largely unknown at this time.

Testing the integrity of the proposed pipelines and some LNG plant infrastructure involves filling them with chemically-treated water for leak and pressure testing.

Chemicals used in hydrotest water typically include oxygen scavengers, biocides, corrosion inhibitors and dyes to help detect leaks. Potential impacts of hydrotest water discharge include oxygen depletion and toxicity effects in waters and on the benthos around the discharge point. While the base case in the ERMP was to reuse as much of the hydrotest water from the proposed domestic gas pipeline as possible before deep well injection, the ERMP also included some modelling of hydrotest water discharge in shallow water off the east coast of Barrow Island. Problems have been identified with the approach used by the proponent to evaluate the potential impacts of hydrotest water discharge to the marine environment. The problems are centred around the toxicity data used (i.e. data for a single freshwater invertebrate) and that it has been applied in a manner inconsistent with guidance offered in the National Water Quality Management Strategy (ANZECC/ ARMCANZ, 2000). With the available information, the proponent has not been able to demonstrate to the EPA that the environmental risk associated with marine discharge of hydrotest water from the domestic gas pipeline or other LNG plant elements into State waters could be managed to an acceptable level.

In view of the current uncertainties and the significant values of the marine environment off Barrow Island, it is EPA's opinion that ongoing discharge of liquid wastes to the marine environment off Barrow Island is not appropriate and should not be approved.

Seismic

The ERMP outlines a 'reference case' marine 4-D seismic monitoring programme to determine if CO_2 injected into the Dupuy Formation behaves as predicted. A "small scale" CO_2 baseline seismic acquisition survey is proposed near the coast north of Latitude Point prior to construction and subsequently at intervals between 2 and 10 years. The ERMP indicates that the marine seismic programme may involve deployment of seismic receiver cables up to 4km in length on the sea floor off the east coast of Barrow Island, where water depths are generally less than 20 m. An alternative method presented in the ERMP would involve deployment of individual receiver pods on the sea floor and these would be recovered after each survey is completed. The potential effects of seismic air gun noise could be expected to be similar to those documented previously for marine mammals (McCauley *et al.*, 2000) and fish (McCauley *et al.*, 2003). In view of the very limited information about the marine element of proposed CO_2 seismic data acquisition programme, further environmental assessment is necessary before an informed view can be reached. The information required for the assessment includes a scientifically robust environmental monitoring and management programme which sets out the measures and schedules to avoid key ecological windows (e.g. sea turtle and marine mammal breeding seasons).

Summary

Having particular regard to the;

- extent and duration of dredging;
- values and conservation status of the marine environment around Barrow Island;
- likely extent and impacts of turbidity and sedimentation on benthic primary producers and other marine biota;

- uncertainty of predictions about impacts;
- uncertainty as to the ability to manage impacts sufficiently to prevent unacceptable impacts; and
- potential impacts of bentonite based drill fluids from HDD, hydrotest water and other liquid discharges;

the EPA considers that the proposal cannot be managed to meet its objectives for this factor and the proposal is therefore environmentally unacceptable.

4.3 Introduced non-indigenous organisms

Description

Barrow Island is a critical conservation asset because it has not been subject to the threatening processes that have drastically reduced native fauna populations on the mainland. As such, the native flora and fauna are much as they would have been over similar habitats in the Carnarvon Basin and adjacent Pilbara prior to European settlement. It is recognised that its island status protects environmental values from introduced predators, competitors, grazers and other human induced pressures. These agents, together with inappropriate fire regimes and disease have driven many native animals to extinction on the mainland. The animals most at risk are those in the "critical weight range" between 35g and 5.5kg, which are easy prey to foxes and cats and compete directly with rabbits, rats and mice (Burbidge and McKenzie, 1989).

Invasive organisms, which establish, proliferate and compete with or predate the native biota are of most concern, but the status of Barrow Island as a nature reserve also means that the introduction of any organism, even one which may be benign, is not consistent with its purpose to protect indigenous biota. Accordingly, this section recognises invasive organisms as the most threatening to the existing biota of Barrow Island but uses the more encompassing term of introduced non-indigenous species to indicate that any taxon which does not naturally occur on the island should continue to be excluded.

It is also important to continue to take all steps possible to exclude introduced organisms from the waters surrounding Barrow Island. Such protection is warranted because those waters in part comprise a designated conservation asset and the exclusion of introduced taxa which may become pests there and elsewhere in Western Australian waters is highly desirable.

In practice, the proponent has concentrated on estimating risk scores for the introduction step. This approach is consistent with the overarching goal of 'no introductions' and seems to be a justifiable starting point because preventing the introduction of organisms is intuitively and practically most desirable, rather than relying on introductions not being able to survive or being detected and eradicated after arrival. This activity has involved a large amount of work by the proponent, its consultants and officers of a number of government agencies participating in public meetings, workshops and expert panel briefings. The EPA is satisfied as to the expertise of the people involved in both making the risk estimates in workshops and providing guidance via an expert advisory panel convened by the proponent.

Submissions

Submissions about this factor included the following comments:

- The proponent has not demonstrated that the risk standards for quarantine can be met with a very high level of confidence. There is a need to consider what would happen in the event of a significant quarantine breach on Barrow Island, which could ultimately result in the loss of significant conservation values, including species extinction.
- The inability to produce risk scoring for survival, detection and eradication must be explained with the provision of an alternative mechanism to describe risk in these areas.
- The pathway assessments and barrier descriptions should be completed prior to environmental impacts occurring on Barrow Island.
- The introduction of exotic animals, plants and microorganisms is the greatest threat to the integrity and biodiversity within Barrow Island.
- The probability of detecting most introduced animals before they become common is low. Eradication in natural areas is difficult, and often also impacts indigenous species.
- There has been no attempt to measure infection of existing pathways operated by Chevron to service the oil field.
- There have been many quarantine breaches with the existing oilfield operations.
- The scale and time frame of the proposed development means that, even with the best of intentions, perfect quarantine control would be impossible.
- There is no indication as to how the continuing surveillance for pests on Barrow Island is to be achieved.
- Long-term monitoring strategies for introduced marine biota need to be developed so that potential impacts and risks to marine ecosystems can be managed to an acceptable level.
- The Marine Quarantine Management Plan should include marine pest surveys of Dampier Harbour (due to the shipping between Dampier Harbour and Barrow Island) to ascertain the degree of risk of translocating exotic species to the waters of Barrow Island. If species of concern are identified as established in Dampier, then appropriate quarantine strategies should be developed.
- The proximity of Barrow Island to Dampier Port and the increase in traffic between the two locations during the construction phase means that there is a risk of invasion of marine pests and from ballast water discharge.
- The Gorgon Joint Venturers have given some recognition to what is at stake with quarantine management and made some laudable efforts to engage experts and the community.
- After considerable community and expert effort with developing standards for acceptable risk, they have since been ignored.

Assessment

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

ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

Risk standards

The most significant potential hazard from this proposal to the terrestrial flora, fauna and vegetation values of Barrow Island is introduced invasive organisms, particularly animal pests, weeds and disease. Data from the ESE Review (ChevronTexaco, 2003a), a Quarantine Risk Assessment (QRA) (ChevronTexaco, 2003b) produced in association with the ESE process, and the ERMP (Chevron, 2005), plus supporting data, illustrate the scale and nature of the increases in proposed movements (barges, aircraft, personnel, equipment, construction material, food, supplies and stores) to Barrow Island, if development of a gas processing complex proceeds:

- At the peak of oil production, up to 50 tankers per year visited Barrow Island; tanker movements are projected to increase from the current 12 per year to up to 160 per year (Chevron, 2005);
- The number of people on the island would rise from approximately 150 – 200 now to 3300 at the peak of construction;
- The proposal envisages a construction period of about 39 months with up to a 10 times increase over current levels in barge movements per week to the island at the height of construction (ChevronTexaco, 2003a, 2003b).

The volume and number of these movements represents the single biggest pathway for the potential introduction of pests and diseases to Barrow Island.

The operators of the existing Barrow Island oil field had recorded 27 breaches of quarantine from 1964 to 2003. To date, potentially invasive animals have either not become established or have been eradicated. A number of introduced invertebrate animal species remain on Barrow Island, including a tramp ant for which the likely impact has not been fully determined. How long this ant species has been present and survived without detection is unknown. A number of weed species have established on Barrow Island and are currently contained, but not eradicated.

Using data from the ESE and the QRA, projected future quarantine breaches were calculated in the EPA's Bulletin 1101 (EPA, 2003), assuming only the current level of control. Given the totals of 51 projected future breaches from barge landings and 31 breaches from personnel landings over the then projected 30 year life of the gas field, a breach would be described as "*virtually certain*" using the descriptors set out in the QRA.

The real question which arose was, what likelihood of a breach would be acceptable? There are no hard and fast rules for this and the EPA recommended that a "try it and see" approach was unacceptable in a class A nature reserve with high conservation values, given the consequences of failure (EPA, 2003). The EPA recommended a precautionary approach, as advocated in EPA Position Statement No. 7, as most appropriate where the environment and conservation values are so high and unique. That approach requires any decision to proceed with development to be based on solid data, enabling sound judgment. The EPA further recommended that, if the project were to proceed, it could only be with a policy of 'zero tolerance of invasions' as a

target and an associated quarantine regime of sufficient, demonstrated rigor to achieve this (EPA, 2003).

The EPA went on to recommend in Bulletin 1101 that;

"- The proponent be required to engage in the development of a set of standards for acceptable risks from invasive organisms to the conservation values of Barrow Island. Such a process should include appropriate technical experts and be structured to ensure an appropriate level of transparency and community involvement; and

- The proponent be required to demonstrate to the EPA, on the advice of DCLM and the DoE, that the risk standards can be met, with a very high level of confidence."

Thus, the test for this assessment was for the EPA to consider whether the risks from introduced species were 'acceptably low'.

The EPA notes and strongly supports the proponent's adoption of the EPA's recommendation that there should be a 'zero tolerance of invasions target' for Barrow Island. The EPA recommended that the proponent demonstrate that an 'acceptably low' level of risk could be achieved and commends the proponent's acknowledgement of this requirement. Such a standard is vital to ensure the survival of terrestrial species found nowhere else in the world.

Consistent with the EPA's recommendation, the proponent organised a number of community and expert meetings and supporting processes to develop standards acceptable to the community and expert representatives for risks from introduced organisms. The process was transparent and rigorous involving experts and community members to define acceptable levels of risk for the establishment of non-indigenous species on Barrow Island. The proponent was congratulated on this process in public submissions and the EPA believes that the process was credible and helpful in establishing a public view on acceptable risk.

That process determined that participants accepted three risk scenarios, with a strong preference for a scenario where the risk of introduction was at the lowest level of 1, on a scale from 1 to 10, qualitatively described as "extremely remote, highly unlikely". The expert and community process determined that scores up to 3 ("slight chance") for introduction would only be acceptable if scores of 1 could be achieved for at least one of the other three steps (survival, detection or eradication) in the process of non-indigenous species control. The proponent has not yet been able to present scores for any of these other three steps.

Risk scores

A key outcome of the community and expert process was a risk standards framework with 'acceptable risk' defined by the participants. This framework (Table 12.1 in the ERMP) listed levels of risk likelihood for four key steps (introduction, survival, detection and eradication) on the way to the establishment of an introduced species on Barrow Island. The levels of risk ranged from 1 ('highly unlikely' or 'virtually certain', depending on the step) to 10 ('certain' or 'almost impossible', depending on the step). The community meetings agreed there were three scenarios where the

combination of risk scores could be acceptable, with a strong preference for scenario one where the introduction score was 1.

The crux of the acceptable scenarios was that the risk score had to be 1, for either the introduction or survival step, for levels up to 3 to be acceptable for the other steps. Alternatively, the risk score had to be 1 for both the detection and eradication steps for levels of up to 3 to be acceptable for the introduction or survival steps. While the community representatives accepted that scores up to 3 may be acceptable on some steps, such acceptance was always conditional on a score of 1 for at least one other step. The EPA notes that the proponents have made a commitment to adopt the risk standards developed by the community based process.

The proponent has involved credible experts in a significant body of work undertaking detailed desktop reviews of the qualitative risks of introducing NIS to the reserve. The proponent has advised that qualitative risk assessment has been completed for 16 introduction pathways identified for the proposal. The proponent's scores are presented in Table 7 below.

Table 7. Qualitative residual risk of introducing non-indigenous species for all pathways

Pathway	Vertebrates	Invertebrates	Plants	Fouling	Bivalves
Sand & aggregate	1	1-2	2		
Food & perishables	2	2	2-3		
People & luggage	2	2	3		
Plant & mobile equipment	3	2	2		
Skid, steel, loose eqpt.	2	3	2		
Containerised goods	1-2	2-3	2		
Crated goods	1-2	3	2		
Air freight	1-2	3	2		
Transfer flights	1	2	1		
Domestic vessel topsides	3	3	2-3		
Sensitive & special eqpt.	1	2	1		
Pre-fabricated modules	1-2	1-3	2-3		
Domestic vessel wetsides				3	3
Direct shipments wetsides				1	1
Domestic vessel ballast				3	1
Direct shipments ballast				1	1

Source: Chevron Australia, Additional Information Package, 2005 and additional data presented to EPA.

The EPA notes that introduction risk scores at the barrier on Barrow Island for the 16 pathways in Table 7 range from 1 in some cases up to 3 in others. Assuming a precautionary view, in only 10 of the 42 cases presented in Table 7, did the level of introduction risk achieve a clear score of 1 found acceptable during the expert and community standards setting process. These scores assume that all risk treatments recommended by the experts are adopted. If those recommendations are

not adopted, there is a clear score of 1 in only 3 cases and scores range up to 5 in one case.

Based on submissions it has received, the EPA understands the community and expert participants in the standards setting process would be very concerned if the results were to be interpreted as implying public acceptance of scores up to 3, without the essential condition that this was only acceptable where a score of 1 is demonstrated for one or more of the other steps.

The proponent's own documentation (Chevron, 2005 – ERMP p 554) states that "In Scenario 1, *if* the introduction score could be reduced to '1', then the risk would be acceptable if the survival score was '2' or less, and the detection and eradication scores were '3' or less. In *combination*, such a set of scores would reduce the perceived risk of establishment to an acceptable level" (emphases added).

The EPA clearly understands from the community representatives that only a score of 1 is acceptable for introductions, in the absence of any information about scores for survival, detection and eradication.

So far, only introduction scores have been assessed. The proponent further states (Chevron, 2006b) that "…the Gorgon Joint Venturers remain cautious as to the application of the present methodology used in assessing the risks of introduction to survival and detection. Similarly, a score for eradication presents difficulty….".

Given that the proponent has only scored the 'introduction' step and argues that scoring the survival, detection and eradication steps is problematic, it is not yet possible to conclude that introduction scores greater than 1 are acceptable.

The proponent points out that its expert advisers considered that the likelihood of introduction as a result of the barriers considered in quarantine hazard workshops could not be further reduced, hence scores could not be reduced below those presented in Table 7. Those experts went on to conclude that risks were 'low' for two pathways considered up to that time, with actual scores from 1 to 3.

Early in the process the EPA accepted that while there were some quantitative data available from past quarantine records, these were unlikely to be comprehensive and might not represent the situation on Barrow Island with a newer quarantine management system. Accordingly, the EPA accepted that a qualitative scoring process for risk, using the best judgment of suitably experienced and independent experts, would be an acceptable method of estimating risk scores.

The EPA also sought advice from scientists with the CSIRO (Hayes et al, 2006 – Appendix 7) and Murdoch University (Hobbs, 2005 – Appendix 10) on the approach taken by the proponents, in the ERMP and AIP. The EPA provided the opportunity for the proponent to respond to the scientific reports (Chevron, 2006f; 2006g – see Appendices 8 and 11) and asked Dr Hayes of CSIRO to respond to some issues raised (Hayes, pers. comm., 2006 – see Appendix 9)

Part of the advice noted that quantitative data on actual performance is required, if the estimates are to be verified and world class quarantine performance demonstrated

(Hayes et al, 2006). While accepting that it was useful to consider qualitative data, in the absence of quantitative data, during the assessment, the EPA notes the CSIRO advice that quantitative data should be used when it is available.

Experience elsewhere

Experience and available data demonstrate that there would be additional breaches of quarantine if the proposal were to proceed. Some 27 breaches have been recorded for Barrow Island so far (ChevronTexaco, 2003a). Some of those breaches would lead to incursions on Barrow Island, as has happened in the past with mice, weed species, tramp ants and other invertebrates recorded so far. Some incursions would be difficult to eradicate, as buffel grass has been to date.

Pimental et al (2001) estimated that more than 120,000 species of alien plants, animals and microbes had invaded Australia, Brazil, India, South Africa, the United States and the United Kingdom. Records for New Zealand show that 212 separate incursions were detected between 1990 and 2003, excluding weeds and forestry pests (Wilson et al, 2004). While improved surveillance and diagnostic methods and increased trade and travel contributed to the rate of detections, the fact remains that a significant number of incursions occurred in an island country with well defined borders where sophisticated bio-security systems were in place.

It has been estimated that 5% of newly identified pest species are practically eradicable (Stephenson, pers comm., quoted in Kriticos, et al, 2005) although some believe 5% to be optimistic and the real figure is probably lower (Kriticos, et al, 2005). 97% of organisms newly detected by Biosecurity New Zealand (BNZ) in the decade to 2005 warranted only a limited ($50,000) response, generally because they either posed a minor risk or were too widely established.

Organisms that presented greater risks and have warranted much greater expenditure have been discovered approximately once every two years in New Zealand during the past decade. On average, BNZ expenditure has been NZ$16.5 million per species in such cases. Data for Western Australia show that 32 new insect pests of agricultural crops established in the 50 years from 1945 and only 3 were eradicated (P. Grimm, pers comm.) The point is that incursions will continue to occur, and eradication can be very expensive and difficult.

Risk of marine incursions

In the marine environment, experience also shows that introductions of marine species have occurred regularly where there is frequent shipping activity. More than 200 introduced marine species have been detected in Australia to date and there is approximately one new introduction every 20 weeks (Ballast Water Management Framework, 2005). Currently there are 10,000 ship visits to Australia annually (Ballast Water Management Framework, 2005). Assuming 160 ship visits per annum for the export of gas and condensate during the operational phase of the Gorgon project, and a project life of 60 years, yields 9,600 ship visits. Using the statistics for Australia, 10,000 visits per annum result in 2.51 introductions per year (equivalent to one per 20 weeks). It follows that about two introductions could be expected during the course of 9,600 ship visits to Barrow Island for export shipping, unless there is a

significantly higher level of control exercised than is now mandated for ships arriving in Australian waters.

Shipping and barging during construction would add to this risk. While the number of ship visits during construction would be relatively small, the number of barges operating between Barrow Island and the Dampier port area would be large. Data presented during the ESE process indicated that there would be about 1100 barge landings per annum during construction and about 350 per annum during operations (ChevronTexaco 2003b). Although barges would not normally be expected to discharge ballast water, the high number of movements presents a real risk of introducing species via hull fouling. This risk is particularly acute since Dampier is highly likely to be infected already with introduced marine species. This is because Dampier is the largest tonnage port in Australia, and large tonnages have passed through this port for over 40 years but there has not been a comprehensive survey for introduced marine species there.

The risk of foreign organisms becoming established in new ports following their discharge in ballast water or from hull fouling is greatly increased if the ports are at similar latitudes with similar environmental conditions. Much of the shipping In practice, the proponent has concentrated on estimating risk scores for the introduction step. This approach is consistent with the overarching goal of 'no introductions' and seems to be a justifiable starting point because preventing the introduction of organisms is intuitively and practically most desirable, rather than relying on introductions not being able to survive or being detected and eradicated after arrival. This activity has involved a large amount of work by the proponent, its consultants and officers of a number of government agencies participating in public meetings, workshops and expert panel briefings. The EPA is satisfied as to the expertise of the people involved in both making the risk estimates in workshops and providing guidance via an expert advisory panel convened by the proponent.into Dampier (20.40 S latitude) would have been from ports in Japan at higher latitudes with a poor climate match with Dampier (Hallegraeff, 1998). More recent increases in iron ore sales from Dampier to China (for example to Guangdong at 23.8 N latitude) are likely to have increased the risk that foreign organisms have been transported to Dampier and established there. There is thus a real risk that organisms are already established at Dampier that could be transported to Barrow Island by barge and other support traffic during construction and operations. Export shipping movements shuttling gas between Barrow Island and India or China would also be between similar latitudes, further increasing the risk of introductions over the 60+ year life of the project.

Hallegraeff (1998) considers that mid-ocean ballast water exchange and heat treatment are the only options offering promise as fully effective, practical, safe, economically viable and environmentally friendly ballast water treatment. While it may be possible for the proponent to design these treatments into shipping operations controlled by it, the EPA notes that the proponent has been unable to make any such commitment on behalf of ships operated by third parties, such as those likely to pick up oil cargoes or spot LNG cargoes.

Introduced species risk outcomes

While the qualitative risk of individual events estimated by Chevron Australia's QHAZ work may be estimated to be low, the large volumes of material, high number of movements to Barrow Island and the long duration of the project mean that both terrestrial and marine incursions would inevitably occur. Such a conclusion is consistent with published, qualitative data based on actual events, as outlined above. These qualitative data also show that some incursions would establish and that eradication efforts for high risk organisms would cost tens of millions of dollars.

The EPA recognises that Chevron Australia proposes a greater level of quarantine control than the management exercised in Australian ports generally. It notes, however, that such a level of control has not yet been demonstrated and would need to be applied 24 hours per day, 7 days a week, 365 days a year for the more than 60 year life of the project. Such a level of control would need to survive many changes of personnel, a range of extreme weather and other emergencies and the possibility of several phases of expansion.

The work on introductions conducted by the proponent shows that, if a quarantine system with the level of rigor contemplated in those studies could be established and maintained, the residual risk scores of introductions for pathways scored to date are often up to 3 (4 in one case). The EPA notes that the proponent asserts that *"They have…provided information to demonstrate that the standards can be met with a very high level of confidence"* (Chevron, 2005, p593). It is unclear to the EPA how this is the case when the evaluated risk scores are up to 3. Risk scores up to 3 do not meet the level of 1 which is the accepted standard set by the public process engaged in by the proponent. Accordingly, the EPA does not have a very high level of confidence that the risk standard of 1 for introductions can be met.

In addition to the outcomes set out above from the detailed work performed by Chevron Australia, the EPA also notes the advice of CALM, other quarantine experts it has consulted and published reports on Australian and New Zealand quarantine services. That advice indicates that it is probable that introduced organisms will enter Barrow Island as a consequence of the Gorgon proposal being established there and operating for over 60 years. That risk is inconsistent with the vesting of Barrow Island as a class A nature reserve.

Quarantine management

Should introduced species become established, the EPA notes that eradication would require sophisticated contingency arrangements requiring significant resources likely to be well beyond the capacity of CALM as the management agency for the island. Eradication measures themselves can pose risks to the native animals. Previous rat eradication on Barrow Island resulted in many native animal deaths because they could not be excluded from the poison bait stations (Morris, 2002). Consequently, either introduced organisms would establish on and around Barrow Island as a consequence of the Gorgon project or adverse impacts on non-target species could occur as a result of eradication efforts. Based on experience elsewhere, once introduced species are established, eradication can require millions of dollars of effort and success cannot be guaranteed.

While the proponent has committed to substantially increase the level of quarantine control over that which applies to the current oil operation, the significant increase in frequency and volume of movements, the duration of the project and the change from a small, long term operations workforce to a large, casual construction workforce introduces significantly greater complexity to the issue of quarantine control. New invasion pathways would also open up, particularly during construction, as materials are secured from new sources via new supply lines (Hayes, 2003; Chevron 2005). The attendant increase in direct disturbance (up to 300ha of new clearing on land and 1650ha on the seabed) would also compound the likelihood of invasive organisms establishing and spreading.

Control of the consequent impacts of an introduction on the values of Barrow Island would be heavily dependent on the controls that can be placed on establishment and the success of detection and eradication plans if establishment does occur. While Chevron Australia has undertaken a large body of work and outlined multiple barriers that could be applied to control the introduction of non-indigenous species to Barrow Island, it has not provided the same level of information to show how introductions, which the EPA's advice indicates would be inevitable for a project of this scale and duration, would be detected and eradicated. As noted in the ERMP;

"the task of detecting a non-indigenous species at an early stage of arrival in the native environment, such that effective remedial action can be undertaken, is a difficult sampling problem because of the rarity of the event in time and space (Short, 2004)."

Consequently the EPA is left with the view that some introductions are inevitable and finds data are not available to demonstrate that such introductions would reliably be detected and eradicated without posing a significant threat to the indigenous biota.

Commitments to quarantine management

Chevron Australia proposes that a Quarantine Management System be established as a subset of an Environmental Management System comprising a series of Environmental Management Plans. This suite of documents has not yet been developed. The EPA notes that an Environmental Review and Management Programme is designed to contain both a review of the environment and impacts on it and a programme of management plans designed to mitigate impacts which cannot be avoided. While the Gorgon proposal may be at an early stage, the issue for the EPA is that it is being asked to provide advice on the acceptability of the proposal in circumstances where details of the proposed management are lacking, where the environment is particularly sensitive, the proposal is particularly large, complex and enduring and has a number of elements which do not have well established examples of impacts having been successfully managed elsewhere. In such circumstances, the EPA is left with either taking a precautionary view of the proposal or accepting unknown levels of risk to the environmental assets of the State with an unknown likelihood of management success.

An alternative approach is to ask the proponent to share the risk by making commitments to achieve measurable outcomes (sometimes known as key performance

indicators) for those elements of the proposal where there is insufficient information at present to judge what the residual impact would be. An example, which the proponent has committed to (Chevron, 2006b), would be to ensure that all detected incursions are eradicated without significant impacts to the native environment. While the means and resources needed to achieve this outcome may not be known at present, the proponent, rather than the State, accepts this risk in committing to achieve a measurable, performance based outcome.

Chevron Australia has made a qualified commitment to establish targets for measuring performance in future, when the EMS is developed. At this point, however, in the absence of management plan details which the EPA can evaluate to form a view as to their likelihood of success, commitments to meet measurable outcomes is the only real surrogate that the EPA could rely on to reach a position on the likely acceptability of critical components of the proposal. While management objectives are set out in Chapter 16 of the ERMP and Chevron's briefing note to the EPA (Chevron, 2006b) for example, measurable targets are often absent. The EPA therefore, cannot conclude, with a very high level of confidence, that the environmental and conservation values of Barrow Island are likely to be protected.

Summary

Having particular regard to the:

- transparent and inclusive process of standard setting involving community and expert participants determining that an score of 1 was the acceptable level of risk of introductions of non-indigenous species to Barrow Island;
- extensive and rigorous desktop work on the risk of introducing non-indigenous species to Barrow Island finding that introduction risk for a majority of pathways is above the risk score of 1;
- advice to the proponent that risk scores could not be further reduced; and
- the risk of introductions from the large number of movements of material, personnel and food, particularly during with a large construction workforce;
- the absence of risk scores for survival, detection and eradication;

the EPA considers the proposal, particularly the prevention of introduction of non-indigenous species to Barrow Island, cannot be managed to meet the EPA's objective in relation to protection of flora, fauna and vegetation values of the conservation reserve and is therefore unacceptable.

4.4 Subterranean fauna and fauna restricted to the development footprint

Description

The proposed development on Barrow Island has the potential to impact on subterranean fauna and the ecosystems they rely on. Subterranean fauna are stygofauna (aquatic groundwater fauna) and troglofauna (air breathing fauna found in caves or karst). Barrow Island is well recognised as being of high conservation significance for subterranean fauna at state, national and international levels. The

subterranean fauna of the island demonstrates a high level of endemicity and species diversity, with over twenty species known only from Barrow Island (Chevron 2005a).

Biota Environmental Sciences carried out subterranean fauna sampling in the proposed gas processing facility area, and in surrounding control and reference sites (Biota 2005a; Biota 2005b). The sampling programme found that subterranean fauna exist within the proposed gas processing facility site. Seven taxa (two troglofauna and five stygofauna) and several undescribed subterranean taxa that occur within the proposed gas processing facility site have not been found elsewhere on the island.

The Barrow Island draculoides (*Draculoides bramstokeri*) and the Barrow Island millipede (*Speleostrophus nesiotes*) are not restricted to the development site, but are listed under the *Wildlife Conservation Act 1950*. Ten species of crustaceans found on Barrow Island are also listed under the *Wildlife Conservation Act 1950*.

Clearing and earthworks for the construction of the gas processing facility and associated infrastructure and operation of the gas processing facility have the potential to impact on subterranean fauna through direct loss of species from habitat destruction and runoff causing sedimentation of the subterranean habitats. Waste water discharge entering subterranean habitats during construction and operations and spills of fuel or hazardous material entering subterranean habitats during construction and operations have the potential to adversely impact on subterranean fauna through contamination and excessive nutrient loading of their habitats.

Construction of the gas processing facility has the potential to impact on subterranean fauna through direct loss of habitat or collapse of karst formations. Unpredicted carbon dioxide migration from failure of carbon dioxide injection facilities or subsurface containment could affect subterranean fauna through acidification of groundwater and accumulation of carbon dioxide above the water table, thereby affecting troglofauna.

The physical presence of the gas processing facility and abstraction of groundwater could affect subterranean fauna through changes to the local hydrology from draw-down reducing stygofauna habitat, reduced groundwater recharge under the gas processing facility and direct loss of species.

The proponent has committed to a range of management measures it considers would minimise impacts on subterranean fauna, including appropriate design of the drainage management system, grey water management, identification of highly karstic areas, minimisation of blasting and control of leaks and spills.

Further sampling and taxonomic work on subterranean fauna has been foreshadowed by the proponent and further hydro-geological work would be done, including modelling of water extraction and re-injection on subterranean fauna habitats. Key performance indicators (KPIs) would be developed to provide measurable indicators of impact. If the KPIs are exceeded, further management actions have been proposed by the proponent, but these have not been specified. Monitoring wells have been established within and outside the development area where subterranean fauna habitat characteristics will be measured, including water levels and quality.

Submissions

The key issues raised in the submissions were:

- Barrow Island has a unique and valuable assemblage of subterranean animals that should be protected.
- The cut and fill required at the gas processing facility will destroy troglobitic fauna habitat, and operation at the facility may result in hydrocarbon contamination of the groundwater habitat of stygofauna.
- *Draculoides bramstokeri* exhibits substantial genetic differentiation across the island, which suggests that limited movement of underground animals occurs.
- An acceptable lack of threat to subterranean fauna species has not been demonstrated. Further information or management plans should be provided to demonstrate impacts on subterranean fauna are acceptable, particularly species that are restricted to the site.
- Additional survey work outside the gas processing facility is required to provide more information about distributions of subterranean fauna species that are listed as possibly threatened by the development.
- Taxonomic work on the subterranean fauna species potentially threatened by the development should be carried out, to improve the certainty of species level identifications.
- The abstraction of groundwater and disposal of treated waste water into the aquifer should be assessed as a potential risk factor for stygal communities.
- The potential impacts on subterranean ecosystems does not include the consequences of waste water re-injection below the island's surface.

Assessment

The EPA's environmental objective for this factor is to maintain the abundance, diversity, geographic distribution and productivity of subterranean fauna at species and ecosystems levels through the avoidance or management of adverse impacts and improvement in knowledge.

Based on surveys to date, seven subterranean taxa have been found beneath the plant site and nowhere else. As the construction camp has also been relocated west of the existing accommodation on Barrow Island, it is not evident that this area has been adequately sampled for subterranean taxa. Two taxa of terrestrial invertebrates (a scorpion and a pseudo-scorpion) have also only so far been found within the development footprint.

If any of these taxa actually occur only on or below the development site, then it is almost certain that they would become extinct when the site is cleared and developed. The terrestrial taxa would be lost because their habitat would be removed by clearing. The subterranean taxa would have to be regarded as lost because cutting and filling would destroy much of the troglobitic habitat, construction would impede the infiltration of rainfall and associated nutrients on which stygofauna depend and operations are likely to lead eventually to the infiltration of spilt hydrocarbons, chemicals or other inputs deleterious to those biota.

The proponent is currently carrying out further surveys on the distribution of subterranean fauna and terrestrial fauna restricted to the proposal footprint to assess whether those species occur outside the development area. The proponent considers that, based on the island's geology, it is likely that the subterranean species are more widely dispersed but this has not yet been demonstrated.

The EPA notes the following advice from the Department of Conservation and Land Management:

- Given the deficiency of data, a precautionary approach should be adopted and impacts on subterranean fauna should be considered a high risk.
- Once adequate sampling has been achieved, the proponents should provide a definitive list of all species that occur below the development footprint and detailed information about whether they occur beyond the footprint.
- Detailed discussion regarding the geology, stratigraphy and hydrogeology, as well as the potential for subterranean fauna use, is required for the development footprint and surrounding reference sites. There is limited geological evidence in relation to subterranean fauna habitat and uncertainty of stratigraphic relationships in the holes examined. Determining whether or not geological strata or fauna habitat are spatially continuous between the proposed impact sites and undisturbed sites is critical. This information is required to determine whether recorded taxa are potentially restricted in distribution to the development footprint.
- The proponents must either collect all of the seven restricted species beyond the footprint, convincingly demonstrate they are likely to be more widespread, or indicate whether they could be managed within the development footprint.
- The proponents should stipulate what proportion of habitat suitable for, and occupied by, troglofauna would be directly destroyed or indirectly impacted by the development.
- The proponents should commit to long-term research programmes aimed at determining the effect of hydrocarbon and carbon dioxide contamination on stygofauna.
- The proponents should provide additional information on the vertical distribution of stygofauna in relation to the anchialine systems under Barrow Island.

The EPA notes that the proponents have committed to carrying out management measures to minimise the impacts on subterranean fauna, from activities such as groundwater drawdown and leakage of injected wastes or carbon dioxide into the zones where those biota live. These effects should be avoidable or manageable with proper study, by locating the area of impact of facilities well below the zone that supports the biota, and by careful management to avoid leaks from the injection facilities where they pass through the biotic zone. However, the EPA notes that there are still some activities which have a high residual risk on subterranean fauna based on current sampling results and knowledge, such as the construction of the gas processing facility.

Summary

Having particular regard to the:

- potential for the extinction of seven subterranean fauna species currently known only from within the proposed gas processing facility site;
- lack of knowledge regarding the distribution and taxonomy of undescribed taxa that could be impacted by construction of the gas processing facility;
- potential impact on subterranean fauna species listed under the *Wildlife Conservation Act 1950*; and
- advice received from the Department of Conservation and Land Management on the additional works required to ensure that impacts on subterranean fauna are acceptable or manageable;

the EPA considers that, on the information available at this time, the construction and operation of the gas processing facility cannot be managed to meet the EPA's objective in relation to subterranean fauna, and is therefore environmentally unacceptable.

4.5 Greenhouse gases

Description

The proposal involves development of gas fields in the Greater Gorgon area (Figure 1). It is proposed to develop the Gorgon and Jansz fields first, and other fields would be developed subsequently once production from the Gorgon and Jansz fields decline naturally, and/or as market demands dictate.

Gas in the Gorgon field contains on average 14 – 15 volume % CO_2 and in the Jansz field about 0.25 volume % CO_2. Greenhouse gases would be emitted by the project principally through venting of some CO_2 removed from the reservoir feed gas prior to processing, and from combustion sources used to supply energy for gas processing.

Injection and venting of CO_2 removed from the reservoir gas

CO_2 would be removed from the reservoir gas feed stream as part of pre-treatment, prior to gas processing. The proponent claimed one of the benefits identified in locating the proposed gas facilities at Barrow Island is the potential to inject the CO_2 removed from the reservoir feed gas, into the subsurface formations below Barrow Island, thereby reducing overall greenhouse gas emissions from the project.

The proponent has carried out extensive investigations of the potential to dispose of reservoir CO_2 by injection into the subsurface. This has included assessment of potential CO_2 injection sites, subsurface geology and stratigraphy, injectivity and capacity of formations to store the CO_2, and likely CO_2 behaviour and movement in the subsurface. Based on the investigations the proponent has outlined a scheme to inject into the Dupuy Formation more than 2000m below the island. The proponent has also considered potential failure modes related to the proposed injection scheme and concluded that the risk of unpredicted leakage or migration to the surface causing environmental impact is low. Extensive monitoring and surveillance would be implemented to monitor the CO_2 plume migration and detect any surface leakage.

The proponent has estimated that on average about 3.1 MTPA of reservoir CO_2 would be removed from the reservoir gas stream. However, the CO_2 removal and injection facilities would be designed to handle a maximum rate of 3.4 MTPA. This is expected to be the maximum anticipated rate of CO_2 removed from the incoming gas stream, and allows for the Gorgon and Jansz fields to each supply up to a maximum of 120% of the gas to the two LNG trains, and for the Gorgon field to supply the domestic gas facilities.

Under routine operations, it is expected that all reservoir CO_2 removed from the incoming gas stream would be injected. However, venting of the reservoir CO_2 would be required during commissioning, periods of facility or injection system maintenance, unplanned downtime and in the event of reservoir or injection well constraints. The proponent anticipates that the amount of CO_2 that would be vented in any 12 months period would be significantly less than 200,000 tonnes CO_2equivalent (CO_2e), however there is potential for a higher level of venting, particularly in the event of injection well failure. Therefore, for the purposes of estimating the total predicted greenhouse gas emissions from the project, the proponent has adopted a reference case of venting 680,000 tonnes per annum (approximately 500,000 tonnes per annum for LNG production and 180,000 tonnes per annum for domestic gas processing), representing 20% of the CO_2 removed from the gas stream. This provides an allowance of approximately 5% for maintenance and compressor down time plus 15% assuming one of the seven planned injection wells is offline. This is considered to represent a worst-case outcome.

The proponent is still carrying out further investigations on the feasibility and costs of CO_2 injection, and is currently drilling a data well to gain further information on the Dupuy Formation, including injectivity and storage potential. The proponent has committed to proceeding with the CO_2 injection scheme unless it is "technically infeasible or cost prohibitive". The current drilling and testing will provide further information to assess feasibility and cost. The proponent has indicated that if it is technically infeasible or cost prohibitive to inject the proposed volume of CO_2, then it would liaise with Government with the intent of maximising the injection of CO_2 within the commercial constraints of the project.

Emissions from gas processing

Greenhouse gas emissions during operation of the gas processing facility would be predominantly from combustion sources used to supply energy for LNG and domestic gas production, and to remove CO_2 from the feed gas stream and inject it into the Dupuy Formation.

Based on a high emissions reference case scenario including:

- 10 MTPA LNG production sourced equally from the Gorgon and Jansz fields;
- 300 TJ/day domestic gas facilities sourced from Gorgon gas field;
- configuration of gas turbines used for electrical power generation;
- waste heat recovery;
- use of fired heaters (linked to use of waste heat recovery on power generation turbines); and
- power generation standby gas turbines operated as spinning reserve,

the proponent has estimated the annual greenhouse gas emissions for gas processing to be approximately 3.3 MTPA once full design rate is reached (approximately 3 MTPA for LNG production and 0.3 MTPA for domestic gas processing and island infrastructure support).

The estimated annual emissions for gas processing include a number of significant efficiency improvements including:

- use of sub-sea technology rather than platform-based offshore gas processing platform;
- changes in LNG process technology; and
- improved waste heat recovery on the gas turbines resulting in a significant reduction in the use of supplementary boilers and heaters.

These improvements, together with the proposed injection of reservoir CO_2 removed from the gas feed stream, have reduced the overall greenhouse gas emissions estimated for the project from 0.89 tonnes of CO_2e per tonne of LNG based on the original project concept in 1998, to 0.35 tonnes of CO_2e per tonne of LNG for the current proposal. Based on benchmarking undertaken by the proponent, this would make the greenhouse gas efficiency of the project comparable with North West Shelf Train 4 and 5 expansion, and other LNG developments around the world. The proponent has identified potential areas for further reductions in the future which could improve the overall greenhouse gas efficiency to about 0.3 tonnes of CO_2e per tonne of LNG.

Total greenhouse gas emissions

The total greenhouse gas emissions estimated for the project based on the reference case including both reservoir CO_2 vented and from gas processing, is approximately 4 MTPA. This would represent an increase in Western Australia's annual greenhouse gas emissions of around 6% based on the State's estimated emissions in 2002 (Western Australian Greenhouse Taskforce, 2004), or about 1% of Australia's total emissions. Australia represents around 1% of the global greenhouse emissions (Western Australia Greenhouse Taskforce, 2004).

In parallel with the CO_2 injection studies, the proponent investigated a number of other greenhouse gas abatement options including sequestration through commercial plantations, revegetation, reduced land clearing and mineral CO_2 sequestration, as well as Australian and overseas market based options. This work indicated that there were a number of limitations and constraints associated with these other options including the scale of abatement measures required to achieve significant offsets (for example, around 100,000 hectares of plantations would be required to offset 1 MTPA CO_2) and cost and legal uncertainties over the estimated 60 year life of the project. Based on this, the proponent has proposed injection of the reservoir CO_2 to reduce the overall greenhouse gas emissions from the project, based on the higher level of certainty, particularly in the area of cost, that it provides.

The proposed subsurface injection of reservoir CO_2 would also provide benefits through demonstration of CO_2 geo-sequestration. To facilitate this, the proponents

have committed to making data on the performance of the project available to the public.

Submissions

The following key points were made in submissions:

- Given the values of Barrow Island possibly at threat due to potential failure of CO_2 injection, a precautionary approach should be adopted so that all potential risks of failures are minimised.
- A submission raised questions related to the location and number of drill centers for the injection wells, evaluation techniques for monitoring injected gas early in the assessment process and monitoring of existing oil production wells in the path of the migrating CO_2.
- The proponent states that should geo-sequestration prove economically or technically unviable, the CO_2 would be vented to the atmosphere. If this is the case, the greenhouse gas emission of the development would be 6.7 million tonnes per annum.
- True commitment to greenhouse mitigation would include the development, promotion and transition to renewable zero-emissions technologies and fuels.
- It is unacceptable that CO_2 is released to the atmosphere when the injection compressor stops.

Assessment

The EPA's objectives for this environmental factor, as set out in its Guidance Statement No. 12 *Guidance Statement for Minimising Greenhouse Gas* Emissions, are to:

- minimise greenhouse gas emissions in absolute terms and reduce emissions per unit of product to as low as reasonably practicable; and
- mitigate greenhouse gas emissions, mindful of Commonwealth and State greenhouse gas strategies and programmes.

To achieve this, the EPA expects that potential greenhouse gas emissions from proposed projects are adequately addressed in the planning, design and operation of projects, and that:

- best practicable measures are applied to maximise energy efficiency and minimise emissions;
- comprehensive analysis is undertaken of unavoidable emissions, to identify and implement appropriate mitigation measures; and
- an on-going programme is implemented to monitor and report emissions and periodical assessment is undertaken of opportunities to further reduce greenhouse gas emissions over time.

The EPA also notes that the opportunity to inject reservoir CO_2 was a key argument for the use of Barrow Island for this project. Accordingly, the EPA considers it essential that injection or equivalent greenhouse gas mitigation action occurs.

The EPA notes that the Gorgon development would result in significant greenhouse gas emissions, expected to be in the order of 4 MTPA after reservoir CO_2 is injected. The EPA recognises, however, that the LNG produced would have a benefit over some alternative primary energy fuel sources such as coal and oil, in terms of the full life cycle greenhouse gas emissions. Gas in the Gorgon field does, however, have a relatively high volume % CO_2, and therefore particular attention does need to be given for this development to abate or mitigate for CO_2 removed from the reservoir gas.

Injection of reservoir carbon dioxide

The EPA supports the mitigation of CO_2 and other greenhouse gases generated by development projects generally. To prevent increases in the quantity of greenhouse gases in the atmosphere would require all greenhouse gases generated by a proposal to be removed or offset.

The EPA notes the proponent's plan for geo-sequestration of reservoir CO_2 removed from the feed gas by injection deep below the ground. The EPA notes that the Department of Industry and Resources commissioned Curtin University of Technology to undertake a technical appraisal of the feasibility for injection of the CO_2 from the development, including reviewing the investigation work undertaken by the proponent (Curtin University of Technology, 2004). The appraisal found that the Dupuy Formation, into which it is proposed to inject the CO_2, appears to have adequate capacity to contain the approximately 125 million tonnes of CO_2 that will be potentially available for injection over the life of the project. The appraisal also found that the Basal Barrow Group seal which overlies the Dupuy Formation should be adequate to contain the injected CO_2 for thousands of years.

The appraisal noted that drilling and testing of the data well currently underway ('Phase 3') will be one of the most important phases to support the detailed feasibility for CO_2 injection. Comprehensive well, geological and geophysical tests and analysis need to be performed to prove the ability to inject the CO_2 at Barrow Island. The appraisal also noted that monitoring the CO_2 plume's migration pathway will be the major issue during long-term storage. The EPA understands that any scheme for injection of the CO_2 into the subsurface would be subject to regulation under the *Barrow Island Act, 2003* and associated State Agreement, and other relevant legislation. This would include addressing long-term responsibility for monitoring and management of the injected CO_2 during injection and after closure of the project. The regulation should also address environmental monitoring necessary to ensure any migration or escape of CO_2 did not result in any significant impacts to fauna or flora on Barrow Island.

At this time the proponent has committed to proceeding with the injection scheme unless it is "technically infeasible or cost prohibitive". Drilling and testing of the data well which is currently underway will provide further information to determine this. Given that one of the benefits identified in locating the gas processing facilities at Barrow Island was the potential to inject CO_2 back into the subsurface, and that the project would result in significant greenhouse gas emissions, the EPA considers the project would not be environmentally acceptable if it did not include a scheme

designed to inject a high percentage of the reservoir CO_2 or otherwise mitigate an equivalent amount of CO_2.

Carbon dioxide emissions from gas processing

The EPA notes that the proponent has adopted a number of efficiency improvements associated with the gas processing for the project to minimise greenhouse gas emissions. These include:

- use of subsea technology rather than platform-based offshore gas processing platform;
- changes in LNG process technology; and
- improved waste heat recovery on the gas turbines resulting in a significant reduction in the use of supplementary boilers and heaters.

The EPA considers these to be consistent with meeting the EPA's objectives for this factor. The EPA notes that the predicted greenhouse gas emissions from gas processing alone would be about 0.27 tonnes of CO_2 per tonne of LNG produced and this is comparable with other LNG developments around the world. Based on current design, the planned energy requirements for the project would meet best practice performance targets for thermal efficiency in new gas fired electrical generation plant.

The EPA notes that, consistent with the EPA's objectives, the proponent has committed to report on and manage greenhouse gas emissions from the project in accordance with a Greenhouse Gas Management Plan. The plan includes a series of longer term greenhouse gas emission performance targets to guide the further reduction of greenhouse gas emissions and to a commitment to participate in government programmes, including the Greenhouse Gas Challenge, aimed at voluntarily reducing greenhouse emissions.

Summary

Having particular regard to the:

- proponent's plans to inject reservoir CO_2 into the subsurface;
- findings of the technical appraisal of the feasibility of injection of CO_2;
- proponent's proposed efficiency improvements for gas processing and commitments to ongoing monitoring, report and reduction of greenhouse gas emissions;

it is the EPA's opinion that for the proposal to be environmentally acceptable, the injection of CO_2 would need to be proven feasible and a scheme designed and implemented to achieve this. Alternatively, if injection was infeasible or not practicable for cost reasons, alternative measures to abate or mitigate the equivalent amount of reservoir CO_2 vented to the atmosphere would be necessary. If injection did not occur, then the chief environmental benefit of locating this project on Barrow Island would be lost.

4.6 Air quality

Description

The ERMP identified that the principal source of air emissions from the LNG plant would be the gas turbines (GTs), used for power generation and gas compression, and the steam boilers. The main air emissions from these sources include; carbon dioxide, oxides of nitrogen (NO_X), carbon monoxide (CO), and volatile organic hydrocarbons (VOCs) along with trace amounts of particulates and sulphur dioxide (SO_2). Carbon dioxide is addressed in the section on greenhouse gas and is not considered further in this section. At around 4400 tonnes per annum (tpa), NO_X was identified as the dominant pollutant.

The proponent has proposed to minimise fugitive emissions by employing best practice technology (such as dry gas seals on compressors and high quality flange seals). The main emission sources listed in the Draft EIS/ERMP are:

- power generation: 3 x 116 megawatt (MW) GTs (dry low NO_X burners);
- gas compression: 4 x 80 MW GTs (dry low NO_X burners); and
- steam generation: 2 x 150 MW boilers.

DISPMOD, the Western Australian coastal air dispersion model, was used to predict local ground level concentrations (GLCs) and TAPM, the CSIRO's model was used to address regional impacts. The air dispersion modelling predicted compliance with the NEPM criteria for NO_X for all the operating scenarios modelled. The emissions of other pollutants during process upset conditions are not predicted to cause significant impacts.

