Oil Exploration Permit EP 325
Exmouth Gulf, Western Australia

Minora Resources NL

Report and Recommendations
of the
Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia
Bulletin 366 November 1988

OIL EXPLORATION PERMIT EP 325

EXMOUTH GULF

WESTERN AUSTRALIA

MINORA RESOURCES NL

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CONTENTS

APPENDICES

FIGURES

i SUMMARY AND RECOMMENDATIONS

Minora Resources NL (Minora) (the proponent) is the operator for a joint venture which has proposed to drill two offshore exploration wells within Exploration Permit 325, which lies in the Exmouth Gulf, between November 1988 and February 1989. These wells are known as the Rivoli and Whalebone Prospects.

The Whalebone Prospect lies within the Ningaloo Marine Park and as such, the Authority has determined that the assessment of that prospect would be inappropriate until after the completion of the current independent review of petroleum exploration drilling in National Parks.

The Rivoli Prospect is located approximately 8.5 km east of the town of Exmouth, about 4 km south of the Ningaloo Marine Park and within the Exmouth Gulf.

Exmouth Gulf is identified in Department of Conservation and Environment (now EPA) Bulletin 104 (1984) as an Environmentally Sensitive Locality (ESL) as is the Ningaloo Marine Park. Bundegi Reef, which forms part of the Ningaloo Marine Park, is defined as a "Sanctuary Zone".

A number of commercial fisheries exist in the Gulf region. These include a prawn fishery, beach seine fishery, wet line fishery, rock lobster fishery and two pearl culture leases. In addition, there is an extensive tourism industry in the area.

The proposed Minora exploration programme would occur in an environmentally sensitive location and, without appropriate management, any environmental disturbance could be of consequence to the marine resources of Exmouth Gulf. However, it has been demonstrated that the risks of an oil spill event are small. There has never been a significant oil spill from an oil exploration drilling operation since the first such well was drilled off Australia in 1964. The Environmental Protection Authority considered that a Public Environmental Report (PER) would be required to adequately assess the proposal.

In this Assessment Report, the Authority has concluded that the proposal is environmentally acceptable and has made the following recommendations:

RECOMMENDATION 1

The Environmental Protection Authority concludes that it would be inappropriate to assess the Whalebone 1 drilling proposal until after the current review of petroleum drilling in National Parks is concluded. The Environmental Protection Authority further concludes that the Rivoli 1 drilling proposal described in the PER is environmentally acceptable and recommends that it could proceed, subject to the Environmental Protection Authority's recommendations in this Assessment Report and the commitments made by the proponent for environmental management including:

(i) compliance with all legislative requirements pertaining to this project;

(ii) adoption of industry and government standards and guidelines for safe exploration drilling practices;

(iii) implementations of the environmental management programme documented in the PER;

(iv) compliance with guidelines provided in the oil spill contingency plan; and

(v) implementation of the monitoring programme outlined in the environmental management programme.

RECOMMENDATION 2

The Environmental Protection Authority recommends that the proponent should include in the Oil Spill Contingency Plan, the capability to contain oil spillages of up to 20 m^3 on or adjacent to the rig. A suitable boom and skimmer device, together with an operator skilled in their deployment, should be permanently stationed on the rig prior to the commencement of drilling.

RECOMMENDATION 3

The Environmental Protection Authority recommends that in order to minimise the likelihood of well failure outside the casing, the proponent should pressure test each new string of casing to the satisfaction of the Director, Petroleum Division, Department of Mines.

RECOMMENDATION 4

The Environmental Protection Authority recommends that, before approval is given for drilling the Rivoli 1 well, Minora undertake to accept responsibility for any adverse environmental impacts which may occur as a consequence of the proposal, to the satisfaction of the Minister for Mines.

RECOMMENDATION 5

The Environmental Protection Authority recommends that any future development resulting from the exploration drilling proposal, as assessed in this report, should be further referred to the Authority for assessment.

1. INTRODUCTION

Minora Resources NL (Minora) is the operator for a joint venture comprising Minora, Giorno Pty Ltd, Wespet Pty Ltd and Barrack Energy Limited. The joint venture was granted Exploration Permit 325 (EP325) in November 1987.

Minora propose to drill two offshore exploration wells in Exmouth Gulf (see Figure 1) between November 1988 and February 1989.

(i) Whalebone - located about 4.3 km east - southeast of Bundegi Reef, some 10 km west of the boundary between the Ningaloo Marine Park Environmentally Sensitive Locality (ESL) and the Rowley Shelf Special Protection Locality (SPL), and 3.7 km north of the boundary between Ningaloo Marine Park ESL and Exmouth Gulf ESL.

(ii) Rivoli 1 - located approximately 8.5 km east of the town of Exmouth and about 9 kms south of the Ningaloo Marine Park boundary. This proposed well would also be located in the Exmouth Gulf ESL.

This assessment report considers the information provided in the Public Environmental Report (PER) that was prepared for this proposal together with submissions from the Public and Government Departments and further details supplied by Minora. Issues discussed include the effects of drilling operations on the marine ecosystem, the effects of a potential oil spill on the marine ecosystem, impacts of spilled oil on the prawn and pearl oyster industries and major environmental risks.

2. PROJECT DESCRIPTION

Minora proposes that a jack-up drilling rig be towed to the prospect sites and, once in position, the legs would be jacked down to the sea-floor and the floating platform would then be jacked up some 20-30 m above the sea surface.

Each well would take approximately 30 days to complete. A stand by vessel would be stationed permanently in close proximity and crew changes of personnel from Perth would be via fixed wing aircraft with helicopters ferrying crew between Exmouth airport and the rig offshore.

3. EXISTING ENVIRONMENT AND USE

The proposed Rivoli and Whalebone oil well, both lie within Exmouth Gulf. The eastern shore of the Gulf is comprised largely of extensive areas of shallow mud flats and mangrove habitats, while the western or North West Cape side of the Gulf contains beach, intertidal platform and coral reef habitats.

There are three major conservation areas in the region - Cape Range National Park, Ningaloo Marine Park and the islands within Exmouth Gulf. The offshore islands, Exmouth Gulf and the Ningaloo Reef tract are also designated Special Protection status.

Department of Conservation and Environment (EPA) Bulletin 104 (1984) has designated these areas Environmentally Sensitive Localities (ESLs) (Figure 2).

The Ningaloo Reef Tract was proclaimed a Marine National Park in September 1987 and is managed by the Department of Conservation and Land Management

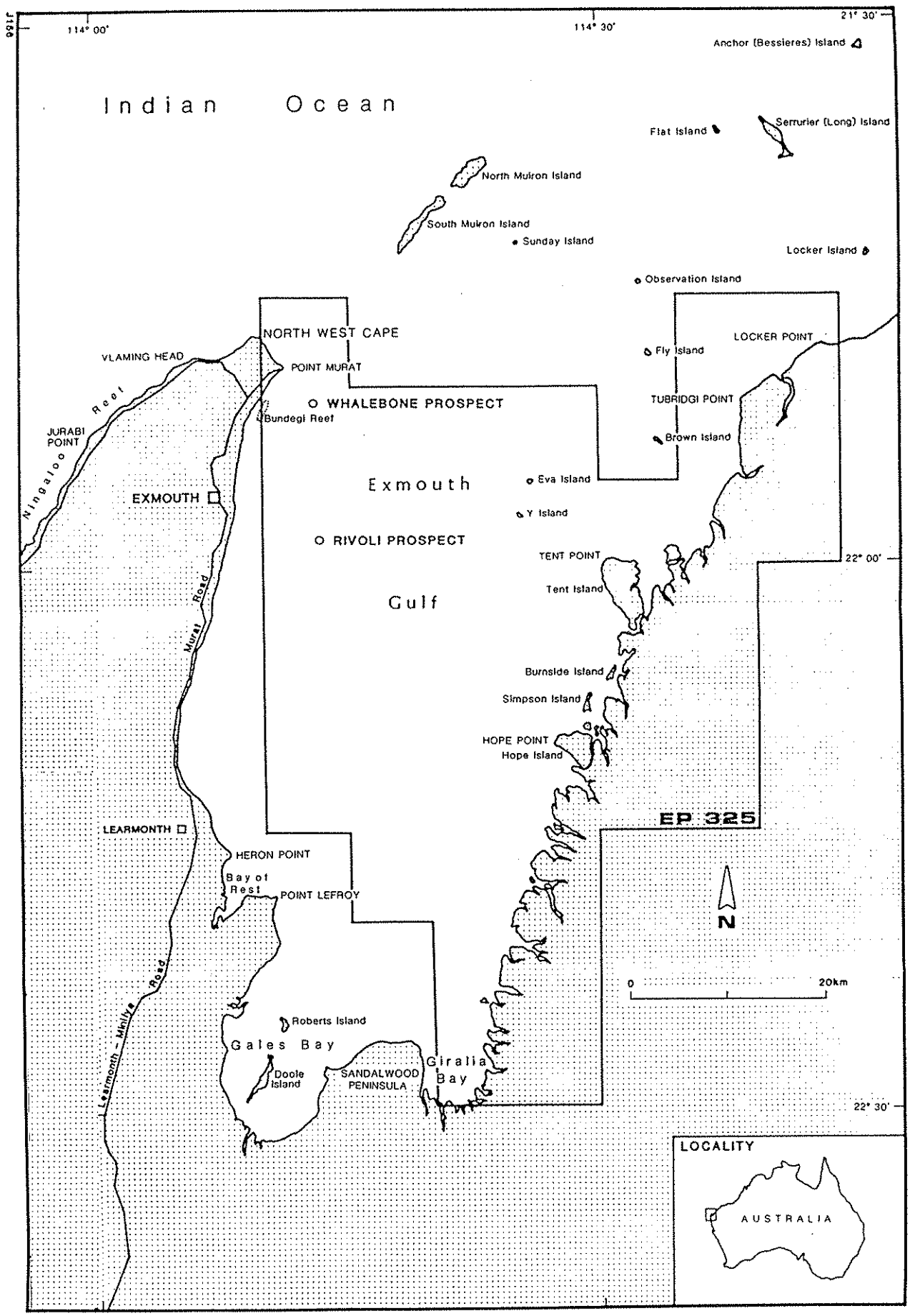

Figure 1 Locality diagram. (from PER, Minora Resoures NL)

(CALM). Bundegi Reef and the marine environment between the reef and the coast are defined as a "sanctuary zone".

At present, an Inquiry into Petroleum Exploration and Development in National Parks and Nature Reserves is being carried out. The terms of reference for this inquiry are in summary:

1. Appropriateness and feasability of extending the principles established by the Government's policy on mineral exploration and mining in national parks and nature reserves, and adapting the associated review mechanisms to petroleum exploration and development activities as they relate to terrestrial and marine conservation reserves.

2. The appropriateness of a specified depth to which reserves can extend below the surface of the earth.

3. If the above investigation reveals that mechanisms established by the Government's policy on exploration and mining cannot be successfully adapted to suit the requirements of petroleum exploration and development, then the Working Group should proceed to consider alternatives.

A number of commercial fisheries operate in the Gulf region. These include:

- a large prawn fishery operating trawlers in the Gulf during the period between 1 March and 15 November each year. The fishery is closed at other times of the year to allow replenishment of prawn stocks;

- a beach seine fishery operating in the Gulf all year round, supplying fish such as mullet, whiting, Perth herring and bream to local and Perth markets;

- a wet line fishery also operating in the Gulf and offshore waters for northwest snapper, emperor and mackerel. Some charter boat operators also hold professional licences in this fishery;

- a rock lobster fisherman operating in Ningaloo Marine Park during the open season of July to October; and

- two pearl culture leases, held in Gales Bay and Giralia Bay, and operating mainly during winter.

