

EIA/005-3/95

EXECUTIVE SUMMARY

Provisional Airport Authority

Proposed Aviation Fuel Receiving
Facility at Sha Chau:
Environmental Impact Assessment

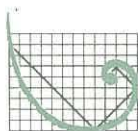
Executive Summary

January 1995

CONSULTING SERVICES BY ENVIRONMENTAL RESOURCES MANAGEMENT

EIA 005-3/95

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For and on behalf of ERM Hong Kong

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Date: 23 January 1995

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CONTENTS

1	<i>INTRODUCTION</i>	1
1.1	<i>BACKGROUND TO THE STUDY</i>	1
2	<i>PURPOSE OF THIS ENVIRONMENTAL IMPACT ASSESSMENT</i>	3
2.1	<i>DOLPHIN STUDIES</i>	3
2.2	<i>CONSTRUCTION PHASE</i>	4
2.3	<i>OPERATIONAL PHASE</i>	5
2.4	<i>ENVIRONMENTAL MONITORING AND AUDIT</i>	5
2.5	<i>KEY ISSUES IDENTIFIED BY THE ADVISORY COMMITTEE ON THE ENVIRONMENT FOR DETAILED ASSESSMENT</i>	5
3	<i>FINDINGS OF THE EIA</i>	6
3.1	<i>JUSTIFICATION FOR SCREENING OUT THE OTHER ALTERNATIVES</i>	6
3.2	<i>CONSTRUCTION IMPACTS</i>	6
3.3	<i>OPERATIONAL IMPACTS</i>	11
4	<i>OVERALL CONCLUSIONS</i>	17
4.1	<i>MARINE ECOLOGY</i>	17
4.2	<i>AFRF RISKS</i>	18
4.3	<i>FINAL CONSIDERATIONS</i>	18

EXECUTIVE SUMMARY

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The Provisional Airport Authority (PAA) proposes, in the interim term, to supply aviation fuel to Chek Lap Kok Airport from an Aviation Fuel Receiving Facility, hereafter called the AFRF, located in the vicinity of the Chek Lap Kok Airport. The AFRF will receive aviation fuel at an offshore fixed receiving facility from vessels between 3,000 and 10,000 dwt. It will transfer the fuel directly to an on-airport tank farm via subsea twin pipelines. Between 1 and 4 vessels are expected to use the AFRF per day.

The AFRF is intended as an interim arrangement for supply of aviation fuel until the completion of the preferred solution, which is a pipeline supply direct from an off-airport source to the on-airport tank farm. It is anticipated that the AFRF will be operational for 5 to 7 years and thereafter it will be used only as an emergency back-up facility.

1.1.1 AFRF Area & Site Selection

In searching for a potential location for the AFRF, the PAA in conjunction with Government; comprising Civil Aviation Department (CAD), Marine Department (MD), Environmental Protection Department (EPD), Fill Management Committee (FMC), Royal Observatory (RO) and Agriculture and Fisheries Department (AFD); considered ten possible areas in the vicinity of the airport (*Figure 1.1a*).

In addition, views of the following other departments and agencies were also sought by the PAA: Economic Services Branch, Planning, Environment and Lands Branch, Planning Department, Lands Department, Fire Services Department, Civil Engineering Department, Territory Development Department, New Airport Project Coordination Office (NAPCO), Royal Hong Kong Police Force, Customs and Excise Department and City and New Territories Administration (CNTA).

During the initial screening exercise certain insurmountable concerns were raised by government which ruled out certain areas, namely:

- CAD/RO required efficient operation of their radars for aviation safety
- MD had strong reservations as to the safety of any AFRF in open water close to marine shipping channels
- FMC considered that siting an AFRF in an area required for future contaminated mud disposal was incompatible.

Other significant issues were also raised as follows:

- EPD required that an initial EIA of the shortlisted areas be conducted followed by a detailed EIA of the selected option.
- AFD, based on advice given them by their Dolphin Research Team (DRT) were concerned that due consideration/assessment be given to potential impacts of the AFRF on Chinese White Dolphins.
- CNTA advised that "Fung Shui" is a sensitive issue and the AFRF should be aligned so as to alleviate potential fung shui issues.

PAA, in conjunction with Government excluded 8 areas from further consideration due to the concerns highlighted above. By this process the ten potential AFRF areas were narrowed to two potentially viable areas, namely at Sha Chau (Area 10) and north of the new airport (Area 1). It was recognised that whilst they both had certain constraints no better alternatives could be identified.

These concerns centred on environmental issues, and an initial environmental impact assessment for the two potential areas was commissioned with a view to:

- establishing the preferable area on environmental grounds;
- identifying any insurmountable environmental problems;
- outlining practical and cost-effective mitigation to minimise predicted impacts; and
- identifying any key issues associated with the preferred area that would require consideration during an Environmental Impact Assessment (EIA).

The results of the initial environmental assessment were presented in an Initial Assessment Report (IAR). The IAR concluded that the site north of the new airport (Area 1) could not be recommended in view of its proximity to the Contaminated Mud Pits (CMPs) and associated potential adverse impacts. The Sha Chau site (Area 10) was therefore recommended to be the environmentally preferable site subject to a detailed EIA study. AFD, however had reservations with regard to Area 10 as they considered that the proposed AFRF could have significant impact on the Chinese white dolphin population around Lung Kwu Chau and Sha Chau. AFD, therefore, requested that the detailed EIA should carefully address the ecological impacts on the population.

An EIA was commissioned to study all the key issues identified in the IAR, associated with the AFRF based on its conceptual design.

It should be emphasised that the overall construction programme for the airport has compressed considerably the time available for these studies.

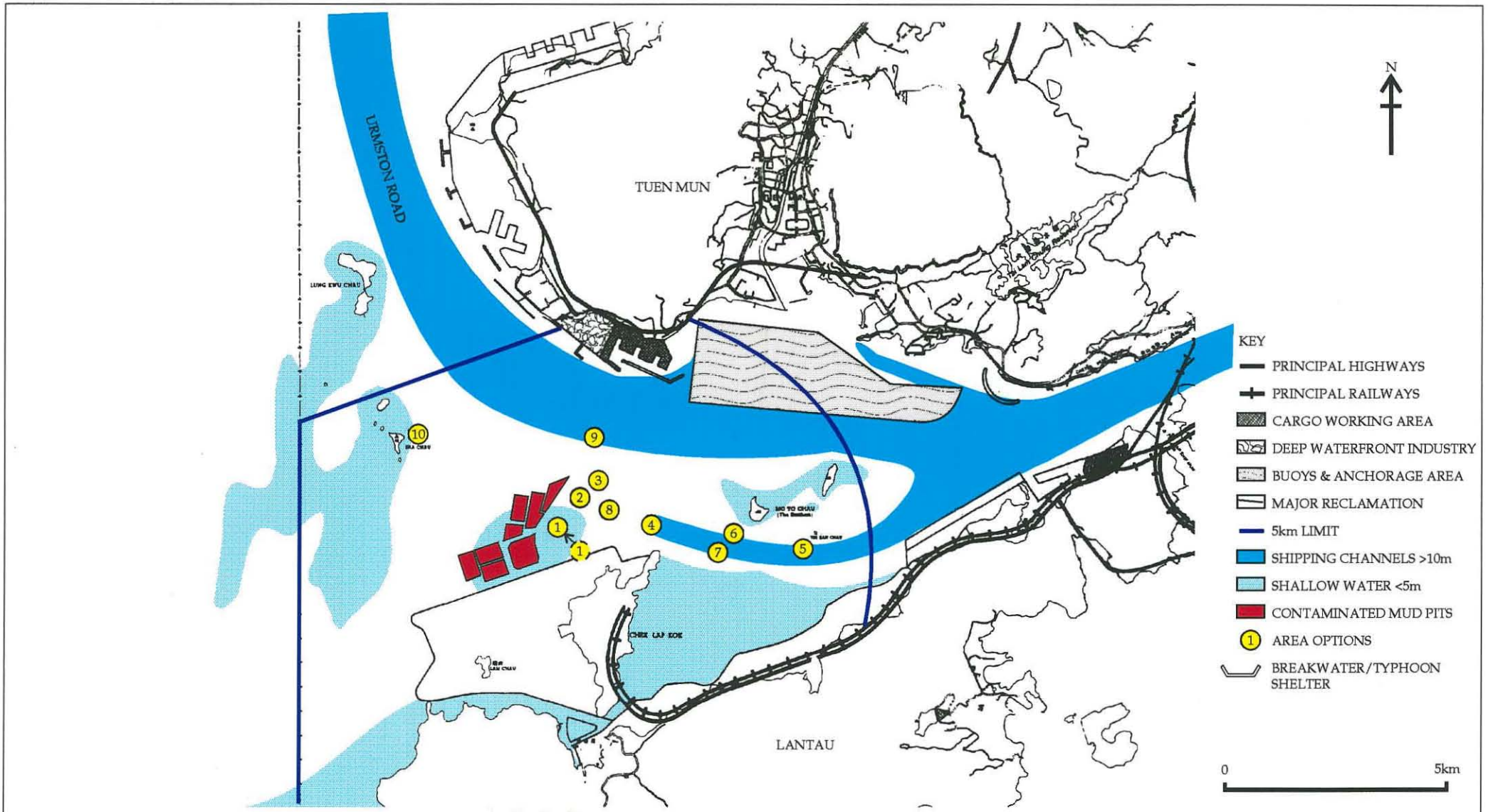


FIGURE 1.1a - CURRENT & PROPOSED DEVELOPMENTS AND INITIAL AREA SELECTION

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The purpose of this Environmental Impact Assessment (EIA) is to assist in minimising pollution, environmental disturbance and nuisance arising from the construction, operation and maintenance of the AFRF by providing information on the nature and extent of the potential environmental impacts and recommending appropriate mitigation measures. Emphasis is placed on the Key Issues identified in the IAR and/or by the Advisory Committee on Environment's (ACE's) EIA Sub-Committee review of that report in mid September 1994 as follows:

