Darwin 10 MTPA LNG Facility

Public Environmental Report

March 2002

Prepared for
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12 March 2002

Reference: 00533-244-562 / R841 / PER

Darwin LNG Plant
Phillips Petroleum Company Australia Pty Ltd
ABN 86 092 288 376

Public Environmental Report

PUBLIC COMMENT INVITED

Phillips Petroleum Company Australia Pty Ltd, a subsidiary of Phillips Petroleum Company, proposes the construction and operation of an expanded two-train Liquefied Natural Gas facility with a maximum design capacity of 10 million tonnes per annum (MTPA). The facility will be located at Wickham Point on the Middle Arm Peninsula adjacent to Darwin Harbour near Darwin, NT. The proposed project will include gas liquefication, storage and marine loading facilities and a dedicated fleet of ships to transport LNG product. A subsea pipeline supplying natural gas from the Bayu-Undan field to Wickham Point and a similar, but smaller 3 MTPA LNG plant were the subject of a detailed Environmental Impact Assessment process and received approval from Commonwealth and Northern Territory Environment Ministers during 1998.

The environmental assessment of the expanded LNG facility is being conducted at the Public Environmental Report (PER) level of the Northern Territory *Environmental Assessment Act* and the Commonwealth *Environmental Protection (Impact of Proposals) Act*. The draft PER describes the expanded LNG facility with particular emphasis on its differences from the previously approved LNG facility and addresses the potential environmental impacts and mitigation measures associated with the project. This document will be available for public review from 18 March 2002 until 19 April 2002 at the following locations:

- Department of Infrastructure, Planning and Environment (DIPE), Ground Floor, Cavenagh House, 38 Cavenagh Street, Darwin, NT
- Darwin Public Library, Civic Centre, Harry Chan Avenue, Darwin, NT
- Casuarina Public Library, Bradshaw Terrace, Casuarina, NT
- Palmerston Public Library, Civic Plaza, cnr University Avenue & Chung Wah Terrace, Palmerston, NT
- Litchfield Shire Offices, 7 Bees Creek Road, Bees Creek, NT
- Environmental Australia Library, John Gorton Building, King Edward Terrace, Parkes, ACT
- State Libraries:
  - Northern Territory Library, Parliament House, cnr Bennett & Mitchell Streets, Darwin
  - State Reference Library of Western Australia, Alexander Library Building, Perth Cultural Centre, Northbridge
  - National Library of Australia, Parkes Place, Parkes, NSW
  - State Library of NSW, Macquarie Street, Sydney
  - State Library of Queensland, South Bank Building, cnr Peel & Stanley Streets, South Brisbane
  - State Library of South Australia, North Terrace, Adelaide
  - State Library of Tasmania, 91 Murray Street, Hobart
  - State Library of Victoria, 328 Swanston Street, Melbourne

The report can be examined for the duration of the public review period on DIPE's Internet site at www.lpe.nt.gov.au/eia. Phillips will be conducting a series of public information sessions during the review period which will be noticed in local newspapers. Persons wishing to comment on the PER are invited to make written submissions by close of business on 19th of April 2002 to:

Dr Janice Warren
Office of Environment and Heritage
Department of Infrastructure, Planning and Environment (DIPE)
GPO Box 1680
Darwin, NT 0801
E-mail: janice.warren@nt.gov.au
Fax: (08) 8924-4053

Submissions will be treated as public documents unless confidentiality is requested. Copies of all submissions will be forwarded to Phillips Petroleum Company Australia Pty Ltd. Written submissions should be typed in black on A4-sized paper. A version of the PER is available either in hard copy (purchase price $30.00) or CD-ROM (free of charge) from the following location:

Ms Teresa Gray
Phillips Petroleum Company Australia Pty Ltd
Level 5, NT House, 22 Mitchell Street, Darwin NT 0800
GPO Box 2266, Darwin NT 0801
Tel: (08) 8981-8666 Fax: (08) 8981-6636

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INTRODUCTION

This document is a Public Environmental Report (PER) for a proposal to construct and operate an expanded Liquefied Natural Gas (LNG) plant on Wickham Point near Darwin, Northern Territory of up to 10 million tonnes per annum (MTPA) capacity (Figure ES1). It is being submitted by Phillips Petroleum Company Australia Pty Ltd (the proponent) to provide the Northern Territory Government, agencies of the Commonwealth of Australia, and the public with the information necessary to allow an informed appraisal of the environmental acceptability of the proposed project.

The PER builds on environmental assessment documents previously prepared and subjected to public review in 1997 and approved by both NT and Commonwealth environmental ministers in 1998 for the construction and operation of a proposed 3 MTPA LNG facility at the same location. Construction of the original proposed facility was deferred due to global economic issues. The objective of the PER is therefore to identify the key modifications to the current project from that previously approved by regulatory authorities in 1998, and consequently assess the potential impacts and management requirements for those environmental effects associated with the expansion in plant capacity.

The earlier environmental assessment also identified the impacts associated with an expanded facility producing up to 9 MTPA of LNG at Wickham Point. As this document describes, the impacts of the proposed 10 MTPA LNG facility are not substantially different to those associated with the 9 MTPA design.

THE PROPONENT

Phillips Petroleum Company Australia Pty Ltd, a subsidiary of Phillips Petroleum Company, is the proposed developer and operator of the LNG facility located at Wickham Point. Phillips Petroleum Company has over 30 years of operating experience with the production and shipping of LNG. Phillips Petroleum Company was the first company to market LNG to Japan with the startup of its Kenai, Alaska, plant in 1969. Since that time, the company has pursued LNG licensing and commercial operations in many locations including the United States, Europe and Africa.

Phillips Petroleum Company, through subsidiary companies, controls a 58.5 percent interest in the unitised Bayu-Undan gas and gas-condensate field in Area A of the Zone of Cooperation (ZOC) located in the Timor Sea between East Timor and Australia. When a new Treaty is ratified by Australia and East Timor, this area will be renamed the Joint Petroleum Development Area (JPDA). The proven plus probable reserves of the Bayu-Undan field are estimated to be 400 million barrels of liquids and 3.4 trillion cubic feet (TCF) of gas.

In addition to its interests in the Bayu-Undan field, Phillips Petroleum Company, through various subsidiary companies, also holds a 30% share of the Greater Sunrise field operated by Woodside in the central Timor Sea. This major gas field lies partly within the JPDA and partly in waters under Australian jurisdiction and has reserves of approximately 300 million barrels of liquids and 9 TCF of gas.

Phillips proposes to use natural gas produced from one or both of these fields plus gas anticipated to be available during the life of the LNG facility from other strategically important Timor Sea gas fields to supply the Wickham Point LNG plant.

Contact Details

The designated Proponent for the proposed Darwin LNG Project is:

Phillips Petroleum Company Australia Pty Ltd
Attention: Dr Stephen Brand
Level 5 NT House
22 Mitchell Street
DARWIN NT 0800
GPO Box 2266
Darwin, Northern Territory
DARWIN NT 0801

THE PROPOSED PROJECT

The objective of the project is to transform a portion of the gas reserves of Bayu-Undan and possibly other fields into high quality LNG at a globally competitive price, and in a safe, reliable, environmentally responsible manner, provide a product for export and thereby produce revenue from the sale of the product. The balance of these gas resources will be available to supply natural gas to domestic customers in the Northern Territory.

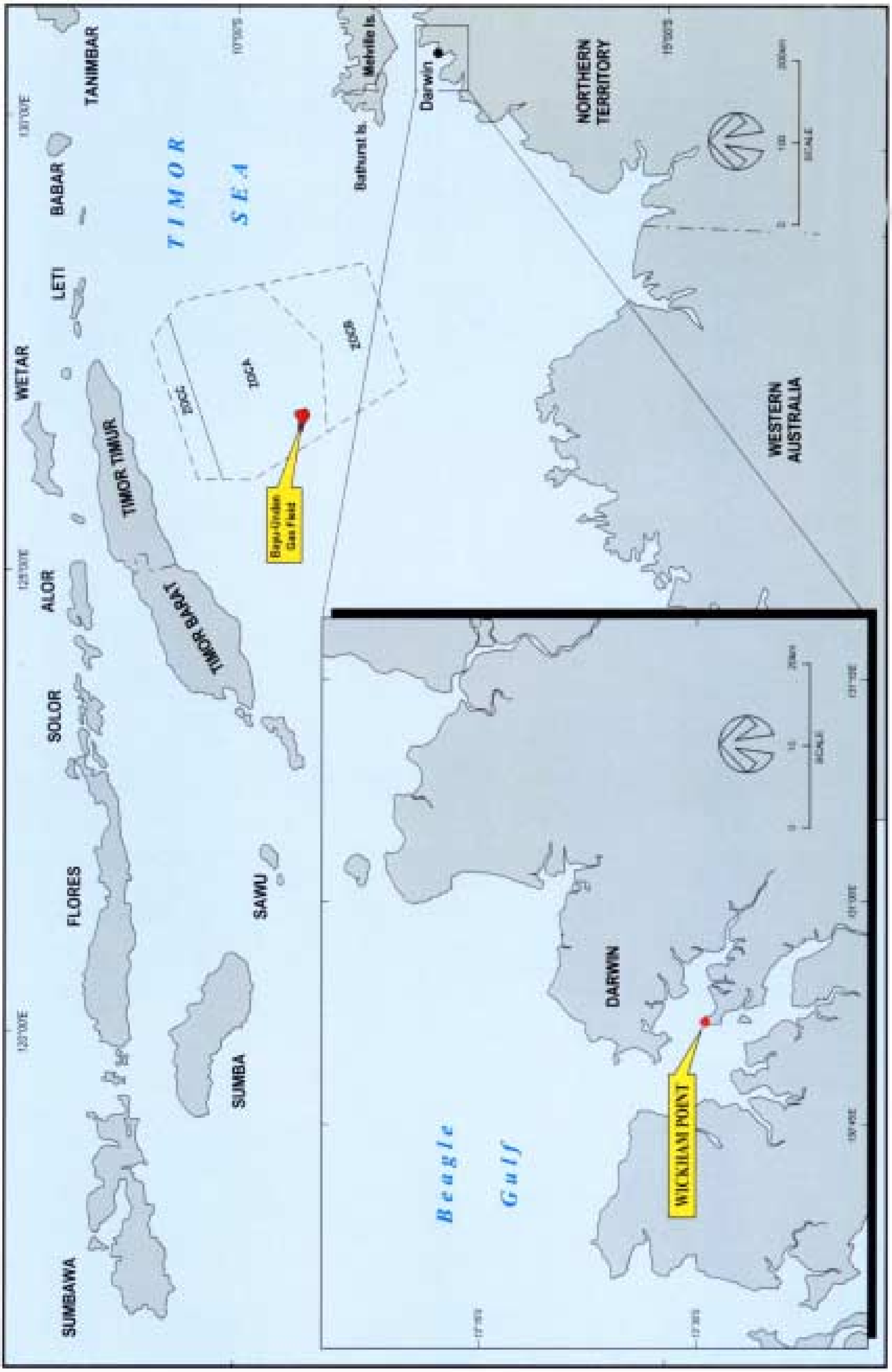
The justifications for the project are that it will:

1) fulfill the terms of the treaty between Australia and East Timor and its production sharing contracts which stipulate that commercial hydrocarbon resources within the JPDA shall be developed;

2) contribute substantial income to the region by way of royalties, taxes, and demand for local goods and services;

3) provide increased opportunities for employment while diversifying the economic base of Darwin; and

4) generate export earnings for Australia.



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Phillips Petroleum Company Australia Pty Ltd
10MTPA LNG PLANT AT WICKHAM POINT - PER EXECUTIVE SUMMARY

LOCATION PLAN

Figure ES1

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Previous Project Assessment

The Proponent previously (August 1997) submitted a Draft EIS to the NT Department of Land, Planning and Environment (NT DLPE) and Environment Australia (EA) for evaluation of a proposal to construct a 3 MTPA LNG Plant at Wickham Point in Darwin, linked by a subsea pipeline from the Bayu-Undan gas field.

The Draft EIS was subject to Government and public review (under both the Commonwealth *Environment Protection (Impact of Proposals) Act 1974* and the NT *Environmental Assessment Act 1982*) until end September 1997. Submissions received from government and public were considered and appropriate measures were submitted in response to address each issue raised during the public review process.

In January 1998, Phillips filed a Supplement to the Draft EIS in response to the comments received during the public review process. In particular, the Supplement included a revised site development plan for a possible expansion of the facility to 9 MTPA LNG on Wickham Point, information relating to the probable impacts from such expanded plant, an updated draft of the Preliminary Environment Management Plan (EMP) and a summary of Proponent commitments. EA and NT DLPE issued separate Environment Assessment Reports in March 1998 to confirm project acceptance, which concluded that the 3 MTPA LNG Plant could proceed subject to Phillips' implementing the proposed project in accordance with commitments made in the Supplement and the additional recommendations made by EA and NT DLPE.

In May 2001, a Notice of Intent (NOI) was submitted to NT DLPE for a proposed LNG facility of up to 10 MTPA at the same Wickham Point location. In Phillips' opinion, the current 10 MTPA proposal represents the optimum sized LNG facility for location at the Wickham Point site and it is unlikely that any material expansion of such facility, other than de-bottlenecking improvements, would be considered in the future.

Phillips wishes to amend its approved 3 MTPA LNG project and to secure environmental approvals for a larger facility of up to 10 MTPA. The current PER will facilitate completion of the EMP to the satisfaction of the (now) NT Department of Infrastructure, Planning & Environment [NT DIPE, formerly NT DLPE] and EA as a condition of project approval. Environmental approvals for the gas pipeline from Bayu-Undan to Wickham Point are being handled separately through the NT Department of Business Industry and Resource Development (NT DBIRD, formerly NT DME) in accordance with the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999*. Two of four licenses under P(SL)A regulations have been issued for this pipeline.

Major Components of Proposal

As with the previously approved 3 MTPA facility, the proposed 10 MTPA project will involve construction and operation of the following major components:

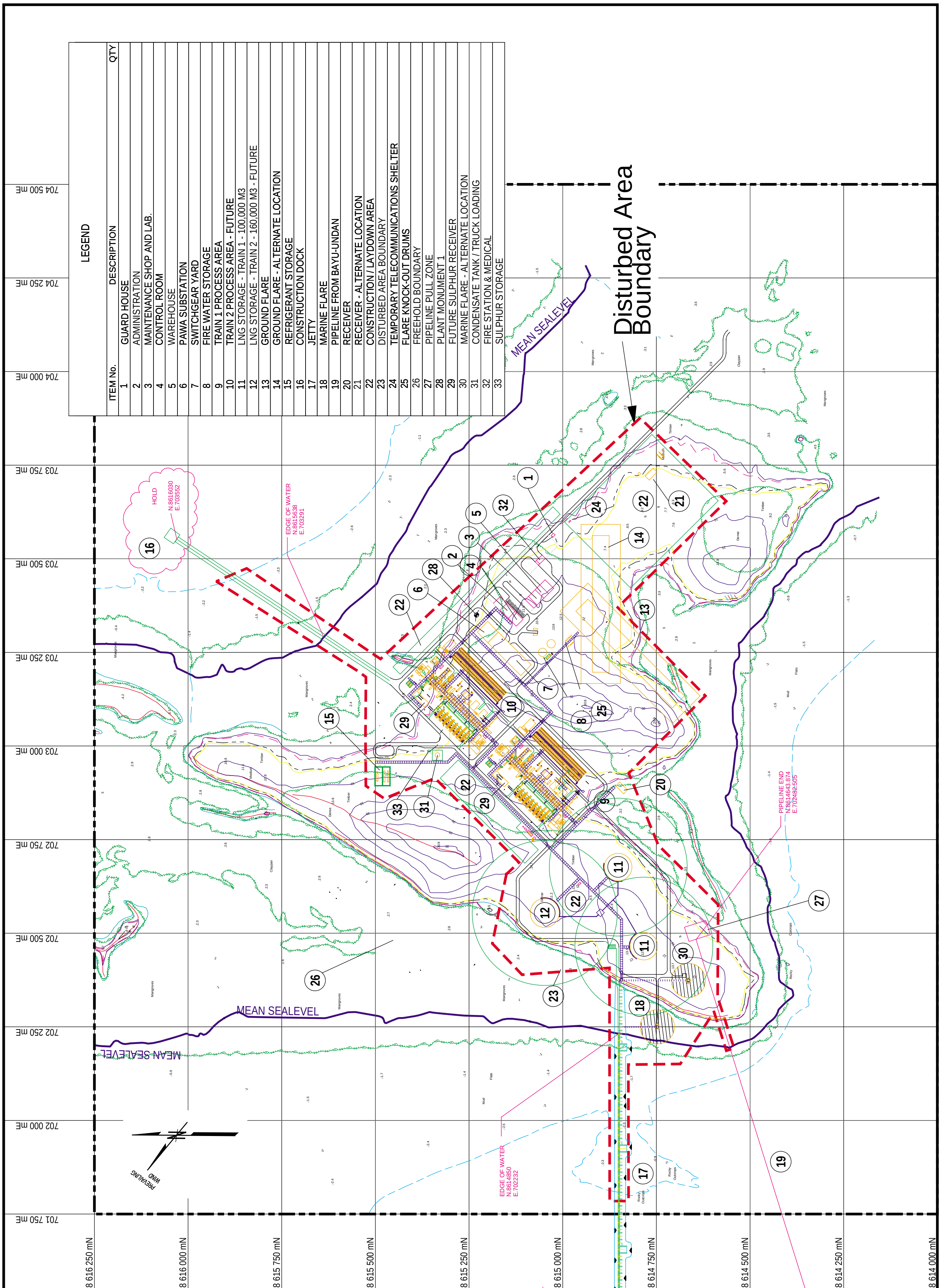
- An LNG plant utilising the Phillips Optimized Cascade LNG Process which comprises:
  - gas processing facilities to remove impurities and refrigerate the natural gas;
  - product storage tanks;
  - plant infrastructure and utilities;
- A loading jetty on the west side of Wickham Point in Middle Arm of Darwin Harbour to transfer product to tankers for shipping to market;
- A construction dock on the north-east side of Wickham Point in East Arm of Darwin Harbour for transfer of building materials and heavy equipment; and
- A dedicated fleet of large, specially constructed ships to transport LNG from Wickham Point to global markets.

The project will comprise the same major components as proposed for the previously approved 3 MTPA Project, but will differ principally in the capacity of the LNG plant and its layout on Wickham Point (shown in Figure ES2). The construction of an access road along Middle Arm Peninsula originally proposed as part of the 3 MTPA project is now being coordinated by the NT Government and is not addressed further in the PER.

Key Project Modifications

The principal differences between the approved plant design and the proposed new plant design are as follows:

- The disturbed area envelope has increased in size and changed shape slightly, in regard to the spill impoundment area, the main flare area, and the south eastern part of the plant site.
- Instead of one 3 MTPA LNG process train, the present facility proposal will now comprise two LNG process trains totalling up to 10 MTPA. These trains will use the Phillips Optimised Cascade LNG process as presented in the Draft EIS. This process is based on the LNG technology used in Phillips' Kenai LNG Plant. This facility has been operating over 30 years and was the world's second commercial LNG project and the first to export LNG to Japan. This process was also selected for the Atlantic LNG Project in Trinidad. This plant started up in June 1999 and currently has two expansion trains under construction and a fourth under design.



LEGEND

ITEM No.	DESCRIPTION	QTY
1	GUARD HOUSE	
2	ADMINISTRATION	
3	MAINTENANCE SHOP AND LAB.	
4	CONTROL ROOM	
5	WAREHOUSE	
6	PAWA SUBSTATION	
7	SWITCHGEAR YARD	
8	FIRE WATER STORAGE	
9	TRAIN 1 PROCESS AREA	
10	TRAIN 2 PROCESS AREA - FUTURE	
11	LNG STORAGE - TRAIN 1 - 100,000 M3	
12	LNG STORAGE - TRAIN 2 - 160,000 M3 - FUTURE	
13	GROUND FLARE	
14	GROUND FLARE - ALTERNATE LOCATION	
15	REFRIGERANT STORAGE	
16	CONSTRUCTION DOCK	
17	JETTY	
18	MARINE FLARE	
19	PIPELINE FROM BAYU-UNDAN	
20	RECEIVER	
21	RECEIVER - ALTERNATE LOCATION	
22	CONSTRUCTION / LAYDOWN AREA	
23	DISTURBED AREA BOUNDARY	
24	TEMPORARY TELECOMMUNICATIONS SHELTER	
25	FLARE KNOCK-OUT DRUMS	
26	FREEHOLD BOUNDARY	
27	PIPELINE PULL ZONE	
28	PLANT MONUMENT 1	
29	FUTURE SULPHUR RECEIVER	
30	MARINE FLARE - ALTERNATE LOCATION	
31	CONDENSATE TANK / TRUCK LOADING	
32	FIRE STATION & MEDICAL	
33	SULPHUR STORAGE	

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10MTPA LNG PLANT AT WICKHAM POINT - PER EXECUTIVE SUMMARY

PROPOSED 10MTPA LNG FACILITY LAYOUT

Figure ES2

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- The increased plant capacity will result in increased volumes of atmospheric emissions and waste materials requiring disposal (refer Tables ES1 and ES2).
- Instead of two LNG storage tanks there will be three larger tanks.
- The new facility will not produce commercial quantities of other LPG products (i.e. propane and butane) for export as originally proposed, as the feed stock gas will be processed offshore to remove LPGs. Hence, the LPG storage tanks have been eliminated from the current design. The only other saleable product will be much smaller volumes of stabilised condensate than had been included in the original design.

The construction dock will now contain a dredged berthing pocket to –6 m AHD at the seaward end, instead of a gravel pad exposed at low tide.

The length of the shiploading facility has been reduced by about 100 m and limited (if any) dredging of material (<100,000 m^3) is expected in the turning basin and at the jetty head. These volumes represent no significant changes from the original EIS.

- Instead of an elevated main flare as originally proposed for the 3 MTPA plant, a large ground flare is proposed for the 10 MTPA plant and has been relocated to the south side of the plant site. This change was made to accommodate a proposed future road transport corridor from Darwin to Palmerston, and an air traffic corridor for aircraft approaching Darwin Airport.
- A metering facility has been relocated to the south of the main plant area where the metering and conditioning of gas for delivery to domestic markets will occur;
- The shore crossing for the offshore pipeline onto Wickham Point has been relocated 200 m south of the point identified in the original EIS.
- Approximately 90-100,000 m^3 of hydrotest water from the LNG and condensate storage tanks will need to be discharged once only into Darwin Harbour prior to plant start-up. This discharge will be undertaken in accordance with NT DIPE requirements with appropriate reference to the National Water Quality Management Strategy (NWQMS) Guidelines.

Table ES1 Estimated LNG Facility Solid Waste Quantities

Type of Solid Wastes	Quantity Kg/yr		
	3 MTPA	9 MTPA	10 MTPA
Waste Lubricating Oils	8,300	20,750	16,000
Spent Oils	950	2,375	1,500
Cellulose	1,020	2,500	2,000
Biological Sludge	4,000	6,000	5,000
Inorganic Sludge	200	500	400
Oily Sludge	40,000	80,000	60,000
Spent Solvents	100	250	200
Ceramic Balls	3,100	7,750	5,500
Molecular Sieve Waste	35,380	88,450	72,000
Trash	50,000	120,000	80,000

Table ES1 shows that the solid waste generated for the proposed 10 MTPA facility does not incrementally increase across the board. While higher than the 3 MTPA base case facility, there is a substantial reduction in volumes from that originally estimated for the 9 MTPA facility. Volume reductions are due to the efficiencies achieved by utilising a two train versus a three train operation. Reductions in the number of trains directly relates to reductions in waste generation, for instance less spent lube oil resulting from a fewer number of compressors.

Table ES2 Comparison of Emissions from 3 MTPA, 9 MTPA, and 10 MTPA LNG Plants

Emissions in Tonnes per Year

Case	PM	SO_2	NOx	CO	CO_2	TOC/CH_4
3 MTPA	374	6	3,174	1,623	1,713,772	1,675
9 MTPA	1,097	18	9,244	4,800	5,070,441	5,010
10 MTPA	537	130	6,152	1,942	4,559,940	464

Table ES2 shows that the emissions for the proposed 10 MTPA plant, while generally higher than the 3 MTPA facility, in most cases reflect a substantial reduction in emissions from that estimated for the 9 MTPA facility. This is as a result of improvements in the 10 MTPA design to include vapour recovery systems, addition of waste heat recovery equipment, and changes in the heat rating and efficiency of equipment. The exception to this downward trend is in relation to sulphur dioxide (SO_2). In the earlier proposal, H_2S removed in the amine treatment unit was to be vented to atmosphere and the partial combustion of H_2S to form SO_2 was not accounted for in the emission inventory. In the current proposal an acid gas incinerator has been provided to combust all H_2S removed. Therefore, SO_2 emissions are higher than the original proposal.

Construction Summary

Prior to commencement of works at the site, the environs of the major plant components will be surveyed in detail to provide accurate topographic and bathymetric charts of the work site.

The access road to be constructed by the NT Government during the 2002 dry season will enable construction equipment, materials and personnel to be readily transported to the site. A pipeline to carry fresh potable water to the site will be constructed by the NT Government and will link into the Northern Territory Power and Water Authority (PAWA) supply system to the plant. Once the site has been cleared, the construction dock will be constructed and a temporary electricity supply from PAWA will be obtained.

Dredging of the approach channel to, and installation of, the construction dock will also be undertaken early in the construction programme.

After site preparation, the LNG plant will be constructed. Construction of the LNG tanks, LNG train, utilities, storage and loading system, product shiploading facility and flares will occur during this phase.

The final phase of construction is the start-up and commissioning of the project facilities. The utilities are started up first, followed by the LNG train, then the storage and loading facilities. Start-up and commissioning overlaps the operational phase.

Initial site preparation is anticipated to commence in late 2002 or early 2003. Construction of the first phase (one process train up to 5 MTPA) of the proposed LNG facility is anticipated to commence in early 2003 and be completed by late 2005. Construction of the second LNG process train, if additional gas supply arrangements can be secured, is expected to commence in late 2003 and be completed in late 2006. First loadout of LNG is anticipated in early 2006.

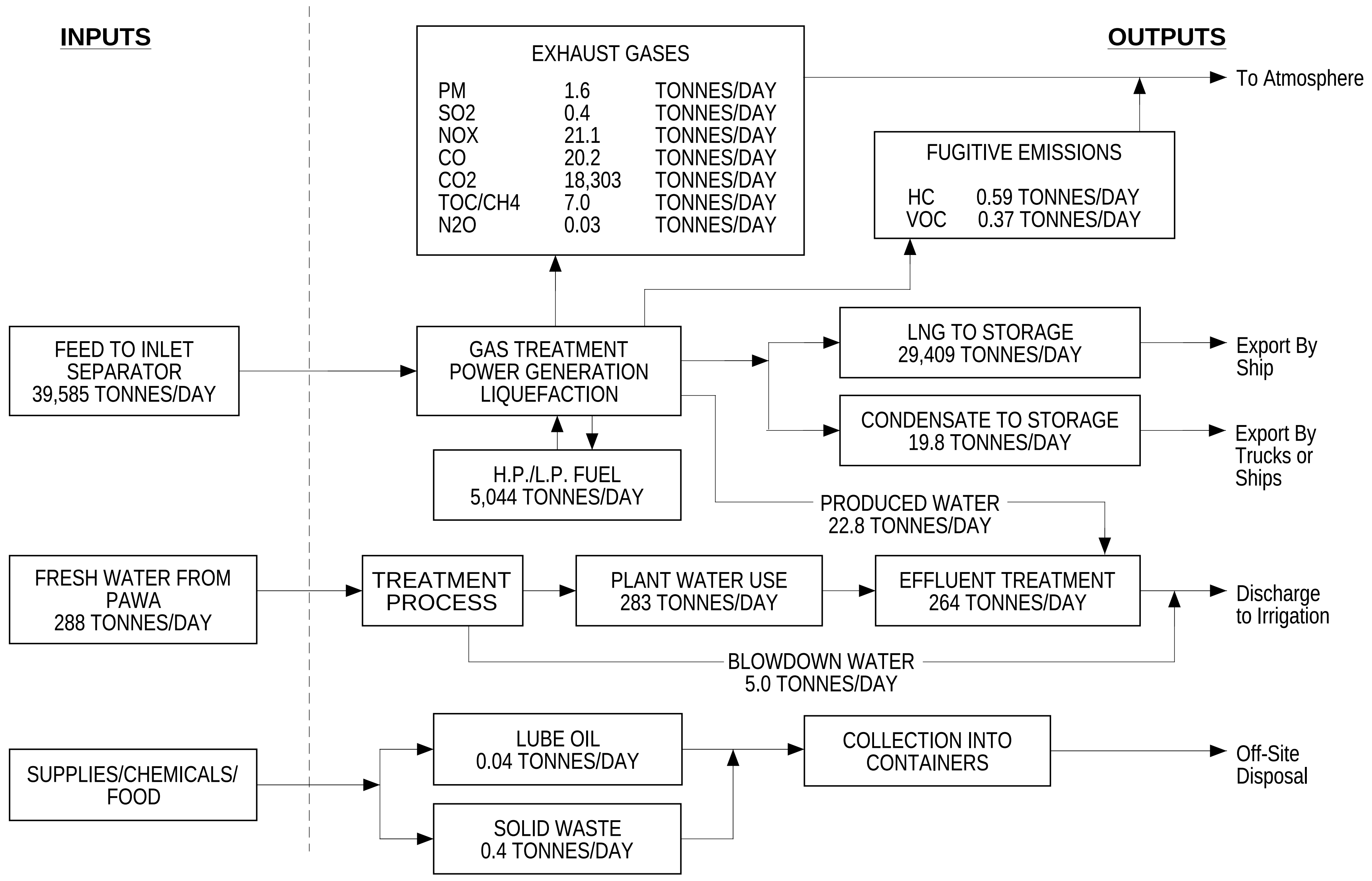
The construction workforce in Darwin will peak at approximately 1,600 personnel during this period if both trains proceed in sequence. Many of the construction jobs will be associated with a particular phase of work and thus will not last for the entire construction period.

Operations Summary

An LNG plant is a very clean industrial facility. The plant will utilise clean natural gas for energy requirements and small amounts of potable water for process and domestic requirements. Atmospheric emissions and potential waste streams have been estimated and are summarised in the mass balance diagram presented overleaf (Figure ES3).

The LNG plant will be designed for continuous 24 hour operation. The only planned shutdown of the plant will be for routine maintenance on the plant equipment and for periods when the LNG tankers undergo their required maintenance. The LNG facility will be operated by a workforce of up to 120 full-time personnel. Most of the utilities consumed in the LNG facility will be produced within the limits of the plant. Similarly, most of the wastes produced in the LNG facility will be treated within the limits of the plant.

The LNG facility will liquefy natural gas (Figure ES2) and produce LNG at a nominal capacity of 10 MTPA. Operation of the project will basically involve the treatment of the gas to remove hydrocarbon liquids, water, carbon dioxide and other impurities, then liquefaction of the gas and its storage prior to loading onto tankers for shipping to market (Figure ES4). Further detail on the major components of the project is provided below and is generally consistent with the facility description included in the original EIS with any exceptions noted.