Since the release of the ERMP, the plant design has been revised by deleting the two 150 MW boilers and adding a fourth GT for power generation. The main emission sources for the revised plant are:

- power generation: 4 x 116 MW GTs (conventional burners); and
- gas compression: 4 x 80 MW GTs (dry low NO_X burners).

This change will reduce the GLC of NOx mainly due to:

- the deletion of the boilers; and
- the gas turbines with conventional burners run hotter than those with DLN and so the exhaust plume of a conventional unit is more buoyant.

This change will increase the output of NO_X from about 4400 tpa to about 6100 tpa. An emission reduction of approximately 30,000 tonnes of CO2 per annum can be expected when operating conventional combustion systems over DLN technology to achieve the same power output from the power generation facilities.

Hydrogen sulphide (H_2S) may at times be emitted at levels likely to create an odour nuisance but below World Health Organisation human health standards.

Submissions

Submissions from government agencies and the public indicated that:

- A management plan for dust (including risk to biodiversity) should be prepared.
- Best practice management for all emissions to reduce impacts on the environment should be adopted.
- Air emissions have the potential to affect not only human health but the vegetation on Barrow Island. Impacts of the emission of oxides of nitrogen include bleaching or killing of plant tissue, reduced growth rate and leaf fall.

Assessment

The EPA's objective for this factor is to ensure that emissions, by meeting statutory requirements and acceptable standards, do not adversely affect environmental values or the health, welfare and amenity of people and land uses.

NO_X is the predominant pollutant emitted from GTs and since the revised design increases these emissions from 4400 to 6100 tpa, the EPA requested that revised air dispersion modelling be undertaken.

The revised air dispersion modelling shows that the increase in NO_X emissions is offset by the greater buoyancy of hotter plumes from the GTs fitted with conventional burners. For all of the operating scenarios modelled, the maximum predicted 1 hour NO_2 GLC is 52% of the NEPM criteria. The EPA notes that the NEPM criteria for NO_2 are designed to protect human health and no data has been provided on the effects on emissions on flora and fauna of Barrow Island. It is considered that NO_x deposition has the most potential for impact from emissions. Modelling in the ERMP has shown deposition should not exceed international guidelines. The deposition of nitrogen on Barrow Island is predicted to be between 0.2 and 1.8 kilograms per hectare per annum. While this is much less than the World Health Organisation (WHO) guideline, the relevance of the WHO guideline to Barrow Island's vegetation is uncertain.

Although the maximum PM10 GLC could exceed the NEPM criteria during a shut down, the NEPM would be met at the accommodation site. The emissions of other pollutants during process upset conditions are unlikely to cause significant impacts. The EPA notes that H_2S emissions of 62$\mu g/m^3$/hour if CO_2 injection fails exceed the WHO odour standard of 14 $\mu g/m^3$/hour. Since the accommodation facilities have been moved away from the plant site, H_2S should not become an odour nuisance in the accommodation and messing area. Potential toxicity to fauna is thought to be low, but this would need to be confirmed by appropriate monitoring. The EPA notes that impacts on regional air quality from a human health perspective are predicted to be negligible.

Summary

The EPA notes that the proposed use of best practice for fugitive emissions control and agrees that best practice is appropriate. The EPA also notes the use of natural gas for fuel results in levels that meet NEPM criteria and WHO (for deposition) criteria. The relevance of these human health criteria to the flora and fauna of Barrow Island is less certain.

Having particular regard to the:

- best practice control of fugitive emissions;
- revised air dispersion modelling;
- capacity for a condition requiring a FEED report; and
- capacity for a condition requiring an AQMP,

it is the EPA's opinion that the air quality aspect of the proposal could be managed to meet the EPA's environmental objectives for this factor, provided appropriate conditions were made legally enforceable.

5. Conclusions

Having considered the proponent's Environmental Review and Management Programme report and supplementary information, public and government agency submissions, separate expert advice and the proponent's response to submissions, the EPA has concluded that the overall impacts of the proposal would be environmentally unacceptable. While the proponent has identified measures through the environmental assessment to reduce impacts and risks to the key terrestrial and marine environmental values, it is the EPA's judgment that the extent of predicted impacts and degree of residual uncertainty and risks posed by the proposal remain unacceptably high. Where insufficient data exist, the level of resources required to manage an issue to an acceptable level of risk is not presently known. If the proponent makes a commitment to manage the issue to a standard acceptable to the EPA, then such a commitment represents a cost risk to the proponent. But in the absence of this risk being assumed by the proponent, that same risk is transferred to the State and borne by the public environmental assets which form part of the endowment of Western Australia. The key areas where significant impacts or risk of impacts remain are:

- risk of impacts to flatback turtle populations;
- impacts on the marine ecosystem from dredging;
- risk of introduction of non-indigenous species; and
- potential loss of subterranean and short range endemic invertebrate fauna species.

The proponent has not been able to demonstrate to the EPA that the sensitive conservation and environmental values can be maintained with a high degree of certainty, nor that the risks to those values would be acceptably low in the long term.

Based on the assessment, the EPA does not believe that the proposal could be made environmentally acceptable. The EPA considers that there are a number of key factors which would not be manageable to achieve an acceptable environmental outcome.

Accordingly, the EPA recommends that, from an environmental point of view, the proposal should not be permitted to proceed as proposed.

6. Other advice

The EPA has some recommendations that have come out of its assessment that are relevant to existing circumstances on and around Barrow Island.

Size of Barrow Island Port

The EPA considers that a process to rationalise the Barrow Island port area to the smallest possible size to allow safe shipping operations should be implemented by the Government as a priority. The EPA understands that the Government has already made a decision to examine this issue and supports its early implementation.

Governance of current operations

The EPA notes that Chevron Australia acts as operator for the oil field that continues on Barrow Island nature reserve today. A number of contractors service that oil field and Barrow Island is also used as a transit point to support other offshore operations. The oil field operations are regulated under the terms of lease L1H granted pursuant to the *Petroleum Act 1936 and 1967*. The majority of development on the lease predates the *Environmental Protection Act 1986* and current operations on Barrow Island have not been subject to environmental impact assessment or conditions imposed by the Minister for the Environment. Pollution control aspects of these operations are subject to regulation under Part V of the *Environmental Protection Act 1986*. Regardless of any decision by Government about the Gorgon proposal, these existing operations require additional, up to date environmental conditions, with direct professional oversight by conservation authorities, to ensure the conservation values of the nature reserve are maintained in the long term.

The EPA considers that sufficient agency resources and governance arrangements should be put in place to properly manage existing operations on Barrow Island. These arrangements should pay particular attention to the need to manage multiple responsible entities and ensure that responsibilities are not avoided because it may be unclear who is responsible for a particular incident. For example, if an introduced species arrived on Barrow Island, it would be critical that it was rapidly contained and dealt with, regardless of who was responsible for its introduction. To protect the conservation values of the island and its surroundings, it would be vital that the issue was effectively dealt with, without delays caused by deciding who was responsible or who would pay.

The Conservation Commission is the vesting authority for Barrow Island Nature Reserve. Operational responsibility for the management of actions on nature reserves rests with the Department of Conservation and Land Management.

The EPA considers that significantly upgraded environmental regulatory control is required on Barrow Island, including the capacity for the Department of Conservation and Land Management to better regulate relevant parts of the activities and manage the conservation values of Barrow Island.

The EPA notes that lease L1H is due for renewal in February 2009 and recommends that approaches to include upgraded regulatory control of conservation and environmental matters be examined with a view to including such controls in the lease conditions.

Decision on the Gorgon proposal

The EPA recognises that the Government has previously provided in-principle agreement to the Joint Venturers for restricted access to Barrow Island for gas processing facilities, as a foundation for the development of the Gorgon area gas fields, subject to this environmental impact assessment and other statutory approvals. The EPA also recognises that the Government's decision regarding the current proposal will be based on consideration of social, economic, and strategic issues, as well as environmental matters.

Because the EPA does not consider that its environmental objectives could be met, it has not included recommended environmental conditions for the management of the proposal in this report. If, however, Government was to decide that the proposal may proceed for other than environmental reasons, a set of strict conditions and governance arrangements would be required, along with implementation of the proponent's commitments. A draft framework to guide the necessary content of a possible set of environmental conditions is included in Appendix 4.

7. Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on the relevant environmental factors and principles the EPA considered relevant to the proposal, as set out in Section 4;
2. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objectives and is considered environmentally unacceptable, particularly with regard to the risk of impacts to flatback turtle populations, impacts on the marine ecosystem from dredging, risk of introduction of non-indigenous species and potential loss of subterranean and short range endemic invertebrate fauna species.
3. The EPA therefore recommends that, from an environmental point of view, the proposal should not be permitted to proceed as proposed at Barrow Island.
4. That the Minister notes the EPA's other advice presented in Section 6 and Appendix 4 outlining essential environmental requirements that the EPA considers would need to be applied to the proposal, should the Government decide for other than environmental reasons, that the proposal may be implemented.

Appendix 1

List of submitters

Organisations:
Conservation Commission
Conservation Council of Western Australia
Department of Fisheries
Department of Environment
Department of Conservation and Land Management
Department of Consumer and Employment Protection
Department of Industry and Resources
Department of Environment and Heritage
Department of Indigenous Affairs
Humane Society International
Marine Parks and Reserves Authority
The Chamber of Minerals and Energy
Environmental Weeds Action Network
Western Australian Museum
Wildflower Society of Western Australia
Waterbird Conservation Group
World Wide Fund for Nature

Individuals:

John Allen
Don Bradshaw
Andrew Burbidge
Kylee Carpenter
Jennifer Catalano
Michael L. Guinea
Chris and Yvonne Muller
K. Rasmussen

Appendix 2

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Appendix 3

Summary of identification of relevant environmental factors and principles

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
BIOPHYSICAL			
Flora and vegetation communities	The *Barrow Island Act 2003* allows additional clearing of 300 hectares (ha) of native vegetation on Barrow Island. This would be cumulative on the existing disturbance on the island (about 1050ha), which represents a total of about 6.5% of clearing on the island. The Gorgon Development (Barrow Island) proposal would clear 250ha for the construction of pipelines, gas processing facilities and associated infrastructure. BBG and Mattiske (2005) identified the following significant and restricted vegetation communities and flora species as occurring within the project area: • 0.6ha of the flats community, F4; • 2.99ha of the limestone communities, L3c, L6b, L6c and L6d; • 0.99ha of the coastal communities, C1d, C2e, C4e, C5b and C5c; • 0.3ha of the clay pan community, S1a; • *Corchorus interstans* (Priority 3); • *Melaleuca cardiophylla*; • *Dichanthium sericeum* subsp.	<u>Department of Conservation and Land Management</u> • The location of administration buildings and support facilities does not take advantage of previously disturbed areas. • The ERMP fails to recognise the significance of Barrow Island for biodiversity conservation at the regional, state and national scales. The island provides a refuge for a diverse range of flora and fauna, many of which are endemic to the island and genetically separate to species on the mainland. • The mainland shore crossing for the domestic pipeline should incorporate horizontal directional drilling in the areas of densest mangroves. • The EPA should consider the application of a rehabilitation bond as a default to cover the likely cost of decommissioning and rehabilitation. • Opportunities for the direct transfer of topsoil for the rehabilitation of existing disturbance on Barrow Island should be investigated. • Estimates of areas cleared on Barrow Island are not true values of disturbance as they do not account for indirect impacts such as dust, drainage effects and habitat fragmentation. • The area cleared for roads may be an underestimate of the actual cleared area. • The existing flora list for Barrow Island must be revised, and an inventory developed that is nomenclaturally and taxonomically current and cites only those species represented as voucher specimens in herbaria. The flora conservation status, impacts and management should be revised so that it is consistent with the updated flora list. • Further taxonomic research is required to clarify the status of the 17 unconfirmed plant taxa recorded on Barrow Island. • A quantitative comparison of floristic communities, floristic richness and vegetation types between Barrow Island and the mainland should be undertaken to determine the regional significance of the vegetation on the island. • A fire management regime for Barrow Island should be developed.	**Flora and vegetation is considered to be a key environmental factor and is discussed in Section 3.1.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	humilius; • *Erythrina vespertilio*; • *Grevillea pyramidalis* subsp. *leucadendron*; • *Hakea lorea* subsp. *lorea*; • *Hybanthus aurantiacus*; and • *Whiteochloa airoides*. Some major drainage lines contain restricted vegetation communities. No Declared Rare Flora were recorded within the project area. Flora and vegetation may also be impacted by dust deposition, wildfires and introduced species. 90ha would be cleared on the mainland for construction of the gas pipeline.	<u>Conservation Commission of Western Australia</u> • Barrow Island is a Class A Reserve that has high biodiversity conservation values, and has been reserved from other uses to protect these values. • A range of offsets (to the satisfaction of the Commission and CALM) should be provided to compensate for the loss of environmental values. <u>Department of Industry and Resources</u> • The mainland gas pipeline easement is 30 metres. Recent pipeline projects have used a smaller easement width. Detailed explanation is required for the need for the identified easement width, and measures to minimise the width as far as practicable. <u>Public</u> Non Government Organisations made the following comments: • Twenty-three restricted flora occur on Barrow Island, of which six species would be impacted by the development. Two vegetation communities are considered locally significant. • Existing seismic lines, roads and tracks traverse Barrow Island in high density. Rehabilitation is hampered by low rainfall. The cumulative loss of vegetation within the Class A Barrow Island Reserve is unacceptable. • How much vegetation would be cleared to enable widening, grading and sealing of roads? • A pioneer camp is referred to in the ERMP, but no information is provided about the proposed clearing that might take place.	
Terrestrial fauna	Vegetation clearing will result in the loss of habitat, reduction in carrying capacity, fragmentation and isolation of habitat. Project operations may disturb fauna due to noise, vibration, light and injury from vehicle movement. The following species listed under the WA *Wildlife Conservation Act*	<u>Department of Conservation and Land Management</u> • A more realistic analysis of the risks to island fauna should be undertaken as they are highly vulnerable to disturbances such as fire, disease, genetic diversity depression, loss of habitat and predation. • Over half of the reptiles on Barrow Island have been recorded in the vicinity of the development area. The taxonomy of the reptiles should be determined to confirm their conservation status. Ongoing sampling for reptiles should be undertaken within the development area and elsewhere on Barrow Island.	**Terrestrial fauna is considered to be a key environmental factor and is discussed in Section 3.2.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	1950 and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) have been identified as occurring within the project area: • Barrow Island black and white fairy-wren (*Malurus leucopterus edouardi*); • burrowing bettong (*Bettongia lesueur lesueur*); • Barrow Island golden bandicoot (*Isoodon auratus barrowensis*); • Barrow Island spectacled hare-wallaby (*Lagorchestes conspicillatus conspicillatus*); • Barrow Island euro (*Marcopus robustus isabellinus*); • black-footed rock-wallaby (*Petrogale lateralis lateralis*); and • Barrow Island mouse (*Pseudomys nanus ferculinus*). The following species are not listed under State or Commonwealth Acts, but are considered significant, and have been identified as occurring within the project area: • water rat (*Hydromys chrysogaster*); • land snail (*Rhagada* sp.); • scorpion (*Urodacus* sp. nov. 'barrow'); • pseudoscorpion	• Further survey work and taxonomic work is required for the new and undescribed invertebrates on Barrow Island. • An on-ground fauna survey should be undertaken along the proposed gas pipeline corridor on the mainland. • Further information should be collected on the water rat, and appropriate management strategies developed to avoid and/or mitigate impacts on the species on Barrow Island. • A fauna relocation programme should be developed, which includes a research component that tracks subject fauna, in order to monitor the success of the translocations. • Perimeter fencing should be constructed around the processing facility for the construction and operational phases of the project. • The impacts of fire on fauna should account for the risk of fauna mortality after a fire from exposure, predation, lack of food, and the overall risk of loss of genetic variability and potential fauna extinction. • The assumption that the proportion of fauna impacted by the development would correspond to the proportion of area on Barrow Island to be cleared, which is 1.3%, should be supported with data. This assumption fails to recognise indirect impacts resulting from the development, including spread introduced species and disease, and habitat fragmentation. • Assessment of impacts on fauna of conservation significance on Barrow Island should include an assessment of the potential of the development to affect the conservation status of rare and threatened fauna species. <u>Conservation Commission of Western Australia</u> • Barrow Island is abundant with mammals, reptiles and birds, which have not been affected by introduced feral animals and predators. • There are significant environmental impacts associated with the development, including its footprint and unacceptable risk to the island's unique species, populations and ecosystems. <u>Department of Environment and Heritage</u> • Barrow Island is an internationally significant littoral avifauna site	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	(*Synsphyronus* sp. nov. 'barrow'); • termites (*Nasutitermes triodia*); • mygalomorph spiders; • northern brush tailed possum (*Trichosurus vulpecula arnhemensis*); • spinifex bird (*Eremiornis carteri*); • perentie (*Varanus giganteus*); • leopard skink (*Ctenotus pantherinus acripes*); and • blind snake (*Ramphotyphlops longissimus*). As the total proposed vegetation disturbance is 1.3% of the island, the proponent assumes a corresponding proportion of impact on the terrestrial fauna on the island. A larger proportion (3 to 4%) of the Barrow Island black and white fairy-wren would be impacted. 24 terrestrial and subterranean fauna species are endemic to Barrow Island and another 5 are restricted in their distribution. 90ha would be cleared on the mainland for construction of the gas pipeline. The Pilbara olive python (*Liasis olivaceus barroni*), mulgara (*Dasycercus cristicauda*) and orange leaf-nosed bat (*Rhinonicteris*	because it meets the Ramsar criterion of supporting >1% of a species population for the ruddy turnstone, red necked stint, grey tailed tattler, sanderling, greater sand plover, lesser sand plover, fairy tern and the *opthalmicus* race of the sooty oyster catcher. • A more realistic analysis of risks is required that takes the extreme vulnerability of the island terrestrial populations, indirect impacts and relative habitat use into account. <u>Western Australian Museum</u> • Barrow Island is an important refuge for wildlife species, some endemic to the island, and some extinct on the mainland. • Most populations are at or near carrying capacity, and relocated animals will find difficulty in establishing themselves in already occupied habitat. A detailed monitoring programme should be developed to evaluate the success or otherwise of the translocation of fauna. • Further genetic studies should be carried out on the land snails, *Rhagada* sp. 2, *Quistrachia barrowensis, and Pupoides.* <u>Public</u> Private individuals and Non Government Organisations made the following comments: • The ERMP fails to take into account the vulnerability of the populations on Barrow Island to disturbance. Island populations are relatively small, isolated and highly vulnerable to extinction. • There is insufficient information given on the conservation status of reptiles on the island, which is a concern because more than 50% of the terrestrial reptiles on the island have been recorded in the proposed development area. • The success of the translocation of fauna is questioned. • The extreme vulnerability of island populations to disturbance or invasion is not given adequate weight in the ERMP or the risk assessment. Analysis of risks appears to be understated as assumptions are made that effects would be proportionate to the project's area of disturbance of the island. • A more realistic analysis of risks is required that should take the extreme vulnerability of the island terrestrial populations, indirect impacts (including	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	aurantius) are EPBC Act listed species that are likely to occur along the pipeline route.	the fragmentation of habitats and the introduction of invasive plants animals or diseases) and relative habitat use and significance into account. • In the absence of a successful fauna translocation programme, it would have to be assumed that all fauna within the development footprint would be killed directly or indirectly (e.g. by intra-specific competition). • Barrow Island is recognised as having international importance as a conservation area because of the high level of faunal endemicity, and refuge for fauna (some of which are extinct, or near extinction, on the mainland). • Barrow Island supports birds under the Ramsar Convention on Wetlands of International Importance and JAMBA and CAMBA. • The proposed vegetation disturbance would jeopardise breeding, feeding and orientation of important avifauna. • The development near Town Point includes littoral and terrestrial habitats used by shorebirds, seabirds and landbirds. Direct loss of some of these habitats and disturbance to surrounding areas is likely to affect local avifauna. The report fails to say in what way and to what extent these birds are likely to be affected. • Lights and gas flares pose major risks and problems to birds, particularly breeding of the wedge tailed shearwater. This impact has not been resolved by the proponent. • The Barrow Island white fairy-wren is listed as Vulnerable under State and Commonwealth Acts. Their protection should be raised, not lowered. • Town Point is an important site to the spinifex bird, singing honeyeaters, grey tailed tattlers and greater sand plovers. The inevitable impact on these species is unacceptable. • Because of the long construction phase (at least 39 months) fauna would be without the habitats they presently rely on for a very long time. These impacts are not at all clear and need to be worked out. • The Avifauna Technical Report states that there is insufficient knowledge of the distribution and abundance of protected and migratory shore bird species on Barrow Island and of the significance to them of the impacted areas. • The Avifauna Technical Report states that major gaps remain in existing	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		knowledge on the distribution and seasonality of birds in the potential impact area, and how species' distribution varies throughout the year. • Further baseline information is required on short range endemic invertebrates on Barrow Island. • What measures are proposed to reduce deaths associated with trenching?	
Subterranean fauna	Barrow Island has a high conservation value for subterranean fauna at regional, state, national and international scales. There is a high level of endemicity and species diversity of subterranean fauna, with over 20 species known only to occur from Barrow Island. The following development activities have the potential to impact on subterranean fauna: • excavation of karstic geology and alteration to surface hydrology for the construction of the gas processing plant and associated infrastructure; • excavation or leveling of coastal limestone formations for the construction of onshore infrastructure; • spills of chemicals or other pollutants entering the groundwater during construction and operation; • construction of the gas delivery pipeline, particularly in the coastal sections of the route; and • groundwater drawdown	<u>Department of Conservation and Land Management</u> • All drilling for the proposed gas development must be cased through formations that are likely to host stygofauna. • The cut and fill required at the gas facility would destroy troglobitic fauna habitat, and operation at the facility may result in hydrocarbon contamination of the groundwater habitat of stygofauna. The proponent identified the residual risk to subterranean fauna as high with serious to severe consequences. • *Draculoides bramstokeri* exhibits substantial genetic differentiation across the island, which suggests limited movement of underground animals occurs. • An acceptable lack of threat to subterranean fauna species has not been demonstrated. Further information or management plans should be provided to demonstrate impacts on subterranean fauna are acceptable. • Additional survey work outside the gas processing facility is required to provide more information about distributions of subterranean fauna species that are listed as possibly threatened by the development. • Management plans for any subterranean fauna species that appear to be restricted to that site should be prepared. • Taxonomic work on the subterranean fauna species potentially threatened by the development should be carried out, to improve the certainty of species level identifications. • Approvals must be sought to remove habitat of *Speleostrophus nesiotes* and *Draculoides bramstokeri* at the gas processing plant. • The abstraction of groundwater and disposal of treated waste water into the aquifer should be assessed as a potential risk factor for stygal communities.	**Subterranean fauna is considered to be a key environmental factor and is discussed in Section 3.3.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	associated with water supply bores. Biota (2005) identified that in the area of the proposed gas processing plant there are: • endemic subterranean fauna present; • two troglofauna species (*Speleostrophus nesiotes* and *Draculoides bramstokeri*) listed under the *Wildlife Conservation Act 1950*; and • undescribed stygal and troglofauna taxa not currently known from elsewhere on the island.	<u>Conservation Commission of Western Australia</u> • Barrow Island has a unique and valuable assemblage of subterranean animals. <u>Public</u> Non Government Organisations made the following comments: • The potential impacts on subterranean ecosystems does not include the consequences of waste water re-injection below the island's surface. • Subterranean taxonomic work is yet to be completed.	
Introduced terrestrial organisms	15 introduced plant species have been recorded on Barrow Island. Environmental weeds of particular concern are: • buffel grass (*Cenchrus ciliaris*); • spiked malvastrum (*Malvastrum americanun*); • black berry nightshade (S*olanum nigram*); • sow thistle (*Sonchus oleraceus*); • kapok (*Aerva javanica*); and • whorled pigeon grass (*Setaria verticillata*). Clearing and earthworks for the gas processing facilities, pipelines and	<u>Department of Conservation and Land Management</u> • The proponent has not demonstrated that the risk standards for quarantine can be met with a very high level of confidence. There is a need to consider what would happen in the event of a significant quarantine breach on Barrow Island, which could ultimately result in the loss of significant conservation values, including species extinction. • The risk assessment process fails to consider the introduction and spread of weeds as an environmental risk factor to biodiversity. • Information on the current distribution and abundance of weeds on Barrow Island, the current weed management regime, and progress in controlling or eradicating weeds should be provided. • Barrow Island is one of the largest islands in the world that is without any introduced vertebrates. <u>Conservation Commission of Western Australia</u> • The inability to produce risk scoring for survival, detection and eradication must be explained with the provision of an alternative mechanism to describe risk in these areas.	**Introduced terrestrial organisms is considered to be a key environmental factor and is discussed in Section 3.4.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	associated infrastructure on Barrow Island have the potential to assist the spread of introduced species. There are no introduced vertebrate fauna species on the island. Some introduced invertebrate species occur on the island. Historically, introduced rats and mice have been found on the island. These species have now been eradicated. • The proponent established a Quarantine Expert Panel (which later changed its name to the Quarantine Advisory Committee) to advise on terrestrial and marine quarantine management for Barrow Island. The Panel identified 16 priority pathways that require the development of quarantine barriers. Barrier details for these pathways have been identified. The risk assessment was focused on the likelihood of introducing non-indigenous species to Barrow Island, and to a lesser extent on the likelihoods of survival, detection and eradication. The Panel subject each pathway to a risk assessment process and scored the stages of infection (introduction, survival,	• The pathway assessments and barrier descriptions should be completed prior to environmental impacts occurring on Barrow Island. <u>Department of Environment and Heritage</u> • The introduction of exotic animals, plants and microorganisms is the greatest threat to the maintenance of the highly significant biological diversity of Barrow Island. The extreme vulnerability of island populations to disturbance or invasion is not given adequate weight in the risk assessment. • There are many more pathways that need to be considered for quarantine. • There are no protocols for the eradication of introduced species. <u>Public</u> Private individuals and Non Government Organisations made the following comments: • The introduction of exotic animals, plants and microorganisms is the greatest threat to the integrity and biodiversity within Barrow Island. • The probability of detecting most introduced animals before they become common is low. Eradication in natural areas is difficult, and often also impacts indigenous species. • There has been no attempt to measure infection of existing pathways operated by Chevron to service the oil field. • There have been many quarantine breaches with the existing oilfield operations. • Protocols for eradication of introduced species once they establish have not been developed. • The proposed development would create serious risks to the unique, fragile and threatened ecosystems of Barrow Island, especially regarding the introduction of pest and weed species. • The scale and time frame of the proposed development means that, even with the best of intentions, perfect quarantine control would be impossible. • The large number of the workforce has the potential to dramatically	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	detection and eradication) on a scale of 1 (infection is extremely rare) to 10 (infection can occur throughout the year). The Panel considered that a pathway with a risk score of 2 or 3 for introduction was acceptable only if the risk score for survival/detection and or eradication was 1. Similarly, a risk score of 2 or 3 for detection or eradication was considered acceptable if the risk score for introduction was 1.	increase the use of existing tracks, create new tracks and spread weeds and pests. • There is no indication as to how the continuing surveillance for pests on Barrow Island is to be achieved. • Extinction risk of endemic biota and introduction of feral animals through quarantine breaches should be considered a high risk receptor.	
Soil and landform	The clearing of vegetation and earthworks during construction would disturb the soil profile and alter the landform. The key potential impacts associated with this include erosion and sedimentation, soil compaction and inversion, disturbance to significant geological features, and change in landform.	No submissions received.	Management of soil and landform would be addressed in the project Environmental Management Plans. **Soil and landform is not considered to be a key environmental factor.**
Surface water	The clearing of vegetation and earthworks during construction have the potential to disturb the natural drainage patterns and create sedimentation of the natural drainage systems. The storage and handling of wastes and disposal of liquid waste via injection to deep aquifers has the potential to impact the surface water quality. Spills or leaks of chemicals and fuels from pipelines, infrastructure and equipment have the potential to	No submissions received.	Measures to minimise impact on surface water would be implemented, including: • erosion and sedimentation control measures to limit sediment generation and transportation to natural drainage systems; • a stormwater drainage management system; • waste management measures; and • design controls and a programme of verification and validation testing, inspection, monitoring and maintenance of equipment. Surface water would be addressed in the project Environmental Management Plans.

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	contaminate the surface water.		Environmental Management Plans. **Surface water is not considered to be a key environmental factor.**
Groundwater	Two main aquifers have been identified: the unconfined shallow aquifer; and the confined Flacourt Sands saline aquifer which is between 900-1200 metres deep. Process water is pumped from the Flacourt Sands aquifer, while the shallow aquifer is used for domestic purposes. The storage and handling of wastes and disposal of liquid waste via injection to deep aquifers has the potential to impact the groundwater quality. Spills or leaks of chemicals and fuels from pipelines, other infrastructure and equipment have the potential to contaminate the groundwater.	<u>Department of Conservation and Land Management</u> • Options for the potable water supply on Barrow Island or from the ocean requires further investigations. <u>Department of Environment</u> • Three options for the water source are provided, with no direction on which option would be pursued. The option to use a tertiary aquifer needs careful management due to potential effects on the saltwater/freshwater interface. • There is a high potential that any spill, leak or discharge of contaminating materials from storage and processing facilities would result in migration to the groundwater. Best practice precautions and constructions should be undertaken to prevent land and groundwater contamination on Barrow Island. • Deep injection of carbon dioxide has the potential to change the acidity of the receiving groundwater, thus changing the subsurface physical conditions. • Barrow Island is not proclaimed under the *Rights in Water and Irrigation Act 1914*. • The spill response plan should include remediation measures for situations where contaminated material has migrated to underlying soil and groundwater and demonstrate an ability to be able to mobilise appropriate recovery equipment within a short time frame. <u>Western Australian Museum</u> • There appears to be no assessment of the nature of the groundwater system on Barrow Island, despite a long history of usage and spoilage of the groundwater resource by petroleum operations. This information is necessary	The Hydrocarbons and Chemical Spills Plan is outlined in the Technical Appendix A1. Groundwater modelling is being undertaken as part of ongoing studies of the hydrogeology of the development area. The data and modelling would be used to refine management plans. **Groundwater is considered to be a key environmental factor in terms of impact on subterranean fauna, and is discussed in Section 3.3.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		for any risk assessment of activities that might impact on the groundwater, and the subsequent risks to groundwater ecosystems, that would be associated with normal operations and accidental contamination from both land and sea. • The lack of groundwater modelling, and of information on the vertical and lateral transmissivity of the karst system prevents assessment of the likely extent of impact on the unconfined aquifer of any contamination from pipeline or plant related escapes or marine spills. <u>Public</u> Private individuals made the following comment: • High quality environmental conditions, especially for impacts on stygofauna, should be required for groundwater abstraction activities.	
Marine fauna	BBG (2005) identified over 100 marine species listed under State or Commonwealth Acts as occurring, or likely to occur, in the water surrounding Barrow Island, including: • great white shark (*Carcharodon carcharias*); • whale shark (*Rhincodon typus*)l • green turtle (*Chelonia mydas*); • flatback turtle (*Natator depressus*); • loggerhead turtle (*Caretta caretta*); • humpback whale (*Megaptera novaeangliae*); • blue whale (*Balaenoptera musculus*); • spinner dolphin (*Stenella*	<u>Department of Conservation and Land Management</u> • The proposed location of the gas processing facility at Town Point is within a significant rookery for the flatback turtles, and is likely to disturb their nesting patterns during construction and operation. The project would require significant light emissions, and the ERMP does not demonstrate that the impacts of light to turtles on the east and west coasts would be fully mitigated. • A complete island survey of turtle nesting beaches should be carried out in order to gain a better understanding of the distribution of turtle nesting on the island, and to consider the proposed impact sites in their broader context. • Green turtle nesting occurs throughout the year, with low numbers of hatchlings emerging in winter months as well. Subsequently, turtle protection measures must take effect throughout the year. • The data available on dugong distribution and abundance in Barrow Island coastal waters are not conclusive. Targeted surveys to obtain more reliable data on the likelihood of impacts on dugongs should be undertaken. • The ERMP notes that blasting associated with the excavation of the access channels would cause injury or mortality to fish and can potentially injury or kill turtles. More information is required on the spatial and temporal	**Marine fauna is considered to be a key environmental factor and is discussed in Section 3.5.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	longirostris); • striped dolphin (*Stenella coeruleoalba*); and • dugong (*Dugong dugon*). The Barrow Island region supports EPBC Act listed green turtles and flatback turtles that migrate over large distances and return to the island to breed, and provides foraging grounds for turtles that nest elsewhere. green turtles use the west coast and north east corner of the island. flatback turtles are endemic to Australia and have a significant nesting site along the east coast of the island. Town Point is a significant flatback turtle rookery. Lighting, dredging, noise, vibration and altered beach dynamics have the potential to impact on sea turtles.	extent of blasting. • Physical disturbance to turtle nesting beaches during construction must be minimised, with activities avoided during the nesting season. A programme of monitoring turtle activity at affected beaches before, during and after construction work should be implemented, as well as a programme to mitigate any detrimental impacts on turtle nesting from beach disturbance. • Any deaths of turtles and dugongs should be reported to CALM. • A turtle monitoring programme should be implemented. <u>Department of Environment and Heritage</u> • The impacts from dredging on marine benthic habitat, which are utilised by listed threatened and migratory species, are very large. There is uncertainty about recovery potential and flow-on effects that may affect habitat structure and food webs. • Barrow Island and all the waters within a 20 kilometre radius are listed as habitat critical to the survival of green turtles in the Commonwealth Recovery Plan for Marine Turtles in Australia. • The flatback turtle and green turtle rookeries are considered significant because they are not subject to threats from introduced predators. • Barrow Island provides important inter-nesting and foraging habitats for turtles which feed on seagrass and macroalgae on the seabed. • The gas processing facility, materials off-loading facilities and causeway would disturb the nesting patterns of the flatback turtles, which use the beaches to the north and south of Town Point as major nesting sites. • Flacourt Bay is an important green turtle nesting habitat. • The EIS acknowledges that there would be adverse impacts on turtles from dredging and light emissions. However, these impacts are not resolved or adequately mitigated. • Construction work near turtle nesting beaches at night during peak nesting seasons should be avoided, non-essential lighting should be eliminated, light shields, shades, design and non reflective surface should be utilised. Regular light audits should be conducted with provisions for upgrades as technology improves.	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		<u>Public</u> Private individuals and Non Government Organisations made the following comments: • The proposal would have significant impact on sea turtles, particularly the green turtle and flatback turtle including: o impacts on breeding from alteration of beach foreshores and light pollution; o impacts from oil pollution from the ships berthing on the proposed jetty; o impacts on nesting females and disorientation of hatchlings from lighting; o impact from construction and operational noise; o dredging through prime turtle habitat would impact turtles feeding and basking in the area; o physical disruption to areas of the seabed and the generation of sedimentation and turbidity from dredging would impact on the seagrass beds, which are a critical foraging habitat for turtles; o water currents from construction of the causeway would impact on nesting sites; and o a thorough understanding of turtle nest site selection or of what effects changed currents may have on the structure of the beach is not available. • The ERMP acknowledges the threats to the sea turtles, but does not provide any guarantee that the impact of the development, on the east coast and the west coast, would be mitigated successfully. • The Commonwealth Recovery Plan for Marine Turtles in Australia identifies development at nesting habitats as a major threat to North West Shelf (Western Australia) marine turtle populations. • The Dredging and Spoil Disposal Management Plan should be prepared before development, as the impacts of dredging on the turtle populations could be significant and unavoidable. • The risk to flatback turtles is critical and almost certain for the populations nesting on the beaches to the north and south of Town Point. • A precautionary approach must be taken due to the uncertainty regarding the use of the beaches by the turtles and the effectiveness of dredge modifications.	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		• Unlike the mainland, Barrow Island flatback turtle rookeries are free from predation by foxes. • Further information is required on the distribution of and potential impacts on dugongs around Barrow Island.	
Benthic primary producer habitats	The waters surrounding Barrow Island are part of the Montebello-Barrow Island Marine Conservation Reserves. There would be direct disturbance on marine ecological communities and their habitat from dredging, spoil dumping, construction of the pipeline and other infrastructure, which would impact or burial of any vegetation that occurs on up to 1,390ha of the seabed which would be dredged, have dredge spoil dumped on it or would be otherwise disturbed. Up to a further 10,000ha may be indirectly affected by anchor scars, sedimentation, increased turbidity or light reduction during dredging. BBG (2006) identified the following benthic primary producer habitats within the development area: • macroalgae-dominated intertidal limestone reef platform; • subtidal limestone reef platform with macroalgae and scattered corals; • reef platform/sand with scattered seagrass; and	<u>Department of Conservation and Land Management</u> • The proposed construction of a solid structured causeway is likely to have greater impacts on natural sedimentation processes than an open structure. • Marine biodiversity surveys and finer scale benthic habitat mapping should be undertaken, to assess whether the benthic habitats impacted by the project are limited to the project area or are more widespread throughout the region. • In Appendix B6, modelling has produced a visible plume extending across a substantial area of the marine management area and marine park. Information on the temporal extent of this plume is required. • More information is required on the methods used to determine cumulative areas of change of coral reef communities and seagrass and macroalgal communities affected in the marine park. • Information should be provided on the methods used for estimating cumulative impacts of plumes on the marine environment, in order for a detailed assessment to be made on the cumulative loss of benthic primary producers (BPPs) and their habitats. • High resolution benthic habitat mapping in areas potentially affected by the plumes should be undertaken. • Further information should be provided on the requirements for ongoing maintenance dredging, spoil dumping locations and potential impacts of maintenance dredging on the marine environment. <u>Department of Environment</u> • Greater technical justification is required for the assumptions that there would be full recovery of macroalgal and macroalgal/scattered coral BPP habitats, and the (temporary or permanent) loss of BPP habitat would not effect the overall ecosystem integrity.	**Benthic primary producer habitats is considered to be a key environmental factor and is discussed in Section 3.6.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	• coral habitats.	• All discharges to the marine environment should be clearly specified. • There are uncertainties associated with the hydrodynamic modelling, transport modelling and prediction of ecological impacts, in the marine environmental impact prediction for dredging and spoil dumping. • The assumption that hard corals are a suitable surrogate for predicting the response of other critical coral reef communities, algal reef or seagrass communities to turbidity and sedimentation should be justified. • Total suspended solids and sedimentation thresholds are applied to hard corals only, and other components of coral reef habitat are not considered. • Caution needs to be exercised when making assumptions about the capacity of BPP habitats to recover from significant impact over generalised time frames (30 years in the ERMP) due to the uncertainty about recovery potential, recovery trajectories and consequences of flow-on effects for food webs that may be associated with changes in habitat structure and function over time. • The potential toxic effects of drilling mud, from the horizontal directional drilling on the west coast, on benthic biota should be discussed. • The requirements of the EPA Guidance Statement No 29 have not been met. For example, the impact and avoidance principles for the pipeline and optic fibre cable routes have not been considered. • The assumption that sediment deposited in the intertidal and nearshore subtidal on the east coast of Barrow Island would be rapidly mobilized and transported should be substantiated. • The biological monitoring during dredging should address impacts on each of the BPP habitats at threat from the dredging and spoil dumping activites. • The timeframes for implementing responses to exceedances of various criteria should be clarified. • Further work should be done for each of the spill types to map probability contours. • The development should be consistent with the objectives of the Montebello/Barrow Islands Marine Conservation Reserves. The ERMP does	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		not contain adequate evaluation of the impacts of the proposal against the targets for ecological and social values in the Management Plan for the Marine Conservation Reserves. <u>Department of Fisheries</u> • Alternative dredging techniques that can improve dredge plume outcomes should be developed. • The proposal should be amended to reduce the dredge plume impact to the marine environment to meet, as a minimum, the EPA Guidance Statement No 29 and targets set for the Marine Conservation Reserve. Alternatively, greater consideration should be given to other development options and to different dredging operations that may increase the size of aggregate and reduce the extent of the plume. <u>Department of Industry and Resources</u> • More information is required on the expected quantities and impacts of maintenance dredging over the life of the development. • The management strategies for dredging during coral spawning periods need to be clarified. <u>Department of Environment and Heritage</u> • Corals are assumed to be a suitable surrogate for predicting the responses of other key elements of BPP communities to turbidity and sedimentation. This assumption should be substantiated or preferably, each BPP habitat should be looked at separately. • Only impacts on large, hard corals are considered for the risk assessment. • An updated sediment quality report should be provided, which explains deviations in the Sediment Sampling and Analysis Plan methods and changes to the layout plan for dredging and disposal. <u>Western Australian Museum</u> • Baseline marine biodiversity studies and long-term monitoring strategies need to be developed to supplement and improve the existing limited information base. • Before construction begins, a study of currents and their potential	

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
		impacts should be undertaken. <u>Public</u> Private individuals and Non Government Organisations made the following comments: • The proponent has not committed to a stringent enough monitoring and intervention strategy for dredging. Would there be a process in place whereby the dredging would stop immediately should unacceptable impacts be observed? Who would oversee this process, and what would be done? • The proposed construction of a solid structured causeway is likely to have greater impacts on natural sedimentation processes than an open structure. • Concern regarding the impacts of the dredging plume and the causeway construction on marine communities. • The ERMP fails to adequately assess the risks from sedimentation and pollutants on the marine benthic community and coastal and nearshore habitats on Barrow Island. • Physical disturbance from the construction of the causeway, jetty, access channels and dumping grounds would have an almost certain major impact on BPPs and shallow benthic and coastal communities. • Why is it not guaranteed that dredging would stop during and around the time of coral spawning? • The BPP habitat cumulative loss thresholds (as outlined in the EPA Guidance Statement No 29) are seriously breached.	
Introduced marine organisms	There are 16 marine pest species listed by the National Introduced Marine Pest Information System. Quarantine for the proposed development would apply to all non indigenous marine species. The Quarantine Advisory Panel was involved in developing: • a Quarantine Management System;	<u>Department of Conservation and Land Management</u> • Contingency plans and protocols for the inspection and treatment of hull infestations, particularly for foreign vessels should be developed. <u>Western Australian Museum</u> • Long-term monitoring strategies for introduced marine biota need to be developed so that potential impacts and risks to marine ecosystems can be managed to an acceptable level. <u>Department of Fisheries</u> • The Marine Quarantine Management Plan should include marine pest	**Introduced marine organisms is considered to be a key environmental factor and is discussed in Section 3.4.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	• a community consultation strategy; • a series of infection modes and effect analysis and hazard and operability workshops; and • a draft Quarantine Policy for the proponent.	surveys of Dampier Harbour (due to the shipping between Dampier Harbour and Barrow Island) to ascertain the degree of risk of translocating exotic species to the waters of Barrow Island. If species of concern are identified as established in Dampier, then appropriate quarantine strategies should be developed. <u>Public</u> Non Government Organisations made the following comments: • The proximity of Barrow Island to Dampier Port and the increase in traffic between the two locations during the construction phase means that there is a risk of invasion of marine pests and from ballast water discharge. • The ERMP does not adequately consider the risks posed to the marine environment by introductions of invasive species.	
POLLUTION			
Greenhouse gas emissions	The estimated greenhouse gas emissions during the construction and commissioning of the gas processing facility would be between 1.64 and 1.74 million tonnes per annum CO_2e. The estimated greenhouse gas emissions over the life of the development, with geosequestration, is 4 million tonnes per annum CO_2e. Without geosequestration it would be 6.7 million tonnes per annum CO_2e.	<u>Department of Conservation and Land Management</u> • Given the values of Barrow Island possibly at threat due to potential failure of CO_2 re-injection, a precautionary approach should be adopted so that all potential risks of failures are minimised. <u>Public</u> Private individuals and Non Government Organisations made the following comments: • The proponent states that should geosequestration prove economically or technically unviable, the CO_2 would be vented into the atmosphere. If this is the case, the greenhouse gas emission of the development would be 6.7 million tonnes per annum. • True commitment to greenhouse mitigation would include the development, promotion and transition to renewable zero-emissions technologies and fuels. • It is unacceptable that CO_2 is released to the atmosphere when the re-injection compressor stops.	**Greenhouse gas emissions is considered to be a key environmental factor and is discussed in Section 3.7.**
Air quality	The gas processing facility would emit the following: • carbon dioxide (CO_2); • oxides of nitrogen (NO_x);	<u>Department of Conservation and Land Management</u> • A management plan for dust (including risk to biodiversity) should be prepared.	**Air quality is considered to be a key environmental factor and is discussed in Section 3.8.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	• carbon monoxide (CO); • volatile organic compounds (VOCs). • sulfur dioxide (SO_2); • hydrogen sulfide (H_2S); and • particulates. Potential high H_2S concentrations are associated with failure of re-injection of H_2S along with CO_2. Dust emissions would be generated during construction and site development from vegetation clearing, earthmoving activities, blasting and vehicle movement. Dust emissions have the potential to impact on human health, visual amenity, water catchments, vegetation and fauna in the area.	<u>Department of Environment</u> • Best practice management for all emissions to reduce impacts on the environment should be adopted. <u>Public</u> Non Government Organisations made the following comment: • Air emissions have the potential to affect not only human health but the vegetation on Barrow Island. Impacts of the emission of oxides of nitrogen include bleaching or killing of plant tissue, reduced growth rate and leaf fall.	
Noise and vibration	Noise would be generated during drilling, installation, commissioning, production and decommissioning stages of the proposed offshore development, the materials off-loading facility and jetty works. SVT (2004) carried out a noise impact assessment for the development and found that the noise levels for the construction of the gas processing facility were considered on a worst-case scenario where the cumulative sound power level for all activities reaches 140	<u>Department of Conservation and Land Management</u> • Given the unknown impacts of noise and vibration on Barrow Island fauna, a precautionary approach should be adopted, with activities causing noise and vibration, such as blasting, prohibited in areas and during periods when their effects are likely to impact detrimentally on marine and terrestrial fauna. • A monitoring programme should be developed to detect whether noise and vibration have a detrimental impact on fauna, and avoidance and/or mitigatory measures should be developed in the event that impacts are detected. • A management plan for noise and vibration (including risk to biodiversity) should be prepared. <u>Department of Environment</u> • The noise emissions from the plant, particularly during construction, would affect the turtles at their nearby breeding sites.	**Noise and vibration is considered to be a key environmental factor in terms of impact on sea turtles, and is discussed in Section 3.5.**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	decibels. It was considered unlikely that noise from blasting would reach the 90 decibel limit at the camp site. Noise and vibration from the proposed development has the potential to impact on fauna in the area.	would affect the turtles at their nearby breeding sites.	
Light	Most external work lights on floating drill rigs and pipe-lay barges would be kept on 24 hours per day. Lights would be required on vessels (e.g. dredges) during LNG plant construction, pipeline and optical cable installation, materials off-loading facility, jetty and shipping channel construction. Facilities that would require lighting during operation include the gas processing facility, export jetty and tankers, village and recreational facilities. Lighting at these areas may create light spill.	<u>Department of Conservation and Land Management</u> • Infrastructure and facilities should be moved inland to minimise impacts of light emissions on the coast. • The risk assessment for impacts of light emissions on turtles should be revised to adopt a precautionary approach given that the long-term impacts of light emissions from the development are unknown. • A 'zero lightfall policy' for Barrow Island at turtle nesting beaches during the nesting season should be implemented. • A light management strategy and a monitoring programme for light emission impacts on turtles should be developed. • A management plan for light (including risk to biodiversity) should be prepared. <u>Public</u> Non Government Organisations made the following comments: • Increased lighting would attract gulls and terns to forage in the area, and increase their predation of turtle hatchlings. • The proponent concedes that lighting has the potential to affect marine fauna, notably sea turtles and some seabirds. The problems associated with lighting have not been sufficiently resolved.	**Light is considered to be a key environmental factor in terms of impact on sea turtles and some birds, and is discussed in Sections 3.2 and 3.5.**
Liquid and solid waste disposal	The proposed development would generate significant amounts of industrial and general wastes. The major liquid discharges that would be associated with the development are: ballast water; deck drainage; drilling fluids; produced	<u>Department of Conservation and Land Management</u> • The options for treating and disposing of waste water generated by the development, such as re-injection into the subsurface formation and disposal of sludge on the mainland, must be fully assessed in terms of potential environmental impacts. • Further information is required on the proposed output from the current	Liquid and solid waste disposal, including hazardous waste, would be addressed in the project Waste Management Plan. The proponent's response to submissions stated that the waste water would be injected into formations deep beneath Barrow Island and well

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	formation water; hydrostatic test water; water maker brine; and storm water. Surplus treated effluent, brine waste and contaminated streams, such as stormwater, would be re-injected into deep wells on Barrow Island. Solid wastes that would be generated by the development include: plastic; general domestic waste; food waste; tyres; and non hazardous drums and containers. All solid wastes would be removed from Barrow Island. The following wastes would be reused and recycled where possible: vegetation, rock and soil overburden; drilling fluids and cuttings; scrap pipe, metal fabrication, insulation, concrete and general construction materials; and packaging. Dredge spoil would be disposed to the seabed at the south-east section of the Barrow Island port boundary. The spoil would be disposed in an area of sandy seabed of appropriate bathymetry to minimise the changes in substrate type.	sewage outfall. • Further information is required on the wastewater from the dehydration treatment of the gas. • More detail is required on the nature of the power generator coolant water discharge to the environment. • More information is required in relation to the brine waste disposal unit. • Management plans should require all wastes to be removed from Barrow Island unless otherwise approved by CALM. <u>Public</u> Non Government Organisations made the following comments: • What are the consequences of injecting salt below Barrow Island? • It is unacceptable that a specific waste water storage and treatment system has not been proposed for assessment in the ERMP.	away from subterranean fauna. Disposal of sludge would be to an approved waste management site. The proponent's response to submissions stated that if the dehydration water could not be recycled (due to presence of contaminants) it would be classified as 'process water', and treated in the oily water system. The proponent's response to submissions stated that the facility would be directly air cooled, but some of the utilities such as lube oil systems may also contain a closed loop cooling circuit which would in turn be air cooled. The proponent's response to submissions stated that the brine waste disposal would be injected into a formation (150–250 metres) beneath Barrow Island which is well below known stygofauna habitat. Further information on water source and re-injection depths would be available, including a hydrogeological assessment. **Liquid and solid waste disposal is not considered to be a key environmental factor.**
Hazards and spills	The proposed facilities and infrastructure for the development have the potential to release hydrocarbon or chemical leaks or spills to the groundwater and the	<u>Department of Environment</u> • There is a high potential that any spill, leak or discharge of contaminating materials would migrate to the underlying groundwater and potentially have a negative impact on soil and groundwater quality and any subterranean species that may be located within these habitat	The proponent's response to submissions stated that the leak detection systems and technology would be investigated during detailed design. The proponent's response to submissions stated

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	marine environment. Best practice measures would be implemented to reduces the risk of spills and leaks. Asia Pacific ASA (2005) carried out three-dimensional spill trajectory and fate modelling for various potential spills from the proposed development.	subterranean species that may be located within these habitat. <u>Department of Industry and Resources</u> • The proposed leak detection techniques for pipelines and ancillary lines are not outlined. <u>Public</u> Non Government Organisations made the following comment: • The inevitable oil pollution that would result from the ships berthing on the proposed jetty is a serious cause for concern.	that the issue of potential spills is considered firstly through prevention, and secondly through implementation of an Oil Spill Contingency Management Plan. **Hazards and spills is not considered to be a key environmental factor.**
SOCIAL SURROUNDINGS			
Cultural heritage	There are no listed ethnographic sites on the Register of Aboriginal Sites on Barrow Island, but there are 13 listed archeological sites. None of these sites would be impacted by the proposed development. Further detailed ethnographic and archaeological studies would be undertaken prior to construction within the proposed development area on Barrow Island (including the seabed) and on the proposed domestic pipeline route on the mainland.	<u>Western Australian Museum</u> • Comprehensive archeological surveys should be conducted over Barrow Island prior to construction. • The Executive Summary states that a review of underwater video surveillance, side-scan sonar and bathymetry surveys of the proposed development areas has not produced any evidence of maritime heritage sites. Who undertook that review, what was the level of knowledge and expertise of that person in relation to identifying submerged cultural heritage and what was the process of review? <u>Department of Indigenous Affairs</u> • Comprehensive archeological and ethnographic surveys of the areas to be affected should be undertaken. • The Cultural Heritage Management Plan should be provided to the Department of Indigenous Affairs.	The proponent's response to submissions stated that the review was undertaken by professional subsea experts (Fugro 2003). This data was inspected by a qualified maritime archaeologist. From the data inspected, no evidence of shipwrecks was apparent. Detailed marine surveys would be reviewed by a maritime heritage archaeologist/historian at the time the pipeline and optical fibre routes and disturbance areas are being finalised. Cultural heritage would be addressed in the Cultural Heritage Management Plan. A draft Plan is provided in the ERMP. **Cultural heritage is not considered to be a key environmental factor.**
Public health and safety	The proponent has established an Occupational Health and Safety system. The workforce would be restricted to particular areas on Barrow Island, including the camp site and development site.	<u>Department of Consumer and Employment Protection</u> • The potential impact of cyclones on the workforce should be further evaluated. • The risk associated with the CO_2 pipeline requires further consideration. • The intention for the feed-gas and Dom-gas pipelines to be above ground on the island is not consistent with the requirements of the AS 2885.1-1997 Pipelines – Gas and liquid petroleum.	The proponent's response to submissions stated that the proponent would liaise with the Department of Consumer and Employment Protection regarding work safety. The feed-gas and Dom-gas pipelines would now be below ground. **Public safety is not considered to be a key**

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Key Environmental Factors
	development site.		**environmental factor.**

PRINCIPLES		
Principle	**Relevant Yes/No**	**If yes, Consideration**
1. The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In application of this precautionary principle, decisions should be guided by –* *(a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* *(b) an assessment of the risk-weighted consequences of various options.*		
	Yes	In considering this principle, the EPA notes the following: • The proponent engaged in a rigorous process involving experts and community members to define acceptable risk standards for the introduction of non-indigenous species on Barrow Island. However, no data have been provided by the proponent about the effectiveness and certainty of control at the survival, detection or eradication steps so the EPA has taken a precautionary approach. • There is uncertainty regarding the extent and degree of impact of fine sediments which would be generated by the dredging, and their distribution in the marine environment. • There is a limited level of knowledge, multiple threats, potentially high consequences and subsequently low level of certainty in what the impacts may be on the flatback turtle population, and how any impact could be effectively managed. • There is potential for subterranean fauna and terrestrial invertebrate fauna to become extinct as a result of implementation of the proposal.
2. The principle of intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.*		

PRINCIPLES		
Principle	**Relevant Yes/No**	**If yes, Consideration**
	Yes	In considering this principle, the EPA notes the following: • Although the proponent has agreed to efficient energy use, the carbon dioxide emissions are very high, particularly without geosequestration. • This proposal has a projected life of over 60 years, and as more gas is discovered in the future, Barrow Island could become a hub for gas production and carbon dioxide injection for a century or more.
3. The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*		
	Yes	In considering this principle, the EPA notes the following: • Barrow Island retains critical biodiversity conservation values that occur nowhere else. • The waters surrounding Barrow Island and the wider region are also a haven for marine fauna. • Fauna populations on Barrow Island are relatively small, isolated and highly vulnerable to extinction.
4. Principles relating to improved valuation, pricing and incentive mechanisms *(1) Environmental factors should be included in the valuation of assets and services.* *(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.* *(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems.*		
	No	
5. The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*		
	No	In considering this principle, the EPA notes the following: • The proponent has agreed to minimise waste generation by encouraging reuse, recycling and reduction of products. • Liquid and solid waste disposal, including hazardous waste, would be addressed in

PRINCIPLES		
Principle	**Relevant Yes/No**	**If yes, Consideration**
		the project Waste Management Plan. • All solid wastes are to be removed from Barrow Island.