- Chinese White Dolphins;
- Construction phase impacts;
- Operation phase impacts;
- Environmental Monitoring and Audit; and
- Key Issues raised by ACE EIA Sub-committee.

These issues are summarised below.

2.1

DOLPHIN STUDIES

Consideration of the findings of the IAR led to the identification of the potential impacts to Chinese White Dolphins (*Sousa Chinensis* - hereafter referred to as *Sousa*) which had been sighted in the marine waters north of Lantau, around Sha Chau and Lung Kwu Chau Islands as a key issue. A two staged detailed dolphin study was immediately undertaken with the following objectives:

- Optimising the AFRF location (the *Site Selection Study*) in the vicinity of Sha Chau with regard to environmental impacts by minimising potential impacts on *Sousa*; and
- Identifying practical and cost-effective mitigation measures and Environmental Monitoring and Audit (EM&A) requirements to minimise the scale, extent and severity of construction and operation impacts on *Sousa*.

The *Site Selection Study* comprised of a one month intensive field survey and an international literature survey from which a site was selected for further study. From the outset the Consultants liaised in consultation with AFD *Sousa* research studies such that an appreciation of the latest data could be incorporated into the PAA studies. Secondly, the field results were synthesised with a detailed impact assessment (July - August 1994) of the construction, operation and maintenance of the AFRF on *Sousa*. The results of the dolphin studies are summarised below:

- based upon the sighting records obtained in the one-month *Site Selection Study* survey, areas contained within Sites C and E had the lowest observed *Sousa* habitat usage of the six indicative AFRF sites, and were

therefore recommended as the preferred sites for the location of the AFRF. Of the two, Site C provides a slightly reduced buffer between areas of relatively higher and lower usage, compared to that provided by Site E, and for this reason Site E was marginally recommended over Site C for the AFRF location on purely *Sousa* related grounds; and

- the *Site Selection Study* (included as *Annex B*) also concluded that surveys conducted over longer periods may indicate that *Sousa* exhibits other patterns of habitat usage under different seasonal or other conditions. For example, recent results received from limited land based survey work, over a two hour period observed from over 4 km from Sha Chau undertaken by AFDs Dolphin Research Team (DRT) on 12 October 1994 indicated the presence of *Sousa* within Sites C and E. These most recent DRT sightings were taken at a time after the construction of the CAD jetty at Sha Chau was underway and thus may not reflect an unimpacted site condition; although this can not be scientifically substantiated at this time.

Following the *Site Selection Study*, Site C was selected by the PAA as their preferred site for the AFRF location, due to ease of orientation to currents, the greater water depth (and hence lower dredging requirement) and potential difficulties and interference with the Civil Aviation Department's radar on Lung Kwu Chau and other requirements imposed by Site E.

2.2

CONSTRUCTION PHASE

Issues requiring further study included:

- *Water Quality*: Including impacts of construction activities such as dredging, pipelaying and piling and assessment of alternative methods with respect to Water Quality Objectives. Assessment of potential interference with CMPs from pipelaying.
- *Waste Management*: Assessment of quantities, quality, and means and location of disposal for dredged, construction and other material.
- *Marine Ecological Impacts*: Assessment of impacts of construction activities.
- *Noise*: Assessment of AFRF construction and cumulative noise impacts.
- *Cultural*: Assessment associated with temple and graves on Sha Chau.
- *Other Considerations*: Cumulative impact assessment of the non-PAA developments on Sha Chau.

OPERATIONAL PHASE

Issues include:

- *Water & Sediment Quality*: Assessment of impact of maintenance activities including dredging and regular discharges.
- *Waste Management*: Solid and liquid waste disposal and associated impacts.
- *Risk to life*: Consideration of the risks from the total operations of the AFRE, including shipping through the Ma Wan Channel.
- *Environmental Risk*: An appraisal of the frequency, scale, extent and severity of an aviation fuel spill and assessment of direct and indirect marine ecological impacts from spills.

ENVIRONMENTAL MONITORING AND AUDIT

Definition of requirements and any necessary programme for impact compliance monitoring.

KEY ISSUES IDENTIFIED BY THE ADVISORY COMMITTEE ON THE ENVIRONMENT FOR DETAILED ASSESSMENT

Information requested by the ACE EIA Sub-committee based on their assessment of the IAR on 12 September centred on:

- the impact of the project on the Chinese White dolphin and Chinese King Crab and prawn fisheries;
- greater integration of the risk assessments between Ma Wan Channel and this interim facility;
- more details on ecological risk;
- benthic studies related to the site and coastal ecological issues;
- hydrodynamic modelling with regard to Sha Chau;
- justification for screening out the other alternatives; and
- an assessment of what other government departments or agencies are or are proposing to build on Sha Chau.

All these key issues are included within the EIA scope.

This Study, and those that preceded it, have been constrained by the overall construction programme of the airport. The environmental studies have been completed without the benefit of seasonal baseline monitoring of sensitive marine species. As a result, in some areas it has been possible to assess the absolute acceptability of impacts. However, in other areas it has not been possible to be conclusive. Thus an approach has been taken whereby all practical mitigation measures recommended should be considered and further evaluated during detailed design and operations.

The main findings are summarised as follows:

- Justification for Screening Out the Other Alternatives;
- Construction Impacts;
- Operation Impacts;
- Conclusions; and
- Final Considerations.

3.1 *JUSTIFICATION FOR SCREENING OUT THE OTHER ALTERNATIVES*

Following a request from the ACE EIA Sub-committee the EIA describes and *Section 1.1* of this Executive Summary reviews the process by which the ten potential AFRF areas were narrowed down, by the PAA in conjunction with Government, to two potentially viable areas, namely at Sha Chau and north of the new airport for an initial environmental assessment.

3.2 *CONSTRUCTION IMPACTS*

The EIA has determined that there are no impacts associated with AFRF construction noise and as a result no mitigation is suggested or required.

3.2.1 *Construction Water Quality*

Preferred Methods of Construction

The use of closed grab clamshell dredgers (or any other method that can be shown to give equivalent or lower impact) is the preferred method for dredging and for pipeline installation, and the specification of this in the contract specification is therefore also recommended, subject to detailed evaluation of engineering feasibility. This form of mitigation would significantly reduce the scale of impacts resulting from the AFRF project. The reduction of direct water quality impacts will result in reduced indirect impacts upon water sensitive receivers from changes in water quality, including marine biota within the Study Area.

Contaminated Mud Pits (CMPs)

The strict adherence to the recommended 150m 'buffer zone' between the CMPs and AFRF service corridor will prevent any interference with the CMPs and any associated contaminant release and thus any unacceptable environmental impacts.

Hydrodynamics

Based on tidal flow modelling and on coastal geomorphological appraisal, the construction of the turning basin and fairway for access to the sites from the Urmston Road main channel will not change the hydrodynamics in the Study Area, and will have negligible impact on the stability of the beaches (sand bar/tombolo) connecting Sha Chau to the nearby Islets, raised as a potential concern of the ACE EIA Sub-committee.

EM&A

EM&A, in the form of the existing PAA procedures will be required to monitor and audit the efficacy of measures to mitigate any impacts on water quality resulting from AFRF construction.

3.2.2

Construction Waste Management

Disposal of Dredged Sediments

The assessment has concluded that provided the recommended mitigation measures are strictly adhered to, potential impacts of the dredging works and associated sediment disposal will be minimised, ensuring protection of short term local water quality. It is therefore anticipated that no unacceptable impacts will result from the dredging, transport and disposal of the marine sediments.

The dredged material will be suitable for disposal at a gazetted marine disposal ground. This will, however, be subject to further sediment analysis in detailed design stage to confirm the sediment quality and finalise the required disposal allocation.