There is an established tourism industry in the area with the region becoming a major winter tourist destination. There is also a United States Naval Communications Station and the Royal Australian Air Force base at Learmouth.

4. PUBLIC AND GOVERNMENT SUBMISSIONS

Eighteen submissions were received from Federal and State Government Departments, conservation groups and individuals, during the public review period. A summary of the issues raised is provided at Appendix 1.

The predominant concerns related mainly to the unique ecosystem of the area, alternatives, likely hydrocarbons (oil type), the probability of oil spills, the possibility of pollution from drilling fluids and cuttings, the use of dispersants in the case of an oil spill, safety concerns, possible inaccuracies in the PER and comments on Volume 3 of the PER, and the Oil Spill Trajectory Analysis. A detailed review of submissions is included in Appendix 1.

5. ENVIRONMENTAL IMPACT ASSESSMENT

This proposal has several potential environmental impacts because of the location of the two wells in the Exmouth Gulf.

At present, an independent enquiry is being conducted into the issue of petroleum drilling in National Parks. This enquiry follows on from, and follows similar guidelines, to the enquiry into Mining in National Parks which has been recently concluded. Because of this review, the Environmental Protection Authority has found that it would be inappropriate to assess the the proposal to drill the Whalebone 1 well within the Ningaloo Marine Park at this time. However, the proposal to drill the Rivoli 1 well has been found to be environmentally acceptable, subject to a series of controls and conditions.

RECOMMENDATION 1

The Environmental Protection Authority concludes that it would be inappropriate to assess the Whalebone 1 drilling proposal until after the current review of petroleum drilling in National Parks is concluded. The Environmental Protection Authority further concludes that the Rivoli 1 drilling proposal described in the PER is environmentally acceptable and recommends that it could proceed, subject to the Environmental Protection Authority's recommendations in this Assessment Report and the commitments made by the proponent for environmental management including:

(i) compliance with all legislative requirements pertaining to this project;

(ii) adoption of industry and government standards and guidelines for safe exploration drilling practices;

(iii) implementations of the environmental management programme documented in the PER;

(iv) compliance with guidelines provided in the oil spill contingency plan; and

(v) implementation of the monitoring programme outlined in the environmental management programme.

5.1 SEISMIC SURVEY

Seismic survey methods now utilise non-explosive sources such as the air-gun. Although these methods appear to have little effect on marine organisms, there is little published information documenting the effects. Furthermore, as the seismic survey proposed in the PER is located in the Ningaloo Marine Park, the Environmental Protection Authority considers that it would be inappropriate to assess the proposal until after the current review of petroleum exploration in National Parks is concluded.

5.2 EFFECT OF ROUTINE DRILLING OPERATIONS

It is considered that apart from oil spillages, the only detectable impacts will arise from the short term relatively continuous discharge of drill cuttings and occasional discharges of drilling fluid. The primary impact of drill cuttings on the marine environment is physical burial of the sea

floor. Bentonite and Barite cuttings will precipitate on the bottom, but will be dissipated by tidal and thermal currents. It is anticipated that the impacts will be low, due to a large dispersal envelope, continuous currents and movement of fauna.

Drilling fluids vary substantially in composition and toxicity. The seawater/polymer drilling fluid system which was finally selected by Minora is considered under United States Environmental Protection Agency guidelines to be "non-toxic". Minora has given an under taking that no oil based drilling fluids will be used.

5.3 POTENTIAL EFFECTS OF AN OIL SPILL

The major environmental concern associated with the proposal is the potential for marine oil pollution on a large scale as a result of a blow out during drilling, and the subsequent effects of spillage control and clean up operations.

5.3.1 POTENTIAL SOURCES OF OIL SPILLAGES

There are three potential sources of oil spillages associated with the proposal. These are:

(i) spillage of diesel fuel during refuelling of the rig. If a spillage occurred, the pump could be shut down immediately;

(ii) flow testing on the well is also recognised as an area of risk. Equipment used allows the well to be shut in at several stations both down the hole and on the surface;

(iii) a blow-out. Should such an event occur, the amount of oil which would escape is dependent on several factors:

- permeability of the producing formation;
- pore pressure of the producing formation;
- thickness of the producing interval;
- obstructions and fluids in the well;
- amount of time before the well bridged over or was brought under control; and
- viscosity of the oil.

Mechanical clean-up is the preferred method for dealing with oil spills. The nearest location of mechanical clean-up equipment is at Port Hedland and, according to the Oil Spill Contingency Plan, it would take 2.5 hours for its transfer to the site (addendum G) and 2 hours for the arrival of the nearest operator from Perth (addendum D). This response time is not adequate to contain a continuous spill.

It is stated that a boom and skimmer device will be permanently stationed on the rig "upon approaching the objective" (when the drill gets close to the oil), along with an operator. Although booms and skimmers can become ineffective in rough seas or strong current conditions, they are the only

practical means of collecting oil from the sea's surface. The on-site presence of the boom and skimmer equipment as well as the presence of personnel skilled in their deployment, should be confirmed prior to the commencement of drilling.

The most common spill, due to fuel handling mishaps or a temporary failure of the blowout preventers, can result in a minor spill of 10 m^3 to 20 m^3, lasting for one to two hours. Such small spillages of between 10 m^3 and 20 m^3 are significantly more common world wide than full scale blow outs during exploratory drilling operations. Appropriate environmental safety requirements should include the capability to contain oil spillages of 20 m^3, on or adjacent to the rig.

RECOMMENDATION 2

The Environmental Protection Authority recommends that the proponent should include in the Oil Spill Contingency Plan, the capability to contain oil spillages of up to 20 m^3 on or adjacent to the rig. A suitable boom and skimmer device, together with an operator skilled in their deployment, should be permanently stationed on the rig prior to the commencement of drilling.

5.3.2 PROBABILITY OF A SPILL OCCURRING

The risk of any of the above spillages occurring is extremely small, particularly with the application of modern drilling technology and an understanding of the origin of formation pressures.

Exploration wells are designed to control sub-surface pressures and so eliminate the risk of hydrocarbons escaping at the surface. This is achieved by correct casing design, drilling fluid engineering, well head design, drilling techniques and modern drilling engineering where formation pressures are monitored as drilling proceeds.

Several independent electronic systems and individuals monitor the drilling fluid volumes and any gains are immediately reported to the driller who takes immediate action to shut in the well using the Blow Out Preventers. The well is then monitored to determine the extent of the 'kick'. Should it be genuine (and in many cases it may not be, nevertheless the crews are trained to react to any gain in drilling fluid volumes), the invading fluid is circulated out under pressure while heavy drilling fluid is circulated down to the bit, so as to create a hydrostatic pressure at the over pressure zone greater than the formation pressure. Once this heavier drilling fluid is circulated throughout the system the well can be opened and drilling resume.

A well would only blow-out if all the warning signs were ignored and the casing, well head and blow out preventers failed. These critical components are designed with large safety factors and rated greatly in excess of requirements. The Blow Out Preventers and well heads are also tested at least once a week.

The first Australian offshore exploration well was drilled in 1964. Since then over 500 offshore exploration wells have been drilled.

There have been no reported "significant oil spills, requiring clean up" from an offshore exploration well. It is acknowledged that the likelihood of a significant oil spill from this proposal is minimal, however precautionary

measures should aim to further minimise this risk. Crews are trained to be 'kick' responsive and it is proposed that practices be held every shift under varying circumstances. It is also proposed that Blow Out Preventers be tested at least once per week.

Minora proposes that it will test the casing when first run off, if the operator is concerned about the wear and tear on it. Minora claim that this is standard practice throughout the industry. However, informed submissions argue that it is standard practice for all casing to be pressure tested before use. Regardless of the above, it is considered that due to the environmental significance of the drill site, the more stringent measures are appropriate.

RECOMMENDATION 3

The Environmental Protection Authority recommends that in order to minimise the likelihood of well failure outside the casing, the proponent should pressure test each new string of casing to the satisfaction of the Director, Petroleum Division, Department of Mines.

5.3.3 OIL SPILL EFFECTS

Both of the proposed oil exploration wells lie within the Exmouth Gulf. As such, they are enclosed within three sides (see Figure 1). The area itself includes the Ningaloo Marine Park, including Bundegi Reef, to the north west and extensive mangrove communities to the north east. In addition, there are extensive fishing, prawning and pearl oyster industries in the Gulf.

The actual effect of an oil spill on these resources is difficult to predict because very little is known about the effect of local oil on tropical marine organisms.

The potential effects of an oil spill on both the Ningaloo Marine Park and the local mangrove communities of the Exmouth Gulf have been examined. The extent of damage to coral reef assemblages is very variable and depends on a number of factors. Most incidents of coral mortality have occurred in areas where the coral was exposed by low tide and directly coated by the oil. Oil floating on the surface above corals, has been shown to have little adverse effect on the corals below. In addition, clean up programmes for oil polluted sand beaches are relatively straight forward.

The effects of oil pollution of mangrove assemblages are long-term and can take decades to recover. Apart from damage to the mangroves themselves, the sediments and small inhabitants can also be affected. It is impossible to clean up a mangrove area affected by oil using conventional means.

Exmouth Gulf is an important nesting site for two species of marine turtle. Green and Loggerhead Turtles have been identified on North and South Muiron Islands and on Serrurier Island. All three islands could be polluted by an oil spill. The conservation status of both species of turtle is listed in the United Nations Nature Conservation publication Red Data Book; Green Turtles are listed as endangered, Loggerhead Turtles as vulnerable. Both species breed during the proposed exploratory drilling period.

Although the PER concludes that based on all the technical and historic evidence presented, the chances of a major oil spill are extremely small, it also recognises that the major environmental concern associated with this proposal is the potential for an oil spill. It is pointed out in the PER (P44), that assuming a worst case scenario, 90,000 tonnes of oil could pollute the Gulf and that even much smaller spills under unfavourable winds could rapidly pollute Bundegi Reef, parts of the Marine Park or the mangrove assemblages.

In the unlikely event that an oil spill occurs and is unable to be contained or deflected with a boom system, Minora intends to track the spill and if it is considered likely to have an impact on mangroves along the eastern shores of the Gulf, to apply chemical dispersants. The application of dispersants requires approval of the State Committee for Combatting Marine Oil Pollution.

Dispersants remove an oil slick from the water's surface and disperse it through the water column. Dispersant use then may become a trade off between the potential impact upon intertidal fauna and the exposure of subtidal organisms, a point that is clarified in the following paragraph.

The oil may be left to float on the surface and may be collected before or after drifting ashore. If it drifts ashore and reaches the mangroves, then it is almost impossible to clean up and the mangrove assemblages will die.

If treated with dispersants, the oil will be dispersed through the water and affect subtidal organisms such as prawns or oyster stocks. In other words, the use of dispersants in Exmouth Gulf may reduce the potential effect from spilled oil on mangroves, but at the expense of increased impact on prawn fish and pearl oyster stocks.

Minora acknowledges that the question of whether dispersants should be applied to spilled oil moving towards the mangroves bordering the eastern side of Exmouth Gulf requires further evaluation. The uncertainties which exist regarding both the effectiveness and the effects of dispersant application are acknowledged in the PER.

The PER makes the judgement that the mangroves fringing the eastern coastline of Exmouth Gulf are a regionally important ecological resource and suggests that, for both ecological and commercial fishery reasons, it would be preferable to risk short-term (3-5 years) disruption to the prawn fishery rather than risk long-term (30-40 years) damage to the regional ecosystem and perhaps also the prawn industry.