Appendix 4

Possible Draft Framework for Environmental Conditions

Essential environmental conditions if the proposal were to be implemented

The type of issues that would need to be included in environmental conditions if the Government permitted the proposal to be implemented are outlined below. A possible draft framework for a set of conditions to deal with these issues appears at the end of this Appendix.

Further work would be required by the proponent and the State on modelling and analysis to determine the practicality of some measures and the likely impact and acceptability of any proposed changes to the proposal or its management.

The construction period would be one of the most vulnerable times from the point of view of potential incursions of non-indigenous species and other environmental impacts. It would be critical that conditions to manage construction were in place well before ground disturbing activity commenced. This includes the gathering of any background data or baseline surveys.

Flatback turtles

The EPA considers that there is insufficient data available to conclude that the proposal could be implemented without significant impacts to flatback turtles in particular and possibly other marine fauna in general. If Government determines that the proposal may be implemented, it would not be possible to say whether even the strictest feasible controls on lighting would adequately protect the flatback turtle population. Since one third of the regional population of flatback turtles nest on Barrow Island, every possible step would have to be taken to reduce the inevitable reductions likely in nesting success and hatchling survival due to lighting and glow impacts and other direct and indirect effects like boat strike or dredge impacts. A range of useful suggestions, such as the placement of tanks and a high wall to screen plant lighting, have been made (Limpus, 2006) to further reduce impacts. These are not currently part of the proponent's design and should be required if the proposal is permitted to proceed.

Offsetting research and other positive management actions to enhance the chances of this species' success at Barrow Island and elsewhere would be critical. It is important to note, however, that these offsets would not guarantee to control the likely population level adverse impacts on the flatback turtles which currently use Barrow Island and its surrounding waters for breeding, juvenile development and feeding.

Dredging

Given the importance of the marine habitats around Barrow Island and the potential for extensive impacts over more than 60 weeks of dredging, the EPA considers that any decision by Government to allow the proposal to proceed would need to ensure that the dredging operations adopted the best practice available to minimise the generation and dispersal of turbidity and sediment. Dredging would need to operate under the strictest possible conditions consistent with the importance of the environment and its values. Even then it would still pose a significant threat to the marine environment because not all aspects can be adequately predicted or managed. The EPA has not been convinced that conditions could be devised that would make

the proposal acceptable. It would be important, however, that strict conditions were imposed to control impacts as far as possible.

In addition, the risk posed to the key ecological processes that maintain the area's high diversity and productivity would need to be reduced to a tolerably low level. Accordingly, to reduce risk to the recruitment of corals and ultimately to the structure and function of coral communities, the EPA recommends that turbidity generating activities associated with construction of marine facilities cease in sufficient time prior to coral spawning so as to allow turbidity to return to background levels prior to the predictable coral mass spawning events in autumn each year. Turbidity generating activities should not recommence until after the mass spawning event. Dredging should also cease during the flatback turtle aggregation and nesting periods.

Given the high level values at stake, dredging conditions would need to be more onerous than those expected for other ports with many users, and would not be a precedent for those other port developments in less sensitive environments. The dredging proposal would need to demonstrate that best practice available would be applied.

Alternatives which relocate the dredging, reduce the extent and amount of dredging by extending the jetty, relocate the spoil ground or involve active management to significantly reduce fines production and liberation may result in reduced impacts but would require appropriate data acquisition and predictive modelling to determine what those impacts may be and whether they would be environmentally acceptable. The EPA has not been presented with sufficient information to make an informed assessment of any such alternatives at present, though it would expect appropriate information to be supplied by the proponent to allow this to happen should alternatives be considered further.

Strict monitoring of the amount of fines generated at the dredge cutter head and cessation of dredging if fines generation was greater than predicted would be required. Fines generation by overflows from the hopper barges should not be permitted. The EPA understands that dredging by the Army Corps of Engineers in the United States regularly proceeds without overflows being permitted (Palermo and Randall,1990). If the proposal was to be allowed to proceed, a similar level of control would need to be exercised here. Strict performance standards should be applied for light attenuation caused by turbidity in the water and for sedimentation around the dredged areas.

The EPA notes it is likely that the proponent would need to factor in significant extra controls on the dredge like 'green pipes', silt valves, baffles and additional down time to achieve the stringent conditions that should be applied to the proposal if it is approved. The EPA understands that such controls are routinely used adjacent to the Great Barrier Reef Marine Park and at other sensitive locations. Strict monitoring should be undertaken of fines generation at the dredge cutter head, and operations should stop if fines exceed the predicted level. Monitoring would also be required to determine when sub-lethal impact levels are reached on corals outside the direct zone of impact.

Decisions on when the dredge should cease operations for environmental reasons are made by government regulators in the Great Barrier Reef Marine Park, rather than left to the operator, and a similar model should be considered if the Gorgon proposal is allowed to proceed. If such a group is established, its members and the State would need to be indemnified against any contractual or financial liability resulting from the decisions of the group, as is the case in the Great Barrier Reef Marine Park model.

Introduction of non-indigenous species

If Government was to approve the proposal, the most stringent level of conditions for quarantine would be required. Risk assessments for the outstanding introduction pathways and steps to establishment of non-indigenous species should also be completed before ground disturbing activity commences.

An important input to the management of risk is an adequate set of baseline surveys to determine what species are present on Barrow Island and in the surrounding waters prior to the commencement of ground disturbing activity. It is understood that planning for statistically sound invertebrate surveys has been undertaken recently but comprehensive baseline surveys for invertebrates on the island and introduced marine organisms in State waters have not yet been completed. The EPA considers that adequate baseline surveys would need to be completed prior to the start of any ground disturbing activity.

The EPA is aware that an introduced tramp ant has recently been found at the rubbish tip and that known weed infestations have not yet been eradicated. These examples of invasive species should be eradicated at the earliest opportunity to demonstrate the ability to effectively eradicate introduced invertebrates and weeds.

The EPA notes that the proponent has set a key performance indicator as ‘no marine pests will be introduced to the waters surrounding Barrow Island infrastructure by Gorgon project vessels’ (Chevron, 2006b – Briefing Paper No. 2). While this indicator would be entirely appropriate in a busy port with many users, it is not sufficient for waters zoned for marine conservation or as a marine park. Waters with these zonings are adjacent to the waters surrounding the infrastructure in this case.

It is appropriate that all practical steps are taken to keep all introduced organisms out of conservation and park zones, not just designated pests. There are in fact only 16 taxa on the interim trigger list of marine pests for Australian waters. It would also be important that ships which are not ‘Gorgon project vessels’ (such as third party tankers loading condensate or some LNG cargoes produced by the proposal) also do not introduce non-indigenous organisms. Based on the advice it has received, the EPA recognises that it would be more difficult to maintain strict quarantine in the marine environment than on land. The highest possible standards should, however, always be applied to such an important marine conservation asset as the waters surrounding Barrow Island.

While ships currently visit an offshore terminal to export oil and barges land on Barrow Island from the mainland to service current operations, the amount of traffic would increase many fold for this proposal. It must be assumed that unsurveyed ports like Dampier are high risk with respect to introduced marine species. Even though it

can be difficult to prevent introduced marine organisms being moved by currents or on the ships currently operating, all reasonable steps should be taken to prevent increases in the risk of introductions to the marine environment.

Carbon dioxide mitigation

If the proposal was approved by Government and the proponent decided that injection of carbon dioxide was technically infeasible or cost prohibitive, alternative arrangements should be required to ensure that an equivalent amount of carbon dioxide was offset. The EPA notes that under these circumstances, the environmental benefit of accessing Barrow Island, to permit carbon dioxide injection, would be lost.

Subterranean fauna

If the proposal were to be allowed to proceed, it would be incumbent on the proponent to promptly undertake studies to locate the taxa so far known only from the project footprint in similar environments elsewhere on the island or demonstrate convincingly why it is likely that they do occur elsewhere and hence would not be driven to extinction.

Depending on the results, this work could lower the level of risk but there is currently no certainty that that would be the case. Short of finding these taxa elsewhere, or at least demonstrating that there is a high likelihood that they occur elsewhere, a real risk exists that they would become extinct as a result of the proposal.

Air quality

Should the proposal proceed, the EPA believes that nitrogen deposition and its effect on vegetation should be monitored at a number of sites. The EPA agrees that best practice is appropriate and recommends that the proponent be required to prepare a Front End Engineering Design (FEED) report which demonstrates that the proposed works adopt best practice pollution control measures to minimise emissions.

The EPA recommends, should the proposal proceed, that the proponent be required to prepare an Air Quality Management Plan (AQMP) that specifically addresses (amongst other items) the monitoring of:

- stack emissions;
- ambient GLCs; and
- nitrogen deposition and its effect on vegetation.

Governance and other requirements

Together with stringent conditions, a rigorous governance regime is required to manage the conservation values of Barrow Island .

Governance of Gorgon development

If the Gorgon proposal were approved, the need to manage quarantine in particular, but also other environmental and conservation matters, would be even more important than it is now. Such management would also be more complex, because the task

would become much bigger and more urgent during construction with several responsible entities involved.

The *Barrow Island Act 2003* provides for a Barrow Island Consultative Council (BICC) to enable co-ordination of action, if the Gorgon development proceeds. It is critical that the Council be led and resourced in a way that prevents accountability being divided and action delayed. If the proposal were to proceed, the EPA considers that the Department of Conservation and Land Management should be provided with sufficient power and resources to act quickly to ensure that problems which threaten the conservation values of Barrow Island are rectified promptly. If such problems are not rectified promptly, then the Department or other appropriate agency should have the power to rectify the problem and then subsequently charge full cost recovery to those responsible.

The *Barrow Island Act 2003* also provides for some staff and resources for the Department of Conservation and Land Management to manage this proposal on Barrow Island. The EPA understands that these resources do not include provision of resources such as a boat and helicopter time to enable rapid and effective response around the island. It would be important for the Department of Conservation and Land Management to be able to manage operations in the surrounding waters because of its responsibilities associated with the marine conservation reserves, as well as on the island. The EPA considers that sufficient additional resources should be provided to facilitate such operations in a manner that ensures interactions are properly co-ordinated and conservation values are protected and maintained on Barrow Island Nature Reserve and in the surrounding waters for which the Department of Conservation and Land Management is responsible.

Other agencies also have important responsibilities associated with the environmental performance of the Gorgon proposal. The Department of Fisheries has responsibility for implementation of marine quarantine laws for ships operating within State waters. The maintenance of proper marine quarantine with respect to ballast water and introduced organisms attached to ships' hulls would be vital for the proper protection of the marine values of the waters surrounding Barrow Island.

If the proposal is implemented, sufficient staff and resources should be provided for the Department of Fisheries to discharge the added responsibilities flowing from the large amount of shipping associated with the Gorgon proposal. Such resources should recognise the peak in shipping during construction but also the need to provide quarantine services for the life of the operation. If the proposal proceeds, shipping or dredges travelling directly from overseas ports to Barrow Island should be inspected prior to departure by appropriate officers of the Department of Fisheries to ensure that marine values are protected in the State waters off Barrow Island.

The Australian Quarantine Inspection Service (AQIS, a federal agency) has responsibility for quarantine related to shipping arriving in Australia from overseas. A particular difficulty here is that international quarantine is governed by international agreements that are limited in their protective capacity by the requirement not to unduly hinder the free passage of ships. The level of quarantine protection appropriate to Barrow Island is higher than the usual standard required for ships operating between normal ports. It is noteworthy that the proponent has proposed the

application of a higher standard of management to the ships it controls than would normally be the case. Other vessels, however, would not have the same level of management.

The Department of Environment is responsible for managing environmental protection, particularly pollution prevention, during construction and operations. Recognising the remote location, large size of the proposal and the need for prompt attention to issues, the EPA considers that the Department of Environment should be provided locally with sufficient staff and operational resources to adequately service the proposal, should it proceed, during construction and operation.

The EPA further recommends that appropriate mechanisms are put in place to ensure that appropriate staff and resources continue to be provided to the Departments of Conservation and Land Management, Environment and Fisheries for the 60+ year duration of the proposal.

The Department of Industry and Resources has responsibility under various Acts including the *Petroleum Act 1936 and 1967*, the *Petroleum (Submerged Lands) Act 1982* and the *Barrow Island Act 2003* for regulating a number of environmental aspects of this proposal with requirements for environmental plans for various construction and operations activities. The *Barrow Island Act 2003* would be used to manage issues arising from the handling of carbon dioxide. The EPA considers that special attention would need to be given to preventing leaks at the surface or underground where such leaks could adversely affect biota or the habitats on which they depend.

The possibility exists for officers of other agencies to be delegated as inspectors for the purposes of the *Environmental Protection Act 1986*. The EPA considers that, if the proposal proceeds, agencies should examine the opportunities for appropriate delegations under the EP Act and the other relevant Acts, to provide continuous and efficient coverage of all issues that require regulatory supervision.

The construction period would be one of the most vulnerable times from the point of view of potential incursions of non-indigenous species and other environmental impacts. Accordingly, the EPA considers that provision should be made to set up the necessary regulatory resources immediately, if the proposal proceeds.

Summary

If Government was to decide that this proposal may proceed, then the EPA believes that a number of conditions and governance requirements should be imposed which are designed to limit impacts as far as possible. Within the framework of conditions and governance recommended above, these requirements include:

- An appropriate governance arrangement for the supervision, auditing and monitoring of compliance with any conditions designed to slow the demise of values likely to be adversely affected by the proposal;
- Single point accountability for all management on the island, which is appropriately resourced for the duration of the proposal and has the capacity to manage existing and future users in a way which avoids

dilution or avoidance of responsibility, by any of the users of the island, for environmental impacts;

- A comprehensive, mandatory quarantine programme;
- Clear responsibility for the eradication of any non-indigenous species introduced to the island. If the proponent cannot eradicate any such introduction within a specified timeframe, government agents should undertake the eradication and recover the costs from the proponent or any other responsible parties;
- Stringent conditions on dredging aimed at strictly controlling the generation and dispersal of turbidity and sediment;
- Comprehensive modelling and monitoring of parameters which show any impacts on turtle populations and the environmental resources on which they rely, including food, habitat and nesting beaches;
- Mitigation actions for impacts likely to occur to turtles, including offsetting actions where effective management cannot be achieved in the project area, and;
- Injection of carbon dioxide or alternative mitigation of an equivalent amount of carbon dioxide to that contained in the produced gas.

Possible Draft Framework for Environmental Conditions

GORGON GAS PROJECT:
BARROW ISLAND CLASS A NATURE RESERVE

Standard Conditions

Standard wording to be included for generic conditions 1 to 5

Biodiversity Protection

6 Terrestrial Biodiversity-related Investigations

6-1 The proponent shall, within six months following the formal authority issued to the decision-making authorities under section 45(7) of *the Environmental Protection Act 1986*, prepare a draft Scope of Biodiversity-related Investigations document which encompasses those areas surrounding the proposed new clearing or other infrastructure areas, and the balance of Barrow Island to provide regional context.

The objectives of the Biodiversity-related Investigations are to;

- establish a comprehensive baseline of bio-physical conditions against which periodic review can be used to detect non-indigenous organisms and environmental changes, enable causes to be investigated and to form a basis for corrective action if required.
- maintain the abundance, diversity, geographic distribution, conservation status and productivity of biota at genetic, species and ecosystem levels through the avoidance or management of adverse impacts and improvements in knowledge.

The draft Scope of Biodiversity-related Investigations shall include investigation of the following matters:

1. the occurrence and spatial extent of floristic and vegetation communities at local and regional scale;
2. the condition of floristic and vegetation communities identified in Item 1 above;
3. the occurrence and spatial extent of restricted ecological communities;
4. the occurrence and extent of any Declared Rare and Priority Flora as defined within the *Wildlife Conservation Act 1950* and other significant flora;
5. the role and significance of ecological linkages;
6. characterisation of landform;
7. the identification and spatial extent of fauna habitat, including specifically, habitat for Threatened, Priority listed and other significant Fauna, and significant Short Range Endemic fauna, and other significant invertebrate taxa;

8. the occurrence and abundance of vertebrate fauna, including specifically, threatened fauna as defined in the *Wildlife Conservation Act 1950* or the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*; Priority fauna as defined and listed by the Department of Conservation and Land Management (CALM); and species requiring specialised habitats or resources;
9. the occurrence and abundance of significant Short Range Endemic and other significant invertebrate taxa;
10. groundwater systems and the occurrence and distribution of groundwater-dependent ecosystems; and
11. introduced plant and animal species, location and severity status.

6-2 The proponent shall, within six months following the formal authority issued to the decision-making authorities under section 45(7) of *the Environmental Protection Act 1986*, submit the draft Scope of Biodiversity-related Investigations document required by condition 6-1 for review to the Department of Conservation and Land Management.

6-3 The proponent shall, within twelve months following the formal authority issued to the decision-making authorities under section 45(7) of *the Environmental Protection Act 1986*, submit a revised Scope of Biodiversity-related Investigations document, taking into account all comments and recommendations (if any) received under condition 6-2, to the Minister for the Environment for endorsement on the advice of the Conservation Commission or the Marine Parks and Reserves Authority as appropriate and the Department of Conservation and Land Management.

6-4 The proponent shall make the endorsed Scope of Biodiversity-related Investigations document referred to in condition 6-3 publicly available.

6-5 The proponent shall conduct biodiversity-related investigations in accordance with the endorsed Scope of Biodiversity-related Investigations document referred to in condition 6-3.

6-6 Prior to the commencement of plant commissioning, the proponent shall prepare and submit a Biodiversity-related Investigations Report to the satisfaction of the Minister for the Environment on the advice of the Conservation Commission or the Marine Parks and Reserves Authority as appropriate and the Department of Conservation and Land Management which details the results of biodiversity-related investigations conducted as required by condition 6-5.

The Biodiversity-related Investigations Report shall include the following:

1. certification that the endorsed Scope of Biodiversity-related Investigations document is complete;
2. key biodiversity values to be protected;
3. indicators, parameters and/or criteria to be used in measuring maintenance of the key biodiversity values identified;

4. outcomes and findings for each of the matters investigated;
5. surveyed plans detailing critical areas not to be disturbed and defined buffer areas around those critical areas; and
6. surveyed plans detailing the development areas, outside which no disturbance or indirect impacts shall occur.

6-7 The proponent shall make the Biodiversity-related Investigations Report required by condition 6-6 publicly available in a manner approved by the Department of Conservation and Land Management.

7 Protection of Biodiversity

7-1 The proponent shall, unless otherwise approved by the Minister for the Environment on advice of the Conservation Commission or the Marine Parks and Reserves Authority as appropriate and the Department of Conservation and Land Management, implement the proposal in a manner which does not cause or contribute to the direct or indirect impact on the following:

1. rare or restricted floristic communities, vegetation or ecological communities and key ecological linkages identified in the Biodiversity-related Investigations Report;
2. Declared Rare Flora, unless the disturbance is approved under the *Wildlife Conservation Act 1950*;
3. significant populations of Priority Flora identified in the Biodiversity-related Investigations Report required by condition 6-6;
4. significant habitat for Threatened, Priority listed and other significant fauna, significant Short Range Endemic fauna, and other significant invertebrate taxa identified in the Biodiversity-related Investigations Report; and
5. other significant bio-diversity values identified in the Biodiversity-related Investigations Report.

7-2 Without limiting condition 7-1, the proponent shall ensure that construction and/or operational activities do not cause or contribute to the following:

1. any significant adverse impact on any groundwater-dependent ecosystems identified by the Biodiversity-related Investigations Report;
2. waterlogging of significant areas of dry land vegetation;
3. any increase in distribution or severity status of introduced plants and animals (as identified in the Biodiversity-related Investigations Report);
4. placing any species or ecological community into a higher category of threat; and
5. causing disturbance in defined buffer areas and areas not to be disturbed identified in the Biodiversity-related Investigations Report.

7-3 Three months prior to ground-disturbing activities, the proponent shall prepare a listed fauna management plan to the satisfaction of the Minister for the Environment on the advice of the Department of Conservation and Land Management that provides for the translocation or other management of vertebrate fauna which occur within the area of ground-disturbance and which are listed under the Wildlife Conservation Act 1950.

7-4 Prior to ground-disturbing activities, the proponent shall ensure to the extent practicable that any listed vertebrate fauna are translocated or managed as required by the Department of Conservation and Land Management in accordance with the plan required by condition 7-3.

Terrestrial Environment Protection

8 Terrestrial Quarantine

8-1 Prior to ground disturbing activities, the proponent shall prepare a Terrestrial Quarantine Management Plan to the requirements of the Minister for the Environment on the advice of the Conservation Commission, the Department of Conservation and Land Management and the Department of Agriculture and Food.

The objectives of the Terrestrial Quarantine Management Plan are to ensure:

- that establishment does not occur on Barrow Island of taxa which are not native to Barrow Island; and
- beyond world's best practice quarantine management is used to prevent the introduction of species and genotypes which are not native to Barrow Island.

The Plan shall include:

1. Consistent with condition 6 above, a programme of statistically sound baseline biological surveys to determine those taxa native to Barrow Island and those which have been introduced, up to the time when ground disturbing activity commences. All taxa found subsequently will be regarded as introduced non-indigenous taxa unless the Conservation Commission, acting on the advice of the Department of Conservation and Land Management or the WA Museum as appropriate, determines that they were likely to be native taxa not previously identified.

2. Consistent with condition 6 above, a programme of statistically sound ongoing biological monitoring surveys to detect the presence of introduced non-indigenous taxa and to determine the extent of changes to the biota of Barrow Island.

3. Development of an appropriate model to determine the effectiveness of introduced species interception actions which uses real interception data and the model outputs to continuously improve interception procedures and performance.

4. An outline of the facilities to be provided and provisions to be made for ensuring that field collections are adequate and that taxa collected are accurately determined, properly curated, electronically recorded and archived.

5. Procedures for the effective integration of these plans with other operators on and around Barrow Island.

6. A risk analysis of all potential introduction pathways for non-indigenous organisms and barriers to be applied to each pathway to ensure that the risk of introduction[+] of non-indigenous organisms achieves a qualitative risk rating score of 1*, or some other standard agreed by the Conservation Commission on the advice of the Department of Conservation and Land Management and the Department of Agriculture and Food.

7. Procedures for inspection and approval by an authorised inspector before loading for Barrow Island and at unloading on Barrow Island of all materials, vessels, aircraft, personnel and any other item to be landed on Barrow Island.

8. Procedures for ensuring that any item which is not approved by an authorised inspector is denied entry to Barrow Island and immediately returned to the mainland.

9. Procedures for obtaining the prior approval of the Department of Conservation and Land Management for authorised inspectors.

10. Procedures to maintain a panel of independent experts capable of providing risk ratings for all relevant taxonomic groups and other necessary advice on the application and likely effectiveness of quarantine measures, including barriers, surveillance, detection and eradication of introduced taxa.

11. Procedures for regular monitoring across Barrow Island with sufficient power to detect introduced non-indigenous taxa with a level of confidence determined by the Department of Conservation and Land Management.

12. Procedures for responding to introduced non-indigenous taxa, including specific plans for high risk taxa (such as rodents, foxes, cats, Asian house geckos, certain invertebrates, and non-endemic plants including buffel grass and kapok), maintaining appropriate stocks of readily available containment and response equipment and trained personnel and undertaking appropriate introduction response action.

13. Beyond world's best practice contingency plans for eradication of introduced non-indigenous taxa and appropriate response mechanisms to ensure the plans can be implemented quickly and effectively. These plans and implementation procedures are to incorporate provision of up

to date advice from the panel of independent experts referred to in item 10 above. Such advice shall include provisions for maintaining at an acceptable level, to the satisfaction of the Conservation Commission on the advice of the Department of Conservation and Land Management, the effects of any eradication action on other organisms.

14. Procedures for deciding on eradication action, including avoidance of significant impact on non-target species, maintaining appropriate stocks of readily available containment and eradication equipment and undertaking appropriate eradication action, based on advice from the panel of independent experts required by item 10 above.

15. Provision for reporting to the Department of Conservation and Land Management any potential introduction or introduction of non-indigenous taxa within 12 hours of detection.

16. Maintenance of complete electronic records, including on a geographic information system accessible to relevant state government agencies, of all breaches of procedures, potential introductions and introductions of non-indigenous taxa (regardless of whether those introduced taxa actually become established on Barrow Island) and corrective action taken to rectify breaches, potential introductions and introductions.

17. Protocols for regular independent audits, at least quarterly, during all construction phases and then annually, of the quarantine procedures in place, their effectiveness and any corrective action required.

18. Annual public reporting of all breaches, potential introductions and introductions of non-indigenous taxa, and corrective action taken, including eradication actions in a manner approved by the Department of Conservation and Land Managment.

19. Provisions for continuous improvement with an annual review and update of the plan, with provisions for a major review and update every five years.

20. Provision for the inclusion of requirements consistent with the Bio-security and Agriculture Management Bill as appropriate to the protection of conservation values on Barrow Island.

21. Provisions for these conditions to form part of all contracts let by the proponent where those contracts may require the application of these conditions.

8-2 The proponent shall ensure that no soil is transported to Barrow Island unless it has been treated to a standard where an inspector approved by the Department of Conservation and Land Management certifies that there are no viable plants or animals or parts or propagules thereof nor

any viable pathogenic micro-organisms present at the time of landing on Barrow Island [#].

8-3 The proponent shall maintain and implement an effective monitoring programme of sufficient statistical power (see note 8) to demonstrate that any soil transported to Barrow Island meets the requirements of condition 8-2, ensure that programme is regularly and independently audited and report annually and publicly on the performance and effectiveness of that facility.

8-4 The proponent shall implement the Terrestrial Quarantine Management Plan required by condition 8-1, to the satisfaction of the Conservation Commission, on the advice of CALM and the Department of Agriculture and Food.

8-5 The proponent shall make the Terrestrial Quarantine Management Plan required by condition 8-1 publicly available in a manner approved by the Department of Conservation and Land Management.

[+]Note – 'Introduction' means the landing of an organism, propagule or part of an organism which is not indigenous to Barrow Island at a place inside the border to Barrow Island. The border means the low water mark at the lowest astronomical tide of Barrow Island Nature Reserve, including all islands forming part of that reserve, except for the landing of foodstuffs and goods for use in the purpose built kitchen for the proposal, where the border shall be defined as above and also including the outward side of the external walls, roof and floor of that purpose built kitchen. [seek advice on this definition]

*Note - Risk ratings are to be scored qualitatively by appropriately qualified experts using the scheme set out in Table 12-1 entitled 'Risk Score Definitions' on page 551 of Volume II of Draft Environmental Impact Statement/ Environmental Review and Management Programme for the Gorgon Development or other manner as approved by the Conservation Commission on the advice of the Department of Conservation and Land Management.

[#] Note - Approved prior treatment for soil shall be by heating at 121^{o}C for 2 hours, or heat treatment in an autoclave at 121^{o}C and 103 kPa for 15 minutes, or heat treatment in an autoclave at 134^{o}C and 103 kPa for 4 minutes, or gamma irradiation at 50 kGray. [Recommended by Australian Antarctic Division and understood to be AQIS requirements for soil importation.]

9 Short Range Endemic Taxa Confined to the Development Footprint

9-1 Prior to ground disturbing activity at the gas plant site, the proponent shall prepare a Short Range Endemic Taxa (*defined below) Management Plan to the requirements of the Minister for the Environment on advice of the Conservation Commission and the Department of Conservation and Land Management.

The objective of the Short Range Endemic Taxa Management Plan is to ensure that short range endemic taxa as here defined continue to exist as viable populations elsewhere on Barrow Island.

This plan shall detail:

1. actions to protect habitats on which Short Range Endemic Taxa depend, as recognised by the approved Biodiversity Investigations Report; and

2. monitor identified Short Range Endemic Taxa populations.

9-2 The proponent shall implement the Short Range Endemic Taxa Plan required by condition 9-1.

9-3 The proponent shall make the Short Range Endemic Taxa Plan required by condition 9-1 publicly available in a manner approved by the Department of Conservation and Land Management.

9-4 The proponent shall submit the findings of the Short Range Endemic Taxa Plan required by condition 9-1 to the Conservation Commission, the Department of Conservation and Land Management and the Western Australian Museum.

* For the purposes of this Statement, Short Range Endemic Taxa are defined as those confined to the surface of, or beneath the proposed development footprint at any time prior to clearing of that footprint.

10 Subterranean Fauna

10-1 Prior to ground disturbing activities, the proponent shall undertake surveys for subterranean fauna in accordance with a Subterranean Fauna Survey Plan prepared to the requirements of the Minister for the Environment on advice of the Conservation Commission and the Department of Conservation and Land Management.

The objective of the Subterranean Fauna Survey Plan is to ensure that adequate sampling is planned and undertaken so that it can reasonably be concluded with a high degree of confidence that all, or nearly all, of the species occurring in the impact area have been collected.

The Subterranean Fauna Survey Plan shall set out procedures and measures to:

1. survey areas likely to be affected by project operations; and

2. survey areas with similar habitats outside the areas to be affected by project operations to establish the conservation significance of fauna within the areas to be affected.

10-2 In the event that the results of the surveys required by condition 10-1 indicate that there is a risk of loss of subterranean species or communities as a result of project construction or operations, the proponent shall institute management measures in

accordance with a Subterranean Fauna Management Plan prepared to the requirements of the Minister for the Environment on advice of the Conservation Commission and the Department of Conservation and Land Management.

The Subterranean Fauna Management Plan shall set out procedures and measures to:

1. avoid and/or demonstrate management of impacts on subterranean fauna species and/or communities and their habitats where the long-term survival of those species and/or communities may be at risk as a result of project operations;

2. monitor the distribution and abundance of species and/or communities of subterranean fauna, groundwater levels, groundwater quality and other relevant aspects of subterranean fauna habitat to ensure that the long-term survival of subterranean fauna species and communities is not compromised as a result of project operations; and

3. take timely remedial action in the event that monitoring indicates that project operations may compromise the long-term survival of subterranean fauna and / or communities.

10-3 Prior to the commencement of water extraction for the project, the proponent shall, if applicable, implement the Subterranean Fauna Management Plan required by condition 10-2.

10-4 The proponent shall make the Subterranean Fauna Management Plan required by condition 10-2 publicly available in a manner approved by the Department of Conservation and Land Management.

Marine Environment Protection

11 Marine Quarantine

11-1 Prior to ground disturbing activity, the proponent shall prepare a Marine Quarantine Management Plan to the requirements of the Minister for the Environment on the advice of the Marine Parks and Reserves Authority, the Department of Conservation and Land Management and the Department of Fisheries.

The objectives of the Marine Quarantine Management Plan are to ensure;
- that establishment does not occur in the surrounding waters of Barrow Island of taxa which are not native to those waters, and
- beyond world's best practice quarantine management is used to prevent the introduction of species and genotypes which are not native to the surrounding waters of Barrow Island.

The plan shall include:

1. A programme of statistically sound baseline biological surveys to determine those taxa native to the waters surrounding Barrow Island and those which have been introduced, up to the time ground disturbing activity commences. All taxa found subsequently will be regarded as introduced non-indigenous taxa unless the Marine Parks and Reserves Authority, acting on the advice of the Department of Conservation and Land Management or the Western Australian Museum as appropriate, determines that they were likely to be native taxa not previously identified.

2. A programme of statistically sound ongoing biological monitoring surveys to detect the presence of introduced non-indigenous taxa and to determine the extent of changes to the biota of the surrounding waters of Barrow Island.

3. Development of an appropriate model to determine the effectiveness of introduced species interception actions which uses real interception data and the model outputs to continuously improve interception procedures and performance.

4. An outline of the facilities to be provided and provisions to be made for ensuring that field collections are adequate and that taxa collected are accurately determined, properly curated, electronically recorded and archived.

5. Procedures for the effective integration of these plans with other operators on and around Barrow Island.

6. A risk analysis of all potential introduction pathways for non-indigenous organisms by all vessels entering the surrounding waters of Barrow Island which includes, as a minimum, information on:

   a) the potential introduced species in the ports from which vessels arriving at Barrow Island have originated;
   b) the marine biological, physical and chemical characteristics of the ports as it relates to the potential introduced species;
   c) risks presented by different vessel types, including the speed at which they travel through the water, length of time they remain at Barrow Island after arrival,
   d) any other risks presented by different vessel types which may arrive at Barrow Island.

7. The analysis is to be most detailed for high risk ocean-going vessels such as dredges and barges which may have numerous cavities, are slow moving, and will remain in the surrounding waters of Barrow Island for extended periods. The analysis is to include risks presented by ballast water and hull-fouling organisms, including all internal areas exposed to seawater such as cooling pipes and sea chests.

8. Details of all potential introduction pathways for introduced non-indigenous organisms and barriers to be applied to each pathway to ensure that the risk of introductions achieves a risk-rating agreed by the Marine Parks and Reserves

Authority on the advice of the Department of Conservation and Land Management and the Department of Fisheries.

9. A requirement to clean ocean-going vessels determined as presenting greater than an acceptably low risk prior to their departure from their port of origin for Barrow Island. The cleaning will include all topsides and outer surfaces and all internal areas open to seawater, including cooling water pipes and sea chests. Vessels are to be pre-inspected after cleaning, but prior to departure for Barrow Island, by an inspector approved by the Department of Fisheries. The pre-inspection is to be at the proponent's expense. A vessel which is not in a clean condition in the opinion of the inspector will not be allowed to enter the surrounding waters of Barrow Island.

10. Procedures for obtaining agreement by the Marine Parks and Reserves Authority on the classification of ocean-going vessel risk.

11. Procedures for obtaining the prior approval of the Department of Conservation and Land Management for authorised inspectors.

12. Procedures, for ocean-going vessels where they are not in conflict with any more stringent requirement in this statement, for regularly updating and implementing the latest International Maritime Organization and Australian Quarantine Inspection Service inspection and treatment processes for ballast water and hull fouling and adherence to the Australian Single National Interface for handling ballast water and hull fouling when that programme is implemented.

13. Procedures to ensure that only oceanic ballast water is discharged from ocean-going vessels in the surrounding waters of Barrow Island.

14. Reference to the Australian national standard [ask Dept of Fisheries for correct reference] for marine quarantine protection.

15. Adequate inspection of ocean-going vessels for cleanliness of outer surfaces and internal areas open to seawater, including cooling water pipes and sea chests, of vessels at Barrow Island using suitably qualified divers where necessary. A roster of divers to be employed shall be approved by the Department of Fisheries in advance.

16. Procedures for sampling of ballast waters and inspection of areas open to sea water by an authorised inspector before discharging ballast water in the surrounding waters of Barrow Island

17. Collection, analysis and reporting on ballast water samples by an accredited laboratory for every vessel carrying ballast water taken on outside the surrounding waters of Barrow Island where such water is to be discharged within the surrounding waters of Barrow Island in compliance with this Plan.

18. A survey of the Port of Dampier and other mainland supply bases where such a survey has not been performed within the last two years, and surveys to be repeated every two years, for introduced marine species to the satisfaction of the Marine Parks and Reserves Authority on advice of the Department of Fisheries and the Department of Conservation and Land Management. This survey is to be conducted within six months following the approval of this proposal.

19. Cleaning of all service vessels operating between the Western Australian mainland and Barrow Island before they enter service. The cleaning is to include all topsides, and external and internal areas exposed to sea water, including, the hull, cooling water pipes and sea chests. All wash water and debris is to be collected and treated. Vessels are to be pre-inspected after cleaning, but prior to departure for Barrow Island, by an inspector approved by the Department of Fisheries. The pre-inspection is to be at the proponent's expense. A vessel which is not clean in the opinion of the inspector will not be allowed to enter the surrounding waters of Barrow Island.

20. Once in use, all service vessels are to be inspected every three months either out of the water or by divers approved by the Department of Fisheries. Vessels which are not clean in the opinion of the inspector will not be allowed to re-enter the surrounding waters of Barrow Island.

21. Provision for variation by the Department of Fisheries of inspection frequency, based on results of inspections of service vessels undertaken in the first twelve months, to allow the inspections every six months.

22. Re-cleaning of service vessels on an annual basis. Following experience gained in the first two years of the project, the Department of Fisheries may vary the required re-cleaning interval.

23. Procedures to maintain a panel of independent experts capable of providing risk ratings for all relevant taxonomic groups and other necessary advice on the application and likely effectiveness of quarantine measures, including barriers, surveillance, detection and eradication of introduced and potentially introduced taxa.

24. Procedures for responding to introduced non-indigenous taxa, including specific plans for high risk taxa, maintaining appropriate stocks of readily available containment and response equipment and trained personnel and undertaking appropriate introduction response action.

25. Procedures for deciding on eradication action, including avoidance of significant impact on non-target species, maintaining appropriate stocks of readily available containment and eradication equipment and undertaking appropriate eradication action, based on advice from the panel of independent experts required by item 22 above.

26. Beyond world's best practice contingency plans for eradication of introduced taxa and appropriate response mechanisms to ensure that the plans can be

implemented quickly and effectively. These plans and implementation procedures are to incorporate provision of up to date advice from a panel of independent experts required by item 22 above. Such advice is to include provisions for maintaining at an acceptable level, to the satisfaction of the Marine Parks and Reserves Authority on the advice of the Department of Conservation and Land Management and the Department of Fisheries, the effects of any eradication action on other organisms in the marine environment.

27. Provision for reporting to the Department of Fisheries and the Department of Conservation and Land Management any introduction or potential introduction of non-indigenous taxa within 12 hours of detection.

28. Procedures for regular monitoring within the surrounding waters of Barrow Island with sufficient statistical power to detect introduced non-indigenous taxa with a level of confidence determined by the Department of Fisheries.

29. Maintenance of complete electronic records, including on a geographic information system accessible to relevant state government departments, of all breaches of procedures, potential introductions or introductions of non-indigenous taxa (regardless of whether those introduced taxa actually become established in the surrounding waters of Barrow Island) and corrective action taken to rectify breaches, potential introductions or introductions.

30. Protocols for regular independent audits, at least quarterly, during the construction phases and then annually, of the quarantine procedures in place, their effectiveness, and any corrective action required.

31. Annual public reporting of all breaches, potential introductions or introductions of non-indigenous taxa and corrective action taken, including eradication actions, in a manner approved by the Department of Conservation and Land Management and the Department of Fisheries.

32. Provisions for continuous improvement with an annual review and update of the plan, with provisions for a major review and update every five years.

33. Provisions for these conditions to form part of all contracts let by the proponent where those contracts may require the application of these conditions.

11-2 The proponent shall implement the Marine Quarantine Management Plan required by condition 11-1.

11-3 The proponent shall make the Marine Quarantine Management Plan required by condition 11-1 publicly available in a manner approved by the Department of Conservation and Land Management and the Department of Fisheries.

12 Marine Turtles

12-1 Prior to ground-disturbing activities and in consultation with the Department of Conservation and Land Management, the proponent shall prepare

a Marine Turtles Monitoring and Management Plan to the requirements of the Minister for the Environment on advice of the Department of Conservation and Land Management.

The objectives of this plan are;
- to implement darkness strategies to prevent lights or glow interfering with nesting female turtles or hatchlings;
- to ensure the ongoing population viability of the Pilbara regional population of Flatback turtles.

This Plan shall address monitoring, research and management to:

1. gather adequate data to model and determine the effects of earthworks on land and in the sea, noise and vibration, light overspill and any other impacts on the population size, breeding and hatching success and ongoing population viability of marine turtles nesting on Barrow Island, particularly Flatback turtles (*Natator depressus*) using an appropriate population model approved by the Department of Conservation and Land Management;
2. implement darkness strategies to prevent lights or glow from the plant, accommodation, support facilities, causeway, materials offloading facility and jetty from being visible to the naked eye from ground level on the beaches used by turtles during turtle nesting and hatching seasons;
3. require use of the marine offloading facility and the WAPET landing to be confined to daylight hours in turtle nesting and hatching seasons;
4. avoid, mitigate, manage or offset impacts such that the viability of the population and breeding and hatching success of marine turtles in the Pilbara region is not significantly reduced; and
5. undertake on-going research and monitoring for the life of the project on the biology of marine turtles for the purpose of better management around Barrow Island and elsewhere and to determine appropriate mitigating actions that could be undertaken to offset impacts.

12-2 The proponent shall implement the Marine Turtle Management Plan required by condition 12-1.

12.3 The proponent shall make the Marine Turtle Management Plan required by condition 12-1 publicly available in a manner approved by the Department of Conservation and Land Management.

12.4 The proponent shall provide a report annually, which shall be publicly available, on the results of monitoring, research and management in a manner approved by the Department of Conservation and Land Management.

12.5 The proponent shall continuously improve the turtle management plan by annual review, or such other period as the Department of Conservation and Land Management determines, in consultation with the Department of Conservation and Land Management.

Dredging

13 Baseline and Post Dredging Marine Habitat Surveys

13-1 The proponent shall, within six months following the formal authority issued to the decision-making authorities under section 45(7) of *the Environmental Protection Act 1986*, and prior to the commencement of any works that may adversely affect the marine environment/ seabed disturbing activity, prepare and submit a draft Scope of Baseline Marine Habitat Survey document for review to, and for endorsement by, the Department of Conservation and Land Management.

13-2 At least 3 months prior to the commencement of dredging operations, the proponent shall conduct a comprehensive field survey, consistent with the approved Scope of Baseline Marine Habitat Survey document to quantitatively determine the current distribution, composition and condition of marine habitats (see Note 7 below) within the area that may be affected by the construction or operation of marine facilities associated with the Gorgon development, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority and the Marine Parks and Reserves Authority. The area that may be affected is defined as the zone of influence of the proposed dredging shown in Figure 3 of Chevron, 2006e, and the potential visible plume associated with the proposed HDD shown in Figure 11-7 of Chevron, 2005a.

As part of the survey, the proponent shall:

1 Prepare spatially accurate maps showing the location, spatial extent of the different marine habitat types, percentage cover and condition of each component of their associated benthic communities including scleractinian corals, macroalgae, filter feeders and seagrass and provide these data in an electronic form to the EPA and the Marine Parks and Reserves Authority.