Construction Works Waste

It is anticipated that no significant adverse environmental impacts from construction works wastes will arise during the AFRF construction period, provided that non-sediment construction waste arisings are handled, transported and disposed of using approved methods and that no solid or liquid wastes enter surrounding marine waters.

Construction Impacts on Marine Ecology

Preliminary Marine Ecological Survey

Following a request from the ACE EIA Sub-committee to include a dedicated consideration of the marine ecology at and around Sha Chau, the results of a preliminary marine ecological survey, including benthic studies and coastal ecological studies, indicate that the sub-tidal invertebrates and fish community of the area are of both ecological and fisheries interest. The area supports a high diversity of fish and shrimp, many of which are commercially important species (eg. sole, flounder, croakers, flat heads and penaeid shrimps). Penaeid shrimps and sole were particularly abundant. Juvenile fish, shrimps, crabs and molluscan egg cases were commonly found, indicating the high fisheries value of the area. It is likely that the area may serve as an important spawning and nursery ground for these commercially important species.

Sensitive Marine Ecological Receptors

The sensitive ecological receptors identified are:

- penaeid shrimp and other important commercial fish species;
- the habitat as a nursery and spawning ground of marine animals in general and penaeid shrimps and food fish in particular; and
- sea pens and stone corals.

Potential Impacts

Dredging activities during the construction phase of the AFRF are likely to locally increase the turbidity of water and sediment deposition rates and modify the bottom substratum, and hence potentially affect the sensitive receptors described above. The ecology and survival of sea pens and stone corals, juvenile stages and recruitment of fish and shrimps in the area are of particular concern. However, it should be noted that the sediment plume modelling simulations, undertaken to simulate the fate of sediment lost to suspension during dredging associated with the AFRF, predicted minimal elevation of suspended solid (SS) levels. In addition, the loss of suspended solids to the marine environment can be minimised provided that practical mitigation measures recommended in this report are included in construction contracts and fully implemented. It should also be noted that there are proposals by FMC to dredge sand in the area to the east of Sha Chau. Thus at the time of the proposed AFRF construction, the seafloor ecology in the area of the access fairway may already have been disturbed by dredging activities in the Urmston Road.

Seasonal Considerations Including the Chinese King Crab

Following concern raised by the ACE EIA Sub-committee to include consideration of the potential value of the Sha Chau area for the Chinese King Crab the EIA has included a review of seasonality effects.

Fish and benthic communities in Hong Kong typically exhibit marked seasonal variations and thus the preliminary survey does not take any account of seasonal changes. Judging from the documented occurrence of the Chinese King Crab species in similar habitats in the vicinity, the absence of this species in the survey may only reflect the seasonal occurrence of this species in the area. The importance of the area as a nursery and spawning ground for penaeid shrimps, food fish and the Chinese King Crab needs to be further established so that appropriate mitigatory measures can be introduced.

Further Marine Ecological Studies

It is thus recommended that:

- a detailed ecological study be carried out in parallel with the further AFRF design stages, with a view to assess the importance of the area as a nursery and spawning ground for fish, penaeid shrimps and the Chinese King Crab in the area such that the most appropriate mitigation measures can be identified;
- appropriate mitigation measures should be developed in the detailed design stage, based on the detailed ecological survey, to protect any ecologically sensitive species which are identified to be impacted by facility construction;
- strict pollution control measures be introduced during the construction phase of the facility; and
- local restocking of penaeid shrimps, sea pens, stone corals and commercial fish species should be considered to mitigate the environmental impact, if significant impacts are identified by more detailed survey work.

3.2.4 *Construction Impacts on Sousa*

Potential Impacts

Following a request from the ACE EIA Sub-committee to include EIA consideration of the potential impacts from AFRF construction on *Sousa*. The following activities were identified as having the potential to impact on *Sousa*:

- dredging activities;
- pipeline construction;
- general construction noise;

- berth construction;
- construction vessel movements;
- general construction activities; and
- background activities.

Evaluation, Mitigation and Monitoring

In view of these potential impacts, the EIA concluded that every opportunity must be taken to minimise potential impacts on *Sousa* arising from the construction works. With regard to mitigation the following measures were considered and a comprehensive package of mitigation measures and controls recommended:

- Selection of dredging method and equipment
- Dolphin impact monitoring programme
- Pollution control measures
- Selection of berth construction method
- Selection of submarine pipeline route
- Minimisation of noise disturbance
- Scheduling of construction works
- Vessel movements

The *Sousa* mitigation measures and controls recommended in this Report for the construction stage should be incorporated in the detailed design of the AFRF. As such it is considered that the implementation of this comprehensive package of mitigation measures and the recommended monitoring and audit requirements will minimise the potential for both direct and indirect impacts on *Sousa* from the AFRF construction.

3.2.5

Cultural Impacts

Information from the Antiquities and Monuments Office indicates that Sha Chau is designated a "Special Site of Archaeological Interest" (SSAI/NT 18) on account of the considerable quantity of prehistoric and historic artifacts discovered in past investigations. There is also a Tin Hau Temple on the island, built in 1862, which is a Grade II historical building. In addition, it is understood that the fishermen have two or three ancestral graves on the island behind the temple, which may also have clan significance.

The AFRF will be an offshore facility and there will be no land-based construction. Thus, direct physical impacts on these culturally significant features will be avoided. The proposed offshore fixed receiving facility will be essentially a horizontal structure on piles comprising two vessel berths approximately 320 m long, 5 m high and 15 m wide. This horizontal form is expected to minimise the intrusion to the open aspect (Fang Shui) of the temple and graves. In addition, the proposed offshore berths are located to the northeast of Sha Chau, therefore avoiding direct intrusion to the "Fung Shui" of the temple which has a northwest aspect.

Other Government Construction Proposed on Sha Chau and Possible Cumulative Impacts

Following a request from the ACE EIA Sub-committee to include a description of other Government construction proposed on Sha Chau the following sub-section briefly describes other construction proposals and assesses the potential for cumulative impacts.

CAD Radar

CAD propose to build an Approach Surveillance Radar (ASR) Station and a Secondary Surveillance Radar (SSR) Station located on the high area of Sha Chau Island. A CAD jetty is currently being constructed to provide a service access to the island. The CAD jetty is to be located on the eastern coast of the southern Sha Chau island with a pathway constructed from the CAD jetty leading to the Stations. Construction works for the CAD jetty commenced in July 1994 and are scheduled for completion in June 1995, and thus the jetty will be completed when, subject to government approval, the construction works for the AFRF commence in July 1995. No direct cumulative impacts on water quality are therefore anticipated to arise, from the construction of the CAD jetty.

Submarine Power Cable

A submarine power cable (SPC) extending from Chek Lap Kok to Sha Chau will be required to provide power for CADs ASR and SSR Stations. Further, a power supply to Lung Kwu Chau will be required to serve the DVOR/DME Stations on the Island. China Light & Power and the Government are considering a SPC route from Sha Chau. The SPC from Chek Lap Kok to Sha Chau will be laid within the proposed services corridor for the AFRF. The proposed tentative route of the cable is planned to broadly parallel the AFRF twin pipeline although and its exact routing and construction timing will be finalised at the detailed design stage.

The SPC section from Chek Lap Kok to Sha Chau will be installed between December 1995 to February 1996. Although the installation schedule for the AFRF submarine pipeline (estimated construction duration of 2-3 months) cannot be confirmed at this stage, it is presently understood that it will not coincide with the SPC installation. Impacts from the installation works for the SPC are not anticipated to have a adverse potential water quality impacts although this will be verified during the detailed design basis-EIA upon finalisation of construction techniques.

OPERATIONAL IMPACTS

The EIA has determined that there are no significant impacts associated with AFRF operational noise and as a result no mitigation is required.

3.3.1 *Operational Water Quality and Movement Impacts*

Pollution Control

No polluted discharges into the marine waters from the facility should be permitted and no solid nor liquid wastes should be allowed to enter the marine waters at the facility. This is in line with PAA's conceptual design.

Maintenance Dredging

Other activities such as fuel vessel operation and movements and maintenance dredging (during subsequent back-up and emergency use) will not cause any unacceptable impacts on water quality, provided mitigation measures, including the use of dedicated fuel shuttle vessels, operational controls over vessel movements and low impact maintenance dredging techniques, are implemented, subject to their engineering feasibility.

3.3.2 *Operational Waste Management*

Operation Waste Controls

It is considered that, assuming that appropriate handling, storage and removal of the identified solid and liquid waste arisings from the AFRF are followed, potential water quality impacts and marine biota impacts will be minimised.

Waste Monitoring and Audit

Stringent waste management monitoring and audit will be necessary to ensure that the correct disposal requirements for the various waste arisings are being implemented.