If an oil spill occurred and did affect prawn stocks, pearl oyster stocks and the general fishing industry, there would obviously be direct social and economic costs to these industries until the fisheries recovered.

Much of the prawn fishery is dependent upon the export market, and is highly dependent on an established reputation for consistent supply and premium quality. Accordingly the prawn fishing industry would be extremely sensitive to reductions in prawn stocks or tainting of prawn supplies.

Similarly, experience elsewhere has demonstrated the high sensitivity of the pearl oyster to spilled oil. Spawning of pearl oysters in Exmouth Gulf occurs during the spring and summer, with residual spawning occurring through to early autumn, which would be the time proposed for this exploration drilling.

Although Rivoli 1 lies outside the 5 km State limit, potential pollution effects may occur inside State waters. Before drilling commences, Minora should make a commitment to Government that it will accept responsibility for such impacts.

RECOMMENDATION 4

The Environmental Protection Authority recommends that, before approval is given for drilling the Rivoli 1 well, Minora undertake to accept responsibility for any adverse environmental impacts which may occur as a consequence of the proposal, to the satisfaction of the Minister for Mines.

The Environmental Protection Authority acknowledges that the potential scenarios which may develop from the exploration programme under consideration are numerous. No oil or gas may be discovered and if there is a discovery, it may or may not be commercial. The Environmental Protection Authority considers that any future activities which the joint venturers may wish to take beyond their current proposal would need to be assessed.

RECOMMENDATION 5

The Environmental Protection Authority recommends that any future development resulting from the exploration drilling proposal, as assessed in this report, should be further referred to the Authority for assessment.

6. CONCLUSION AND RECOMMENDATIONS

The Public Environmental Report has been submitted to provide an environmental input to decision making on the proposed drilling of the Rivoli 1 and Whalebone 1 exploration oil wells. In preparing this Report, the Authority has considered the assessment of the Whalebone 1 well,

located within the Ningaloo Marine Park, to be inappropriate until after the completion of the independent enquiry into the petroleum exploration drilling in National Parks. In considering the Rivoli 1 well, the Authority has considered a range of documentation and technical information and has been assisted by contributions from the public and other Government agencies.

The proposed Minora exploration programme would occur in an environmentally sensitive location and, without appropriate management, could potentially involve considerable risks to the marine resources of Exmouth Gulf. While the risks of an oil spill event are seen as minimal, the environmental consequences of a spill could be serious.

Oil exploration activities in this area can be appropriately managed to minimise the already small risk of deleterious impacts upon the environment. The Environmental Protection Authority considers that sufficient information has been provided to establish that the Rivoli 1 proposal would be environmentally acceptable subject to Minora implementing the management commitments in their PER and compliance with the recommendations in this report.

APPENDIX 1

REVIEW OF SUBMISSIONS

SUMMARY OF SUBMISSIONS

Eighteen submissions were received from Federal and State Government departments, conservation groups and individuals.

The following concerns were expressed in these submissions and have been collated under broad headings for greater simplicity.

1. THE ECOSYSTEM

The PER states that the proposed seismic survey will have "no adverse effects on the marine ecosystem". However it is admitted that "there is little published information about the effects of modern seismic methods." What little work that has been done relates to Tiger Prawns. What would be the effect on fish and larger marine mammals such as Dugong?

The PER states that the major ecological resources of the region, which are those most likely to be affected by an oil spill, "provide extensive feeding grounds for migratory wading birds". Despite this statement, the PER has given insufficient attention to marine birds.

Various submissions have voiced concern for the effects of an oil spill on marine turtles in the area.

Important nesting sites for two species, Green and Loggerhead, have been identified on North and South Muiron Islands and on Serrurier Island (Figure 17). All three islands, but Serrurier Island in particular, could be polluted by an oil spill. The conservation status of both species of turtle is listed in the IUCN Red Data Book; Green Turtles are listed as endangered, Loggerhead Turtles as vulnerable. Both species breed during the proposed exploratory drilling period.

Two other species of turtle, Flatback and Hawksbill, are also known to occur in the Exmouth Gulf Region. These species may also be vulnerable to the effects of an oil spill.

The consequences of the discovery of oil in commercial quantities has been noted. It has been pointed out that the EPA must consider whether the installation of production platforms, pipelines, tank farms, shipping facilities and settlements within a tourism center and Marine Park are appropriate. They must also decide whether the risked social and environmental cost is substantially exceeded by the (risked) profit and royalty income.

From an environmental perspective, the difference between drilling the Whalebone prospect within the Park or the Rivoli prospect outside the Park is purely geographic. The environmental impacts are virtually the same.

2. ALTERNATIVES

The proponent has offered no evidence to support the viability of the areas proposed for drilling. The anticipated seven-well programme over six years indicates that other plays and prospects exist within the permit.

It has been noted that the area of park around Whalebone is only a small portion of the permit and that the majority of the permit area is outside the Marine Park. As a consequence, it has been suggested that as the area has not even been adequately explored with seismic, the operator may be merely testing for public reaction to exploration drilling within reserves or offering the Whalebone prospect as a "sacrifice" to ensure the viability of the Rivoli prospect.

It is argued in submissions that Ningaloo, as the World's second largest barrier reef system (after the great barrier reef) deserves similar protection to the Barrier reef where oil drilling has been banned. It is argued that with a reef of such international significance and high scientific value, the possible benefits of oil exploration do not outweigh the potential environmental costs of a drilling accident.

No surveys have been carried out by the proponent, of the marine biota of Exmouth Gulf. The absence of biological baseline data for the area makes assessment of the proposal on the marine biota of the area, impossible.

Bundegi Reef is included within the Sanctuary Zone of Ningaloo Reef Marine Park. It is suggested that any proposal to drill in this significant area should be separately assessed and should require a separate PER.

It is suggested that the proponent provide guarantees that if the proposal goes ahead, and in the event of an oil spill causing damage to either the fishing, prawning or pearl oyster operations in Exmouth Gulf, fair compensation would be paid. This might involve the company taking out an adequate insurance policy to that effect.

3. LIKELY HYDROCARBONS

The PER assumes that if oil is encountered at either of Minora's two prospects, it would be light Australian crude similar to that found at the Saladin oilfield. However, crude oils that have been encountered in the region vary greatly.

The production from Barrow Island at 32 API is not Australian Light Crude, which is about 46 API. Moreover, the oils to the south and west of Barrow Island are heavier again, reaching a low of about 17 API in the Robe River embayment. The Rough Range petroleum (just south of the intended drilling site) has the consistency of grease at room temperature.

The fate and persistence of oil spilled into the marine environment varies substantially with the nature of the oil and the PER's assumption that Saladin oil would be encountered subtantially understates the possible impacts of an oil spill. For example, the estimates for Saladin oil (which are adopted in the Minora PER) are that 80-90 percent of oil spilled on the sea surface would evaporate within six hours, with evaporation over 48 hours expected to reduce the volume by at least 95 percent. In contrast, small-scale field tests conducted using Barrow Island crude oil have indicated that evaporative losses of this oil are only 30-35 percent over 6-24 hours, with further evaporative losses after 24 hours being minimal (Esso Australia Ltd, 1982). The Steedman (1988) oil spill trajectory predictions show that all of Exmouth Gulf is at risk in the event of an oil spill from either of the Minora prospects, with a transit time to prawn licence areas of 30-48 hours.

Although it is generally agreed that the eventuality of an accidental oil spill is extremely low, the PER's conclusion on the level of impact which would result, is questioned.

It is maintained that were a major oil spill to reach the shallows at the eastern side of the gulf, then destruction of a significant portion of juvenile prawns could occur and because of the annual life cycle of the prawns, this could have adverse consequences for the industry for several years. In addition, oil spills which persisted through transit to pearl licence areas in Gales Bay, would significantly impact on pearl oyster stocks.

If the assumption that Saladin Oil would be encountered is wrong, then the PER has probably understated the possible impacts of an oil spill. Several submissions made this point, and estimated that evaporative losses of spilled oil could be as low as 30%, but were probably more likely to be about 50%, not over 95% as estimated in the PER.

4. PROBABILITY OF OIL SPILLS

It is suggested that the PER should more adequately distinguish between the risks of small and large oil spillages. Other exploratory drilling operations have shown three distinct categories of oil spillages:

i) due to fuel handling mishaps or temporary failure of blow-out preventors. Low, 10 m^3 for one or two hours;

ii) a blow-out with a consequent partially controlled oil loss. Moderate, 10-1,500 m^3 for two to three days;

iii) Uncontrolled blow-out. (Rare)

These three distinct categories of oil spillages, each with a different level of probability, deserves a different strategy for risk management.

The claim (P46) that no spillages have occurred in Australia was contradicted on page 52 where a minor spill at Harriet is mentioned. In addition, a blow-out occurred on the Tern field offshore of the Kimberley in Western Australia in the 1970s. Although this blow-out was not environmentally damaging because it was a gas well, nevertheless it took six months to bring under control and demonstrated the enormous impact that would have occurred, should the well have been oil.

It is pointed out in the PER (P44), that assuming a worst case scenario, 90,000 tonnes of oil could pollute the Gulf and that even much smaller spills under unfavourable winds would rapidly pollute Bundegi reef and parts of the Marine Park (Fig.22, P99). Should such important resources be placed at risk - even if the risk is calculated as low?

It is suggested that precautionary measures for preventing large scale blow-outs should include the capability to contain oil spillages of up to 20 m^3, on or adjacent to the rig. In addition, arrangements should be made for immediate boom and skimmer deployment, practice alarm drills should be triggered to test the alertness and capability of the crew and each new string of casing should be pressure tested before drilling ahead, in order to minimise the likelihood of well failure outside the casing.

The nearest location of mechanical clean-up equipment is at Port Hedland and, according to the contingency plan, it would take 2.5 hours for its transfer to the site (addendum G) and 2 hours for the arrival of the nearest operator from Perth (addendum D). This response time may not be adequate to contain a continuous spill and it is suggested that the equipment and an operator should be localised at Exmouth when the drilling is nearing the zone of interest in both wells.

5. DRILLING FLUIDS AND CUTTINGS

It is possible that drilling fluids used may pollute the sea and seafloor in the vicinity of the rig. These fluids can precipitate bentonite and barite on the seafloor. Although barite is accepted as being inert, combined with bentonite it will form a thin, dense, impermeable layer blanketing all algae and sessile fauna such as marine worms and solitary corals.

There is inadequate detail regarding the composition of drilling fluids proposed for use. Drilling fluids vary substantially in composition and toxicity. Should the use of oil based or other toxic drilling fluids be required during the proposed drilling programme, neither their disposal nor the disposal of drill cuttings coated with the fluid should be permitted within Exmouth Gulf. These drilling fluids are usually stored in tanks on board drilling platforms, and could easily be pumped into a barge for discharge onshore.

It is suggested that 334 cubic metres of cuttings would blanket the sea floor for a radius of at least 50 metres from the discharge site, destroying all the seafloor fauna and flora. That the destruction is not visible to an observer above is no defence for the obliteration of an area of Marine Park. Certainly the destruction of a similar area of a National Park at (say) Pemberton would be a source of public outrage.

It appears that much of the detailed removal costs quoted in Appendix 3 are associated with a cumbersome materials handling method. Use of a bottom discharging barge is suggested to greatly reduce these expenses.

6. USE OF DISPERSANTS

The question of chemical dispersion of spilled oil moving towards the mangals bordering the eastern Gulf requires more detailed evaluation than that provided in the PER.