2 Record existing scleractinian corals, macroalgae, filter feeders and seagrass observed within the communities to species level as far as practicable.

13-3 Within three months of completion of dredging operations, the proponent shall repeat the marine habitat survey required by condition 13-2, and prepare and submit a report of the results of the survey, and that this will constitute the first Post Dredging Marine Habitat Survey, and it will quantify the changes that have occurred between the Baseline and Post Dredging Marine Habitat Surveys.

13-4 The proponent shall repeat the Post Dredging Marine Habitat Survey required by Condition 13-3, every 2 years, subject to review after the third Post Dredging Marine Habitat Survey.

14 Establishing Zones of Loss, Impact and No Effect.

14.1 Prior to the commencement of ground disturbing activities in the marine environment or on-shore that may affect the marine environment the proponent shall prepare and submit a Marine Infrastructure Plan (MIP) for all marine

infrastructure associated with the Gorgon Development in State waters to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

14.2 The MIP shall include detailed maps that show all marine infrastructure associated with the Gorgon Project, and all benthic habitats, and associated communities, including coral, that exist within 2km of any marine infrastructure associated with that infrastructure.

14.3 The MIP shall show the final configuration and location of the LNG Channel and Ship Turning Basin, including the navigable area and all batter slopes as part of the LNG Channel and Ship Turning Basin.

14.4 The Plan shall define a Line A that extends no more than 100m from the outer edge of the LNG Channel and Ship Turning Basin, and a Line B that extends no more than 500m from Line A. [see Figure A4.1 for an example].

14.5 The Plan shall define the area encompassed by Line A as LNG Channel Zone 1 (the Zone of Loss), the area between Line A and Line B as LNG Channel Zone 2 (the Zone of Impact) and the area outside of Line B as the LNG Channel Zone 3 (the Zone of No Impact).

14.6 The MIP shall show the final configuration and locations of the Materials Offloading Facility (MOF) Channel and Berth Pockets, including the navigable area and all batter slopes as part of the Materials Offloading Facility (MOF) Channel and Berth Pockets.

14.7 The Plan shall define a Line C that extends no more than 100m from the outer edge of the MOF Channel and Berth Pockets, or the batter slope of the MOF Channel and Berth Pockets, and a Line D that extends no more than 500m from Line C.

14.8 The Plan shall define the area encompassed by Line C as MOF Channel Zone 1 (the Zone of Loss), the area between Line C and Line D as MOF Channel Zone 2 (the Zone of Impact) and the area outside of Line D as the MOF Channel Zone 3 (the Zone of No Impact).

14.9 The MIP shall show the final configuration and location of the solid fill Causeway and Materials Offloading Facility (MOF) including the surface and toe of the built structure as part of the solid fill Causeway and Materials Offloading Facility (MOF).

14.10 The Plan shall define a line E that extends no further than 10m from the outer edge of the solid fill Causeway/MOF and a Line F that extends no further than 50m from Line E.

14.11 The plan shall define an area between the Causeway/MOF and Line E as the Causeway/MOF Zone 1 (the Zone of Loss), the area between Line E and Line F as the Causeway/MOF Zone 2 (the Zone of Impact) and the area outside of Line E as the Causeway/MOF Zone 3 (the Zone of No Impact).

15 Establishing the Environmental Management regime to protect marine biological communities from the potential impacts of Dredging and Spoil Disposal.

15 Prior to the commencement of dredging or filling the proponent shall prepare and submit a Dredging Environmental Management Plan (DEMP) for all dredging and spoil disposal activities required for the construction of marine infrastructure associated with the Gorgon Development in State waters to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

15.1 The DEMP shall identify Monitoring Sites in the Zones of Impact and No Impact for the LNG Channel, the MOF Channel and the Causeway/MOF as defined by the approved MIP required by Condition 14.1, and identify relevant Reference Sites outside of the Zone of Influence as defined by Condition 14.5.

15.2 The DEMP shall set out procedures for monitoring a) the 5 day running median Light Attenuation Coefficient (LAC) of downwelling Photosynthetically Active Radiation (PAR) measured between 1 hour after sunrise and 1 hour before sunset using 2pi sensors and expressed on a $\log_{10}$ basis in units of m^{-1}, b) the median sediment deposition rate measured as sediment deposited in triplicate standard aspect-ratio sediment traps deployed for 7 day intervals immediately above the seabed and expressed as deposited inorganic material in units of $mg/cm^2/day$ and c) sediment accumulation on coral as visual assessment of sediment accumulations on individual coral colonies, at all Monitoring Sites and Reference Sites. Turbidity shall also be measured in Nephlometric Turbidity Units (NTU), and as Total Suspended Solids (TSS) in units of $mg\ l^{-1}$ at all sites to establish relationships between dredging-induced turbidity and LAC and natural turbidity and LAC.

15.3 The DEMP shall set out a detailed Sediment-Effects management regime whereby if the median sediment deposition rate at each monitoring site is greater than the 80^{th} percentile of the sediment deposition rate at the relevant Reference Sites during the same period (the criterion) then this will trigger a) voluntary management actions to alleviate pressure on the environment and reduce median sediment deposition rates at monitoring sites to less than the criterion, and b) an immediate assessment of the degree of coral bleaching and/or injury at impact and reference sites relevant to the site where the sediment deposition rate criterion was exceeded.

15.4 The DEMP shall set out a range of possible voluntary measures that may be required by condition 15.3 and condition 15.7.

15.5 If the assessment of coral bleaching or injury required by condition 15.3 shows that on the second day after the initial exceedence of the sediment deposition trigger the degree of bleaching or injury exceeds 20% in Impact Zones, or exceeds 10% in No Effect Zones, of that occurring at the relevant reference sites, then the proponent shall immediately cease all turbidity generating

activities affecting those locations where exceedances are occurring and continue coral health, sediment deposition and water quality monitoring.

15.6 The proponent may not recommence dredging and disposal activities until the level of coral bleaching and/or injury at all monitoring sites in Impact Zones is less than 20% and bleaching and/or injury at all monitoring sites in No Effect Zones is less than 10% of that occurring at the relevant reference sites and that the median sediment deposition rate and median LAC measurements at Monitoring Sites are less than the 80^{th} percentile of equivalent measures at the relevant Reference Sites.

15.7 The DEMP shall set out a detailed Turbidity-Effects management regime whereby if the five day running median LAC at each monitoring site is greater than the 80^{th} percentile of the LAC at the relevant Reference Sites over the same period then this will trigger a) voluntary management actions to alleviate pressure on the environment and reduce the 5 day running median LAC at monitoring sites to less than the criterion, and b) an immediate assessment of the degree of coral bleaching and/or injury at impact and reference sites relevant to the site where the LAC criterion was exceeded.

15.8 If the assessment of coral bleaching and/or injury required by condition 15.7 shows that on the second day after the initial exceedence of the LAC criterion the degree of bleaching and/or injury exceeds 20% in Impact Zones, or exceeds 10% in No Effect Zones, of that occurring at the relevant reference sites, then the proponent shall immediately cease all turbidity generating activities affecting those locations where exceedances are occurring and continue coral health, sediment deposition and water quality monitoring.

15.9 The proponent may not recommence dredging and disposal activities at sites affecting those locations where exceedances are occurring until the level of coral bleaching and/or injury at all monitoring sites in Impact Zones is less than 20% and bleaching and/or injury at all monitoring sites in No Effect Zones is less than 10% of that occurring at the relevant reference sites and that the sediment deposition rate and LAC measurements at Monitoring Sites are less than the 80^{th} percentile of equivalent measures at the relevant Reference Sites.

15.10 There shall be no underwater blasting associated with construction of marine infrastructure including channels, wharves and LNG and condensate loading facilities unless a suitable management plan is produced and otherwise authorised by the Minister for the Environment on advice of the Environmental Protection Authority and the Marine Parks and Reserves Authority.

15.11 All turbidity generating activities associated with construction of marine facilities shall cease in such time to allow turbidity to return to background levels prior to the predictable coral mass spawning events in Autumn each year, on advice of the Department of Conservation and Land Management.

15.12 Turbidity generating activities shall not recommence until 3 weeks after the mass spawning event to allow for fertilisation, larval competency and settlement.

15.13 Dredging shall cease during the flatback turtle aggregation and nesting periods, each year on advice of the Department of Conservation and Land Management.

16 Governance arrangements for dredging management.

[This requirement may be better structured as a Procedure rather than a Condition]

Given the environmental significance of the marine environment around Barrow Island, and uncertainty surrounding the potential extent and severity of marine impacts, the EPA believes that the environmental management of dredging should be under the direct control of a Dredging Environmental Management Group (DEMG) comprised of the key State and Commonwealth natural resource management and regulatory agencies.

16 The DEMP shall facilitate co-operation with a Dredging Environmental Management Group (DEMG) to be established by Government and funded by the proponent to implement the requirements established under Condition 15 to control the environmental impacts of the dredging operations to meet the environmental objectives established under the MIP required by Condition 14.

16.1 The DEMG is comprised of senior officers from the Department of Conservation and Land Management, Fisheries Western Australia, Department of Environment and the Commonwealth Department of Environment and Heritage.

16.2 The proponent has observer status on the DEMG.

16.3 The DEMG is responsible for directing that dredging operations shall be conducted in a manner that protects the environment when environmental management criteria are triggered.

16.4 The DEMG has the authority to direct any aspects of the dredging operation likely to affect the environment (eg. move the dredge, implement specified management measures, require cessation of overflow, require cessation of dredging) in accordance with the management regime established by the DEMP.

16.5 The DEMG will consider recommendations/advice provided by the MEMS, as set out in 16.7.

16.6 The DEMG will have as its objective ensuring the Environmental Objectives of the DMP are not compromised.

16.7 The DEMP shall require that a Marine Environmental Monitoring Supervisor (MEMS) be appointed to be responsible for overseeing the implementation of the Dredging Management Plan.

16.8 The MEMS will be employed by, or be under direct control of, one of the DMG agencies (eg. CALM) using funds provided by the proponent to cover salary, on-

costs, travel, accommodation, entitlements, allowances and all other expenses incurred in undertaking the required duties.

16.9 The MEMS will report to, and be directed by, the Dredging Environmental Management Group (DEMG).

16.10 The MEMS will have adequate resources, provided by the proponent, to oversee the necessary monitoring and monitoring data interpretation.

16.11 The proponent will ensure that on a weekly basis, and prior to commencement of any works for that period, a detailed schedule of works, and the 24-hour contact details of an on-site proponent's liaison officer whom the MEMS can contact, as and when required, is supplied to the MEMS, at least two days prior to the commencement of those works.

17 Construction of the Solid fill Causeway and Materials Offloading Facility.

17 Prior to the commencement of construction of the Solid fill Causeway and/or MOF the proponent shall prepare and submit a Causeway Construction Management Plan (CCMP) for the management of all activities associated with the construction of marine infrastructure associated with the Solid fill Causeway and Materials Offloading Facility to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

17.1 The CCMP shall specify procedures to ensure the rock armour bund is placed in such a way to ensure all direct disturbance is contained within the footprint specified in the endorsed MIP.

17.2 The CCMP shall specify procedures to ensure that the geotextile bund lining materials are selected and placed, and settlement ponds are designed and constructed, in such a way as to ensure that all fines are retained within the bund walls and not released to the marine environment outside the bunded area and that no turbid water is released from the bunded area unless it is discharged through a pipeline and seabed diffuser located to minimise impacts on marine biota, as agreed by the Department of Conservation and Land Management.

17.3 The CCMP shall specify the location, dimensions and design of the de-watering pipeline and diffuser, and procedures to monitor and manage the quality of any water released from the bunded area through the pipe and diffuser required by Condition 17.2 to ensure the turbidity of the water, expressed as Total Suspended Solids (TSS) in units of mg l^{-1}, is the same or less than that at the point of discharge to the marine environment.

17.4 The CCMP shall specify procedures that apply during construction, and for the life of the project, to monitor the extent of any erosion or accretion of sand, and the profile from MLW to a distance no less than 50m landward of the permanent dune vegetation line, of beaches each side of the Solid fill Causeway and Materials Offloading Facility, and specify procedures to maintain the natural configuration if changes occur.

17.5 The CCMP shall specify procedures that apply during construction, and for the life of the project, to monitor the water quality and benthic habitats and biota in the areas each side of, and potentially influenced by, the causeway and MOF and specify management measures that will be employed if monitoring shows that adverse impacts have occurred.

18 Construction of the shoreline crossing for the Feed Gas Pipeline on the west coast of Barrow Island.

18 Prior to the commencement of development of the shoreline crossing the proponent shall prepare and submit a Horizontal Directional Drilling Monitoring and Management Plan (HDDMMP) for the management of all activities associated with the construction of the shoreline crossing on the west coast of Barrow Island to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

18.1 Polymer based drilling fluids are to be used for horizontal directional drilling and the use of bentonite drilling fluids are not permitted to be used.

18.2 The HDDMMP will establish procedures to ensure that all drill cuttings that contain drilling fluids are retained, collected and removed from Barrow Island and the surrounding waters.

18.3 The HDDMMP will establish a marine monitoring regime in the vicinity of the HDD exit point to demonstrate that drill cuttings that are liberated do not contain drilling fluids and that there is no impact on marine habitats or marine biota at distances greater than 20m from the HDD exit point.

18.4 The HDDMMP will establish protocols to rehabilitate any affected habitat or biota in the event that monitoring required by Condition 18.3 detects impact at distances greater than 20m from the HDD exit point, and to continue monitoring at regular intervals, until recovery is complete.

19 Construction of the LNG and Condensate Wharf and Load-out Facilities.

19 Prior to the commencement of construction of the LNG and Condensate Wharf and Load-out Facilities the proponent shall prepare and submit a LNG and Condensate Wharf and Load-out Facilities Monitoring and Management Plan (LNGWMMP) for the management of all activities associated with the construction of the LNG and Condensate Wharf and Load-out Facilities to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

19.1 The LNGWMMP shall contain an accurate plan showing the location of all piles, and any other infrastructure associated with the LNG and Condensate Wharf and Load-out Facilities and the location of all benthic habitats, and associated communities, including coral, that exist within 200m of any marine

infrastructure associated with the LNG and Condensate Wharf and Load-out Facilities.

19.2 The LNGWMMP shall establish procedures to manage the impacts of drilling, giving particular attention to the use and management of drilling fluids, specify that bentonite drilling fluids will not be used, specify measures to reduce habitat losses to the minimum reasonably practicable and ensure sensitive marine habitats and biota are not impacted at distances of greater than 10m from any infrastructure on the plan required by condition 19.1.

19.3 The LNGWMMP shall establish procedures to manage the impacts of pile placement, giving particular attention to techniques to minimise the generation of sound and pressure waves, to ensure that sensitive marine fauna are not impacted, giving particular attention to environmental windows such as Flatback turtle aggregation and nesting periods and hatching periods.

20 Gas Pipeline and Optic Fibre Cable Laying

20-1 Prior to the commencement of ground-disturbing activities for the proposal the proponent shall prepare and submit a Pipeline and Cable Laying Management Plan (PCLMP) for gas pipelines and the optic fibre cable and ancillary infrastructure, to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

The PCLMP shall:

1 describe the procedures for positioning pipeline and/or cable laying vessels, and support vessels, for the entire length of each pipeline or cable;

2 describe how the procedures in point 1 above have been selected, and how they will be specifically applied, paying particular attention to the wire and chain sweep areas, anchor drag and embedment, positioning and retrieval of anchors, wires and chains, and wash from thrusters and propellers, and managed to minimise impacts on benthic communities from these activities;

3 detail the mooring pattern design, range and bearing from fairleads of individual anchor drops, and to provide maps superimposing the mooring pattern design onto detailed benthic habitat maps of the Barrow Island Port area and the Barrow Island Marine Management Area to show how the mooring pattern has been designed to minimise impact on benthic communities;

4 describe procedures for monitoring and quantifying the area and degree of impact resulting from anchoring, wire and chain sweep, and wash from thrusters and propellers, on benthic communities in all areas traversed within the Barrow Island Port area and the Barrow Island Marine Management Area;

5 describe procedures for monitoring and quantifying the rate, scale and extent of recovery in areas impacted by pipeline and cable laying activities: and

6 detail the reporting procedures to the Department of Conservation and Land Management of the monitoring required by 5 above.

20-2 The proponent shall implement and comply with the PCLMP required by condition 20-1.

20-3 The proponent shall make the PCLMP required by condition 20-1 publicly available in a manner approved by the Department of Conservation and Land Management.

21 Gas Pipelines and Optic Fibre Corridor Route Plans

21-1 Prior to the commencement of ground-disturbing activities for the proposal the proponent shall prepare and submit Corridor Route Plans for gas pipelines, including shore crossings subject to horizontal directional drilling, and the optic fibre cable, to the Minister for the Environment for endorsement on the advice of the Department of Fisheries and the Department of Conservation and Land Management.

The Corridor Route Plans shall:

1 describe the route and area of disturbance for each proposed corridor giving consideration to and including the impacts identified in the PCLMP required by condition 20-1;

2 describe how the selected corridor route complies with the requirements of the Biodiversity-related Investigations Report and how, giving attention to the PCLMP required by condition 20-1, it minimises overall disturbance, caused by both the pipeline route and method of laying, of vegetation, flora, fauna, corals and other important benthic primary producer habitat as appropriate; and

3 describe how the corridor route will be excavated or otherwise disturbed and subsequently rehabilitated.

21-2 The proponent shall implement and comply with the Corridor Route Plans required by condition 21-1.

21-3 The proponent shall make the Corridor Route Plans required by condition 21-1 publicly available in a manner approved by the Department of Conservation and Land Management.

Emissions Control

22 Best Practice Pollution Control

22.1 Prior to submitting a Works Approval application (under Part V of the *Environmental Protection Act 1986*) for works included in the proposal, the proponent shall submit a Front End Engineering Design Report demonstrating that the proposed works adopt best practice pollution control measures to minimise emissions from the plant.

The Front End Engineering Design Report shall set out the base emission rates for major sources for the plant and the design emission targets.

The Front End Engineering Design Report required by condition 22-1 shall address normal operations, shut down, start up, and equipment failure conditions.

Prior to commencement of construction, the proponent shall prepare an Air Quality Management Plan to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

The objective of this Plan is to ensure that best available practicable and efficient technologies are used to minimise and monitor air emissions from the plant.

22.2 The Plan shall include:

1. an air quality improvement plan addressing priority areas, including but not be limited to hydrogen sulphide, nitrogen compounds, butene, toluene, ethylbenzene, xylene (BTEX), acrolene and ozone;
2. an ambient air monitoring programme and a nitrogen deposition monitoring programme;
3. proposed targets and standards4. an emissions monitoring programme, which includes but is not limited to nitrogen compounds, butene, toluene, ethylene, xylene (BTEX), ozone, acrylene and hydrogen sulphide emissions from the plant; and
5. a programme for annual reporting on air quality.

22.3 The proponent shall implement the Air Quality Management Plan required by condition 22-1.

22.4 The proponent shall make the Air Quality Management Plan required by condition 22-1 publicly available in a manner approved by the Department of Environment.

23 Greenhouse Gas Abatement

23-1. The proponent shall undertake all practicable measures to establish and operate a scheme to dispose of carbon dioxide removed from reservoir gases into underground formations for the life of the proposal, to the requirements of the Minister for the Environment, on the advice of the Environmental Protection Authority and Department of Industry and Resources.

Note: "practicable" means reasonably practicable having regard to, amongst other things, local conditions and circumstances (including costs) and to the current state of technical knowledge. In considering the element of costs, regard shall be had for the estimated costs of mitigating the expected mass of CO_2 removed from reservoir gases by alternative means.

23-2. Should it be found impracticable to establish a scheme to dispose of carbon dioxide removed from reservoir gases into underground formations, the proponent shall implement alternative practicable means to mitigate all of the expected mass of carbon dioxide removed from reservoir gases, to the requirements of the Minister for the Environment, on the advice of the Environmental Protection Authority.

23-3 Prior to commencement of construction, the proponent shall develop a Greenhouse Gas Abatement Programme to:

- ensure that the plant is designed and operated in a manner which achieves reductions in "greenhouse gas" emissions as far as practicable;
- provide for ongoing "greenhouse gas" emissions reductions over time;
- ensure that through the use of best practice, the total net "greenhouse gas" emissions and/or "greenhouse gas" emissions per unit of product from the project are minimised; and
- manage "greenhouse gas" emissions in accordance with the *Framework Convention on Climate Change 1992*, and consistent with the National Greenhouse Strategy;

to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

This Programme shall include:

1. calculation of the "greenhouse gas" emissions associated with the proposal, as advised by the Environmental Protection Authority;

   Note: The current requirements of the Environmental Protection Authority are set out in: *Minimising Greenhouse Gas Emissions, Guidance for the Assessment of Environmental Factors, No. 12* published by the Environmental Protection Authority (October 2002). This document may be updated or replaced from time to time.

2. specific measures to minimise the total net "greenhouse gas" emissions and/or the "greenhouse gas" emissions per unit of product associated with the proposal using a combination of "no regrets" and "beyond no regrets" measures (See schedule 2, commitments 12.1 to 12.4, which constitute the proponent's committed offsets package);

3. the implementation and ongoing review of "greenhouse gas" offset strategies with such offsets to remain in place for the life of the proposal;

4. estimation of the "greenhouse gas" efficiency of the project (per unit of product and/or other agreed performance indicators) and comparison with the efficiencies of other comparable projects producing a similar product, both within Australia and overseas;

5. implementation of thermal efficiency design and operating goals consistent with the Australian Greenhouse Office Technical Efficiency guidelines in design and operational management;

6. actions for the monitoring, regular auditing and annual reporting of "greenhouse gas" emissions and emission reduction strategies;

7. a target set by the proponent for the progressive reduction of total net "greenhouse gas" emissions and/or "greenhouse gas" emissions per unit of product and as a percentage of total emissions over time, and annual reporting of progress made in achieving this target. Consideration should be given to the use of renewable energy sources such as solar or wind;

8. a programme to achieve reduction in "greenhouse gas" emissions, consistent with the target referred to in (7) above;

9. entry, whether on a project-specific basis, company-wide arrangement or within an industrial grouping, as appropriate, into the Commonwealth Government's "Greenhouse Challenge" voluntary cooperative agreement programme.

   Components of the agreement programme include:
   1. an inventory of emissions;
   2. opportunities for abating "greenhouse gas" emissions in the organisation;
   3. a "greenhouse gas" mitigation action plan;
   4. regular monitoring and reporting of performance; and
   5. independent performance verification.

10. Review of practices and available technology; and

11. "Continuous improvement approach" so that advances in technology and potential operational improvements of plant performance are adopted.

Note: In (2) above, the following definitions apply:

1. “no regrets” measures are those which can be implemented by a proponent and which are effectively cost-neutral.
2. “beyond no regrets” measures are those which can be implemented by a proponent and which involve additional costs that are not expected to be recovered.

23-4 The proponent shall implement the Greenhouse Gas Abatement Programme required by condition 23-3.

23-5 Prior to commencement of construction, the proponent shall make the Greenhouse Gas Abatement Programme required by condition 23-3 publicly available in a manner approved by the Department of Environment.

24 Groundwater

24-1 Prior to commencement of ground disturbing activities, the proponent shall prepare a Groundwater Abstraction and Management Plan and a Deep Well Injection Plan in consultation with the Department of Water and the Department of Conservation and Land Management, to the requirements of the Minister for the Environment on advice of the Conservation Commission and the Department of Conservation and Land Management.

The objectives of these Plans are to:

a) ensure there are no significant impacts on biota;
b) provide a framework to predict and measure impacts;
c) protect and maintain the quality of the water in the aquifer;
d) protect groundwater dependent fauna such that there are no significant impacts on stygofauna and troglofauna;
e) protect any groundwater dependent vegetation; and
f) define appropriate environmental triggers for contingency plans.

This Plan shall address the following:

1. the layout and specifications of appropriate monitoring sites;
2. protocols and procedures for monitoring and quantitatively determining the effects of water abstraction or waste injection on groundwater dependent vegetation and fauna;
3. threshold levels to be used to determine if and when action is to be taken to protect groundwater dependent fauna and vegetation;
4. the actions (including an immediate reduction in or cessation of the rate of bore water abstraction from or waste injection to affected bores) which will be taken to address the adverse effects on groundwater dependent fauna and vegetation if monitoring reveals that abstraction or waste injection is affecting groundwater dependent fauna and vegetation;
5. reporting requirements; and

6. closure procedures.

24-2 The proponent shall implement the Groundwater and Bore Management Plan required by condition 24-1.

24-3 The proponent shall make the Groundwater and Bore Management Plan required by condition 24-1 publicly available in a manner approved by the Department of Conservation and Land Management.

25 Surface Water

25-1 Prior to ground-disturbing activity, the proponent shall prepare a Surface Water Management Plan to the requirements of the Minister for the Environment on advice of the Department of Conservation and Land Management and the Department of Environment.

The objective and a requirement of this plan is to not permit direct and indirect impacts outside the plant site and associated infrastructure on flora, fauna and landforms.

This Plan shall detail:

1. the layout of the proposal and the components within it;
2. actions to maximise the recharge of clean water, prevent infiltration of contaminated water, prevent runoff of contaminated water and inject contaminated water into deep wells where it will not affect subterranean fauna;
3. locations of infrastructure (eg bunds, storage ponds, roads, pipelines, borrow pits, communications facilities);
4. measures which demonstrate that the impacts of the infrastructure referred to in 3 above on fauna and flora have been avoided; and
5. the specifications, locations, monitoring and maintenance regimes of altered surface drainage mitigation measures.

25-2 The proponent shall implement the Surface Water Management Plan required by condition 25-1.

25-3 The proponent shall make the Surface Water Management Plan required by condition 25-1 publicly available in a manner approved by the Department of Environment.

Weed and Fire Management

26 Weed Management

26-1 Prior to ground-disturbing activities and in consultation with the Department of Conservation and Land Management and the Department of Agriculture and Food, the proponent shall prepare a Weed Management Plan consistent with the Terrestrial Quarantine Management Plan (condition 8-1) to the

requirements of the Minister for the Environment on advice of the Department of Conservation and Land Management.

The objective of the Weed Management Plan is to ensure that weeds already present on Barrow Island are not spread and that new weeds are not introduced and spread.

The Weed Management Plan shall set out the procedures and/or measures for:

1. control and eradication of weed species on and around the plant site and sites of supporting infrastructure;

2. weed control during construction and operation at the plant site and sites of supporting infrastructure;

hygiene and wash-down for all plant and equipment; and

monitoring the success of weed control.

26-2 The proponent shall implement the Weed Management Plan required by condition 26-1.

26-3 The proponent shall make the Weed Management Plan required by condition 26-1 publicly available, in a manner approved by the Department of Conservation and Land Management.

27 Fire Management

27-1 Prior to commencement of ground-disturbing activity and in consultation with the Department of Conservation and Land Management, the proponent shall prepare a Fire Management Plan to the requirements of the Minister for the Environment on advice of the Department of Conservation and Land Management.

The objective of and a requirement of the Fire Management Plan is to ensure that fire and its exclusion and management do not have unintended or unacceptable impacts on the bio-physical values of Barrow Island which underpin its status as a nature reserve.

This Plan shall include:

1. fire prevention measures;
2. liaison with the Department of Conservation and Land Management and co-operation on controlled burns where research shows vegetation types may be dependent on burning;
3. liaison with the Department of Conservation and Land Management and co-operation on research into fire ecology on Barrow Island;

4. fire detection and reporting procedures;
5. the proponent's fire suppression equipment and preparedness measures; and
6. training of personnel for fighting fires.

27-2 The proponent shall implement the Fire Management Plan required by condition 27-1.

27-3 The proponent shall make the Fire Management Plan required by condition 27-1 publicly available, in a manner approved by the Department of Conservation and Land Management.

Rehabilitation and Decommissioning

28 Interim Rehabilitation

28-1 The proponent shall, Prior to ground disturbing activity, the proponent shall prepare and submit a draft Interim Rehabilitation Plan for review to the Department of Conservation and Land Management.

The objectives of the draft Interim Rehabilitation Plan are to ensure that:

a) areas to be rehabilitated following construction and during the course of the project life are properly planned in a manner which promotes self-sustaining ecosystems able to be managed as part of their surroundings and consistent with the requirements of the Department of Conservation and Land Management;
b) agreed completion criteria are established to the requirements of the Department of Conservation and Land Management;
c) planning, implementation and reporting on of rehabilitation is carried out in a manner consistent with industry best practice and subject to continuous improvement;
d) co-ordinated and ongoing research is carried out into the best methods of rehabilitating disturbed sites, consistent with the conservation and environmental values of Barrow Island nature reserve;
e) rehabilitated native vegetation will ultimately develop into sustainable ecological systems which are comparable and compatible with surrounding native vegetation and its land uses, and restores as closely as possible the pre-disturbance biodiversity and functional values;

The draft Interim Rehabilitation Plan shall address the following topics which are relevant to long term sustainable rehabilitation:

1. objectives for rehabilitation, including site-specific variation;
2. an outline of proposed rehabilitation research priorities;
3. conduct and application of research;
4. topsoil management;
5. targets for nutrient cycling;
6. introduced taxa, pest, weed and disease control and management;
7. targets for flora and fauna recruitment, including specific targets for:

the return of recalcitrant species;
the return of key fauna habitat;
the translocation of mature specimens of long-lived species required for fauna habitat;
the re-colonisation of invertebrate fauna; and
the re-colonisation of mycorrhizal fungi;

8. hydrological function;
9. climate change consideration;
10. integration with island-wide management;
11. monitoring and adaptive management;
12. plant species composition, including species vulnerability to and/or dependence on fire;
13. long term sustainability, including criteria for assessing ecosystem sustainability on natural and disturbed land;
14. completion criteria including an overall requirement that no extraordinary residual management liability (above the normal cost of managing undisturbed land on Barrow Island) accrues to the land management authority, unless agreed by the State. Completion criteria to have an objective of achieving integration of the rehabilitation areas into large scale prescribed burning programmes for the purpose of fire management prior to the hand-back of responsibility to the State; and
15. peer review and reporting.

28-2 Within twelve months following the formal authority issued to the decision-making authorities under Section 45(7) of the *Environmental Protection Act 1986*, the proponent shall, prepare and submit a final Interim Rehabilitation Plan, taking into account all comments and recommendations (if any) received under condition 28-1, to the Minister for the Environment for endorsement on the advice of the Department of Conservation and Land Management.

28-3 The proponent shall implement and comply with the endorsed Interim Rehabilitation Plan referred to in condition 28-2.

28-4 The proponent shall make the endorsed Interim Rehabilitation Plan referred to in condition 28-2 publicly available in a manner approved by the Department of Conservation and Land Management.

28-5 The proponent shall review the endorsed Interim Rehabilitation Plan annually and present its findings in an Annual Environmental Report submitted to the Department of Environment.

The review shall include the following:

1. presentation of results of monitoring; and
2. plans for improvement in rehabilitation to meet objectives and targets where necessary.

28-6 The proponent may revise and amend the endorsed Interim Rehabilitation Plan referred to in 28-2, in accordance with the review of condition 28-5 and subject to the amended Interim Rehabilitation Plan undergoing review and revision as specified in condition 28-1.

28-7 The proponent shall submit the amended Interim Rehabilitation Plan referred to in condition 28-6 to the Minister for the Environment for endorsement on the advice of the Environmental Protection Authority and the Department of Conservation and Land Management.

28-8 The proponent shall implement and comply with the endorsed amended Interim Rehabilitation Plan referred to in condition 28-7.

28-9 The proponent shall make the endorsed amended Interim Rehabilitation Plan referred to in condition 28-7 publicly available in a manner approved by the Department of Conservation and Land Management.

29 Final Rehabilitation

29-1 Within 24 months following commencement of ground disturbing activity the proponent shall prepare and submit a draft Final Rehabilitation Plan for review to the Department of Conservation and Land Management;

The objectives of the draft Final Rehabilitation Plan are to ensure that:

a) final rehabilitation of the decommissioned plant site and sites of other infrastructure are rehabilitated in a manner consistent with the surrounding land use and purpose as a class A Nature Reserve.

b) rehabilitation research and trials are targeted to the key issues facing the rehabilitation of the plant site and any remaining supporting infrastructure areas;

c) planning and implementation of rehabilitation is carried out in a manner consistent with industry best practice; and

d) rehabilitated native vegetation will ultimately develop into sustainable ecological systems which are compatible with surrounding native vegetation and its land uses, and approximates as closely as possible the pre-disturbance biodiversity and functional values.

The draft Final Rehabilitation Plan shall address the following topics which are relevant to long term sustainable rehabilitation:

1. objectives for rehabilitation, including site specific variation;
2. an outline of proposed rehabilitation research priorities;
3. conduct and application of research;
4. topsoil management;
5. targets for nutrient cycling;
6. introduced taxa, pest, weed and disease control and management;
7. targets for flora and fauna recruitment, including specific targets for:
   the return of recalcitrant species;
   the return of key fauna habitat;
   the translocation of mature specimens of long-lived species required for fauna habitat;
   the re-colonisation of invertebrate fauna; and

the re-colonisation of mycorrhizal fungi;
8. hydrological function;
9. climate change consideration;
10. integration with island wide management;
11. monitoring and adaptive management;
12. plant species composition, including species vulnerability to and/or dependence on fire;
13. long term sustainability, including criteria for determining ecosystem sustainability on natural and disturbed land;
14. completion criteria including an overall requirement that no extraordinary residual management liability (above the normal cost of managing undisturbed land on Barrow Island) accrues to the land management authority unless agreed by the State. Completion criteria to have an objective of achieving integration of the rehabilitation areas into large scale prescribed burning programmes for the purpose of fire management prior to the hand-back of responsibility to the State; and
15. peer review and reporting.

29-2 At least four years prior to scheduled decommissioning of the project, the proponent shall, , prepare and submit a Final Rehabilitation Plan, taking into account all comments and recommendations (if any) received under condition 29-1, to the Minister for the Environment for endorsement on the advice of the Environmental Protection Authority and the Department of Conservation and Land Management.

29-3 The proponent shall implement and comply with the endorsed Final Rehabilitation Plan referred to in condition 29-2.

29-4 The proponent shall make the endorsed Final Rehabilitation Plan referred to in condition 29-2 publicly available in a manner approved by the Department of Conservation and Land Management.

29-5 The proponent shall review the endorsed Final Rehabilitation Plan annually and present its findings in an Annual Environmental Report submitted to the Department of Environment.

The review shall include the following:
1. presentation of results of monitoring; and
2. plans for improvement in rehabilitation to meet objectives and targets where necessary.

29-6 The proponent may revise and amend the endorsed Final Rehabilitation Plan referred to in condition 29-2, in accordance with the review of condition 29-5 and subject to the amended Final Rehabilitation Plan undergoing review and revision as specified in condition 29-1.

29-7 The proponent shall submit the amended Final Rehabilitation Plan referred to in condition 29-6 to the Minister for the Environment for endorsement on the advice of the Environmental Protection Authority and the Department of Conservation and Land Management.

29-8 The proponent shall implement and comply with the endorsed amended Final Rehabilitation Plan referred to in condition 29-7.

29-9 The proponent shall make the endorsed amended Final Rehabilitation Plan referred to in condition 29-7 publicly available in a manner approved by the Department of Conservation and Land Management.

29-10 A rehabilitation bond shall be applied under the provisions of the Environmental Protection Act.

30 Decommissioning Plan

30-1 Within two years following publication of this Statement, the proponent shall prepare a Preliminary Decommissioning Plan in consultation with the Department of Conservation and Land Management for approval by the Minister for the Environment, which describes the framework to ensure that the site is left in an environmentally acceptable condition, and provides:

1. the rationale for the siting and design of plant and infrastructure to be retained as relevant to environmental protection;
2. a conceptual description of the final landform at closure;
3. a plan for a care and maintenance phase; and
4. initial plans for the management of noxious materials.

30-2 At least four years prior to the anticipated date of closure, or at a time agreed by the Department of Conservation and Land Management, the proponent shall submit a Final Decommissioning Plan designed to ensure that the site is left in an environmentally acceptable condition and prepared on advice of the Department of Conservation and Land Management, for approval of the Minister for the Environment.

The Final Decommissioning Plan shall address:

1. removal or, if appropriate, retention of plant and infrastructure in consultation with relevant stakeholders;
2. rehabilitation of all disturbed areas to a standard consistent with the requirements for a nature reserve; and
3. identification of contaminated areas, including provision of evidence of notification and proposed management measures to relevant statutory authorities.

30-3 The proponent shall implement the Final Decommissioning Plan required by condition 30-2 until such time as the Minister for the Environment determines, on advice of the Department of Conservation and Land Management, that the proponent's decommissioning responsibilities are complete.

30-4 The proponent shall make the Final Decommissioning Plan required by condition 30-2 publicly available in a manner approved by the Department of Conservation and Land Management.

30-5 A decommissioning bond shall be applied under the provisions of the Environmental Protection Act.

Other

31 Solid and Liquid Waste Disposal

31-1 Prior to ground disturbing activity, the proponent shall prepare a Solid and Liquid Waste Disposal Plan, to the satisfaction of the Minister for the Environment on the advice of the Department of Environment.

The objectives of the Solid and Liquid Waste Disposal Plan are to;

g) ensure all solid wastes are removed from Barrow Island in a timely manner.

h) ensure no plant or infrastructure discharges, including waste water treatment plant effluent, reverse osmosis plant brine, hydrotest water and process water waste occur to the ocean.

i) encourage deep well injection of liquid wastes, in a manner which will not affect subterranean biota.

j) encourage discharge of hydrotest water from the domestic sales gas pipeline (Domgas pipeline) in an appropriately controlled way on the mainland.

The Solid and Liquid Waste Disposal Plan shall include:

1. An outline of the facilities to be provided and provisions to be made for ensuring solid wastes are removed from Barrow Island in a timely manner.
2. Investigations and ongoing monitoring to be undertaken to ensure that deep well injection of liquid wastes does not affect subterranean biota.
3. An outline of the facilities to be provided and provisions to be made for ensuring liquid wastes, including waste water treatment plant effluent, reverse osmosis plant brine and process water waste are injected into deep wells in such a way that subterranean biota are not affected.
4. An outline of the facilities to be provided and provisions to be made for ensuring hydrotest water from the domestic sales gas pipeline is discharged in an appropriately controlled way on the mainland.

31-2 The proponent shall implement the Solid and Liquid Waste Disposal Plan required by condition 31-1.

31-3 The proponent shall make the Solid and Liquid Waste Disposal Plan required by condition 31-1 publicly available in a manner approved by the Department of Environment.

32 Coastal stability

Prior to the construction of the marine offloading facility or causeway structures the proponent shall prepare a Coastal Stability Plan to the satisfaction of the Minister for the Environment on the advice of the Department of Environment and the Department of Conservation and Land Management.

The objectives of the Coastal Stability Plan shall be to;

1. define the likely impact of those structures on beach profiles
2. define the effect of those structures on the amount and depth of sand present on beaches on the east coast of Barrow Island, and

3. ensure the continued suitability of those beaches for nesting by Flatback turtles.

32-1 The Coastal Stability Plan shall include;

1. provisions for detailed sediment transport modelling to define the influence of the structures on beach profiles.
2. provisions for the redesign of the structures to mitigate changes to beach profiles.
3. provisions for ongoing monitoring of beach profiles.
4. provisions for restoring beach profiles if monitoring shows that they are changing in ways deleterious to the continued success of Flatback turtle nesting there.

32-2 The proponent shall implement the Coastal Stability Plan required by condition 32-1.

32-3 The proponent shall make the Coastal Stability Plan required by condition 32-1 publicly available in a manner approved by the Department of Conservation and Land Management.

Procedures

1 Where a condition states "to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority", the Environmental Protection Authority will provide that advice to the Department of Environment for the preparation of written notice to the proponent.

2 The Environmental Protection Authority may seek advice from other agencies or organisations, as required, in order to provide its advice to the Department of Environment.

3 Where a condition lists advisory bodies, it is expected that the proponent will obtain the advice of those listed as part of its compliance reporting to the Department of Environment.

4 The Minister administering the *Environmental Protection Act 1986* will establish a formal review mechanism to ensure that a bond is placed on the proponent at the appropriate time to ensure adherence to and completion of environmental programmes, rehabilitation and rectification of damage.

5 In the event that a condition within this statement requires the preparation of a plan, programme or report or the conduct of an investigation prior to ground-disturbing activity, and the proponent wishes to undertake minor or preliminary ground disturbance only, then that minor or preliminary disturbance may be approved by the Executive Director, Department of Conservation and Land Management on behalf of the Minister for the Environment.

In that case, the proponent may effect the minor or preliminary ground disturbance approved by the Executive Director, prior to satisfying the requirements of the condition, provided that the proponent has in writing advised the Chief Executive Officer, Department of Environment of the approval granted.

Notes

1. The Minister for the Environment will determine any dispute between the proponent and the Environmental Protection Authority or the Department of Environment over the fulfilment of the requirements of the conditions.

2. The proponent is required to apply for a Works Approval / Licence / Registration for this project under the provisions of Part V of the *Environmental Protection Act 1986.*

3. Within this statement, to "have in place" means to "prepare, document, implement and maintain for the duration of the proposal".

4. Compliance and performance reporting will endeavour to be in accord with the timing requirements of the *Barrow Island Act 2003*.

5. "Surrounding waters of Barrow Island" means the waters included in any marine management area set out in the Management Plan for the proposed Montebello/Barrow Islands Marine Conservation Reserves and the waters of the Port of Barrow Island [however that is formally described].

6. "Statistically sound" means having a statistical design with sufficient replication to enable rigorous statistical analysis of the data collected, as agreed with the Department of Conservation and Land Management or the Department of Fisheries, on the advice of an appropriately qualified expert in statistics.

7. Where there are scientific difficulties in determining the taxonomy to species level, the proponent shall obtain the advice of appropriate scientific authorities on the practicability of a determination to that level, to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority.

8. Unless otherwise specified, the level of statistical power to be met is the 95% confidence interval.

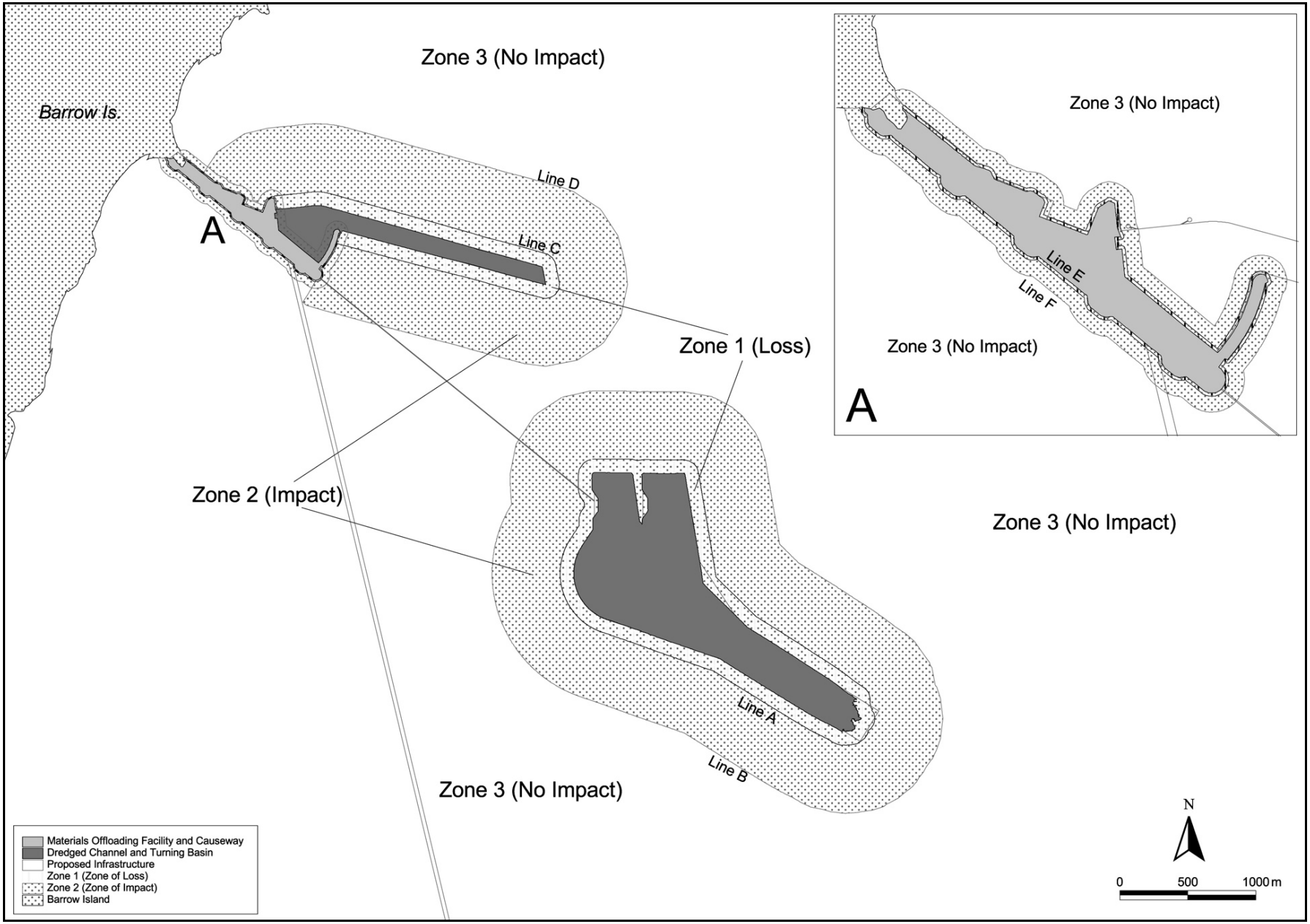


Figure A 4.1: Schematic representation of a section of the Marine Infrastructure plan required by condition 14.1.