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10 MTPA LNG PLANT AT WICKHAM POINT - PER EXECUTIVE SUMMARY

MASS BALANCE FOR LNG OPERATIONS

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Figure ES3

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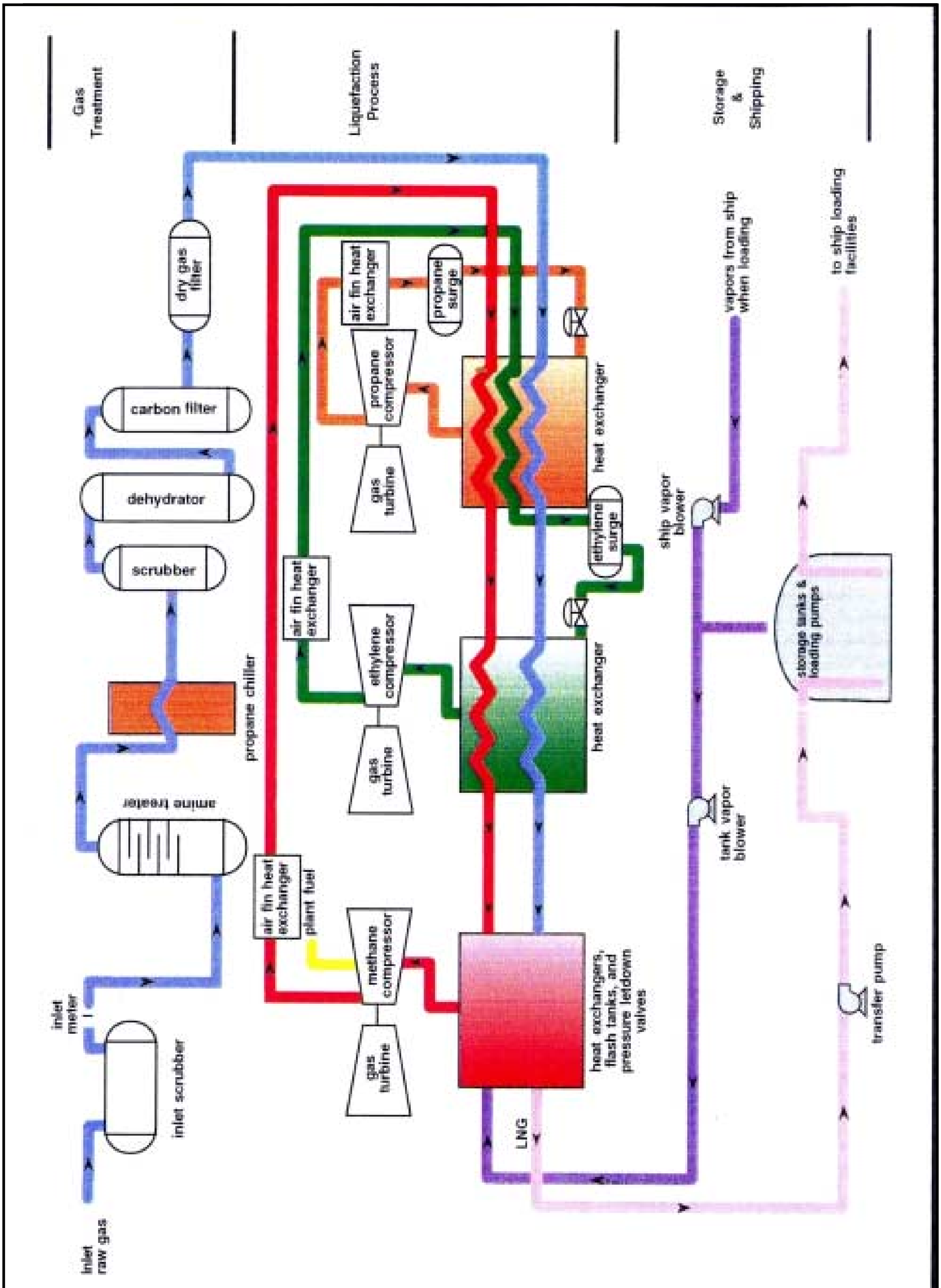

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10 MTPA LNG PLANT AT WICKHAM POINT - PER EXECUTIVE SUMMARY **PHILLIPS OPTIMISED CASCADE LNG PROCESS**	**Figure ES4**
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Major Components

Inlet Metering Facility

An inlet metering facility will be installed to receive the gas from the offshore pipeline to Wickham Point. Any liquids (condensate) collected from the gas stream will be combined with other condensate produced within the plant and stored on site in a 5,000 barrel tank. The facility will also contain filters to remove any particles from the gas and custody transfer meters to measure the rate of gas flow. The facility will also contain inlet gas heaters to warm the gas when needed to avoid freezing and hydrate formation when the gas pressure is reduced.

The gas from the metering facility will be delivered to the LNG plant and also to a pipeline for delivery to domestic gas users.

LNG Plant - Gas Treatment

After the gas is metered it will enter the gas treating section of the LNG plant to remove components within the gas stream that are detrimental to the natural gas liquefaction process. These components are primarily carbon dioxide, hydrogen sulphide and water.

After the gas leaves the treating section it goes through the first stage of chilling that also condenses out some water. The gas then enters a three-bed molecular sieve system to remove the final traces of water. Any water collected is sent to the wastewater treatment system.

The final gas treating step uses two activated carbon beds to remove trace amounts of mercury which may be present to prevent any potential corrosion/damage on downstream brazed aluminium heat exchangers.

LNG Plant - Liquefaction

The gas is subsequently fed to the refrigeration system where it is cooled and liquefied as the LNG product. The refrigeration or liquefaction system uses the Phillips Optimized Cascade LNG Process.

There are three refrigerants (propane, ethylene and methane) used in the liquefaction systems to cool the gas step by step to -160 ºC. These refrigerants are optimally cascaded to provide maximum LNG production utilising all of the available power of the gas turbine drivers, thereby maximising energy efficiency. The plant will use air fin coolers for the heat removal requirements of the liquefaction process, and therefore will not require cooling water.

LNG Plant - Product Storage

LNG produced from the liquefaction process is stored in three double containment storage tanks. Two tanks will be of 100,000 m^3 capacity each, and the third tank will be of 160,000 m^3 capacity. These represent an increase from the 95,000 m^3 capacity tanks included in the original EIS. The storage system includes product pumps for ship loading and a boil off compressor for handling the vaporising LNG.

In the previously approved 3 MTPA project described in the draft EIS and supplement, LPG and some condensate removal was premised at the LNG facility. For the current 10 MTPA proposal, these products will be removed offshore therefore only relatively small amounts of condensate and no commercial LPG are now expected to be recovered at the LNG facility. A storage tank provides approximately one week of storage for stabilised condensate product that may be produced. Disposal of this condensate will be either through a truck loading station to local markets, or through the LNG shiploading facility. The location of the storage tank facilities is shown in Figure ES2.

LNG Loading Facilities

A loading facility will be constructed to transfer LNG (and potentially condensate) produced by the plant to vessels for shipment to markets. The facility is proposed to comprise a 925 m long rock fill groyne abutting the shoreline, with an adjoining open piled trestle structure, approximately 500 m long, leading to a pile-supported (36 m by 16 m) loading dock. A minimum 600 m diameter vessel turning basin and 400 m by 70 m berthing pocket will be established at the head of the loading facility.

LNG Shipping

LNG will be transported from Wickham Point to world gas markets via purpose-built tankers dedicated to the project. At ten million tonnes per annum nominal production, LNG vessels will arrive approximately every two to three days for loading and export. Turnaround time for vessels will be approximately 24 hours, with a product loading duration of approximately 14 hours. The LNG tankers will probably have a draught of 11.5 m and be between 260 and 290 m in length with a carrying capacity of up to 145,000 m^3. The original EIS provided for ships of up to 135,000 m^3 carrying capacity.

Condensate volumes produced during plant operations are expected to be small and hence truck export to local markets is the likely outlet for this product. However, if ship export of this product is required, ship-loading operations are expected to be approximately once a month.

PHYSICAL ENVIRONMENT

Climate

The project area is located within the monsoonal tropics which have distinct wet and dry seasons. In the Darwin area, rainfall is approximately 1,710 mm, most of which falls in the November to March wet season. Humidity over this period averages 70-80% while in the dry season humidity averages 40% and there is virtually no rainfall. Maximum temperatures are hot all year with November being the hottest month with a range of 25 to 33°C. The monthly minimum average temperature is 19°C in July. Prevailing winds in the wet season are light west to north-westerly, freshening in the afternoon due to sea breezes. In the dry season the prevailing winds are south-easterly trade winds. The monsoonal tropics also experience occasional cyclonic activity.

Bathymetry/topography of Project Area

Darwin Harbour is a large ria system, or drowned river valley, of about 500 km^2 formed by post glacial flooding of a dissected plateau. It is an estuary with three major arms known as East, Middle and West Arm respectively, plus a smaller inlet (Woods Inlet). The harbour is relatively shallow, although deep channels (to >20 m) do occur in places. Most of the harbour is less than 10 m deep and much of it is intertidal. The intertidal flats and shoals are generally more extensive on the western side of the harbour than on the eastern side.

In Darwin Harbour a channel of >20 m water depth extends in a south-easterly direction from Darwin Port Limits to the confluence of Middle and East Arms. The channel continues up Middle Arm past Wickham Point.

On most maps and charts of Darwin Harbour, Wickham Point is shown on the north-west tip of Middle Arm Peninsula. This peninsula comprises two small ‘islands’ of terrestrial vegetation surrounded by intertidal mangrove forests which are partially or completely inundated by water at high tide. For the purposes of this report, Wickham Point refers to the westernmost ‘island’ which is the proposed site for the LNG plant.

Wickham Point is roughly triangular in shape and consists essentially of three parallel north-north-east trending ridges separated by narrow valleys. The largest ridge forms the western side of the island and rises at its northern end to form Peak Hill, the highest point on the island at 32 m elevation. The intervening valleys lie between 4 and 8 m above sea level and terminate in small embayments on the north and south coasts of the island.

Geology/Sediments of the Region

Bedrock at Wickham Point consists of meta-sediments of the Early Proterozoic Finniss River Group. These rocks have been metamorphosed to lower greenschist facies and have undergone one major deformation which has produced steep dips and resulted in the pervasive north-north-east strike of the strata. The member of the Finniss River Group present on Wickham Point is the Burrell Creek Formation which consists of a sequence of phyllite, siltstone, shale, sandstone and conglomerate.

The seabed of Darwin Harbour is dominated by gravel. There is a scour zone in the centre of the harbour, where the hard pavement substrate is covered by only a thin veneer of sediment, grading into terrigenous sand offshore from the tip of Wickham Point. The intertidal area off the point itself has fine sands and silts.

Seismicity

The proposed LNG plant site is located in an area of low seismic activity. No earthquakes have been recorded in the immediate vicinity of Darwin since reliable records commenced.

Oceanography

Tides in Darwin Harbour are semi-diurnal with a maximum range of 7.8 m. Water clarity in Darwin Harbour varies significantly on both a tidal and seasonal basis. Spring tides create fast currents which mobilise shallow sediments and increase water turbidity. Water clarity is best during neap tides in the dry season. The wet season results in substantial input of turbid freshwater into the harbour. Negligible freshwater inflow occurs in the dry season.

BIOLOGICAL ENVIRONMENT

Darwin Harbour Habitats

There is a range of intertidal habitats in Darwin Harbour, with rocky intertidal shores predominant along the margins of the headlands. Extensive mangrove assemblages occur on the upper intertidal, giving way to mud and sand flats in the lower intertidal. There are few sand beaches in the harbour itself. Coral communities occur where the substrate is rocky in the lower intertidal and shallow subtidal zones. Subtidally the rocks are dominated by algal communities. Subtidal muds give way to gravelly or pavement bottoms in the channels.

Wickham Point Intertidal

The intertidal mangrove community which surrounds Wickham Point is extensive, and nine floral assemblages have been recorded. Other intertidal communities include rocky shores and pavements, sand beaches, and mud and sand flats.

Marine Fauna

The marina fauna of Darwin Harbour is diverse and comprised of species typically found in the vast Indo-West Pacific Biogeographical Province. The majority of species are widely distributed in this region, with the northern part of the Australian continent being simply a small part of the wider range of species.

Protected species known to occur within Darwin Harbour include turtles, sea snakes, dugongs and dolphins. These animals are protected under the Commonwealth EPBC Act 1999. Most of these animals feed or forage in waters within Darwin Harbour, and turtles and dugongs have also been recorded feeding on seagrass beds adjacent to Channel Island. None of these species are threatened by this project.

Terrestrial Flora and Fauna

The terrestrial flora of the Wickham Point islands is dominated by monsoon/dry rainforest with limited areas of paperbark-dominated woodlands (Figure ES5). No rare or endangered flora species has been recorded at Wickham Point, however the dry rainforest is of regional conservation interest.

The fauna, particularly birds, is diverse, with a number of migratory species known in the area, however none of these species are regarded as threatened in the Darwin region. There appear to be good populations of medium and large sized mammals such as Northern Brown Bandicoot, Northern Brushtail Possum and Agile Wallaby on Wickham Point. None of these species is rare or endangered. The area has not been recently burned and largely lacks introduced weeds and feral animals. The undisturbed nature of the "islands" makes them of conservation interest.

Biting insects (mosquitoes and midges) are common at Wickham Point. The mosquito *Aedes vigilax* is considered to have the greatest potential as a pest and disease vector in the area. It and several other species are known to be vectors for Ross River virus, Barmah Forest virus and Murray Valley encephalitis. In addition, substantial numbers of biting midges breed in the Wickham Point area.

SOCIAL ENVIRONMENT

Darwin is the major city in northern Australia, and the capital of the Northern Territory. The total population in the Darwin region is about 107,000. As a major city, Darwin has a wide variety of infrastructure, including the port, airport, national highways to other cities, and other facilities needed for the LNG plant and its personnel. The nearest community to Wickham Point by highway is Palmerston (population about 25,000).

Wickham Point is the site favoured by the Northern Territory government for clean industrial development such as the LNG plant. Rezoning of the area to accommodate the proposed project will be required but this has been contemplated in long-term land use planning for the Middle Arm area.

Wickham Point is perceived by the Larakia and other Aboriginal people living around Darwin Harbour as being of some significance to them. In 1999 an agreement was reached with various Native Title parties and the Northern Land Council to resolve native title and aboriginal land rights claims previously lodged for the area.

Nine archaeological sites were identified on Wickham Point during the original environmental assessment, most located either within or immediately adjacent to the proposed plant area: six are prehistoric shell middens; two are historic sites dating from World War II; and one is the remains of the "Mud Island" leprosarium. A further five shell middens, and a WWII heritage site, were recently discovered and are currently subject to complete heritage surveys in consultation with the DIPE.

No Aboriginal burial grounds are known on Wickham Point, but it is likely that burials did occur near the leprosarium site and possibly in shell middens in the area. The leprosarium is located north of the LNG plant site and will not be affected by construction of either access road or the LNG plant.

A heritage listed coral community occurs at Channel Island, some 4 km to the south-east of Wickham Point.

Darwin Harbour is widely used for a variety of activities, including recreational fishing, scuba diving, boating, and aquaculture, but these occur well away from the proposed LNG plant and existing port facilities.

The proposed Wickham Point site lies along the flight path to the runway at Darwin's regional airport used by smaller private and commercial airplanes. Discussions regarding minimising its impact upon such operations are continuing with relevant Government and local authorities.

ENVIRONMENTAL EFFECTS ASSESSMENT

The proposed 10 MTPA LNG Facility differs from the approved 3 MTPA facility in a number of ways:

- the facility will be larger that originally approved and will utilise larger LNG storage tanks and LNG ships;
- the feed stock gas will be sourced from a number of Timor Sea gas fields rather that solely from the Bayu-Undan field. This may include gas from the Greater Sunrise and possibly other gas fields, which will be processed offshore to remove LPG's and condensate. As a result, the LNG facility will not produce significant quantities of LPG's or condensate for export;
- the sulphur emissions are greater than previously estimated;
- the use of waste heat and ship vapour recovery equipment which will reduce atmospheric emissions including greenhouse gases from fired equipment; and
- the plant will use more efficient turbines than were available at the time of the Draft EIS, and hence lower emission factors will apply.

The main environmental effects of the new 10 MTPA Facility as compared to the approved 3 MTPA facility will result from the increased capacity of the plant and will be as follows:

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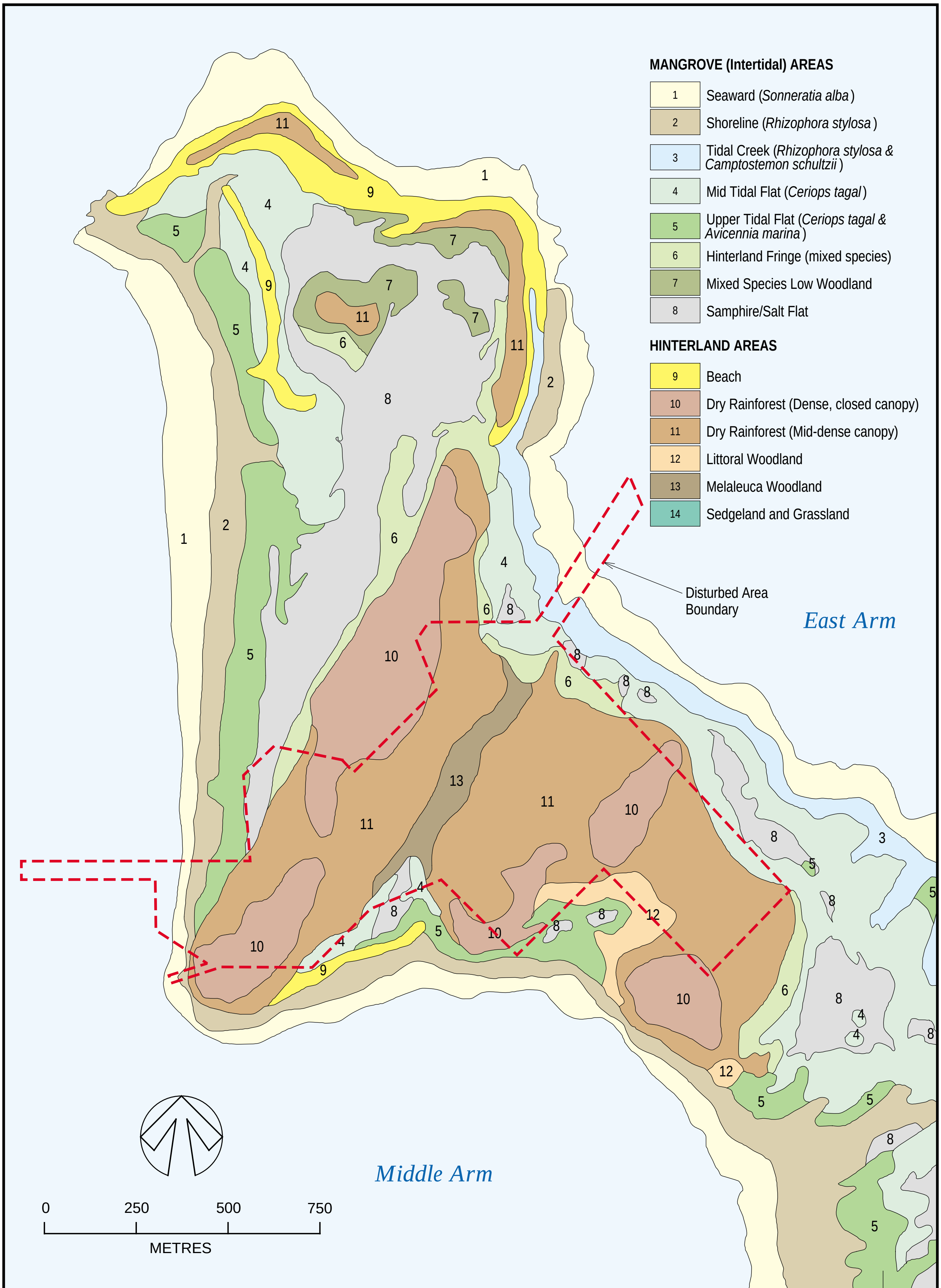

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER EXECUTIVE SUMMARY **PROPOSED 10MTPA LNG FACILITY DISTURBANCE ENVELOPE SUPERIMPOSED ON VEGETATION COMMUNITIES OF WICKHAM POINT**	**Figure ES5**
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- increased area of ground disturbance from 66.8 ha to 88.3 ha;
- increased demand for power generation from 18.2 MW to 48.4 MW;
- increased operating workforce from 75 to 120 personnel;
- increased demand for process water requirements from 6 m^3/hr to 12 m^3/hr;
- increased volume of wastewater disposal requirement from 4.5 m^3/hr to 11 m^3/hr
- increased volume of storage tank hydrotest water discharge prior to plant start-up;
- increased volume of solid waste generated;
- potentially increased public risk environment as result of increased storage tank volumes and shipping movements associated with the larger project;
- increased product shipping movements from 78 to approximately 160 per annum and associated navigation risk using larger vessels; and
- increased atmospheric and greenhouse gas emissions.

Since the previous environmental assessment, the following impact assessment studies have been undertaken to update the baseline information for the existing environment and assess the significance of potential impacts associated with the expanded project:

1. ***Updated atmospheric dispersion modelling***
   A revised air modelling assessment, considering the cumulative impacts of the project in combination with the existing Channel Island Power Station, showed that predicted worst-case concentrations of all pollutants will meet accepted National Environment Protection Measures (NEPM) standards and no adverse effects on the residents of Darwin are anticipated. The selection of efficient gas turbine technology in the revised plant design will ensure that oxides of nitrogen (NO_x) are kept within acceptable levels.

2. ***Greenhouse gas emissions assessment***
   A comprehensive inventory of annual greenhouse gas (GHG) emissions anticipated from the project has been undertaken, identifying the contribution of a range of GHG mitigation efforts incorporated in the plant design. These include the addition of waste heat recovery and additional vapour recovery for ship loading, the use of high efficiency Frame 5D gas turbines, and use of low btu fuel. The outcomes of a greenhouse offsets review is presented in the PER, with offset options to be further investigated through commitments under the voluntary Greenhouse Challenge Programme. The volume of CO_2 produced by the project is approximately 4.5 MTPA compared to 1.7 MTPA for the 3 MTPA LNG project.

3. ***Assessment of heat envelope from flares on air traffic***
   Studies have been completed to address the potential impact of the main process flares on air traffic using Darwin Airport, and the outcomes reviewed by the Civil Aviation Safety Authority (CASA). The main process flare has also been redesigned from an elevated to a multi-burner ground configuration to minimize this impact. Discussions regarding further study requirements and management actions to minimise heat envelope impacts on air traffic with relevant authorities are continuing.

4. ***Wastewater discharge analysis***
   An investigation of options available for wastewater discharge from the proposed LNG plant was undertaken. While the original design for the previous 3 MTPA LNG plant included an outfall for treated effluent to be located along the loading jetty, the current design reflects Phillips' commitment to re-use and recycle wastewater discharges wherever practicable in accordance with NT Government policy. As such, the project will be designed so that all treated wastewater will be used for on-site irrigation. Direct outfall will only be considered as a contingency option.

   During construction of the storage tanks for LNG and condensate product on-site, there will be the requirement to discharge hydrotest water to Darwin Harbour at an agreed rate with DIPE. This will be investigated during the preparation of the final Environmental Management Plan to identify the concentrations and characteristics of any additives which may be required. DIPE approval will be sought prior to commencement of tank construction activities.

5. ***Analysis of solid and semi-liquid waste management***
   The capacity of existing infrastructure and services available in the Darwin region to handle the increased levels of solid and semi-liquid wastes anticipated from the larger 10 MTPA plant design was re-evaluated. As part of this evaluation, relevant waste management operators in the Darwin region were consulted to confirm that the range of non-hazardous and hazardous wastes can be suitably managed and disposed of safely in accordance with the provisions of the *Waste Management and Pollution Control Act 1998* and DIPE general requirements. Phillips' waste management procedure includes waste minimisation guidelines incorporated into the design of the LNG plant.

6. ***Updated noise modelling***
   A revised assessment of the likely noise impacts of the proposed LNG plant was undertaken, in recognition of the potential increase in ambient

noise levels from the expanded plant design. Noise generated by construction vehicle traffic and construction equipment during the construction phase is most unlikely to be noticeable above background at nearby communities, the closest being 7 km from the proposed LNG facility. Noise sources during upset and emergency operating conditions of the LNG plant will be of short duration and very infrequent. Operation of the plant is not expected to result in any unacceptable noise impacts due to the relatively low sound pressure levels associated with the proposed plant components and the relatively large distance to the closest noise sensitive receptor (over 7 km away).

7. ***Revised comparative visual impact assessment***
A comparative visual impact assessment was undertaken to assess the potential effects on visual amenity from the revised 10 MTPA proposal, and in particular how these may have changed from the previous design for the originally proposed 3 MTPA plant. The visual impacts between the 3 MTPA and 10 MTPA plants remained comparable, with the exception of the larger capacity LNG storage tanks. However these are not likely to significantly impinge on the landscape from Darwin Harbour. Some components, such as the main process flares, will now have a significantly diminished visual impact due their reconfiguration to a ground design. Visual impact of the development will be greater for vantage points within 500 m of Wickham Point. Beyond 500 m, the visual impact of the development will gradually diminish. Peak Hill, which stands at 32 m, will continue to buffer the main process area from the primary Darwin Central Business District view.

8. ***A revised hazard analysis and public risk assessment for the project***
A revised Hazard and Risk Assessment and a Preliminary Component Siting Study for the LNG plant was undertaken, with a focus on the changes in risk profile between the previously approved 3 MTPA plant and the currently proposed 10 MTPA plant. The main relevant changes are that now there are two LNG trains instead of one, greater LNG storage capacity than before, and more frequent shipping movements than for the previous proposal.

Though the plant capacity has been increased from 3 MTPA to 10 MTPA, the hazards are not significantly different than those of the previous proposal. The proposed facility will not have propane and butane product, therefore, hazards associated with these products have been eliminated. The fire radiation exclusion zones associated with LNG spill impoundment areas for the LNG Plant and the LNG tanks do not extend beyond the boundaries of the facility, and the increased shipping movements arising from the proposed expansion do not pose substantial additional risk to the people of Darwin.

All potential hazards that could rise from the operation of the LNG Plant are being addressed in the design, and practicable measures to prevent hazardous incidents will be adopted. This will be confirmed through final risk and hazard assessments to be undertaken during the final design phase.

9. ***Assessment of dredging and spoil disposal impacts***
Additional bathymetry information obtained since the approval of the 3 MTPA facility has indicated that the amount of dredging proposed in the turning basin and LNG jetty will be reduced and may not even be required. If it is required, only small volumes will be involved.

Most, if not all, of the dredging will now take place in East Arm for the approach channel and pocket berth to the construction dock. Some 145,000 m^3 (100,000 m^3 previously) of material will require disposal. These volumes represent non-substantial changes to those proposed for the original 3 MTPA plant.

The modelling previously undertaken for the EIS predicted dredging to cause temporary and localised increases in water turbidity. It also predicted that it was most unlikely that Channel Island coral communities will be exposed to water turbidity elevated above background levels as a result of dredging activities at the shiploading facility.

10. ***Updated ecological impact assessment***
The ecological impacts anticipated from the project remain very similar to those predicted for the previously approved 3 MTPA proposal. The most significant change is in relation to the requirement for the permanent removal of some 88.3 ha of vegetation and associated fauna currently existing within the plant site boundary, as compared to 66.8 ha for the approved 3 MTPA development and 100 ha for the 9 MTPA plant design. This represents a 32 percent increase from the original approved level of disturbance. The plant layout has been designed to minimise the amount of mangrove habitat and dry rainforest habitat to be cleared. The loss of good quality rainforest vegetation is recognised as a principal environmental cost of the proposed project. In order to offset this loss, Phillips has entered into discussions with the NT Government regarding the protection of alternative dry rainforest vegetation in the Darwin region for conservation purposes.

11. ***Socio-economic and cultural impact assessment***
The socio-economic environment of Darwin will be affected by the construction phase of the plant site in the following ways: 12 archaeological heritage sites, comprising nine shell middens and three remnants

of WWII sites will be disturbed; restriction of public access to the plant site area; increased road traffic to the plant site; and the costs and benefits of supporting a large construction workforce over a three year period.

The operational effects of the proposed 10 MTPA LNG Plant remain very similar to those identified in the 1997 Draft EIS. The project will produce substantial economic benefits to the region at little cost to the local community, including increased opportunities for employment while diversifying the economic base of the Territory; contribution of income to the region by way of production sharing income, demand for regional goods and services and export earnings.

12. ***A sustainability assessment of the project***
Phillips has undertaken a project sustainability assessment which integrates the environmental, social and economic aspects of the project to give a truer picture of overall sustainability. This assessment is summarised in the "Synopsis of Environmental and Social Costs and Benefits" presented at the end of this Executive Summary.

ENVIRONMENTAL MANAGEMENT

In November 1998, Phillips submitted a Preliminary Environmental Management Plan (EMP) for the original 3 MTPA LNG Plant and associated sub-sea gas pipeline. That EMP superseded previous commitments presented in the Supplement to the Draft EIS in that it was restructured to capture comments and approval conditions provided by Commonwealth and Northern Territory (NT) governments subsequent to their review of the Supplement. As a working document, the Preliminary EMP is not a public document but is generally consistent with the commitments included in the Supplement.

In relation to the proposed 10 MTPA LNG facility, Phillips intends to build on the previous environmental commitments for managing the approved 3 MTPA plant. The finalisation of the EMP will occur in stages following completion of the public review period for the PER and will be focused on reviewing those original commitments for their applicability. Preparation of the final plans outlined in the Preliminary EMP will be undertaken with due regard to the additional level of risk associated with the expanded project and comments received from interested stakeholders.

The overall objectives of the final EMP will be to establish management and monitoring plans which ensure that impacts of the facility are consistent with the PER, that the actual and potential adverse impacts associated with the construction, operation and decommissioning phases of the pipeline in the harbour and LNG plant are minimised, and that compliance with all relevant environmental regulations is achieved. The final EMP will comprise the same components as those outlined in the 1998 Supplement and the Preliminary EMP.

Additional Environmental Management Commitments

The outcomes of the updated assessment studies undertaken for the PER confirm that most of the anticipated environmental effects of the proposed 10 MTPA LNG plant essentially remain the same as those identified for the original 3 MTPA proposal. As such, the commitments detailed in the Preliminary EMP adequately address the majority of the anticipated effects of the project on the biophysical, cultural and socio-economic environments of Darwin Harbour.

However, evaluation of the modified project has identified a number of additional commitments to be implemented by the proponent, and one previous commitment that can no longer be sustained. These are outlined below:

1. ***Air monitoring***
Phillips will quantify the major emission sources following commissioning of the project by a targetted emission testing programme. If appropriate and in cooperation with other industrial proponents and the NT Government, Phillips will undertake to participate in a monitoring system for oxides of nitrogen (NO_x) from key emission sources. While the revised air modelling assessment clearly showed that predicted worst-case concentrations of all pollutants will meet accepted NEPM standards and no adverse effects are anticipated, when due consideration is given to cumulative effects from the existing Channel Island Power Station, NO_x worst case concentrations approach ambient limits.

2. ***Greenhouse emissions***
As part of its commitment to the Commonwealth Government's Greenhouse Challenge Programme, Phillips will develop a Cooperative Agreement with the AGO during the detailed design phase. This will include a corporate commitment to continual improvement in energy efficiency, development of a comprehensive greenhouse gas management strategy, and action plans for cost effective mitigation measures employed in the design of the revised project.

Phillips will continue to investigate other 'no regrets' and 'beyond no regrets' options for greenhouse minimisation. At this time plantation sequestration options, such as investment in oil mallee plantations, offer the greatest potential as tangible offset measures. Phillips will evaluate these options further during detailed design and construction, with periodic reviews throughout the life of the project.

3. Wastewater discharge

Phillips has re-designed the wastewater disposal component of the project. To avoid direct discharge into Darwin Harbour, all treated wastewater will now be used for on-site irrigation. Direct discharge will only occur as a contingency option.