In particular, evaluations should include a more detailed assessment of the conflict between reducing the potential impact from spilled oil to mangroves, while possibly increasing the impact to subtidal organisms such as prawns.

Excessive application of dispersant has been demonstrated to be invariably at rates substantially in excess of recommended rates. Minora should give a commitment to fully train oil spill combat crews in dispersant application.

Dispersant use and type is highly reliant on oil type. It is maintained that the resistance of mangrove to oil and dispersed oil is clearly species specific and oil specific. In addition, dispersants may be relatively ineffective unless applied to the spilled oil prior to weathering.

Consequently, prior to any approval of dispersant use, the Company should conduct field studies to ascertain the relative toxicity of oil and dispersed oil on local mangroves. In addition, bioassay testing should be carried out to determine the relative toxicity of oil and dispersed oil to prawns and pearl oysters. A range of possible disperants, together with a range of Western Australian oils, should be tested.

It is also suggested, that Minora should be requested to provide detailed consideration and advice to the State Combat Committee regarding the suitability of dispersant use in Exmouth Gulf. This analysis should be undertaken prior to any drilling.

7. INDUCED RF VOLTAGES

A one million watt Very Low Frequency (VLF) transmitter is located on the tip of Point Murat and is radiating continuously. Recent field intensity studies have determined that the RF field strength at the proposed Whalebone #1 drilling site (21^{o} 51'S, 114^{o} 13'E) is in

excess of 1.1 (one point one) volts per metre. Taking into account the length of drill sections induced voltages in excess of 60 Volts ac could be expected. The salt air environment combined with the metal structure of the drill platform will provide a serious personnel shock hazard.

8. GROUNDING AND BONDING ARRANGEMENTS

The report does not refer to any special earthing and bonding arrangements to remove the induced RF voltages. Arcing is to be expected resulting in a significant fire and explosion hazard.

9. OIL AND GAS FIRES

The report does not address the possibility of a gas explosion or oil fire. No contingency plans appear to be in place for such events.

10. SEISMIC SURVEYS

The report refers to one day of seismic surveying in the vicinity of Whalebone #1 but does not discuss the danger of transporting, storing and using electrical and electronic detonators within several kilometres of the Naval Communication Station.

11. HELICOPTER OPERATIONS

Reference is made to helicopters but no cautions on flight paths to avoid the following:

a. VLF high tower structures.

b. Numerous transmitting antenae.

c. Commonwealth Prohibited Areas (detailed in Australian Government Gazette G31 dated 14 August 1981).

12. POSSIBLE INACCURACIES

In addition to the previous concerns expressed in the summary of submissions, the following inaccuracies were also claimed:

a) A spillage rate of 1 in 455 has been computed in 1983 by the Commonwealth Dept of Transport in 1983. Since then there have been several major disasters outside Australia which would significantly alter this figure.

b) The PER assumes that if oil is encountered at either of Minora's two prospects, it would be a light Australian crude oil similar to that found at the Saladin oilfield. However, crude oils that have been encountered in wells in the region vary greatly (Philip, 1982), and the possibility of intersecting heavier crudes in Exmouth Gulf cannot be discounted.

c) The persistent references to inert muds is misleading. The discharge of muds containing chromium should be of concern.

The following specific items should also be addressed.

VIII Park was proclaimed before EP325 was granted (see p4, 5).

IX Exploration commitments can be deferred by Government.

XI Turtle, dugong, birds are omitted;
Ecosystem recovers quickly (XI). Recovery takes many years (p25).

P26 The Crown of Thorns is not in Ningaloo, it is present in the Dampier Archipelago.

P28 Trap fishing has been omitted.

P34 The Management Plan covers only State waters. The Australian Government is preparing its own plan for Australian waters.

P36 Management Plan proposes that Use 4 will cease.

P46 There is inconsistency in statements about whether oil
P52 spills have or have not occurred.

P62 More details on actual equipment available on-site is required.

P65 Monitoring - more detail is required. Should be developed in consultation with CALM, Fisheries, EPA.

APP3 The cost, though high, is about 10% of drilling each well.

APP5 The contingency plan needs further discussion prior to approval, eg, all spills should be reported.

- Spills below 0.5 BBL - Drilling Supervisor to maintain log.

- Spills below 25 BBL - records to be kept and supplied to EPA, Mines, CALM.

- What spray equipment is available on-site? What length of boom? What equipment is held by the Navy at Exmouth? What equipment is available for dispersants?

- References to Fisheries and Wildlife are incorrect - now Depts of Fisheries and CALM.

13. VOLUME 3. OIL SPILL TRAJECTORY ANALYSIS

The following technical comments were received from an informed source, relating to the above analysis. The comments have been included as a whole, rather than summarised.

(a) Section 1.1 (Overview)

The report discusses existing oil slick models, including the quite well-proven use of the "3% of the wind speed" rule. This rule, which has both theoretical and observational justification, is generally used in conjunction with other mechanisms of slick advection (eg. tidal currents). However, the technique used in this instance does not resort to the "3%" rule, but rather to the use of a far more complicated (and in my view less robust, for reasons to be given) 2.5D hydrodynamic model.

The statement in the latter part of Section 1.1, that "the slick tends to maintain the same direction as, but lower speed than, the underlying water" is surprising and theoretically questionable. It is based on a misinterpretation of Loucks and Laurence (1971), which itself was based on minimal observational data concerning only one oil spill.

(b) Section 4.5 (2D Circulation Model Results)

The tidal currents in the northwest part of the model are clearly incorrect and influenced by unrealistic open boundary conditions (see Figs. 4.3 and 4.5). It is apparent from Section 4.3 that these boundary conditions were obtained by linear interpolation between defined values at the boundary corners. It is well known within the oceanographic modelling community that linear interpolation of boundary values often leads to poor model simulations in the vicinity of boundaries, and "jet-like" flows associated with the boundary corners (as is apparent in Figs. 4.3 and 4.5). This error in tidal current predictions may lead to incorrect prediction of the oil spill envelopes (Section 5.3) in the northwest corner of the model, where I believe there are sensitive reef areas.

(c) Section 4.5 (2.5D Circulation Model Results)

(i) It is apparent from Appendix C that the 2.5D model uses the input from the 2D model for the specification of the time history of the sea surface slope. However, from Appendix B, it is also apparent that the 2D model uses a formulation of bottom stress based on the depth-averaged current. This formulation is known to be inappropriate to, and inconsistent with, models of the "2.5D" type, especially in shallow

partially enclosed regions such as Exmouth Gulf. In some cases, this error leads to a predicted bottom stress that is in the opposite direction to the correct bottom stress.

(ii) The 2.5D model uses a constant eddy viscosity, and a condition of no bottom slip. This assumption is known to lead to very poor approximations to the variations of current over depth, especially near the sea bed and sea surface (Soulsby, 1983, Stolzenbach et al, 1977).

(iii) The value of eddy viscosity, ν, used in the 2.5D model is not specified. Three points should be noted:

(a) Published formulations of the vertical eddy viscosity (or "momentum exchange coefficient") vary widely. An illustrative diagram of this variation is attached (from Leendertse and Liu, 1975).

(b) The predictions of wind-driven surface current depend strongly on the chosen value of ν, with a proportionality varying between ν^{-1} and $\nu^{-1/2}$, depending on the importance of the Earth's rotation. In a shallow region such as the Exmouth Gulf, the Earth's rotation is relatively unimportant and the predicted surface current varies approximately proportionally to ν^{-1}.

(c) The extent of the oil spill envelope depends strongly on the wind-driven part of the current, which in turn varies proportionally to ν^{-1}. The indeterminacy in ν, noted in (a) above, is hence directly reflected in an indeterminacy in the extent of the oil spill envelope.

(iv) 3.4 The westward flow with a northerly wind (Fig 15) and other examples of the unexpected current rotation to the right of the wind (noted in the report) are most probably an artefact of an unrealistic long-shelf surface gradient induced by the radiation boundary condition. The radiation boundary condition is based on time-dependent solutions of the long gravity wave equations, and while being applicable to storm surge models, is inappropriate to models of the steady-state wind-driven circulation.

(v) 3.5 The radiation condition quoted in Appendix B is incorrect.

(d) General Comments

The particular implementation of the 2.5D model seems inappropriate to the modelling of a surface oil slick. A simpler and more robust model would use a "3% of the wind speed" technique superimposed on a 2D tidal prediction model.

However, the oil spill envelope predictions seem reasonably believable, except for the cases noted above, ie:

(i) Errors in the northwest corner of the model due to incorrect open boundary conditions for the 2D tidal model.

(ii) A rotation of the surface wind-driven current to the right of the wind vector, probably due to the inappropriate application of a radiation boundary condition at the open boundary. Further problems may also be present if the erroneous radiation condition quoted in Appendix B was actually used in the model program.

The surface current seems to be at least 3% of the wind speed (Section 4.5) (which does seem rather large for a current 1 metre below the surface), presumably due to a fortuitous choice of the eddy viscosity. If this eddy viscosity had been decreased by a factor of about 2 (which would be quite plausible, given the uncertainty shown in the attached diagram), then the wind factor would have been increased to about 6%.

In summary, the model seems to get the predictions roughly correct, but for the wrong reasons. Significant errors may, however, be present in the northwest corner of the model, and in association with an incorrect orientation of the surface wind-driven current.

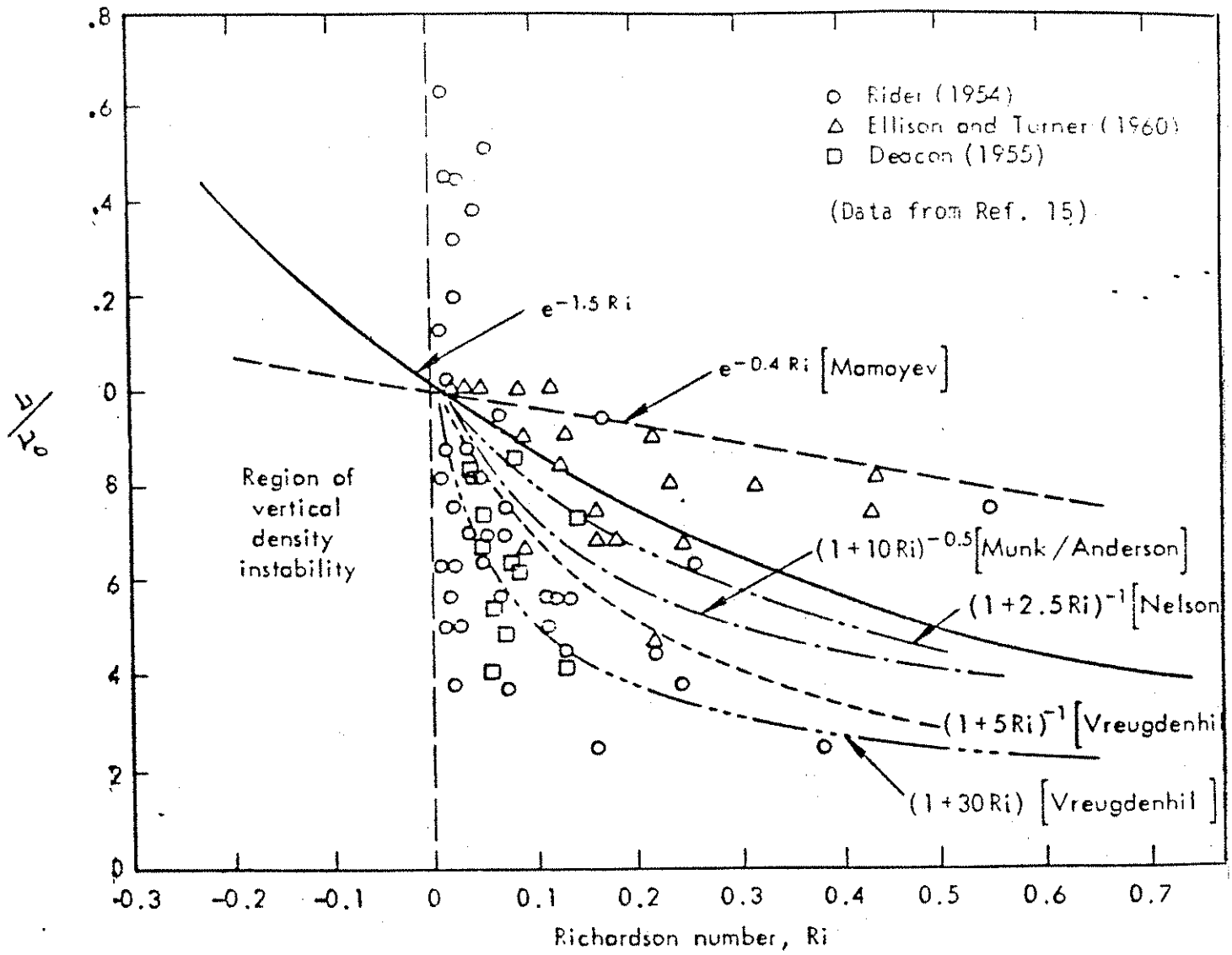

Fig. 7--Ratio of the vertical momentum exchange coefficient in stratified flow and the coefficient in flow with isotropic density as a function of the Richardson number