Appendix 5

Summary of Submissions and
Proponent's Response to Submissions included on Disk 1 inside back cover

Appendix 6

Residual Risk Tables

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
VEGETATION AND FLORA			
Clearing for gas processing facility, pipelines, jetty approaches and associated infrastructure (restricted flora and vegetation communities)	M		
Clearing for gas processing facility, pipelines, jetty approaches and associated infrastructure (general flora and vegetation communities)	L		
Clearing for CO_2 seismic baseline survey (restricted flora and vegetation communities)	M		
Clearing for CO_2 seismic baseline survey (general flora and vegetation communities)	L		
Minor clearing and earthworks restricted to previously disturbed ground (restricted and general flora and vegetation communities)		L	
Re-clearing survey lines for CO_2 seismic monitoring every 5 to 10 years (restricted and general flora and vegetation communities)		L	
Fire from welding, grinding and vehicle exhausts, which can be ignition sources	M		
Fire from maintenance activities and vehicle exhausts, which can be ignition sources		M	
Fire from fall out of burning particles from flare		M	
Low levels of vehicle and equipment exhaust	L	L	
Atmospheric emissions from flaring and venting	L		
Combustion and fugitive emissions of SO_2, NO_x, CO_2, VOCs and particulates		L	
Atmospheric emissions from gas leak through pipeline or equipment failure			L
Atmospheric emissions from flaring			L
Smoke and particulates from fire			L
Atmospheric emissions from gas venting during start up and shut down of gas processing facility			L
Temporary shading from stockpiles and equipment	L		
Long term shading from pipelines		L	
Heat and reflected light from infrastructure		L	
Condensation from cool feed gas pipeline		L	
Dust generation from clearing and earthworks	L		
Dust generation from vehicle and machinery movement on unsealed roads and exposed surfaces	L	L	
Dust generation from wind erosion of stockpiles	L		
Unpredicted CO_2 migration from failure of CO_2 injection facilities			L
Unpredicted CO_2 migration from failure of subsurface containment			L
Spill during storage and transport of fuel or hazardous material	L	L	
Spill or leak during waste storage and disposal	L	L	
Spill or leak from failure of plant, equipment or pipelines	L	L	
Leakage of storage tanks and bunds	L	L	

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
TERRESTRIAL FAUNA			
Clearing of vegetation and structural habitats	M		
Limited clearing and earthworks of previously cleared areas		L	
Periodic clearing on previous survey grid for CO_2 seismic monitoring		L	
Physical interaction with vehicular traffic	M	M	
Physical interaction with operation of equipment and machinery	M	M	
Physical interaction with workforce activities	M	M	
Physical interaction with the presence of infrastructure		M	
Spill during storage and transport of fuel or hazardous material	L	L	
Spill or leak during waste storage and disposal	L	L	
Spill or leak from failure of plant, equipment or pipelines	L	L	
Shading from infrastructure	L	L	
Artificial lighting at night from construction sites and flares	L	L	
Flaring during process upset or emergency	L	L	L
Low levels of vehicle and equipment exhaust (NO_x , SO_x)	L	L	
Combustion and fugitive emissions of SO_2, NO_x, CO_2, VOCs and particulates		L	
Pipeline or equipment failure resulting in the emission of H_2S, BTEX, CO_2 or hydrocarbons	L	L	L
Flaring releasing combustion products or unburnt gas	L	L	L
Smoke and particulates from fire and flaring	L	L	L
Atmospheric emissions from unscheduled start up and shut down of gas processing facility	L	L	L
Dust generation from clearing of vegetation and removal of topsoil	L		
Dust generation from earthmoving	L		
Dust generation from the movement of heavy machinery and vehicles on unpaved surfaces	L		
Dust generation from blasting	L		
Dust generation from the movement of vehicles and machinery on unsealed surfaces		L	
Dust generation from wind erosion of unsealed surfaces		L	
Unpredicted CO_2 migration or release from failure of CO_2 injection facilities, or subsurface containment			L
Unpredicted CO_2 migration or release from emergency venting of CO_2 to atmosphere if injection system breaks down			L
Heat from sources such as power generators, turbines, air coolers, pipelines, earthmoving equipment, welding units and vehicles	L		
Cold from pipelines	L		
Heat from power generators, air coolers, turbines, flares etc		L	
Feed gas pipeline will be at ambient temperature		L	
Noise and vibration from blasting	L		
Noise and vibration from seismic survey	L		
Noise and vibration from the gas processing facility		M	

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
Noise and vibration from the operation of vehicles and equipment		M	
Noise and vibration from flaring		M	
Noise and vibration from seismic monitoring every 5 to 10 years		M	
Fire from vehicles, welding sparks and potential ignition sources	M	M	
Fire from flare event dislodging hot build up from inside flare tower	M	M	
Fire from runoff of water or foam used in fire control near infrastructure	M	M	
SUBTERRANEAN FAUNA			
Clearing and earthworks for the infrastructure	L – H*		
Excavation of material during site preparation	L – H*		
Shallow blasting of cap rock over 40 to 60% of the gas processing facility site	L – H*		
Installation of about 750 piles, to a depth of about 32 metres	L – H*		
Minor clearing and earthworks during operations		L	
Use of treated grey water to control dust at the gas processing facility site contaminating subterranean habitats	M		
Noise and vibration from shallow blasting of cap rock over 40 to 60% of the gas processing facility site	L – M*		
Noise and vibration from the installation of about 750 piles, to a depth of about 32 metres	L – M*		
Spill or leak from failure of proposed bulk storage tanks and containment bund	L	L	
Spill during storage and transport of fuel or hazardous material	L	L	
Spill or leak during waste storage and disposal	L	L	
Spill or leak from failure of plant, equipment or pipelines	L	L	
Unpredicted CO_2 migration from failure of CO_2 injection facilities, or subsurface containment		M	
Physical presence of gas processing facility resulting in impermeable surfaces with no groundwater recharge over 30 to 40% of the site (45 to 60 hectares)		M	
Abstraction of groundwater for reverse osmosis plant		H	
SOIL AND LANDFORM			
Vegetation clearing and earthworks for construction of infrastructure	M		
Minor clearing and earthworks		L	
Generation and disposal of liquid and solid wastes	M	L	
Spill during storage and transport of fuel or hazardous material	M	M	
Spill or leak from failure of plant, equipment or pipelines	M	M	
Horizontal directional drilling fluid release	M	M	

* If subterranean fauna currently found beneath the footprint site are shown to have a wider distribution, the risk is reduced to Low

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
SURFACE WATER AND GROUNDWATER			
Vegetation clearing and earthworks for construction of infrastructure	M		
Minor clearing and earthworks		L	
Sealing of gas processing facility site and road surfaces	M	M	
Generation and disposal of liquid and solid wastes	M	L	
Spill during storage and transport of fuel or hazardous material	M	M	
Spill or leak during waste storage and disposal	M	M	
Spill or leak from failure of plant, equipment or pipelines	M	M	
MARINE FAUNA			
Seabed disturbance from dredging and blasting for marine infrastructure	M		
Seabed disturbance from dumping of dredge spoil	M		
Seabed disturbance from construction of feed gas pipelines and domestic gas pipeline	M		
Seabed disturbance from construction of causeway and open pile jetty	M		
Seabed disturbance from drilling of subsea wells	M		
Seabed disturbance from installation of subsea gathering system	M		
Seabed disturbance from anchoring of drill rigs and pipelay vessel	M		
Seabed disturbance from installation of optical fibre cable to the mainland	M		
Seabed disturbance from localised maintenance dredging		L	
Seabed disturbance from re-suspension of materials at spoil disposal site		L	
Physical interaction with vessels and barges	M	M	
Physical interaction during dredging for shipping channels	M		
Physical interaction with the workforce on Barrow Island	M	M	
Physical interaction during maintenance operations at marine facilities		M	
Physical presence of marine infrastructure, gas pipelines, optical fibre cables and dredged channels		L	
Discharge of stormwater containing chemicals, hydrocarbons and sediments into the marine environment	L		
Deck washdown	L		
Deck runoff and domestic discharges from rigs and other construction vessels	L		
Discharge of hydrotest water from feed gas pipeline containing biocides and corrosion inhibitors	L		
Discharge of drilling fluids	L		
Runoff from hardstand areas such as the jetty, containing chemicals, or hydrocarbons and entering the marine environment		L	
Runoff from decks (operations vessels)		L	
Leaching of anti-foul compounds from painted infrastructure and vessel hulls		L	

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
Flaring during commissioning	M – H		
Night time operation of the gas processing facility and associated infrastructure		M – H	
Flaring during non routine operations			L
Noise and vibration from vessel movements, drilling, dredging, pipelay and piling	M		
Noise and vibration from blasting during dredging on the east coast for marine infrastructure	M		
Noise and vibration from horizontal directional drilling for the west coast shore crossing	M		
Noise from vessel and tanker movements		L	
Noise from subsea gathering system		L	
Small spill or leak caused by small vessel grounding/collision, vessel refuelling, transferring and transport of hydrocarbons and/or chemicals	M	M	
Large spill or leak caused by pipeline failure, larger vessels damaged by grounding or collision, process or operator failure or collision during construction or operations	M	M	
PHYSICAL MARINE ENVIRONMENT			
Seabed disturbance from dredging and blasting for the construction of marine infrastructure	L – M		
Seabed disturbance from dumping of dredge spoil	L – M		
Seabed disturbance from construction of feed gas pipelines, domestic gas pipeline and optical fibre cable	L – M		
Seabed disturbance from drilling of subsea wells and installation of subsea gathering system	L – M		
Seabed disturbance from anchoring of drill rigs, pipelay vessels and dredge vessels	L – M		
Seabed disturbance from localised maintenance dredging		L	
Seabed disturbance from re-suspension of sediments in vessel turning areas		L	
Seabed disturbance from additional wells		L	
Physical presence of marine infrastructure and optical fibre cables		L	
Physical presence of feed gas and domestic gas pipelines		L	
Generation and disposal of liquid and solid wastes entering the marine environment	L	L	
Leaks or spills from the storage and transport of chemicals, fuels or other hazardous material impacting the seabed	L	L	
Leaks or spills from vessel collision or grounding impacting the seabed	L	L	
Leaks or spills from failure of equipment or pipelines impacting the seabed	L	L	
Changes to marine water quality from discharges from marine construction vessels – stormwater, brine from desalination, sewage, grey water and macerated food	L		
Changes to marine water quality from the dredge spoil	L		
Changes to marine water quality from the discharge of hydrotest water	L		

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
Changes to marine water quality from maintenance dredging		L	
Changes to marine water quality from runoff from hardstand areas such as the jetty and materials offloading facility		L	
Changes to marine water quality from the discharge of ballast and bilge water from loading vessels		L	
Changes to marine water quality from leaching of anti-fouling compounds from vessel hulls and marine structures		L	
Leaks or spills from the storage and transport of chemicals, fuels or other hazardous material impacting marine water quality	L	L	
Leaks or spills from vessel collision or grounding impacting marine water quality	L	L	
Leaks or spills from failure of equipment or pipelines impacting marine water quality	L	L	
Physical disturbance of the foreshore from clearing and earthworks for infrastructure	M		
Exposure of potential acid sulphate soils on mainland domestic pipeline and optical fibre cable easements	M		
No clearing or earthworks are expected in foreshore areas during operations		L	
The physical presence of the causeway and dredged channels may potentially affect longshore coastal sediment transport dynamics		L	
The cleared domestic gas pipeline corridor on the mainland impacting on the foreshore		L	
BENTHIC PRIMARY PRODUCERS			
Seabed disturbance from dredging and blasting for the construction of the materials offloading facility, causeway, LNG load-out facility and jetty	M (direct impacts) L – M (indirect impacts)		
Seabed disturbance from dumping of dredge spoil	M (direct impacts) L – M (indirect impacts)		
Seabed disturbance from construction of feed gas pipelines, domestic gas pipeline and optical fibre cable	M (direct impacts) L – M (indirect impacts)		
Seabed disturbance from construction of open pile jetty	M (direct impacts) L – M (indirect impacts)		
Seabed disturbance from drilling of subsea wells	M (direct impacts) L – M (indirect impacts)		
Seabed disturbance from installation of subsea gathering system	M (direct impacts) L – M (indirect impacts)		

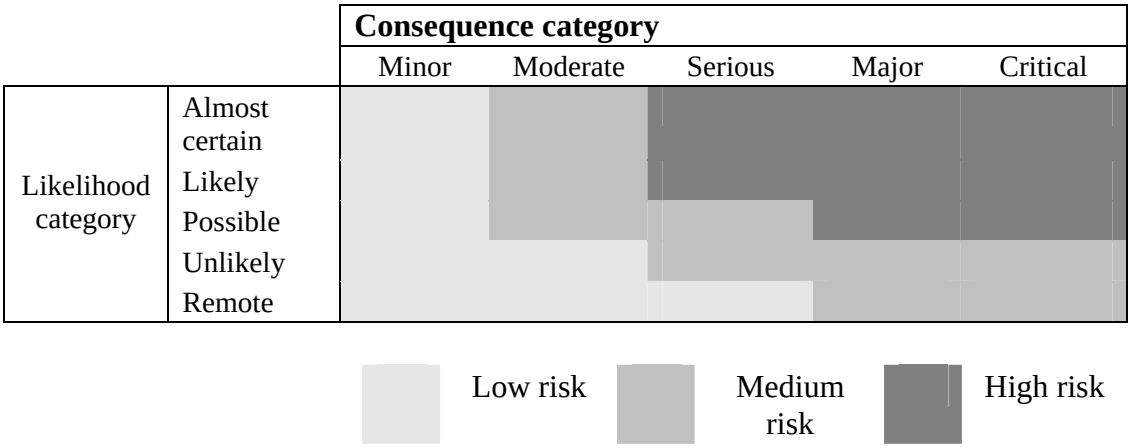
PROPOSED PROJECT ACTIVITY	RESIDUAL RISK		
	Construction & commissioning	Operations	Non-routine
Seabed disturbance from localised maintenance dredging		L	
Seabed disturbance from re-suspension of sediments at spoil disposal site		L	
Small spill or leak from small vessel grounding or collision, refuelling, transferring and transport of hydrocarbons and/or chemicals during construction and operations			L – M
Large leak or spill from pipeline failure, process or operator failure or vessel grounding or collision during construction or operations			L – M
Tanker, barge and other vessel movements	L	L	
Permanent presence of marine infrastructure		L	
Stormwater discharge from construction areas on shore	L		
Deck wash from rigs and other construction vessels	L		
Drilling fluids and cuttings discharged at offshore field	L		
Ballast water discharge	L		
Discharge of hydrotest water containing biocides and corrosion inhibitors	L		
Runoff from hardstand areas containing chemicals		L	
Runoff from decks of tankers and support vessels		L	
Ballast and bilge water discharge		L	
AIR QUALITY			
Low levels of emissions associated with vessels	L		
Low levels of vehicle and equipment exhaust (NO_x , SO_x)	L	L	
Combustion and fugitive emissions of SO_2, NO_x, CO_2, CO, CO_4, VOCs and particulates		L	
Atmospheric emissions from CO_2 leaks			L
Atmospheric emissions from pipeline or equipment failure			L
Atmospheric emissions from flaring			L
Smoke and particulates from fire			L
Start up and shut down of gas processing facility			L
Dust generation associated with clearing and earthworks and vehicle movement	L		
Localised dust generation associated with minor clearing and earthworks		L	

PROPOSED PROJECT ACTIVITY	RESIDUAL RISK			
	Pre-construction	Construction	Operations	Closure
CULTURAL HERITAGE				
Damage to anthropological or archaeological sites from surface disturbing activities	L	H	M	L
Damage to historical sites (terrestrial and underwater) from surface disturbing activities	L	M	L	L
PUBLIC HEALTH AND SAEFTY				
Plant or equipment failure		M	M	
Cyclones or other natural disasters		M	M	
Development standards not maintained		M	M	
Ineffective contract management		M	M	

Construction workforce restricted to construction site and village areas		M	
Traffic accidents from transport of materials, goods and personnel on local roads		L	
Traffic accidents from use of heavy vehicles		L	

Total number of proposed project activities with a Low residual risk	163
Total number of proposed project activities with a Medium residual risk	103
Total number of proposed project activities with a High residual risk	9
Total number of proposed project activities	275
Percentage of proposed project activities that have a Low residual risk	59
Percentage of proposed project activities that have a Medium residual risk	38
Percentage of proposed project activities that have a High residual risk	3

Gorgon Development Environmental Risk Matrix



Appendix 7

Report by CSIRO

Review of Gorgon Gas Development Environmental Impact Statement and Environmental Review and Management Programme

KR Hayes, FR McEnnulty & R Babcock

January 2006

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Review of Gorgon gas development environmental impact statement and environmental review and management programme.

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EXECUTIVE SUMMARY

Chapters 9, 11 and 12 of the Gorgon EIS/ERMP contain some commendable analyses. Unfortunately these rare, and as yet incomplete, examples of good quality work are overwhelmed by too many examples of poor quality analysis. The scoping and definition of terms used to describe impacts in the marine environment needs further work, particularly the meaning of the term 'local'. The joint venturers do not appear to have used a systematic hazard analysis tool to identify and prioritise impacts in the marine environment, and there is no evidence that the beliefs and values of stakeholders and community groups have been formally acknowledged or incorporated into the assessment. Regional risk arguments used in Chapter 11 are not supported by an equivalent regional assessment and are not therefore risk averse.

The level of detail and quality of analysis varies dramatically between marine taxa. Disproportionately large sections of Chapter 11 and the technical appendices are dedicated to potential impacts on coral and some (but not all) species of turtles. The level of detail and quality of work directed to other primary producer communities and protected marine species is cursory and poor. Chapter 11 identifies 45 marine ecosystem components/processes that are directly related to the assessment endpoints and potentially threatened by the construction and operation activities of the Gorgon Gas development. The chapter, however, only specifies performance indicators for 5 of these. The chapter goes on to specify some performance targets but the approach is neither consistent in coverage (targets are only specified for 26 of the ecosystem component and processes) or approach (only 4 of the targets are measurable quantitative values whereas the remainder are qualitative aspirations). The end result is a confusing mix of specific performance indicators, measurable targets, and vague statements of intent and aspiration. Consistency and clarity of approach across all components and processes that are potentially threatened by the development is notably absent.

The joint venturers have clearly put a great deal of effort into developing and implementing a quarantine management system that will protect the endemic and native species on Barrow Island. This is appropriate given that Barrow Island's iconic conservation status largely stems from the absence of introduced terrestrial pests that have exterminated, or continue to threaten, species of plants, birds and mammals on mainland Australia. Unfortunately the quarantine risk management strategies described in Chapter 12, and the additional information package, are fatally undermined by demonstrably flawed logic.

The flaw in the joint venturers logic is best exemplified by considering the effect of 10 totally ineffective quarantine barriers – i.e. ten barriers that each score 10 (infections occur continuously throughout the year) in terms of the likelihood of pathway infection. Under the approach described in the EIS/ERMP the residual risk of introduction for that pathway would be 10-(10-1) = 1 - i.e. the infection is extremely remote, highly unlikely. This is obviously nonsense. The joint venturers describe the resultant QMS as 'world class' but in reality it provides an arbitrary and unquantified level of protection to the endemic, threatened and protected species of Barrow Island. It is also apparent from the detailed pathway analysis that the residual introduction risk of some pathways/biological group combinations exceeds the community expectations (notwithstanding the flawed logic of the risk estimates). The joint venturers' approach to this is unclear.

We recommend that the joint venturers should:

1. in collaboration with stakeholders, augment the current risk assessment with a formalised, systematic and transparent hazard analysis that addresses and prioritises all potential threats to the marine (and terrestrial) environment;

2. conduct quantitative surveys of all relevant (impact and control) subtidal and intertidal habitats;

3. conduct a much more thorough investigation of the distribution, abundance and behaviour of protected marine species in each of the proposed development areas. This is particularly pertinent to the endangered species of loggerhead turtles and olive ridley sea turtle;

4. extend quantitative turtle surveys to fully include the nesting season of green, flatback and hawksbill turtles;

5. develop a management and monitoring strategy for all ecosystem components/process identified in the EIS/ERMP as threatened by the proposed development. Each of these strategies, including the current strategy, should be formally evaluated;

6. incorporate all new and existing bio-physical models into the formal management strategy evaluation recommended above, for all measurement endpoints, as soon as possible;

7. undertake a much more thorough uncertainty analysis, ideally within the risk management framework recommended above;

8. discard the current qualitative decision rules for quarantine barrier selection and replace them with quantitative estimates of efficacy;

9. use the IMEA to prioritise potential quarantine hazards and then use relevant statistical models, in a quantitative risk management analysis, to demonstrate compliance with community expectations; and,

10. augment the proposed marine environmental-match assessment with a species-specific assessment.

We also suggest that the joint venturers consider adopting a quantitative population viability analysis for protected marine species instead of the current qualitative approach. In addition we suggest they consider simplifying the quarantine risk assessment by asking the community to re-specify its acceptance criteria at earlier points in the infection pathway, and establish statistically sound testing and inspection routines at these points to ensure that the community's expectations are met.

In conclusion we believe that in order to reach a good scientific standard the EIS/ERMP needs to develop a comprehensive management strategy for key threatened marine and ecosystem components/processes, supported by considerably better data and analysis, together with a new quantitative approach to quarantine risk management.

CONTENTS

1. INTRODUCTION

1.1 Background

1.1.1 Barrow Island

Barrow Island is situated on Australia's North West shelf approximately 70 kms off the Pilbara coast of Western Australia. The island has a total area of 234 kms^2 and is the largest of a series of islands in this region. Barrow Island supports a diversity of species, some of which have evolved in isolation from the mainland for 8000 years. Its land mass and surrounding waters provide habitat and refuge for 4 endangered species (loggerhead sea turtle, olive ridley sea turtle, southern giant petrel and blue whale), 6 vulnerable species of terrestrial mammal, one vulnerable species of land bird, 3 vulnerable species of sea turtles, 2 vulnerable species of subterranean fish, together with 27 migratory species, all of which are protected under state and commonwealth legislation, including the Environmental Protection and Biodiversity Conservation (EPBC) Act (Chevron Australia 2005).

Barrow Island is internationally recognised for its conservation status. It was declared a Nature Reserve in 1908, and proclaimed a 'Class A' Nature Reserve two years later (Chevron Australia 2005). It has been described as the 'jewel in the crown' of the conservation estate of Western Australia (EPA 2003). The island's iconic conservation status stems largely from the absence of introduced mice, rats, cats, goats, sheep, rabbits and foxes. This is unique for a tropical island of this size. The island provides a haven for native species threatened or exterminated by introduced species elsewhere in Australia and the world. It is home for 24 terrestrial taxa found nowhere else in the world and 5 terrestrial taxa that are restricted elsewhere (EPA 2003).

1.1.2 The proposed Gorgon Development

The Gorgon Joint Venturers (Chevron Australia, Texaco Australia, Shell Development Australia and Mobil Australia) are proposing to build and operate a Liquefied Natural Gas (LNG) and domestic gas processing facility on Barrow Island. The facility will produce approximately 10 million tonnes of LNG per annum, together with 300 terajoules of domestic gas and 2000 m^3 of hydrocarbon condensate per day. Construction of the plant is currently scheduled for late-2006 and is anticipated to operate for approximately 60 years (Chevron Australia 2005).

The key construction elements of the proposed Gorgon Development are:

- sub-sea production centres (18 to 25 well heads) in the Gorgon Gas Field, approximately 70 kms to the North-West of Barrow Island;
- feed gas (approximately 84 kms) and domestic gas (approximately 100 kms) pipelines, together with associated easements and land fall facilities, from the Gorgon Gas Field to the Barrow Island processing facility;

- construction of a gas processing and production facility at Town Point, Barrow Island;
- construction of a materials offloading facility (MOF) with an 800 m causeway and an LNG load-out facility with 3.1 km jetty;
- dredging an MOF access channel and turning basin (approximately 0.8 million m^3) together with a shipping channel and turning basin (between 7 and 8 million m^3) and associated dredge spoil ground (approximately 1500 ha); and
- approximately 2800 barge movements , 94,000 to 170,000 personnel landings between the mainland and Barrow Island, and 1.2 million imported freight tonnes over a 40 month construction period (Chevron Texaco Australia 2003, Chevron Australia 2005).

The key operational elements of the proposed Gorgon Development are:

- An approximate 300 ha footprint that accommodates the gas processing facility, associated infrastructure and pipeline easements;
- power supply and water supply, treatment and disposal facilities;
- greenhouse gas emissions (approximately 4 million tonnes of CO_2 equivalents), NO_x (approximately 4430 tonnes) and SO_x (approximately 0.15 tonnes) emissions, together with approximately 241 tonnes of total emitted particulates (PM10), per annum;
- periodic maintenance dredging of the shipping channel and turning basin;
- 3 LNG ship visits per week and one condensate ship visit per month; and,
- an initial estimate of 200 barge movements per annum and 75 personnel landings per week between the mainland and Barrow island during the operational period of the facility (Chevron Texaco Australia 2003).

1.2 Aim and objectives

The overall aim of this project is to conduct a desk-top review of the Gorgon Gas Project Environmental Impact Statement and Environmental Review and Management Programme (hereafter referred to as the Gorgon EIS/ERMP). The project will review Chapter 9 (Risk Assessment Approach), Chapter 11 (Marine Environment – Risks and Management) and Chapter 12 (Quarantine Risks and Management), associated technical appendices, relevant additional material and other sections of the Gorgon EIS/ERMP document directly relevant to these chapters.

The specific project objectives are:

1. Assess the theoretical underpinnings and practical efficacy of the Gorgon EIS/ERMP with respect to the marine environmental values of Barrow Island;

2. Where appropriate, outline any modifications to the quarantine management system necessary to adequately protect the terrestrial and marine environmental values of Barrow Island;

3. Review the detailed assessments of the three quarantine pathways completed to date;

4. Subject to cost and time constraints, provide specific comments on:

    a. the impact and risks to benthic primary producers and marine fauna, particularly with respect to proposed dredging activities;

    b. the impact and risks to protected marine fauna;

    c. the impact and risks to intertidal habitats;

    d. the dredge plume model validation;

5. Submit a report to the Western Australia Environmental Protection Authority (EPA) covering the above points.

This report represents the project deliverable under the fifth objective. During this review we noted a number of editorial errors in the EIS/ERMP such as incorrect references to figure headings, table legends or entire sections of the document, and various inconsistencies between text, tables and Appendices. This report does not document these errors.

2. CHAPTER REVIEW

2.1 Chapter 9: Risk assessment approach

2.1.1 Methodology

The joint venturers adopt a qualitative risk assessment approach that complies with current Australian standards (AS/NZS 4360:2004). This approach uses a standardised 'risk matrix' to combine qualitative estimates of the likelihood and consequence of undesired events into a single risk estimate. It is important to note, however, that the current Australian and New Zealand standard does not provide comprehensive guidance on the potential pitfalls associated with qualitative risk assessment or ways to try and avoid these pitfalls (Burgman 1999). As a result compliance with the current standard does not guarantee a high scientific standard.

2.1.2 Scientific credibility

The scientific credibility of a qualitative risk assessment is largely determined by the expertise of the group performing the assessment and the manner in which the group's opinions and predictions are elicited, combined, and prioritised. All humans exhibit a range of psychological behaviours that have a profound influence on qualitative risk estimates. Our judgement is adversely affected by personal experience, level of understanding and control over the outcome, its apparent dreadfulness and who ultimately bears the burden of risk. Furthermore when individuals assess risks subjectively they are often influenced by cognitive bias (overconfidence in one's ability to predict), framing effects (judgements of risk are sensitive to the prospect of personal gain or loss), anchoring (the tendency to be influenced by initial estimates) and insensitivity to sample size (Burgman 2001, 2005).

These "psychological frailties" can lead to unfounded certainty– both naïve and sophisticated subjects tend to be more confident about their predictions than they should be. Qualitative assessments may not therefore err on the side of conservatism even when they purport to do so (Ferson and Long 1995). Conversely, the risk matrix approach espoused by current Australian standards can, under certain circumstances, lead to overconservative bias (Cox et al 2005). Furthermore, the same qualitative assessment, conducted by different interest groups, can reach opposite conclusions, when presented with the same data, for no apparent reason (Hayes 2003). These effects undermine the repeatability, transparency and scientific credibility of qualitative risk assessments.

There are a number of hazard analysis and risk assessment techniques designed to maintain the scientific credibility of qualitative risk assessments (Table 2.1). These techniques encourage consistent, systematic evaluation, clear communication and help expose assumptions and value judgements. The joint venturers have adopted some of these techniques. Chapter 9 scopes the assessment. Some measurable effects are predicted in Chapter 11, and Chapter 12 uses formal hazard assessment techniques. Nonetheless serious problems remain in each of these areas (see sections 2.1.3, section 2.2.1 and section 2.3.3 respectively).

Table 2.1 Hazard analysis and risk assessment methods and techniques that help maintain the scientific credibility of qualitative risk assessment

Issue	Methods and techniques
Be representative	Identify all relevant experts and stakeholders and seek to include them in the assessment team from the very start of the assessment.
Scope and define	Ensure the spatial and temporal scope of the assessment is understood by all. Clearly define all predictive terms (such as high, medium or low likelihood and consequence) in terms relevant to the scope of the assessment.
Avoid predictive bias	Use structured elicitation and aggregation techniques to help avoid "psychological frailties" such as insensitivity to sample size, overconfidence, judgemental bias and anchoring (Burgman 2001, 2005).
Identify all possible hazards	Use structured hazard identification techniques such as influence diagrams (Hart et al 2005), fault tree analysis (Haimes 1998, Hayes 2002a), Failure Modes and Effects Analysis (Palady 1995, Hayes 2002b), Hazard and Operability Analysis (Kletz 1999) or Hierarchical Holographic Modelling (Haimes 1998, Hayes et al 2004) to rigorously and systematically identify all possible hazards.
Formally prioritise hazards	Consider using formal prioritisation procedures such as the Analytical Hierarchy Process (Saaty 1988), or Failure Modes and Effects Analysis, when prioritising hazards or combining the predictions of different stakeholders. Keep a careful record of the process, methods and predictions of the assessment.
Monitor and test predictions	Predict measurable effects and monitor these with sufficient sensitivity to test the risk assessment predictions and thereby close the regulatory loop and generate additional data.
Peer review	Seek an independent peer review of the risk assessment and its results.

2.1.3 Scope, definitions and consequence characterisation

The first step in a risk assessment is to carefully define the boundaries and scope of the assessment, and the risk assessment terms used. The Gorgon EIS/ERMP defines all the terms that it uses but in many instances the definitions are circular, unbounded and vague. For example the term 'widespread' is defined as 'impacts extending to areas well-outside the direct impact zone from the development'. This definition lacks boundaries and is too vague (what does well-outside mean in a marine context?). The definition of 'local' is circular – it refers to 'the immediate vicinity of the development' but the term 'immediate vicinity' is not defined and the marine boundary of the 'immediate region' is unclear. Note that these types of problems are repeated for a variety of other terms used to characterise impacts in the marine environment (see below). Finally, the definition of impact as a 'direct interaction of a stressor with the environment' appears to preclude the possibility of indirect effects of stressors, which presumably is not the intent.

Chapter 9 of the EIS/ERMP distinguishes impacts at the level of individual organisms and at a population level. At the individual level the joint venturers use 'sharp' spatial and temporal boundaries to distinguish moderate, serious, major and critical consequences. Sharp boundaries are commonly used in qualitative risk assessment to avoid a phenomena known as 'Sorites Paradox' (Regan et al 2002, Burgman 2005) by giving definition borders to categories (of likelihood and consequence for example) that lie along a continuum. They are an attempt to avoid vagueness (a type of linguistic uncertainty) associated with terms such as low, medium and high. Sharp boundaries, however, are not a good way to avoid vagueness because small changes close to the boundary give rise to (potentially misleading) category changes.

Consider for example the difference between the following impacts on the behaviour of protected marine species: 'local, short term', 'local, long term or widespread short term' and 'widespread long term'. These are defined in the Gorgon EIS/ERMP as minor, moderate and serious consequences respectively. As noted above, the terms 'local' and 'widespread' are problematic in this context. Notwithstanding these difficulties note that a local impact that lasts 5.1 years and a widespread impact that lasts 4.9 years would be assigned the same 'moderate' consequence. Alternatively consider the statement, 'the consequences of deterred nesting and selection of less suitable beaches is considered to be moderate with a loss of a proportion of 3 to 4 seasons of hatchlings'. Note that if hatchling loss lasted 5 seasons the consequences would be deemed 'serious'.

At the population level, the joint venturers place less emphasis on the spatial and temporal boundaries discussed above in favour of population viability criteria. At this level the moderate, serious and major consequences categories for protected species have the same spatial and temporal boundary (local long term or widespread short term) and are defined as 'loss of small number of individuals without reduction in local population viability', 'loss of individuals leads to reduction in viability of local population' and 'loss of local population(s)' respectively. There are two problems here. The first is linguistic uncertainty. The term 'local population' is vague because the definition of local (as noted above) is circular and the term 'small' is undefined in this context. There is considerable scope for different interpretation of these consequence categories leading to very different risk estimates.

The second problem with these definitions is that they do not adequately address the possibility of cumulative impact - i.e. localised, long term, recurrent loss of 'small' numbers of individuals that eventually reduces the viability of local populations resulting ultimately in their loss. Consider for example the impacts associated with maintenance dredging and resuspension caused by the propeller wash of arriving/departing ships and tugs (if any – none are mentioned in the EIS/ERMP) that usually assist large vessels in port. The impacts associated with these activities are recognised to be long term but the consequences are rated low in the EIS/ERMP which by definition implies 'no expected decrease in local population viability'. Coral settlement, however, can be significantly affected by changes in sedimentation as low as 3-10 mg cm^{-2} day^{-1} particularly where it increases from a low base (~1 mg cm^{-2} day^{-1}) (Babcock and Davies 1991, Babcock and Smith 2003). We suspect that the cumulative impact of weekly sediment resuspension for 60 years will have a moderate to serious impact on local populations of coral, depending on the subsequent dispersal of the sediment plumes and how one defines 'local'. Moreover in the absence of a formal population viability analysis (Boyce 1992, Burgman et al. 1993, Possingham et al 1993, McCarthy et al 2001), it is difficult to see how the joint venturers are able to distinguish between the moderate/serious and serious/major consequence categories of any protected species over a 60 year duration. We suggest that the joint venturers consider adopting a quantitative population viability analysis in favour of the current qualitative approach.

2.1.4 Hazard and uncertainty analysis

The hazards and threats associated with the proposed Gorgon development were systematically identified through a number of hazard identification workshops (Chevron Australia 2005). The EIS/ERMP does not, however, describe the formal process, if any, that was adopted in these workshops. It appears as if hazards were simply identified by brainstorming. The resulting list of stressors and associated development activities appears to be comprehensive but in the absence of a formal procedure this is difficult to confirm. There is no record of potentially threatening processes that were deemed irrelevant. For example, are there any electrical or electro-magnetic threats associated with the development? As a result it is possible that potential threats have been overlooked (see also section 2.2.5).

The stressors identified in the EIS/ERMP represent direct threats to the environmental values of Barrow Island. There is no evidence that the joint venturers have systematically evaluated planned and unplanned events, interactions between natural (e.g. cyclones) and Gorgon-induced threats, or antagonistic effects of multiple stressors operating in concert. As a result it is possible that potential threat scenarios have been overlooked or not adequately addressed.

There are various types of uncertainty in environmental risk assessment (Regan et al. 2002, Regan et al. 2003, Burgman 2005, Hayes et al. in review). The EIS/ERMP does not formally recognise different types of uncertainty, or provide any systematic evaluation of uncertainty in its predictions. The joint venturers claim that there is little uncertainty in the exposure mechanisms of planned events and that the exposure mechanisms of unplanned events are well understood. It is very difficult to believe that there is no uncertainty in planned exposure mechanisms in a development of this magnitude at this (relatively early) stage of development. The revised estimates of personnel landings from 170,000 (Chevron Texaco Australia 2003) to 94,000 (Chevron Australia 2005), for example, are indicative of the uncertainty that arises as major developments are planned and progress. Furthermore, in the absence of a hazard analysis

procedure that asks, ‘What can go wrong?’ it is also difficult to accept that the joint venturers have fully explored all potential exposure mechanisms of unplanned events, outside of hydrocarbon leaks and spills.

Overall, the joint venturers’ approach to uncertainty is unclear. The EIS/ERMP claims to adopt a ‘worst-case’ approach, combining the most serious of a range of potential consequences, with the most frequent of a range of potential likelihoods, in its final risk estimates. This approach is not consistently applied (see section 2.2.6), and cannot be verified given the information presented in the EIS/ERMP.

2.2 Chapter 11: Marine environmental risks and management

2.2.1 Methodology

The joint venturers have clearly consulted a large number of stakeholders (Chevron Australia 2005) but there is no evidence in the Gorgon EIS/ERMP that their opinions or beliefs have been formally included within the marine impact/risk assessment. For example, there is no evidence of any formal elicitation techniques, Delphi process, analytical hierarchy process or equivalent techniques to help elicit and aggregate opinions of stakeholders and experts. Chapter 11 of the EIS/ERMP appears to simply portray the beliefs and values of the proponents.

The EIS/ERMP identifies a number of assessment endpoints for five marine ecosystem categories (Table 2.2). In risk assessment parlance, assessment endpoints represent the values that the analyst is trying to protect by conducting the risk assessment. In this example some of the assessment endpoints are very broad and/or poorly specified. Maintenance of ‘environmental value’ for example is extremely vague and open to several alternative interpretations depending on one’s point of view.

Table 2.2 Assessment endpoints for ecosystem components identified in the Gorgon EIS/ERMP

Ecosystem description	Assessment endpoint(s)
Foreshore	Maintain integrity and stability of beaches
Marine benthic habitat, subtidal and intertidal zone	Maintain ecological function and environmental value
Marine benthic primary producers	Maintain ecological function, abundance, species diversity and geographic distribution
Marine fauna	Maintain abundance, species diversity, geographic distribution and ecological function. Avoid, minimise and/or mitigate impacts on locally significant marine communities. Protect EPBC Act listed threatened and migratory species. Protect specially protected (threatened) fauna consistent with provisions of Wildlife Conservation Act 1950
Marine water column	Maintain existing and potential values and ecosystem function

Risk analysts avoid these types of problems by distinguishing what they are trying to protect (assessment endpoints) from what they can actually measure (measurement endpoints). Measurement endpoints are quantitative, measurable characteristics or processes that are related to the assessment endpoints, and are measured to test the predictions of the risk assessment and thereby ensure that the assessment endpoints are met. Measurement endpoints are in effect performance indicators and are often referred to as such.

The EIS/ERMP identifies 45 marine ecosystem components/processes that are directly related to the assessment endpoints and potentially threatened by the construction and operation activities of the Gorgon Gas development. The document, however, only specifies performance indicators (measurement endpoints) for 5 of these (Table 2.3). The document goes on to specify some performance targets but the approach is neither consistent in coverage (targets are only specified for 26 of the ecosystem component and processes) or approach (only 4 of the targets are measurable quantitative values whereas the remainder are qualitative aspirations). The end result is a confusing mix of specific performance indicators, measurable targets, and vague statements of intent and aspiration. Consistency and clarity of approach across all components and processes that are potentially threatened by the development is notably absent.

2.2.2 Impacts on intertidal habitats and benthic primary producers

Chapter 11 of the EIS/ERMP concludes that all residual risks[1] to marine primary producers will be low to medium. Here we interpret marine primary producers to mean inter-and subtidal benthic primary producers. The data, analysis and monitoring program described in the EIS/ERMP, however, do not inspire confidence in these conclusions. Notable omissions in this context include:

- performance indicators and management strategies for all at risk components;
- an adequate description of intertidal and subtidal (benthic) habitats; and,
- a detailed description of the proposed measurement strategies.

A substantial proportion of Chapter 11 is dedicated to impacts on coral species, culminating in a monitoring and management strategy for water quality, sedimentation rates and coral health in a zone of moderate impact and in the zone of the visible plume. The EIS/ERMP uses corals as sentinel species for all other benthic primary producers. The joint venturers' attempt to develop a transparent monitoring and management strategy in this context is commendable. Equivalent management strategies, however, are not specified for the other 41 ecosystem components and process that are threatened by the development, many of which are not benthic primary producers and not therefore represented or protected by the sentinel species approach (Table 2.3). We recommend that a management and monitoring program is developed for all other ecosystem components/process as a matter of high priority. Furthermore we recommend that each of these strategies, including the current strategy, be formally evaluated (see section 2.2.4).

[1] Residual risks are defined in the EIS/ERMP as 'the remaining level of risk after management/treatment measures have been taken into account'.

Table 2.3 Ecosystem components/processes, performance indicators and targets identified in the Gorgon EIS/ERMP (gaps in the table indicate gaps in the EIS/ERMP)

Specific component/process at risk	Performance indicator(s)	Target(s)	Management strategy	Strategy evaluated
Seabed profile		Compliance with EPA guidance statement	No	No
Seabed type			No	No
High profile reef structures			No	No
Long shore coastal sediment dynamics		Transport minimised, no detectable long-term change	No	No
Subtidal sediment size			No	No
Subtidal sediment oxygen profile			No	No
Subtidal sediment chemical composition		No long-term contamination outside of development area	No	No
Intertidal sediment size			No	No
Intertidal sediment oxygen profile			No	No
Intertidal sediment chemical composition		No long-term contamination outside of development area	No	No
Seawater nutrients			No	No
Seawater clarity	Total suspended solids	2d, < 3x TSS (Zone 2); 2d, < 80th percentile median TSS (Zone 3) cf reference sites	Yes	No
Seawater oxygen concentration			No	No
Seawater chemical concentration		Heavy metal limits not exceeded, no long-term contamination outside develop. area	No	No
Seawater pH			No	No
Soil porosity (compaction)			No	No
Soil depth and extent (erosion)			No	No
Foreshore profile			No	No
Soil pH	Soil pH		No	No
Sea-level			No	No
Long shore coastal sediment dynamics		No detectable long-term change	No	No
Mangrove: *Avicennia marina*			No	No
Mangrove: *Rhizophora stylosa*			No	No
Seagrass: *Halophila ovalis*			No	No
macroalgae: *Sargassum* spp.			No	No
macroalgae: *Caulerpa* spp.			No	No
Coral: *Porites lobata*	Bleaching & mortality	< 10% increase in bleaching, < 30% decrease in live cover, cf reference site	Yes	No
Coral: *Acropora* spp	Bleaching & mortality	< 50% increase in bleaching cf reference site	Yes	No
Coral: *Turbinaria bifrons*	Bleaching & mortality	< 10% increase in bleaching, < 30% decrease in live cover, cf reference site	Yes	No

Table 2.3 Ecosystem components/processes, performance indicators and targets identified in the Gorgon EIS/ERMP (gaps in the table indicate gaps in the EIS/ERMP)

Specific component/process at risk	Performance indicator(s)	Target(s)	Management strategy	Strategy Evaluation
Whale shark		Long term viability maintained	No	No
Rock pipefish		Long term viability maintained	No	No
Potato cod		Long term viability maintained	No	No
Humpback whale		Long term viability maintained	No	No
Sperm whale		Long term viability maintained	No	No
Common dolphin		Long term viability maintained	No	No
Bottlenose dolphin		Long term viability maintained	No	No
Dugong		Long term viability maintained	No	No
Green turtle		Long term viability maintained	No	No
Flatback turtle		Long term viability maintained	No	No
Olive sea snake		Long term viability maintained	No	No
Osprey		Long term viability maintained	No	No
Greater sand plover		Long term viability maintained	No	No
Wedge-tailed shearwater		Long term viability maintained	No	No
Infauna communities		No long-term impact to significant communities	No	No
Filter feeding communities		No long-term impact to significant communities	No	No

The EIS/ERMP repeatedly emphasises the low conservation value of the sub- and inter-tidal habitats in the proposed development areas. The document does not, however, scientifically substantiate these statements. The sub- and inter-tidal surveys commissioned by the joint venturers lack quantitative rigour and scientific quality (see sections 3.3 and 3.4 respectively). The data that were gathered during these surveys do not represent an adequate baseline description of the biodiversity and ecological functions in the proposed development areas. There is a notable absence of species lists and quantitative descriptions of diversity, abundance and extent. These information gaps undermine the scientific credibility and approach of the EIS/ERMP. For example, it is impossible to test the assumption that corals, as sentinel species, will provide a conservative indicator of the response of all benthic primary producers to development induced stress. In summary, the sub- and intertidal information presented in the EIS/ERMP does not provide adequate support for the conclusions that it draws and, importantly, does not provide an adequate basis for before/after or control/impact comparisons.

Chapter 9 of the EIS/ERMP highlights the importance of environmental monitoring to confirm the actual impacts of the development and adequacy of its management strategies, but Chapter 11 does not provide an adequate description of how impacts on intertidal habitats and benthic primary producers will be actually measured. In particular, practical and statistical issues are not adequately addressed. There is, for example, no detailed description of how coral cover will be measured (particularly in low or nil visibility conditions) and how appropriate reference sites are determined.

Other issues of concern include the poor characterisation of coral communities in Management Units 3, 5, 6, and 8, anticipated habitat losses in excess of the cumulative loss thresholds in unit 8, and the simplistic interpretation of the literature cited in Section 11.3. The discussion in this section implies that the impacts associated with sediment loads are linear. This is not true. Increasing sedimentation from 1 to 25 mg cm^{-2} day^{-1}, for example, is a much more significant effect than increasing it from 250 to 275 mg cm^{-2} day^{-1}. Furthermore the choice of 5 mg cm^{-2} day^{-1} as a chronic stress load is not justified and data on ‘natural’ sedimentation rates is not presented.

2.2.3 Impacts on protected marine fauna and turtles

Chapter 11 of the EIS/ERMP concludes that residual risks to protected marine fauna ranges from low to high. The data, analysis and monitoring program described in the EIS/ERMP do not inspire confidence in the predictions of low risk, nor that the high risks can be effectively managed.

The document lists 102 protected vertebrate species that ‘may’ be present in the waters around Barrow Island, but the quality and scientific credibility of the data presented in the document varies dramatically between taxonomic groups. The ecology, distribution and habitat preferences of cetaceans, turtles and dugongs is reasonably well described but statements such as ‘development areas do not support aggregations of marine mammals…’ are not supported by quantitative survey results. The quantitative baseline survey that has been commissioned for flatback turtles is not yet complete. Furthermore there is virtually no reliable survey data for sharks, sea snakes and pipefish (see also section 3.1). We recommend that the joint venturers conduct a much more thorough investigation of the distribution, abundance and behaviour of protected marine species in each of the proposed development areas. This is particularly

pertinent to the endangered species of loggerhead turtles and olive ridley sea turtle for which no information is provided (see section 3.2.2). We also recommend that quantitative turtle surveys are extended to fully include the nesting season of green, flatback and hawksbill turtles. These surveys should focus their effort in all relevant development areas.

2.2.4 Management strategy evaluation

Chapter 11 describes a monitoring and management plan for Horizontal Directional Drilling (HDD), dredging and dredge spoil disposal in two impact zones – a zone of moderate impact and a visible plume and sedimentation zone. The successful development and implementation of this type of management tool, for all measurement endpoints, is critical to the successful protection of the marine (and terrestrial) environmental values of Barrow Island.

Uncertainty associated with the dynamics of ecological systems has important financial and environmental implications. In this context, failure to adhere to the performance targets specified for water quality, sedimentation rate or coral health, for whatever reason, exposes the joint venturers to significant financial loss (through project delays) and the community to significant environmental loss (through loss of corals and associated assemblages). Alternatively, failure to recognise actual environmental harm, or inaccurate reports of supposed environmental harm, will cause false negative and false positive results with concomitant environmental and financial implications respectively.

Management strategy evaluation helps minimise the financial and environmental risks associated with measurement and management plans by:

- identifying a range of proposed management options (the strategies);
- turning environmental aspirations into specific and quantifiable performance indicators;
- identifying and incorporating key uncertainties into an evaluation of the consequences, for the chosen performance indicators, of the proposed activity and management strategy; and
- communicating the results effectively to stakeholders and decision-makers.

The monitoring and management strategies specified in the EIS/ERMP do not appear to have been formally evaluated. In particular there is no quantitative evaluation of the likelihood of strategy success or failure and no formal uncertainty analysis. It does not therefore provide confidence that the environment will be protected or that false negative and false positive results will be identified and avoided. Important, but as yet unquantified parameters, identified in the EIS/ERMP include:

- expected recovery rates of impacted coral;
- baseline coral bleaching in the reference sites, dimensions and total coral cover in the reference site and current bleaching levels in the two management zones;
- coral health detection probability in low visibility conditions and the overall statistical power of the measurement and sampling strategy;

- how the zone of the visible plume will be determined and the extent to which this zone will overlap with the zone of sedimentation;
- turnaround time for tier 1 and tier 2 management activities; and,
- the dredge entrainment rate of turtles, effectiveness of controlled trawling methods and turtle deflection devices.

Note that this does not represent an exhaustive list of important parameters. These are simply parameters which we readily recognised as important to the successful implementation of the proposed management and monitoring strategy.

Management strategy evaluation relies on a bio-physical model that captures the dynamic and uncertain behaviour of the natural system in question, the impacts of human activity on this system and the response of the system to the proposed management actions. Importantly some of these components, for example a sediment dispersal model, are already in place for the Gorgon Gas Development (but see comments in section 2.2.8). Furthermore the joint venturers are currently in the process of 'examining the likelihood that corals outside the high and moderate impact zones will be subject to short term pulses of turbidity or sedimentation that may lead to mortality over a protracted period'. The results of this modelling have important implications for the monitoring and management strategy outside of the moderate impact zone but within the visible plume zone. We recommend that all new and existing models are incorporated into a formal management strategy evaluation, for all measurement endpoints, as soon as possible.

2.2.5 Hazard identification and prioritisation

As noted in section 2.1.4 the joint venturers do not appear to have followed a formal hazard analysis procedure to identify and prioritise the potential impacts of the Gorgon development on the marine environment. As a result potential impacts or threat scenarios may have been overlooked or inappropriately prioritised. Chapter 6 for example states that the offshore feed gas pipeline may be stabilised using a top and intermediate rock mattress. Similar rock armouring techniques are proposed for the HDD shore crossing at North White's Beach. Chapter 11, however, fails to identify the source of the rock used to armour and stabilise the pipeline, and does not discuss the potential impacts associated with the extraction and transport of the rock. Weekly resuspension of sediment by arriving/departing vessels and periodic dredging to maintain the shipping channel may also impede the recovery of corals in management units 3, 4 and 8 (and perhaps 5 and 6 depending on plume dispersion) impacted during construction activities.

A relatively high proportion of Chapter 11, and its associated technical appendices, is dedicated to the hazards associated with light, and its potential impacts on turtles. The hazards and impacts associated with underwater blasting and seismic tests, for example, are not afforded anywhere near the same level of detail. The level of detail within the EIS/ERMP is an implicit measure of hazard prioritisation but this is not supported by an explicit prioritisation procedure.

We suspect that a formal hazard analysis procedure would identify additional hazards and threat scenarios and provide a more defensible prioritisation. We therefore recommend that the joint venturers augment the current assessment with a formalised, systematic and transparent hazard

analysis that addresses and prioritises all potential threats to the marine and terrestrial environment.

2.2.6 Uncertainty analysis

In Chapter 9 of the EIS/ERMP the joint venturers state that they have adopted a worst case approach to uncertainty. Worst case deterministic risk assessments are typically 'worst-case' for only one source of uncertainty (variability). They can be useful in risk averse circumstances but they provide an unknown level of protection that may not be 'conservative' because of the other sources of uncertainty that are unwittingly ignored (*pers comm.* Mark Burgman, University of Melbourne). Furthermore this approach is not consistently applied throughout the EIS/ERMP.