During preparation of the final EMP, Phillips will undertake an evaluation of the proposed release of hydrotest water following construction of the storage tanks for LNG and condensate on-site. This will include an analysis of the commercial additives which may be present, their fate and anticipated environmental effects. Management measures to avoid potential adverse effects on the marine environment will be agreed with the DIPE prior to construction.

4. Waste disposal management

The proposed management measures to handle the increased levels of solid and semi-liquid wastes anticipated from the expanded plant design are detailed in the PER. These measures have been revised to ensure compliance with the *Waste Management and Pollution Control Act 1999*, which had not been enacted at the time of the previous assessment.

Waste minimisation and recycling principles will be built into all project operations so as to reduce solid and semi-liquid waste streams where possible.

5. Dry rainforest mitigation

Phillips will continue to work with the NT Government to identify a suitable area of dry rainforest in the Darwin region to be acquired for conservation purposes. Protection of dry rainforest of equal or better quality will offset the loss of dry rainforest required within the project area on Wickham Point.

6. Fauna Corridors

The restructure of major components within the plant site for the revised plant design has markedly reduced areas of natural habitat to the south of the plant. This has therefore created a physical barrier through the fauna corridor for the southern end of Wickham Point. However, due to site adjustments necessitated by the possibility of a future transportation corridor to the north of the plant site on Wickham Point, a suitable fauna corridor will remain on that side of the facility.

7. Public Risks

The PER details the outcomes of the revised Hazard Analysis and Risk Assessment undertaken to address the potential effects of the expanded 10 MTPA plant design and increased movements of LNG tankers in Darwin Harbour. It has been demonstrated that the siting, design, construction and operation of the proposed LNG plant is such that the safety and protection of persons, property and the environment will be maintained.

During the detailed engineering phase of the project, Phillips will undertake the following:

- a final HAZOP (Hazard and Operability) Study, to identify all potential scenarios arising from the failure of valves and controls or other upset conditions;
- a final QRA (Quantitative Risk Assessment), to identify, assess, evaluate and manage all potential risks associated with the project; and
- a detailed Safety Report for the LNG plant, in accordance with relevant Worksafe Australia Standards and prepared on the basis of the HAZOP and QRA studies outlined above.

8. Sustainability Reporting Framework

Phillips has undertaken to develop a reporting framework for assessing the design, construction and operation of the project consistent with the principles of Ecological Sustainable Development. Integration of the environmental, social and economic aspects of the project into a logic framework will enable Phillips to track its performance towards sustainable development of the LNG project. This will ultimately establish a tangible means to openly communicate the company's goals, objectives and performance measures through a public Sustainability Reporting process.

MONITORING PROGRAMME

The aim of the Environmental Monitoring Programme will be to test and validate the main predictions regarding the project effects which have the potential to adversely impact the environment. The monitoring programme also ensures that potential environmental effects are minimised and that the facility complies with any regulations governing particular activities.

EMERGENCY RESPONSE

A revised Hazard and Risk Assessment has been undertaken for the PER, to take into consideration the potential effects of the expanded plant design and increased shipping movements for the current revised proposal.

Emergency Response Manuals will be developed to control and manage:

- LNG plant accidents;
- LNG carrier accidents; and
- oil spills.

A series of Oil Spill Contingency Plans (OSCPs) will be prepared by Phillips to enable effective response during both the construction phase and the operation phase of the project.

DECOMMISSIONING

Phillips remains committed to the original position stated in the Preliminary EMP that, at the end of the project life, the plant will be decommissioned in accordance with standard practice applicable at the time.

Once all resources are exhausted and no feed is available for the LNG plant, plant equipment and piping will be purged of hydrocarbons. Plant and office equipment will be sold where possible unless the facility is sold as is. Equipment that cannot be sold will be disassembled and sold as scrap or disposed of in accordance with current regulatory guidelines. This includes the construction dock and product loading jetty.

The plant site will be rehabilitated as agreed with the Northern Territory Government and the native title parties.

SYNOPSIS OF ENVIRONMENTAL AND SOCIAL 'COSTS' AND 'BENEFITS'

In summary, the environmental and social 'costs' of the proposed project will principally be:

- alteration of a part of Wickham Point (88.3 ha) from a relatively unmodified wilderness 'island' to an industrial plant site (in accordance with community expectations as outlined in *Darwin Regional Land Use Structure Plan 1990*);.
- loss of 67.2 ha of good quality dry rainforest, or monsoon thicket (and associated fauna) , which is a remnant vegetation type that is of regional conservation value. This will be offset by protection of another area of dry rainforest in the region;
- modification of intertidal pavement and sand flat in the vicinity of the construction dock and the loading jetty, and their replacement by structures which will be recolonised by various marine organisms more suited to the new habitats;
- loss of seven, and possible disturbance of three, archaeological sites on Wickham Point (seven Aboriginal middens and three World War II heritage sites);
- increased road and harbour traffic during the construction phase and increased demand on community services, infrastructure and accommodation as a result of the construction workforce;
- restricted public access to the plant site and 500 m safety exclusion zone around the loading facility and construction dock;
- modified flight path for southern approaches to the north/south runway at Darwin Airport, dependent on current discussions with CASA;
- high volume discharge of carbon dioxide into the atmosphere (4.5 MTPA). Offset options will be investigated through the Greenhouse Challenge Programme;
- low volume discharge of atmospheric emissions of NO_x, SO_2, and PM10 at acceptable concentrations below NEPM standards; and
- low volume disposal of a range of hazardous and non-hazardous wastes to approved onshore sites in accordance with government requirements.

The above costs will be balanced to a large extent by the following environmental and social 'benefits' of the project:

- development of new sources of energy and production of clean burning LNG for industrial fuel purposes and natural gas for domestic use;
- financial contribution to the Governments of Australia and East Timor through revenue sharing resulting from the development of the gas reserves in the Timor Sea through processing at the Darwin LNG project;
- significant contribution to the regional economies of East Timor and Australia via export earnings and income sharing, taxes and salaries and purchases of goods and services during the construction and operation phase of the development;
- the use of LNG and natural gas as a preferred fuel for existing and new facilities, in place of alternative fossil fuels, will reduce global greenhouse gas emissions in accordance with the objectives of the Kyoto Protocol;
- provision of significant employment and training opportunities in Darwin during the construction phase of the development, that will result in a more diverse skilled labour force for support of future oil and gas developments in the region;
- diversification of the local economic base and the supply of infrastructure for future long term development of Timor Sea gas reserves;
- the project will be developed with a commitment to ensure responsible management of all aspects of the project in accordance with the principles of Ecologically Sustainable Development (ESD) in consultation with the community;
- the project will not threaten any populations of rare or endangered species, nor will it threaten currently designated conservation reserves in the Darwin area. In fact, the conservation of dry rainforest habitat in the Darwin area will increase once a suitable portion of that habitat is located, purchased and placed in reservation; and
- given that the environmental risks posed by the project are minimal and manageable, and that biodiversity will not be threatened and conservation reserves will be increased, and also given the

economic and social benefits that will accrue to the community of Darwin if the project proceeds, it is considered that future generations of Territorians will applaud the decision by this generation to proceed with the project.

With the exception of higher atmospheric emissions, higher levels of rainforest impacts and higher economic activity, these environmental and social "costs" and "benefits" are generally the same for both the approved 3 MTPA LNG facility and the proposed 10 MTPA LNG facility.

1. INTRODUCTION

1.1 OBJECTIVE AND STRUCTURE OF DOCUMENT

This document is a Public Environmental Report (PER) for a proposal to construct and operate a Liquefied Natural Gas (LNG) plant on Wickham Point near Darwin, Northern Territory (Figure 1.1) of up to 10 million tonnes per annum (MTPA) capacity. It builds on environmental assessment documents previously prepared in 1997 and approved in 1998 for the construction and operation of a proposed smaller 3 MTPA LNG facility at the same location. Construction of the original proposed facility was deferred after the assessment was completed due to global economic issues.

The PER is submitted by Phillips Petroleum Company Australia Pty Ltd to provide the Northern Territory Government, agencies of the Commonwealth of Australia, and the public with the information necessary to allow an informed appraisal of the environmental acceptability of the proposed project. Phillips Petroleum Company Australia Pty Ltd has been established to construct and operate the new LNG facility and replaces the original proponent of project, Phillips Oil Company Australia.

This PER has six sections structured generally in accordance with Northern Territory Department of Infrastructure, Planning and Environment (DIPE, formerly DLPE) Guidelines for the PER (which are presented in Appendix A):

- *Section 1* introduces the proponent and the proposed project, highlighting the primary changes to the previous environmental assessment for the proposed 3 MTPA LNG plant undertaken in 1997/'98. It also presents a brief description of the environmental assessment requirements for the Northern Territory and Commonwealth Governments, and introduces the scope of works undertaken for the PER.
- *Section 2* describes the project, including its major components and their construction and operation phases, and identifies the changes from the project description previously outlined in the original Draft EIS (1997) and Supplement of 1998.
- *Section 3* describes the physical, biological, cultural and socio-economic environment in which the project will operate.
- *Section 4* analyses the potential and anticipated environmental effects of the proposed expansion, including a revised risk assessment analysis for the expanded plant design. Its principal focus is to discuss those aspects of the LNG project which have changed since the original 3 MTPA LNG assessment was completed.
- *Section 5* outlines the environmental management programme proposed for the expanded project, and builds on the preliminary environmental management commitments made by the proponent in the previous assessment of the smaller plant.
- *Section 6* acknowledges sources of information used in the development of the PER, the published literature and reports referred to in the text, and presents a glossary of technical terms used in the PER.

Technical appendices, which provide detailed information on impact assessment studies undertaken to address the effects of the proposed expansion, are included in this report.

1.2 THE PROPONENT

Phillips Petroleum Company is an integrated petroleum company with interests around the world. Headquartered in Bartlesville, Oklahoma, the company had 38,600 employees, $35.4 billion of assets and $22.5 billion of annualized revenues at September 30, 2001. A description of the company as contained in its most recent "Quarterly Fact Sheet" and additional information can be found at :

http://www.phillips66.com/about/brief.pdf.

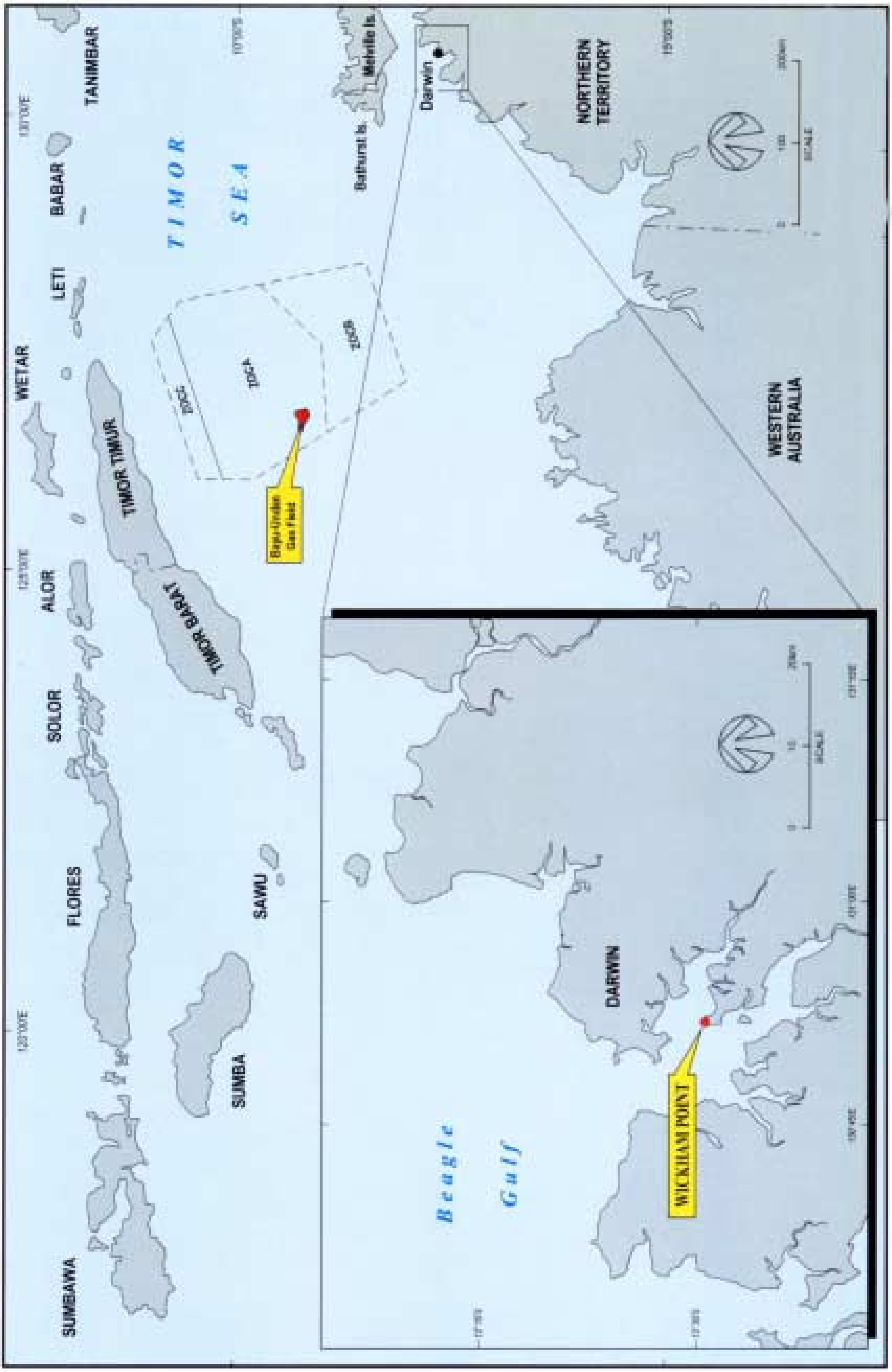
On September 14 2001, the company closed its acquisition of Tosco Corporation, positioning Phillips as a leading petroleum refining and marketing competitor in the United States.

The company operates in a range of countries worldwide, undertaking the following core activities:

- petroleum exploration and production on a worldwide scale;
- natural gas gathering, processing and marketing in the USA;
- petroleum refining, marketing and transportation primarily in the USA;
- chemicals and plastics production and distribution worldwide; and
- technology development and licensing worldwide.

Phillips Petroleum Company has a strong exploration and production (E&P) group that contributes to Phillips' integrated strengths by exploring for and producing oil, natural gas and natural gas liquids (NGL) on a worldwide scale.

As the company's largest segment, E&P had assets of US$14 billion at December 31 2000, and conducted exploration in 14 countries, producing in nine: the United States, the Norwegian, Danish and U.K. sectors



Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 1.1**
Report No.	R841	**LOCATION PLAN**	URS
Date	Dec 01		

of the North Sea, Canada, Nigeria, Venezuela, the Timor Sea between East Timor and Australia, and offshore China. Average worldwide crude oil production for 2000 was 437,000 barrels per day (B/D), and worldwide gas production was approximately 1.4 billion cubic feet per day.

Prior to combining its gas gathering, processing and marketing assets with those of Duke Energy in 2000 to form Duke Energy Field Services, Phillips Petroleum, through its Gas Gathering, Processing & Marketing (GPM) subsidiary, was one of the largest natural gas liquids producers in the US. The plants and systems operated by GPM were and remain among the most efficient in the natural gas industry. Phillips Petroleum retains significant interest in the GPM business through its equity interest in Duke Energy Field Services.

Phillips Petroleum Company has over 30 years of operating experience with LNG. Phillips Petroleum Company was the first company to market LNG to Japan with the startup of its Kenai, Alaska, plant in 1969. Since that time, the company has established LNG commercial operations across many locations around the world including the United States, Europe and Africa.

Phillips controls a 58.5 percent interest in the combined Bayu-Undan gas condensate field in Area A of the Zone of Cooperation (ZOC) located in the Timor Sea between East Timor and Australia. When a new Treaty is ratified by Australia and East Timor, this area will be renamed the Joint Petroleum Development Area (JPDA). All future references in this document will adopt the JPDA name for this major region. The proven plus probable reserves of the Bayu-Undan field are estimated to be 400 million barrels of liquids and 3.4 trillion cubic feet (TCF) of gas. Phillips Petroleum LNG Pty Ltd will be developer and operator of the LNG facility located at Wickham Point.

In addition to its interests in the Bayu-Undan field, Phillips Petroleum Company, through various subsidiary companies, also holds a 30% share of the Greater Sunrise field location in the central Timor Sea and operated by Woodside. This major gas field lies partly within the JPDA and partly in waters under Australian jurisdiction and has proven plus probable reserves estimated to be 300 million barrels of liquids and 9.2 TCF of gas.

Phillips proposes to use natural gas produced from one or both of these fields plus gas anticipated to be available during the life of the LNG facility from other strategically important Timor Sea gas fields to feed the Wickham Point LNG plant. Phillips' approach since 1996 in relation to Timor Sea gas development has been and remains to gather and transport gas from a variety of fields to a central location near Darwin to treat, process and distribute gas to a number of domestic and export customers. The proposed LNG facility represents one of several viable market opportunities for Timor Sea gas.

The person nominated as representative for the Proponent and contact details are as follows:

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Australia 0801

1.3 PROPONENT'S HEALTH, SAFETY AND ENVIRONMENTAL POLICY

Phillips recognises that Health, Environment and Safety (HES) is inextricably linked to financial and operating performance, and has a proven commitment to developing and implementing a management system that integrates HES into every aspect of business. This HES Management System is part of a larger systems-based approach to achieving operating excellence throughout the company.

The company's Health, Environment and Safety Policy, as adopted by the Australasia Division, is summarised below:

"Phillips Petroleum Company Australasia Division will conduct all operations in a manner that protects human safety and health, the environment and company property, while complying with all applicable laws and regulations. Moreover, the company will strive for continuous improvement in these areas.

Health, Environment and Safety protection is a line responsibility that extends to all levels of management. All employees and contractors are to perform their work in accordance with this policy.

This policy is carried out through the following practices:

- *seeking continual improvement of the health, environmental and safety management systems through the use of the Process for Safety and Environmental Excellence;*
- *providing the necessary resources;*
- *informing employees of this policy and providing them the training to safely perform their individual responsibilities and duties safely and in an environmentally responsible manner;*

- *providing relevant safety and health information to contractors and requiring them to provide proper training to perform their individual responsibilities safely and in an environmentally responsible manner;*
- *incorporating health, environment and safety requirements at the design phase and in operations;*
- *reviewing and reporting the performance of the company's operations and facilities on a periodic basis;*
- *conducting industrial hygiene, safety and environmental reviews of existing facilities and properties for acquisition or sale;*
- *establishing and maintaining communications on health, environment and safety issues with our communities, as well as with concerned groups and regulatory agencies;*
- *providing appropriate equipment for the safe performance of the work;*
- *establishing, maintaining, and reviewing with our communities, as well as with concerned groups, Emergency Readiness Plans to minimise health impacts, injuries, damage to environment, and/or property loss to the community or company; and*
- *encouraging and supporting sound research and engineering to produce technology and products consistent with Phillips Petroleum's objectives.*

Any employee who knowingly violates applicable health, environment and safety policies, laws and/or regulations will be subject to disciplinary action, up to and including discharge.

The complete commitment of all employees and contractor personnel is essential to accomplishing Phillips Petroleum Company's Australasia Division's goal of being a safe and environmentally responsible operator.

Stephen R. Brand
President
Phillips Australasia Division"

1.4 BACKGROUND TO PROPOSAL

1.4.1 Previous Project Assessment

The Proponent has previously (August 1997) submitted a Draft EIS to the NT DIPE and Environment Australia (EA) for evaluation of a proposal to construct a 3 million tonnes per annum (MTPA) LNG Plant at Wickham Point in Darwin, linked by a subsea pipeline from the Bayu-Undan gas field [Dames & Moore (D&M 1997)].

The Draft EIS was subject to Government and public review (under both the Commonwealth *Environment Protection (Impact of Proposals) Act 1974* and the NT *Environmental Assessment Act 1982*) until end September 1997. Submissions received from government and public commentators were considered, and appropriate measures were submitted in response to address each issue raised during the public review process.

In broad terms the original project evaluated in 1997/98 included the construction and operation of the following major components (Figure 1.2):

- a subsea pipeline up to 36 inches in diameter from the Bayu-Undan field to an LNG plant on Wickham Point in Darwin Harbour;

- a 3 MTPA air cooled LNG plant which comprises:
  - gas processing facilities to treat and liquefy the natural gas and to recover LPG product,
  - product storage tanks,
  - plant infrastructure and utilities,
  - three plant flares, and
  - on-site power generation facilities;

- a loading jetty on the west side of Wickham Point to transfer product to tankers for shipping to market;

- a construction dock on the north-east side of Wickham Point for transfer of building materials and heavy equipment that may not be suitable for road transport to the plant site;

- an access road through the Middle Arm Peninsula to the plant site; and

- the transportation of LNG and other products to markets using a number of large ships (95 - 135,000 m^3 capacity).

In January 1998, Phillips filed a Supplement to the Draft EIS in response to the comments received during the public review process (D&M 1998a). The Supplement plus the original Draft EIS together constituted the Final EIS for that project and formed the basis for government decisions regarding the environmental implications of the original project. It included a revised site development plan for a possible expansion of the facility to 9 MTPA LNG on Wickham Point, information relating to the probable impacts from such expanded plant, an updated draft of the Preliminary Environment Management Plan (EMP) and a summary of Proponent commitments.

Environment Australia (EA) and NT DIPE responded to the Supplement in February and March, 1998, respectively, by issuing separate Environment Assessment Reports which concluded that the *3 MTPA LNG Plant could proceed subject to Phillips' implementing the proposed project in accordance with commitments made in the Supplement and the additional recommendations made by EA and NT DLPE.*

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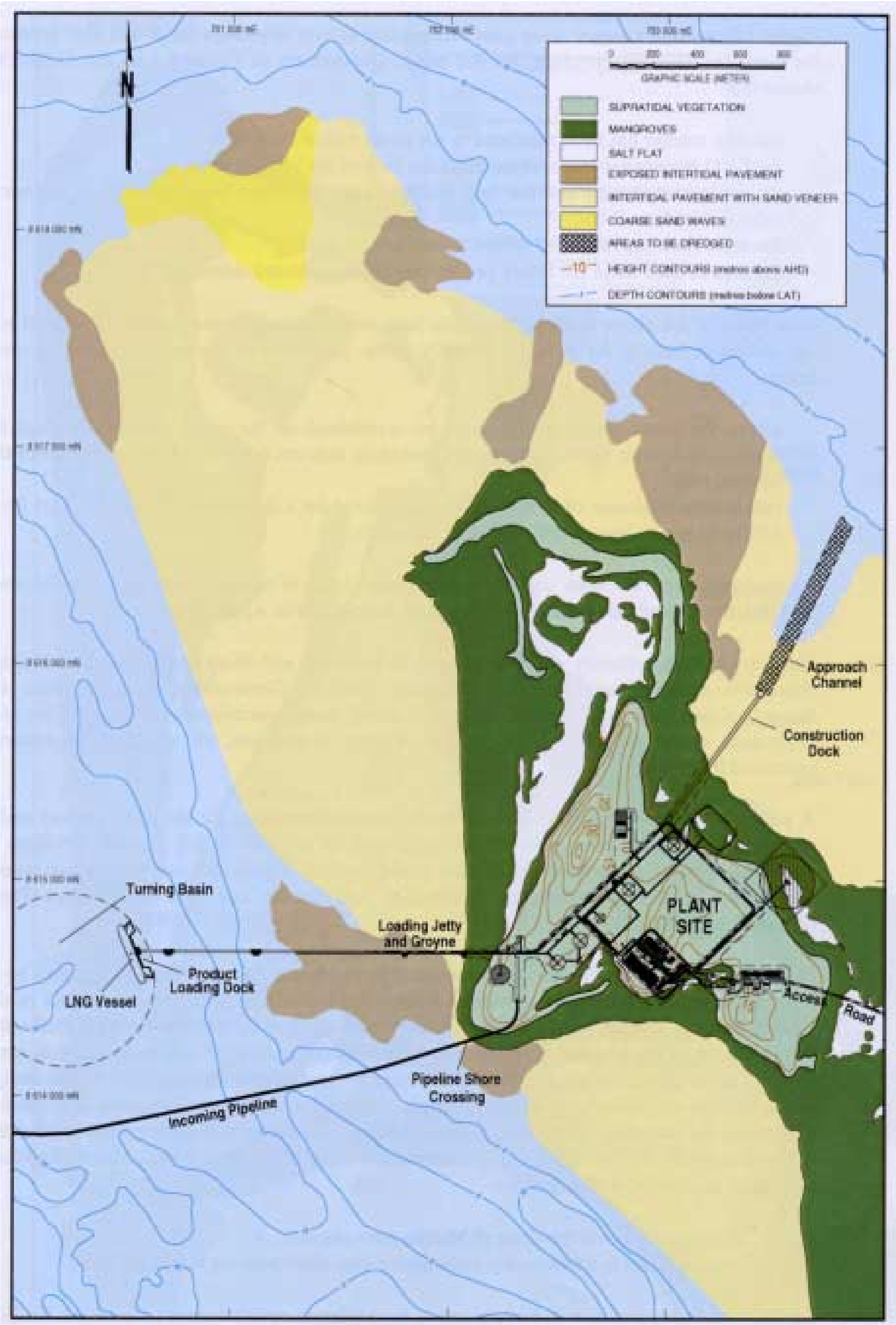

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 1.2**
Report No.	R841	**MAJOR COMPONENTS OF APPROVED 3 MTPA LNG PROJECT**	URS
Date	Dec 01		

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Letters from both the Commonwealth and Northern Territory Ministers for the Environment confirmed project acceptance. Information regarding a possible 9 MTPA plant was considered during the review process as indicative of the effects of a larger manufacturing facility but approval was limited to the 3 MTPA plant.

The principal recommendations in the NT DIPE Assessment Report (Nos 1 and 2) are reproduced below. EA issued essentially identical recommendations.

> "*Recommendation 1*
> The proponent shall ensure that the proposal is implemented in accordance with environmental commitments and safeguards identified in the Darwin LNG Plant draft Environmental Impact Statement, as modified in the Supplement to the draft EIS and as recommended in this assessment report."

> "*Recommendation 2*
> In preparing the Environmental Management Plan the proponent shall include any additional measures for environmental protection and monitoring contained in recommendations made by the Commonwealth and Northern Territory Governments with respect to the proposal. The EMP shall be referred to Environment Australia and relevant NT agencies for review prior to finalisation, after which it shall become a public document. The EMP shall form the basis for any approvals and licences issued under the forthcoming Waste Management and Pollution Control Act."

In April 1998, a meeting was convened by NT DIPE involving the Proponent and all major government agencies associated with the project to develop an Implementation Strategy for the recommendations made by the NT and Commonwealth governments. Arrangements for responsibilities to be assumed by relevant agencies in implementing final approvals were agreed upon at the meeting. In summary, NT DME assumed responsibility for matters related to the marine pipeline, EA assumed responsibility for matters related to greenhouse gas emissions, and NT DIPE assumed responsibility for all remaining matters related to the construction and operation of the LNG plant.

Subsequent to the above meeting, the Preliminary EMP was updated in November 1998 and expanded to capture all NT DIPE and EA recommendations, and to include EA's comments, identify the responsible and advisory authorities for each recommendation, and provide clarification of interpretation for each recommendation as required (D&M 1998b).

With the potential cooperative development of the Bayu-Undan and other central Timor Sea gas fields, there are now sufficient gas reserves in the Timor Sea to support a larger LNG plant than originally envisaged by Phillips, which was based solely upon the reserves of Bayu-Undan. In May 2001, a Notice of Intent (NOI) was submitted by Wickham Point Pty Limited, an affiliated company of Phillips Petroleum Company Australia Pty Ltd, to NT DIPE for a proposed LNG facility of up to 10 MTPA at the same Wickham Point location (URS 2001; Figure 1.3). In Phillips' opinion, the current 10 MTPA proposal represents the optimum sized LNG facility for location at the Wickham Point site and it is unlikely that any material expansion of such facility, other that de-bottlenecking improvements, would be considered in the future.

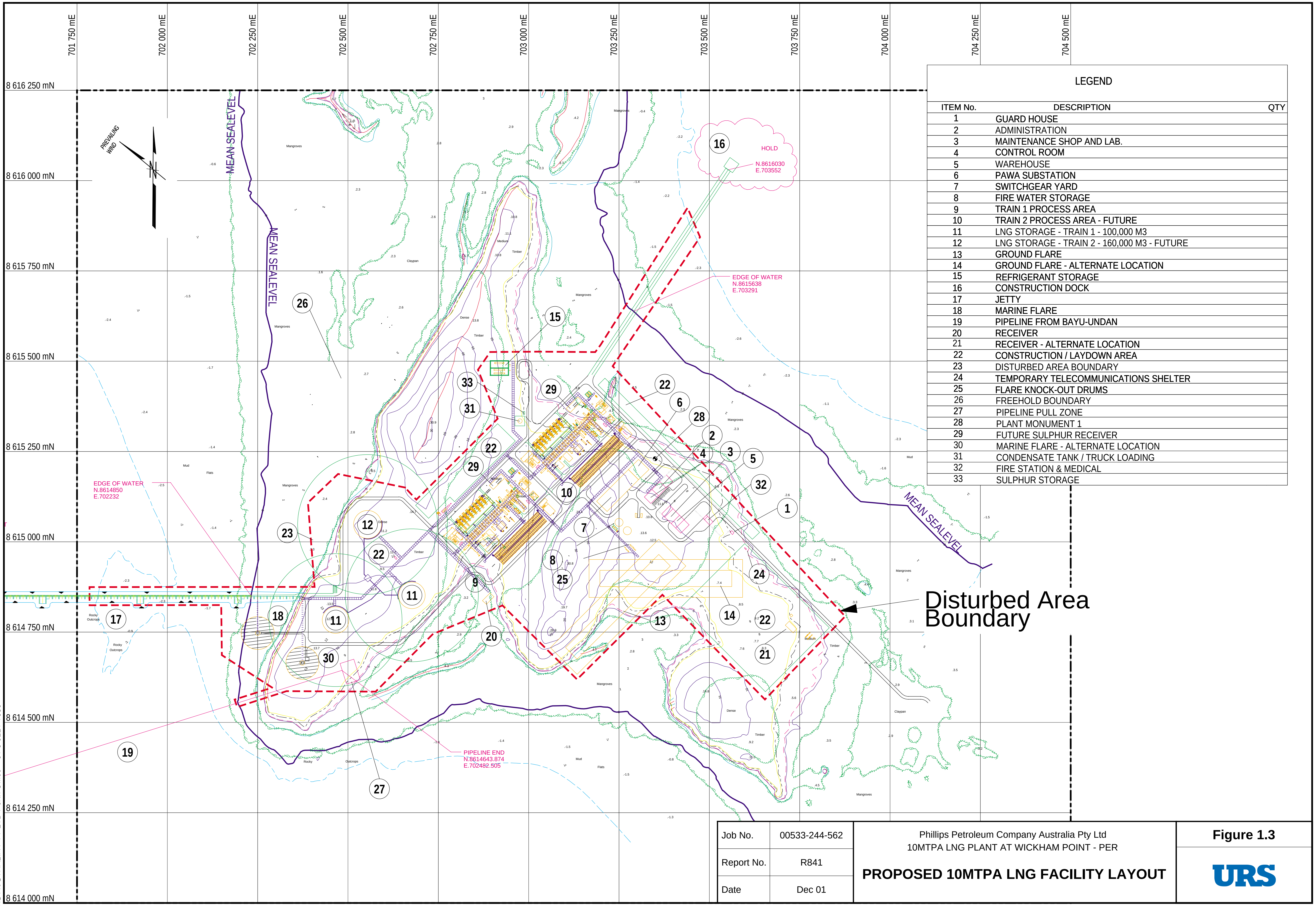
The current PER builds upon the previous environmental assessments, and will facilitate completion of the EMP to the satisfaction of the (now NT Department of Infrastructure, Planning and Environment (NT DIPE; formerly NT DLPE) and EA as a condition of project approval.