APPENDIX 2

PROPONENT'S RESPONSE TO SUBMISSIONS

ATTACHMENT 1 to Minora Resources NL
letter dated 2 November 1988

SPECIFIC RESPONSES BY EP 325 JOINT VENTURERS TO EPA

SUMMARY OF SUBMISSIONS - ITEMS 1 - 12

ITEM 1 - THE ECOSYSTEM

1. ITEM 1 - PARAGRAPH 1

There is evidence to suggest larger fish and marine mammals are not affected by modern seismic methods.

The little work that has been done locally refers to tiger prawns and to pearl shell. However, work done elsewhere (mainly the United States) is reviewed by Pierce (1984) and Linton et al. (1984) who concluded that non-explosive sources (such as the airgun proposed for use in this survey) appear to have little adverse physiological effect on marine organisms. Pierce (1984) concluded that "based on the weight of the evidence, no demonstrable harm to fish or marine mammals results from the use of air guns for geophysical research". The US National Marine Fisheries Service also concluded that geophysical exploration did not adversely affect migrating whales.

A substantial amount of this type (airgun) of seismic work has been conducted by various companies in the North West Shelf region of Western Australia and no incidence of mortality either involving fish, dugong or other marine organisms has been reported.

The seafloor habitat in the vicinity of the area proposed for seismic survey is not the type of habitat where either large fish congregate (because no shelter is available) or dugongs reside (because it is too deep and has no food supply). Any large fish or dugongs found in these waters would be passing through the area.

The seafloor habitat is similar to that found extensively throughout Exmouth Gulf where a major seismic survey of the type proposed was conducted for Minora over a period of 30 days last year. To our knowledge no incidences of damaged marine organisms arising out of that survey have been reported.

2. ITEM 1 - PARAGRAPH 2

We feel that the Public Environmental Report ("PER") has given sufficient attention to marine birds. The PER has attempted to accept an even handed approach to the attention given to all marine resources in the area. Birds are just one of many organisms that might be affected by an oil spill.

Table 3 of the PER summarises known effects of oil, sensitivity to oil and recovery rates of all marine organism groups known to occur in the region, including birds. Mangroves and coral reefs have been given greatest attention in the PER because these assemblages can take a long time to recover and extensive damage to these assemblages, if it occured, would be expected to cause measurable changes in local ecosystem character. However, whilst individual migratory wading birds (or flocks) might be adversely affected by an oil spill, any loss would be a temporary & localised effect and would not markedly modify either the population size of the species or the ecosystem of which they are a part.

3. ITEM 1 - PARAGRAPHS 3, 4 AND 5

The potential vulnerability of turtles to the effects of an oil spill is acknowledged. This issue is of course not unique to the Exmouth Gulf as turtles exist in many areas throughout the North West Shelf region, where many developments have taken place without jeopardizing the turtle population.

The Joint Venturers' consultants, Le Provost Semeniuk & Chalmer, have extensively considered the possible impact of an oil spill on the turtle population including a consideration of particular aspects such as the probable effects of an oil spill on food supplies, breeding and nesting places.

In short, mindful of the results of that review, every effort would be made to protect the turtle population from any adverse effects should an oil spill occur, in the same way that appropriate steps would be taken to protect any other creatures that might be affected.

Details of the consultants' review in relation to turtles may be obtained if so required.

4. ITEM 1 - PARAGRAPH 6

The Joint Venturers reject the contention that "the EPA must consider" whether matters relating to possible future oil production are appropriate. The proposal in question relates to exploration only.

To attempt to guage whether such matters as production platforms or tank farms are appropriate in the context of the assessment of any exploration programme is in our view, clearly premature and, equally as clearly, impossible at this stage.

The potential scenarios which may develop from the exploration programme now under consideration are numerous. No oil or gas may be discovered. If there is a discovery it may or may not be commercial. It may or may not be oil. If it is commercial the development options may be vast. There may or may not be one or any number of production platforms. There may or may not be one tank or tank farm etc.

The Joint Venturers recognise that the State can seek further environmental assessment of any activities that the Joint Venturers may wish to undertake beyond their current proposal. This is the appropriate course of action which allows the State to assess environmental impacts based on firm and detailed proposals and to weigh any possible development benefits against those impacts.

We would add that oil is a particularly strategic material essential to our life-style. There is no other product or material which at this stage can replace its versatility and cost effectiveness in energy or manufacturing. Currently Australia's oil reserves are rapidly depleting. Replacement reserves must be found or we will become increasingly dependent on imported oil. This scenario has far reaching and unpleasant implications for our community.

We submit that the idea of banning oil exploration in the area to minimise environmental risk is idealistic in the context of Australia's dwindling petroleum reserves and put shortly, is simply not practical when, as we submit is the case here, appropriate steps will be taken to protect the environment.

5. ITEM 1 - PARAGRAPH 7

While the actual environmental impacts of an oil spill would be similar at each site, the potential impacts arising out of an oil spill would not be the same as far as the marine park is concerned, because one well (Rivoli-1) is some 13 km further removed from the park than the other (Whalebone-1). This means that, in the event of an oil spill, more time is available for both weathering and containment/diversion/recovery of oil before the park waters are encountered.

ITEM 2 - ALTERNATIVES

6. ITEM 2 - PARAGRAPHS 1 & 2

Minora's detailed analysis of all the available geological and geophysical data has shown that both the Whalebone and Rivoli prospects have the potential to contain hydrocarbons and are worthy of exploration by drilling.

This assessment is not a recent one. It was based initially on data available prior to the State Government calling for tenders for exploration in EP 325 early in 1987.

In fact, because of the paucity of information available about the Permit in general it was only the favourable assessment of the prospectivity of Whalebone and Rivoli that caused the Minora led consortium to bid so competitively for the rights to the Permit.

Without those two highly promising drilling targets the Joint Venturers would have committed to drill considerably less wells and otherwise have offered a lower level of commitment in the Permit. The Joint Venturers' favourable assessment of Whalebone and Rivoli was clearly outlined in their tender documents submitted on 23 October 1987.

The early and favourable assessment of the prospects is further supported by the fact that the decision to drill Whalebone has been made without further physical exploration of the prospect. The small seismic survey proposed in the current application will merely clearly define the drilling target.

The company rejects any suggestion that the application to drill Whalebone is anything other than a legitimate and highly promising exploration activity. That suggestion is speculation made entirely without any basis, and is untrue.

The Joint Venturers' would not be acting in the best interests of their shareholders if they did not seek to discover the potential of the prospects, especially given the basis on which they bid for the Permit. The Joint Venturers regard exploration of both the Rivoli and Whalebone features as an essential part of determining the petroleum potential of the Permit.

7. ITEM 2 - PARAGRAPH 3

In response to the assertion that drilling should not proceed on the Ningaloo Reef the fact is that neither Whalebone-1 nor Rivoli-1 is even near the reef. The North West Cape lies between the Permit and the Ningaloo Reef.

8. ITEM 2 - PARAGRAPH 4

Brief surveys of the distribution of major shallow water habitats were conducted by the proponent, and have been conducted previously for other studies (North West Cape Marina PER). Sufficient information was available from these surveys and from published works (primarily Jones, 1986) to allow identification of the major biotic assemblage groups likely to be encountered in the Exmouth Gulf region. Furth more, large quantities of detailed biological data would not have greatly improved the accuracy of the assessment of potential effects of the project because of difficulties in predicting impact conditions and the organisms response to those conditions.

It should be noted that a programme to monitor some significant components of the biota have been recommended and that base line data will be collected prior to the programme starting.

9. ITEM 2 - PARAGRAPH 5

Part of Bundegi Reef is included in a sanctuary zone. This proposal does not involve drilling within the designated sanctuary zone.

10. ITEM 2 - PARAGRAPH 6

The Joint Venturers reject the suggestion that they provide guarantees that if an oil spill damages fishing, prawning or pearl oyster operations in Exmouth Gulf fair compensation would be paid.

There are numerous specific requirements and regulations governing protection of the environment which must be followed when exploration activities are carried out and the Joint Venturers will ensure not only that those requirements and regulations will be met but also that any additonal measures that they feel are warranted to protect the environment will also be implemented.

The question of whether compensation is payable to any person or group in the unlikely event of a significant oil spill, and if so the amount payable, is a matter for the courts to determine having regard to all relevant circumstances at the time.

It would in our view be quite inappropriate at this stage for the Joint Venturers to provide a guarantee as requested when, if damage occurred, it may not result from any negligence on their part. For example, they should not be held responsible if a third party's vessel collided with the rig and caused a spill because of the negligence of the master of the vessel, unlikely as that event also might be.

We are not aware of any instance where explorers have been required to provide guarantees of the kind suggested for those fishing operations. We would add that those operations are not the only legitimate uses of the State's waters. The Joint Venturers have a reasonable expectation that they should be allowed to explore in the area pursuant to the Petroleum Act 1967 (W.A.) and the EP325 Permit.

With regard to the question of insurance, the Joint Venturers have in place or are negotiating insurance cover of the kind and level usually provided in the industry for such exploration activities. We would be prepared to discuss the extent of the cover with any interested parties should approval to drill be granted.

11. ITEM 3 - LIKELY HYDROCARBONS - PARAGRAPHS 1 and 2

All available geological and geochemical data indicates that the most likely hydrocarbon type to be found in the prospects is light Australian crude with API gravity in the range 40-48°.

Throughout the world oils of varying chemical compositions and attributes are found. Oil is a naturally occurring substance and is common in many environments.

The viscosity of oil is measured on the API scale.

Heavy oils have API gravity less than 20 degrees API
Medium gravity oils are between 20 and 30 degress API
Light oils have API gravity between 30 to 48 degrees API
Above 48 degrees API oils are considered condensates.

Various oils have differing wax contents. This is generally a function of either plant or animal sources. Waxy crudes generally become solid at low temperatures.

Some oils have sulphur content. These are referred to as sour crudes where as sweet crudes have no or low sulphur content. All oil produced in Australia is sweet.