In Chapter 11 the joint venturers adopt a best – anticipated – worst case approach for sedimentation impacts on coral that explicitly recognises that coral's resistance to turbidity is variable. Other inherently variable parameters, such as nesting turtle population estimates, turtle recruitment rate and hatchling mortality rate, however, are treated in a deterministic fashion. We therefore recommend that the joint venturers undertake a much more thorough uncertainty analysis, ideally within the framework of a formal management strategy evaluation.

2.2.7 Regional risks

Many of the 'low' risk assignations in Chapter 11 are justified by the joint venturers on the basis that the species/habitats impacted at Barrow Island are well represented through-out the region. This is not a risk averse strategy, particularly in the absence of any formal assessment of existing or potential threats to species/habitats in the entire Pilbara region. This approach exposes the species and habitats in the area to the 'Tragedy of the Commons" (Hardin 1968) wherein industries and developments throughout the region individually claim that their activities are low risk because species/habitats that they impact are well represented. This approach can only be defended from a risk assessment perspective if the joint venturers increase the boundaries of the assessment to include the entire Pilbara, and thereby assess the cumulative impacts of all activities in this region. There is, however, no evidence of this in Chapter 11 of the EIS/ERMP and we are unaware of any equivalent assessment.

2.2.8 Sediment dispersal model

The additional information package does not provide a detailed description of the sediment dispersal model (GCOMD) used in the EIS/ERMP. These types of models are now freely available as downloadable software and we would not therefore expect to see such a description. The implementation of the model, however, is critical to its efficacy. We would therefore expect to see a detailed description of how the model was set, how the resolution was chosen, how it resolves the bathymetry, what the boundary conditions are and how they work, how the density structure is specified and maintained, what kind of mixing scheme is used, and so on. It is difficult to comment on the efficacy of the model in the absence of this information.

The model clearly simulates tidal currents well. Suspended sediment plumes, however, will remain in suspension over many tidal cycles. Tidal movement largely represents a background back-and-forth motion. The dredge plume will also be subject to lower frequency events such as

extreme wave or current conditions – i.e. the plume may propagate by settling during calm weather, and being resuspended under higher wave or current conditions. Importantly we do not know if and how the model simulates these events and are therefore unable to gauge the potential accuracy of the model under the range of actual environmental conditions that will be experienced during the dredging operation.

2.3 Chapter 12: Quarantine risks and management

2.3.1 Methodology

The introduction and establishment of non-indigenous species (NIS) is considered to be the primary potential threat to the conservation values of Barrow Island (EPA 2003). The joint venturers assert that they collaborated closely with community groups and stakeholder, to develop a 'world class' Quarantine Management System (QMS) that responds to this threat in a manner which meets the communities expectations. The Quarantine Management System is based on three assessment techniques:

- an Infection Modes and Effects Analysis (IMEA) that identifies and prioritises quarantine hazards;
- a Preliminary Barrier Assessment (PBA) that identifies potential quarantine barriers that are subsequently carried through to a detailed design phase; and,
- a Quarantine Hazard (QHAZ) workshop that evaluates the quarantine risks associated with the detailed design and design improvements and controls.

The PBA is only needed in the absence of a detailed development design which prevents execution of the full-scale QHAZ workshop. Hence, at the conceptual design stage all three techniques are employed resulting in a 7 step QMS process that systematically identifies all potential quarantine risks and management options to reduce these risks to a level that is consistent with community expectations. At a detailed design stage the PBA is unnecessary, the QHAZ and its planning step follow immediately from the IMEA, reducing the QMS to a 5 step process (Chevron Australia 2005).

The joint venturers have identified 13 terrestrial exposure pathways and 9 marine exposure pathways and three biological groups: vertebrates, invertebrates and plants. Note that this results in 66 group/pathway combinations across the marine and terrestrial environment, in a 7 step (conceptual design) or 5 step (detailed design) QMS process. The total number of evaluation steps in the QMS process therefore ranges from 330 to 462. To date the joint venturers have only completed approximately 100 of these steps (Chevron Australia 2005).

2.3.2 IMEA and QHAZ

Infection Modes and Effects Analysis (IMEA) (Hayes 2002b) is a variant of a well trusted hazard identification tool, Failure Modes and Effects Analysis that has a long history of successful industrial application (Palady 1995). IMEA is designed to systematically identify and

prioritise potential biological hazards. It is important to note that IMEA provides robust hazard rank scores. It is not designed to provide robust measures of absolute risk and its results should not be interpreted in this manner. The QHAZ procedure adopted by the joint venturers is based on HAZOP analysis (Kletz 1999). Again this is a well tried, proven methodology that allows the proponents to systematically explore deviations from the intent of each quarantine barrier.

Technical Appendix D2 demonstrates that the joint venturers have a good understanding of IMEA and HAZOP. The biological groups and invertebrate sub-groups identified in the Appendix and additional information package are sensible. The application of IMEA and QHAZ in this quarantine context is highly commendable. Note, however, that similar approaches do not appear to have been applied to other hazards associated with the proposed development. The IMEA may be improved slightly by reducing the number of scoring categories from ten to five. This may facilitate the workshops. In our experience participants at IMEA workshops often have difficulty distinguishing between scores of (for example) 3 and 4, or 7 and 8.

The IMEA methodology appears to have been implemented appropriately but we cannot verify this because the EIS/ERMP does not contain records of any of the IMEA workshops, or more importantly, the results of these workshops. The variance associated with the IMEA scores, for example, provides interesting insight into the group's deliberation process. These data, together with the final hazard rank scores, are not presented in the EIS/ERMP or the additional information package. It is also unclear how the joint venturers have used the results of the IMEA. Priority pathways addressed in the additional information package, for example, were 'nominated by the Quarantine Expert Panel' and not apparently prioritised via the IMEA. The results of the QHAZ are also not presented here, presumably because none had been completed when the EIS/ERMP was released.

2.3.3 Quarantine barriers and community expectations

The quarantine barrier selection method, or more specifically the decision rules which they are based on, is seriously flawed. This is undoubtedly the most important error in the proposed QMS. This error arises because the joint venturers have incorrectly interpreted the IMEA infection scores to represent absolute measures of risk. They do not - they are only robust in a relative, not an absolute, sense (see above). This error is most damaging in the decision rules that qualitatively combine infection scores at each pathway step into an overall introduction score. Here the joint venturers propose that if the effectiveness score of *m* barriers - scored in terms of the likelihood of pathway infection with the barrier in place – is *n* or less, then the overall residual risk of introduction for that pathway is *n*-(*m*-1).

The rationale behind the joint venturers' approach is that multiple barriers along a pathway, each of which individually reduce the risk of infection, must reduce the overall risk of infection. This proposition is true but the overall risk reduction, and ultimate level of protection provided by multiple barriers, cannot be accurately measured using semi-quantitative scoring systems such as the infection scores of the IMEA. This approach is analogous to the flawed logic of qualitative risk calculations that assert that the product of two 'low' probabilities is 'very low' (Hayes 2002c). The product of two 'low' probabilities does not equal 'very low' - it's just lower than 'low'– you cannot say any more than this without resorting to quantitative risk estimates. Similarly the joint effect of two quarantine barriers that each reduce the likelihood of infection

to a slight chance is something lower than a slight chance. Nothing else, however, can be defensively deduced from this logic.

The flaw in the joint venturers' logic is best exemplified by considering the effect of 10 totally ineffective quarantine barriers – i.e. ten barriers that each score 10 (infections occur continuously throughout the year) in terms of the likelihood of pathway infection. Under the approach described in the EIS/ERMP the overall residual risk of introduction for that pathway would be 10-(10-1) = 1 - i.e. the infection is extremely remote, highly unlikely. This is obviously nonsense and clearly not a sound basis for a 'world class' QMS.

The reality of the joint venturers' approach to quarantine barriers is an arbitrary, unquantified level of quarantine protection that can not demonstrably meet community expectations. It is unfortunate that this logic features early on in the QMS process because everything from this point forward is fundamentally flawed and scientifically indefensible. We strongly recommend that the barrier selection analysis be completely re-done.

We suggest that the only defensible way forward from this point is for the joint venturers to use the work completed to date to:

- in close collaboration with the community re-specify the qualitative expression of their expectation into a quantitative measure of quarantine risk;
- use existing information sources to quantify a range of possible infection metrics for each pathway/group, together with the expected range of import units (tonnes of aggregate, number of personnel visits, etc) for each pathway;
- quantify the likelihood of detection and sterilisation for promising quarantine barrier methods; and,
- quantify the residual risk of infection and compare this to the community expectation.

The statistical sensitivity of a range of potential quarantine procedures is well described in the international literature (see for example Hayes et al. 2005a, Redmund et al. 2001, Yamamura and Katsumata 1999). We recommend that the joint venturers use the IMEA to prioritise potential quarantine hazards and then use relevant statistical models such as these in a quantitative risk management approach.

We also note that many of the infection pathways described in the EIS/ERMP are long and complicated. In some cases this may preclude confident quantitative risk estimate predictions. If this proves to be the case the joint venturers should consider simplifying the assessment by asking the community to re-specify its acceptance criteria at earlier points in the pathway, and establish statistically sound testing and inspection routines at this point to ensure that their expectations are met. Note this approach does not preclude quarantine management activities at later points in the event chain.

2.3.4 Marine quarantine threats

The joint venturers' assessment of marine quarantine threats is poor. The EIS/ERMP notes that the marine environment is exposed to NIS from a number of sources, many of which are

independent of the proposed development activities. This is true but it is not sufficient rationale to ignore the sources of marine NIS that are directly associated with the proposed development. The potential for new trading routes linking Barrow Island to new sources of potential NIS is particularly important in this context (see Carlton 1996). The proposed development will entail weekly visits by LNG ships to Barrow Island. The EIS/ERMP, however, does not identify the international ports of departure and trading routes of these vessels relative to existing international routes in the Pilbara region. It is not possible therefore to assess the extent to which Barrow Island will be exposed to potential new marine pests.

The EIS/ERMP notes that 'prior to accepting marine vessels from international ports, an environmental matching risk assessment will be undertaken to determine if environmental conditions are compatible for the translocation of species'. The waters around Barrow Island are warm and fully saline. We therefore suspect that an environmental matching risk assessment will provide little if any risk resolution for the vast majority of ports in low latitude areas of the world (see Barry et al. submitted). We therefore recommend that the joint venturers augment the environmental match assessment with a species-specific assessment based on, for example, the potential next pest list (Hayes and Sliwa 2003, Hayes et al. 2005b).

The baseline survey conducted in the waters around Barrow Island (Technical Appendix D7) is cursory, poorly described and apparently incomplete. The sampling methods are described in very general terms such as 'diving', 'snorkelling' and 'samples were collected'. It is not clear from this which areas were surveyed and how, for example, dinoflagellate species were collected and identified. The sensitivity of the survey methods relative to target species is completely ignored. Furthermore the reference to the target marine species (declared pest species) is out of date and ignores the potential next pests identified in the new National System for the Prevention and Management of Marine Pest Incursions (Hayes et al 2005).

Finally, the efficacy and practicality of the suggested management measures for hull fouling threats is dubious. The EIS/ERMP does not appear to recognise the threat posed by niche areas on vessels (Coutts and Taylor 2001) and does not describe how wetted hull surfaces of vessels will be inspected and cleaned/disinfected, particularly for large (> 25m) vessels.

2.3.5 Detailed pathway assessments

The detailed pathway assessments described in the additional information package provide a comprehensive description of the infection pathways and potential quarantine barriers. The arguments provided here, however, are largely mute because of the flawed logic that pervades the residual risk estimates (section 2.3.3). The substantial data contained within these assessments, however, could support a quantitative risk management approach. For example, the joint venturers note that an outline of the quantity and frequency of personnel and cargo movements are presented at the start of each quarantine risk assessment workshop. This type of data could help inform a statistically valid inspection and testing routine.

The infection pathways described for each of the priority pathways represent planned events. This analysis could be improved by also considering the effect that unplanned events along the infection pathway may have on the residual risk estimates. These types of events can be postulated using the formal hazard techniques discussed in section 2.1.4 and section 2.2.5.

It is apparent from the detailed pathway analysis that the residual introduction risk of some pathways/biological group combinations exceed the community expectations (notwithstanding the flawed logic of the risk estimates). The joint venturers' approach to this is unclear. Technical Appendix D3 notes that the joint venturers' inability to meet the community's expectations became apparent in the early quarantine workshops. As a result the Appendix recommends an establishment quarantine endpoint as opposed to an introduction endpoint. The additional information package, however, does not appear to acknowledge this, discuss it or recommend quarantine barriers between the introduction and establishment steps.

Extending the quarantine assessment from introduction to establishment lengthens the assessment event chain and thereby increases the complexity of the infection pathway. This increases the difficulty of the risk assessment. We suggest that the joint venturers consider shortening these event chains by seeking (in close collaboration with stakeholders) assessment and measurement endpoints earlier in the infection pathway.

3. TECHNICAL APPENDIX REVIEW

3.1 Protected Marine Species

3.1.1 Methodology

Appendix C6 – Protected Marine Species (PMS) – was prepared by RPS Bowman Bishaw Gorham Environmental Management Consultants. The consultants were engaged to conduct a literature review of protected marine species occurring within the proposed development area. In addition, the Appendix includes "opportunistic field observations" collected during intertidal, and marine benthic habitat surveys conducted by the consultants.

The Appendix states that the literature review was conducted with the assistance of independent researchers, Universities, the Western Australian Museum (WAM) and other State and Federal government organisations. Literature and data sources cited in the Appendix, however, are based primarily on the web-based information and restricted government department surveys on several taxonomic groups or un-referenced information. The habitat and food preferences of turtles, for example, are based on web-based information sheets Environment Australian (2000/1) rather than the scientific papers used to produce them. While the distribution of two whale species "occurring in the Barrow Island region" are referenced as "listed on the DEH website". Many sections of the Appendix are based on a single general text such as Storr et al. (1986). Unpublished WAM fish data is included for nearby areas but there is no obvious information from university studies. Notable references that do not appear to have been sourced include: Allen (2000), Fry et al. (2001), Pogonoski et al. (2002), Hutchins (2003), and Guinea and Whiting (2005).

3.1.2 Results

The Appendix lists 102 protected vertebrate species that 'may be' resident, occasional visitors or migrants in the waters around Barrow Island. It contains a useful description of which aspects of the development potentially threaten the PMS, a concise explanation of West Australia's marine conservation park and nature reserve system and a good summary of relevant national and international legislation.

The quality of information and scientific credibility of the Appendix varies between taxonomic groups. The distribution and habitat preferences of cetaceans, turtles and dugongs are reasonably well described. More quantitative information on the areas used by dugongs and resident populations of several dolphin species is needed, however, to determine whether or not they will be impacted by the proposed development. Reliable data is also absent for a number of (non-migratory) whale species that are listed as likely to be present in waters around Barrow Island. This data could be obtained from the DEH *Species Profile and Threats web-based Database*(http://www.deh.gov.au/cgi-bin/sprat/public/sprat.pl).

There is a pervasive lack of reliable survey data for the listed sea snakes and fish (sharks, pipefish, seahorses and seadragons and serranids). The Appendix is replete with statements such

as ‘appears to be...abundant around Barrow Island’ (sea snakes), ‘may occur near Barrow Island’ (sharks) and ‘unconfirmed sightings have been made’ (seadragons). Anecdotal information of this type is insufficient support for the purposes of, and the current conclusions drawn by, the EIS/ERMP. Seadragons, for example, are a temperate, southern Australian species that (to our knowledge) have never been recorded in sub-tropical or tropical waters. The presence, abundance and distribution of all PMS, both inside and outside the development’s impact zones, should be properly addressed via a quantitative sampling strategy.

This problem is compounded by the absence of information on the reproductive behaviour, preferred habitat and diet requirements of PMS. This data could identify locations around Barrow Island where PMS, if they were present, may aggregate to reproduce and feed, and hence the likelihood that they would be affected by the proposed development. There are 32 EPBC listed species of Sygnathids (sea dragons, seahorses and pipefish) and 14 EPBC listed species of sea snakes. The Appendix does not address the presence, abundance, habitat or dietary preferences of any of these species.

Relevant information sources that do not appear to have been used include:

- the diet and reproductive behaviour of sea snakes in northern Australia (Fry et al. 2001, Guinea and Whiting 2003, Philips and Hale 2005);
- distribution, habitat and diet information for seahorses listed in Fishbase http://www.fishbase.org; and,
- habitat, distribution and ecology of seahorses, pipefish and Serranid fish (Hutchins 2003, Pogonoski et al. 2002, Allen 2000)

This does not represent an exhaustive list of relevant literature. These are simply examples that are readily apparent to us. As a literature review, the Appendix fails to examine all relevant and readily available literature on all PMS listed in the EIS/ERMP. It also fails to determine whether the PMS are definitely present in the proposed development areas, with the exception of some species of sea turtles and migratory whales. Furthermore, it fails to address the presence of PMS on the approach to, and shore crossing of, the mainland end of the proposed domestic gas pipeline. This may be due to the presence of an existing pipeline in the preferred location (East of Passage Island), but nonetheless the alternative shore crossing (East of Cowle Island) should be addressed.

3.2 Sea Turtles

3.2.1 Methodology

Appendix C7 – Sea Turtles – was prepared by RPS Bowman Bishaw Gorham Environmental Management Consultants. It provides an overview of the literature for species known from the Barrow Island region. It also summarises the results of two summer monitoring programs of turtle nesting sites and three light influence experiments conducted by Pendoley Environmental Pty Ltd for Sinclair Knight Merz. We are not qualified to comment on the efficacy and quality of the light experiments. The Appendix also notes that surveys were carried out between 1998

and 2004 and that selected beaches were routinely monitored but does not provide details of the methodology, timing and location of these surveys.

The Appendix describes two quantitative turtle nesting site surveys conducted in the summer of 2003/04 and 2004/05. The first survey included areas around a proposed pipeline crossing at Cape Dupuy. The pipeline landfall locations, however, were subsequently altered so the 2003/04 surveys targeted the wrong area. Sampling locations for the second survey were reduced and altered to include proposed development sites and adjacent beaches, and sampling was extended into February to cover the peak period of green turtle nesting. The survey methodology, based largely on turtle tracks in the sand, is clearly explained. It is not clear from the discussion, however, whether different species can be easily distinguished on this basis, or whether sampling once a month on spring low tide is sufficient, given the variability in numbers. The data is presented as number of animals per kilometre of beach per night to allow a comparison of the relative nesting effort for each species between beaches.

3.2.2 Results

The Appendix introduction states there are 6 species of sea turtles in northern WA waters, but of the 4 species typically found nesting on the north-west shelf, only three are commonly found in the Barrow Island region: the green, flatback and hawksbill turtles. The Appendix contains no information on the presence, distribution or nesting behaviour of loggerhead turtles and the olive ridley sea turtle. This is an important omission.

The literature review could be improved by more specific reference to the species found on Barrow Island, and species-specific summaries of their breeding and feeding activities (supported by appropriate citations), and a more thorough definition of the habitat terms that are subsequently used.

The surveys confirm that Barrow Island is an important nesting and feeding site for green, flatback and hawksbill turtles on a regional scale. It shows that turtle nesting numbers can exhibit high variability on a short term and annual basis. The 2003/2004 survey provides a baseline of turtle nesting activity around the island. Important information in Pendoley (2005), however, was not included in the environmental consultant's summary, including the fact that successful turtle nesting events only resulted from 50% of counted turtle tracks and that the Barrow Island populations of flatback, green and hawksbill turtles represent a significant proportion of the total estimated populations in the entire North West region.

Flatback turtles appear to nest predominately on the mid-east coast beaches adjacent to the proposed development site. Hawksbill nest sites have been found all around the island and appear to favour small rocky beaches and rubbly beach corners on the north east coast where the shallow sand depth precludes successful green or flatback nesting. These nesting preferences suggest that the survey methodology (which is based largely on sand tracks) may not be adequate for this species. Green turtles feed all year round on algae-covered rocky inter- and sub-tidal platforms of the west coast of Barrow Island. These turtles aggregate in spring and summer to mate. The location of these aggregations relative to the proposed development area, however, is not clearly stated.

Survey data is presented for various beaches on Barrow Island but their importance/proximity to the proposed development areas is not consistently described. Furthermore monitoring was not

conducted during the entire nesting period of all three species that are discussed. Surveys were conducted during November, December, January and February. Data presented in the introduction, however, suggests that hawksbill nesting activity starts in August, peaks in October and diminishes in November. Furthermore the emergence of young flatback turtles in April after a 6 to 8 week incubation period suggests that flatback females may still be laying eggs in March. These results suggest that the survey period should have been extended to cover the months from August to March.

Monitoring data is only provided on nesting females. Some information on the presence, abundance and habitats of (adult and juvenile) turtles around Barrow Island at other times of the year is provided but needs to be quantified. The satellite telemetry study lacks information on the methodology and number of turtles sampled. This data shows green turtles are using the beach, rocky intertidal/subtidal platforms, rock pools and shallow inshore zones for such activities as feeding, nesting, resting and mating, throughout the proposed west coast development zone. All future survey activity should also clearly identify turtle nesting, inter-nesting, feeding and resting grounds relative to the proposed development locations. This information is not currently presented in a clear and concise format. Total number of turtle nests, together with number of animals per kilometre of beach, would also assist in identifying significant turtle aggregations.

3.3 Marine Benthic Habitats

3.3.1 Methodology

Appendix C8 – Marine Benthic Habitats – was prepared by RPS Bowman Bishaw Gorham Environmental Management Consultants. The consultants were engaged to survey marine benthic habitats in the proposed development areas. The consultants highlight the importance of benthic habitats stating that ‘the twin goals of maintaining biodiversity and maintaining ecosystem function can be achieved through protection of the benthic habitats on which the ecosystems depend.’ (Chevron Australia 2005).

The survey of marine benthic habitats was achieved via a ‘review of available information’ and a combination of snorkel and video transects conducted in August 2002, January 2003 and January 2004. Video footage was examined by marine biologists in order to characterise benthic habitats and assemblages. This information was supplemented by examination and photographs taken during the snorkel dives.

The Appendix does not describe how different habitats are identified, distinguished or assigned a conservation status. It does not describe the measurements (if any) that were taken or how many divers/biologists were used in the survey or the field conditions (e.g. visibility) at the time of the survey.

3.3.2 Results

Appendix C8 is of a low scientific quality. It lacks detail, quantitative rigour and does not adequately describe the benthic ecosystem function or biodiversity. The cited literature is

potentially useful but does not appear to have been used to assist in the design and implementation of the surveys. The Appendix identifies a few organisms to species level but (in contrast to the terrestrial survey results) there is a notable absence of any species lists.

The coral communities surrounding Barrow Island are poorly described. Species that are present or characteristic of the various reefs, defining criteria for 'high-profile' reefs, and the proportional cover are not adequately or consistently described, particularly for Turtle Bay, the southern end of the Lowendal Shelf and the Barrow Island Shoals. The Appendix notes that Dugong Reef is degraded but does not describe which species are missing, the extent of coral cover relative to other areas, how much coral is still alive and whether or not there is any evidence of recovery. The Appendix also notes that the extent and composition of the fringing coral communities of the northeast and east of Barrow Island are unknown.

The Appendix highlights the importance of seagrass and macroalgae to marine food webs and as habitat for other marine organisms. The Appendix does not, however, recognise that they are ecologically and geomorphologically different and are likely to react differently to stressors (e.g. sedimentation) associated with the proposed development. Some species of seagrass are listed but it is not clear whether these species were actually observed during the survey, and there is no information on their distribution and abundance.

The situation is similar for the macroalgae habitats which make up 40% of benthic habitats in the Montebello/Barrow islands marine conservation area. Absent information that would allow some assessment of the relative risk to these areas, includes whether algal communities are uniform across the entire conservation area, or whether different types of algal communities are present and if so what the actual algae composition is. The Appendix alludes to differences between communities on the west and east coasts of Barrow Island, but the extent, species composition, diversity etc. of the two coasts are not developed further.

The description of infaunal soft-sediment and filter feeding communities is particularly poor. Filter feeding communities are likely to be the most diverse assemblages of invertebrates in the region. The Appendix recognises that the habitat value of these areas depends on how well developed these assemblages are, but provides no estimate of diversity or abundance, does not characterise different assemblages and does not assess their relative extent in the proposed development areas. The Appendix notes that areas covered periodically by transient sand sheets will have invertebrate assemblage that are more sparse than other areas, but it does not identify these areas or document how extensive they are.

3.4 Intertidal Habitats

3.4.1 Methodology

Appendix C9 - Intertidal habitats - was prepared by RPS Bowman Bishaw Gorham Environmental Management Consultants. The appendix provides information on six intertidal habitats (e.g. limestone reef, sand and mudflats, mangrove forests) found in the Barrow Island/Pilbara region (including the adjacent mainland) describing the geomorphology, flora and faunal assemblages. The subsequent description of proposed development areas, however,

is brief and it is not readily apparent which of the intertidal habitats is relevant to each of the proposed developments.

The consultants appear to have conducted a single intertidal survey at spring low tide on the 26th to 28th January 2004. The area between the very low intertidal to supra-tidal zones was examined but survey methods are not described. Furthermore, there is no evidence of a comprehensive literature survey, collection of physical samples, lodgement of samples with appropriate museums or the involvement of any taxonomic experts. Potentially important data sources such as Wells et al. (2000) and MarLIN (http://www.marine.csiro.au/marlin/) do not appear to have been consulted.

The authors acknowledge that the alternate mainland crossing site (East of Cowle Island) was not adequately sampled, stating "the intertidal comprises of a flat limestone pavement extending approximately 400m seaward of the mangrove zone. The uppermost extent was not examined but the exposed limestone pavement extends at least 80m into the mangrove forest". (Chevron Australia 2005). No reasons are provided for this omission

3.4.2 Results

Appendix C9 is of a low scientific quality. It lacks detail, the survey methods are not described and there is no quantification of the presence of intertidal flora and fauna. Terms used are descriptive (eg. appears to be, moderately to densely vegetated…) and generalise over the entire region rather than the specific proposed development sites. Very few organisms are identified to species level and (in contrast to the terrestrial survey results) there is a notable absence of any species lists. The appendix provides a limited description of large obvious flora and fauna such as macroalgae, corals, crabs, gastropods, barnacles and fish. All these species can be observed by eye and we therefore suspect that few (if any) specimens were physically collected. Smaller macrofauna such as polychaete worms and small crustaceans, taxa groups that can be important indicators of environmental damage, are not mentioned. There is no evidence that the infauna (sediment fauna) was sampled at all.

Large species such as turtles, dugongs, dolphins, sharks, crustaceans and gastropods utilise intertidal habitats at high tide. The appendix does not assess presence/absence, distribution, seasonality, foraging behaviour, etc of these species beyond a photo of sharks foraging over intertidal flats. There is no discussion of the importance of the seagrass/macroalgae beds, either as a food source for grazing dugongs and turtles, or as a refuge for juvenile fish species during high tide.

There is very little information on the supratidal (dry sand and rocky areas at the top of the beach). This area is used by nesting turtles (addressed in Appendix C7) and as a foraging area for terrestrial vertebrates (e.g. lizards, water rats, possums and bandicoots) and invertebrates (isopods etc.). We assume that these species are addressed in the terrestrial appendices. The intertidal zone is also an important seabird roosting and foraging area. The Appendix notes that a juvenile sea eagle was found roosting in the mangroves near the proposed mainland pipeline crossing. We assume the presence/absence, distribution, seasonality, foraging behaviour, etc of other seabirds (including migratory waders protected by international treaties) are addressed in Appendix C3.

Appendix C9 concludes that the intertidal habitats of the east and west coast of Barrow Island, including the potential pipeline landfalls at North White's Beach and Flaucourt Bay, and the Town Point Causeway and landing, are of low conservation value. It is difficult to concur with this conclusion given the lack of detail provided in the Appendix. The description of the intertidal zone in the Town Point area is particularly insufficient given the development proposed for this area.

The scientific quality of the Appendix would be markedly improved by the inclusion of:

- a map of the surveys area showing their proximity to the proposed development areas;
- details of the survey and sampling methods used;
- some measure of the level of certainty of the identifications,
- quantified estimate of the intertidal fauna and flora to enable comparisons between areas; and,
- a list of species/taxa found in each surveyed area.

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4. CONCLUSIONS AND RECOMMENDATIONS

Chapters 9, 11 and 12 of the Gorgon EIS/ERMP contain some commendable analysis. The joint venturers attempted to carefully scope the assessment and define the terms they used. They recommend a measurement and monitoring strategy for impacts on water quality and benthic primary producers, and have used systematic hazard analysis tools to identify quarantine hazards associated with the construction and operation of the Gorgon gas project. Unfortunately these rare, and as yet incomplete, examples of good quality work are overwhelmed by too many examples of poor quality analysis.

The scoping and definition of terms used to describe impacts in the marine environment needs further work, particularly the meaning of the term 'local'. The definition is currently circular, vague and open to different interpretations. The joint venturers do not appear to have used a systematic hazard analysis tool to identify and prioritise impacts in the marine environment. There is no evidence that the beliefs and values of stakeholders and community groups have been formally acknowledged or incorporated in the qualitative risk assessment. Many of the low risk predictions in Chapter 11 are justified on grounds of regional integrity, but are not supported by an equivalent regional assessment. This is not a risk averse management strategy. Furthermore this approach fails to recognise that the conservation status of Barrow Island is greater than the sum of its parts – i.e. the conservation value of Barrow Islands is greatly enhanced by the combination of its largely uninterrupted ecosystem components and processes.

The level of detail and quality of analysis varies dramatically between marine taxa. Disproportionately large sections of Chapter 11 and the technical appendices are dedicated to potential impacts on coral and some (but not all) species of turtles. The level of detail and quality of work directed to other primary producer communities and protected marine species is cursory and poor. Technical appendices C6, C8 and C9 are particularly poor. The literature review, surveys and data collation described here lack rigour and do not adequately support the risk assessment predictions made in Chapter 11. The chapter does not specify performance indicators, measurement or management strategies for the vast majority of assessment endpoints (valued ecosystem components and processes) that it identifies. Instead it is characterised by a few measurable performance indicators scattered amongst a sea of vague statements of intent. Consistent approach, supported by high quality analysis, is notably absent. All of these problems, coupled to the lack of a formal analysis of uncertainty analysis and sharp boundaries between different consequence categories, seriously undermine the scientific credibility of Chapter 11.

Burgman et al. (1999) note that population viability analysis is frequently ignored in favour of qualitative risk protocols, and highlight the weaknesses of these approaches for threatened species. All of these weaknesses, and more, are apparent in Chapter 11 of the Gorgon EIS/ERMP. Put simply the qualitative risk assessment and data presented by the joint venturers are not good enough to provide a high level of confidence that the threatened and endangered marine species in and around the waters of Barrow Island will continue to exist when the development is eventually decommissioned.

The joint venturers have clearly put a great deal of effort into developing and implementing a quarantine management system that will protect the endemic and native species on Barrow Island. This is appropriate given that Barrow Island's iconic conservation status largely stems

from the absence of introduced terrestrial pests that have exterminated, or continue to threaten, species of plants, birds and mammals on mainland Australia. Unfortunately the quarantine risk management strategies described in Chapter 12, and the additional information package, are fatally undermined by demonstrably flawed logic. The joint venturers describe the resultant QMS as 'world class' but in reality it provides an arbitrary and unquantified level of protection to the endemic, threatened and protected species of Barrow Island.

In completing this review we have made a number of recommendations. These are summarised as follows. We recommend that the joint venturers should:

1. in collaboration with stakeholders, augment the current risk assessment with a formalised, systematic and transparent hazard analysis that addresses and prioritises all potential threats to the marine (and terrestrial) environment;

2. conduct quantitative surveys of all relevant (impact and control) subtidal and intertidal habitats;

3. conduct a much more thorough investigation of the distribution, abundance and behaviour of protected marine species in each of the proposed development areas. This is particularly pertinent to the endangered species of loggerhead turtles and olive ridley sea turtle;

4. extend quantitative turtle surveys to fully include the nesting season of green, flatback and hawksbill turtles;

5. develop a management and monitoring strategy for all ecosystem components/process identified in the EIS/ERMP as threatened by the proposed development. Each of these strategies, including the current strategy, should be formally evaluated;

6. incorporate all new and existing bio-physical models into the formal management strategy evaluation recommended above, for all measurement endpoints, as soon as possible;

7. undertake a much more thorough uncertainty analysis, ideally within the risk management framework recommended above;

8. discard the current qualitative decision rules for quarantine barrier selection and replace them with quantitative estimates of efficacy;

9. use the IMEA to prioritise potential quarantine hazards and then use relevant statistical models, in a quantitative risk management analysis, to demonstrate compliance with community expectations; and,

10. augment the proposed marine environmental-match assessment with a species-specific assessment.

We also suggest that the joint venturers consider adopting a quantitative population viability analysis for protected marine species instead of the current qualitative approach. In addition we suggest they consider simplifying the quarantine risk assessment by asking the community to re-specify its acceptance criteria at earlier points in the infection pathway, and establish

statistically sound testing and inspection routines at these points to ensure that the community's expectations are met.

In conclusion we believe that the EIS/ERMP needs to develop a comprehensive management strategy for key threatened marine and ecosystem components/processes, supported by considerably better data and analysis, together with a new quantitative approach to quarantine risk management, in order to reach a good scientific standard.

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Appendix 8

Response from Chevron to Report by CSIRO

Response of the Gorgon Joint Venturers to

"*Review of Gorgon Gas Development Environmental Impact Statement and Environmental Review and Management Programme*"
(CSIRO 2006)

Introduction

The West Australian Environmental Protection Authority (EPA) engaged the Commonwealth Scientific Industrial Research Organisation (CSIRO) to review of Chapters 9, 11, and 12 of the Draft EIS/ERMP and Additional Information Package. Chevron has been provided with a copy of the report, entitled: *Review of Gorgon Gas Development Environmental Impact Statement and Environmental Review and Management Programme* by KR Hayes, FR McEnnulty and R Babcock (January 2006) referred to hereafter as "the Review". The EPA has asked the Gorgon Joint Venturers to comment on the Review.

In doing so, the Gorgon Joint Venturers noted a number of subjective statements, factual discrepancies, interpretive biases and misunderstandings not normally associated with work undertaken by CSIRO. We believe these have resulted in inappropriate conclusions and an Executive Summary that is deficient.

The Review appears to have taken an academic or theoretical approach rather than that which is consistent with widely utilised Environment Impact Assessment practices and practicable methodologies, as implemented in Western Australia pursuant to the provisions of the Environment Protection Act 1996 (WA). This fundamental difference in approach is not surprising considering the research focus of CSIRO. Furthermore, the Review does not appear to acknowledge the EPA's advice in Information Bulletin 1011 (EPA, 2003) which was instrumental in the Gorgon Joint Venturers' design of the risk assessment and quarantine process described in the Draft EIS/ERMP.

It would also appear that although the Review authors note in Section 1.2 that they reviewed "relevant additional material", they did not source, understand or utilise the full extent of the publicly available information on the quarantine and risk assessment effort undertaken by, or on behalf, of the Gorgon Joint Venturers (see Gorgon Project website: www.gorgon.com.au). In missing this opportunity, the Review authors did not adequately acknowledge the risk assessment and quarantine process – a process developed and supported by a wide range of experts, applied in a transparent and inclusive manner and in a way that is responsive to Information Bulletin 1101 (EPA, 2003).

The Gorgon Joint Ventures have included in this document comments on each of the Review's 10 recommendations. However, the principal concern centres on the comments on Chapter 12 Quarantine Risks and Assessment which is reflected in the Executive Summary. In particular, comments such as "fatally undermined by demonstrably flawed logic" and the accompanying example are made without regard to all of the available information, based on misinterpretation and are clearly incorrect.

Quarantine

Review Section 2.3.1 Methodology

The Review authors incorrectly state the Quarantine Management System (QMS) is based on three assessment techniques and lists the Infection Modes and Effects Analysis (IMEA), Preliminary Barrier Assessment (PBA) and Quarantine Hazard (QHAZ) techniques. This

reflects a shallow understanding of the components of the QMS as set out in detail by the Gorgon Joint Venturers (Draft EIS/ERMP, Section 12.6, pages 584-591). The Gorgon Joint Venturers very clearly commit to the development of the QMS under the principles of the ISO 14001 standard for Environmental Management Systems. While the QMS is informed by risk assessment as a tool for making good management decisions, it relies on a robust ISO 14001-based management system to protect the conservation values of Barrow Island. Those with experience in environmental management systems would clearly see the applicability and parallels of that process to quarantine management systems and would not confuse an assessment technique with a management system process. The Review appears to demonstrate a lack of understanding by the authors of both management systems and assessment techniques.

The Review authors refer to a seven step QMS process. This is also incorrect. The seven step process is entitled 'Step-by-step flowchart of the Quarantine Risk Assessment Method' (Draft EIS/ERMP, Figure 12-3, page 550).

Review Section 2.3.2 IMEA and QHAZ

The Review authors acknowledge the application of IMEA and Hazard and Operability (HAZOP) as well trusted hazard identification tools and recognise that the Gorgon Joint Venturers application of those tools in the quarantine risk assessment process is highly commendable. The Review authors also recognise that the Gorgon Joint Ventures have a good understanding of IMEA and HAZOP.

The Review states that the authors were unable to verify the application of the IMEA methodology as the Draft EIS/ERMP did not contain the records or results of the IMEA workshops. It is not normal practice to produce all of the IMEA results in an environmental impact assessment document. However, in an attempt to inform the community and maintain transparency, the practice of the Gorgon Joint Venturers has been to make these workshop reports (and results) freely available to the Department of Environment (DoE)/EPA, Department of Conservation and Land Management (CALM) and interested stakeholders (Draft EIS/ERMP, page 561). There is a considerable body of information that is publicly available on request or through the Gorgon website that would fully address the author's requirement for verification. It is regrettable that these records and results (and the record of all community workshops) do not appear to have been considered in the Review, as this would have avoided speculation in Section 2.3.2 and would have provided the authors with the confidence of the rigour of the process used by the Gorgon Joint Venturers.

Review Section 2.3.3 Quarantine Barriers and community expectations

The Gorgon Joint Venturers have not in any situation used qualitative judgements of risk to represent absolute measures of risk, as suggested by the Review (page 17). The Gorgon Joint Venturers have undertaken a systematic process to identify threats of introduction on various pathways and qualitatively scored the likelihood of infection to gain an understanding of the relative severity of infection threats. In doing so, the Gorgon Joint Venturers have sought advice from independent experts to consider only effective quarantine barriers for the identified threats. The suggestion (page 18 of the Review) that the Gorgon Joint Venturers would consider ineffective quarantine barriers to prevent introductions is incorrect and irrational. Effective pre-border quarantine barriers include (but are not limited to): physical, chemical or biological treatments; visual or instrumented inspections; inspection/auditing/testing for compliance; prequalification of suppliers; training of personnel; and administrative and contractual controls. In addition to the pre-border barriers, a number of effective quarantine barriers are proposed at the border, where the Gorgon Joint Venturers will have custody and control of people and goods in an

environment where any residual organisms that might slip through pre-border barriers are contained. Post-border quarantine barriers are the surveillance and monitoring programs to provide early detection of any organisms that may be introduced and to have an effective response strategy to deal with organisms once detected.

In the Executive Summary, the Review authors are particularly critical of the quarantine risk assessment method, which is largely due to the reference of 'Decision Rules' in the Draft EIS/ERMP. The Review states: *"the quarantine risk management strategies described in Chapter 12, and the additional information package, are fatally undermined by demonstrably flawed logic."*

In Section 2.3.3, the Review authors extrapolate the concept of Decision Rules to a nonsensical conclusion. The Gorgon Joint Venturers disagree with this extreme application of Decision Rules. This type of application was not foreshadowed or intended in the Draft EIS/ERMP. All barriers considered for quarantine management must contribute to a sustained reduction in risk. If the authors had consulted with the Gorgon Joint Venturers, or other stakeholders involved in this matter, they would have learned that Decision Rules have not been used for the assessment of any pathway. The Gorgon Joint Venturers, in consultation with experts and the community, have made a commitment to drop them altogether. This outcome was recorded in the Quarantine Advisory Committee minutes and the record of the Community Consultation Meeting, 10 November 2005. Both these records are a matter of public record and are freely available on the Gorgon website. It should be noted that there was subsequently no mention or use of Decision Rules in the Additional Information Package. The Gorgon Joint Venturers found a way (post-Draft EIS/ERMP) to structure the risk assessment workshops to facilitate independent expert judgement regarding an overall pathway score for the risk of introduction without the need for Decision Rules. It appears the authors were unaware of this important fact with the result that much of the quarantine criticism of Chapter 12 of the Draft EIS/ERMP.

The Gorgon Joint Venturers have also developed a qualitative risk assessment methodology as a legitimate means of estimating the risk of introduction. This process was developed after extensive consultation in response to the EPA Bulletin 1011 (2003). It has been supported and endorsed by experts, accepted by the community and the EPA, and documented in the Draft EIS/ERMP. The Review, however, calls for quantitative assessment methods, quantitative estimates of quarantine barrier efficiency and statistical models which have not been tested with independent experts or stakeholders. Given the narrow database, nationally or internationally for the types of breaches of quarantine barriers might apply to the Gorgon Development, the Gorgon Joint Venturers do not support replacing the well considered and accepted qualitative process with a theoretical and untested quantitative approach, as proposed by the Review authors.

Review Section 2.3.4 Marine quarantine threats

The Review authors assert that Gorgon Joint Venturers' "assessment of marine quarantine is poor." This statement reflects a lack of recognition of the significant progress being made on the marine pathway (Draft EIS/ERMP, Section 12.4.4, page 561). The Gorgon Joint Venturers reject this value judgement of the assessment of marine quarantine risk.

Marine quarantine threats to Barrow Island have progressed through PBA workshops in most cases (Draft EIS/ERMP, Table 12-3, page 561). To date, two IMEA, two PBA and one QHAZ workshop have been undertaken for marine vessels, involving six independent marine experts. The assessment of marine quarantine risk is subject to the same rigorous methods as demonstrated for the three priority pathways described in the Additional Information Package and it is progressing toward completion.

The Review suggests that the Gorgon Joint Venturers have proposed a rationale to ignore the sources of marine non-indigenous species (NIS) that are directly associated with the

proposed development (page 19). This is not the case. The authors have misinterpreted and misapplied the Gorgon Joint Venturers' statement (Draft EIS/ERMP, Section 12.4.3, page 558) with regard to the discussion of standards for acceptable risk in the marine environment compared to the standards being developed for the terrestrial environment:

> *"Community expectations for acceptable risk, based on terrestrial flora and fauna, were recognised to be problematic for the waters surrounding Barrow Island when non-indigenous species could arrive quite independently of proposed development activities. Expert advice indicated that the risk standards were impractical for the prevention of introducing marine organisms."*

It would appear that the Review authors have confused the setting of standards for acceptable risk as required by EPA Bulletin 1101 (EPA, 2003) with the commitments of the Gorgon Joint Venturers to comprehensive risk management for all pathways of introduction (Draft EIS/ERMP, page 593). The Gorgon Joint Venturers are committed to comprehensive risk management for all pathways of introduction including those associated with the marine environment.

The Review notes that the proposed development will entail weekly visits by LNG ships to Barrow Island (page 19), and states that it is not possible to complete a risk assessment without knowledge of the ports of departure and trading routes of these vessels. The Gorgon Joint Venturers have acknowledged that some pathways, such as international LNG shipping routes, are not yet defined and could not be fully described at the time of the publication of the Draft EIS/ERMP. These pathways will be subject to the same rigorous risk assessment process to develop effective quarantine barriers. The Review author's comments regarding the use of the "potential next pest list" (page 19) have been considered by the Gorgon Joint Venturers and are included in current thinking.

The Review notes that the baseline survey work conducted in the waters around Barrow Island (Draft EIS/ERMP, Technical Appendix D7) is incomplete. It is also portrayed as "cursory" and "poorly described", which does not recognise its stated purpose (Draft EIS/ERMP, page 547). The work described in Technical Appendix D7 is not the marine baseline survey for Barrow Island. Rather, it is an important first step recommended by marine experts from the Western Australian Museum, the Western Australian Department of Fisheries, the University of Western Australia and other independent specialists. This was a targeted survey of areas at Barrow Island where species were most likely to have been introduced and it represented a preliminary baseline of possible introductions of declared marine pest species. This targeted survey provided useful information for subsequent detailed survey efforts. The Draft EIS/ERMP clearly stated that a broader scope baseline survey of Barrow Island marine introductions would be undertaken and that focused inspections of mainland ports of origin would be conducted.

The Review also states that "the efficacy and practicality of the suggested management measures for hull fouling threats are dubious" (page 19). The Gorgon Joint Venturers reject this claim. The Gorgon Joint Venturers are in the process of developing detailed quarantine barriers for hull fouling organisms, with advice from marine pest experts from the Western Australian Museum, the Western Australian Department of Fisheries, the University of Western Australia and other independent specialists. The Draft EIS/ERMP contains no detailed discussion of quarantine barriers for hull fouling, but does state that the cleaning of wetted surfaces is feasible from the experience of experts undertaking such cleaning in Western Australian waters and that cleaning will be confirmed by qualified inspectors.

Proposed barriers for hull fouling have now been tested for domestic vessels on the logistic supply chain in a QHAZ workshop. Notwithstanding the opinion of experts that the marine pathways can be approached differently from the material pathways, due to the

contiguous nature of the water column between the mainland and the island (compared to the long period of isolation of the two associated terrestrial habitats), the Gorgon Joint Venturers developed a set of barriers that were tested in a QHAZ for hull fouling of localised domestic shipping. The outcome of this assessment recorded risk scores that match the expectations of the community in terms of the three scenarios which represent the set of standards for acceptable risk. The Gorgon Joint Venturers recognise that such a judgement is made cognisant of the conditions set for detection and eradication as shared activities in the standards for acceptable risk.

Review Section 2.3.5 Detailed pathway assessments

The Review acknowledges the Additional Information Package provides comprehensive descriptions of the infection pathways and potential quarantine barriers. But the Review authors discount the detailed pathway assessments on the basis of the criticism in Section 2.3.3 of the Review. As stated in the Gorgon Joint Venturers' response to Section 2.3.3, the Decision Rules were not utilised for any of the assessments including those published in the Additional Information Package. Much of the critical comment by the Review authors on the detailed pathway assessment is hence meaningless.

The Review also raises the concern that the residual introduction risks of some pathways/biological group combinations exceed the community expectations. This is a concern that could have been dealt with appropriately if all the records of the community workshops and consultation (as mentioned above) had been considered. The Gorgon Joint Venturers have addressed this matter with the EPA in the accompanying letter.

Response to Recommendations

The following are the Gorgon Joint Venturers' replies to each of the recommendations in the Review.

Recommendation 1

In collaboration with stakeholders, augment the current risk assessment with a formalised, systematic and transparent hazard analysis that addresses and prioritises all potential threats to the marine (and terrestrial) environment.

To date, 29 QHAZ Workshops, 10 IMEAs and eight PBAs have been completed with the express objective of formally conducting an analysis of hazards and associated risks in a systematic and transparent manner. This work has involved the community and independent experts to identify the associated hazards and risks, to develop conceptual barriers that effectively manage the hazard and associated risk and then to tests such preliminary barrier designs against the "best available" knowledge as presented in a formal quarantine hazard workshop (QHAZ). The Gorgon Joint Venturers are confident in the ability of the independent experts to evaluate and judge the proposed barriers in each of the identified material pathways and has no reason to demonstrate a lack of confidence in the outcomes of the workshops. These are well-documented and will be used to continuously improve the performance of the system in terms of effectiveness and efficiency.

With reference to the criticism in the Review on the Gorgon Joint Venturers' focus on marine turtles and coral assemblages in the Draft EIS/ERMP without a formalised hazard identification process, such criticism highlights the reviewers' focus on process rather than outcome. Historically, the marine areas around Barrow Island have been little studied. Marine biota within the region, especially the invertebrates and plants that comprise a large proportion of the marine biodiversity, have received little attention from scientific

institutions. Despite their regional biodiversity significance, many of the smaller marine species of northern Australia have not yet been named and the supporting ecological processes poorly understood. The Gorgon Joint Venturers recognise the relatively small spatial scale of the proposed marine infrastructure, the constraints associated with limited comparative data and the poor level of taxonomic resolution for many marine groups. It is the opinion of the Gorgon Joint Venturers that the recommendation to augment the existing program by further collaboration with stakeholders and have yet another formalised, systematic and transparent process to identify hazards is unwarranted.

With regard to the recommendation to address and prioritise all potential threats to the marine (and terrestrial) environment, the Gorgon Joint Venturers are of the opinion that , in practical scientific terms, biological systems are never fully inventoried nor all processes that support them fully understood. Therefore, attempting to address all potential threats is not a sustainable scientific position given the paucity of the knowledge available to science, and can not be supported or justified by the Gorgon Joint Venturers.