1.4.2 History of Project since Approval obtained in 1998

Shortly after environmental approvals were issued for the 3 MTPA plant at Wickham Point in 1998, the LNG market underwent a dramatic downturn principally as a result of weakening economic conditions in the principal LNG receiving nations in Asia. Phillips suspended engineering work on the LNG project and focused its efforts on developing the liquids phase of the Bayu-Undan field. During the intervening period, Phillips concentrated gas marketing efforts on domestic opportunities but also continued to seek LNG customers for a Darwin plant. Phillips also continued to progress development of the necessary gas pipeline infrastructure to deliver Timor Sea gas to customers in Australia.

In September 2000, Phillips entered into an agreement with Multiplex Constructions relating to construction of a gas pipeline from the central Timor Sea to Darwin. The agreement covered engineering, design and survey work in preparation for procurement, fabrication and installation of a pipeline from Bayu-Undan to a site at Wickham Point in Darwin Harbour. Multiplex, with the support of its principal subcontractors, Kvaerner, Saipem and EMC, provided Phillips a lump-sum, fixed-cost price relating to installation of a 26-inch pipeline along with options for several larger pipeline sizes. The former size would be adequate for the supply of Bayu-Undan gas alone, while the larger capacity option would accommodate the gathering and transportation of larger volumes of gas from other Timor Sea gas fields.

In February 2001, Phillips, Woodside and Shell finalised principles for co-operative development of the Bayu-Undan and Greater Sunrise resources. The agreement was designed to combine the early gas delivery potential of the Bayu-Undan gas and condensate development



LEGEND

ITEM No.	DESCRIPTION	QTY
1	GUARD HOUSE	
2	ADMINISTRATION	
3	MAINTENANCE SHOP AND LAB.	
4	CONTROL ROOM	
5	WAREHOUSE	
6	PAWA SUBSTATION	
7	SWITCHGEAR YARD	
8	FIRE WATER STORAGE	
9	TRAIN 1 PROCESS AREA	
10	TRAIN 2 PROCESS AREA - FUTURE	
11	LNG STORAGE - TRAIN 1 - 100,000 M3	
12	LNG STORAGE - TRAIN 2 - 160,000 M3 - FUTURE	
13	GROUND FLARE	
14	GROUND FLARE - ALTERNATE LOCATION	
15	REFRIGERANT STORAGE	
16	CONSTRUCTION DOCK	
17	JETTY	
18	MARINE FLARE	
19	PIPELINE FROM BAYU-UNDAN	
20	RECEIVER	
21	RECEIVER - ALTERNATE LOCATION	
22	CONSTRUCTION / LAYDOWN AREA	
23	DISTURBED AREA BOUNDARY	
24	TEMPORARY TELECOMMUNICATIONS SHELTER	
25	FLARE KNOCK-OUT DRUMS	
26	FREEHOLD BOUNDARY	
27	PIPELINE PULL ZONE	
28	PLANT MONUMENT 1	
29	FUTURE SULPHUR RECEIVER	
30	MARINE FLARE - ALTERNATE LOCATION	
31	CONDENSATE TANK / TRUCK LOADING	
32	FIRE STATION & MEDICAL	
33	SULPHUR STORAGE	

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Phillips Petroleum Company Australia Pty Ltd
10MTPA LNG PLANT AT WICKHAM POINT - PER

PROPOSED 10MTPA LNG FACILITY LAYOUT

Figure 1.3

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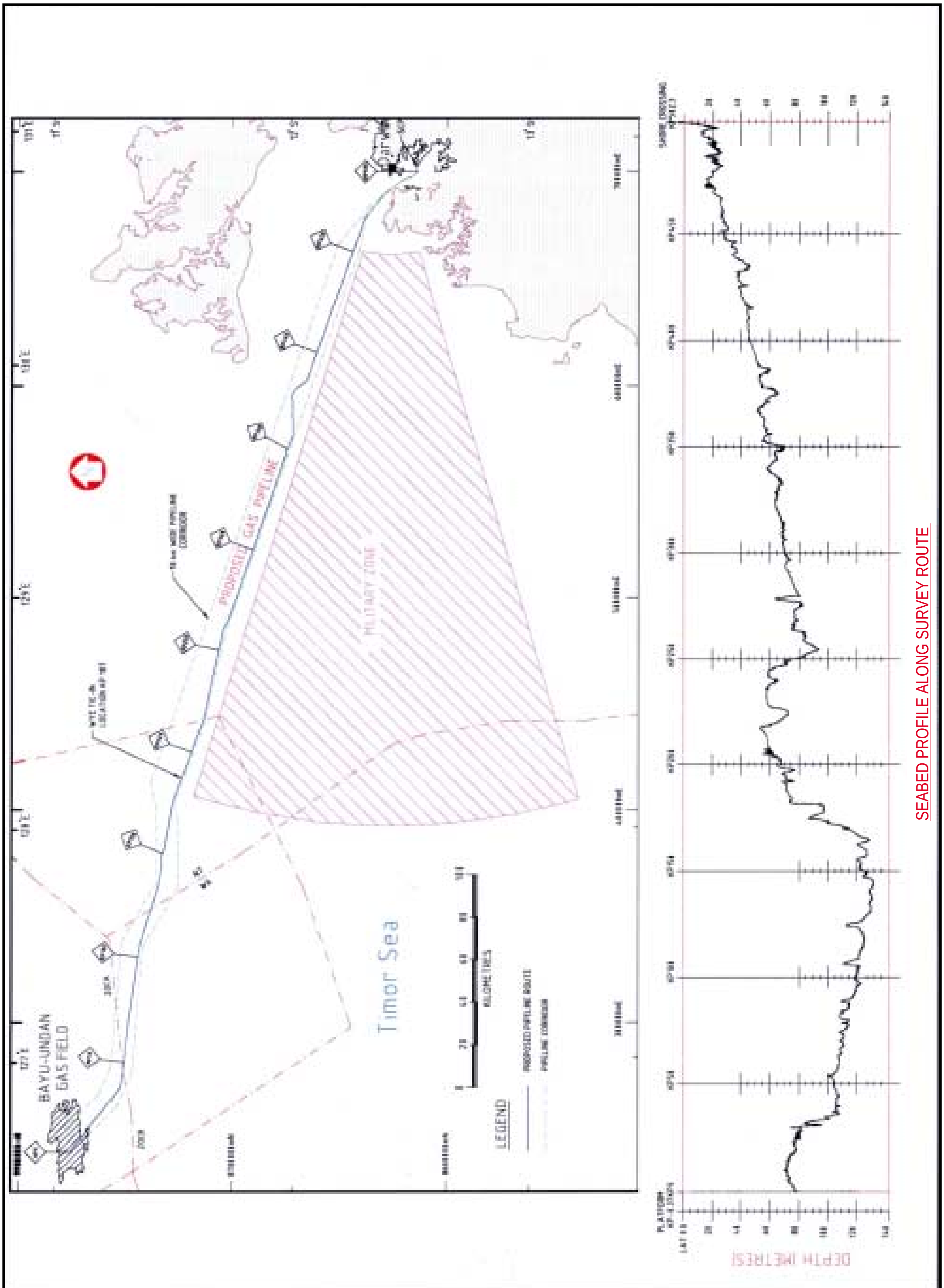

Job No.	00533-244-562		Phillips Petroleum Company Australia Pty Ltd 10 MTPA LNG PLANT AT WICKHAM POINT - PER **PIPELINE ROUTE AND SEABED PROFILE**	**Figure 1.4**
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with the larger gas reserve base of the Greater Sunrise fields to attract the greatest number of customers for Timor Sea gas. The agreed principles covered supply of gas and marketing of LNG, pipeline infrastructure and field optimisation. As a consequence of this agreement, Phillips increased its share of the Greater Sunrise fields to 30 percent.

On 1 August 2001, Phillips announced that the offshore pipeline from Bayu-Undan to Darwin was being deferred indefinitely pending resolution of several critical legal, fiscal and taxation matters relating to the terms of Production Sharing Contracts (PSCs) under a new Timor Sea Treaty between Australia and East Timor. At the current time, discussions between the governments and the holders of relevant PSCs are continuing.

In addition to steps taken to progress the requisite environmental approvals, Phillips has also continued to progress other matters critical to the success of the proposed LNG venture.

In 1996 Phillips applied to the Northern Territory to acquire a site on Wickham Point for the installation of gas processing facilities and/or distribution to other domestic markets within the Northern Territory or interstate. All matters relating to Native Title and Aboriginal Land Rights claims affecting both the plant site and offshore pipeline route have been resolved, as a result of an agreement executed in 1999 between the Proponent and various native title parties. The NT Government completed the acquisition of native title in mid-2000 and is in a position to offer land to non-government parties under the terms of its acquisition. Phillips and the NT Government have concluded negotiations on terms associated with Phillips long term interests in Wickham Point and will finalise necessary agreements when a commitment to the Bayu-Undan gas export project is secured.

In 1997 Phillips applied for several licenses for the offshore pipeline from Bayu-Undan to Wickham Point (Figure 1.4). In April 2001, the first two of four licenses required by Australian authorities were issued to Phillips Pipeline Australia Pty Ltd. Preliminary discussions with the Timor Gap Joint Authority on various gas export options have been conducted, and a Gas Development Plan is being drafted. As a consequence of these efforts, customers have begun to demonstrate confidence in the Timor Sea as a significant new source of gas for LNG production, greenfields gas processing and interstate domestic gas sales purposes.

In March 2001 a Phillips' affiliate executed a Letter of Intent for the sale of 4.8 million tonnes of LNG to El Paso Energy to be delivered to North American markets commencing in 2005. The long-term supply of gas for this market was expected to be the reserves of Greater Sunrise with Bayu-Undan supplying gas to the facility until such time as the Greater Sunrise project we operational. While there is some question about the status of Greater Sunrise development, Phillips is continuing to market Bayu-Undan gas to other LNG customers and believes there is a strong possibility that such customers can be secured within a reasonable timeframe. As a result of these developments, Phillips wishes to amend its approved 3 MTPA LNG project as noted herein and to secure environmental approvals for the larger 10 MTPA facility.

In addition, the NT Government is currently in the process of constructing the arterial road corridor through Middle Arm Peninsula, which will provide the necessary road access to the proposed Wickham Point plant site. A detailed geotechnical site survey has recently (August 2001) been completed to obtain current baseline data on the geophysical condition of the area.

Environmental approvals from the Commonwealth and NT governments were issued for the pipeline between Bayu-Undan and Wickham Point in early 1998. The NT and WA governments have issued two of four pipeline licences relating to this pipeline. These licences incorporate conditional approval relating to the discharge of hydrotest water from a subsea wye-piece located 186 km south-east of the Bayu-Undan field. Any remaining environmental matters relating to the pipeline will be managed through amendments to the Environment Plan by the NT Department of Business Industry and Resource Development (NT DBIRD, formerly NT DME) in accordance with the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999*. Therefore, this PER does not address the subsea pipeline between Bayu-Undan and Darwin.

1.5 THE CURRENT PROPOSAL COMPARED TO PREVIOUS PROJECT

As with the previously approved 3 MTPA facility, the proposed 10 MTPA project will involve construction and operation of the following major components:

- an LNG plant utilising the Phillip's Optimised Cascade LNG Process which comprises:
  - gas processing facilities to remove impurities and refrigerate the natural gas;
  - product storage tanks;
  - plant infrastructure and utilities;
- a loading jetty on the west side of Wickham Point in Middle Arm of Darwin Harbour to transfer product to tankers for shipping to market;
- a construction dock on the north-east side of Wickham Point in East Arm of Darwin Harbour for transfer of building materials and heavy equipment; and
- a number of large ships to transport LNG from Wickham Point to global markets.

The project will comprise the same major components as proposed for the previously approved 3 MTPA Project, but will differ principally in the capacity of the LNG plant and its layout on Wickham Point (shown in Figure 1.3). The access road, which will be constructed by the NT Government, has been relocated slightly and incorporated into a major arterial transport corridor originally proposed for construction by the NT Government in the Darwin Regional Land Use Structure Plan 1990. The main process flare has been relocated to the south of the process area also as a result of this transport corridor and has been redesigned from a single elevated flare to a multi-burner ground level configuration.

The principal differences between the approved plant layout shown on Figure 1.2 and the proposed new plant layout shown on Figure 1.3 are as follows:

- the disturbed area envelope has increased in size and changed shape slightly, in regard to the spill impoundment area, the main flare area, and the south eastern part of the plant site;
- instead of one 3 MTPA LNG process train, the plant will now comprise two LNG process trains totalling up to 10 MTPA. These trains will still use the Phillips' Optimised Cascade LNG process as described in the Draft EIS. The increased plant capacity will result in increased volumes of atmospheric emissions and waste materials requiring disposal;
- instead of two LNG storage tanks there will be three larger tanks;
- the new facility will not produce commercial quantities of other LPG products (i.e. propane and butane) for export as originally proposed, as the feed stock gas will be processed offshore to remove LPGs. Any recoverable LPG products will be blended back into the finished LNG product. The only other saleable product will be small volumes of stabilised hydrocarbon condensate;
- the construction dock will now contain a dredged berthing pocket to –6 m AHD (Australian Height Datum) at the seaward end, instead of a gravel pad exposed at low tide;
- the length of the shiploading facility has been reduced by about 100 m to avoid the need for dredging in the turning basin;
- instead of an elevated main flare as originally proposed for the 3 MTPA plant, a large ground flare is proposed for the 10 MTPA plant;
- a metering facility has been located to the south of the main plant area where the metering and delivery of gas to domestic markets will occur; and
- the shore crossing for the offshore pipeline onto Wickham Point has been relocated 200 m south of the point originally identified.

Initial site preparation, involving the access road to Wickham Point being constructed by the NT Government and some preliminary land clearing for the pipeline installation project, will be required in late 2002. Construction of the first phase (one process train up to 5 MTPA) proposed LNG facility is anticipated to commence in early 2003 and be completed by early 2006. Construction of the second LNG process train, if additional gas supply arrangements can be secured, is expected to commence in late 2003 and be completed in late 2006.

1.6 ENVIRONMENTAL ASSESSMENT REQUIREMENTS AND PROCEDURES

1.6.1 Northern Territory Legislation and Licence Requirements

The *Environmental Assessment Act (1982)* and the *Environmental Assessment Administrative Procedures (1984),* under which the Act is implemented, form the basis of the Northern Territory environmental assessment process. The Northern Territory Minister for the Environment (the Territory Minister) is responsible for administering the Act and Procedures. The primary purpose of the assessment process is to provide for appropriate examination of proposed new projects that may cause significant environmental impact.

The level of environmental assessment varies depending on the sensitivity of the local environment, the scale of the proposal and its potential impact. Generally, there are four phases in the environmental assessment process:

Phase 1: Notice of Intent (NOI). An NOI for the proposed expanded LNG project was submitted to the Northern Territory Government on 9 May 2001. The NOI provided an outline of the proposed development to assist the Minister and his department to determine what level of environmental assessment was required for the proposed development. Information within the NOI and consultation with other relevant agencies enabled the DIPE to prepare guidelines concerning matters to be addressed in a PER or an EIS.

Phase 2: Level of Assessment - PER or EIS? If the proposal is considered to have significant environmental impact, the proponent is directed to prepare a PER or an EIS by the Minister. The primary difference between the two is:

- PER - deals with proposals that have environmental issues that are considered limited;
- EIS - the environmental impacts are considered significant in terms of site specific issues, off-site issues, conservation values and/or nature of the proposal.

Phase 3: Public Review of Guidelines and Assessment Report. Draft guidelines covering issues to be addressed in the PER were released for public and government review on 21 July 2001. On 31 October 2001, final guidelines were issued by the Minister for the Environment (Appendix A).

Upon lodgement of the Draft PER by the proponent, the documents are made available for public and government review and comment. The period for public review and comment for a Draft PER is a maximum of 28 days.

Phase 4: Final Documents. For a PER, the NT DIPE (formerly DLPE) will prepare an assessment report and recommendations for approval by the Minister, who in turn forwards the report and recommendations to the responsible Minister for incorporation in lease or license conditions, and relevant management procedures. The assessment report and recommendations represent a consolidation of issues raised by the advisory bodies and in the public comments.

Licence conditions for the plant (if approved) will be established in accordance with the *Waste Management and Pollution Control Act 1999.*

1.6.2 Commonwealth of Australia Legislation

The original 3 MTPA LNG project has already been assessed under the *Environment Protection (Impact of Proposals) Act 1971* (*EPIP Act*), which was replaced with the *Environment Protection and Biodiversity Conservation Act 1999* in July 2000.

The *Environmental Reform (Consequential Provisions) Act 1999* provides transitional arrangements between the old legislation and the new Act, which determines that the project remains under the EPIP Act. A referral was submitted to EA on 13 August 2001 to confirm that assessment of the PER under NT legislation addresses the requirements of both the NT and Commonwealth Governments. After a period of public comment, the Commonwealth Minister for the Environment confirmed on 20 September 2001 that assessment of the project as a new proposed action under the *EPBC Act* is not warranted. Rather, the revised proposal will be assessed primarily under the NT *Environmental Assessment Act*, and concurrently reviewed under the provisions of paragraph 10 of the Administrative Procedures approved under the *EPIP Act* (EPIP Administrative Procedures).

1.7 SCOPE OF WORKS UNDERTAKEN FOR PER

1.7.1 Investigations

Since the time of the previous environmental assessment, the following impact assessment studies have been undertaken to update the baseline information of the existing environment and identify potential impacts associated with the expanded project:

- an updated atmospheric emissions inventory for the proposed expanded project;
- a review of Greenhouse gas emissions, best practice management options and offsets review and assessment;
- an assessment of the safety risk to the public of the increased plant capacity and increased shipping movements;
- a visual impact assessment of the new plant layout;
- an analysis of wastewater discharges and management options;
- an investigation of dredging and spoil disposal management requirements;
- additional archaeological studies on Wickham Point;
- noise modelling of the expanded facility;
- revised social impact assessment of the project;
- an onshore and offshore geotechnical/geophysical survey;
- an ecological impact assessment, including investigation of options for mitigating any loss of dry rainforest at Wickham Point; and
- a sustainability assessment of the project;

The outcomes of the above investigations are summarised in detail in Section 4 of this report.

1.7.2 Consultations

During the preparation of the Draft PER, the Proponent consulted the following organisations regarding the proposed expanded LNG project:

- NT Department of Lands, Planning and Environment (now Department of Infrastructure, Planning and Environment, DIPE)
- NT Department of Mines and Energy (now Department of Business, Industry and Resource Development)
- NT Parks & Wildlife Commission (now DIPE)
- Environment Australia
- Australian Greenhouse Office
- NT Department of Transport and Works (now DIPE)
- Darwin Port Corporation
- NT Department of Primary Industry and Fisheries (now Department of Business, Industry and Resource Development)
- Civil Aviation Safety Authority
- Territory Health Service (now Department of Health and Community Services)
- NT Herbarium.

The assistance of these stakeholders is acknowledged in Section 6.1 of this report.

2. PROJECT DESCRIPTION

2.1 INTRODUCTION

This section describes the proposed project, including its major components and their construction and operation phases, taking into account changes from the project description previously outlined in the original Draft EIS and Supplement (D&M 1997, 1998a).

This section describes the project in sufficient detail to enable the reader to understand what will be constructed, where it will be constructed, how it will be constructed and how it will be operated on completion of construction. Waste products and materials generated during both the construction and operation phase are also described. The section concludes with comments on the final selection of Wickham Point over other alternative locations in the Darwin region as the preferred site for LNG manufacturing facilities.

The purpose of the LNG plant is to receive natural gas, via the Bayu-Undan to Darwin pipeline. This offshore pipeline was previously assessed and approved. The pipeline will terminate at Wickham point as shown in Figure 1.3. The gas will then flow through a "pig" receiver. This receiver is designed to allow the isolation and removal of special pipeline equipment, commonly called "pigs", that are sent through the pipeline for maintenance and/or inspection purposes. The gas will then go through metering facilities, which measure the gas received onshore for use in pipeline monitoring and gas sales accounting. The metering facilities will also have equipment to heat, filter, and remove any trace liquid if required to meet gas delivery requirements for both the LNG plant and the needs of the domestic gas users. The installation of these heaters is a change from the previously assessed 3 MTPA project and the emissions associated with such are further discussed in Section 2.5.4.1. The gas from the metering facility will then flow to the LNG Plant and also to a pipeline that will leave Wickham point for delivery to domestic gas users.

The gas to be processed into LNG will use the Phillips Optimised Cascade LNG process. An overview of this process is provided in Figure 2.1. This process is based on the LNG technology used in Phillips' Kenai LNG Plant. This facility has been operating over 30 years and was the world's second commercial LNG project and the first to export LNG to Japan. This process was also selected for the Atlantic LNG Project in Trinidad. This plant started up in June 1999 and currently has two expansion trains under construction and a fourth under design. Prior to export to overseas markets by a dedicated fleet of specially constructed LNG tankers, the processed LNG will be stored onsite. As part of the processing, small volumes (up to 100 barrels per day) of condensate will also be produced and either consumed in various local fuel-based markets or exported from the LNG jetty.

Section 1.5 details the key changes to the current LNG project from that previously approved by regulatory authorities in 1998. The following section therefore focuses on the current project description. The reader is encouraged to refer to the NOI submitted by the Proponent in May 2001 (included as Appendix B) for additional details on the difference between the 3, 9 and 10 MTPA plant inputs and outputs. These are also addressed at the beginning of Section 4.

2.2 MAJOR COMPONENTS OF CURRENT PROPOSAL

The proposed project for which approval is sought will involve construction and operation of the following major components (Figure 1.3):

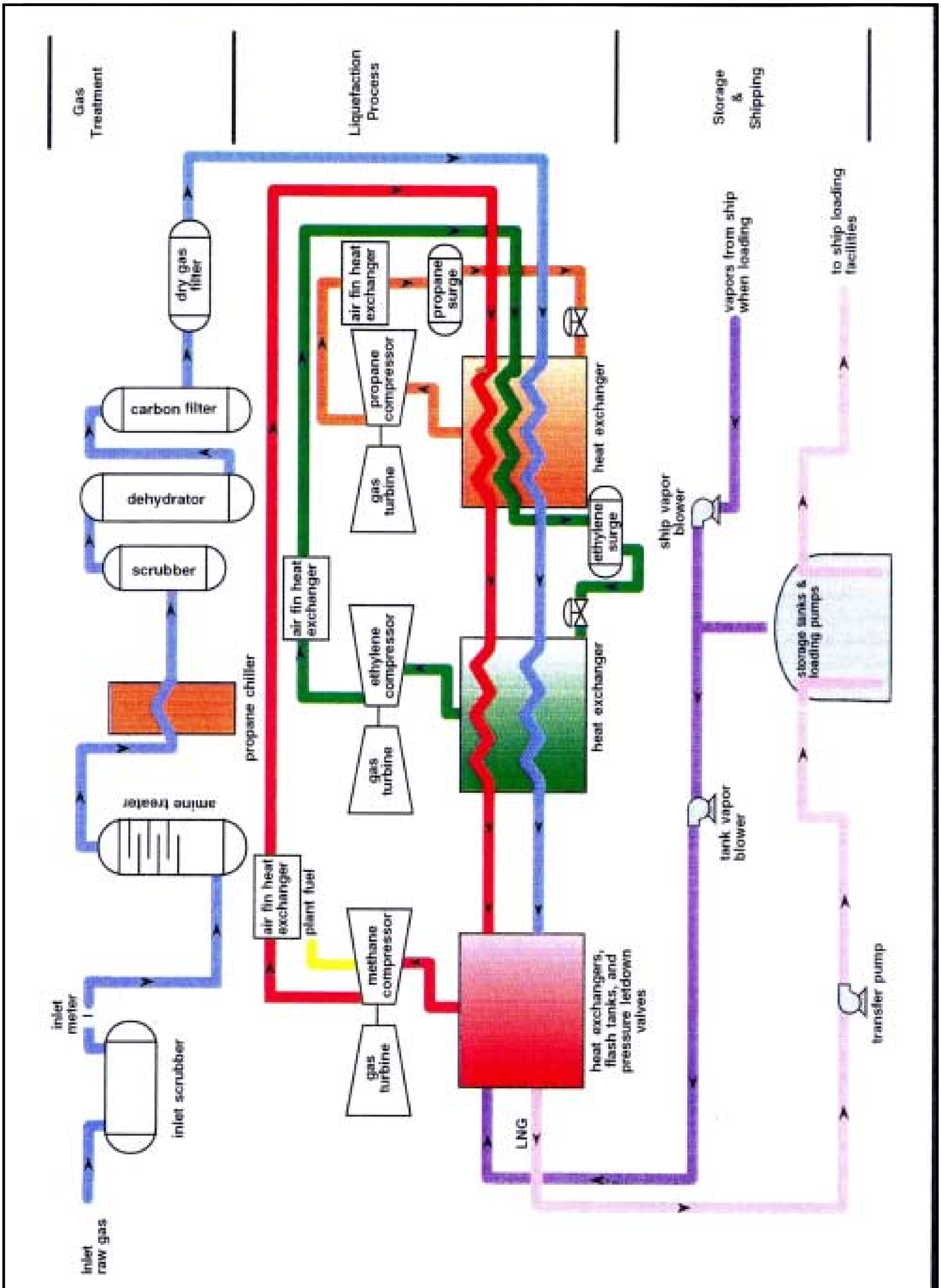
- a multiple-train LNG plant of up to 10 MTPA capacity which comprises:
  - gas processing facilities to remove impurities and refrigerate the natural gas,
  - product storage tanks,
  - plant infrastructure and utilities;
- a loading jetty on the west side of Wickham Point in Middle Arm of Darwin Harbour to transfer product to tankers for shipping to market;
- a construction dock on the north-east side of Wickham Point in East Arm of Darwin Harbour for transfer of building materials and heavy equipment;
- a dedicated fleet of large ships to transport LNG from Wickham Point to global markets; and
- an inlet metering station to meter and condition a portion of the incoming gas stream for domestic natural gas sales.

The following subsections provide a technical description of each of the above components, followed by a description of the construction programme. A description of how the facilities will be operated and the waste materials generated completes this section of the report.

2.3 DESCRIPTION OF MAJOR COMPONENTS

2.3.1 Inlet Metering Facility

An inlet metering facility will be installed to receive natural gas from the offshore pipeline to Wickham Point.



Job No.	00533-244-562		Phillips Petroleum Company Australia Pty Ltd 10 MTPA LNG PLANT AT WICKHAM POINT - PER **PHILLIPS OPTIMISED CASCADE LNG PROCESS**	**Figure 2.1**
Prep. By	TM	29 Nov 01		URS
Chk'd By	ILP	29 Nov 01		
Revision No.		0		

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A pipeline pig receiver will be located in the metering facility for use during any pipeline maintenance activities. The pipeline is expected to operate liquid free, however a small liquids knockout drum will be provided to collect any liquids that may be carried by the gas. Any liquids (condensate) collected from the gas stream will be combined with other condensate produced within the plant. The facility will also contain filters to remove any particles from the gas and custody transfer meters to measure the rate of gas flow. The facility will also contain inlet gas heaters to warm the gas when needed to avoid freezing and hydrate formation when the gas pressure is reduced.

The gas from the metering facility will be delivered to the LNG plant and also to a pipeline for delivery to domestic gas users, therefore providing two alternative routes for the pipeline gas.

2.3.2 LNG Plant

Two LNG trains are premised to liquefy natural gas (Figure 1.3, items 9 & 10) and produce a nominal capacity of 10 MTPA for the facility.

2.3.2.1 Gas treatment

After the gas is metered it will enter the gas treating section to remove components within the gas stream that are detrimental to the natural gas liquefaction process. These components are primarily carbon dioxide, hydrogen sulphide and water.

First, the gas is contacted with an aqueous solution of amine to remove carbon dioxide, and small quantities of hydrogen sulfide and other sulfur components contained in the gas (collectively called acid gas). The acid gas is absorbed by the amine solution. The acid gas (mostly CO_2) is then stripped from the amine solution in a stripper and then incinerated for abatement of any hydrocarbon or sulfur compounds in the stream. If the carbon dioxide is not removed, it will solidify during the LNG liquefaction process.

After the gas leaves the amine treating section it goes through the first stage of gas chilling that also condenses out some water. The gas then enters a three-bed molecular sieve system to remove the final traces of water. Any water collected is sent to the wastewater treatment system. Any hydrocarbon liquids removed are further processed and stabilised within the facility.

The final gas treating step uses two activated carbon beds to remove trace amounts of mercury which may be present to prevent any potential corrosion/damage on brazed aluminum heat exchangers located downstream in the process.

2.3.2.2 Liquefaction

The gas is subsequently fed to the refrigeration system where it is liquefied as the LNG product. The refrigeration or liquefaction system uses the Phillips Optimised Cascade LNG Process. Figure 2.1 is a process system layout with the path of the gas flow highlighted to assist the reader in visualising how the gas is processed in the individual plants.

There are three refrigerants (propane, ethylene and methane) used in the liquefaction systems to cool the gas step by step to -160 ºC. These refrigerants are optimally cascaded to provide maximum LNG production utilising all of the available power of the gas turbine drivers, thereby maximising energy efficiency. Each of the three refrigeration systems uses two 50 percent or three 33 percent capacity refrigerant turbine compressor sets with common condensers, chillers and accumulators. Each of the compressors is driven by a gas turbine. The plant will use air fin coolers, instead of a cooling tower, for the heat removal requirements of the liquefaction process, and therefore will not require cooling water.

2.3.2.3 Product storage

LNG produced from the liquefaction process is stored in three double containment storage tanks. Two tanks will be of 100,000 m^3 capacity each, and the third tank will be of 160,000 m^3 capacity. The storage system includes product pumps for ship loading and a boil off compressor for handling the vaporising LNG.

In the previously approved 3 MTPA project described in the draft EIS and supplement, LPG and condensate removal was premised at the LNG facility. Subsequent to the conclusion of the EIS for the 3 MPTA facility the decision was taken by the Bayu-Undan participants to recover these products at the offshore production and processing facilities. Consequently for the current 10 MTPA proposal, only relatively small amounts of condensate and no LPG are now expected to be recovered at the LNG facility.

For comparison purposes, current expected condensate volumes are approximately 19.8 tonnes/day for the 10 MTPA facility compared to 400 tonnes/day discussed and approved in the draft EIS and supplement for the 3 MTPA facility. A storage tank provides approximately one week of storage for stabilised condensate product that may be produced. The location of the storage tank facilities is shown in Figure 1.3 (item 31). Disposal of this condensate will be either through a truck loading station for delivery to local markets or through the LNG loading facility onto a tanker for delivery to overseas markets.

2.3.3 LNG Shiploading Facilities

A shiploading facility will be constructed, as shown in Figure 1.3, to transfer LNG and small volumes of condensate produced by the plant to vessels for shipment to markets. The following criteria were used to determine the length and orientation of the loading jetty facility:

- ensuring safe and reliable access for marine vessels to service the site;
- minimising the extent of dredging to reduce level of environmental impact and dredging costs;
- avoiding seafloor features that might complicate the design, construction or operation of the facility; and
- avoiding disruption of other marine traffic, both in the deep draught channel and nearshore waters.

The facility is proposed to comprise a 925 m long rock fill groyne abutting the shoreline, with an adjoining open piled trestle structure, approximately 500 m long, leading to a pile-supported (36 m by 16 m) loading dock. The loading dock and associated facilities are described in detail in Figures 2.2 and 2.3. A minimum 600 m diameter vessel turning basin and 400 m by 70 m berthing pocket will be established at the head of the loading facility.