The submissions questioning the likely gravity of oils discovered based their premise on the range of oils found in the basin. The API gravity of oils found in the Exmouth and Barrow sub-basins is as follows:

Barrow Island	34	degrees	API	
Harriet	37	"	"	
South Pepper	44	"	"	
North Herald	44	"	"	
Chervil	44	"	"	
Saladin	48	"	"	
Rough Range	34	"	"	
Mardie	17	"	"	(not on production)

All the oils produced in the basin are considered light oils.

Many factors influence the gravity of oils. We are able to explain the variation of oils in various parts of the basin. Factors influencing oil gravity are as follows:

* Geological Age of Source Rocks: Generally older rocks produce high gravity oils.

* Depth of Burial of Source Rocks: The temperature and pressure that source rocks are subjected to is thought to be the major factor in the resultant oil gravity. Generally with higher temperature and pressure higher gravity oil is sourced.

* Basinal Position of Source Rocks: This factor is related to temperature. Generally higher geothermal gradients are found on the basin margins. This results in higher temperatures at shallower depths than in the central basin areas.

* Tectonics: Source rocks subject to active stress regimes generally produce higher gravity oils.

* Type of Source Rock: Organic material found in source rocks laid down in marine conditions generally sources high gravity oils. Source rocks deposited in terrestrial environments generally source heavier and waxier oils.

* Biodegradation: After an oil has been sourced and is reservoired in a pool bacteria introduced to the oil may cause biodegradation. This results in much heavier oil and in extremes leads to asphalts and tars. This factor is important in the Carnarvon Basin.

The source rocks most likely to source oils to be found in the proposed wells are the marine siltstones and claystones of the Jurassic aged Dingo Claystone which are the source of the Saladin, South Pepper, Chervil and North Herald oil fields which are the closest analogous fields. In EP 325 and surrounding areas large volumes of Dingo Claystone are located in the Oil Window, the temperature zone where oil is generated. Geochemical data from samples of Dingo Claystone throughout the basin show it to be a marginal quality source rock which sources the light oils found in the basin.

By comparison, the oil found at Rough Range-1 is thought to be sourced from older Permian aged Byro Group source rocks (Parry and Smith 1988) which have different source potential. We do not anticipate Permian sourced oil in Rivoli-1 or Whalebone-1 as the Permian rocks are located too deep to produce significant quantities of oil.

The oil found at Barrow Island and Harriet has been demonstrated geochemically to be a combination of both older heavy biodegraded oil and younger light oil expelled in three separate phases from the Dingo Claystone (Kopsen and McGann 1985). This results in 36 to 37 degree API oil produced from the fields, which is still rated as Australian Light Crude.

The oil found in the Robe embayment onshore is approximately 17 degrees API (Mardie Oil Field). This oil has been severely biodegraded. Being reservoired so close to surface it was ideal for bacteria to feed upon. This oil is too viscous to produce commercially to the surface.

The other fields in the basin are typical Dingo Claystone sourced oils similar to those anticipated in the Whalebone and Rivoli prospects. There is no valid reason to expect biodegradation, different source rocks or mixed oils in these prospects.

We do not anticipate high wax content in any oils discovered, as the organic material sourcing oils in the area is marine rather than terrestial.

12. ITEM 3 - PARAGRAPH 3

The evaporation and weathering characteristics of Light Australian Crude have been reviewed by Kagi (1988). He shows that oils of the type expected in these prospects are highly volatile and that they weather and evaporate rapidly in the climatic conditions of the area.

13. ITEM 3 - PARAGRAPHS 4, 5 and 6

The probability of such a worst case scenario is so low as to be virtually impossible. It must be remembered that the proposed exploration wells are controlled drilling exercises into a known geological structure.

It is acknowledged that in the worst case scenario, a major oil spill (uncontrolled 1-6 month blow out) advancing along a broad (50 km) front may possibly severely impact prawn stocks in the region which would have a consequent effect on the fishery until stocks recovered. Prawn stocks have been markedly reduced in the past as a result of both overfishing and unfavourable cyclonic activity, and have generally taken 3-5 years to recover under a reduced fishing effort regime.

Such an impact from a major oil spill, however, is likely only if the oil actually comes into contact with the prawns (or pearl shell). Weathered light oil floating above these organisms is unlikely to cause adverse impacts on local stocks.

However, in the event of a moderate, partially controlled oil spill (i.e. 10-1 500 m^3 for 2-3 days), it is doubtful that sufficient area of prawn nursery would be affected to cause anything but a slight, short-term reduction in fishable stock. Surveys of the impacts of large oil spills (100,000 to 200,000 tons) on commercial fisheries were conducted by Wardley-Smith (1976) and Cormack (1984). The major points arising from these studies were that :

(i) the natural over production of larvae during spawning is sufficient to compensate for local losses incurred during an oil spill; and

(ii) the immigration of larvae from adjacent unpolluted areas will compensate for losses in an affected area.

These studies concluded that the impacts of oil spills were relatively minor and were impossible to detect within the natural cyclic variability in fisheries recruitment.

As referenced earlier we maintain a Saladin type oil will be found. The evaporation rates of that oil have been evaluated by Kagi in the Wesminco ERMP (1985) and are consistent with the PER.

14. ITEM 4 - PROBABILITY OF OIL SPILLS - PARAGRAPH 1

Minora reiterates that the possibility of an oil spill is most unlikely. We do not see the need to "more adequately distinguish between the risks of small and large oil spillages". The PER adequately addresses this point - refer Volume 1 page 43.

In any case, the first Australian offshore exploration well was drilled in 1964. Since then over 500 offshore exploration wells have been drilled and even though oil spills in excess of 80 litres must be reported there have been no reported "significant oil spills, requiring clean up" from an offshore exploration well (Refer: Petroleum Division, Dept of Primary Industry and Energy, Canberra).

Minora does not consider that the "categories of oil spillages", referred to under Item 4 and the comments that accompany them are accurate for Australian experience. They may or may not have occurred in other parts of the world. It would be inappropriate to have regard to those categories and comments in the case of the oil exploration industry in Australia, where a high standard of professionalism exists throughout the offshore industry both on the side of the Operator and the Contractor.

In this proposal, it is submitted that the Operator has correctly designed the wells and by the Contractor maintaining and regularly testing its equipment and training its crew (which it is obliged to do under Government regulations) the risk of an escape of hydrocarbons is minimal.

In addition approval to drill is only granted by the governing authority if they consider that the Operator and its selected contractors are capable of drilling an offshore exploration well in a safe and efficient manner and that the supervisors, crews, etc. are adequately trained and experienced.

In the last 20 years advances in both geological and geophysical techniques have greatly enhanced the knowledge on a likely prospect, especially when wells have been drilled in the basin. as is the case in the Exmouth sub-basin of the Carnarvon Basin. It is accepted that there is a very low risk of encountering abnormally pressured reservoirs in the Exmouth Gulf.

This however does not mean that the wells would be drilled without any regard for possible over pressure. As is standard industry practice offshore, overpressure detection techniques will be used throughout. These techniques were developed in the Gulf of Mexico in the mid 1960's, gained industry acceptance in the early 1970's and were first introduced into Australia in 1977 by ESSO in the Bass Strait. (Ref: Exploration Logging).

Should there be a "seepage" of oil from the well, the flow could be shut off almost immediately by setting a barite or cement plug.

In light of the above, the oil spill plan detailed in the PER has been developed to cater for a spill, which could be contained using the available on site resources of the Operator. It also caters for a spill that is clearly beyond the control of on site equipment, i.e. an uncontrolled blowout.

15. ITEM 4 - PARAGRAPH 2

The spill from Harriet occurred during production operations, not during exploration drilling.

The blowout on Petrel (not Tern) in 1969 was a gas blowout. It occurred when an overpressured gas reservoir was encountered without warning and would not have occurred using today's technology.

16. ITEM 4 - PARAGRAPH 3

The PER recognises that the major environmental concern associated with the proposal is the potential for an oil spill. However, it concludes that, based on all the technical and historical evidence available, the chances of a major oil spill are extremely small.

The Ningaloo Marine Park Draft Management Plan. May 1988, clearly recognises that exploration for petroleum within the Park boundaries is legitimate and that the Minister for Conservation and Land Management has the power to impose conditions on these activities and subject them to environmental impact assessment.

That environmental assessment is now being undertaken in the form of the PER.
Minora reasserts that because of the extremely low possibility of adverse environmental impacts the proposals to drill should be allowed to proceed.

17. ITEM 4 - PARAGRAPHS 4 AND 5

These matters have been substantially addressed in the PER p62, Oil Spill Contingency plan appendix 5. However to amplify, a boom and skimmer device will be permanently stationed on the rig upon approaching the objective, along with an operator as is standard practice for all operations in environmentally sensitive areas.

Industry practice is that crews are trained to be "kick" responsive and practices are held every shift under varying circumstances. A record of these practices is made in the official well record.

Regulations state that Blow Out Preventers are tested at least once per week. Casing is tested when first run or if the operator is concerned about the wear and tear on it. Both these practices are standard throughout the industry.

The adoption of the above practices is set out in Minora's "Drilling Operations Manual" which was submitted to the Mines Department with our application to drill Rivoli-1 and Whalebone-1.

It should be drawn to the attention of concerned parties that Minora has contracted a rig, the "Maersk Valiant" which has operated in Australian waters for 6 years, maintaining over that time 25% of its original crew. It therefore rates as one of the most experienced rig operations as a whole in Australia being supported by Maersk Drilling, Copenhagen, who operate 34 offshore rigs worldwide and rated 7th largest rig operator in the world. They are held in high regard by the international oil industry.

18. ITEM 5 - DRILLING FLUIDS AND CUTTINGS

ITEM 5 - PARAGRAPH 1

Minora reasserts that neither the intended drilling fluids nor the drill cuttings will cause any significant or long term damage of the environment. This is evidenced by the results of studies on the Bundegi-1 well site.

Approximately 720 * 50 kgs sacks of barite will be used in the drilling of Rivoli-1, Whalebone-1 since there is no need to weight up the system to control formation pressures. This would be used throughout the well and in turn dispersed throughout the mud system. The amount likely to be dumped at any one time is 780 kgs maximum, which would be dispersed in the sea by tidal and thermal currents. Being in the region of 8 microns in diameter and having a SG of 4.33, a particle would take 139 hrs to settle through a water depth of 19 metres. With an average current in the Gulf of 1.8km/hr an average particle of barite would eventually settle on the bottom after travelling a distance of 250kms, using Stokes Law (Particle size ranges from 2 microns to 80 microns giving a settlement distance of 1.8km to 4008km.)

Bentonite particles being much larger and much less dense than barite, would take a minimum of 19,195 hrs to settle, again using Stokes Law. With this large dispersal envelope and with continual currents and movement of the fauna etc. on the sea bed it is difficult to imagine that any fauna would be smothered to the point of endangering its existence.

The negligible effect on the sea bed fauna of drilling Bundegi-1 is stated in the PER, p39.

19. ITEM 5 - PARAGRAPH 2.

At the time of writing the PER it had not been decided as to which drilling fluid engineering company would be awarded the contract and therefore the final composition of the fluid was not

known. The seawater/polymer system which has since been selected and vetted by the Fisheries Dept (Howard Jones) has LC-50 values as follows, for material used to drill the following hole sizes:

Hole size (inches)	96 hour LC-50 values (ppm)
36" & 26"	900,000
17 1/2"	900,000
12 1/4"	95,000-105,000
8 1/2"	74,000-100,000

To determine the above LC-50 value Mysidopsis Bahia are introduced into the suspended solids phase of the mixture. The survival rate after 96 hrs determines the LC-50 value of the drilling fluid mixed with seawater. This method of measuring LC-50 values is accepted by the EPA in the USA, who consider that values in excess of 30.000 ppm are non toxic. Refer: Magcobar/Inco Drilling Fluids.