3.3.3 *Operational Impacts on Marine Ecology*

Marine Ecological Impacts

The preferred method for the construction of the AFRF on a piled structure will reduce the loss of seabed and marine habitat, and thus the structure will have a minimal physical presence in the marine environment. The movement of AFRF vessels to the facility is unlikely to have direct impacts on free swimming biota, such as fish and invertebrates. In addition, fish communities disturbed by the AFRF construction works are likely to return to the area and there is precedent for such facilities enhancing marine activity due to colonisation of the piles by marine organisms which lead to increased fish levels which, in turn, provide food for marine mammals further up the food chain. Thus, it is anticipated that, in normal operation, the AFRF facility will have minimal impact on the marine ecology around Sha Chau.

Fishery Resources

Fishing activities which may be interrupted during the pipeline installation will return to normal during operation. Therefore, no operational impacts on the marine ecology are envisaged from the operation of the submarine pipeline system to the on-airport storage tanks.

3.3.4 *Operational Impacts on Sousa*

Potential Impacts

Following a request from the ACE EIA Sub-committee to include EIA consideration of the potential impacts from the AFRF operation on *Sousa*, the following operational AFRF activities were identified as having the potential to impact on *Sousa*:

- vessel operation and movements;
- fuel spillage;
- solid and liquid waste generation;
- maintenance dredging; and
- background activities.

It is apparent that there will be no impacts on *Sousa* associated with the normal operation of the submarine pipeline system to the on-airport storage tanks. Further operational impacts will be minimised with the implementation of practical measures detailed below:

Package of Mitigation Measures and Controls

With regard to mitigation the following measures were considered and a package of mitigation measures and controls recommended:

- Dolphin impact monitoring programme
- Pollution control measures
- Input into selection of submarine pipeline route
- Input into reduction of noise disturbance
- Input into vessel movements

The package of mitigation measures and controls recommended for the operation stage should be incorporated in the detailed design of the AFRF. As such it is considered that the implementation of these mitigation measures and the recommended monitoring and audit requirements will minimise the potential for both direct and indirect AFRF operation impacts on *Sousa* and other ecologically sensitive marine species identified.

3.3.5 *Risk to Life*

The levels of risk from the transportation of aviation fuel through the Ma Wan Channel to the proposed AFRF at Sha Chau have been semi-quantitatively estimated as requested by the ACE EIA Sub-committee. Currently there are no risk guidelines (RGs) or criteria for mobile sources in

Hong Kong so the most appropriate local and international guidelines have been used for benchmarking purposes. These are not strictly applicable (although it is noted that transport risk guidelines may be proposed in the near future). However, the level of risk lies generally in the 'ALARP' region of both the Hong Kong RGs (which apply to fixed land-based installations) and proposed maritime UK Health & Safety Executive RGs. In these circumstances, it is appropriate to try to reduce risks to a level '*as low as reasonably practical*'. The study has shown that, even at airport opening, the risk levels from the marine transport of aviation fuel to the AFRF to populations in the vicinity of the shipping routes are still of a magnitude where the available guidelines indicate practical means should be sought to further reduce risk levels.

The need for risk mitigation in the Ma Wan Channel is demonstrated by the assessment in previous studies of background risk levels expected in 2006. Whilst the contribution from the AFRF is relatively small, any additions to the numbers of Dangerous Goods cargoes using the channel will only further increase risk levels that will already be high.

The question remains as to whether the AFRF and its five to seven year operation can be termed ALARP in accordance with the above discussion. To comply with the ALARP principle, it is necessary to show:

- It is not practicable to construct a pipeline by airport opening date; and
- The pipeline will be constructed as soon as is reasonably practicable (ASARP).

PAA inform that they, in consultation with government, have concluded that, based on Government policy as well as a combination of technical, programme, and commercial reasons a permanent pipeline cannot be *now* in place for airport opening. The programme for construction of a permanent pipeline which has been supplied by PAA, indicates that almost five years are required. This is based on the assumption that the consultative and decision making process has been completed. Even if a go-ahead were given immediately a pipeline could not be in place until late 1999 or 2000. Given the above, it was concluded that an interim facility was required.

PAA have noted that the temporary AFRF will be in full time operation for approximately 5-7 years. This is based on projected fuel demand and operator investment returns. However the PAA have stated their commitment to work closely with Government and commercial interests to ensure that the permanent facility is brought on-line as soon as reasonably practical (ASARP) after airport opening.

Compliance with the ALARP principle centres on the definition of 'reasonably practical'. It is acknowledged that this definition is usually expressed in terms of the technical feasibility and costs of a mitigation measure, in this case the permanent pipeline, versus its benefits on risk grounds. Since the reasons why a permanent pipeline might not be able to be constructed for up to 5 - 7 years after airport opening are a combination

of technical and non-technical factors the AFRF is not strictly ALARP. However, if there are 'insurmountable' reasons for the 5 - 7 years timescale of AFRF operation, clearly the pipeline is not a practicable mitigation measure at the present time.

Other relevant points are as follows:

- The risk increases with tonnage transported through the Ma Wan Channel and the risks from the 5,000 dwt vessels used in the study lie within the ALARP region of the HK RGs at 1997 demand levels further emphasising the benefits of a permanent pipeline as soon as is practical.
- Any marine aviation fuel transportation should be by a modern design of tanker with high standards of safety as proposed for the around 5,000 dwt AFRF tankers. Use of double hulled tankers is recommended if practical, cost effective and meet Marine Department conditions.
- The risks to populations west of Ma Wan on the mainland along Urmston Road are expected to be of higher consequence on the one hand (due to greater populations at risk) but lower frequency on the other (due to greater ease of navigation that in the Ma wan channel). The net effect is, however, an increased contribution to the overall level of risk from AFRF operations.
- Some of the conceptual mitigation measures need further evaluation as recommended, and the possibility of reduction in risk to life may coincide with an increase in risk to the environment. For example if routes via South Lantau were used, instead of the Ma Wan Channel and Urmston Road, risks to life would be dramatically reduced but significantly greater risk would be posed to ecologically sensitive receivers in the event of a spill.

Further detailed quantified study at detailed design stage is required to estimate risk levels more accurately and to evaluate the relative practicality and cost effectiveness of the mitigation measures proposed, in accordance with the ALARP principal, over the operational period of the AFRF.

The overall conclusion is that PAA have, in selecting a piped aviation fuel supply for the long term, adopted a low risk option for fuel supply to CLK that will give risk levels in the acceptable region of all guidelines considered. The AFRF is an interim solution to be operated whilst a permanent supply option is pursued. Since the reasons why a permanent pipeline might not be able to be constructed for up to 5 - 7 years after airport opening are a combination of technical and non-technical factors the AFRF is not strictly ALARP. The risk levels are within an area where risks should be mitigated to a level as low as reasonably practical. These mitigation measures should concentrate on the AFRF operations given that there is no practical alternative in the interim term.

Following a request from the ACE EIA Sub-committee the EIA included consideration of environmental risk. Overall the results of the spill modelling show a low likelihood of impact to sensitive shorelines. However since the main mechanisms of spill decay include adsorption on suspended particulate matter and emulsification, impacts to benthos, commercial fisheries and spawning areas after a spill are more likely. It is considered that agglomeration and subsequent sedimentation will not be of great concern as suspended solid levels rarely reach levels that would promote these processes. More detailed studies are warranted prior to commissioning to fully investigate the probable outcomes and to facilitate spill response capability and planning requirements such that, if a spill does occur, resources will be adequate to minimise its effects in line with the recommendations given in this Report.

Consideration of the likely frequency of these spills, on a theoretical basis about one chance in 750 per year indicates that the probability of more than one major release in the lifetime of the AFRF is very remote. However, historical data for Hong Kong Waters indicate 13 major spillages over a twenty year period of which two concerned aviation fuel. Hence, given that a chance of a significant release is still possible in ecologically sensitive waters, spill response capability at Sha Chau should be well planned and supplied with modern equipment concomitant to the worst case credible spill. The equipment should be well maintained both at the AFRF and at a support base near to the likely transport routes since events may occur at a remote location.

Marine Department will retain authority over spill clean up and the Licensee should cooperate fully with them and assist with advice from their spill plans. The potential for conflict between response for a spill that might occur in say, PRC waters but effect HK coastal communities should be addressed by the HK Government i.e. Marine Department.

Prior to AFRF commissioning, preliminary recommendations made in this report will need to be substantiated by detailed spill modelling and forecasting such that the extent of equipment, resources and training needed are known to ensure sensitive marine and coastal ecosystems are protected with the best practical means available.

MARINE ECOLOGY

The EIA has indicated that as a result of the locational proximity of the AFRF to identified and potential marine ecological sensitive resources, including Chinese White Dolphins and possible marine biota spawning and nursery grounds, that comprehensive construction and operational stage mitigation will be needed to minimise AFRF project impacts. Therefore, in order to prevent and minimise impacts all recommended mitigation clauses, unless shown to be impractical, should be included in construction contracts and in the facility design and operational requirements.