2.3.4 Construction Dock

A construction dock [Figure 1.3 (item 16) and Figure 2.4] is required to receive heavy equipment, pre-fabricated process modules and possibly plant personnel. The facility will comprise a 20 m wide (width at top) rock fill groyne, extending approximately 470 m to the north-east of the plant site into the East Arm, and a rock fill dock approximately 50 m wide and 30 m deep. A 200 m by 40 m berthing pocket, and an approach channel approximately 1 km long by 70 m wide dredged to – 6 m AHD will be provided.

The frequency of arrivals at the dock will vary throughout the LNG plant construction period. The dock may continue to be used at low frequency during the operational phase of the plant.

2.3.5 LNG Tankers

LNG will be transported from Wickham Point to world gas markets via purpose-built tankers dedicated to the project (shown in Plate 1, see page 2-14).

All LNG tankers are of a double-hull design and their cargo containment systems are classified as either a membrane or self-supporting design. The self-supporting design consists of the most recognisable LNG tanker feature, i.e. a spherical tank profile as used on the North West Shelf LNG project. This design also includes the prismatic LNG tanker used by Phillips' Kenai LNG project in Alaska.

The LNG tanker design used by the Phillips Kenai LNG plant is shown in Figure 2.5. Each ship carries liquefied natural gas in four tanks using the IHI Self-Supporting, Prismatic Tank, Type B containment system. Each tank is constructed from heavy aluminium plate fabricated to a prismatic shape, allowing each tank to match the form of the ship's hull. All of the tanks contain a complex system of inner structure that absorbs stress fluctuations resulting from wind, wave, cargo load and temperature changes. A longitudinal and lateral 'swash' bulkhead is integrated into the structure of each tank to help prevent sloshing of the LNG, especially while the ship is in a partially loaded condition.

Gas evaporation, or 'boiloff', is collected, compressed and used as fuel in the ship propulsion system. Fuel requirements in excess of this natural 'boiloff' can be supplied by fuel oil or by forced vaporising of the LNG cargo.

The LNG tankers will probably have a draught of 11.5 m and be between 260 and 290 m in length with a carrying capacity of up to 145,000 m^3.

2.4 CONSTRUCTION OF MAJOR COMPONENTS

2.4.1 Construction Programme and Schedule

The construction phase of the project will involve major engineering projects as follows:

(i) clearing of the plant site and construction of the plant components;

(ii) construction of LNG storage tanks, and

(iii) construction of the ship loading facility and construction dock, plus associated dredging and spoil disposal.

Figure 2.6 provides the current schedule for engineering, construction and initial operations of the new 10 MTPA LNG facility.

Prior to commencement of works at the site, the environs of the major plant components will be surveyed in detail to provide accurate topographic and bathymetric charts of the work site.

The access road to be constructed by the NT Government will enable construction equipment, materials and personnel to be readily transported to the site. A pipeline to carry fresh potable water to the site will be constructed by the NT Government, and will link into the Northern Territory Power and Water Authority (PAWA) supply system. Once the site has been cleared, the construction dock will be installed and a temporary electricity supply from PAWA will be obtained.

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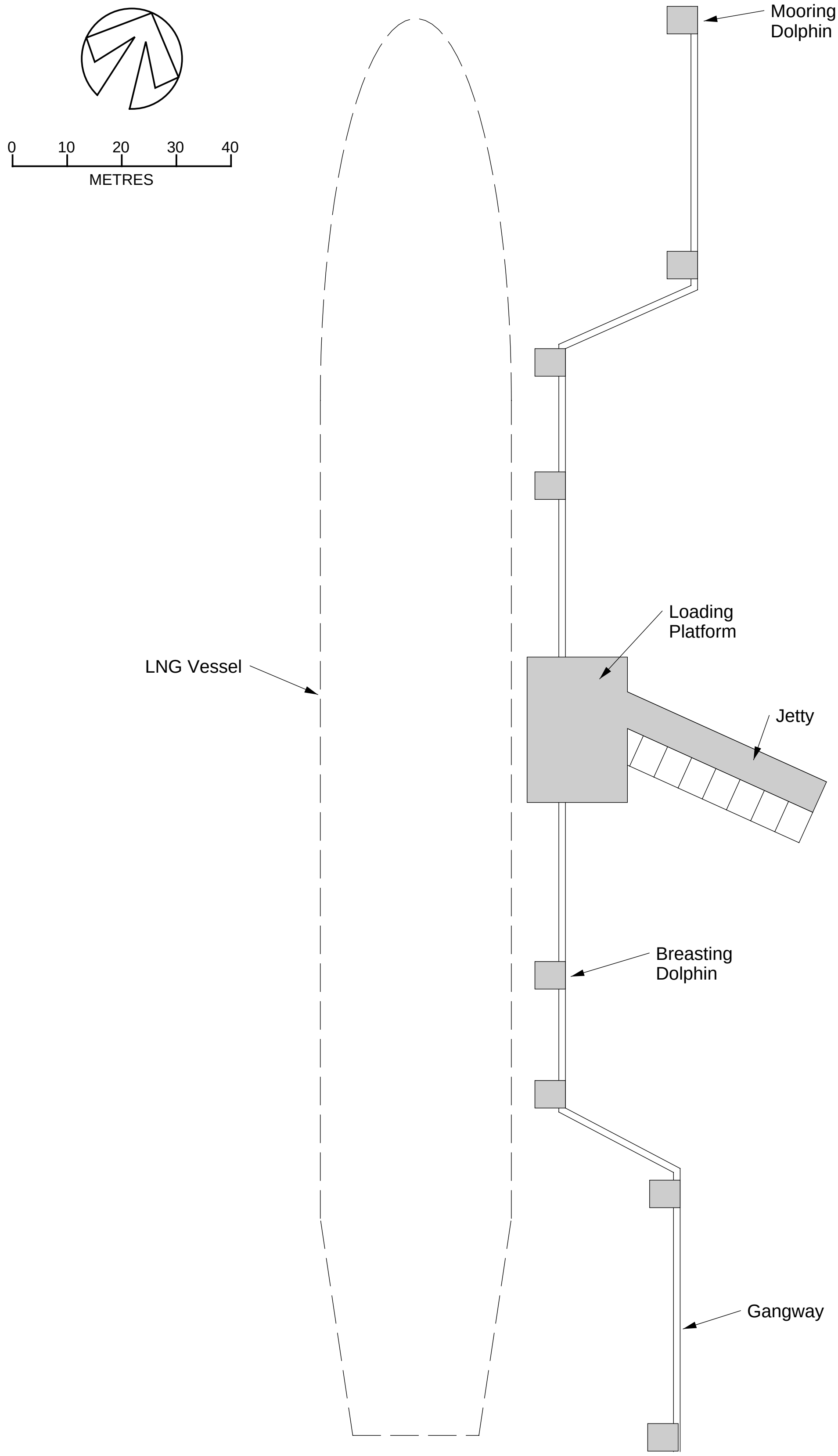

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Chk'd By	ILP	29 Nov 01
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10 MTPA LNG PLANT AT WICKHAM POINT - PER

PRODUCT LOADING DOCK OVERALL PLAN

Figure 2.2

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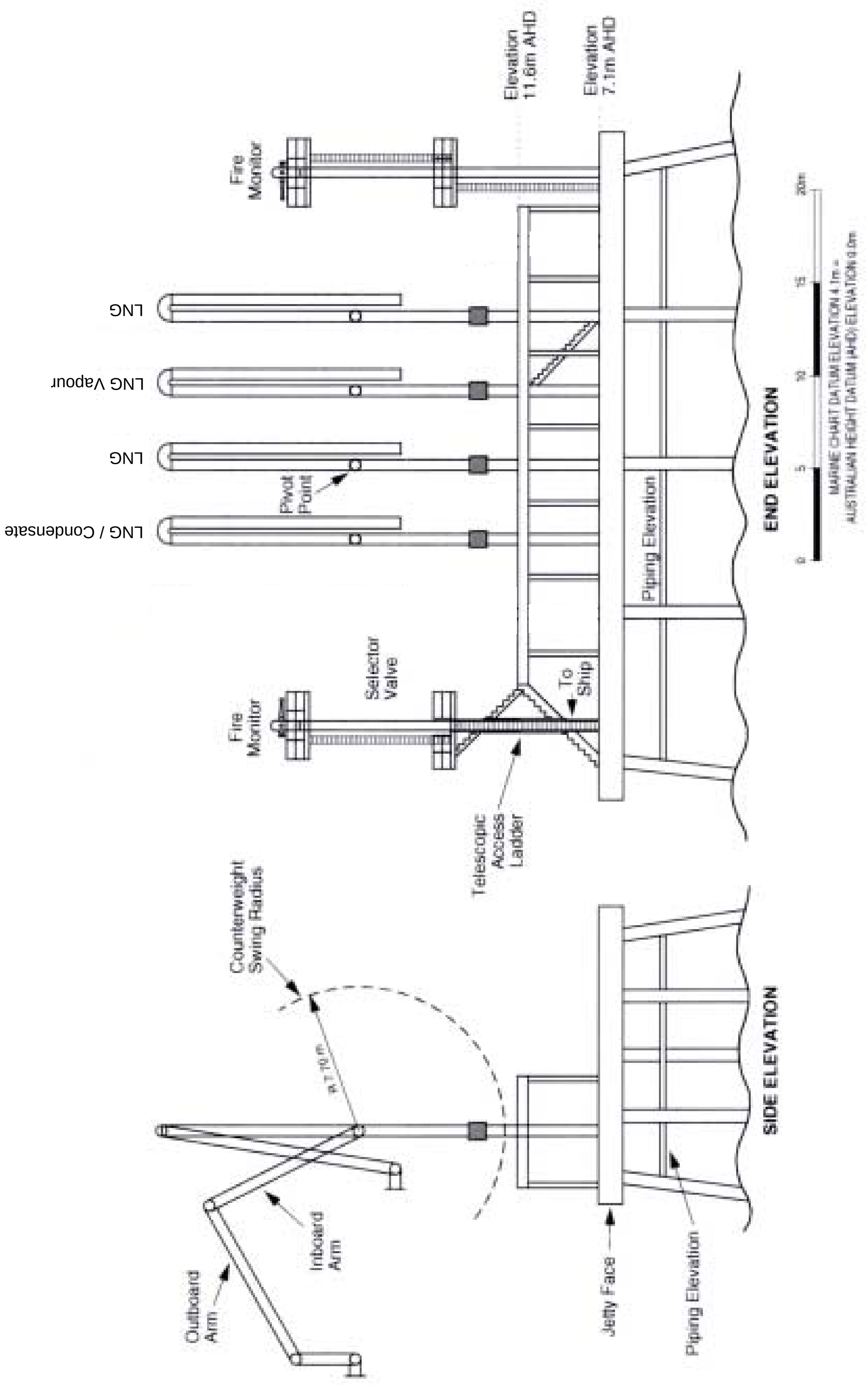

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**PRODUCT LOADING DOCK
LOADING ARMS**

Figure 2.3

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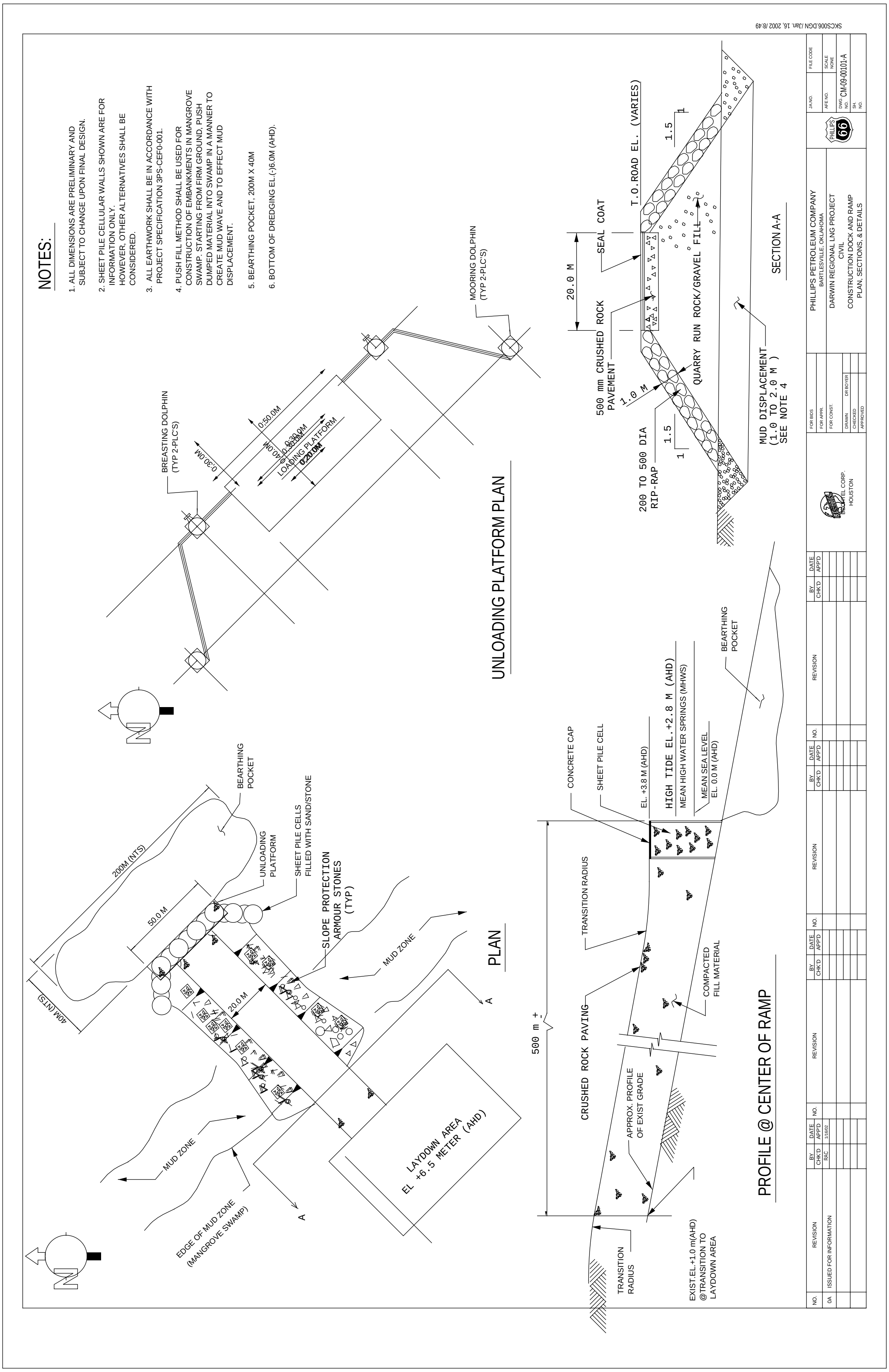

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CONSTRUCTION DOCK

Figure 2.4

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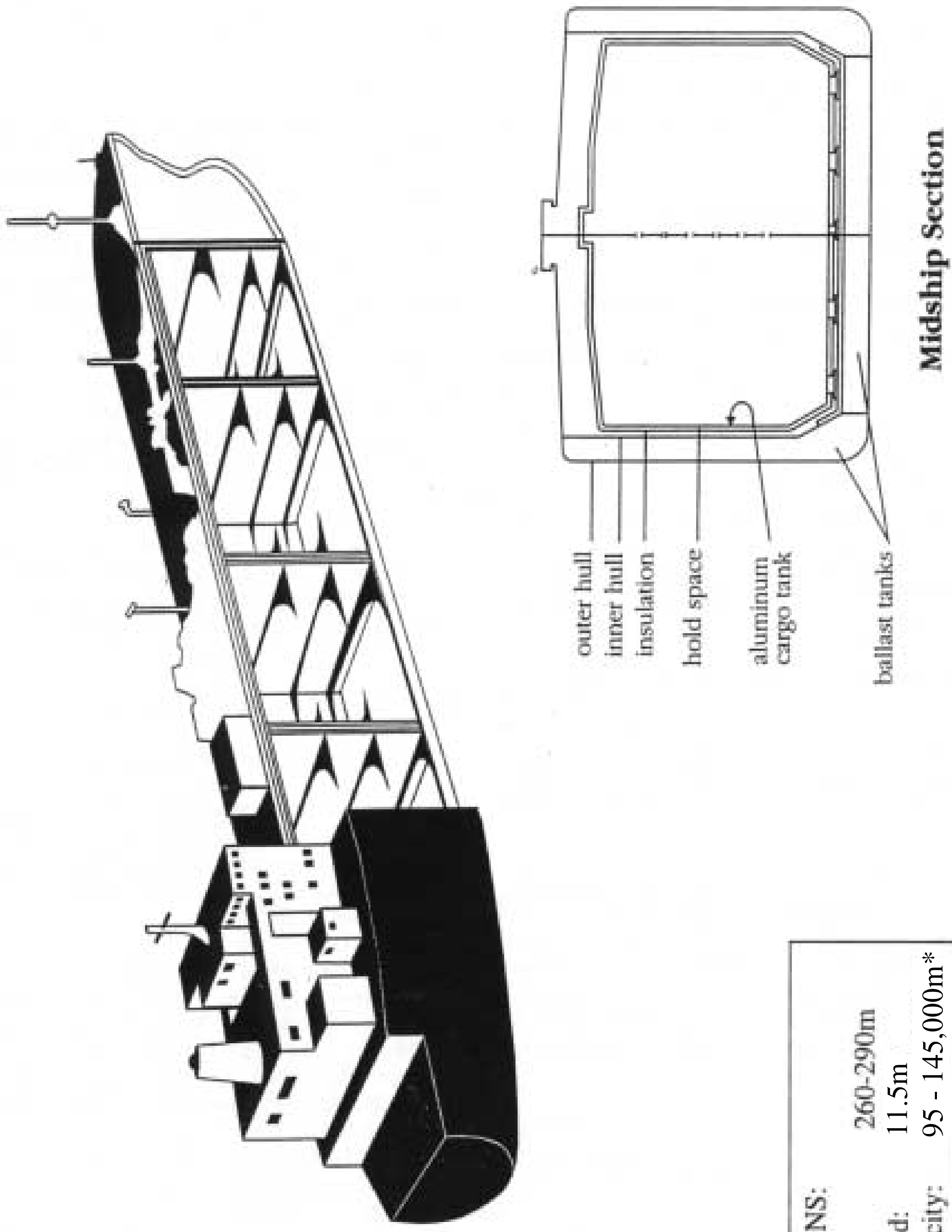

DIMENSIONS:

Length:	260-290m
Draft Loaded:	11.5m
Cargo Capacity:	95 - 145,000m*

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TYPICAL LNG TANKER SCHEMATIC

Figure 2.5

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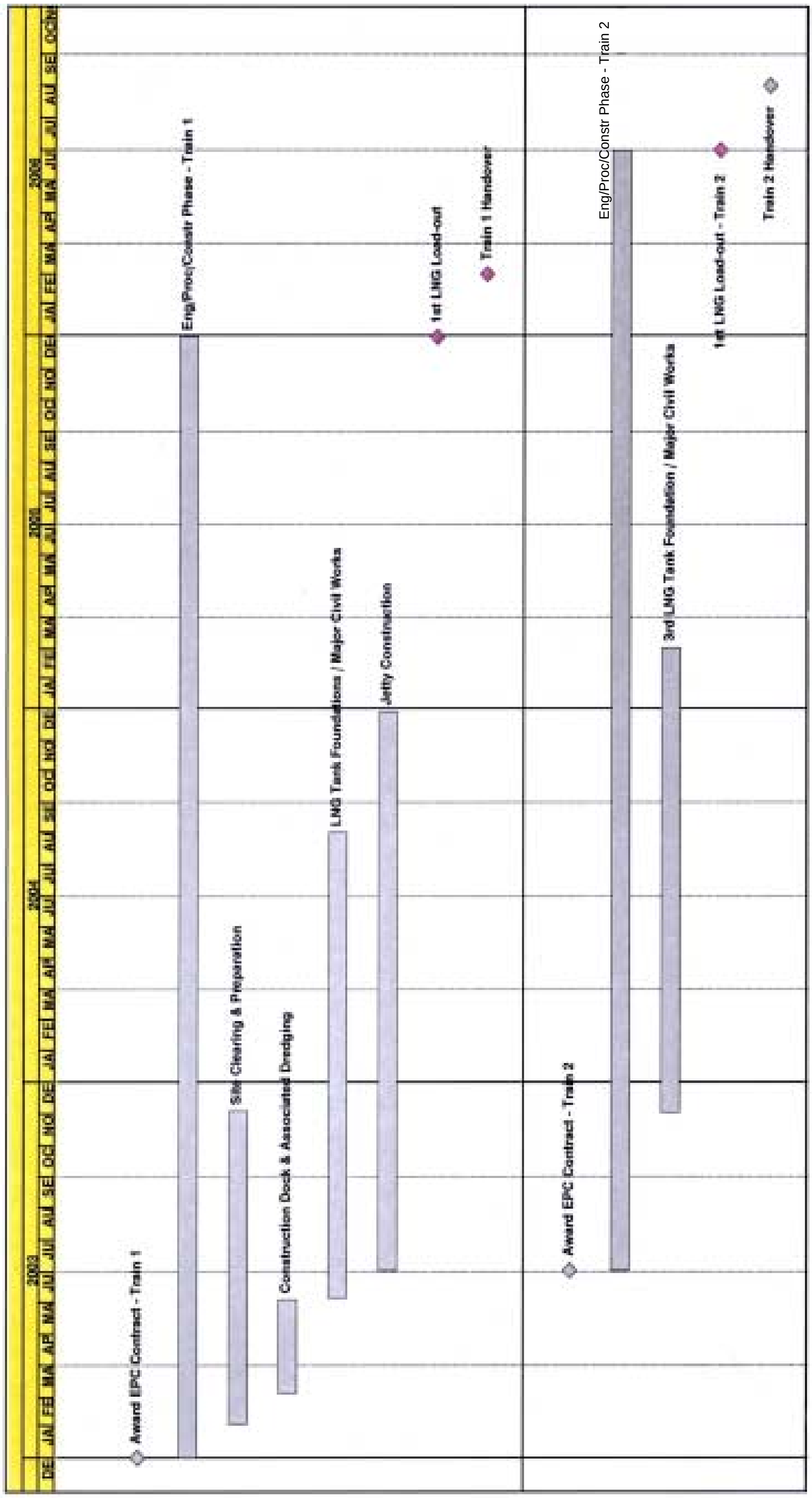

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10 MTPA LNG PLANT AT WICKHAM POINT - PER

10 MTPA LNG FACILITY SUMMARY SCHEDULE

Figure 2.6

URS

Dredging of the approach channel to the construction dock and minor dredging in the turning basin for the loading jetty will also be undertaken early in the construction programme.

After site preparation, the LNG plant will be constructed. Construction of the LNG tanks, LNG trains, utilities, storage and loading system, product shiploading facility and flares will occur during this phase.

The final phase of construction is the start-up and commissioning of the project facilities. The utilities are started up first, followed by the LNG train, then the storage and loading facilities. Start-up and commissioning overlaps the operational phase.

Construction of each LNG train and associated support facilities will take approximately three years. The actual plant construction schedule will be dependent on the LNG market conditions. First delivery of LNG is expected in early 2006.

Most of the construction work will be performed during the day, but in rare instances work will be performed at night where necessary.

2.4.2 LNG Plant

2.4.2.1 Site preparation

The plant site has been located to minimise the amount of earthworks, as well as to utilise the western ridge to shield it from view from Darwin. The plant elevation will be determined (subject to the minimum elevation required to prevent flooding of the site) so that cut and fill ratio are equal, and hence it is anticipated that there will not be a requirement for fill to be trucked in to the site. Preliminary earthwork calculations indicate that the required volumes are: 1,600,000 m^3 of ‘cut’ and 1,000,000 m^3 of ‘fill’, excluding the jetty groyne. Thus the ‘fill’ requirement is less than the ‘cut’. Excess cut will be disposed of on site by terracing the laydown areas and/or used in the jetty groyne construction. It is unlikely that sufficient stone of suitable quality will be available on site to provide the armour stone for the jetty groyne, therefore it is proposed to import armour stone to the site from local quarries.

Because of the hilly nature of the site, significant rock excavation will be required. The preferred method of excavation will be via the use of typical earthmoving equipment, such as excavators and bulldozers. Blasting will only be pursued, with appropriate safety and environmental protection, as a final option.

In recognition of the ecological value of the dry rainforest vegetation on the site (refer Section 3.3.3), the plant layout has been designed to minimise loss of this vegetation community. The area to be cleared has been restricted to some 88.3 ha. This represents a 32 percent increase from the 66.8 ha clearance approved under the 3 MTPA EIS process. The entire area within these limits (refer Figure 1.3) will be cleared of all materials, including trees, downed timber, brush and rubbish, at or above the natural ground surface. This material will be disposed of as appropriate (refer Section 4). Trees outside of the project limits will remain and be protected during construction.

It is also anticipated that there will be no need to remove in situ mangrove mud for disposal offsite. Mud layers are relatively thin (1 - 1.5 m) and, as such, can be squeezed out from under surcharged fill using the mud wave technique. None of the mangrove areas reclaimed in this manner will bear major loads requiring stable foundations.

Once the site has been levelled, it will be graded to contain runoff and direct it to appropriately constructed drains after first passing through silt traps to control input of sediment-laden water to the harbour.

2.4.2.2 Construction workforce

Construction of the total capacity LNG plant and supporting facilities will create an estimated demand for up to approximately 1,600 skilled and unskilled workers in peak periods. The various phases of construction are expected to last for a total of approximately three to four years. Many of the construction jobs will be associated with a particular phase of work and thus will not last for the entire construction period. Figure 2.7 shows the buildup of the construction workforce for this project for the staggered construction of two LNG trains. It is estimated that 25% of the workforce will be obtained from the Darwin area with the remaining 75% being sourced from outside Darwin.

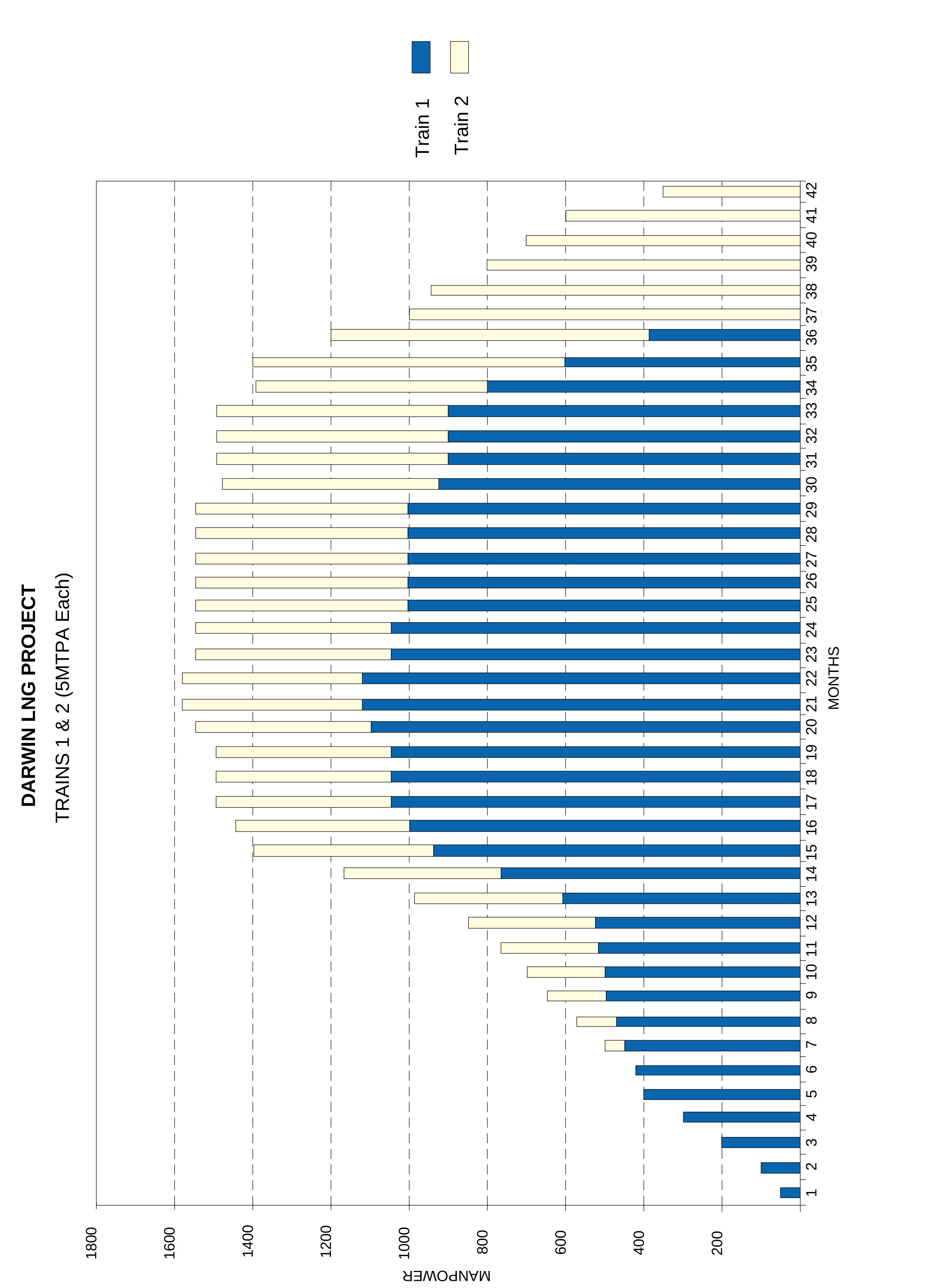
The construction workforce will be housed in existing accommodation available in Darwin and transported to and from the site each day either by buses or by ferries from Darwin Harbour. If necessary, a construction camp will be established.

2.4.2.3 Utilities required during construction phase

Water: It is anticipated that PAWA will supply the site with 80 m^3/hr of fresh/potable water through a 15 cm line during the construction phase of the plant.

Electricity: Early during construction, the contractor will tie into the PAWA local utility grid, and PAWA will supply the site with 4 megawatts of power.

Communications: It is envisioned the Telecommunications Services of the Northern Territory will supply local phone communications, to be supplemented with cellular telephones, marine radios (ship-to-shore) and hand-held UHF/VHF radios for field usage. Subcontractors will be required to establish a compatible communication system.



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10 MTPA LNG PLANT AT WICKHAM POINT - PER

WORKFORCE PERSONNEL REQUIRED FOR PLANT CONSTRUCTION

Figure 2.7

Fuel storage: During the construction phase, diesel fuel will be used for pumps, generators, compressors and earthmoving equipment. The diesel fuel will be stored in tanks or drums that will be provided with impervious berms, and synthetic liners will be used underneath the tanks and drums to prevent contamination to the ground or surface waters. Sand or other absorbent materials will be used to collect small leakages and sumps will be strategically located to contain any large spills in the unlikely event that they should occur.

Fencing: The plant site will have perimeter fencing and manned entrance and exit gates. The fence will be approximately 1.83 m high with barbed wire on top.

Temporary facilities: Temporary construction facilities to support all phases of construction will include the following:

- guard house;
- personnel/briefing/induction facility;
- site construction offices,
- field offices,
- warehouse,
- customs clearance/receiving office,
- batch plant and material yard,
- bulk materials laydown yard,
- vehicle and equipment repair shops,
- vehicle and equipment parking areas;
- medical facility;
- portable toilets; and
- fire fighting equipment storage.

Some of these facilities may be incorporated into the permanent plant facilities. Those not converted for use during operations will be removed from the site.

2.4.2.4 Construction of facilities

Once the plant site surface has been graded, compacted and stabilised, construction of permanent facilities will commence. This will include:

- administration building,
- warehouses and laboratory,
- power generation equipment,
- process plant,
- storage tanks for LNG and condensate,
- safety systems and ground flares,
- ship loading pumps and piping.