A major consideration in selecting M-I Drilling Fluids to supply the drilling fluid expertise was the fact that they operate their own environmental laboratory in Houston, USA (the only drilling fluid company to do so) and using this facility they are prepared to derive LC-50 values as the mud was formulated in the field. No oils will be used in the composition of the drilling fluid.

20. ITEM 5 - PARAGRAPH 3.

This paragraph is emotive and demonstrably incorrect. It ignores the results of a study commisioned by WAPET in 1978 and corroborated by the Fisheries Dept, showing that there was a negligible effect on the seafloor ecology from drilling Bundegi-1. Refer PER p39. In that case the cuttings were dispersed in a very short period. It also ignores the fact the area has been modified by previous prawn trawling and will be further modified by future trawling.

21. ITEM 5 - PARAGRAPH 4

For the reasons as outlined above the application of a mechanical means of disposal of cuttings is unnecessary.

The possible use of a bottom discharging barge into which the cuttings would be dumped is impractical because:

(i) The barge would have to be tied up to the rig for long periods, posing a hazard to both vessels in the event of violent weather changes.

(ii) The barge would have to be loaded in the same cumbersome manner using skips, sufficient of which would have to be held on board the rig to act as a storage buffer in the event that the barge had to be towed clear of the rig due to adverse weather conditions.

22. ITEM 6 - USE OF DISPERSANTS - PARAGRAPHS 1 to 6

It is acknowledged that the question of whether dispersants should be applied to spilled oil moving toward the mangroves bordering the eastern side of Exmouth Gulf requires further evaluation. It was assumed that this evaluation would be provided by the State Committee for Combating Oil Pollution during their review of the Minora Oil Spill Contingency Plan.

The uncertainties which exist regarding both the effectiveness and the effects of dispersant application are acknowledged in the PER. The suggestion that dispersant application would be contemplated in this situation was made in deference to guidelines provided by the Mines Department and in DCE Bulletin No. 104, and recommendations by various authors (Knapp. 1987; Thorhaug, 1987; Getter et al., 1985) that if sensitive and highly important ecological resources (such as mangroves) are threatened by an oil spill, it may be necessary to afford these a higher priority for protection over other sensitive resources in the area which are judged to be of lesser ecological importance.

The PER does make the judgement that the mangroves fringing the eastern coastline of Exmouth Gulf are regionally an extremely important ecological resource and suggests that, for both ecological and commercial fishery reasons, it would be preferable to risk short-term (3-5 years) disruption to the prawn fishery rather than risk long-term (20-30 years) damage to the regional ecosystem and perhaps also the prawn fishery.

The above judgment is based on the worst case assessment that the prawns would be adversely affected by an oil spill and whilst indications from the literature are that larvae and juveniles are sensitive to contact by oil. as would occur if the oil was dispersed, there are also indications that prawns may not be affected by oil floating above them.

Prawn fisheries do occur in close proximity to producing oilfields. The best documented case is the commercial fishery for Penaeus aztecus which is based in the Gulf of Mexico where more than 11,500 offshore oil wells occur. Catch statistics for this fishery have been analysed by Wardley-Smith (1976) who showed that no reduction in the growth of the fishery has occurred that can be related to the oil industry. Neff & Anderson (1981) conducted toxicity tests on Penaeus aztecus and found it extremely tolerant of the water soluble fraction of Louisiana crude oil. Thus the assumption that the prawns would be affected by an oil spill is a conservative worst case assessment.

The recommendations to apply dispersants to mangroves, however, are based on experience overseas with oil types and climatic conditions different to those found in northwest Australia. Le Provost Semeniuk & Chalmer's experience with the light volatile oils of the Varanus,South Herald and Saladin fields is that the weathered residue is not heavy and tarry, instead it is relatively light and very similar to diesel fuel. This is substantiated by work conducted for the Wesminco ERMP by Kagi(1985) and in a recent Australian Petroleum Exploration Association (APOA) publication (Kagi et al., 1988).

Avicennia mangroves tend to be killed as a result of oil smothering the pneumatophores, thereby inhibiting gaseous exchange. Diesel fuel does not appear to adversely affect mangroves. Qualitative evidence for this is provided by inspection of ports along the northwest coast such as Onslow, Sams Creek (Cape Lambert) and Port Hedland where fuelling and bilge water spillages are relatively common and yet no evidence of mangrove mortality exists (except for one patch of mangroves in Port Hedland Harbour believed to have been caused by spillage of heavy engine oil).

Kagi (1988), in his review of weathering characteristics of North West Shelf oils, infers that because of their light volatile nature, a spill management option may be to physically disperse the oil by increasing agitation of the water surface and thereby increasing evaporation rates.

Thus there appears to be a case for reconsideration of the need to apply dispersants to the light volatile crudes of the type characteristic of developments in the region to date, particularly if 24 hours of weathering is available before important mangrove resources are threatened.

It is agreed that this issue should be further evaluated, but that the most appropriate authority to conduct this evaluation is the State Committee for Combating Oil Pollution, not Minora.

The suggestion that Minora should be requested to conduct field tests to provide advice to the State Committee for Combating Oil Pollution regarding the suitability of dispersant use in Exmouth Gulf is considered somewhat premature and alarmist at this stage, particularly given that the probability of finding oil is small and that the probability of a major oil spill is minimal. However, should oil be found and a production development proposed, then there is merit in the suggestion, particularly regarding mangroves. Such tests, however, should be conducted not by Minora alone, but on a collaborative basis between the State and the oil industry since both groups will benefit from the information obtained.

Minora is prepared to provide assistance to the State Committee for Combating Oil Pollution in line with its legal and contractual obligations to the State.

23. ITEMS 7 AND 8 - INDUCED RF VOLTAGES AND THEIR EFFECTS

Both Minora and Maersk Drilling (the rig owners) believe there is no danger imposed by induced RF voltages to the rig, personnel or the environment.

All rigs, by their very nature and construction, but in particular offshore rigs, because of the sharp relief they present in their working environment, have all components adequately earthed to the superstructure to guard against lightning strike. An offshore rig's superstructure is earthed by its contact with the sea and in the case of the Maersk Valient through its footings on the sea floor. Once casing is run in the ground (approx. 1½ days after commencing operations) an even more effective earthing path is created.

Maersk Drilling, Copenhagen, therefore consider the risk of arcing, causing an explosion or fire on the rig, to be nil.

In 1982 Murat #1 was drilled onshore on the very tip of the NW Cape in the shadow of the Communications Base without any arcing occurring.

24. ITEM 9 - OIL AND GAS FIRES - PARAGRAPH 1

The Application to Drill, (which must be approved by the Mines Department prior to drilling the well), contains an Emergency Response Plan, which sets out the Operator's response to various emergencies, such as a fire or explosion on the rig.

25. ITEM 10 - SEISMIC SURVEYS - PARAGRAPH 1

The reference to seismic surveys using explosives as an energy source is totally incorrect. The proposed seismic energy survey will use airguns as the energy source. Such sources have been used in the area several times previously.

26. ITEM 11 - HELICOPTER OPERATIONS - PARAGRAPH 1

The helicopter operators, Bristows, having worked in the Exmouth area for 21 years, are fully aware of restrictions imposed in and around the area of the Communications Base. Restricted areas are marked on the aeronautical charts for the region.

27. ITEM 12 - POSSIBLE INACCURACIES

ITEM 12 - PARAGRAPHS (a),(b) and (c)

(a) As quoted by the Petroleum Division of the Department of Primary Industry and Energy, Canberra, "there have been no significant oil spills from any exploration well drilled

offshore Australia". As pointed out previously, events outside of Australia have no relevance and do not alter the exemplary record of the Australian offshore exploration industry.

(b) This has been answered under Item 3.

(c) No Chromium compounds will be used in the mud.

ITEM 12 - POINT VIII

Although the Park was gazetted in April and May 1987 Minora first requested the area be gazetted for petroleum exploration in March 1987.

The sequence of events leading to the proclamation of the Park and the granting of EP 325 is as follows:

* March 1987, Minora requested WA Mines Department to gazette the area ex the permit EP 41.

* April 1987, WA Mines Department advised Minora that the next round of offshore releases would be June 1987.

* July 24th 1987 WA Mines advertised the area (L87-14) available for application.

* October 23rd 1987 - Applications closed.

ITEM 12 - POINT IX

Based upon discussions and correspondence with other parties having interests in the Exmouth Gulf, we understood the most appropriate time to conduct exploration activities in the area would be from mid November to the end of February (the off season for prawning). Accordingly Minora set in motion a sequence of events commencing in May this year. This timetable was aimed at fulfilling Minora's commitment to drill three exploration wells in the second year of the permit commencing 23 November 1988.

To achieve this aim Minora has entered into several contractual obligations with third party contractors and has purchased over $1,300,000 worth of material so as to enable the Joint Venturers to fulfill this commitment. Any deferral of drilling is likely to cause significant cancellation costs to the Joint Venture. We are unlikely to be able to obtain a rig at a later date. With these contractual and financial commitments and the expected other consequences of deferral we do not consider deferral as an option.

ITEM 12 - POINT XI

Turtles, dugongs and birds are not omitted. The distribution of habitats important to these organisms is clearly indicated in Figure 17 - Marine resources. Their use of various shallow marine habitats is also indicated in appropriate sections of the bilogical environment description (Section 3.2).

In the context in which the statements on ecosystem recovery are used, they are both accurate since they refer to different ecoystem types under different types of stress (natural versus oil spill). The report is consistent in its identification of mangrove and coral reef assemblages as being the most sensitive habitats that also take more time to recover. However, many of the other habitats and assemblages; particularly the beach, rocky shore and seagrass flats, have been shown to recover quickly from oil spill damage in tropical marine habitats. The recovery rate of these assemblage/habitat groups is summarised in Table 3.

27. ITEM 12 - PAGE 26

The statement regarding the Crown of Thorns starfish occurred in a section of the report that included a discussion of general ecological principles and characteristics of the marine ecosystem for the region - that region being the North West Shelf. The statement was not meant to imply that the starfish occurs in Ningaloo Marine Park, but instead that it is known to occur in the region.

However, Le Provost, Semeniuk and Chalmer would be surprised if it does not occur in the park because they have observed the starfish on reef adjacent to the Montebello, Lowendal and Thevenard Islands and can think of no reason why it should not have occurred on Ningaloo Reef in the past or that it will not be there in the future given the dynamic nature of the distribution and abundance of Crown of Thorns starfish on the North West Shelf reefs, the Great Barrier Reef and elsewhere in the world.

28. ITEM 12 - PAGE 28

In the information provided by the Fisheries Department (Figure 15), trap fishing was not identified as being a commercial fishery in Exmouth Gulf. Subsequent enquiries have confirmed that a few trap fishermen work the region but that most boats are based in Onslow because of better wharfage and gear handling facilities.

Trap fishing tends to be conducted in deep waters (greater than 10 m) adjacent to reef structures. As such the fishery is most unlikely to be adversely affected by the proposal. However, in the unlikely event of chemicals being used to disperse an oil spill, any traps in the path of the spill may be fouled by oil.

ITEM 12 - PAGE 34

We cannot understand the relevance of the statement to the PER as we make no reference to either the State or Federal Management plans on page 34.