Impacts to Sousa

Survey results of this study and AFD's DRT study currently indicate currently high incidence of *Sousa* sightings in the Sha Chau/Lung Kwu Chau compared to other areas in Hong Kong waters. It is considered that, given that Sha Chau was determined by PAA in consultation with government as the only viable area for the AFRF, the potential direct or indirect negative impacts on *Sousa* should be minimised by the adoption of a package of mitigation measures.

The preliminary results of AFD's Dolphin Research Team's studies indicate that *Sousa* frequently move over a wide area and thus Sha Chau comprises only one part of *Sousa*'s habitat range within the estuarine waters of the Pearl River Delta. Hence any potential impacts on *Sousa* arising from the construction and operation of the AFRF may be less than would be the case had the field survey results indicated sole utilisation of the marine waters around Sha Chau by *Sousa*.

It is considered that the construction methods and mitigation controls recommended will further reduce and should minimise impacts to *Sousa*. The interim operation phase will last up to 5 to 7 years. It is considered that the operational procedures and controls recommended over all vessels, AFRF operation and personnel should minimise the potential for operational phase disturbance and impacts on *Sousa*.

The mitigation measures and controls are, where practical, to be incorporated in the detailed design and operation of the AFRF to minimise the potential for both direct and indirect impacts on *Sousa*. The recommended monitoring and audit requirements during construction and temporary operation will provide a pro-active means of evaluating the efficacy of mitigation measures and identifying any requirements for additional mitigation.

4.1.1 *Additional Marine Ecological Survey Work*

Additionally the EIA identified the need for further detailed marine ecological survey work to characterise the possible value of the area as a nursery and spawning ground and to identify the presence of species which may only use the site at certain times of the year, including the Chinese King Crab. The results of this survey, to be undertaken in parallel with the AFRF design, will enable the formulation of precise mitigation measures "tailored" specifically to any valuable species identified that may be impacted by either the AFRF construction or operation and effects on spill response planning.

4.1.2 *Environmental Management Plan*

The recommendations made in this Report should be incorporated into the comprehensive Environmental Management Plan to be developed by the Licensee for the AFRF.

4.2 *AFRF RISKS*

With regard to the risk assessment, the results have indicated that the levels of risk to life associated with the AFRF operation in the vicinity of Sha Chau are negligible in the context of the potential risks in the Ma Wan Channel and to mainland populations along Urmston Road, west of Ma Wan. The Risk Assessment concludes that the level of risk is such that permanent operation of AFRF vessels through the Ma Wan Channel would not be acceptable. The levels of risk predicted are such that the AFRF operational period should be minimised by the expediting the construction of a permanent fuel pipeline system.

The study indicates that the risk of a major spill at either the AFRF or along the shipping routes is remote although such an occurrence cannot be discounted. Note that there are already significant quantities of dangerous goods being shipped through these waters and the temporary one to four daily vessel movements of aviation fuel should be seen in this context. However, in the event of a spill, the proximity of the AFRF to sensitive ecological receivers dictates that detailed study is necessary to formulate the best practical means of spill response, both in respect of where it is most detrimental for spills to occur and what resources would best mitigate the potential impacts.

4.3 *FINAL CONSIDERATIONS*

This assessment has been completed on a compressed programme to enable the AFRF to be in place for airport opening. The EIA has assessed an interim AFRF at Sha Chau, operational for up to 5 to 7 years, and thereafter to be used only as an emergency back-up facility. From previous studies detailed in the Report, Sha Chau is the only viable site.

The PAA is committed to working closely with Government and private sector parties to ensure that the permanent facility is brought on-line as soon as practical after airport opening.

It should be noted that there is insufficient information to fully evaluate potential impacts to *Sousa*, marine ecology, fisheries, benthic communities and the coastal ecosystem. As a result, follow on studies have been recommended so that the potential impacts can be fully evaluated and appropriate mitigation measures identified. These studies will be implemented during the detailed design phase of the AFRF.

In respect of *Sousa*, a package of mitigation measures and controls recommended for both the construction and operation stages are to be incorporated, by PAA or other parties under PAA supervision or licence in so far as they are practical and cost-effective. As such it is considered that the implementation of the recommended measures should minimise the potential for both direct and indirect impacts on *Sousa* from the AFRF construction and operation.

In respect of all other issues this report has concluded that there are not likely to be any significant impacts in any areas of the AFRF construction or operation provided that the recommended mitigation measures or equivalent are adopted, wherever practical.

**Potential Effects of a Proposed Aviation Fuel Receiving Facility at
Sha Chau on the Health and Survivability of the Indopacific
Humpback (Chinese White) Dolphin, *Sousa chinensis*, in Waters
North of Lantau Island, Hong Kong Territory**

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March 9, 1995

Description of the Species, Worldwide

The species *Sousa chinensis* was first described for western science by Osbeck (1757) as a "snow-white dolphin" seen alive in the South China Sea and trapped in nets in the Pearl River estuary. It was then named *Delphinus chinensis*. This dolphin is now recognized as one species ranging from the southern tip of South Africa, all along the east coast of Africa, to the southern shores of the Middle East, around India, through Malaysia, down to the northern shores of Australia, and north into the South China Sea [a separation into western (*S. plumbea*) and eastern (*S. chinensis*) species has been proposed, Ross *et al.* 1994]. It is probable that the distribution is not continuous and that near-separate populations exist. Numbers and population status are not known, and it is likely that at least in some places, local animals are endangered, mainly due to accidental killing in fish and shark nets (distribution information from Leatherwood *et al.* 1983, Evans 1987, and Jefferson *et al.* 1994; endangerment information from Harwood and Hembree 1987, Cockcroft *et al.* 1990 and Ross *et al.* 1994).

Indopacific humpback dolphins reach maximum lengths of 3.2 m in males and 2.5 m in females, and weigh up to 285 kg (Leatherwood *et al.* 1983; Jefferson *et al.* 1994). They are similarly-shaped to the bottlenose dolphin, with a well-defined snout and high falcately-curved dorsal fin. Most humpback dolphins to the west and south of Indonesia have a prominent mid-back fleshy hump on which sits the dorsal fin. Those to the east,

southeast, and northeast of Indonesia lack this hump, or exhibit it in strongly muted form.

Humpback dolphins can vary greatly in coloration, from off-white or light gray in young calves off South Africa, to gray in adults, to whiter variably-marked older adults. To the east of Indonesia, color variability appears to be particularly great, with white, light gray, and darker colorations in both calves and adults. Some animals are also highly mottled, gray and white; and on white surfaces, a strongly pink hue is common (Leatherwood *et al.* 1983, Ruxton 1983, pers. comm.; pers. observ.). The gray coloration shows abrasions and scratches particularly well and many dolphins are recognizable by their markings. In Chinese waters, calves tend to be gray and become more pale with age. Subadults are a mottled grayish-pink, and adults are pinkish-white (Zhou Kaiya *et al.* 1980, Hammond and Leatherwood 1984).

Indopacific humpback dolphins are generally found alone or in small groups, from 1 animal to 25, with an average in South Africa of about 6 (Saayman and Tayler 1979); and in Moreton Bay, Australia, of 2.4 (Corkeron 1990). Cockcroft (pers. comm.) estimates that in most areas studied average density along shore is only one dolphin per five kilometers. Little is known of reproductive patterns, although groups usually appear to have all age classes and both sexes represented, with a possible hint at a multi-male, multi-female (polygandrous) breeding society, as has been suggested for bottlenose dolphins (Wells *et al.* 1987, Würsig 1989). Females have one calf at intervals greater than two years, and appear to nurse for at least over one year and possibly for several years (Cockcroft 1992, pers. comm.). Calves are about 100 cm long at birth (Perrin and Reilly 1984). Mating and calving in Plettenberg Bay, South Africa, occurs year-around, with a definite peak in summer (Saayman and Tayler 1979).

Humpback dolphins live close to shore, hardly ever venturing from land more than 1 kilometer or into water deeper than 10 meters (Saayman and Tayler 1973, 1979, Cockcroft 1990, Corkeron 1990). They feed on nearshore, often estuarine, fishes and squid; and do not appear to have as wide and varied a feeding range as the bottlenose dolphin (Saayman and Tayler 1979, Barros and Cockcroft 1991). Much feeding appears to be on

mangrove or rocky-bottom (when available) associated fishes, and destruction of such habitats could have profound implications on the survivability of a localized group of humpback dolphins. While feeding is often around rocky coastlines, dolphins off South Africa preferentially use sandy bays for rest and social activities (Saayman and Tayler 1979).