The proposed location of these and other facilities within the plant site is shown on Figure 1.3.

Construction standards/design principles

Generally, where an appropriate Australian Standard exists, then it shall be used in preference to an International Standard, with the latest edition of the code or standard being used, including addenda, supplements, or revisions at the date of the commencement of detail design, will be used unless specifically agreed otherwise.

Many areas of the design will not be covered by an appropriate Australian Standard. Where no applicable Australian Standard exists, then the appropriate American or International Code, Standard, or Recommended Practice will be specified and enforced.

Where conflict exists between Codes and Standards the descending order of precedence shall be as follows:

- Northern Territory Legislation
- Australian Statutory Requirements.
- Australian Codes and Standards
- American Codes and Standards
- International Codes and Standards
- Project Specifications

The minimum plant, elevation will be set by a detailed hydrodynamic study that will consider storm tide level, including allowances for cyclone wave set up, astronomical tide, and wave run up against the rip-rapped embankments. Above this elevation, the plant elevation will be set by the desire to balance cut and fill to minimise the need for importing fill or disposing of excess cut. It is expected that this will result in a final plant elevation of between 6.5 and 7 m above AHD.

A seismic study of the area has been conducted. Based on this information, the civil/structural design will be Unified Building Code Zone 1 or Zone 2b.

2.4.2.5 Construction wastes

Construction waste will be divided into hazardous or non-hazardous in accordance with applicable Northern Territory regulations. Examples of typical construction waste are shown in Table 2.1. Treatment and disposal of these wastes are described in Sections 4 and 5.

Table 2.1 Typical Construction Waste Classifications

Waste	Classification
Construction debris contaminated by oil or organic compounds	Hazardous
Empty drums	Non-hazardous if triple rinsed
Empty paint and coating containers (water-based without metals)	Non-hazardous
Empty paint and coating containers (oil-based without metals)	Hazardous
Aerosol containers	Non-hazardous if empty and depressurised
Trash (waste paper, plastics, cardboard, etc.)	Non-hazardous
Wood and scrap metal	Non-hazardous
Dryland and mangrove vegetation	Non-hazardous
Marine muds	Non-hazardous
Spent oils	Hazardous
Excess fill	Non-hazardous
Domestic garbage and food waste	Non-hazardous
Domestic wastewater	Non-hazardous

2.4.3 Ship-loading Facilities and Construction Dock

The characteristics of the ship loading facility and construction dock have changed slightly from the previous proposal. Information is presented here for completeness of information.

The rock groyne is not anticipated to adversely affect coastal processes and harbour hydrodynamics as it will be constructed in line with an existing rocky promontory which is exposed at mid tide level (Plate 2). The effects of the groyne structure on hydrodynamics have been investigated in the previous (1997) EIS (refer Section 7.2.3.2 and Appendix E in D&M 1997), and shown to be minimal.

The groyne will be constructed with 2:1 sloping sides, and a crest width of 13 m, and will comprise approximately 430,000 m^3 of rock and earth fill protected by 80,000 m^3 of armour stone. The earth fill material will come from on-site cut and armour rock will be sourced from an existing off-site quarry. The groyne will gradually extend from the shore out toward the jetty.

The trestle structure will comprise a concrete deck supported on steel beams, with a two-tiered steel pipe rack, all supported by steel pile caps on tubular steel piles. The loading dock will be a pre-cast concrete deck on steel framing, supported by tubular piles. Mooring and breasting dolphins will comprise vertical steel piles, connected to the loading dock by long-span lattice type steel catwalks. The length of the trestle structure has been reduced from 550 m to approximately 500 m and the length of the rock groyne has been reduced from 1000 m to approximately 925 m as a result of a review of recent bathymetry information that allows this reduction in length with no significant changes in dredging from the original EIS.

Plates 3 and 4 show the intertidal area on which the construction dock is to be built. The dock will comprise a bulkhead of steel sheet piles backfilled with approximately 300,000 m^3 of earth fill and armour stone to form a rubble mound groyne. The sources of armour material will be the same as those for the groyne section of the shiploading facility.

Dredging of the approach channel to and the berthing pocket for the construction dock is anticipated to produce approximately 145,000 m^3 of similar material. An additional 30,000 m^3 of material will be removed by dozer for the landward penetration through the mangroves. These volumes represent no significant changes from the original EIS.

Detailed bathymetric survey of Middle Arm undertaken for this project indicates that sufficient depth exists to allow unhindered access to and from the shiploading facility even at low tide for vessels of 11.5 m draught. Middle Arm channel is about 20 m deep on average. Hence capital dredging of approaches to the jetty through Middle Arm is unlikely. Ongoing discussions with Darwin Port Corporation confirm preliminary indications that the loading facility berth is unlikely to require maintenance dredging.

A cutter-suction dredge will be used for all dredging. The Darwin Port Corporation has previously expressed interest in taking dredge spoil for disposal as landfill at the East Arm port development. The proponent supports this approach, however if this is not timely or feasible, application will be made for sidecasting of the dredged materials.

PLATE 1: Typical LNG tanker at Kenai product loading dock.

PLATE 2: Intertidal rock stacks, pavement and mangrove fringe at base of proposed loading facility

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PLATE 3: Proposed construction dock alignment.
Plant site behind, Channel Island Power Station in background.

PLATE 4: Intertidal rock stacks, pavement and mangrove fringe at base of proposed construction dock.

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Date	Dec 01		

2.5 OPERATION OF PROJECT

2.5.1 Operation Phase Activities

Operation of the project will basically involve the treatment of the gas to remove hydrocarbon liquids, water, carbon dioxide and other impurities, then liquefaction of the gas to produce LNG which will be stored in tanks at the plant site (refer Section 2.5.2.4). This treatment process will produce some atmospheric emissions (principally carbon dioxide) and low volumes of wastewater. Further detail is provided below.

2.5.2 LNG Plant

2.5.2.1 General

The LNG plant will be designed for continuous 24 hour operation. The only planned shutdown of the plant will be for routine maintenance on the plant equipment and for periods coordinated with required maintenance of the LNG tankers. Availability of the plant for both scheduled and unscheduled maintenance is expected to be over 93%. During periods of unplanned shutdowns, scheduled maintenance and ship loading, some gas flaring will occur.

Upon completion of the pipeline and the transfer of the first gas from the Timor Sea fields, the LNG plant will start up in a step-wise process. Typically, the first systems started in the plant will be the utility systems followed by the refrigeration compression. Natural gas is then introduced into the system for liquefaction.

To ensure the safe startup and operation of the plant, a comprehensive operational safety management programme will be pursued to ensure the overall effectiveness of hazard control through all stages of activity. The primary elements of this programme will be:

(1) site operating procedures;
(2) personnel training;
(3) emergency procedures;
(4) pre-startup safety review; and
(5) regular audits and reporting.

Site operating procedures will be written to identify personnel responsibilities and to document start-up, normal and abnormal operations, and shutdown situations. Personnel training will utilise the framework of a computer-based training system. Emergency procedures will be prepared for plant control action required to achieve safe holding and shutdown conditions, and to ensure the safety of personnel. The pre-startup review will be structured to ensure that all construction meets intended specifications, written safety, operating, maintenance and emergency procedures, and that these specifications and procedures are in place and the training of personnel has been completed.

A safety policy and procedure manual will be prepared for the Darwin LNG plant. The safety policies and procedures will be subject to periodic audits and reviews to ensure continued effective performance, with audit findings being contained in written reports. Any hazardous incident which may occur will be investigated to establish the factors contributing to its cause, and recommendations made for any necessary changes to procedures and practices.

2.5.2.2 Workforce

A 10 MTPA LNG plant will be operated by a workforce of up to 120 full-time personnel. The workforce will consist of approximately 40 personnel in plant operation, 50 supporting plant maintenance, and the remainder as technical and administrative support. It is anticipated that plant personnel will live in the Darwin/Palmerston vicinity and access the plant primarily via the Channel Island road.

2.5.2.3 Utilities

Utility requirements of the plant include potable water, electricity, fire protection, communications and fuel storage. Most of the utilities consumed in the LNG facility will be produced within the limits of the plant. Similarly, most of the wastes produced in the LNG facility will be treated within the limits of the plant.

Water: During the operations phase, plant water requirements will be less than 12 m^3/hr. It is premised that the Northern Territory PAWA will continue to supply water after the construction phase is complete. Water requirements are shown in Table 2.2.

Table 2.2 Water Requirements of the LNG Plant during the Operational Phase

User	Requirements, m^3/hr
Potable water	6.7
Process water	2.5
Fire water flush	1.0
20% margin	2.0
TOTAL	12

Note: The current design basis is using hot oil in the Waste Heat Recovery System. Phillips is evaluating an option of generation of steam instead of using hot oil. If a steam generator (boiler) is used, additional 4 m^3/hr water will be required for make-up.

Electricity: In the present design, electricity is generated by gas turbine generator sets installed within the LNG plant area. Up to 45 megawatts of installed electrical generation capacity will be required for a full 10 MTPA LNG facility. Phillips is discussing power supply inter-relationships and cooperation with the Northern Territory PAWA. Emergency power generation within the plant will be from additional diesel-driven generator sets which produce 400 Volt power from diesel engines. The emergency power will be sufficient for a safe and orderly shutdown and operation of critical utilities as well as for bringing the facility back into production.

Fire Protection: The Fire and Safety System includes several parts. The primary system is the firewater system which includes water storage, a pumping facility and an underground distribution loop which includes hydrants, monitors, hose reels, deluge systems and a sprinkler system. One Hi-ex foam system for the LNG impoundment area has been provided. Combustible gas and hazardous gas detection systems, as well as low temperature detectors, are incorporated into the layout design to facilitate rapid response to any uncontrolled release of dangerous materials.

The plant layout philosophy maximises the use of passive protection in the form of equipment spacing and drainage of possible liquid spillages away from critical equipment. Active measures such as fire and gas detection, a fire water system and over-pressure protection are included in the design.

Communications: As for the construction phase, the Telecommunications Services of the Northern Territory will supply local phone communications, to be supplemented with cellular telephones, marine radios (ship-to-shore), and hand-held UHF/VHF radios for field usage.

Fuel Storage: Natural gas will be used as a combustion source for major equipment during plant operations. Diesel used for firewater pumps and emergency generators will be stored in the Diesel Storage Tank with a capacity of 40 m^3. The tank will be provided with a full containment dyke to hold both the entire contents of the tank and a 24 hour rainfall event anticipated once per 25 year return period.

Effluent Treatment: The facility includes effluent treatment for both the process wastewater streams and potentially contaminated stormwater. Process wastewater and contaminated stormwater will be routed to a corrugated plate interceptor (CPI) oil/water separator unit for removal of oil and grease and suspended solids. Treated effluent will be routed to an irrigation system for landscaping. A separate treatment package has been provided for treating sanitary wastes. Treated effluent from the sanitary treatment plant will be dechlorinated and will be used for irrigation of the landscape. Holding tanks will be provided to ensure that the treated effluent is safe for using for irrigation or ocean disposal. In the unusual event that onshore irrigation is unavailable, the treated effluent from the CPI oil/water separator will also be routed to a discharge point on the trestled portion of the jetty.

Additional Utilities/Support System Description

The **Flare and Relief System** will dispose of waste gases and emergency vents from the process and utilities. The system is composed of several parts: a ground flare of size 375 m long x 70 m wide, consisting of a wet and dry flare to burn hydrocarbon releases from the LNG Plant; and a marine flare (13 m high) which combusts vapours displaced from the ships' tanks during initial loading periods. The ground flares will be provided with a wall constructed out of fire resistant material for protecting plant equipment and personnel from heat radiation.

The marine flare will operate each time an LNG tanker comes in warm after its annual maintenance from the dry dock for approximately 12 hours duration while the onboard LNG tanks are cooling down. Also, two hours of purging to the marine flare is expected when the tanker arrives in cold. The ground flares are anticipated to operate less than 108 hours/year (see Section 2.5.4.1).

The **Refrigerant Storage System** provides storage volume for refrigerant make-up to the process as well as de-inventory volume for the process loop during maintenance. Two separate systems, one for ethylene (vacuum jacketed and pressurised) and one for propane are included.

Miscellaneous Storage is provided for several other fluids used by or available to the process such as diesel fuel and lube oil.

A **Fuel Gas System** is provided to supply natural gas to high pressure users such as refrigerant turbines and power turbines, and low pressure users such as the start-up fired heaters and flare systems.

A **Hot Oil System** is used as the heating medium for the amine system as well as the stabiliser for heavies removal. This is a closed loop circulation system with four waste heat recovery units installed on four refrigerant turbines exhaust. One fuel gas fired heater is provided for start-up and as a spare unit.

Compressed air is supplied from two motor driven air compressors and an emergency diesel driven compressor. The air is cooled and dried to a –54 °C dew point.

Nitrogen is provided (99.95% pure) from a package unit which includes a pressure swing absorption (PSA) production unit with independent liquid nitrogen storage and vaporisation for header pressure maintenance.

2.5.2.4 Storage

LNG will be stored in three double containment storage tanks. Two tanks will be of 100,000 m^3 capacity each and the third tank will be of 160,000 m^3 capacity. Each tank will comprise an inner container fabricated from 9% nickel-steel surrounded by approximately 1 m of perlite insulation, contained within an outer steel reinforced concrete wall. The inner tanks will contain the LNG product at its boiling point of -161±5 °C at a pressure slightly above atmospheric. No refrigeration will be necessary. Heat leakage (minimised by insulation) will produce a small amount of boil-off gas which will be recovered.

LNG will be held in the storage tanks until it is transferred to the loading facility for loading into ships for export. The LNG will be pumped from the tanks via pipework connections through the roofs using in-tank pumps (three per tank with one spare) to obviate the need for any sidewall penetrations.

In addition to LNG, a number of other potentially hazardous products and chemicals will be stored in bulk at the LNG plant.

The characteristics of the potentially hazardous substances handled/stored at the facility in large bulk quantities are outlined below. These substances have characteristics such as flammability or corrositivy that require special storage and/or handling considerations.

Natural Gas (Feed Gas)
Flammable Asphyxiant Gas

Flash Point:	- 195 °C
Boiling Point:	- 172 °C
Flammable Limits (v/v air):	.9% / 15.0%
Molecular Weight	16.1

LNG (Liquefied Natural Gas Product)
Cryogenic Liquid, Flammable Asphyxiant Vapour
Flammable as Natural Gas

Boiling Point:	- 161.5 °C
Molecular Weight:	16.1
Flammable Limits (v/v air):	4.9% / 15.0%

Ethylene (Refrigerant)
Flammable Cryogenic Liquid, Flammable Asphyxiant Vapour

Molecular Weight:	28.05
Boiling Point:	- 117.94 °C
Flammable Limits (v/v air):	2.75% / 28.6%

Propane (Refrigerant)
Flammable Pressurised Liquefied Gas,
Flammable Asphyxiant Vapour

Molecular Weight:	44.1
Flammable Limits (v/v air):	2.1% / 9.8%
Stoichiometric (v/v air):	4.0%
Boiling Point:	- 42.1 °C

Condensate (Product)

Molecular Weight:	80
Flammable Limits (v/v air):	1.1% / 7.5%
Reid Vapor Pressure	70 KPa
Auto Ignition Temp.	225 °C

Amine Solution (Diglycolamine, DGA)
Pure Component Physical Properties

Boiling Point	221 °C
Specific Gravity	1.057
pH	12.3 – 13.5

Storage and loading facilities are also provided for the condensate product. A 5,000 barrel tank will receive the liquid as it is delivered from the Condensate Stabilizer. A Lease Accounting Custody Transfer (LACT) Unit meters and pumps the condensate to a truck loading station and/or to the ship loading facility.

2.5.3 Ship Loading Operations

The loading facility will be capable of handling LNG tankers with capacities of up to 145,000 m^3. LNG will be transferred to the ships via the loading pumps in the storage tanks and two loading arms, with a separate vapour loading arm transferring ship vapours to a vapour recovery system onshore. Methane vapour produced in the LNG storage tanks due to heat gain, or displaced by liquid as the tanks are filled, is recovered by the boil-off compressor and sent back into the liquefaction system.

During ship loading, additional vapours are produced during the cool down of the LNG ship loading line and displaced from the ships as they are filled. Some of these vapours are used to displace the LNG being removed from the storage tanks during loading. The remaining vapours will be gathered and compressed by boil-off gas compressors and routed back to the LNG liquefaction section for recovery and re-liquefaction. When a ship arrives warm, which is generally after the ship has gone through its scheduled maintenance which occurs every 2.5 years, the warm vapours generated during this cool down process will be more than the boil–off compressors can handle and these vapours will need to be routed to the marine flare.

Vessels for LNG loading will enter Middle Arm of Darwin Harbour and proceed to the loading facility to be located on the west side of Wickham Point. At ten million tonnes per annum nominal production, LNG vessels will arrive approximately every two to three days for loading and export. Turnaround time for vessels will be approximately 24 hours, with a product loading duration of approximately 14 hours. Depending on the market serviced, each train will require up to eight dedicated LNG tankers with a total of 80 combined tanker loads per year per train.

Condensate volumes produced during normal plant operations are expected to be small, less then 100 bbls per day. A condensate loading arm may also be constructed on the loading facility to enable occasional exports by small tankers.

Tugs will be utilised for berthing assistance and departure, and to provide sufficient assistance to allow the vessels to be docked in winds up to 12-15 m/s dependent on wind direction and when the current is less than 2 knots. Winds over 10 m/s are extremely rare and currents greater than 1 m/s only occur for periods during spring tides but are reduced for a sufficient enough time near high and low water to allow safe manoeuvring of vessels

There are no tidal constraints for vessel loading since the natural channel is sufficiently deep to allow unhindered access at all tides for vessels of 11.5 m draught. Waves at the port are generated by local winds and are not likely to affect manoeuvring or berth occupancy. The vessel will be required to leave the dock during periods when cyclonic wind conditions are anticipated.

2.5.4 Operation Wastes and Emissions

LNG plants are typically very clean facilities. The plant will utilise natural gas for energy requirements. A mass balance for normal operations is presented in Figure 2.8. It shows that there will be essentially three input streams of materials to the plant:

(i) natural gas from the pipeline which has been treated to remove liquids and is provided as feed gas to the plant;
(ii) potable water for domestic, process and firefighting purposes to be provided by PAWA; and
(iii) miscellaneous supplies and chemicals required for the operation and maintenance of the plant.

These inputs will be processed into product (LNG and stabilised condensate) for export. Table 2.3 presents the physico-chemical characteristics of the feed gas and each of the plant products. The process will generate a range of atmospheric emissions, wastewater discharges, and solid and semi-liquid wastes for disposal off-site.

Atmospheric emissions and potential wastewater and solid/semi-liquid waste streams have been estimated and are summarised below.

2.5.4.1 Atmospheric and fugitive emissions

The air emissions which are expected to be released by the plant under normal operating conditions have been estimated and are presented in Table 2.4.1, and start-up/upset scenarios shown in Table 2.4.2.

The emissions shown above represent the expected emissions in an average year for the facility. Vapours from a cold ship will be sent to the marine flare for the first two hours during the 14 hour loading process to both further cool the ship and purge out impurities. Vapours generated while cooling down a warm ship will exceed the design limitation of the vapour recovery equipment as well as contain impurities that must be purged from the system and will also be sent to the marine flare.

To minimise air emissions from the LNG facility, waste heat recovery and additional vapour recovery for the ship loading vapour has been introduced into the plant design. The design in the original EIS did not incorporate this equipment. As mentioned in section 2.5.2.3, discussions are in progress with PAWA on the potential for PAWA to supply power to the site. If this occurs, the emissions shown for the power generation turbines would be reduced at this site and the same or smaller emissions instead attributed to the power generated at PAWA's Channel Island facility.

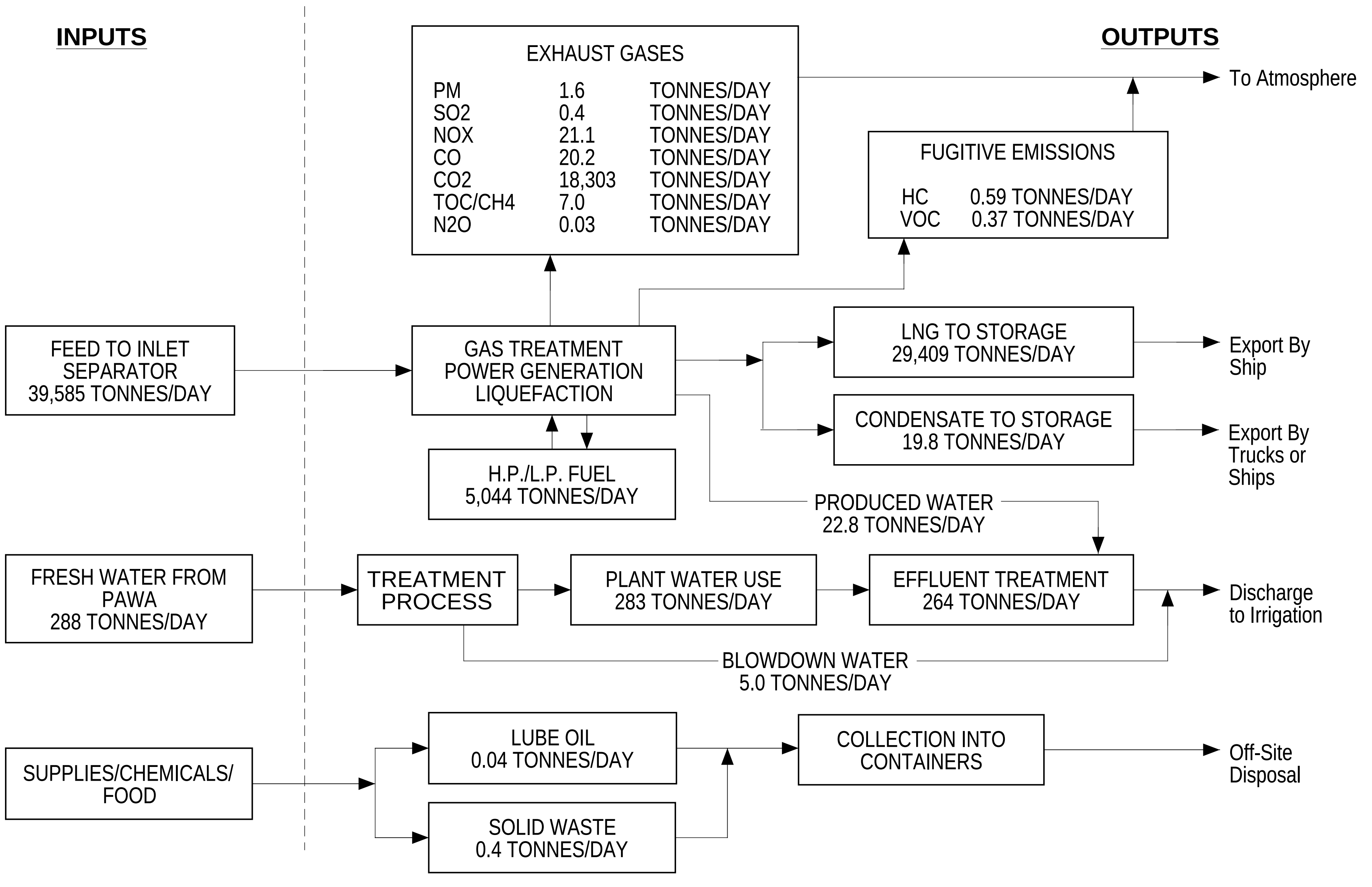

Figure 2.8

MASS BALANCE FOR LNG OPERATIONS

Phillips Petroleum Company Australia Pty Ltd
10 MTPA LNG PLANT AT WICKHAM POINT - PER

Job No.	00533-244-562	
Prep. By	TM	29 Nov 01
Chk'd By	ILP	29 Nov 01
Revision No.		0

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Table 2.3 Physical and Chemical Characterisation of Feed Gas and the Products of the Plant

Stream Description		Feed Gas	LNG in Storage	Stabilised Condensate Product
Temperature	**°C**	25	-160	43.3
Pressure	**kPa(a)**	5295	103.4	105
Density	**kg/m3**	49.2	463.1	711.6
Helium	**mol%**	0.1	0	0
Nitrogen	**mol%**	3.87	0.06	0
Carbon dioxide	**mol%**	6.11	0.01	0
Methane	**mol%**	79.83	87.31	0
Ethane	**mol%**	8.26	10.34	0
Propane	**mol%**	1.57	1.97	0
I-butane	**mol%**	0.12	0.16	0.03
N-butane	**mol%**	0.1	0.13	0.21
Pentanes Plus	**mol%**	0.02	0.03	99.77

For any power generation equipment installed at the LNG facility, the use of Dry Low NOx combustors, or other equipment designed to achieve a similar reduction in NOx emissions, is proposed. The refrigerant compressor gas turbines will use a lower btu fuel that by itself will lower NOx emissions by 30.1% when compared to using a typical high btu natural gas. The use of this low btu fuel also improves turbine horsepower efficiency and therefore reduces overall emissions from this equipment. Section 4.3.1 further discusses details on the atmospheric modelling and the various mitigation efforts undertaken to minimise air emissions from the facility.

Bechtel also reviewed the available process flow diagrams (PFD) and process instrumentation diagrams (PID) for the LNG plant in order to develop equipment counts for fugitive emissions estimates (leaks). The equipment of interest included piping connectors, flange connections, open ended lines, pumps, valves and other piping equipment.

The emissions factors used for estimating the fugitive emissions from the process streams were primarily based on USEPA publications. These factors are specific for oil and gas production operations, and were developed from data gathered from the industry by the American Petroleum Institute (API) and evaluated by the US Environmental Protection Agency. The fugitive emission rates derived for the proposed project, for both the originally proposed 3 MTPA plant and the current 10 MTPA plant design, are presented in Table 2.5.

Job No.	00533-244-562	
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Revision No.	0	

00533244r011f2-9.dgn

Phillips Petroleum Company Australia Pty Ltd
10 MTPA LNG PLANT AT WICKHAM POINT - PER

LIQUID WASTE SCHEMATIC

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Figure 2.9

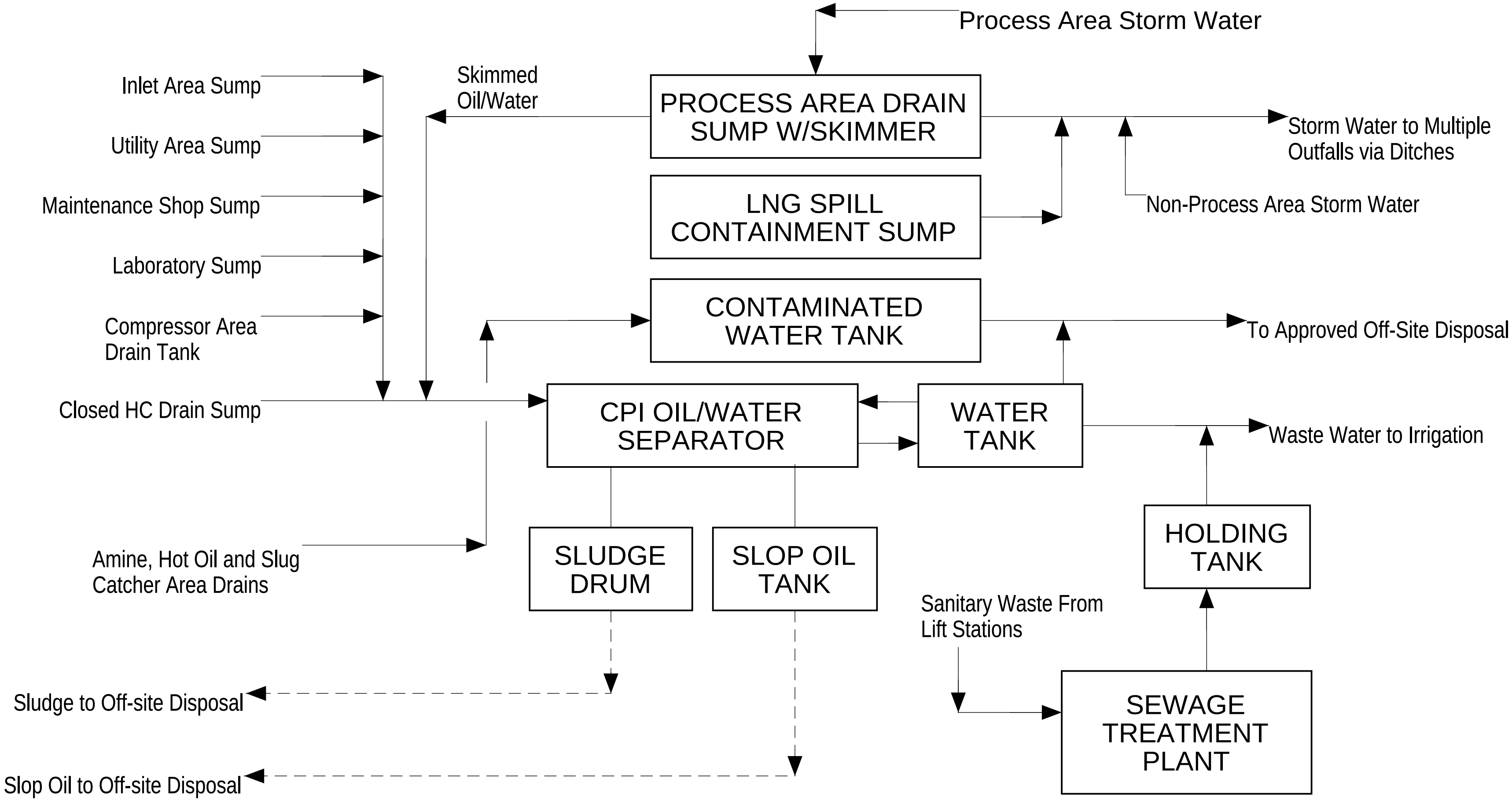


Table 2.4.1 Air Emission Inventory (Base Case)

Source	Emission Rate (kg/hour)							Total Annual Emission Release (tonnes)						
	PM	SO_2	NO_X	CO	CO_2	TOC/CH_4	N_2O	PM	SO_2	NO_X	CO	CO_2	TOC/CH_4	N_2O
Heaters/Flares														
Inlet Gas Heaters (Metering Facility)	0.297	0.020	3.904	3.279	4,996	0.429	0.009	2.599	0.176	34.199	28.727	43,761	3.762	0.081
Acid Gas Incinerator														
Fuel	0.138	0.058	1.819	1.528	2,586	0.200	0.004	1.126	0.475	14.818	12.447	21,069	1.630	0.035
Acid Gas in Feed Gas		15.893			222,540			0	129.480	0.000	0.000	1,812,987	0.000	0.000
Flare Pilots & Purge Gas	0.006	0	0.078	0.065	90.950	0.009	0.000	0.048	0	0.632	0.531	740.9	0.070	0.002
Flares														
Marine Flare														
a) Warm Ship Cool-down	0.000	0	33.761	183.7	57,012	69.508	0.116	0.000	0	3.241	17.635	5,473	6.673	0.011
b) Cold Ship Cool-down	0.000	0	72.081	392.2	121,723	148.4	0.247	0.000	0	21.913	119.2	37,004	45.114	0.075
Gas Turbines														
Refrigeration Compressor/Turbines	63.855	0	724.8	174.0	295,018	28.735	0.597	520.2	0	5,904	1,418	2,403,455	234.1	4.866
(16 Frame 5D's)														
Power Generation Turbines														
(7 Solar Mars 100S's)														
a) Normal Operation w/o Ship Loading	1.616	0	20.974	41.947	28,313	20.974	0.057	9.391	0	121.9	243.7	164,519	121.9	0.331
b) Normal Operation w/ Ship Loading	1.733	0	21.875	43.751	30,364	21.875	0.061	4.049	0	51.101	102.2	70,931	51.101	0.143
Total :	**67.6**	**16.0**	**879.2**	**840.5**	**762,642**	**290.1**	**1.1**	**537.4**	**130.1**	**6,152**	**1,942**	**4,559,940**	**464.3**	**5.5**

Table 2.4.2 Air Emission Inventory (Start-Up and Emergency Releases)

Source	Emission Rate (kg/hour)							Total Annual Emission Release (tonnes)						
	PM	SO_2	NO_X	CO	CO_2	TOC/CH_4	N_2O	PM	SO_2	NO_X	CO	CO_2	TOC/CH_4	N_2O
Heaters/Flares														
Startup Regeneration Gas Heater	0.167	0.011	2.203	1.850	2,818	0.242	0.005	0.064	0.004	0.844	0.709	1,080	0.093	0.002
Startup Hot Oil Heater	1.930	0.131	25.389	21.327	32,488	2.793	0.060	1.183	0.080	15.569	13.078	19,921	1.713	0.037
Flares														
Wet Flare														
Plant Upset	0.000	2.141	287.9	1,566	531,041	592.6	0.985	0.000	0.026	3.454	18.795	6,372	7.112	0.012
Dry Flare														
Plant Upset	0.000	0.000	241.3	1,313	445,111	496.7	0.826	0.000	0.000	23.162	126.029	42,731	47.687	0.079
Marine Flare														
Maintenance	0.000	0.000	5.489	29.867	9,269	11.301	0.019	0.000	0.000	3.366	18.315	5,684	6.930	0.012
Total :	**2.1**	**2.3**	**562.2**	**2,932**	**1,020,728**	**1,104**	**1.9**	**1.2**	**0.1**	**46.46**	**176.9**	**75,788**	**63.5**	**0.1**

Case Basis

Wet Flare Source: Plant Feed Gas

Upset

Rate (kg/hr) (25% of design rate)	222,000
Emission Duration (hours/year)	12

Dry Flare Source: Plant Feed Gas

Upset

Rate (kg/hr) (25% of design rate)	186,500
Emission Duration (hours/year)	96

Marine Flare Source: LNG Storage Tank Vapors

Maintenance

Rate, based on tank heat leakage (kg/hr)	3,472
(two 100,000 m^3 and one 160,000 m^3 tanks)	
Emission Duration (hours/year)	613
Assumed Plant Availability	93%

Table 2.5 Comparison of Fugitive Emissions from the 3 MTPA and 10 MTPA Plants

Equipment Type	3 MTPA Plant	10 MTPA Plant
	Total Count (approx.)	**Total Count (approx.)**
Connectors	400	880
Flange	5,150	11,340
Open ended lines	0	0
Pump seals	50	100
Valve	1,300	1,900
Other	250	550
TOTAL COMPONENTS	**7,150**	**13,770**
Compound	**Emissions (kg/hr)**	**Emissions (kg/hr)**
Nitrogen	0.425	1.105
Carbon dioxide	0.114	0.296
Methane	2.968	7.717
Ethane	0.469	1.219
Ethylene	0.005	0.013
Propane	3.924	10.202
I-butane	0.515	1.340
N-butane	0.576	1.498
Pentane Plus	0.111	0.289
Water	0.401	1.043
Hydrogen sulphide	0.000	0.000
DGA amine	0.201	0.523
I-Pentane	0.252	0.655
N-Pentane	0.162	0.421
Hexane Plus	0.215	0.559
TOTAL VOCs	**5.961**	**15.50**
TOTAL HYDROCARBONS	**9.398**	**24.436**
TOTAL EMISSIONS	**10.34**	**26.88**

2.5.4.2 Wastewater discharges

Figure 2.9 summarises the sources of liquid waste within the plant site, their proposed treatment and disposal. There are basically three liquid waste disposal streams:

(i) clean stormwater runoff from clean parts of the site will be discharged via drains into the intertidal zone at selected points adjacent to the site;

(ii) small quantities of semi-liquid/solid materials (such as sludge and slop oil from the CPI separator) will be disposed off site at approved facilities

(iii) very low volumes of process wastewater, plus low volumes of utility water from cleaning operations or testing of fire fighting equipment, and potentially contaminated stormwater runoff from the plant process area, will be routed to the CPI separator for treatment. Treated wastewater will be routed to an irrigation system for landscaping.