ITEM 12 - PAGE 36

We fail to see the relevance of this item to the PER.

ITEM 12 - PAGES 46 & 52

This has been addressed under Item 4 (Point 14 above).

ITEM 12 - PAGE 62

The equipment held on site will consist of:

1) A Vikoma skimmer capable of recovering a maximum of 100 tonnes of oil per hour.

2) A Vikoma Sea Pack boom 450 metres in length.

3) Approved dispersant will be held on the rig and application equipment will be carried by both workboats.

ITEM 12 - PAGE 65

We believe the monitoring detail provided is more than adequate for a limited duration exploration activity.

The level of monitoring detail supplied is no less than has been supplied in previous Environmental Review and Management Programmes (ERMPS) for oilfield developments, and in fact, the oil spill contingency plan is probably the most detailed that has been produced yet for environmental approval purposes.

The normal procedure for past developments has been to produce detailed monitoring programmes (in consultation with relevant government departments) subsequent to receipt of Environmental Protection Authority (EPA) conditions of approval. Hence, the recommendation is appropriate and will be acted on.

ITEM 12 - APP3 - Please refer to Item 5 above

ITEM 12 - APP5

The first two points can be incorporated into the Oil Spill Contingency Plan if required. Equipment descriptions are set out above under the reference to P62. In addition to this equipment, WAPET have available helicopter mountable spraying equipment which they are prepared to place at our disposal should the need arise.

We are prepared to discuss these matters with the appropriate government authorities.

ITEM 13 - OIL SPILL TRAJECTORY ANALYSIS - refer to Attachment 2.

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APPENDIX 2 (Cont'd)

TELEFAX REF. NO. 3718

TO: LEPROVOST SEMENIUK & CHALMER FAX NO.: 368 2294

ATTN: I LEPROVOST

FROM: STEEDMAN LIMITED JOB NO.: A8769

DATE: NOVEMBER 1, 1988

SUBJECT: REPLY TO PUBLIC ENVIRONMENTAL REPORT. OIL EXPLORATION PERMIT EP325 - EXMOUTH GULF - OIL SPIL TRAJECTORY ANALYSIS SECTION

The following addresses the important comments point by point.

Section 1.1 (Overview)

1. ref. (a): The 2.5D modelling technique has been widely used; e.g. Jelesnianski (1970); Forristall (1974); Fandry (1983).

2. ref. (a): The motion of oil slicks relative to the surface coastal waters is poorly understood. Shear between the oil slick and the surrounding water body is to be expected.

Section 4.5 (2D Circulation Model Results)

3. ref. (b): All numerical models have problems specifying the open boundary conditions; e.g. Roed and Cooper (1987). This applies equally to a theoretical formulation or a measurement programme.

4. ref. (b): A linear interpolation scheme to each grid point on the open boundary tidal conditions was used. The linear interpolation method is commonly used; e.g. Flather and Heaps (1975); Flather (1976); Fandry (1981). In our opinion linear interpolation is an acceptable method.

.../2

5. ref. (b): Errors near the boundary may lead to incorrect oil spill trajectories. However the errors, if they exist, cannot be readily quantified and they should not affect the results in the model interior where the proposed Minora exploration wells are located.

Section 4.5 2.5D Circulation Model Results

6. ref. (c)(i): The formulation is consistent with the literature; e.g. Jelesnianski (1970) and more recently Fandry (1983).

7. ref. (c)(i): It is only a matter of opinion that the formulation of 2D and subsequently 2.5D models will not be applicable to Exmouth Gulf. The 2D model has been tested against water level data and produced accurate results. (Steedman Limited (1985) report no. R298 prepared for Department of Marine and Harbours).

8. ref. (c)(i): We agree that the depth averaged current may flow in the opposite direction to the (non-depth averaged) near bottom currents, particularly near the coast (e.g. Csanady, 1982). However this does not invalidate the modelling technique used.

9. ref. (c)(ii): The 2.5D model uses a no slip condition. Only two methods are used by modellers, (i) slip and (ii) no slip conditions. The assumption of no slip condition is also commonly used, e.g. Fandry (1981; 1982; 1983) and applicable to this class of problem.

10. ref. (c)(iii): The formulation of the eddy viscosity used is explicitly given in appendix C, section C1.3.

11. ref. (c)(iii): We agree with the statements concerning the variations of the eddy viscosity ν. Other variations of the eddy viscosity are also possible; e.g. Davies (1977); Forristall (1980). However we made the judgement that the depth dependent formulation of eddy viscosity was appropriate. Again this assumption is used by the other modellers, e.g. Forristall (1974); Fandry (1983).

12. ref. (c)(iv): The model formulation has been checked and is consistent with other circulation models of this class, e.g. Forristall (1974); Fandry (1983). Given the nature of the model we do not see why the results are mathematically incorrect.

13. ref. (c)(iv): As a matter of interest, local fishermen believe there exists a westerly flow, of type shown in figures 4.3 and 4.5, during a northerly wind.

.../3

14. ref. (c)(v): The radiation condition was not explicitly defined, and the definition of U was omitted; U is the mass transport. Given this term, the radiation condition quoted in appendix B is correct and consistent with the literature; e.g. Pandry (1981); Roed and Cooper (1987). This approach is a variation of the more general Sommerfeld radiation condition.

General Comments

15. ref. (d): The 'simple and more robust model would use 3% of the wind speed', but such a simple technique cannot deal with the shoreward movement of the surface waters. The physics of the surface flow do not allow continuous onshore movement (mass transport); e.g. Csanady (1982).

16. ref. (d): Given the scope of work, the comment 'fortuitous choice of eddy viscosity' is unwarranted. All the magnitudes of the coefficients and parameterization chosen throughout the model are consistent with values reported in the literature. In some cases different authors vary the coefficients to 'tune the model' to produce the results they require. This was not done in this case as there was insufficient measured data.

17. ref. (d): As there is no field data (measured currents and wind speeds, etc), thus no model calibration was undertaken.

18. ref. (d): It is our opinion that the model chosen, the model formulation, the model computer code and the forcing data (tide elevations and winds) were appropriate for the scope of work.

    Much of the comment in the review is opinion only. Modelling practice has a wide and diverse range of opinion and a large amount of judgement is used to produced practical results. The review does not alter our initial judgement concerning the model and the results remain a reasonable estimate of the oil spill trajectories.

19. References are available if requested.

RA.

ATTACHMENT 3 to Minora Resources NL
letter dated 2 November 1988

LIST OF REFERENCES (not cited in PER but quoted here in item 6)

Kagi, R., 1985: A preliminary report on the behaviour predicted for spills of oils from Chevuit No. 1, North Herald No. 1 and South Pepper No.1 in the Barrow Island region of Western Australia. Unpublicised report to Western Mining Corporation Ltd - Petroleum.

KAGI, R. FISHER, S., & ALEXANDER, R., 1988: Behaviour of petroleum in northern Australian waters; in Proceedings, North West Shelf Symposium, Perth, Western Australia, 1988.

KNAP, A.H., 1987: Effects of chemically dispersed oil on the coral Diploria strigosa. Mar. Poll. Bull., 18(3): 119-122.

APPENDIX 3

PROPONENT'S COMMITMENTS TO ENVIRONMENTAL MANAGEMENT

Minora Resources NL hereby commit themselves to comply with commitments made in this PER. Specifically this means that Minora will:

(i) comply with all legislative requirements pertaining to this project;

(ii) adopt industry and government standards and guidelines for safe exploration drilling practices;

(iii) implement the environmental management programme documented in this PER;

(iv) comply with guidelines provided in the oil spill contingency plan;

(v) implement the monitoring programme outlined in the environmental management programme.

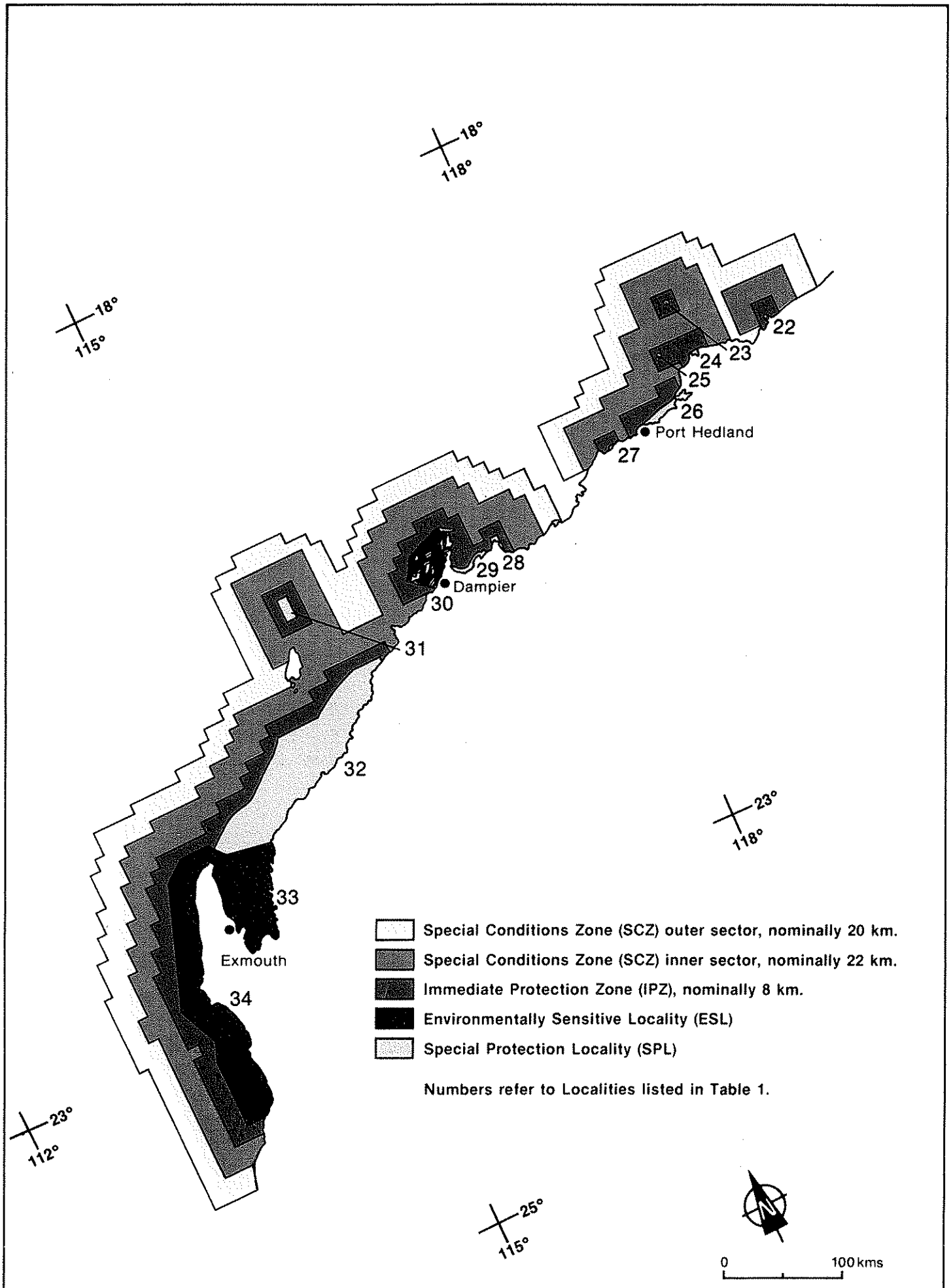

Figure 2 Environmentally significant areas and associated buffer zones.
(from DCE (now EPA) Bulletin 104)