Humpback dolphins appear to be shy of boats throughout their range, rarely riding the bow or stern pressure waves. However, when carefully approached by vessels, they will continue their feeding, traveling, socializing, or resting activity to within about 20 meters of the vessel (G.J.B. Ross, pers. comm.). They also will ride the bow wave of a boat which approaches carefully and at just the right speed (usually mid throttle) of an about 15 meter size vessel (Leatherwood, pers. comm.). They occasionally leap clear of the water, as well as head slap, tail slap, flipper slap, and lift the tail high upon submerging for a dive. They are known to occasionally associate with bottlenose dolphins off South Africa, but multispecies aggregations are relatively rare (Saayman and Tayler 1973, 1979). They are also known to be prey of sharks off both Africa and Australia (Saayman and Tayler 1979, Corkeron 1990, respectively), and of killer whales (Saayman and Tayler 1979). It is likely that these nearshore shallow water dolphins are generally not as affected by large predators as are the open pelagic delphinid species.

Humpback dolphins appear to vocalize somewhat like bottlenose dolphins, with production of clicks, rapid click sequences (often sounding like "screams"), and whistles. These sounds tend to concentrate above 3 KHz, and have been recorded as high as 30 KHz (Zbinden *et al.* 1977). Some of them probably reach higher in frequency, but to my knowledge the requisite recording attempts with high frequency gear have not been reported. Whistles are frequency modulated and tend to last 0.5 to 2.0 seconds; "screams" have much harmonic structure and thereby cover a broad range. It is likely that high frequency clicks are used for echolocation and that whistles and rapid click sequences tend to be used for intraspecific communication. In the Indus Delta, the highest intensities of humpback dolphin sounds appeared to be above the frequency ranges of fishes, crustaceans and ambient noises (Pilleri *et al.* 1982). This is similar to the situation for bottlenose dolphins, where most sound production is above 4 KHz (Lilly and Miller

1961); however, bottlenose dolphins do produce some social sounds below 2 KHz (Schultz *et al.* 1993), and it is possible that humpback dolphins do so as well. No detailed audiograms of hearing sensitivity exist for humpback dolphins, but from studies of similar-sized odontocete species, it is very unlikely that they have sensitive hearing below about 0.8 KHz (summarized by Richardson *et al.* 1991, in press).

Description of the Species in Hong Kong Waters

Indopacific humpback dolphins occur in Hong Kong waters as part of their northern range in the Pacific Ocean. There, they do not show the marked mid-dorsal hump, and body coloration varies between snowy white, white-pink, gradations of gray, and white-gray mottled (Zhou Kaiya *et al.* 1980, Ruxton 1993, pers. comm.). Natural variations in coloration and marks and scars on all but some very light animals make possible individual recognition by photography and high resolution videography. The eye is black in most animals; this dark eye spot appears particularly striking when they lift their heads clear of the water, apparently to scan their surroundings in-air.

Humpback dolphins appear to occur reliably to the north and west of Lantau Island, including the area immediately west of the mainland of the New Territories. Group sizes in the recent past ranged from 1 to about 15, with very occasional larger groups to about 30 to 50 (Ruxton 1993, pers. comm.). Dolphins could be found anywhere in this relatively shallow water area, but have a definite preference to within 1 km of shore. A formerly-reliable area of encounter was the immediate region around the Brothers Islands (Mo To Chau) to the northeast of Chek Lap Kok Island, but recent heavy industrial use of this area may have made it less favored (Joanna Ruxton, Steward Pryke, 1993, pers. comm.).

Since 1994, the major development of an airport on and to the west of Chek Lap Kok Island has destroyed previous habitat of humpback dolphins. However, it is a positive sign that dolphins are re-inhabiting areas around the Brothers Islands (now leveled to just above water level by blasting activities

in 1993-1994) and the new airport. They especially favor an area southwest of the new airport, where a thin channel is formed between Lantau Island and the airport (World Wildlife Fund Sighting Reports). Preliminary studies of present (March 1995) dolphin distribution in the Hong Kong Territories also show Sha Chau Islands and the Urmston Road to be dolphin habitat (ERM 1994, Porter 1994, Parsons 1995). Unfortunately, the lack of systematic censuses makes it presently impossible to tell how many dolphins utilize these areas, and the relative importance of the different habitats in the area. Since humpback dolphins clearly favor shallow waters near reefs, islands, and current boundaries in other parts of the world (Saayman and Taylor 1979, Jefferson *et al.* 1994); it is likely that the islands of Sha Chau, Lung Kwu Chau, and Pak Chau are, indeed, areas of heavier use than relatively open ocean between Urmston Road and the new airport.

Human-Produced Sounds of Relevance

The proposed Sha Chau Aviation Fuel Receiving Facility (AFRF) will consist of a piled pier structure and of vessels maneuvering in the area to offload fuel. During construction, there will be human activities, including generators, supply and personnel vessels, and either percussive piling or drill-pile construction. During operation, human activities will continue in the form of generators, supply and personnel vessels, and tankers. The immediate area of Sha Chau will be ensonified by anthropogenic noise (ERM, 1994). Because of this fact, we must consider the likely sounds to be produced by human activities, likely reactions by the dolphins, and potential mitigation measures. Because detailed behavioral reaction studies have not been carried out on Indopacific humpback dolphins, I draw upon our much larger data base on dolphins from other studies. Fortunately for comparisons, we have found that general rules of sensitivity tolerance and habituation apply, not only among species of odontocete cetaceans, but among social mammals in general (Richardson and Würsig, 1991, in press).

Ambient noises, produced by wind, surf, rain, distant shipping, and other non-biological and biological factors, are usually of an unwanted nature: they tend to clutter or mask biological sounds of interest to animals

(Greene, in press). Almost all of the energy of ambient noises is below 1.0 KHz (Wenz 1962). Usual distant ship traffic noise in relatively shallow water (as in Hong Kong) has its greatest energy at about 20-300 Hz (0.02-0.3 KHz) below the frequencies of sensitive hearing capabilities of the smaller odontocete cetaceans (Wenz 1962, as recalibrated by Greene, in press, Richardson *et al.* 1991). However, medium size vessels broadcast loud sounds at energies 30 to 60 Hz (0.03 to 0.06 KHz), and these relatively low frequencies can travel for tens of kilometers in all directions (Greene, in press). A more detailed discussion of frequency and intensity of sound output by small boats, small ships, and commercial vessels and supertankers can be found in Richardson *et al.*, 1991, in press.

The noises of operation by the fuel facility are likely to be much less than those of the tankers and other vessels. However, construction of the facility will put much noise into the water, whether it be by boring holes for the facility piling (a lower intensity noise which will last for weeks to months) or by percussive piling. The latter projects sharp-onset energy into the water, of greater intensity than for boring, but the overall procedure takes less time. Tunnel boring (probably broadly applicable to the present case) is known to have strong components at 30-100 Hz (0.03-0.1 KHz) in shallow waters (Malme and Krumhansl 1993), while percussive piling has major energy at 30-40 and up to 100 Hz (Johnson *et al.* 1986). Percussive sounds may be received underwater as far as 10-15 km from the source. Tunnel and other drilling sounds, on the other hand, tend to attenuate more rapidly, and in shallow water appear to project a maximum of 3.7 km (Miles *et al.* 1987).

Dolphin Reactions to Human Activities

Most species of dolphins tend not only to tolerate vessels, but even approach them, often to ride the bow or stern pressure waves of the vessel. While this behavior is known to reduce energetic cost of travel (Hertel 1969, Williams *et al.* 1992), it is likely a form of play in most situations. Dolphin reactions to boats appear to be closely attuned to their group behavior: in general, resting dolphins avoid boats, foraging ones ignore them, and socializing ones approach (Würsig and Würsig 1980, Norris *et al.* 1994).

Bottlenose dolphins reside in many bays, channels, and estuaries used by vessels ranging in size from large tankers down to fishing and sport boats (Barham *et al.* 1980, Shane 1980, Acevedo 1991, Henningsen and Würsig 1992). Although bottlenose dolphins have been most studied worldwide, other species also often habituate well to even heavy human traffic. For example, harbor porpoises, Dall's Porpoises, and killer whales are found in ferry lanes in the Juan de Fuca Strait, British Columbia (Heimlich-Boran 1988), white whales inhabit industrial areas of the St. Lawrence Seaway (Blane 1990), and common dolphins come into even the at-times human congested harbor of La Paz, Mexico (Würsig, pers. observ.).

While toothed whales tend to generally tolerate shipping noise remarkably well there are exceptions. Most notably, high arctic beluga whales in heavy ice in spring are known to swim rapidly away from icebreaking ships at distances as great as 35-50 km (Cosens and Dueck 1988, Finley *et al.* 1990). However, this extreme reaction is no longer present later in spring and summer; and it is thought to be related to the sense of confinement provided by heavy ice, and perhaps to the unaccustomed nature of industry sounds after a winter of relative absence of human activity. A broad generalization leads us to the realization that in the absence of negative reinforcing stimuli (like being hunted), dolphins tolerate human activities after a short period of habituation. They are probably generally more tolerant than baleen whales, because their sound production occurs above the frequency levels of most anthropogenic sounds, and their sensitivity of hearing is also not good below about 1.0 KHz, where human-made noises concentrate (Ridgway 1983). It is therefore very improbable that social and feeding sounds are masked by shipping and other activities at distances greater than about 100 to 300 meters.