Low volumes of treated sewage will be pumped to a sewage treatment plant and treated effluent will be routed to an irrigation system after dechlorination. Holding tanks have been provided for the treated effluent to ensure that the water quality is suitable for irrigation. In the event of heavy rainfall, the treated effluent may be discharged to the ocean. The water quality values shown in Table 2.6 are for normal operating conditions of the treatment units.

Table 2.6 Anticipated Effluent Quality

Water Quality Indicators	Anticipated Effluent Quality
pH (in standard units)	6.5 – 8.5
BOD_5	20
TSS	20/60 max
Oil and grease	20 (none visible)
Temperature	$1^{o}C$ above ambient
Floatable/settleable matter	None
Arsenic	None Expected
Cadmium	None Expected
Total chromium	None Expected
Copper	None Expected
Iron	None Expected
Lead	None Expected
Manganese	None Expected
Mercury	None Expected
Nickel	None Expected
Silver	None Expected
Zinc	None Expected
Acute toxicity	None
Coliforms	< 400 MPN

Note : MPN = Most Probable Number

2.5.4.3 Solid and semi-liquid wastes

Sources of solid wastes in the LNG plant are: administration and office buildings, plant area, amine and dehydration units, sewage treatment plant, demineralisation unit, CPI separator, hot-oil system and mercury removal catalyst units (Table 2.7).

Wastes generated in the LNG plant are classified as hazardous and non-hazardous in accordance with Northern Territory’s “Waste Management and Pollution Control Act”, December 2000. Non-hazardous wastes sanitary sludge, demineralisation sludge, molecular sieve waste, and trash. Hazardous waste may include spent solvents, waste lubricating oils, spent oils, oily sludge, and mercury contaminated carbon beds. It is anticipated that the above wastes can be disposed of safely within Australia.

2.6 CONSIDERATION OF ALTERNATIVE SITES

As part of the original environmental assessment in 1997, Phillips undertook a detailed review of a range of alternative sites for the location of the LNG plant. The selection process examined sites near Darwin and on the Island of Timor:

- Four sites on Timor Island:
  (1) Kupang;
  (2) Suai on the south coast of East Timor;
  (3) Vikeke on the south coast of East Timor;
  (4) east coast of Roti Island, and
- Four sites in the Darwin area of the Northern Territory:
  (1) Point Margaret, on Cox Peninsula, west of Darwin;
  (2) Glyde and Gunn Points, to the north-east of Darwin;
  (3) Masson and Raft Points, on Cox Peninsula, west of Darwin;
  (4) Wickham Point, on Middle Arm Peninsula in Darwin Harbour.

Table 2.7 Comparison of Anticipated LNG Plant Solid Waste Generation from the 3 MTPA and 10 MTPA Plants

Type of Solid Wastes	Source of Solid Wastes	Classification	Quantity kg/yr	
			3 MTPA Plant	10 MTPA Plant
Waste lubricating oils	Plant area	Hazardous	8,300	16,000
Spent oils	Hot-oil system	Hazardous	950	1,500
Cellulose	Plant area	Non-hazardous	1,020	2,000
Biological sludge	Sewage treatment plant	Non-hazardous	4,000	5,000
Inorganic sludge	Demineralisation unit	Non-hazardous	200	400
Oily sludge	CPI separator	Hazardous	40,000	60,000
Spent solvents	Plant area	Hazardous	100	200
Ceramic balls	Dehydration unit	Non-hazardous	3,100	5,500
Molecular sieve waste	Dehydration unit	Non-hazardous	35,380	72,000
Mercury-contaminated carbon beds	Mercury removal unit	Hazardous	*	*
Trash	Plant area	Non-hazardous	50,000	80,000

Note: * The carbon utilised for mercury removal has sulphur impregnated in the pores of the carbon granules. Based on preliminary testing of the Bayu-Undan gas, the amount of mercury that would accumulate over the life of the project would be approximately 3.3 kg/yr. This would equate to a 20 year life for a single carbon bed (which contains some 24,000 kg of carbon) and the current LNG plant design includes two such beds. In addition, it has been the experience of a leading carbon supplier that the carbon does not test hazardous for mercury based on the United States EPA test method for toxicity and meets current standards for disposal in industrial landfills.

The sites were evaluated qualitatively on the basis of the following site selection criteria:

- the location of an LNG plant at the site must be environmentally acceptable to the public and government authorities;
- the proposed site should be within an area zoned or considered by government to be acceptable for industrial development to facilitate granting of the necessary approvals;
- there should be no impediments to obtaining freehold title to the necessary land;
- port facilities must be capable of providing safe passage and sheltered berthing for 95 - 145,000 m^3 LNG tankers;
- the berthing dock should be close to shore to minimise trestle and LNG loading line and vapour recovery costs;
- the site must be at least 150 ha in area to allow for potential expansion to three LNG trains (nine million tonnes per annum);
- the harbour must be able to handle LNG tanker traffic for up to nine million tonnes of LNG per annum, LPG tanker traffic and other uses;
- the terrain should preferably minimise site preparation work and disruption to the local environment;
- there should be a minimum one kilometre wide buffer zone between the plant and surrounding developments;
- geotechnical properties of the site should provide adequate foundation formations to support plant equipment and storage tanks;
- materials for construction should be obtainable on or near the site;
- the site should be tectonically stable;
- the site should have the capability of receiving large, heavy shipments of equipment or modules either overland or by barge;
- the site should be located to ensure there are minimal disruptions to the LNG plant and marine shipment facilities from the effects of wind, waves, tides, currents and siltation;
- there should not be any major impediments to providing the required infrastructure on site;
- the site should preferably be located in an area where the infrastructure and necessary skills for plant construction and operations are readily available; and
- construction costs should be minimised.

This evaluation, along with quantitative estimates of site preparation and construction costs formed the basis of a site selection for the project (see Section 4.3.3 of the 1997 EIS, D&M 1997).

Wickham Point on the Middle Arm Peninsula was identified as the preferred site, chosen after consideration of infrastructure availability, construction costs, workforce availability, berthing conditions, water depths, land availability, foundation conditions, and environmental implications. Subsequently, the EIS process confirmed the adequacy of this site for the LNG facility and the necessary steps were undertaken to progress native title acquisition, site allocation, and pipeline approvals associated with this preferred location. As a result of this effort, Wickham Point is immediately available to development of the LNG facility described in the document. No other site can offer the necessary security of tenure and certainty of access.

The evaluation of Glyde Point demonstrated advantages to Wickham Point only in terms of the availability of suitable land for industrial use. However, it was rejected as a preferred option due to the exposed nature of the coastline to north-west winds, the requirement for extensive dredging to be undertaken, the lack of infrastructure and access from Darwin suburbs, and strong spring tidal currents and shallow shoals and reefs which would present navigation hazards for vessels.

Phillips believes that Wickham Point remains the best location for LNG production facilities in the Darwin region and the only location that can support early development options for Timor Sea gas.

3. DESCRIPTION OF EXISTING ENVIRONMENT

3.1 INTRODUCTION

This section describes the physical, biological, cultural and socio-economic environment in which the proposed 10 MTPA LNG project will be constructed and operated.

The information presented in this section is largely a summary of detailed field surveys undertaken in the preparation of the 1997 Draft EIS and Supplement of 1998. However, this has been updated by new information or data which has become available since the original assessment, through recent literature reviews and consultations with various specialists.

In accordance with guidelines set by the NT DIPE, a focus has been retained on the main features of the environment likely to be affected by the proposed expansion, particularly in relation to the Darwin airshed and harbour catchment.

3.2 PHYSICAL ENVIRONMENT

3.2.1 Regional Geomorphic Setting

Darwin Harbour, with an area of about 500 km^2, is a large ria system, or drowned river valley, formed by postglacial marine flooding of a dissected plateau. In its southern and south-eastern portions the harbour has three main components: East, West and Middle Arms which merge into a single unit, along with the smaller Woods Inlet, before joining the open sea. Freshwater inflow to the harbour occurs from January to April, when estuarine conditions prevail in all areas (Hanley 1988).

Over the 6-8,000 years since Darwin Harbour was formed by rising sea levels, erosion from the adjoining terrestrial environment has carried substantial quantities of sediment into the harbour. This sediment now forms much of the intertidal flats which veneer the pre-flooding bedrock.

It is proposed to locate the LNG plant on land located at the western end of Middle Arm Peninsula in Darwin Harbour, between the East and Middle Arms of the Harbour. Both arms are the estuaries of rivers which during the wet season drain much of the hinterland behind Darwin and Palmerston (Figure 3.1). Elizabeth River flows into East Arm, while the Darwin and Blackmore Rivers flow into Middle Arm.

3.2.2 Topography and Bathymetry

3.2.2.1 Wickham Point topography

Wickham Point is on the north-west tip of Middle Arm Peninsula. This peninsula comprises two small ‘islands’ of terrestrial vegetation surrounded by intertidal mangrove forests which are partially or completely inundated by water at high tide (Figure 3.1). For the purposes of this report, Wickham Point refers to the westernmost island which is the proposed site for the LNG plant. The topography of Wickham Point is shown on Figure 1.3.

The island is roughly triangular in shape and consists essentially of three parallel north north-east trending ridges separated by narrow valleys. These ridges are strike ridges oriented along the prevailing direction of the steeply dipping bedrock formation. They are steep-sided, particularly on their coastal margins, and generally have narrow foot slopes. The largest ridge forms the western side of the island and rises at its northern end to form Peak Hill, the highest point on the island at 32 m elevation. The central ridge is shorter and decreases in height to a rocky bar extending into the mudflats at its northern end while the eastern ridge is reduced to a low shelf at its northern end. The intervening valleys lie between 4 and 8 m above sea level and terminate in small embayments on the north and south coasts of the island.

Swampy conditions develop in the valley between the western and central ridge during wet weather. No permanent streams are present on the island though it is evident that intermittent flows occur in the shallow gullies on the sides of the ridges during the wet season.

The island is surrounded by an extensive zone of tidal flats which are widest on the northern side and narrowest at the south-western side of the island. The tidal flats are gently inclined surfaces underlain by sand in low tidal areas and mud in mid-high tidal levels. Mangroves typically occupy the mid-high tidal mud flats and form a peripheral belt around the entire island. Within the high tidal mud flats, areas of salt flats and samphire flats have developed as a result of hypersaline groundwater conditions precluding mangrove establishment. Spits and cheniers occur as elongate narrow sand/gravel deposits either attached to or separate from the island. Some bars of bedrock are exposed at places in the salt flats and tidal flats (Plates 2 and 4).

3.2.2.2 Darwin Harbour bathymetry

The bathymetry of Darwin Harbour is shown in Figure 3.2. A channel of >20 m water depth (below LAT) extends in a south-easterly direction from Darwin Port Limits to the confluence of Middle and East Arms. The channel favours the eastern side of the harbour, with broader shallower areas occurring on the western side. The intertidal flats and shoals are generally more extensive on the western side of the harbour than on the eastern side.

The channel continues into East Arm at water depths of >15 m LAT, the bathymetry in this area has been modified by previous dredging for the East Arm Port development. A slightly deeper channel extends into Middle Arm, up to the western side of Channel Island and a localised depression of >30 m LAT depth known as Town Hall. A shallower channel (generally <10 m LAT depth) separates Wickham Point from Channel Island and terminates in Jones Creek.

A recent geotechnical/geophysical study of the project undertaken by Fugro on behalf of Phillips, has detailed the bathymetric profiles and seabed features for the proposed loading facility, turning basin and construction dock. The area of the trestle portion of the export jetty has a typical water depth of 1-3 m closest to the rock platform, before increasing to a depth of approximately 15 m nearest the loading facility. The bathymetry of the proposed vessel turning basin ranges between 15 to 17.5 m. Both the loading facility and turning basin is now proposed 125 m east of the original location to avoid a shallower mound of 10-11 m depth (shown in Figure 3.2) and thereby reduce dredging requirements. The area of the proposed construction dock on the north-eastern side of Wickham Point ranges between 0 - 2 m in depth along its length.

3.2.3 Climate

The closest meteorological station with comprehensive climatic data to Wickham Point is at Darwin Airport, a distance of approximately 12 km to the north. The nearest meteorological station, situated on the Channel Island Power Station site some 4 km to the south, is only part of the mesoscale network and is not subject to the same level of data quality assurance as Darwin Airport.

The project area is located within the monsoonal tropics. Over the 60 year period between 1941 and 2001, average annual rainfall in Darwin is approximately 1710 mm, most of which (approximately 87%) falls in the November to March wet season (Bureau of Meteorology 2001). Humidity over this period averages 70-80% while in the dry season humidity averages 40% and there is virtually no rainfall.

Maximum temperatures are hot all year with November being the hottest month with a range of 25 to 33°C. The monthly minimum average temperature is 19°C in July.

Prevailing winds during the wet season are light west to north-westerly, freshening in the afternoon due to sea breezes. In the dry season, the prevailing winds are the south-easterly trade winds (Parkinson 1996). Wind roses for Darwin Airport are presented in Figure 3.3.

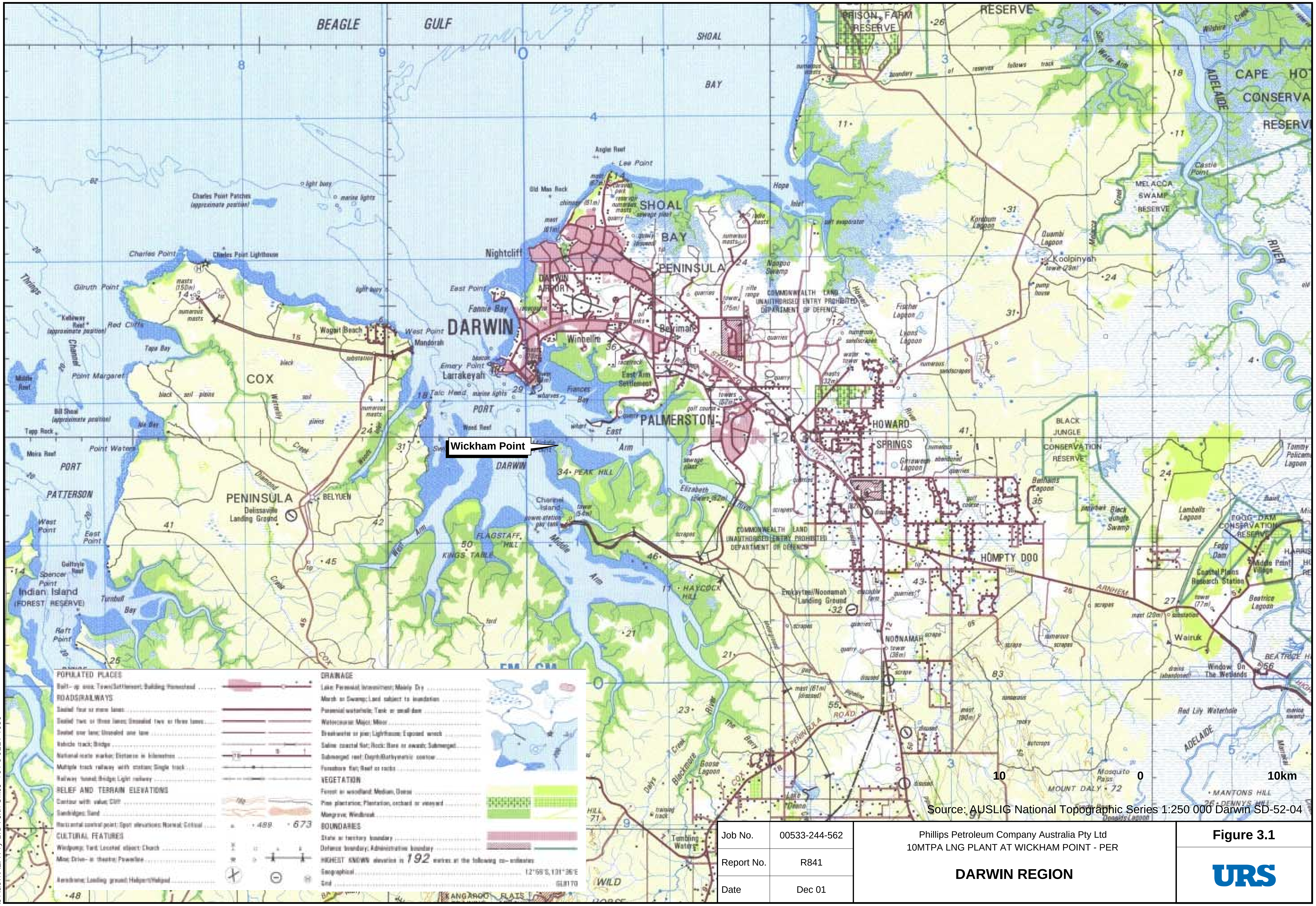
The monsoonal tropics also experience cyclonic activity. The cyclone season in northern Australia extends from October to April (DCC 2001a). Tropical cyclones cause most damage within a distance of 50 km from the coast; once a cyclone has passed onto landfall it weakens rapidly, but resultant storm surge can be of concern to coastal developments and flood damage can result from associated squally rains.

3.2.4 Darwin Harbour Hydrodynamics

Darwin Harbour is characterised by a macrotidal regime. Tides are predominantly semidiurnal (two highs and two lows per day), with a slight inequality between the successive tides during a single day, but nearly diurnal tides occur for a two day period during the neaps. The lowest spring tides of the year occur during October, November and December. Tidal excursions range from 8 to 15 km during springs and 2 to 8 km during neaps (Semeniuk 1985; Hanley & Caswell 1995).

Byrne (1988) summarised data on the hydrodynamics and coastal processes of Darwin Harbour, with particular reference to the area of Fannie Bay and Cullen Bay. The harbour is considered well protected, with wind-generated waves typically less than 0.5 m with periods of two to five seconds. The majority of waves are generated within the harbour or in Beagle Gulf. The available data did not include cyclonic conditions, but predicted waves during cyclones would be of the order of 3 to 3.5 m.

Wave modelling conducted by GHD-Macknight (GHDM 1997) considered the ambient wave climate at the proposed loading facility site to be generally short crested waves with mean wave periods of less than 3 seconds. During the summer months, waves from the north-west sector could reach heights up to 1 m, although average wave height was less than 0.5 m. Average wave conditions during the winter months were predicted to be even less. It was considered that tsunamis and swell waves (long period waves) could not occur within Darwin Harbour due to its orientation and the protection from ocean swells by Melville and Bathurst Islands.



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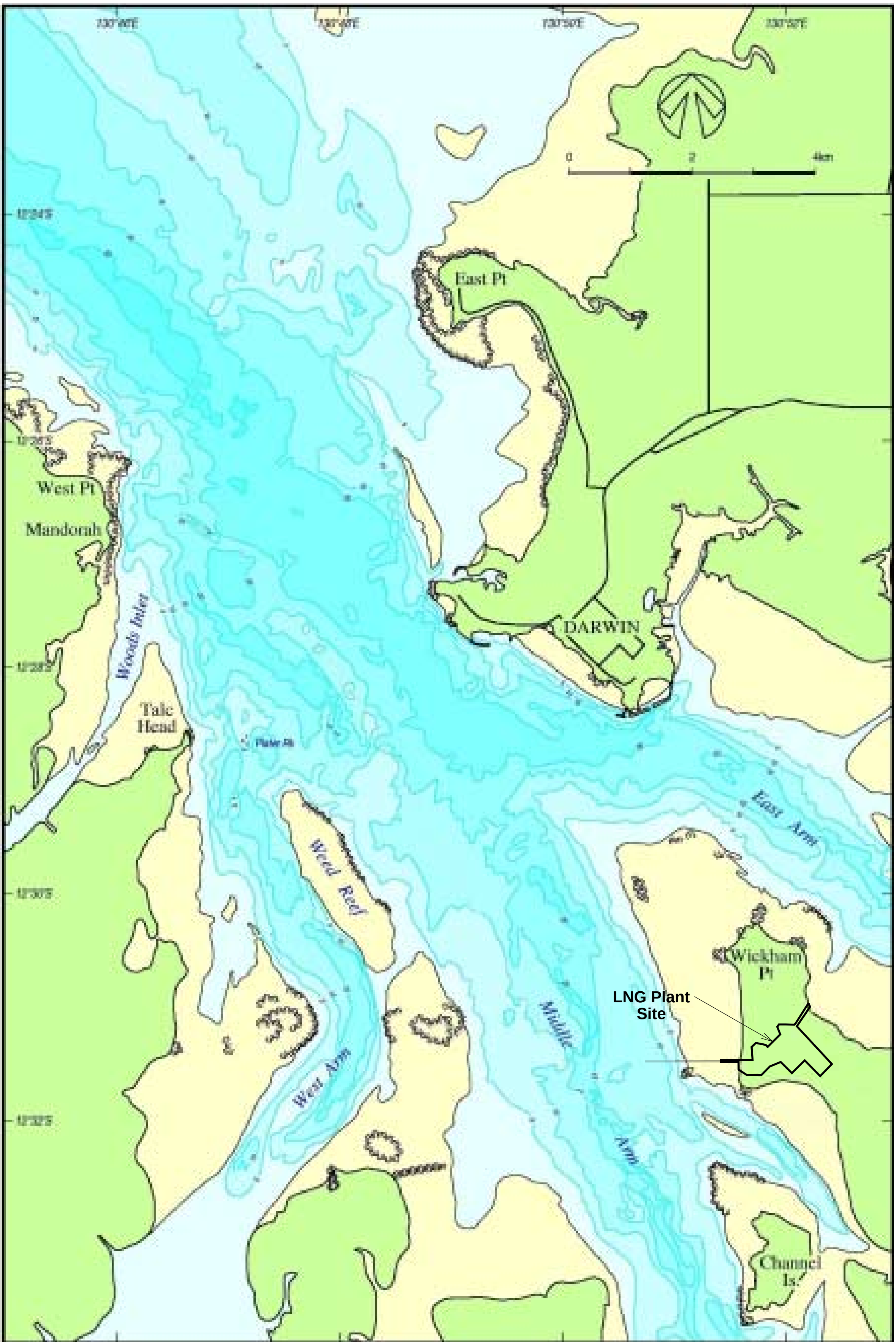
10MTPA LNG PLANT AT WICKHAM POINT - PER

DARWIN REGION

Figure 3.1

URS



Job No.	00533-244-562
Report No.	R841
Date	Dec 01

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10MTPA LNG PLANT AT WICKHAM POINT - PER

BATHYMETRY OF DARWIN HARBOUR

Figure 3.2

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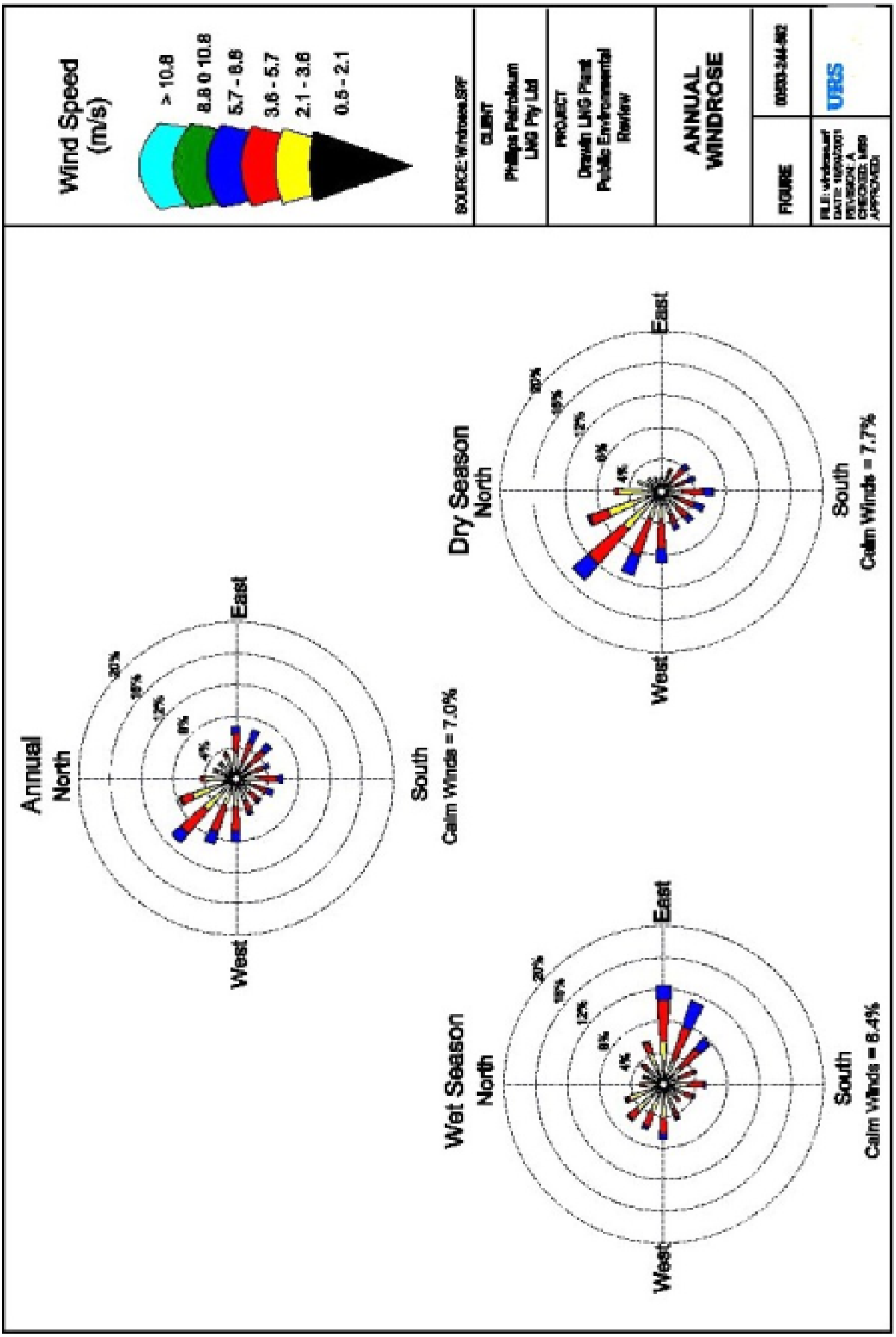

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 3.3**
Report No.	R841	**WIND ROSES - DARWIN AIRPORT**	URS
Date	Dec 01		

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Extreme wave conditions were modelled by GHDM (1997) using wind data from Cyclone Tracy. Waves with significant wave height of 4.5 m, and average periods of ~7.5 seconds, were found to occur at the entrance to Darwin Harbour. However, these waves were found to be affected by bathymetry as they propagated towards the proposed loadout facility site, reducing to a height of ~0.7 m.

Extreme high water levels at Wickham Point, taking into account cyclone storm surge, cyclone wave set-up and astronomical tide, were estimated by VIPAC (1994 in GHDM 1997) to be 3.8 m (10 year return period), 5.1 m (100 year) and 6.4 m (1,000 year) (D&M 1998a). The minimum plant elevation will be set by a detailed hydrodynamic study that will consider storm tide level, including allowances for cyclone wave set up, astronomical tide and wave run up against embankments. It is expected that this will result in a final plant elevation of between 6.5 and 7 m AHD.

Numerical modelling of tidal current circulation in Darwin Harbour was conducted by GHDM (1997) to determine current speeds and directions at the proposed loading facility. The model indicated maximum current velocities in the proposed turning basin area to be 1.3 m/sec (flood tide) and 1.1 m/sec (ebb tide), with velocities decreasing closer to the Wickham Point shoreline. Current velocities were lower in the shallower channel between Wickham Point Peninsula and Channel Island, and flood tide water moved up the main channel of Middle Arm rather than flowing around the north side of Channel Island. A simulated wet season water inflow of 10,000 m^3/sec into Middle Arm resulted in a decrease in flood tide velocity of 0.2 m/sec and an increase in ebb tide velocity of 0.2 m/sec.