Recommendation 2

Conduct quantitative surveys of all relevant (impact and control) subtidal and intertidal habitats.

The marine technical appendices were criticised by the Review authors on the basis of lack of comprehensive inventory data and fine scale distributional data for all marine species. As noted in response to 1 above, historically, the marine areas around Barrow Island had been little studied. Marine biota within the region, especially the invertebrates and plants that comprise a large proportion of the marine biodiversity, have received little attention from scientific institutions. Despite their regional biodiversity significance, many of the smaller marine species of northern Australia have not yet been named. Further, detailed inventory studies are only relevant over small spatial scales which, combined with the limited size of the proposed marine infrastructure, the constraints in sampling a remote marine area for which there are little comparative data, and the poor level of taxonomic resolution for many marine groups necessitated, in the opinion of the Gorgon Joint Venturers, justifies a habitat-based approach. Detailed inventory data are of little use without regional comparisons and this needs significant advances in taxonomic resolution of northern Western Australia's marine environment. Recognising this, and the fact that the proponent cannot be expected to resolve all of the shortfalls of current scientific knowledge in the area and the region, the Gorgon Joint Venturers have adopted a more realistic approach to the assessment. This approach relies on characterising marine benthic habitats to facilitate protection of rare or structurally diverse habitats in facility planning. These habitats are likely to be important to maintaining local and regional biodiversity.

The habitat-based assessment follows the assumption that protecting the full range of physical and biotic habitats on which the biotic diversity is dependent will protect the whole ecosystem. This is the basis of most impact assessments and is also used extensively in identifying important conservation areas, including the establishing marine and terrestrial protected areas. Marine reserves are generally designed on the basis of a broad habitat map – not on the distribution of individual taxa or known pockets of biodiversity based on site specific and comprehensive inventories of all taxonomic groups.

Although, the nearshore facilities proposed for the Gorgon Development are almost wholly within the Montebello/Barrow Island Marine Conservation Reserve, there is no development planned for high conservation areas, for example Marine Parks or benthic habitat protection areas. This indicates that the widespread marine assemblages in the area are of lower level of conservation significance than both the areas gazetted for Marine Parks and protection areas and the terrestrial environment of Barrow Island.

Habitat-based assessments tend to be more conservative than the inventory-based approaches. The Gorgon Joint Venturers have accommodated the shortfalls in knowledge, such as the current lack of taxonomically specific inventories for all the relevant marine ecosystem components and lack of data on fine-scale distribution of even the more important (listed threatened) marine taxa by following the precautionary principle. The risk assessment criteria and information gaps were treated very conservatively. This approach tends to increase false positive errors, therefore acting in favour of environmental conservation. For example, sygnathids (pipefish) are discussed at length in the Review and criticism is levelled due to the absence of survey data of the development areas. Although sygnathids have not been specifically targeted in sampling at Town Point, or included in an exhaustive inventory for the intertidal and subtidal reef area, they are assumed to be present in the area for the purposes of the risk assessment. The actual distribution of sygnathids is likely to be temporally dynamic, depending on population fluxes in the general area. Inventory surveys of the reefs at Town Point may fail to collect specimens of sygnathids, despite a series of surveys, but cannot conclude they do not occur there due to uncertainty in sampling efficiency and temporal representativeness. Destructive sampling, for example using rotenone poison, would be necessary and would have a similar impact to the development, thus negating any potential benefits of confirming the presence of the fish. The habitat-based assessment followed in the Draft EIS/ERMP recognised the potential for sygnathid use of the intertidal and subtidal habitats that are present that Town Point and concluded that they may be present at some time.

As a result of confidence in the habitat-based assessment and in recognition of the shortcomings in qualitative inventory surveys, the Gorgon Joint Venturers rejected the notion of conduct quantitative surveys of subtidal and intertidal habitats that may be impacted by the proposed marine infrastructure in the development footprint.

Recommendation 3

Conduct a much more thorough investigation of the distribution, abundance and behaviour of protected marine species in each of the proposed development areas. This is particularly pertinent to the endangered species of loggerhead turtles and olive ridley sea turtle.

The Gorgon Joint Venturers remain committed to an iterative process in managing the identified impacts as well as the unintended consequences of the proposed project. The Gorgon Joint Venturers are of the opinion that a blanket approach to the distribution, abundance and behaviour of protected marine species in each of the proposed development areas is adding no incremental value to the management of biodiversity within and around the development footprint. This commitment includes a monitoring and surveillance program to detect any environmental change that may occur as a result of the proposed development. Should loggerhead turtles and Olive Ridley sea turtles emerge as species of interest, the Gorgon Joint Venturers would, in conjunction with all relevant stakeholders, collaborate in developing a species action plan which may incorporate investigations into the distribution, abundance and behaviour of such species marine species, protected or otherwise.

Recommendation 4

Extend quantitative turtle surveys to fully include the nesting season of green, flatback and hawksbill turtles.

The Gorgon Joint Venturers are conducting tracking studies of flatback turtles to determine their foraging and inter-nesting habitats. The presence of resident and possible hibernating flatback turtles will be investigated in the winter of 2006. The results of these surveys will influence the management plans, but not the assessment of impacts, as a very conservative approach has been followed in assessing risks.

A tagging and monitoring program for adult turtles and sea-finding success for hatchlings on the beaches most likely to suffer impacts due to the development will be undertaken during construction and for least three years post-construction. This includes the continuation of the current program of tagging turtles and track counts on appropriate beaches.

The Gorgon Joint Venturers are committed to ensuring that flatback turtle breeding success is maintained on Barrow Island. This commitment will be reinforced by the monitoring and surveillance program which informs the conservation management of the species. It is not intended to extend this commitment to other turtle species as there is no information to indicate other turtle species, such as the hawksbill turtle, require the same degree of scientific endeavour. However, in time, should newly acquired knowledge indicate otherwise, the Gorgon Joint Venturers will adapt the prevailing management to account for this information.

Recommendation 5

Develop a management and monitoring strategy for all ecosystem components/ process identified in the EIS/ ERMP as threatened by the proposed development. Each of these strategies, including the current strategy, should be formally evaluated.

The Draft EIS/ERMP sets out the preliminary management measures that will form the backbone of detailed Environmental Management Plans (EMP). These EMPs will follow the published framework (Appendix A). The completion of the EMPs is held in abeyance pending the outcome of the environmental approval process. Once the project has certainty, it can progress to the level of finalising the EMPs.

Additional detail on specific monitoring programs, including additional baseline sampling in and around the development footprint, the detection, monitoring and surveillance programs designed to detect incursions of marine pests and record possible changes in the environment, will be provided in the final EMPs. These will be formulated in consultation with, and to the satisfaction of, the regulatory agencies with sufficient opportunity for other stakeholder to actively participate in their preparation.

Recommendation 6

Incorporate all new and existing bio-physical models into the formal management strategy evaluation recommended above, for all measurement endpoints, as soon as possible.

The Gorgon Joint Venturers are developing a set of EMPs which will be to the satisfaction of the regulatory agencies and other stakeholders. Stakeholder will have sufficient opportunity to actively participate in their preparation.

The Gorgon Joint Venturers accept that such an approach may result in the inclusion of bio-physical modelling, but question the necessity and feasibility of the recommendation to "incorporate all new and existing bio-physical models into the formal management strategy evaluation". This recommendation is not accepted.

Recommendation 7

Undertake a much more thorough uncertainty analysis, ideally within the risk management framework recommended above.

The Review authors may not agree with the approach to the impact assessment, notwithstanding the Gorgon Joint Venturers' response to the recommendations made above. However, the Review made no specific criticisms of risk rankings provided in the Draft EIS/ERMP. The Gorgon Joint Venturers maintain that the information the Draft EIS/ERMP provides sufficient basis for assessment, given the highly conservative (precautionary) nature of the risk assessment process.

For example, the assertion made in the Review that: "The revised estimates of personnel landings from 170,000 (ChevronTexaco Australia 2003) to 94,000 (Chevron Australia 2005), for example, are indicative of the uncertainty that arises as major developments are planned and progress" (page 7). Such a statement demonstrates a lack of understanding of project development and the precautionary approach taken toward assessing the impacts of development. The fact that the estimate of personnel landings has been reduced as the basis for the impact assessment has no correlation with uncertainty. The reduction in personnel landings reflects management decisions on how to execute the development of the proposed gas plant. The impacts are assessed on the basis of the maximum number of personnel landings foreseen with good engineering analysis. The impact assessment uses conservative judgments of the consequences and likelihood of impacts, to categorise risk in a precautionary manner and propose appropriate management strategies.

The Review reports (page 15) that "In Chapter 9 of the EIS/ERMP the joint venturers state that they have adopted a worst case approach to uncertainty." In fact, the term "worst case" does not appear anywhere in Chapter 9. In other Chapters of the Draft EIS/ERMP, the term is used in the context of a very severe, but credible hazard scenario. The Review also states that the only source of uncertainty considered was "variability", which arises from natural stochasticity of living systems. The criticism that other sources of uncertainty have been "unwittingly ignored" is unfounded. Another very important source of uncertainty, "incertitude", or incomplete knowledge, was recognised in the assessment methodology, and dealt with in the process of making conservative judgments of consequences and likelihood in the absence of empirical data.

The Gorgon Joint Venturers do not support the recommendation, as the foundations for it is questionable due to the incorrect interpretation or lack of understanding of the work completed to date.

Recommendation 8

Discard the current qualitative decision rules for quarantine barrier selection and replace them with quantitative estimates of efficiency.

The Decision Rules were discarded in October 2005; a decision openly communicated to the Quarantine Advisory Committee in October 2005 and community stakeholders in November 2005, some two months prior to publication of the Review.

The purpose of the Decision Rules was to assist in the synthesis of an overall pathway score for the likelihood of introduction, from the scores recorded at all of the intermediate pathway steps. They were proposed in the Draft EIS/ERMP as a heuristic technique for combining infection scores for barriers proposed at a number of pathway steps (Draft EIS/ERMP, pages 564-566).

In practice, when undertaking QHAZ workshops for the first time (after publication of the Draft EIS/ERMP), the facilitator of the workshops proposed an alternative that proved to be more acceptable to independent experts:

- Workshop participants were asked to score the likelihood of infection at the first pathway step, as a result of the suite of prescriptive quarantine barriers proposed at the first pathway step.
- Workshop participants also scored the likelihood of infection at the first pathway step, if all of the recommendations in the QHAZ for the first pathway step were adopted ('treated' risk score). Generally, the treated risk score is lower than the score for the barriers as proposed in the Barrier Selection Document presented as the basis for the workshop.

- At each subsequent pathway step, the scores from the previous step were taken to be the starting point for infection. A new score for the likelihood of infection was recorded at each subsequent pathway step, incorporating the starting point from the previous step and considering the next set of barriers and any threats of re-infection of cargoes. Thus, the infection score at each intermediate step of the pathway represents the likelihood of infection as a result of all of the prescriptive barriers proposed from the source of the cargo up to that point on the pathway.
- Following this approach, the scores at the last pathway step (arrival of the cargoes at Barrow Island) represent the overall likelihood of introduction for the pathway, taking into account all of the pathway steps and the prescriptive quarantine barriers presented to workshop participants.

The scoring in the QHAZ workshops was witnessed by observers from the Department of Environment/EPA Service Unit and the Department of Conservation and Land Management.

The Decision Rules cannot be replaced with quantitative estimates of efficiency, as recommended by the Review authors. Consultation with experts consistently reinforced the view that quantitative judgments of barrier effectiveness (efficiency) were not possible without data to underpin the estimates. The qualitative likelihood of introduction for the overall pathway were based on precautionary judgments by independent experts in the absence of data, noting that the recorded scores may be overstated in some cases, e.g. there could be opportunities to realise a lower score if some data were available. Under no circumstances did the recorded scores underestimate the likelihood of introduction in the opinion of workshop participants.

Recommendation 9

Use the IMEA to prioritise potential quarantine hazards and then use relevant statistical models, in a quantitative risk management analysis, to demonstrate compliance with community expectations.

The Review appears to have been prepared without reviewing all of the publicly available workshop records, including the reports for 10 IMEA workshops. All of the workshop reports were provided to the Department of Environment, the Department of Conservation and Land Management, and other stakeholder observers (as well as all workshop participants). All of the workshop reports have been published on the Gorgon Project website: www.gorgon.com.au.

The IMEA workshops assisted the Gorgon Joint Venturers and stakeholders prioritise potential quarantine hazards, leading to the identification of the three 'priority' pathways for early assessment that were published in the Additional Information Package. The IMEA workshops more broadly identified the greatest threats of infection for the Gorgon Joint Venturers to focus resources on in developing effective quarantine barriers.

The recommendation to use "relevant statistical models" does not add value to a qualitative risk assessment, where the risk scores (1 to 10) should not be given any more significance than a convenient shorthand for qualitative definitions of likelihood. Nor would such a suggestion facilitate the comparisons with community expectations for risk.

It is essential to note that the qualitative risk scores are not an end in themselves. Rather, they are a mechanism for understanding risk and taking appropriate management actions. The suggestion of risk scores demonstrating "compliance" with community expectations would fall short of the overall goal of protecting the conservation values of Barrow Island and the surrounding waters. Without trivialising the substantial effort undertaken to perform risk assessments of all of the pathways, it is only one (important) element of a

robust Quarantine Management System, developed under the principles of ISO 14001 and ISO 9001 management system standards.

Recommendation 10

Augment the proposed marine environmental-match assessment with a species-specific assessment.

There is benefit in species-specific assessments of potential threats of introduction for marine pests. These types of assessments can be undertaken to augment environmental matching assessments for vessels that visit ports where surveys have been completed to identify potential pest species of concern. For the majority of ports where such rigorous surveys have not been completed, it is impossible to use a species-specific assessment.

The Gorgon Joint Venturers do not propose to conduct port surveys of any ports where cargoes are loaded. Instead, the Gorgon Project will take a precautionary approach for vessels making up the majority of visits to Barrow Island on the logistics supply pathway, and has proposed effective quarantine barriers which have been tested in a QHAZ workshop. Although the Gorgon Joint Venturers have stated their support for a collaborative baseline survey of the Port of Dampier (Draft EIS/ERMP, page 547), in the absence of such data the proposed quarantine barriers would effectively prevent introductions for organisms that might be present in the Port.

Allowing for the lack of a baseline survey of the Port of Dampier, the workshop participants have noted that the likelihood of introduction cannot be reduced any further on this pathway, regardless of any specific marine organisms which may have been introduced to this mainland Port.

Other examples of precautionary quarantine measures are the slipping, inspection and cleaning of jack-up rigs and dredge vessels during construction, and recognition of the new IMO performance standards for ballast water treatment systems which will apply to LNG carriers and other vessels following commencement of operation of the proposed gas plant in 2010, and beyond.

Appendix 9

Letter from Dr Keith Hayes, CSIRO on Disk 2 inside back cover

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25th April 2006

Dear Dr. Cox

Quarantine Management System for the Gorgon Gas Development

Thankyou for your letter of the 20th April 2006.

The strengths of the Quarantine Management System (QMS) for the proposed Gorgon Gas development lie in the multi-disciplinary team that Chevron Australia gathered to develop the system, and the detailed hazard analysis that this team has conducted. This provides a good basis for a "world class" QMS. I agree that the decision to remove the decision rules published in Table 12-6 of the Environmental Review and Management Plan (ERMP) removes the "fatal flaw" in the QMS that we referred to in our recent review of the ERMP.

To achieve a "world class" QMS, however, I believe it is essential that Chevron Australia:

- translate the infection score for each of the last pathway steps into a quantitative performance indicator – i.e. quantitative predictions of the expected number of organisms that will reach Barrow Island (for relevant biological groups) for each year of construction and operation;
- develop and implement a monitoring strategy that is designed to detect these organisms with a high level of statistical certainty;
- identify the key uncertainties in the predictions and monitoring strategy and test the robustness of the strategy to this uncertainty; and,
- provide for a regular independent audit of the monitoring strategy and its outcomes.

The steps described above provide a "safety net" against unforeseen events and errors of judgement that all people are prone to when making qualitative assertions about quarantine risks. Moreover, without this type of analysis I cannot see how Chevron Australia will be able to test the efficacy of their proposed quarantine barriers, identify deviations in the QMS over the lifetime of the Gorgon Gas project or demonstrate to the community that Barrow Island is actually being protected from the quarantine hazards associated with the project.

Finally, I note from the minutes of the Special Meeting of the Gorgon Quarantine Advisory Committee (held on the 6th October 2005) that the committee remains concerned that Gorgon has not "taken the opportunity to collect data on the rates and types of infection of existing pathways to Barrow Island". I agree with the committee that this is of concern and emphasise that this type of data could provide an empirical starting point for the development of the quantitative performance indicators recommended above.

Please do not hesitate to contact me further if you wish to discuss any of these recommendations further.

Yours sincerely,

Keith Hayes

Appendix 10

Report by Professor Richard Hobbs

Review of and Advice on Gorgon ERMP and Related Documents

Terrestrial Conservation Issues

Report prepared by:
Professor Richard J Hobbs
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November 2005

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CONTENTS

Review of and Advice on Gorgon ERMP and Related Documents

Objectives

The objective of this report is to provide an independent review of the documentation available regarding the proposed Gorgon development on Barrow Island.

Detailed objectives are:

Review the Gorgon ERMP, relevant appendices and related documents,

- generally in regard to the protection of conservation values on the Barrow Island Class A Nature Reserve, and
- particularly with regard to the likelihood of the proposed management plans adequately ensuring that those conservation values will not be compromised by the introduction of invasive species or diseases.

Provide advice as to the:

- adequacy of the proponent's information to enable proper assessment of any significant environmental impacts relevant to the conservation of biota on Barrow Island likely to arise as a result of the Gorgon proposal;
- likely effectiveness of management plans to mitigate potential impacts sufficiently to ensure the conservation values of Barrow Island are sustained;
- need for any other studies to adequately assess environmental impacts likely be significantly affect conservation values;
- need for any other management measures to secure the conservation values of Barrow Island from impacts likely to arise as a result of the Gorgon proposal;
- desirability of any significant changes to the Gorgon proposal to reduce likely impacts on the conservation values of Barrow Island, and
- overall likelihood of the conservation values of Barrow Island being sustained if the Gorgon proposal was to proceed.

EXECUTIVE SUMMARY

1. Barrow Island is a unique conservation resource with irreplaceable conservation values. These values have not been adequately accounted for in the analyses used to justify selection of Barrow Island as the location for development rather than other possible locations.

2. The risk assessment process used is limited by uncertainties and data gaps, and underlying assumptions are not always made clear.

3. The main risk assessment process (Chapters 9 and 10) does not make it clear that invasive species constitute a significant risk to the conservation values of Barrow Island, and concludes instead that no high risk stressors can be identified.

4. It is clear that invasive species pose the greatest actual and potential threat to the conservation values of Barrow Island. The proposed development significantly increases the likelihood of invasion by changing five of the six key phenomena affecting invasion probabilities.

5. The proposed Quarantine Management System is an ambitious attempt to reduce the potential for invasion to agreed acceptable levels. However, the information provided so far does not indicate that this system will achieve these goals, for the following reasons:
    a. To date, detailed analysis is available for only 3 out of 12 or more possible invasion pathways
    b. This analysis does not demonstrate that an acceptable level of risk is achieved
    c. There is no estimate of current infection rates on existing pathways
    d. The short timeframe under which development is scheduled militates against adequate quarantine measures being in place during construction.
    e. There is not adequate consideration of the possible introduction of harmful disease organisms
    f. There is not an adequate detection and eradication protocol to deal with species which evade quarantine barriers

6. A number of key areas where more information is required are identified, as are specific areas where other management measures may be appropriate.

7. Given the current status of the information provided in the Gorgon ERMP, it is not possible to conclude that the conservation values of Barrow Island will be sustained if the Gorgon proposal was to proceed in its current form.

1. Introduction

The proposed development of the Gorgon and other gas fields represents a significant opportunity in terms of economic and social returns to Australia, and Western Australia in particular. There seems little doubt that the development is likely to proceed. The main question to be considered, however, is whether Barrow Island is a suitable location for the development and whether it is possible to site the development on Barrow Island without significantly compromising its conservation values.

The Draft Environmental Impact Statement/Environmental Review and Management Programme for the Proposed Gorgon Development Main Report and supporting appendices and related documents (herafter referred to as the Gorgon ERMP) represents a significant body of work which aims to address, and develop management strategies for, the various environmental and other impacts of the proposed development of the Gorgon gas field and the use of Barrow Island as the location of the associated gas production facility.

This report considers only the elements of the Gorgon ERMP which are relevant to the protection of terrestrial conservation values on the Barrow Island Class A Nature Reserve.

2. Conservation values on Barrow Island

Review the Gorgon ERMP, relevant appendices and related documents,

- *generally in regard to the protection of conservation values on the Barrow Island Class A Nature Reserve*

2.1 Selection of Barrow Island over other potential locations

A key element that must be considered in relation to the protection of conservation values on Barrow Island is whether the rationale for siting the development there is sufficient. Barrow Island is internationally recognised as an area of outstanding conservation significance because of its almost unique faunal assemblages and virtual lack of non-native species. Butler (1987) commented that it “contains one of the richest assemblages of wildlife found on any Australian offshore island”. This must be set against the broader conservation picture, with Australia having the worst record of mammalian extinctions of anywhere in the world, largely as a result of inappropriate management regimes and the impacts of feral animals since European colonisation (Burbidge & Friend 1990; Burbidge & McKenzie 1989; Short & Smith 1994; Szabo 1995). The presence of a fauna which is representative of the terrestrial fauna which would have been present on the Australian mainland prior to European settlement makes the island’s conservation values amongst the highest in Australia. This, coupled with the possibility that some island fauna populations have developed distinct genetic traits which differentiate them from other populations elsewhere, means that the island is largely irreplaceable in any conservation

reserve network (e.g., Pressey et al. 1994; 2004). These values have been retained even in the presence of the existing oil industry activities.

The conservation significance of Barrow Island is therefore incontestable. The uniqueness of the island does not however show up clearly in the comparative analysis carried out of the biodiversity values of alternative locations (Main Report, Table 3.2, Table 3.4). The breakdown of the attributes of each location into individual components hides the more holistic viewpoint which would clearly place Barrow Island as of considerably more importance than any of the other potential locations.

A further major issue is that it is very difficult to place a monetary value on the conservation significance, and hence the underlying biodiversity and heritage value is not included in any financial analysis of the use of Barrow Island for development. Table 3.3 (Main Report) provides a comparison of key cost driver components across the alternative locations, which indicates that Barrow Island is the least cost alternative. This analysis, coupled with associated considerations of technical convenience, is the primary driver of the choice of Barrow Island as the site for development. There are growing attempts to build effective valuation systems which can take account of non-monetary values, and the value of living systems to humans is increasingly recognised (Costanza et al. 1997; Millennium Ecosystem Assessment 2005; Toman 1998). Despite this, it is still very difficult to build such considerations into financial balance sheets, and non-monetary values are frequently ignored or discounted.

A key consideration in this case is that the values of Barrow Island, as discussed above, are high and irreplaceable, and any loss of such values would be largely permanent and irreversible. This loss is not in terms of any given species, but relates to the loss of the unique set of circumstances which has maintained Barrow Island as an intact ecological community which is mostly free from harmful non-native species. This is the true cost which has to be considered in any risk analysis of the potential impacts of development. While the irreplaceability of Barrow Island's values has been noted in public submissions and commented on in passing in the economic analysis (Technical Appendix F1, p21), there was no real attempt to deal with the issue effectively. The statement "there may be little or possibly no demonstrable loss of environmental values" (Technical Appendix F1, p21) has to be matched by the opposite argument that there *is* the possibility of irreversible loss of irreplaceable values.

2.2 Risk assessment framework

The basis of the analyses in the Gorgon ERMP is risk assessment, as outlined in the Main Report, Chapter 9. While this is an acceptable and recognised approach, which has been developed in detail in the Gorgon ERMP, there are some important issues to be considered in judging its efficacy. The field of risk assessment is rapidly developing, and new ideas and techniques are increasingly available (e.g., Burgman 2005). However, certain limitations remain, as recently summarised by MacGill & Siu (2005):

1. People's knowledge is what determines the way they perceive, define and assess risk issues.
2. Risk issues are a combination of physical and social qualities and properties
3. Risk issues are pervaded by uncertainty and crises of trust
4. Risk issues are intrinsically dynamic, changing in profile over time and across geographical and cultural space
5. The effectiveness of risk management interventions rests on the quality of the knowledge (scientific and social) on which they are based, and on the internal congruence of that knowledge.

Wandall (2004) further emphasises that "risk assessment is subject to a number of methodological limitations causing uncertainties that are unlikely to be resolvable". Such limitations include uncertainties caused by data gaps and extrapolations, and Wandall suggests that in cases of uncertainty, "risk assessors will have to rely on assumptions, rather than facts".

Such issues underlie the approach undertaken in the Gorgon ERMP. A key element is ensuring that issues of uncertainty and the assumptions made in the face of that uncertainty are made transparent and accounted for in the process. In the sections that follow, areas where significant uncertainty remains or is not accounted for are highlighted.

2.3 Risk from invasive species

Chapter 10 of the Main Report (p302) indicates that no high risk stressors have been identified. However, the risks from invasive species are not given a mention here. Indeed invasive species are not listed in Chapter 9 as stressors associated with the proposed development activities. The introduction of non-native animals, plants and microorganisms nevertheless poses the greatest threat to the integrity of the biodiversity within the Barrow Island Nature Reserve. The risk to the island's biodiversity from quarantine failure is far greater than the risks posed by any of the other factors considered here. While this topic is considered in detail in Chapter 12 (and is discussed further in Section 3 below), it is somewhat misleading to claim in Chapter 10 that there are no high risk stressors identified. This section should be clearly linked to Chapter 12, and quarantine failure identified as the highest risk to the island's biodiversity.

3. Introduction of invasive species or diseases

Review the Gorgon ERMP, relevant appendices and related documents,

- *particularly with regard to the likelihood of the proposed management plans adequately ensuring that those conservation values will not be compromised by the introduction of invasive species or diseases.*

3.1 Importance of invasive species

As indicated in Section 2.3, the introduction of non-native animals, plants and microorganisms poses the greatest threat to the integrity of the biodiversity within the Barrow Island Nature Reserve. The importance of invasive species and their impacts on natural and managed ecosystems, and the ensuing costs, is increasingly recognised worldwide (Mooney et al. 2005; Pimentel et al. 2000). The Gorgon ERMP correctly recognises this and details a strategy for minimising the potential impacts of invasive species, mostly through a program of pre-border prevention.

3.2 Factors affecting likelihood of invasion

Successful invasion by a species not native to a given area depends on a number of factors, which include the transport of organisms or propagules (such as seeds), their successful establishment in the new area, subsequent growth and survival to reproductive maturity, followed by successful reproduction and spread. Carlton (1996) has identified six major ways in which opportunities for invasion are likely to increase, as outlined in Table 3.1. How each of these six phenomena may be affected by the proposed Gorgon development is indicated in Table 3.2. The key message from this table is that the development will almost certainly increase the likelihood of invasions occurring simply because of the increases in the number of donor regions, environmental changes during and after development, frequency of invasion windows, and increased numbers of vectors. This set of considerations differentiates the proposed development from the existing oil enterprise. The existing enterprise has resulted in the arrival and establishment of invasive species on the island (see Section 3.3), and the proposed enterprise greatly increases the probability that further invasions will occur.

Table 3.1. Phenomena likely to result in changed probability of invasion (DR = Donor Region, RR = Recipient Region) (From (Carlton 1996)

Phenomenon	**Processes involved**
Changes in donor region	Environmental changes in DR lead to: • Population increases of resident species making more individuals available for transport • Range expansion of local species into previously uninhabitable areas of DR, making these species available for transport *Resident and local species may be either native or introduced* New introductions of non-indigenous species occur within DR: • New species available for transport
New donor regions	New DRs become available: • New species available for transport • New genomes with different adaptive regimes than previously-transported populations of the same species from other DRs become available for transport
Changes in recipient region	Any environmental changes in RR that lead to altered ecological, biological, chemical or physical states, thus changing the susceptibility of the RR to invasions.
Invasion windows	Invasions occur when the proper combination of colonizing conditions occurs, followed by the proper combination of conditions that permit the long-term establishment of reproducing populations. These combinations may or may not be dependent on changes in the RR.
Stochastic inoculation events	The release of a very large number of inoculants into the RR, increasing (among other considerations) potential reproductive success.
Dispersal vector changes	Vector size, speed, and quality increase leading to: • Increase in inoculant species diversity • Increase in abundance of inoculated species • Increase in number of post-trasport “fit” individuals New vector emerges from same donor region

Table 3.2. How phenomena listed in Table 3.1 can be affected by processes relevant to Barrow Island

Phenomenon	**Processes relevant to Barrow Island**
Changes in donor region	• N/A
New donor regions	• Increased number of donor regions due to different supply origins of equipment, vehicles, materials, food supplies etc
Changes in recipient region	• Disturbances related to construction etc • Increased numbers of personnel • Increased vehicular traffic on island
Invasion windows	• More frequent transport of invasive organisms • More frequent quarantine breaches • More disturbance due to construction etc • Increased soil fertility through NO_x inputs
Stochastic inoculation events	• Unauthorised ballast water release • Undetected colonies of organisms in cargo • Bioterrorism
Dispersal vector changes	• Increased numbers of ships and aeroplanes visiting island • Increased numbers of personnel travelling to island • Increased amounts of cargo, packaging etc • Increased amounts of foodstuff

3.3 Adequacy of proposed measures

As outlined in the Gorgon ERMP, the proponent is attempting to develop a quarantine system which aims to be better than anything that currently exists anywhere in the world. This is a commendable aim, and the success of this quarantine system is essential to the maintenance of the biodiversity values of Barrow Island. However, a realistic assessment of the likelihood of success needs to be made.

Essentially, to achieve the stated aims of protecting the biodiversity of Barrow Island, the quarantine system needs to be fail-safe. However, it is unlikely that there is such a thing as a perfect quarantine system, and all systems will fail from time to time because of human error, smuggling, and the impossibility of preventing the transport and establishment of all organisms travelling with people, equipment, packaging etc under all circumstances. The failure rate can certainly be managed, and is dependent on the design and integrity of the system, the people running it, the effectiveness of treatment of all possible invasion routes, the sampling rate of cargo inspection and so on.

The Gorgon ERMP outlines an ambitious attempt to develop an effective quarantine system. However, the chances of doing this successfully in the first instance must be considered slim, given the short time available and the desire to work to tight construction deadlines. Although necessary for quarantine success, it is questionable

whether full implementation of potentially-restrictive quarantine measures will take precedence over construction timetables once the project gets underway. For instance, the proposed establishment of the pioneer camp for the project had a putative schedule for building to commence at the beginning of 2006, and this would certainly be prior to all of the quarantine management plans being completed yet alone approved. This suggests that the likelihood of early quarantine failures may be higher than indicated

The Gorgon ERMP details the known past quarantine incursions (Main Report p 543), indicating that a number of species have established on the island, some of which were subsequently eradicated. Of particular concern are the incursions of mice and black rats. Three records of incursions by house mice via food cargoes and drilling equipment provide an indication of the invasion potential of these rodents. Interpretation of the presence of black rats on the island includes (1) the suggestion in the Gorgon ERMP (Main Report p543) that they may have been introduced by pearlers in the late nineteenth century, (2) the possibility that they were introduced by oil field operations or (3) that they swam there from nearby islands (see Section 3.5, below). If (1) is true, this indicates that the monitoring system used on the island was insufficient to detect the species earlier, while (2) indicates the potential for inadvertent transport of this species.

Despite the further information provided in the Additional Information Package, the proponents have been unable to demonstrate to date that they will be able to meet the 'Community expectations for acceptable risk' developed under the guidance of the Quarantine Expert Panel (pp 555-556). The three 'priority' pathways detailed in the Additional Information Package all show final infection scores allocated by the experts above '1' (Additional Information Package, pp. 8-9, 12, and 18). In other words, the pathway analyses indicated that the expectation that "The introduction is extremely remote, highly unlikely" is not likely to be realised. This indicates that Scenario 1 (Figure 12-4) cannot be achieved, and also places the other scenarios in doubt. This is because:

(1) it is not possible to allocate a survival score of less than 8 for organisms which have been introduced (as there will always be a proportion of organisms that will survive on the island once they arrive, as already demonstrated by the range of weed species present, rats, mice, and the recently-discovered non-native ant species) and
(2) the proponent is unable to demonstrate that detection and eradication scores will be less than 4.

Only three 'priority' terrestrial pathways have been completed to the 'barrier design' stage, plus some progress on marine pathways. Progress on detailing these pathways was slow, with the information being delivered only in late October 2005. There are, however, at least 12 pathways in total, and it must be questioned whether there will be sufficient detail on all pathways, properly evaluated, in place and tested before construction commences. Of particular concern is equipment that will be shipped directly to Barrow from overseas.

While the emphasis has been on the most obvious pathways and species/groups likely to be transported, there also needs to be consideration of other possibilities. For instance, organisms have been found to be successfully transported in aircraft undercarriage, and

particularly invasive species such as the Brown Tree Snake, which has had very destructive impacts on the native biota on Guam (Rodda et al. 1997; Savidge 1987), have been detected in long-distance transport vectors on numerous occasions (Vice & Vice 2004).

3.4 Disease organisms

The Gorgon ERMP provides little information on the movement of microorganisms related to construction and development. There has been minimal effort to survey the island's biota for natural or invasive diseases, and little effort to determine the potential for movement and spread of potentially harmful microorganisms. The potential impacts of novel diseases on wildlife populations is currently being graphically illustrated in Tasmania by the devil facial tumour disease which is greatly reducing numbers of Tasmanian Devils (Bostanci 2005). The potential importance of disease organisms in the Barrow Island situation is reviewed in the Gorgon ERMP Technical Appendix D8, but very little of this information is considered in the main report.

3.5 Likelihood of detecting successful invasions

While most emphasis in the Gorgon ERMP has been placed on prevention of invasion via management of potential pathways, there remains a significant residual risk of invasion which must be taken seriously. Monitoring and early detection of invasions is essential if the potential threat that such invasions pose is to be adequately dealt with. Monitoring undertaken to date is likely to have been inadequate to address this issue fully, and proposed monitoring systems must take into account the difficulty in detecting rare and elusive species (Thompson 2004).

A recent salutary example of this has been provided by work from New Zealand, where an individual rat was released on a rat-free island to test detection and trapping efficiency. Despite intense trapping efforts, the rat evaded capture for 18 weeks and swam 400m across open water to a neighbouring island, before finally being captured (Russell et al. 2005). The authors conclude that "The exceptional difficulty of this capture indicated that methods normally used to eradicate rats in dense populations are unlikely to be effective on small numbers, a finding that could have global implications for conservation on protected islands".

Given the known effects of invasive species such as rats on island ecosystems and their fauna (Simberloff 2001; Thorsen 2000), there is a significant risk to the conservation values of Barrow Island arising from the increased invasion potential due to increased traffic to the island coupled with the difficulty of detecting and eradicating an invasion once it has happened. The longer a species goes undetected in the early stages of invasion, the less opportunity there is to intervene, the fewer options remain for its control or eradication, and the more expensive any intervention is (Mack 2000).

The risk based approach taken in the Gorgon ERMP scores infection, survival, detection and eradication. Almost all of the reported work has been on infection, with some

attention to survival, but little to detection and virtually nothing to eradication. There appears to have been no effort to develop protocols for eradication of invasives should they establish. Given the increased probability of a successful invasion occurring (Section 3.2) and the problems with detecting invasions outlined in this section, it is not possible to conclude that the proponents can confidently assert that they have adequately dealt with the issue of invasive species. Considerably more effort needs to go into developing sound and comprehensive protocols for detection and eradication.

4. Adequacy of proponent's information

Provide advice as to the:
adequacy of the proponent's information to enable proper assessment of any significant environmental impacts relevant to the conservation of biota on Barrow Island likely to arise as a result of the Gorgon proposal

4.1 Information on infection of existing pathways

The background work via the QEP and its recommendations, and the series of IMEA and QHAZ workshops on three major pathways, while very useful, has been wholly a paper-based study. Invited experts at the workshops had to suggest risk scores without any hard data. To date there has been no attempt by the proponent, despite recommendations from the QEP and experts at workshops, to measure infection of existing pathways. This is a relatively easy task, given the current volume of plane and sea travel to Barrow, and would provide some essential data with which to assess the increased risk posed by significantly increased volumes of traffic.

4.2 Biological survey expertise

The proponent does not appear to employ a biologist to coordinate surveys, despite early recommendations by the QEP. A small number of environmental scientists are employed, but there is apparently little "in-house" biological expertise, with the proponent relying instead on short term consultancies to conduct the necessary survey and monitoring work. While the experts employed in these consultancies undoubtedly have excellent credentials, there is a clear need for more adequate coordination of survey and monitoring efforts, especially if the necessary level of baseline survey and monitoring to allow early detection of invasive species is to be instigated.

4.3 Invertebrate data

Existing baseline data on invertebrate fauna that is present on Barrow are rudimentary. Terrestrial invertebrate fauna surveys have only recently started and have so far consisted only of a minor 'pilot' project. A problem with invertebrate survey is that results are often slow to accumulate since collections tend to be large and identifications take a long

time, with many groups having to be referred to experts elsewhere. The brief pilot study has already detected one introduced 'tramp' ant species (Jonathon Majer, personal communication), indicating that claims of lack of introduced species are based on very incomplete data. Baseline studies on terrestrial invertebrates seem to be a case of 'too little too late'. This is an important problem, since invertebrate invasions can have profound consequences for island biota, as illustrated by the crazy ant (*Anipolepis gracilipes*) on Christmas Island (Green et al. 1999; O'Dowd et al. 2003).

4.4 Baseline surveys of other groups

While extensive survey work has been undertaken for the Gorgon ERMP, this has largely concentrated on the areas directly impacted by the development, and has taken the form of "snapshots". It is questionable whether the level of survey undertaken so far can constitute an adequate baseline against which to measure change, particularly in relation to invasive species.

5 Likely effectiveness of management plans

Provide advice as to the:
likely effectiveness of management plans to mitigate potential impacts sufficiently to ensure the conservation values of Barrow Island are sustained

The key areas of concern have been discussed in detail in Section 3, and centre around the efficacy and sufficiency of the proposed Quarantine Management System. From the materials provided to date, the evidence suggests that the management system will not deliver the degree of quarantine protection agreed to through community consultation.

6 Need for further studies

Provide advice as to the:
need for any other studies to adequately assess environmental impacts likely be significantly affect conservation values

From previous sections, the need for further studies has been highlighted in the following areas:

1. Comprehensive analysis of the full range of pathways for invasive species incursion.
2. Design and testing of a suitable detection and eradication protocol, including the development of adequate baseline data and monitoring procedure
3. Analysis of infection rates in existing pathways
4. Detailed invertebrate sampling and analysis

5. More comprehensive analysis and treatment of disease organisms of potential importance

7 Need for other management measures

Provide advice as to the:
need for any other management measures to secure the conservation values of Barrow Island from impacts likely to arise as a result of the Gorgon proposal

7.1 Disease organisms
The potential importance of disease organisms in the Barrow Island situation is reviewed in the Gorgon ERMP Technical Appendix D8 and D9, and a number of possible management actions are outlined there (for instance, disinfecting foot baths at the airport). However, none of these management options has been included in the main report. It seems important that such measures are implemented if the stated goals of quarantine are to be achieved.

7.2 Specific management actions in relation to quarantine
A range of specific management options need to be considered if the proposed quarantine management system is to be effective. Examples include using rodenticide in containers, effective quarantine and inspection of food, and selection of products from Australian suppliers wherever possible.

7.3 Integration of management strategies for existing and proposed developments

While there is little reference in the Gorgon ERMP to the existing oil extraction operations and infrastructure on Barrow Island, it will be essential that management strategies and protocols for these existing operations be integrated with those for the proposed gas development.

8 Desirability of any significant changes to proposal

Provide advice as to the:
desirability of any significant changes to the Gorgon proposal to reduce likely impacts on the conservation values of Barrow Island

The main significant change to the proposal that would reduce the likely impacts to the conservation values of Barrow Island would be the reconsideration of locating the development elsewhere.

Other proposed changes have been outlined in other sections of this report.

9 Likelihood of conservation values being sustained

Provide advice as to the:
overall likelihood of the conservation values of Barrow Island being sustained if the Gorgon proposal was to proceed.

While the Gorgon ERMP goes to significant lengths to recognise the conservation values of Barrow Island and to devise management strategies to sustain these values, the underlying problem identified in Section 2 remains. This is that Barrow Island represents a unique conservation resource and any threats to its overall integrity and value should be minimised. The fact that the Gorgon development could proceed using a location other than Barrow Island is central to the decision of whether the development on Barrow should proceed or not. The decision to use Barrow Island is based almost entirely on economics and technical convenience, and cannot be justified in conservation terms.

While the proponents have provided considerable detail on all aspects of environmental management of the development, the primary threat to the integrity of Barrow Island remains – namely the risk of establishment, spread and ecosystem impact of invasive species. The proposed Quarantine Management System rightly concentrates on pre-border measures to reduce the likelihood of invasion, but the proponents have not adequately established that this system will be effective, and have provided little detail on measures to detect and eradicate successful incursions. Lessons from other parts of the world, including many islands, indicate that invasive species can have devastating effects on island biota and ecosystems. Hence it is not possible to conclude that the conservation values of Barrow Island will be sustained if the Gorgon proposal was to proceed in its current form.

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Appendix 11

Response from Chevron to Report by Professor Richard Hobbs on Disk 2 inside back cover

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17 March 2006

Mr Warren Tacey
Warren Tacey
Department of Environment
PO Box K822
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Dear Mr Warren Tacey

Proposed Gorgon Development – Murdoch Review of Draft EIS/ERMP

Please find attached our comments on the report prepared by Professor Richard Hobbs of the School of Environmental Science at Murdoch University on aspects of the Draft EIS/ERMP for the Proposed Gorgon Development.

Thank you for the opportunity to consider his views and respond. I understand that both his report and our response will be made public at the release of the EPA Report and Recommendation.

Yours sincerely

Russell Lagdon
Gorgon HES Manager

Encl (1)

Cc Tim Kahn Department of Environment & Heritage

Dist Colin Beckett, Joe Gregory, Norm Taylor, Peter Coghlan, Ross Mathewson, Johann Van Der Merwe

Doc ID G1-CO-LTR-CVXPH-DEEPH-0000002

The Gorgon Joint Venturers Response to the Murdoch Review of the Draft EIS/ERMP

The West Australian Environmental Protection Authority engaged Professor Richard Hobbs from the School of Environmental Sciences at Murdoch University to perform a review of the Gorgon Development Draft EIS/ERMP and Additional Information Package. The Gorgon Joint Venturers have been provided with the report, entitled: *Review of and Advice on Gorgon Environmental Impact Statement and Environmental Review and Management Programme*, by Hobbs, R. J. (November 2005), referred to here as the 'Murdoch Review'. The opportunity to comment on this review is welcomed by the Gorgon Joint Venturers as it continues the transparent process that has been applied to the Draft EIS/ERMP and the matter of quarantine in particular. The Gorgon Joint Venturers also welcome the helpful suggestions in the Murdoch Review as they continue to improve their quarantine management plans to protect the conservation values of Barrow Island and the surrounding waters. The Murdoch Review recognises the issues associated with quarantine and their approach and expectations do not differ greatly from that of the Gorgon Joint Venturers.

The Gorgon Joint Venturers agree with the Murdoch Review that the conservation values of Barrow Island are unique and that invasive species pose a risk to these values. The Venturers appreciate the recognition in the Murdoch Review that the development of a world-class Quarantine Management System for the Proposed Gorgon Development is an ambitious attempt to reduce the increased risk associated with the change in the invasion probability (From Table 3.1 and Table 3.2). However the Ventures disagree that the progress to date suggests that a management system as proposed by the Venturers will not deliver the degree of quarantine protection agreed to through the community consultation process.

Risk Assessment Framework

The Murdoch Review acknowledged that the risk assessment approach undertaken by the Ventures is an acceptable and recognised approach, and that it is rapidly developing as a preferred scientific approach in challenges that require a qualitative adjudication. The Venturers in observing the advice of EPA as set out in their report and recommendation on the Environmental, Social and Economic Review of the Gorgon Development, (Bulletin 1011 2004); have developed this qualitative risk assessment methodology as a legitimate means of estimating the risk of introduction of non indigenous species in consultation with experts and the community.

As set out in Section 2.2 by the Murdoch Review, the Ventures understand and accept the limitations of risk assessment and have not utilised it as an exact science. In this context, the Venturers have used a conservative approach to assessing risk as a precautionary measure. In cases, where limited information eroded the confidence of the Ventures to determine risk, significant resources were made available in an attempt to fill the information gaps that had been identified. As an example, a competent invertebrate baseline survey for Barrow Island could not be uncovered in agencies or with the existing oilfield operator. Therefore the Ventures have funded a pilot baseline survey and a second extensive baseline survey to establish for the first time a detailed understanding of the invertebrate assemblages in the vicinity of the proposed Development and a range of disturbed sites on the Island. Such an approach has resulted in a better understanding of the risk associated with the proposed development. The Venturers and independent experts are not required to rely on assumptions and anecdotal evidence but have verifiable facts when assessing the potential quarantine risk.

Introduction of Invasive Species or Disease

The Ventures acknowledge the opinion in the Murdoch Review that invasive species, when ignored, are potentially a high risk threat in all ecosystems and if such species manages to establish they have the potential to be a high risk stressor. The Ventures highlighted this risk by dedicating an entire chapter in the Draft EIS/ERMP to Quarantine Management. In hindsight there could have been clearer linkage between Chapter 10 dealing with the Terrestrial Environment - Risks and Management and Chapter 12

Quarantine - Risks and Management. By dealing with quarantine and the potential introduction of non-indigenous species in a separate chapter, it was intended to highlight the importance of the matter rather than include it as a subsection in chapters in both terrestrial and marine environments.

The Venturers are well aware of the growing global concern of the environmental impacts and accompanying economic costs on ecosystems of invasive species. It is this awareness, coupled with the conservation status of Barrow Island that drives the Venturers to develop a Quarantine Management System that is setting new benchmarks. This awareness and system has a "zero tolerance" to the introduction of non-native species to Barrow Island.

In developing the Quarantine Management System, the Ventures are well-advanced in completing a quarantine management plan that incorporates detailed information on invasive species phenomena, species action plans, monitoring plans and eradication responses. In the management plan, attention is paid to biology and factors that influence potential introduction of non-native species as a result of the development's. These include the dispersal potential of organisms within the identified pathways of introduction, establishment of an individual(s) on the Island, the likelihood of survival and reproduction of such individuals and the subsequent colonization potential of the species.

The Venturers are very aware that the scale of the proposed Gorgon Development differs significantly from the existing oil field operations on the Island. The relative success of the existing quarantine management program has informed the proposed Gorgon Development. Specific attention has been and continues to be given to externalities such as an:

- increase in the number of suppliers and their respective locations (donor regions),
- stochastic and deterministic events within these source locations that may effect the risk profile (e.g. predictable floral blooms of buffel grass or kapok at the marine loading facility in Dampier or unexpected nuptial flights of termites after a rain event),
- perturbation on the Island as a result of the proposed development or unrelated environmental change that creates favourable habitat for colonization,
- opportunistic and episodic events that present a colonization window for species that require a juxtaposition of a unique/specific set of environmental conditions, and
- substantial increase in vectors to and on the Island that increase the inter-island dispersal and mobility of non-native species.

Adequacy of proposed measures

The Venturers agree with the Murdoch Review that the development of the Quarantine Management System is an ambitious project that requires considerable resources in the form of people, financial, technological, ingenuity and leadership to ensure the integrity of the system.

Over the 40 years of successful oilfield operation, quarantine management on Barrow Island has developed into a sophisticated, practicable process that has significantly contributed to the conservation values present on the Island. One of the strengths of this process has been the application of lessons learned over the years. Quarantine management is embedded in every project undertaken on Barrow Island and in every logistical activity. Visitors to the Island, whether from government agencies or community organisations, understand that there is pervasive quarantine culture that has developed over time. This is an accomplishment in which the operator takes considerable pride.

The Joint Venturers appreciate the challenge of developing a world class QMS for the proposed Gorgon Development which seeks to build on the legacy of the existing successful quarantine management program in a manner that can accommodate the increased activities associated with the proposed development. The QMS will incorporate the principles of ISO 9001 and ISO 14001 and will populate

the existing operational systems of the Joint Venturers and the operator (Chevron Australia) with quarantine procedures and requirements.