Overall, there is little doubt that dolphins can hear vessel and other noises, even when these are not in their primary frequencies of sensitivity. It is important, however, that these noises should not mask important communication and echolocation abilities. Dolphins are similar to terrestrial mammals that have been studied; they habituate to ongoing noises and activities remarkably well when these do not present other negative stimuli (such as active harassment or hunting). There is likely to be an upper limit to

tolerance of man made activities, when dolphins abandon an area (few examples exist, but San Diego Bay may be one, although it is unclear whether pollution, reduction of fish supplies, or noise were primary factors in dolphins leaving the bay). Dolphins are intelligent social mammals that will tolerate or habituate to considerable human activities if an area is important for other reasons, such as food and shelter.

It is perhaps unfortunate that these predators who feed on the upper levels of the food chain habituate so well to human activity: areas of industry also tend to be areas of pollution, often with high PCB, DDE, heavy metal, and other toxin loads. Indeed, the highest toxin loads to have been described in mammals come from dolphins living in industrialized area (for example, Subramanian *et al.* 1987, Tanabe 1988, Law 1992). It is known that toxin loads can have important deleterious effects on reproductive and other parameters, as has been shown especially well for beluga whales (Martineau *et al.* 1988)

Potential Impacts of the AFRF

The following assessments rely on review of the extensive published literature on terrestrial animal, dolphin, and other marine mammal behavior; interviews with workers familiar with dolphins of the genus *Sousa*; and personal experience with approximately 20 cetacean species, including *Sousa*. This section has been edited by Steve Leatherwood, Chairman of the Cetacean Specialty Group, IUCN; and Director of the Ocean Park Conservation Foundation (I thank him for his advice; any errors remaining are my own, however).

I. Potential Impacts

A. Construction of the AFRF may well initially cause dolphins to vacate the immediate area (within 300 meters of the facility), but they will likely habituate to construction noise within days to weeks. They can reasonably be assumed to again utilize the site during latter stages of construction or soon after construction is complete. Facility construction and operation noises are below the major sensitivities of hearing of delphinids of the size of *Sousa*, and therefore, we expect no significant masking of sounds or other sound-related problems.

B. With vessel traffic as proposed for use of the site, it is likely that dolphins will initially avoid the immediate and possibly the general areas (within about 300 meters of the AFRF and the off loading tankers) around the AFRF, but will habituate to the traffic and return to the general area. (There is the possibility of an escalation of other traffic in the general area, as part of China's overall increased use of Pearl River associated waterways. The present analysis does not include such potential increase in traffic, but this needs to be discussed in an overall management plan and potential sanctuary status; see below).

C. The immediate area of presence of the AFRF (probably within about 300 meters of the facility and associated tankers) is not likely to be used by the dolphins, and therefore this immediate area will be lost as dolphin habitat. This may change with time, especially as the pilings of the facility attract faunal assemblages which may serve as partial prey for the dolphins.

D. Dolphins at south Sha Chau, Pak Chau, and Lung Kwu Chau should not be affected by construction or operation of the AFRF (However, they may be affected by other construction and servicing activities in the area unless and until a sanctuary is established and administered; see below).

E. The Sha Chau AFRF by itself is not likely to greatly affect dolphin distribution or habitat use, since the dolphins in the Hong Kong "population" range outside of the Sha Chau/Lung Kwu Chau area.

F. Cumulative effects to dolphins in west Hong Kong waters must be considered in an overall Chinese White Dolphin management plan. Due to ship traffic, jet airplane noise, over-fishing, habitat degradation (including probably unsafely stored toxic wastes in mud pits in the area), habitat loss, and potential problems associated with inadequately treated sewage, Chinese White Dolphins in future may well be killed, avoid, or totally abandon waters north of Lantau Island. Although this is not directly a part of the present Sha Chau AFRF facility consideration, I would be remiss in not pointing out that marine mammals are often at risk of health and life in highly industrialized and polluted waters.

II. Recommended Mitigation Measures.

A. The AFRF to consist of a piled structure, not blockwork, as the former impacts the environment less, provides for more flow through the facility, attracts fish, and may even attract dolphins to the area.

B. The use of boring or percussive pile construction to be evaluated after further information is supplied on relative noise levels, frequency sweeps, and times of operation of the two alternatives. In brief, boring is of less noise intensity but lasts longer than percussive; percussive is very noisy but lasts for a relatively short time.

C. Vessel screw and associated noise of tankers and other support vessels to be adjusted as much below 300Hz in primary frequency as absolutely practicable, since dolphins on which hearing has been studied are relatively deaf to even loud noises below this frequency.

D. Propeller shrouding to reduce cavitation and other noises to be investigated. Detailed data on the efficacy of propeller shrouding exist, and have shown that noises are reduced substantially, while for some situations increasing efficiency and maneuverability of boat operation.

E. Solid and liquid waste containment at the AFRF.

F. A dedicated training program for AFRF and boat personnel, with the need for environmental impact and human sensitivity training.

1. Environmental impact to be reduced from the AFRF.

2. Maneuvering of boats to be as dolphin-friendly as possible.

G. Artificial reefs to be investigated, as feeding stations for dolphins, and as a means of increasing the general productivity of an area already damaged.

H. Daily time out from AFRF construction and operation to be mandated. Further investigation needs to establish the best times of day for time outs.

I. Other mitigation to be proposed as indicated by results of further research, as per items III. and IV., below.

Two major considerations enter into the recommendation to allow the AFRF to proceed. These are:

A. Assure that the AFRF is indeed only a temporary, interim, facility. This interim status should be written into the permitting of the facility, with monitoring by government and by environmental organizations to assure that the permanent pipe-line is built and the interim facility is phased out. As well, written statement must be made and enforced about using the facility

after the interim time only for emergencies and not for "spill-over" use as a regular or occasional occurrence.

B. Create, monitor, and enforce a marine sanctuary in the Sha Chau/Lung Kwu Chau area.

1. Core use area, with limitations on fishing, no other but AFRF industrial traffic, no other but very limited traffic for research.

2. Buffer zone, with limited and well-controlled activities.

3. Sanctuary should be approximately 1,000 hectares (as a minimum) in size, if it is to properly safeguard habitat around the islands.

III. Summary of Focused Studies, for AFRF Construction and Operation (The detailed protocol for these studies will be presented as a separate report).

A. Land-based Sha Chau study, to theodolite track and describe habitat use patterns and behavior of dolphins in the immediate area of Sha Chau, before, during, and after construction of the AFRF, and before and during AFRF use. This is preferably done by someone with experience in gathering and interpreting behavior in general, as well as specific to odontocete cetaceans. It is furthermore appropriate that such studies make use of Global Information System (GIS) mapping currently being prepared for Hong Kong, as GIS analyses permit flexible re-evaluation of future scenarios.

B. Boat-based studies to obtain reliable and comparable data on distribution patterns, compositions, group sizes, and affiliations and habitat use of dolphins in a wider area; by use of standardized line-transect methodology, associated photo-identification and behavioral observations, and interpretation. An extensive body of literature exists on this topic, and problems of weather and other sightability factors have been well-analyzed. I recommend that this be done in systematic fashion by a researcher intimately familiar with the literature, the protocols to be applied, the analysis procedures, and the carefully reasoned interpretations that can be made by survey methods, after consideration of their limitations. Above all, comparisons on habitat use and preferences should not be made until proper protocols have been applied and defended. For example, previous and present boat surveys have been unreliable because they do not stay on transect after a dolphin groups sighting. Proper protocol dictates that the survey be

continued and (if possible) a separate vessel stays behind to count and photo-identify dolphins.

C. Compare and cross-calibrate above survey method with air surveys on a series of days of joint platform work.

D. Photographic recognition studies to be continued and expanded, preferably outside of Hong Kong waters as well (see below).

E. Other studies to be initiated for comparison of numbers outside of the Sha Chau area, preferably in Chinese waters adjacent to west Hong Kong (for example, off islands southwest of Lantau Channel; as well as off Macau, Qi'ao Island, and Neilingding Island). This can partially be done by air, if calibrations of C., above, are successfully made. However, it will still be critically important to photo-identify in order to look for potential instances of longer-distance travel of recognizable animals.