The QMS will be supported by a Quarantine Management Plan that identifies the key performance indicators as determined in the QHAZ process, the actions and procedures required for compliance and the measurements to ensure compliance. The management plan will cascade into all the operations of the Development. Both the QMS and the QMP will be subject to audit and review to ensure the desired outcomes. Progress to date supports the completion and full implementation of the system prior to construction.

Meeting community expectations

The Venturers have a different view to that expressed in the Murdoch Review on the ability to meet the community expectations for quarantine standards. This difference may be the result of a view developed by the author without the benefit of a complete set of available information at his disposal.

In line with the advice of EPA, the Venturers have embarked on a very robust, rigorous and transparent public process that aims to meet the community expectations of acceptable risk associated with the proposed Development. Through collaboration with independent experts and the broader community, the Venturers have a confidence in their abilities to develop an efficient and effective QMS which will ensure that the risks to the conservation values are acceptable and manageable, and meet the community expectations.

To date, the Gorgon Joint Venturers have held 28 workshops involving 29 independent technical specialists to assist and advise in the development of:

- an array of quarantine management measures,
- a set of barriers for the identified pathways that reduce residual risk of each item designated for the Island,
- detailed quarantine procedures underpinning the respective barriers,
- detection, monitoring and surveillance plans, and
- response and eradication strategies in the event of a quarantine breach.

In this context, it is the opinion of independent technical specialists, supported by advice from the Quarantine Advisory Committee that the risk of introductions to Barrow Island is low. This was reported in the Additional Information Package.

The workshops have been professionally facilitated to ensure that the risk scores and definitions have been consistently applied by the participants, and a wealth of experience has been gained to demonstrate how the scores are interpreted in practice. The accuracy of the judgments are assured through the proven risk assessment practice of engaging technical experts as a group, where debate and discussion was conducted openly and transparently among independent experts. In the event of uncertainty or differences of opinion, the range of scores was recorded in every case. The results of all workshops are published on the Gorgon quarantine website. Ultimately, the accuracy of scoring rests with the independent experts who have repeatedly attended workshops and exercised their interpretation of the scores with their colleagues.

The Joint Venturers have developed a set of standards for acceptable risk, with advice from experts and substantial community input. These standards are presented in Boxes 12-9 through 12-12 of the Draft EIS/ERMP. Details of the three priority pathways are presented in Part 2 of the Additional Information Package, which shows how the standards have been met in a rigorous and transparent manner for the three priority pathways, relying on the judgment and advice of independent experts participating in QHAZ workshops.

The Joint Venturers transparently discussed the possibility that introduction scores could not be reduced to a score of '1' (*The infection is extremely remote, highly unlikely*) in the Risk Standards Workshops #2 and #3

(Technical Appendix D3), and also reported this to the wider community during the development of the risk standards framework (starting with Community Consultation Meeting #2, 20 April 2004, and in subsequent meetings). The Joint Venturers discussed the additional measures that have been adopted in these situations. The community expressed the view in these Risk Standards Workshops, that there should be a commitment to 'a risk scaling of 3 (*There is a slight chance of infection*) as an upper limit'. The introduction scores for the pathways presented in Part 2 of the Additional Information Package and the subsequent scores in five other pathways are consistent with this upper limit, and meet the Joint Venturers' standards for acceptable risk (Boxes 12-9 through 12-12 in the Draft EIS/ERMP, pages 557-560).

As stated in the Additional Information Package, it is important to note, based on the advice of independent experts attending the QHAZ workshops, the scores for introduction cannot be further reduced, other than through the use of fumigation. The use of fumigation chemicals can have negative environmental consequences and hence this has been reserved as a measure of last resort in situations where cargo is discovered to contain organisms that have evaded the multiple barriers applied prior to transport to Barrow Island. The experts also expressed the view, on many occasions, that the scores for introductions reflect a precautionary judgment of risk (maximum scores) based on a lack of performance data for the proposed barriers. As experience is gained with the barriers that are used as the basis for scoring, an iterative process of review and improvement will occur as required by the QMS to further reduce the risk of introduction.

Disease organisms

As recommended by the Quarantine Expert Panel, the Venturers obtained advice on potential threats of disease by way of desktop studies. These reports are presented in Technical Appendices D8 and D9 of the Draft EIS/ERMP. Micro-organism threats to terrestrial vertebrate fauna were addressed by the School of Veterinary and Biomedical Sciences at Murdoch University. The plant pathogen threats were discussed by the Curator of the Plant Pathology Herbarium of the Queensland Department of Primary Industries and Fisheries. Potential pathogens and their hosts were identified in these studies, such that quarantine management would take them into account when developing barriers, particularly for the food and perishables and personnel pathways.

Experts have concluded that although risks associated with disease introduction exist, there are varying perceptions on the level of this risk. Notwithstanding this, the Venturers remain confident the proposed housekeeping and cleanliness requirements are sufficiently robust to ensure a very high standard of quarantine compliance. This will significantly reduce the stochastic probability of an unforeseen introduction within a poorly understood dynamic of a disease.

Detection, monitoring, surveillance and eradication

The Venturers agree with the Murdoch Review comments in Section 3.5 on Likelihood of detecting successful invasions. The primary focus in preventing the establishment of non-indigenous species on Barrow Island has been placed on preventing introductions through the barrier design, but the proposed Development will include detection, monitoring, surveillance and eradication. The aim of the detection, monitoring and surveillance program is to detect incursions of non-indigenous species along any of the pathways, and /or on the Island, by employing a logical methodology for surveys at regular time intervals during the pre-construction, construction, and operational phases of the development. Detection will trigger an Eradication Response Strategy that consists of a detection plan, incursion report, agency and operator contacts and authority, response inventory (eg. equipment and instructions), category of incursion and category of response, response protocol and Species Action Protocol aimed at containing and eradicating any introduction.

The Venturers recognise that eradication efforts will be organism-specific and have committed to a rapid response strategy utilising the advice of technical specialists (Section 12.5.9 of the Draft EIS/ERMP).

The detail of the strategy is being developed and will be subjected to peer review and field training exercises prior to the commencement of construction activities for the proposed Development. Chevron Australia, as the operator of the existing oilfield, has experience in effective response for introduced rats, mice and several species of plants on Barrow Island.

An important part of the Response Protocol will be pre-existing contingency plans for specific types of quarantine breaches and emergency situations that might occur (e.g., medical evacuation, distress of a vessel at sea requiring assistance). The Eradication Response Strategy will be completed prior to the start of construction.

Timely completion of pathways

The pathways will be completed in a timely manner. By agreement with the EPA and the Quarantine Expert Panel, the Venturers had focused on the delivery of the three critical pathways that were believed to be the most difficult and had the earliest application in the construction schedule. These were Sand Aggregate, Personnel and their Luggage, and Food and Perishables. The Joint Venturers have committed to complete all pathway assessments, develop pathway-specific barriers, test the proposed barriers in QHAZ workshops with independent experts and implement the barriers prior to the start of those materials being required on Barrow Island. To date ten of the fifteen pathways have been completed with risk scores that meet the risk standards. The pathway assessments will be complete by April 2006, enabling the Joint Venturers to trial barriers, collect data and implement proposed barriers for each pathway over a three month period prior to the start of construction.

The ground-truthing of barrier performances has commenced and a program that verifies the performance of the existing quarantine management procedures for the oil operation is being executed. Preliminary information indicates that quarantine compliance was achieved for the mobilisation and shipment of the two recent investigative works programs, the 52-man camp and the geotechnical drilling program. These investigative works were subject to a number of effective barriers that are proposed for the Development construction effort.

Adequacy of the information

The Venturers have presented a vast body of information in the Draft EIS/ERMP including a very detailed statement of its quarantine commitment. In addition, all the outcomes of the public consultation meetings, community workshops, the reports on all the IMEAs and PBAs, the Quarantine Advisory Committee meeting records, the QHAZ records and an informative quarantine website is freely available to all stakeholder. There is general consensus amongst the participating stakeholders that the progress to date is sufficiently adequate, notwithstanding philosophical differences of opinion about the rationale for a qualitative versus quantitative risk assessment process

In all of the workshops experts used their experience and knowledge to inform the assessment process. The Venturers are in the process of assessing the existing supply chain procedures to ascertain their effectiveness as measured against the newly developed logistic solutions for Barrow Island.

Baseline data

The Venturers agree with the Murdoch Review that only limited baseline data existed on invertebrate fauna on the Island. In preparing the Draft EIS/ERMP, the Venturers in consultation with biodiversity experts assessed the level of baseline knowledge on Barrow Island. It was established that notwithstanding the long period as a Class A Nature Reserve, no acceptable invertebrate baseline exists. In response, the Venturers agreed to an invertebrate pilot study with a contractual commitment for a second phase baseline survey to adequately sample the immediate surrounds of the development footprint and a range of disturbed sites on the Island. This program was endorsed by the Quarantine Advisory Committee and has been subject to independent peer review.

Likely effectiveness of management plans

The Venturers disagree strongly with the views expressed in the Murdoch Review that the QMS will not deliver the degree of quarantine protection agreed through community consultation. It would appear that the Murdoch Review has failed to incorporate readily available information on commitments to quarantine management as reflected in the QHAZ documentation. As such, the Review offers comments without regard for the progress in terms of developing procedures and requirements for quarantine and detection, monitoring and eradication protocols. The review also ignores over two years of consultation with experts and the community on matters directly informing the management of quarantine that will safeguard the conservation values of the Barrow Island and surrounding waters. Given these limitations, it is not surprising the Murdoch Review has a different understanding of the Quarantine Management System as stated in the Draft EIS/ERMP and the emerging Quarantine Management Plan. The Murdoch Review has not demonstrated an appreciation and complete understanding for the process the Venturers have embarked upon to develop a world-class QMS. The QMS is informed by risk assessment as a tool for making good management decisions. The QMS relies on a robust ISO 14001-based multi-facetted management system to protect the conservation values of Barrow Island and not a simple series of options and procedures condensed in a manual format.

Conclusion

The Venturers appreciate the contribution the Murdoch Review has made to the process of developing a competent Quarantine Management System. The opportunity the Murdoch Review created to benchmark the progress to date against another independent and valued stakeholder is welcomed. The limited differences of opinion regarding the adequacy of baseline surveys, the timeframes for completion and implementation of the Quarantine Management System and the effectiveness of management plans are partially the result of a limited exposure of the author to progress to date. The Gorgon Joint Venturers remain committed to explore all reasonable contributions and opinions of all the stakeholders to ensure the Development remains faithful to its commitment of a "world-class Quarantine Management System" that embraces a "zero tolerance to the introduction of non-indigenous species to Barrow Island".

Appendix 12

Report by Dr Colin Limpus on Disk 2 inside back cover

MARINE TURTLE CONSERVATION AND GORGON GAS DEVELOPMENT, BARROW ISLAND, WESTERN AUSTRALIA

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REPORT

TO

ENVIRONMENTAL PROTECTION AUTHORITY, WESTERN AUSTRALIA
&
DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT, WESTERN AUSTRALIA

19 May 2006

Marine turtle conservation and Gorgon Gas Development, Barrow Island, Western Australia

Colin James Limpus

1. Introduction

This report is in response to a request from the Environmental Protection Authority and Department of Conservation and Land Management, Western Australian on 9 May 2006 to provide advice on:

- Likely impacts on marine turtle populations of the Gorgon proposal to construct and operate a liquefied natural gas processing and export facility on Barrow Island.
- Action to protect the flatback turtle population in the future, and
- Action for future monitoring of these turtle populations.

2. Summary of turtle biology relevant to the Gorgon Proposal

2.1. Turtle species

Barrow Island supports internationally significant nesting populations for two species of threatened species of marine turtles (green turtle, *Chelonia mydas*, and flatback turtle, *Natator depressus*), and minor nesting by a third (hawksbill turtle, *Eretmochelys imbricata*). The biology of these species has been reviewed recently for Western Australia (Limpus, 2002) and for Australia (Limpus, in press a,b,c,d)

The marine turtle populations that aggregate for breeding in Western Australia (WA) are all genetically discrete from other populations of the respective species that breed in other Australian states and neighbouring countries (Broderick et al. 1994; Dutton et al. 2002; Moritz et al. 2002). The biological consequences of this are:

- For each species, groups of rookeries on adjacent islands and mainland beaches form the interbreeding population of the stock for each species within WA.
- Because of temperature dependent sex determination, it can be expected that beaches with different temperature profiles will produce hatchlings with different sex ratios. Complementary rookeries producing both male and female hatchlings are critical for the viability of each population.
- The large breeding groups (major rookeries) have the greatest potential for providing the large-scale hatchling recruitment necessary for maintenance of population viability for large stocks of each species in WA.
- If any stock of WA turtles is seriously depleted or lost, turtles of the same species from outside of WA will not recruit to replace the WA nesting turtles within human management time frames. Such replacement can only be expected over a timeframe of thousands of years.

Flatback turtles: The nesting population on the eastern beaches of Barrow Island is a major part of the Pilbara Coast genetic stock management unit. (Dutton et al. 2002). This summer breeding Pilbara Coast (Northwest Shelf) stock effectively will not interbreed with the neighbouring winter (mid year) breeding flatback stock that aggregates to breed in western Arnhem Land and Bonepart Gulf (Limpus, in press d).

The Pilbara Coast nesting population could account for 30% or more of the total breeding population for this species that is endemic to the Australian continental shelf (Limpus, 2002, 2004). Although the size of the annual nesting population has been incompletely quantified, the sampled nesting is consistent with 500 to 1000 flatback turtles nesting annually on Barrow Island (ERMP TAC6 Attachment 1; K. Pendoley, pers. comm. May 2006). This Barrow Island population is not only significant for Western Australia, it is one of the few documented large nesting aggregation for the species. This makes it an internationally significant rookery for the species. In order of magnitude, about 70% (~500 females annually) of Barrow Island flatback turtle nesting occurs on the mid east coast beaches (Mushroom, Tank, Terminal, Bivalve, Inga and Yacht Club Beaches. ERMP TAC7 Appendix 1). These beaches lie immediately to the north and south of Town Point where most of the infrastructure for the Gorgon Project will be located (ERMP Ch08).

Green turtle: The very large nesting population on the western beaches of Barrow Island is a major part of the Northwest Shelf genetic stock (management unit) (Moritz et al. 2002). This Northwest Shelf genetic stock is internationally significant, being one of the few remaining very large green turtle breeding populations remaining globally (Hirth, 1997; IUCN, 2004). North White's Beach, the beach identified for the Barrow Island shore crossing of the feed gas pipeline on the western side of the island supports only a trivial amount of nesting (ERMP TAC7 Attachment 1).

Both these Western Australia turtle stocks have been, and continue to be subjected to a range of negative impacts from human activities within their nesting, migratory and foraging ranges that give concern for the long term viability of each species as a whole in WA (Limpus, 2002). Any reduction in population dynamics performance for these species at Barrow Island resulting from the Gorgon Development will further reduce the long term survival prospects for these species in WA. Similarly any enhancement of population performance that can be achieved through this Gorgon Development will increase their survival prospects.

2.2. Marine turtle sensory ability

Marine turtles have an acute sense of **smell** that depends on water being drawn into the mouth and flushed out through the nostrils rather than water being inhaled via the nostrils. They appear to have no sense of **taste** (Manton et al. 1972). Their **vision** is good with them seeing a similar visible spectrum to the human eye as well as seeing in the ultraviolet range. Their eyes may not form as clear an image when out of water. Their **hearing** is limited because they do not have external ears but they can hear low frequency sounds (vibrations) outside the range of the human ear. They do not hear the frequencies that can be heard by the human ear.

Marine turtles can detect **magnetic fields**. Hatchlings are imprinted to the earth's magnetic field in the region of their birth while older turtles appear to be imprinted to other locations including foraging area(s) and courtship areas (Lohmann and Lohmann, 1994,1996). Using a mental "map" and the earth's magnetic field, marine turtles are able to repeatedly travel to the same locations along approximately direct migratory pathways between the feeding, courtship and nesting areas. At a local scale,

other cues may also be used to assist in navigation between resting, foraging and basking areas (Avens and Lohmann, 2003).

2.3. Habitats

Barrow Island and adjacent marine areas provides essential habitat for a wide range of the life history stages for marine turtles, including courtship areas, internesting habitat, nesting beaches and foraging habitats. Barrow Island provides terrestrial habitat for breeding turtles including their eggs and hatchlings. The adjacent marine habitats provide courtship and internesting habitat for breeding turtles and pelagic and benthic foraging habitat for non-breeding turtles.

Courtship area(s): a tidal or sub-tidal marine area where courtship between the migrating adult males and females occurs.

Mating turtles do not feed or only feed to a limited extent. Courting turtles may also bask by day or night on beaches. This occurs extensively with green turtles on Barrow Island's western beaches (Limpus, 2002, in press b). This should not be confused with low tide stranding of females as they return to sea from the nesting beach (ERMP TAC7).

The courtship habitat used by flatback turtles that breed on Barrow Island has not been identified. There is no evidence that flatback turtles come ashore to bask at any phase of their life history. It is presumed that most flatback courtship will occur in deeper coastal waters not necessarily adjacent to the nesting beach.

Internesting habitat: the marine habitat occupied by breeding adult females while they ovulate and prepare eggs for laying.

This habitat will occur offshore but at variable distances from the nesting beaches, depending on the species and coastal topography. Females, as they prepare for the next laying event, return repeatedly to the internesting habitat following the laying of each clutch of eggs. Preparation of a clutch for laying takes about two weeks. Therefore a green turtle laying an average of 5 clutches for the season will spend about 10 weeks in the internesting habitat. A flatback turtle that averages 3 clutches of eggs per season will spend about 6 weeks in the internesting habitat. Turtles in the internesting habitat do not feed or only feed to a limited extent while they are producing eggs. They live off stored fat reserves at these times.

Results of recent satellite telemetry of four internesting flatback turtles from the mid eastern beaches of Barrow Island have yet to be fully analysed. However, preliminary assessment (K. Pendoley, pers. comm.) indicates that:

- These females spent most of their internesting periods well offshore and outside the area likely to be impacted by dredging.
- Each female remained within the immediate inshore area of her nesting beach for a few days immediately following each nesting event.

Each nesting turtle will transit through the immediate inshore area as they approach and leave the beaches. With approximately 500 nesting females nesting on these beaches and each, on average, laying three clutches per

season, these nesting turtles should spend from 1,500 to 4,500 “turtle-days” within the vicinity of the dredging operations during the course of a nesting season. This should approximate to a daily presence of 35-75 internesting females swimming in the vicinity of the dredging operations during the breeding season.

Green turtle internesting habitat for Barrow Island is expected to be spread throughout inshore waters in less than 18m depth along the entire northwestern and northern coast (ERMP TAC7).

Nesting beach(s): the terrestrial habitat where adult females come ashore to lay eggs above the high tide level.

The adult female does not necessarily return to breed at the beach of her birth but can be expected to breed within its general region (Limpus, unpublished data). She chooses her nesting beach while she is within the internesting habitat and travels to the beach when she is ready to lay a clutch of eggs. Nesting mostly occurs at night. Having chosen a nesting beach, the nesting female can be expected to return for repeated nesting to the same beach both within a breeding season and across successive breeding seasons, unless there are disturbance factors which may cause her to change nesting beaches. Long-lived individuals can be expected to breed for more than ten seasons spanning about 30 years of breeding life (EPA Turtle Research database). Because of this behaviour, we can hypothesise that the choice of nesting beach made by the female as she commences her breeding life will influence her choice of nesting beaches in subsequent breeding seasons. The adult female responds to light horizons when choosing her nesting beach (Salmon, 2003) and when returning to the sea from the beach.

Eggs incubate in the beach sands without parental care to produce hatchlings that dig their way unaided to the beach surface. Incubation period, incubation success and hatchling sex ratio are a function of beach sand temperatures within the nest. Incubation success / hatchling production depends on egg survival which is strongly influenced by beach stability. Erosion and flooding by rising water tables cause death of eggs. Hatchlings do not use the beach or immediately adjacent waters for feeding or resting. Hatchlings are imprinted to the earth’s magnetic field as they leave the nest and are probably imprinted to the smell of the first water that they contact. They orient towards light horizons at low angles of elevation to find their way to the sea and swim perpendicular to wave fronts as they disperse from the beach.

The pivotal temperature for each of the turtle stocks, the temperature profiles for the WA nesting beaches, and the sex ratio of hatchlings produced at the major nesting beaches have yet to be recorded or published. These data are unknown at this time.

Offshore currents for pelagic dispersal of post-hatchlings: After an initial swimming frenzy which takes the hatchlings some 10s of kilometres offshore, they change behaviour to commence feeding as they drift in pelagic waters.

While green turtles are dispersed by currents into oceanic pelagic waters, flatback post-hatchlings remain in neritic (near shore) pelagic waters.

Foraging habitat for non breeding turtles: The marine habitats surrounding Barrow Island support year-round foraging populations of marine turtles (Prince, 2001).

The coral reef, rocky reef, algal turfs and seagrass beds adjacent to Barrow Islands (ERMP Ch.8) will support foraging green turtles. The dense beds of seapens off the east coast of Barrow Island (ERMP, TA C8) will support foraging flatback turtles. Hawksbill turtles will be foraging on selected algae, sponges, soft corals and other invertebrates on the coral and rocky reefs. Loggerhead turtles will be foraging primarily on molluscs and crabs across a wide range of hard and soft-bottomed habitats. For each species, the population can be expected to include the full size range of turtles from young immature turtles recently recruited from the pelagic post-hatchling life history phase to large adults. For each species, these foraging turtles may be a mix of genetic stocks and should include representatives from all stocks with breeding areas within ~2000km of the foraging area. While some of the foraging turtles may be part of the Barrow Island breeding population, most will not. However, for each species, the vast majority will be part of the same genetic stock as breeds on Barrow and nearby islands.

3. Hazards to marine turtle survivorship and successful population dynamics associated with the Gorgon Project at Barrow Island

3.1. Photopollution

In 1985, Verheijen introduced the term "Photopollution" which he defined as "degradation of the photic habitat by artificial light". Modern society's modification of light horizons at turtle nesting beaches through the use of night lighting and other artificial light sources creates a habitat that "repels female [turtle]s from nesting beaches and causes the death of many of their hatchlings" (Salmon, 2003).

The disorientation behaviour of adult and hatchling marine turtles in response to altered light horizons is similar for all species (Limpus, 1971; Limpus and Reed, 1985; Limpus et al. 2003; Lohmann et al. 1997; Salmon, 2005; ERMP TAC7 Attachment 2). Limpus (2002) and Salmon (2003) describe the avoidance of nesting beaches with bright light horizons by nesting females and associated population declines. On the Woongarra Coast in eastern Australia, there has been a progressive decline in loggerhead turtle nesting on Kellys Beach (The 2nd best nesting beach in the district prior to the mid 1970s.) that has paralleled the proliferation of street, housing and motel lighting illuminating the horizon of the nesting beach since the 1970s (Queensland EPA Turtle database; C. Limpus, unpublished observations). Some 30yr later, Kellys Beach now supports a trivial level of nesting with none occurring on most nights of the nesting season. Paralleling this decline at Kellys Beach there has been an increase in nesting at Oaks Beach about 10km to the north within the remaining "dark horizon" coastline. However, Oaks Beach is not a suitable incubator for turtle eggs, having the poorest nesting success for all beaches in the district and

being one of the most erosion prone beaches in the district with associated higher risk of erosion of nests during storms.

Individual lights as point sources can disorient hatchlings turtles in close proximity (up to hundreds of metres). The scale of the impact zone being a function of type of light and light intensity (ERMP TAC7 Attachment 3). However, the diffuse glow of many lights of a township or large industrial facility shining at and reflected into the night sky can cause the disorientation of hatchlings on beaches up to 4.8km from the light sources (C. Limpus, unpublished observation at US Virgin Islands). Similarly, the diffuse glow over modestly illuminated tourist resort buildings behind a forested dune margin attracted hatchlings from up to 0.5km out to sea back onto the beach (C. Limpus, unpublished observation at Heron Island). Vessels with deck lights on and at anchor off turtle nesting beaches in the Great Barrier Reef in the absence of a moon at night attract and trap hatchling turtles dispersing from the beaches (C. Limpus, unpublished observations). Predatory fish, dolphins and birds such as silver gulls will target the trapped hatchlings swimming in the light pool around a vessel. Any impact that increases the time that hatchling turtles spend in crossing through the shallow waters off the nesting beach can be expected to increase hatchling mortality because of the associated increased fish and bird predation on these turtles (Gyuris, 1994).

The Gorgon Project infrastructure including the gas processing facility (GPF), flare system, materials offloading facility (MOF), administration and maintenance facilities, roads, airport, construction village (including recreational facilities) associated with Town Point and other locations close to the east coast have the potential to drastically alter the light horizons behind and over the most important flatback turtle nesting beaches in Western Australia. The MOF, LNG jetty and associated navigation lighting have the potential to extend these altered light horizons for some 4.4km out to sea from Town Point. The LNG jetty extends diagonally across the approaches to the beach to the south of Town Point.

Maintenance of dark horizons behind and over the nesting beaches should be a primary strategy when planning for the long term survival of significant marine turtle populations. However, the ERMP (sections 6.2, 7.3) make it clear that the total Gorgon facility on shore and on the causeway and LNG jetty will not be dark and hence will not maintain the natural dark horizon that is part of the key parameters that cues turtles to nest on these beaches (Salmon, 2003).

While there will be more extensive night use of lighting during construction, there also will be extensive continuing use of night lighting during the 60+ years (approaching two generations for flatback turtles) of operational phase in addition to intermittent light from the flare(s), vehicle traffic on the causeway and jetty and from ship loading operations (x3 24hr periods per week) plus other shipping. The ERMP (Section 7.3) identifies a number of useful tactics for reducing light intensity and light spillage, including use of long wavelength lighting, shaded lights, reduced height bollards, facing lights away from beach, reducing lighting on reflective surfaces, ground-based flares, motion detector switching and maximising daylight hours where “lighting” is essential. While the ERMP implies dramatic reductions in lighting effects over a conventional lighting regime, it gives no assurance that the achieved reduction will keep changes to the light horizons at a level that is not disruptive to nesting turtles and a level that does not increase hatchling mortality.

The starting premise regarding the fate of the Barrow Island mid east coast flatback nesting population if this facility is constructed as currently proposed is that the shift away from a dark horizon behind and over the nesting beaches will have two significant negative impacts on population dynamics:

- The size of the nesting population on these beaches will decline substantially over the next few decades. It is presumed that this will be primarily the result of 1st time breeding females choosing to nest at darker beaches further along the coast and that conditions associated with these other beaches outside the currently preferred nesting sites will be less suitable for production/appropriate dispersal of vigorous healthy hatchlings of the appropriate sex ratio.
- During periods when the moon is not above the horizon and during overcast periods, there will be increased incidence of hatchling disorientation. This will lead to increased mortality of hatchlings through increased predation while on the beach and their being lost inland. Increased time spent crawling on the beach results in less active hatchlings with reduced stored fat reserves reaching the water. This will result in slower swimming hatchlings crossing inshore waters with increased risk of predation and a reduction in how far the hatchlings can swim out to sea before the swimming frenzy ceases.

Hatchlings swimming from the beach will swim approximately perpendicular to the beach but they also will move laterally under the influence of the long-shore tidal currents (ERMP AIP). These lateral currents will transport a portion of the nightly hatchling production from an extended area of adjacent beaches past the LNG jetty and moored vessels. This will enhance the likelihood of hatchlings being trapped within brightly illuminated areas adjacent to the jetty and moored vessels. This will further increase hatchling mortality.

While it has not been tested, it is highly likely that the convergence of tidal currents that occurs off Town Point with the associated off shore current may provide an important mechanism in efficient dispersal of hatchlings from these beaches. The causeway, MOF and LNG Jetty is being constructed within this potentially critical convergence zone.

3.2. Low frequency sound, vibrations and movement

Marine turtles hear low frequency sounds/vibrations. This aspect of their biology has been little studied. Preliminary studies at Barrow Island indicate that hatchlings will respond to some sounds/vibrations and move towards a small generator (ERMP TAC7 Attachment 2). Within the Great Barrier Reef, we have observed green turtles shifting their nesting distribution away from a vessel with no deck lights but generator running and moored about 0.5km from the beach (C. Limpus, unpublished observation). In contrast, green and loggerhead turtles that are long term residents on the reef adjacent to Heron Island Harbour have habituated to vessel activity around them with resulting minimal disturbance caused by the vessels.

Marine turtles coming ashore to nest respond negatively to large things (including large animals and upright people) moving near them. Their normal response is to abort that particular nesting attempt and to return to the sea and move to try nesting at some point further along the beach.

There will be considerable low frequency noise from generators, other machinery on the shore, docks and jetty and noise from engines and generators on moored and moving vessels. There will be moving vehicles with lights along the causeway and jetty. These noise sources and obvious large moving objects will be concentrated along the linear array of structures approximately in the middle of the preferred nesting beaches.

It is to be expected that this noise pollution and vehicle traffic will cause adult turtles approaching the beach for nesting to move away from the causeway/jetty area. This should result in a reduction in nesting attempts on the beaches immediately adjacent to the causeway at Town Point. It is unlikely that the internesting turtles will spend sufficient time in close proximity to the sources to allow for their habituation to these disturbance effects. Given the uncertainty regarding the intensity of the geographical range of the disturbance effect, the extent of displacement of nesting females cannot be estimated at this time.

In contrast, based on the preliminary studies at Barrow Island, the possibility exists that low frequency vibrations may attract hatchlings. If this occurs, then the nett impact of this attraction will be to further aggregate hatchlings towards the illuminated structures of the causeway, jetty and moored vessels.

Where possible, generators and other fixed machinery that produces low frequency sound should be mounted on vibration absorbing foundations.

3.3. Changing hatchling production with nesting beach selection
With any substantial shift of nesting distribution between nesting beaches, there are likely to be changes in hatchling sex ratio resulting from differences in beach sand temperatures. The direction and magnitude of such a sex ratio response to flatback turtles shifting away from nesting on any of the preferred mid east coast beaches of Barrow Island can not be determined with the available information.

Any shift of flatback nesting to the beaches that are not part of the preferred mid east coast beaches of Barrow Island is presumed to provide less than optimal conditions for hatchling production and dispersal. At this time data were not available that would allow my assessment of issues such as beach stability under storm conditions, nesting success, incubation success, hatchling sex ratio, hatchling survival and hatchling dispersal at representative beaches within the preferred mid east coast beaches and at other less preferred nesting beaches on the island.

3.4. Dredging (habitat modification)
Dredging of navigation channels and the turning basin will cause a direct reduction in available foraging grounds available for the locally foraging green, hawksbill, loggerhead and flatback turtles. Given the low density of turtles per hectare expected in these habitats, the long term impact of this direct foraging habitat loss should be a permanent population reduction in the order of magnitude of tens of turtles. The dredging and spoil dumping will cause an increase in turbidity and down current sedimentation over a considerably wider area on food resources. High turbidity and sedimentation can be expected to kill off seagrass and other food sources dependent on photosynthesis, lasting possibly for a few years after dredging (Preen and Marsh, 1995). There is likely to be a change in distribution of benthic invertebrate prey such

as seapens in areas impacted by increased sedimentation. Overall, the dispersed sediment loads generated by dredging and spoil dumping can be expected to cause some additional population reduction beyond that cause by direct loss of habitat.

However, loss of potential turtle food resources through modification of benthic habitats that result from the dredging and other port construction operations will not have an impact on the internesting turtles nor will it impact on the dispersing hatchlings, given that these life history phases do not require food.

3.5. Dredging (direct turtle mortality)
Suction dredges kill turtles during dredging operations in other locations (Greenland et al. 2004). Death of turtles can be expected with dredging operations off the mid east coast beaches of Barrow Island because of the proximity to the large flatback nesting population and the presumed mixed foraging population of green, hawksbill, loggerhead and flatback turtles.

With 35-75 internesting flatback turtles daily within the inshore waters off the mid east coast nesting beaches, it is not unreasonable to anticipate that some of the internesting females as well as some of the resident foraging turtles will be killed during the dredging operations. However, no estimate of an expected annual mortality from dredging can be made at this time.

Dredging mortality could be reduced by ensuring that the year or so of planned dredging operations does not encompass more than one breeding season. Where possible, down time from dredging operations should be time tabled to coincide with peak nesting season.

The Brisbane Ports Corporation which is responsible for dredging for most ports in Queensland operates with a Code of Practice that addresses reducing turtle mortality. Within the USA, the US Army Corp of Engineers has considerable experience in the area of dredging with minimal impact on marine turtles.

3.6. Boatstrike
After dredging has established channels, it can be expected that foraging turtles will use the edges of dredged channels as resting areas. This is likely to cause an increase in density of foraging turtles in the vicinity of the channels designed for shipping traffic.

Within the confines of channels, especially at low tide, large propellers have the capacity to suck objects not attached to the substrate through the propeller. For turtles this will result in injury or death. In Queensland, a high proportion of turtles killed through boat-strike/propeller damage are associated with dredged shipping channels (Queensland EPA StrandNET database). Where injuries are not fatal, it is not uncommon for the injured turtle to take years for recovery and to be removed from the breeding population during those years.

Turtle deaths and injuries can be expected from turtle interactions with operating vessels in the dredged channels and turning basin. However, no estimate of an expected annual mortality from vessel interactions can be made at this time.

Apart from having the vessel travel at low speed, no suggestions are made for tactics for reducing this source of mortality.

Additionally it can be noted that in eastern Australia, in marina developments with walls composed of irregular shaped boulders, marine turtles will aggregate to feed on the benthic fauna and flora of the "artificial reef" and to rest/sleep in the crevices of the walls (C. Limpus, unpublished observations). With approximately 3km of wall surface (= new "rocky reef") proposed for the causeway and MOF off Town Point, it can be expected that turtles, especially juvenile green and hawksbill turtles, will aggregate around this new habitat. These turtles will also be susceptible to collision.

3.7. Vehicle traffic on nesting beaches

Vehicle traffic at beach crossing sites on nesting beaches by day or night can cause death of turtle eggs through compression or erosion of the nest. Any tyre ruts remaining after vehicles exit the beach become significant obstacles to hatchling turtles and can trap the hatchlings and seriously delay their entry to the sea.

In general, vehicle damage to turtles, their eggs and hatchlings are easily managed through strict management of vehicle use:

- Strictly minimise vehicle access to beaches.
- Move vehicles to points along the beach by utilising access from behind the dunes.
- Do not use vehicles on the beach or within sight of the beach at night during the nesting season;
- Where vehicles must access beaches,
    - Restrict dune crossing to as narrow a strip as possible;
    - Where a vehicle must move along the beach, wherever possible restrict travel to below the high tide mark. This allows the tide to remove tyre ruts.
    - When turtles lay eggs within "road" ways and work areas used during construction of beach crossings, the eggs should be removed within a few hours of being laid and with no vertical rotation to a safe incubation site within the normal nesting habitat of a preferred nesting beach.

If managed appropriately, vehicle usage on beaches should have no negative impacts on the viability of the turtle populations.

3.8. Staff use of beaches

I am starting with the assumption that the construction and operations staff for the facility and crews from visiting vessels will not be permitted to bring pets such as dogs and cats to the island. This needs to be strictly enforced.

Use of beaches by day for recreational activities such as swimming, sailing, board riding and fishing should have no detrimental impact on the nesting turtles or on egg incubation. However, such activities by night can be detrimental to the turtles. It is recommended that the turtle nesting beaches be closed to general access from dusk to about 6.ooam during the turtle nesting and hatchling season.

Staff, out side of their employed duties, may wish to assist with turtle conservation activities. With appropriate training, persons resident on the island have the potential to make a significant contribution by assisting the management agencies and

research/monitoring consultants in turtle monitoring, research and management. This option should be considered.

3.9. Laying the Feed gas pipeline and associated shore crossing

The laying of the feed gas pipeline across the inshore habitats and the associated shore crossing for the pipeline at North White's Beach will cause short term, localised disturbance to courting turtles in the area. It is unlikely that this will cause any reduction in population function for the courting green turtles. Similarly, the shore-based work at North White's Beach will have an impact on a trivial proportion of the island's green turtle nesting population.

4. Maintaining sustainable populations

Not all species of marine turtles in Australia are equally well understood with respect to their biology (Limpus, in press a,b,c,d). The green and loggerhead turtle populations of eastern Australia are among the best understood for their population dynamics. This has permitted comprehensive modelling of their biology and development of rigorous heuristic modelling of their population dynamics (*C. mydas*: Limpus and Chaloupka, 1997; Chaloupka and Limpus, 1998; Chaloupka, 2001, 2002; Chaloupka et al. 2004; Chaloupka, 2004. *C. caretta*: Chaloupka, 1998; Slater et al. 1998; Chaloupka and Limpus, 1998, 2001, 2002; Chaloupka, 2003; Chaloupka et al. 2004).

This approach to modelling marine turtle populations when applied to other species/populations is also proving to be informative (Chaloupka and Limpus, 1997; Chaloupka, 1998, 2001; Balazs and Chaloupka, 2004; Bjorndal et al. 2005).

There are insufficient demographic data for key life history parameters such as age at maturity and age/sex based survivorship data for flatback turtles to enable a comparable reliable model to be developed for this species. Until such models are available to test the population performance of flatback turtles under the impact of different multiple threats, we can apply some of the general lessons being learned from the green turtle and loggerhead turtle models. Analysis with these models produces some common outcomes:

- When mortality increases by as little as only a few percent above natural mortality levels at any life history stage and continues over the time frame of a turtle generation (a few decades), a marine turtle population will decline significantly.
- Consistent annual losses from a population of the order of 5-10% of a life history stage above natural mortality levels can be expected to cause serious population declines within one generation and reduce populations towards extinction within about 100yr (several generations). Under these conditions, IUCN threatened species criteria would indicate that the population should be considered to be under significant threat.
- When anthropogenic mortality factors impacting a population are removed, recovery of the population will be slow. For example, the decline caused by loss of a few percent of the adult green turtles from a population over 50yr can be expected to require ~150yr for the population to recover after the mortality factor is removed (assuming that no other mortality factors are operating on the population).

- When absolute numbers of turtles killed are considered, the loss of a few hundred adult females can have a similar population impact as the loss of thousands of immature turtles. Indeed, the loss of a single breeding adult could be equivalent to the loss of many thousands of hatchlings in terms of the population dynamics for the species.

There is a reasonable probability that the combined continuing impact over the ~60yr life of the Gorgon project of changed light horizons at the beach and noise transmission into inshore waters will contribute to a significant reduction in the flatback nesting population at the preferred nesting beaches of mid east coast of Barrow Island within 20 to 30 years.

There is a reasonable probability that there will be an increase in hatchling mortality on the beaches and in the adjacent waters as a result of the altered light horizons of the Gorgon project. There is a reasonable probability that, through standard management of light, this mortality increase can be kept at a modest level. However, with even an increase in hatchling mortality of only a few percent per year over and above natural mortality rates but extending over the decades of the project, this population can be expected to decline in the long term. Such decline will only be in evidence when that next generation of turtles return as first time breeding turtles in several decades time.

There is a reasonable probability that a small number of internesting flatback turtles will be killed by the dredging. This mortality will add to the more significant hatchling mortality and the consequences of scaring of the nesting females from the beaches.

Collectively, these impacts imply that there is a reasonable probability that the Gorgon Project as it is currently planned threatens the viability of the most important flatback turtle rookery in Western Australia. The principal problems are linked to changing from dark horizons over the nesting beaches to illuminated horizons.

If the project cannot be relocated to some less sensitive site off Barrow Island or to a site within the interior of Barrow Island from where dark light horizons over the beach will not be impacted, and if there is a serious desire to retain a robust flatback nesting population on the eastern beaches of Barrow Island as an integral part of this iconic island, then the lighting strategies underlying the planning for the Gorgon facilities at Town Point need to be rethought and refocussed towards maintaining dark horizons.

Darkness is the preferred management option when it comes to secure management of marine turtle rookeries. Where darkness cannot be achieved by containing necessary light within enclosed opaque areas, the principals being promoted for management of elevated dark horizons by Salmon (2003) and Tuxbury and Salmon (2005) need to be incorporated into design of the facilities.

Design the landscape and architecture of the facilities to create a high-elevation opaque/dark horizon from the viewpoint of the nesting beaches that separates all facilities from the beaches. Consider the following:

- Create a high-elevation dark horizon on the seaward aspects of all facilities with external lighting and hence light spillage.

- Construct a high solid “multi-story” height wall around the perimeter of facilities to create an artificial elevated dark horizon inland of the beaches.
- The height of the above horizon-wall could be enhanced if it was built on top of a large/high bund wall of “soil” surrounding the land-based facilities. This bund wall could be constructed using the dredge spoils from the channels and mooring area. This latter action would have the added benefit of reducing broad scale marine habitat loss from spoil dumping at sea and the associated turbidity and siltation.
- Large structures equivalent to “multi-story buildings” that do not require external lighting can be built on the seaward side of facilities and be part of the surrounding “wall”. This may be a potential use of tall gas storage tanks.
- Office buildings can be built with no windows/doors opening through walls on the seaward side.
- A wall like this may need passageways for wildlife at ground level. If so, then light baffles can be constructed. The same would apply for vehicle and pedestrian movement through gates.
- Light baffles should be installed on all door opening from brightly illuminated areas to the outside of buildings.
- A wall like this may have some value in containing invasive species.

All lighting that is not essential for “external use” where it would cause light spillage should be contained within light proof containers. A container may be on the scale of a building or down to the scale of a box. For example,

- Consider placing instrument areas and valves that need extensive lighting inside ventilated rooms rather out in open areas.
- Can the seaward side of gas processing facilities be closed off to create opaque walls?
- Instead of outdoor floodlit recreation areas such as tennis courts, use indoor areas.

For lights that must be used in the open environment, the recommended starting point for planning such lighting should be with the question of “How can dark horizons be maintained?” Consider the possibilities:

- Investigate new lighting designs beyond those in current use, including “monochromatic” LED lights, low pressure sodium vapour lights in a search for more turtle friendly lighting while recognising that no light source that can cause any disorientation of the turtles is desirable for use.
- Use proximity relays switches and time switches to have lights turned on only when required.
- Re-examine why lighting is required at each specific location and design lighting to provide illumination for that specific purpose. For example, when contrasted with the level of lighting used to mark aircraft runways and for illuminating navigation lanes for shipping, road ways do not need to be illuminated by numerous bright overhead lights on elevated bollards. This is usually argued from a safe operations perspective. Bright lights may be needed for high speed vehicle use but safe operations can be achieved with less light fixtures and lowered lighting levels of the carriage way with vehicles travelling at lower speeds.

- Remove high beam capacity from all vehicles and adjust vehicle speed limits to maintain safe operations.
- Intermittent flashing lights with a very short on-pulse and long off-interval are non disruptive to marine turtle behaviour, irrespective of the colour. Flashing marine navigation lights do not cause disorientation of turtles. Consider increasing use of this type of lighting for marking carriage ways, walk ways, entrances, exits and key work areas.
- Equipping staff with head lamps, as is done in the mining industry, and reduce fixed lighting of the work area and design tasks/work areas to maximise use and efficiency of this type of lighting rather than illuminating the entire work area.
- When using head spots, increase use of reflective signage and demarcation of areas from a work place health and safety perspective.
- With recreation facilities such as outdoor barbeque areas, have the lighting on time switches set to turn off at 7.30pm.

Vessels moored at the jetty for loading have the potential to cause significant increases in hatchling mortality. Lighting on these vessels should be managed in the same way as for the rest of the facilities. All unnecessary lighting should be contained within the vessel and no light spillage occurring from portholes. The lighting of the vessel should be designed and/or modified before it is commissioned to enter this area of operations. Navigation/anchor lights on top of masts can be accepted. Bright deck lights need to be addressed to find ways to shield them.

Significantly reduce impacts on turtle populations by ensuring that the year or so of planned construction (island based facilities, causeway and jetty) and dredging operations does not encompass more than one breeding season. Where possible, down time from drilling and construction at beach crossing sites and from dredging operations should be time tabled to coincide with peak turtle breeding season.

The rare, short term emergency use of extensive bright lights, while disruptive to turtles for the duration of their use, will have minimal long term impacts on the population function. However, design this emergency lighting from the perspective of maintaining a dark horizon where ever possible.

Given that some lighting at existing facilities at Barrow Island is already altering the light horizons over the nesting beaches, re-design lighting at other existing facilities on Barrow Island to reduce their contribution to altering the light horizons over turtle nesting beaches.

5. Monitoring

Just as industrial plants have “work place health and safety” officers, the Gorgon Project should appoint staff with the role and authority to provide a safe environment for turtles, including particularly maintenance of the dark horizons.

A monitoring program should be in place prior to commencement of construction and maintained through out the life of the Barrow Island based project that is designed to:

- Detect long term changes in the distribution of turtle nesting, hatchling survivorship, orientation of adult and hatchling turtles within beaches adjacent to all facilities altering light horizons.

- Identify any shift of turtle nesting activity away from existing favoured beaches adjacent to facilities and towards less favourable beaches with respect to turtle population dynamics.
- Identify and quantify hatchling mortality relative to changed lighting horizons, including in the water in the vicinity of the causeway and jetty.
- Monitor the occurrence of sick, injured and dead turtles on Barrow Island, its surrounding inshore waters and the surrounding region. This stranding program should include identification of cause of injury and death of the turtles. While results of the stranding project should be reported annually, any significant change in the temporal or spatial change of strandings should be reported to the Government and Gorgon management immediately.

Because the Gorgon Project will impact the major breeding area for the Pilbara Coast flatback turtle stock, it has the capacity to impact on the entire stock. Therefore, the monitoring program should:

- Encompass not only the Barrow Island nesting beaches but also representative major nesting beaches for this stock.
- Address all life history phases including internesting and nesting females, eggs, hatchlings, pelagic foraging post-hatchlings and benthic foraging turtles of all sizes from immature to adult turtles.
- Quantify other threatening processes impacting on this stock of turtles throughout their range and which will have a cumulative impact on the stock over and above the direct impacts of the Gorgon project.

It would be appropriate for the Gorgon Project to be the focal point for a regional monitoring of the Western Australian flatback stock.

Given the significance of the impacts of this Gorgon Project on flatback turtles for Western Australia, all turtle research and monitoring associated with this project should be overseen and peer-reviewed by an independent expert panel. The roles of the panel should include the examination of:

- The key issues to be addressed by the research and monitoring projects;
- The appropriateness of the proposed research or monitoring projects to provide the information required;
- The rigour of the analysis and presentation of results.

This expert panel should have a role in providing advice to Government management, Gorgon Project management and technical staff involved in the research and monitoring.

Protocols need to be established where by the result of the monitoring program can be integrated with ongoing management planning of the project to facilitate its continued improvement in performance with respect to turtle conservation.

6. Off-set actions

Given that the Gorgon Project if constructed at the planned site on Barrow Island will have a negative impact on Western Australian flatback turtle stock, actions should be set in train to off-set the impacts of the Barrow Island facilities with projects that will contribute to enhancement of this turtle stock.

The Gorgon Project should contribute financially and in–kind as appropriate to support the following actions:

Increase production of vigorous, healthy, correctly imprinted hatchlings at nesting beaches by:

- Control feral predators on mainland nesting beaches. This should include a project to engage land owners along the mainland coast in protection of turtle nesting habitat and reduction of feral predation of eggs on their land.
- Rescue doomed eggs: Relocate doomed eggs from habitat with high natural egg mortality (such as below high tide level or on beaches that are erosion prone) to nearby areas within the natural nesting habitat that have high incubation success. All egg relocation to be completed within three hours of the eggs being laid and with the minimum of rotation of the eggs.

Support research to fill the gaps in our understanding of flatback turtle life history, particularly:

- Distribution, habitat use and diet of pelagic post-hatchling flatback turtles;
- Distribution, habitat use and diet of benthic foraging immature and adult flatback turtles;
- Quantify growth and age at maturity of flatback turtles;
- Quantify annual survivorship of flatback turtles by sex, maturity and age/size;
- Define the pivotal temperature for the Pilbara Coast flatback turtle stock and define the temperature profiles for the major nesting beaches for this stock.

Based on the results of the above research:

- Support a state wide community education project to enhance public participation in activities that reduce human induced mortality and that contribute to maintenance of good quality habitat for the species.
- Support the implementation of conservation actions to reduce human induced mortality of flatback turtle throughout their range in Western Australia.

It would be appropriate for the “independent expert panel” overseeing the Gorgon Project to be expanded to provide oversight of all research and monitoring projects associated with all Oil-Gas industry projects of the Pilbara Coast. A primary task of such an expert panel would be to address a major deficiency in current planning with respect to the Pilbara Coast Oil-Gas industry, namely the cumulative effects of multiple oil-gas production and processing facilities in the region.

Support a scholarship scheme targeted at the international market to attract collaboration by the academics with world leadership skills with respect to researching key turtle biology / conservation management issues, including improving our understanding of turtle vision and sea finding behaviour and the development of management to minimise impacts of altered horizons.

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