F. Begin a study to compare genetic/chromosome affinities of dolphins in Hong Kong waters and other areas. This work may shed light on potential population discreteness in the Hong Kong/Macau areas. It, along with expanded photographic studies, can help us to judge whether the Hong Kong animals are or are not part of a more extensive population range. However, I caution that if the latter is true -- if Hong Kong animals range widely and are not behaviorally or genetically distinct -- this is not to be used as a justification for reducing or otherwise degrading the waters of Hong Kong.

G. Monitor the environment around Sha Chau, as discussed in the AFRF Environmental Impact Assessment.

H. Initiate an experimental artificial reef (see also II.G., above), and judge its efficacy relative to monitoring of dolphins in the area, especially by III.A. and III.B., above. For example, one might pick three disjunct areas, with relative high, medium, and low previous recorded dolphin use. Then one would monitor the areas before, during, and subsequent to installation of reefs. One would need to also dive on the reefs and -- in systematic (quadrat) fashion -- sample reef faunal assemblage.

I. Investigate the possibility of a dedicated radio tracking study of dolphins, if genetic and photographic studies are inconclusive on ranges of local animals. Capture and tagging/tracking work would be carried out by a highly experienced telemetry team.

IV. General Studies and Procedures

A. Continue and expand toxin analyses of carcasses recovered. The best possible laboratories are to be used for marine mammal analyses of concentrations of heavy metals, PCB's, DDT and derivatives, and other toxins.

B. Necropsies of recovered carcasses should be conducted by an experienced marine mammal veterinarian/pathologist, with tissue storage and cataloguing as per established modern techniques. Tissue distribution for toxin, genetic, pathology data as per established techniques and protocol.

C. Age and reproductive studies to be carried out by experienced personnel and by established well-recognized procedures.

D. Authorize and form a committee of researchers to establish a Hong Kong Waters Marine Mammal Management Plan. The committee will assess potential problems of cumulative effects on the ecology, behavior, social organization, and general well-being of marine mammals of Hong Kong waters, and make recommendations for potential action.

V. Concluding Statements

A. The AFRF at Sha Chau, by itself, is not likely to have negative effects on *Sousa* as a population.

B. However, we must consider the potential for harm from cumulative effects, as listed in I.F., above.

C. Strongly consider setting aside well-regulated marine sanctuary areas.

D. The Sha Chau and Lung Kwu Chau area can be such a sanctuary of high priority in dolphin habitat.

E. The sanctuary and the interim AFRF at Sha Chau can co-exist, with the understanding that the AFRF is, indeed, only an interim maximum of 7-year life facility, to be used for emergencies only after the permanent pipeline is put into use.

F. For *Sousa* to continue to exist in what are presently Hong Kong waters, it is imperative that marine sanctuaries are created and honored; and that future marine habitat degradation be kept to a minimum or even, where feasible, be reversed. I support the creation of the present AFRF facility as an apparently important necessity for efficient opening and early operation of the new Hong Kong airport. I support it because I do not see this facility as by itself harming the health of the local *Sousa*. I insist, however, that

cumulative effects can create such harm, and that Hong Kong must consider an overall marine habitat and marine mammal strategic survival plan in order to keep *Sousa* a part of the area.

I urge environmentalists and others to re-focus their concerns: The dangers to the ecosystem and to *Sousa* do not come from the proposed AFRF facility and its relatively minor noise input to the waters of Hong Kong. Although the real dangers of pollution and habitat decimation are less easy to track than "a facility" or several tankers; I strongly urge that real, not imagined, problems be addressed by environmental advisors, managers, and legislators.

References (is attached)

Addendum I: Critique of recent and present studies on Indopacific humpback dolphins in Hong Kong waters, with recommendations for improvements
(is attached)

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Addendum I: Brief Description and Critique of Recent and Ongoing Studies of *Sousa* in Hong Kong Waters (Comments prepared by B. Würsig, Texas A&M University, 16 March, 1995)

In early 1993, I advised the Hong Kong government on the potential impact of the Siu Ho Wan sewage outfall on the Chinese white dolphins of Hong Kong waters. As part of my report, I prepared a detailed proposal, in close collaboration with Joanne Ruxton of the World Wide Fund for Nature, Hong Kong, of research needs to identify numbers, population status, occurrence patterns, and aspects of health of these dolphins. Two major tools I then proposed were initiated and pioneered for dolphins by my wife Melany Würsig and me in the 1970's: theodolite tracking from shore and photographic recognition of individuals. A one-week reconnaissance in Hong Kong waters showed that these techniques could be well-adapted for this area and these animals. The tools are indeed powerful to aid in population status assessments, but they must operate in conjunction with properly designed and carried-out line transect surveys in order to allow for an assessment of the status of a group or groups of animals in an area.

I was pleased to hear in late 1993 that two students, working under the direction of Professor Brian Morton of the Swire Institute of Marine Sciences, would be carrying out some of the research proposed in my report, featuring theodolite tracking, photographic recognition, and line transect surveys. I have carefully reviewed these reports, for they are the best avenues towards gaining insight on the present status of Chinese white dolphins in Hong Kong waters.

The reports represent "work in progress", and can therefore not be judged on final merits. The young researchers have made laudable progress in their first year of work, and much more needs to be done to solidify and extend their information.

In brief, Ms. Porter's study report needs cumulative sighting frequency figure(s) and level of effort information. Most importantly, the work needs line transect surveys uninterrupted by stopping for photographic recognition work; and an explanation of

what kind of surveys were run, where, when, for how many hours, at what Beaufort sea states, and with what results. Without this information, it is presently not possible to evaluate how many dolphins utilize Hong Kong waters, nor relative preferences for certain areas. Even with this information, from properly run surveys, the "population" cannot be defined until work is done outside of Hong Kong waters, potentially consisting of a combination of a) surveys, b) photographic identification, c) radio tracking, and d) comparative genetic studies. Ms. Porter recognizes this, and has proposed that future work should include surveys and photo identification outside of Hong Kong waters. I have met with her, and she has expressed that she is eager to begin with work outside of Hong Kong waters as soon as appropriate permits and logistics are in place.

The report by E.C.M. Parsons provides more detail, not on methods of theodolite tracking and behavioral sampling (such as theodolite station height, cone of visibility, viewing area relative to sunstreak, behavioral data gathering and analysis protocols, etc.), but on results. Results are presented on numbers of animals sighted per search hour per theodolite station area per month. This information will, with further work, give valuable insight to potential changes in distribution by season and inter-year. At present, the data are likely to be influenced by as yet undetectable inter-year variability, especially as may relate to the stated heavier-than-usual Pearl River water flow in the 1994 season(s).

The Discussion section of Parsons' report does not limit itself to speculation surrounding the preliminary results. Instead, it terms certain behavior (that may actually represent feeding) as "stressed", and attempts to link a decline of dolphin sightings at one site (Sha Chau as seen from Castle Peak) as causative of human activity; without presenting the necessary data on behavior, movement patterns, and distribution before, during, and after the human activity. (I do not doubt that dolphins moved away when noisy human activity impacted the area; this is a common ~~startle~~ response, and it can last for at least days. However, the logical leap from

general occurrence pattern to causative link is premature with information given).

E.C.M. Parsons presents an appendix that lists recent known deaths of *Sousa* in Hong Kong waters, and extrapolates the stranding record into a line towards population extinction. The picture drawn is a bleak one and could possibly be true. Fortunately in the present case, the extrapolation may rest on incomplete knowledge of *Sousa* population numbers: a) The dolphin "population" of Hong Kong is probably not closed, but instead is likely to be contiguous with adjacent waters, thus making the equation used invalid; b) The assumption of initial "population" size (of 50) is not supported by data presented in either the Porter or Parsons reports; and c) We have no information on how the stranded animals died. At best, they died from natural causes (unrelated to human activity). In this case, the stranding record may be high for the past year simply due to increased human vigilance or awareness, and numbers of animals utilizing the area (though not all at once) may then be much larger than the present 50 to 100 animals proposed by the Swire team. At worst, all dolphins died due to human activities and there is, indeed, a severe problem if the population is not large. It is my suspicion (also untempered by actual data but from knowledge of dusky and bottlenose dolphins in other areas) that the truth of dolphin mortalities lies somewhere between effects from natural causes and human habitat degradation. At any rate, it is important to ascertain, as rapidly as possible, probable or confirmed causes of deaths of as many stranded dolphins as possible.

In summary, the preliminary reports by the student members of the Swire research team are just that -- preliminary at this time, and in need of standardized census protocol, statistical analyses, and continued guidance. I recommend that the research follows established census, theodolite tracking, and behavioral data sampling protocols; and that it be periodically reviewed by a panel of researchers with established credentials in the fields of ethology, behavioral ecology, census methodology, and marine mammalogy. The results have the capability of standing as important hallmarks in our knowledge of the genus *Sousa* in general, and the dolphins of

Hong Kong and adjacent waters in particular. I commend the Hong Kong Agriculture and Fisheries Department and the Swire Laboratory for their efforts in initiating this important work.