Salinities in Darwin Harbour vary considerably during the year, particularly in the arms where freshwater influence is greatest during the wet. Salinities throughout the harbour are about 37 parts per thousand (ppt) during the dry season, with surface and bottom depths having similar salinities. At the height of monsoonal inflow during March, areas in the middle of the harbour such as Weed Reef (Figure 3.2) can decrease to 27 ppt. Salinities in the arms, which are more influenced by freshwater inflow can reach as low as 17 ppt. The water at this time is highly stratified, with salinities on the bottom being as much as 12 ppt higher than on the surface. As the rains cease runoff decreases, and salinities return to their higher dry season levels (Parry & Munksgaard 1995).

With its tropical location, water temperatures in Darwin Harbour are very high, but some seasonal variations do occur. Temperatures range between 31 and 32 °C for most of the year, but they decrease to about 29 °C during the height of the wet season. In contrast to salinities, there is little temperature stratification in Darwin Harbour during the wet season (Hanley & Caswell 1995).

Light levels reaching the sea surface in Darwin Harbour are very high. However, because of water turbidity the light is rapidly dissipated, and even within the space of a few metres levels can become very low, particularly during the wet when turbidity levels are very high. Even at a depth of only 3 m below the surface light levels during the wet can be as low as 7.7% of surface levels. Light levels near the bottom can be as low as 1% of surface levels during the wet season (Hanley & Caswell 1995).

3.2.5 Hydrology (Surface and Groundwater)

The LNG plant site on Wickham Point is underlain by early Proterozoic sediments of the Burrell Creek Formation, which at the site comprise shale, siltstone, sandstone, and phyllite. Outcrop is limited to two small sandstone ridges. A fine-grained sandy colluvium forms scree slopes on the base of the ridges.

The Burrell Creek Formation which underlies the peninsula is generally impermeable and holds only limited water in fractures, which may be of limited extent. Minor groundwater may be retained in the colluvium during the wet season. Groundwater stored in the colluvium and fractures is likely to be utilised by the vegetation or lost through evaporation.

One prominent drainage line transects the valley to the east of Peak Hill while several smaller creek lines become evident during the wet season.

3.2.6 Geology, Soils and Sediments

3.2.6.1 Wickham Point terrestrial geology and soils

An evaluation of the local geology; landforms and soil types (their characteristics, erodibility and potential for acid generation), was prepared using a variety of data sources including topographic maps, geological maps, land systems reports, aerial photography, other references and by fieldwork in October 1996. This has been supplemented by recent geotechnical/geophysical investigations undertaken by Fugro on behalf of Phillips, which involved airborne electromagnetic and aeromagnetic surveys, resistivity profiling, refraction tomography, downhole seismic testing and subsurface stratigraphy studies through bore drilling.

Bedrock in the local region consists of meta-sediments of the Early Proterozoic Finniss River Group which were deposited by turbidity currents in a submarine fan environment. These rocks have been metamorphosed to lower greenschist facies and have undergone one major deformation which has produced steep dips and resulted in the pervasive north-north-east strike of the strata.

The member of the Finniss River Group present on Wickham Point is the Burrell Creek Formation which consists of a sequence of phyllite, siltstone, shale, sandstone and conglomerate. Prominent quartz veining up to 1m in width has been noted in several areas, particularly on the ridges that may contribute in part to their resistance to erosion. The overburden ranges in thickness from a few decimeters up to 4 m in the proposed plant area; and the overburden thickness tends to increase towards the lower footslope and valley floor. The overburden consists mostly of sands, silts and clays. The underlying rock varies considerably in strength both laterally and vertically.

An extensive cycle of deep weathering, erosion, re-sorting and lateritisation occurred throughout the Top End of the Northern Territory during the Late Tertiary and resulted in the development of what is termed the Koolpinyah Surface. Parts of this surface are present on the island and take the form of laterite deposits on the bench areas of lower slopes of the flanks of the ridges and as extensive platforms near sea level.

There is a prominent ferricrete pavement near sea level and it appears to extend seawards out to the low tide level as a capping on the shallow nearshore reefs. Only material from the zone of iron enrichment in the laterite profile has been found on Wickham Point to date but material from the underlying mottled zone has been encountered in the offshore boreholes drilled for the investigation of the jetty alignment.

Offshore subsurface stratigraphy is represented by 5 m to 9.5 m of sediment in the LNG tee head area underlain by phyllite and meta-siltstone of the Burrell Creek formation. The rock is extremely to distinctly weathered. The sediment thickness along the trestle varies from about 4.5 m to 7.0 m. The underlying rock is stronger than at the tee head.

Tidal mudflats which form a broad platform around Wickham Point can be divided into mangrove flats and salt flats. These mudflats are composed of Quaternary marine alluvium which consists of clay, silt and some fine sand, commonly with shell fragments and organic matter in the mangrove zone and salt crusting on the salt flats. In front of the western mangrove fringe of Wickham Point is a broad intertidal flat up to 1.2 km wide and overlain by a sand and mud veneer of variable thickness. At the southern tip of Wickham Point is an expanse of exposed pavement, supporting three intertidal rock stacks, which extends nearly 1 km westwards from the mangrove fringe. A sloping rock platform extends some 100 m southwards from the mangrove fringe.

Cobbles and boulders rounded by wave action are observed in the strand line deposits behind the mudflats on the north-western side of Wickham Point. These deposits are the result of strong wave action that does not now occur on the landward margin of mudflats. Such deposits would have to pre-date the formation of the mudflats.

Cheniers are barrier beach deposits built by wave action in front of the actual shoreline. The cheniers are formed from Quaternary beach deposits consisting of fine to coarse quartz sand with shell and occasional coral fragments. The sandbanks which provided the sand for the formation of the cheniers have been buried by the more recently formed mudflats.

3.2.6.2 Darwin Harbour sediments

Michie (1988) reported three sources of sediments available to Darwin Harbour:

- breakdown of rocks in the catchment area by weathering and erosion;
- remobilisation of existing sediments, including partially consolidated sediments; and
- sediments of biogenic origin, including those derived from corals.

Most harbour sediments are a mixture of all three types. There is a general annual cycle of sediment deposition during the wet season and erosion during the dry.

The seabed of Darwin Harbour is dominated by gravel. There is a scour zone in the centre of the harbour, where the hard pavement substrate is covered by only a thin veneer of sediment, grading into terrigenous sand offshore from the tip of Wickham Point. The intertidal area off the point itself has fine sands and silts.

3.2.7 Seismicity

A detailed discussion of regional seismicity of the local area was included in Appendix G of the Draft EIS, and is summarised below.

The proposed LNG plant site is located in an area of low seismic activity. No earthquakes have been recorded in the immediate vicinity of Darwin since reliable records commenced. The nearest recorded earthquake epicentre to the plant site is located at Bathurst Island, 100 km north-west of Darwin. This earthquake epicentre is the southernmost of a line of three recorded epicentres extending north of Melville Island. A cluster of four other epicentres have been recorded approximately 270 km south of Darwin in the vicinity of Fitzmaurice River.

There is no evidence to date that any of these epicentres are active in the Darwin region.

3.3 BIOLOGICAL ENVIRONMENT

3.3.1 Terrestrial Biota

3.3.1.1 Flora

Vegetation Communities of Wickham Point

Aerial photograph interpretation and field surveys, conducted during both the dry and wet seasons, were used to describe the vegetation of Wickham Point as part of the original environmental assessment. A vegetation map of Wickham Point is presented as Figure 3.4 and a full report on the vegetation survey is provided in Appendix H of the Draft EIS (D&M 1997).

The vegetation of the Wickham Point end of Middle Arm Peninsula comprises extensive intertidal areas supporting mangrove forests (Plate 5) and salt flats that completely surround two upland or hinterland areas rising to a maximum elevation of 32 m at Peak Hill. These islands of hinterland are largely vegetated with monsoon rainforest (which is expressed as dense vine forest, Plate 6) covering an area of approximately 180 ha. Limited areas of paperbark dominated woodland also occur on Wickham Point.

Within the survey area, 161 species from 138 genera were recorded. Of these, 44 species or 27% of the total were recorded during the wet season surveys, indicating they were stimulated to growth by the wet season. The rainforest was the richest vegetation formation (and covered the largest area of dryland vegetation on the islands) with 99 species, followed by Melaleuca woodlands with 37 species, mangroves with 28 species, and eucalypt woodlands with 24 species.

The Wickham Point survey area covered 1,515 ha (15.15 km^2) of mangrove and salt flat vegetation. Within the intertidal zone, eight distinct plant communities or floristic zones were found. These zones were arranged roughly parallel to the shore or tidal creeks and rivers. The zones often comprised almost monospecific stands at predictable topographic elevations above mean sea level. The pattern of zonation of the eight mangrove communities was mapped by Brocklehurst and Edmeades (1996). Distribution of the zones is shown in Figure 3.4.

With regard to dry land or terrestrial plant communities the major plant community is monsoon rainforest, also known as rainforest, vine forest or vine thicket, which covers the majority of Wickham Point.

The floristic zones of the intertidal and dry land areas are summarised below:

Seaward: Map Unit 1. An almost monospecific band of *Sonneratia alba* aligned roughly parallel to the shore of Wickham Point is inundated twice daily, by every tide, and consists of woodland 4 to 8 m tall in unconsolidated soft mud substrates (Plates 4, 5).

Shoreline: Map Unit 2. This unit merges with the seaward zone. The dominant mangrove species is *Rhizophora stylosa*, which typically forms a closed canopy forest 6–10 m in height.

Tidal Creek: Map Unit 3. The tidal creek unit merges with the seaward zone. Again the dominant mangrove is *Rhizophora stylosa*, which also forms a closed canopy forest 6–10 m in height in this zone. Associated species include *Camptostemon schultzii, Avicennia marina* and *Bruguiera parviflora.* There is regular tidal inundation and the zone has deep root-structured muds.

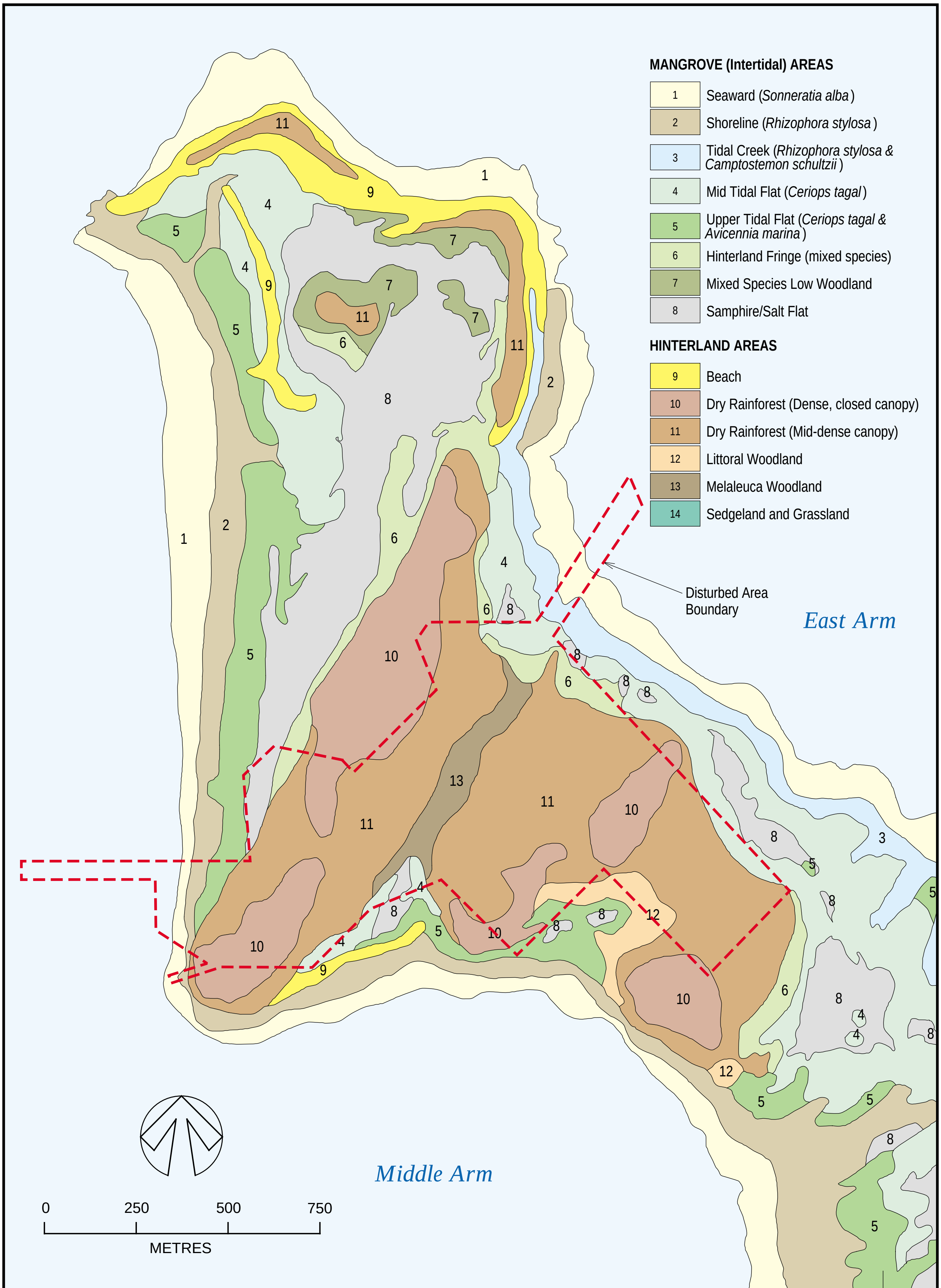
Mid Tidal Flat: Map Unit 4; and Upper Tidal Flat: Map Unit 5. *Ceriops tagal* is the dominant and often monospecific mangrove species. It forms dense, low forests typically with a closed canopy 2 to 4 m high. Tree height varies in response to salinity and fresh water inflow, height being greater where fresh water inflow is greatest. Tidal inundation occurs every fortnight on spring tides. Substrates are firm sandy to gravelly muds with seasonally high soil salinities.

Hinterland Fringe: Map Unit 6. This zone is characterised by taller mixed species mangrove stands. *Ceriops tagal* is often the dominant species, forming dense closed canopy forests to 6 m along the landward margin. There is freshwater inflow during the wet and very infrequent tidal inundation. *Lumnitzera racemosa, Bruguiera exaristata* and *Excoecaria ovalis* are the common species

Mixed Species Low Woodland: Map Unit 7. This unit is composed of taller mixed species mangrove stands. *Ceriops tagal* is often the dominant species, forming dense closed canopy forests to 6m along the landward margin. Freshwater inflow and very infrequent tidal inundation occur. Other common species include *Avicennia marina* and *Lumnitzera racemosa.*

Salt Flat: Map Unit 8. There are extensive bare hypersaline flats on the upper intertidal flat where salinity rises above that tolerated by mangroves. The flats may support scattered patches of samphire and are typically fringed by stunted *Avicennia marina* and *Ceriops tagal.*

Beach: Map Unit 9. The beach habitat comprises an open woodland, well separated trees to 8 m tall. A number of pantropical species such as *Gyrocarpus americanus, Hibiscus tiliaceus* and *Cordia subcordata* may be present. Patches of vine forest with *Drypetes lasiogyna, Micromelum minutum* and abundant vine species (*Tinospora smilacina, Capparis sepiaria, Abrus precatorius* and *Gymnema geminatum*) tend to occur on the upper dune areas. Strand plants such *as Ipomoea pes-caprae* and *Sesuvium portulacastrum* are found on the lower dune areas.



Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER **PROPOSED 10MTPA LNG FACILITY DISTURBANCE ENVELOPE SUPERIMPOSED ON VEGETATION COMMUNITIES OF WICKHAM POINT**	**Figure 3.4** URS
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Date	Dec 01		

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PLATE 5: Mangrove fringe (*Sonneratia alba*) on intertidal pavement.

PLATE 6: Dry monsoon rainforest vegetation.

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Dry Rainforest (dense canopy): Map Unit 10. This unit is composed of dense, closed canopy, vine-rich rainforests. Dominant species include *Acacia auriculiformis* and *Sterculia quadrifida* as scattered emergents in the upper stratum*. Drypetes lasiogyna, Diospyros compacta* and *Glycosmis trifoliata* are the dominant species in the mid-stratum.

Dry Rainforest (mid-dense canopy): Map Unit 11 (Plate 6). These are vine thickets with a more open canopy comprising a higher proportion of semi-deciduous species. Scattered emergent species include *Acacia auriculiformis, Eucalyptus tectifica* and *E. polycarpa.* Dominant mid stratum species include *Dodonaea platyptera, Hakea arborescens* and *Strychnos lucida.*

Littoral Woodland: Map Unit 12. This unit occurs on areas of shallow, skeletal soils particularly on the coastal margins. The dominant species include *Eucalyptus tectifica* and to a lesser extent *Brachychiton diversifollus* and *Sterculia quadrifida. Acacia auriculiformis* is a ubiquitous canopy species in this community.

Melaleuca Woodland: Map Unit 13. *Melaleuca* spp. (paperbarks) become dominant in areas of freshwater flow or seepage.

Sedgeland & Grassland: Map Unit 14. A small area with a perched water table supports a sedgeland and grassland community with low trees and shrubs capable of withstanding brackish conditions.

Weeds

Very few weed species have been recorded at Wickham Point to date. Within the rainforest habitat the most abundant weed is *Lantana camara*. Lantana is a declared noxious weed and in other areas of Australia is a serious threat to native vegetation (National Weeds Strategy Executive Committee 2000). It is an invasive species that smothers native plants and makes access difficult. Most plants found outside town areas in the Northern Territory have been garden escapes, and have tended not to spread under NT conditions and so Lantana is not yet a major problem (NT DPIF 1998). At Wickham Point and within other rainforests locally, this species typically coexists with native flora as a rambling understorey shrub. In some areas with a more open canopy, dense Lantana thickets occur. Minor areas of *Hyptis suaveolens*, the vine Wild Passion Fruit *Passiflora foetida* and the declared noxious weed Mission Grass *Pennisetum polystachion* were also observed. These species were confined largely to open areas with high light intensity such as the beach habitat and littoral woodland or the fringes of dry rainforest areas. The dense canopy rainforest is relatively free of introduced species.

3.3.1.2 Fauna

The terrestrial fauna of Wickham Point were documented through field surveys and reference to existing reports and databases, and summarised in detail in Appendix I of the Draft EIS. Significant fauna areas are shown in Figure 3.5.

Five habitat types were recognised for the previous fauna survey. These were Eucalyptus open forest; mangroves, margins and samphires; monsoon rain forest; paperbark woodland; and intertidal flats.

Amphibians

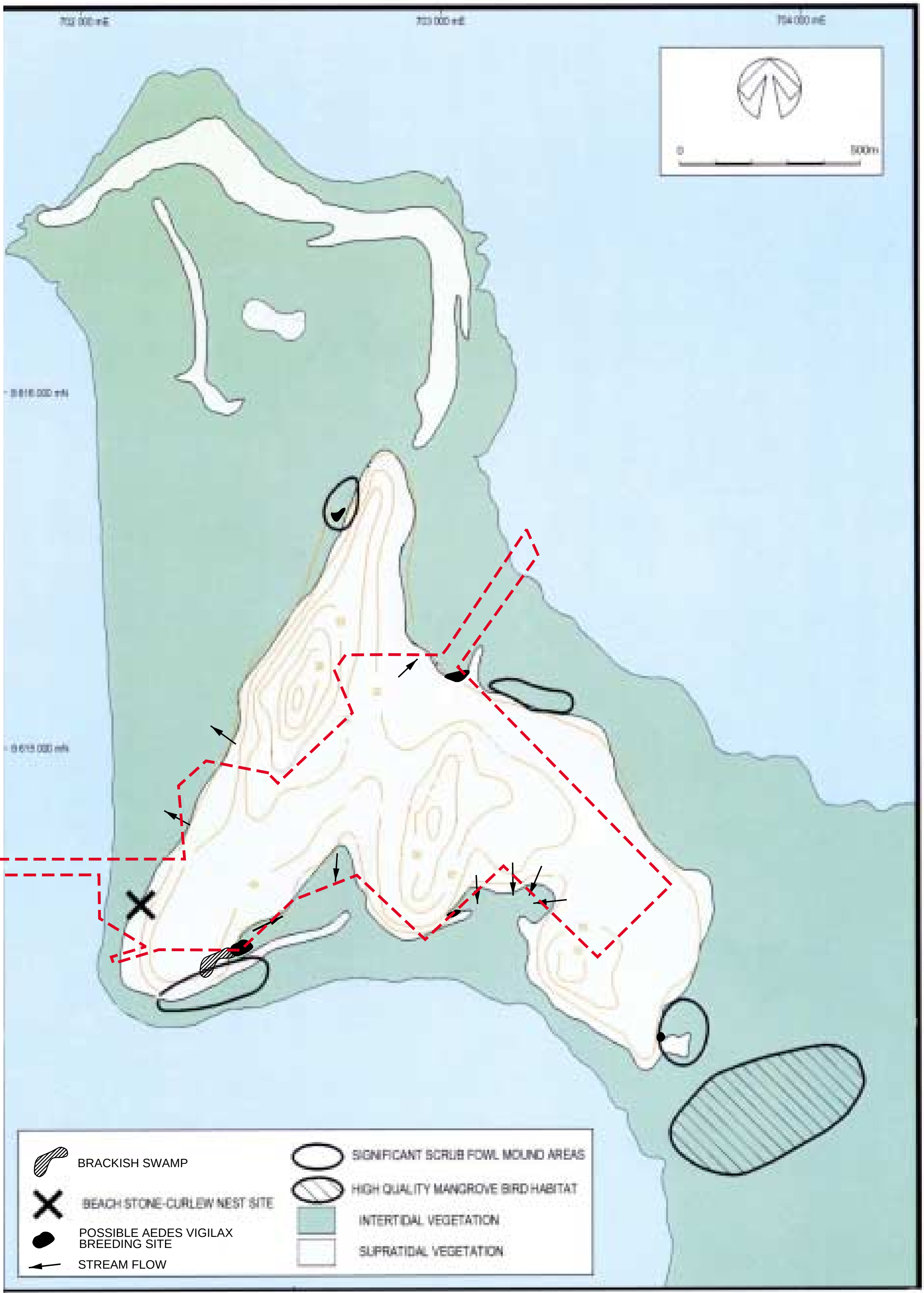
Seven frog species were recorded during the previous survey. All were found only during the wet season survey in the Eucalyptus open forest habitat of the mainland peninsula. Frogs were common in waterlogged sedge areas and especially around a seasonally flooded gravel quarry near the proposed access route. The most common species were Brown Tree Frog (*Litoria rothi*) and Dwarf Tree Frog (*L. bicolor*).

No amphibians were observed on the islands. These habitats are hostile to amphibians, which generally require freshwater for breeding, and are intolerant of saline conditions. Some seasonal freshwater areas do exist on the islands, so it is possible that frogs may occur there. Four species, Dwarf Tree Frog, Green Tree Frog (*Litoria caerulea*), Desert Tree Frog (*L. rubella*), and Marbled Frog (*Limnodynastes convexiusculus*) have been previously recorded in mangrove margin and littoral habitats in the Northern Territory.

Reptiles

Eleven species of reptiles were recorded during the survey, including one species of crocodile, and 10 lizard species. The most common species were small skinks of the genus *Carlia*, of which three species were observed. *Carlia munda* was the most abundant, and was found in all non-marine habitats. *Carlia amax* was only observed around rocky areas within the monsoon vine thickets. Two skinks, *Glaphromorphus darwiniensis* and *G. douglasi,* were generally confined to the monsoon vine thickets and paperbark forest habitats. The latter species, which was common at Wickham Point, is the only reptile species known to have a preference for the vine thickets habitat in the Darwin area (Martin & Freeland 1988).

Estuarine Crocodiles (*Crocodylus porosus*) occur in Darwin Harbour and a management program for this species is in effect in the area. Crocodiles are occasionally seen on the mudflats and in the small mangrove creeks around Wickham Point.



Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 3.5**
Report No.	R841	**SIGNIFICANT FAUNA AREAS AND BITING INSECT BREEDING SITES**	URS
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Four species of water snake are specialised for life in mangroves. Although they were not observed in the previous study, they are very likely to occur in this area. These species are Bockadam (*Cerberus rhynchops*), White-bellied Mangrove Snake (*Fordonia leucobalia*), Richardson's Mangrove Snake (*Moron richardsoni*) and Little File Snake *(Acrochordus granulatus*). Two species of sea snake are also reported to be mangrove dwellers (O'Gower 1979). These are the Port Darwin Sea snake (*Hydrelaps darwiniensis*) and the Elegant Sea snake (*Hydrophis elegans*).

Additional reptile species known to occur in littoral habitats in the Darwin area include the Northern Bluetongue Skink (*Tiliqua scincoides*), Northern Water Dragon *(Gemmatophora temporalis*), Mitchell's Water Monitor (*Varanus mitchelli*), Common Keelback *(Amphiesma mairii*) and Children's Python (*Liasis childreni*). Species such as Burton's Legless Lizard (*Lialis burtonis*), Children's Python, King Brown Snake (*Pseudechis australis*), Moon Snake (*Furina ornata*) and Common Tree Snake (*Dendrelaphis punctulatus*) are common in the East Arm and Palmerston area and would be expected to occur at least on the mainland peninsula.

Birds

Ninety species of birds were recorded in the study area. An additional 93 species are known to occur in littoral habitats within Darwin Harbour and are likely to also be present at Wickham Point (D&M 1997). The birds most commonly observed during surveys were Bar-shouldered Dove (*Geopelia humeralis*), Sulphur-crested Cockatoo (*Cacatua galerita*), Helmeted Friarbird (*Philemon buceroides*) and Yellow Oriole *(Oriolus flavocinctus*). All of these species were frequently observed in both surveys, and were found in a range of habitats.

More bird species (57) were observed in mangrove associated habitats than in any of the other habitats. The next richest habitat was Eucalyptus open forest, with fewer species observed in the other habitats. Because of the small area of the study site, many of the species recorded could be expected to move between several habitats.

A number of birds are more or less restricted to mangroves. These include Chestnut Rail (*Eulabeornis castaneoventris*), Collared Kingfisher (*Todiramphus chloris*), Red-headed Honeyeater (*Myzomela erythrocephala*), Mangrove Robin (*Eopsaltria pulverulenta*), Mangrove Golden Whistler (*Pachycephala melanura*), Melville Cicadabird *(Coracina tenuirostris melvillensis*) and White-breasted Whistler (*Pachycephala lanioides*). Some of these species are uncommon and restricted to well developed mangrove stands, so the occurrence of so many specialised species is indicative of high quality habitat.

Some bird species live primarily in monsoon vine forest. These species include Rainbow Pitta (*Pitta iris*), Rose-crowned Fruit-dove (*Ptilinopus regina*), Emerald Dove *(Chalcophaps indica*) and Orange-footed Scrubfowl (*Megapodius reinwardt*). Many of the mangrove and vine forest specialists freely move between these two habitats, so the occurrence of good representative examples of each habitat in close proximity at Wickham Point is beneficial to those species. For example, Rose-crowned Fruit-doves were frequently observed or heard in mangroves during the survey.

A great deal of seasonal variation was observed in bird species and numbers between the two surveys. Similar numbers of species were observed in each seasonal survey (67 in the dry; 62 in the wet), but only 38 species were recorded on both field surveys, indicating that the area has a very high proportion of transient or seasonal migrant species compared to residents. These species are made up of groups such as migratory waders, (e.g. Little Curlew *Numenius phaeopus*, Curlew Sandpiper *Calidris ferruginea* and Ruff *Philomachus pugna*) and other wet season visitors such as Pied Imperial Pigeon (*Ducula bicolor*), Rainbow Bee-eater (*Merops ornatus*) and Dollarbird (*Eurystomus orientalis*). A number of "wet" season visitors were recorded during the September survey, which is the usual time for the arrival of seasonal migrants.

One prominent feature of the site is the occurrence of many large nesting mounds of the Orange-footed Scrubfowl (Plate 7). This species was commonly seen, often in pairs, near the mounds during both surveys. The mounds were all located along the beach/mangrove margin interface, especially in areas proximate to monsoon vine forest (Figure 3.5).

Mammals

Fifteen mammal species (including two introduced species) were recorded during the field surveys. Small mammal trapping rates were low; only 0.5% in the dry season and 0.4% in the wet. The only rodent observed was the Grassland Melomys (*Melomys burtoni*), which was trapped in paperbark woodland, and was observed at night in sedgelands bordering mangroves. This species is common in littoral habitats around Darwin and has been recorded from mangroves previously (D&M 1993).

The Northern Brown Bandicoot (*Isoodon macrourus*) is a common species in the study area. Diggings, disturbances and tracks were observed in many locations around the mangrove margins and in the Eucalyptus open forest. Tracks across the samphire flats indicate that this species forages in these areas at low tide. A Northern Brushtailed Possum (*Trichosurus arnhemensis*) was trapped in paperbark forest on the main island, and tracks of this species were also frequently encountered.

PLATE 7: Nesting mound of the Orange-footed Scrubfowl.

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Agile Wallabies (*Macropus agilis*) were occasionally observed around the mangrove fringes and their tracks were also seen on the samphire flats.

Microchiropteran (insectivorous) bats were recorded frequently in Eucalyptus open forest, over tributaries and water bodies and using flyways on mangrove/open forest ecotones. Survey of microchiropteran bat species within open forest recorded three species using ultrasonic call detection. The most common was the Little Northern Freetail-bat (*Mormopterus loriae*). The Little Northern Freetail-bat and the Large-footed Myotis (*Myotis molluccarum*) were also recorded over mangroves and tidal creeks in the vicinity of the proposed access route. One species recorded during the survey, the Common Bentwing-bat (*Miniopterus schreibersii*) is known to regularly roost in caves or similar structures (Dwyer 1995). A large "camp" of Black Flying Foxes (*Pteropus alecto*) was observed in the mangroves along the north-western edge of Wickham Point during the wet season.

Aquatic Fauna

There are no permanent freshwater habitats on Wickham Point or the adjacent mainland peninsula. However, wet season freshwater habitats are present in some areas of the mainland peninsula along the proposed access route. No pure freshwater fish species were observed in these areas, but juvenile Ox-eye Herring (*Megalops cyprinoides*) were observed in one small runoff stream. It is likely that these seasonal freshwater areas provide breeding sites for some other estuarine and coastal freshwater fishes.

Introduced Species

Evidence of Feral Pigs (*Sus scrofa*), in the form of tracks, diggings and a skull was found on Wickham Point. However, very little disturbance was noted and it appears that there are no permanent populations of this species on Wickham Point. It is probable that individual animals occasionally cross the mudflats to the islands in the wet season and forage for brief periods before returning to the mainland. One Feral Cat (*Felis catus*) was observed in the monsoon vine forest at Wickham Point. Numbers of this species are also probably low, but the presence of cats in the area is of concern given that numbers of mammals such as bandicoots and possums seem relatively high.

No introduced amphibians, reptiles or birds were observed during the field surveys although the Rock Dove (*Columbia livia*) and the Asian House Gecko (*Hemidactylus frenatus*) do occur in the Darwin area and the latter species is found in littoral habitats.

Biting Pests

Appendix J of the Draft EIS summarised details of a survey of the biting midges and mosquitoes of the Wickham Point area conducted by the Medical Entomology Branch of the Territory Health Services (THS) in February 1997, to assess potential biting insect problems and the associated pest and disease problems faced by both construction workers and the permanent workforce (D&M 1997).

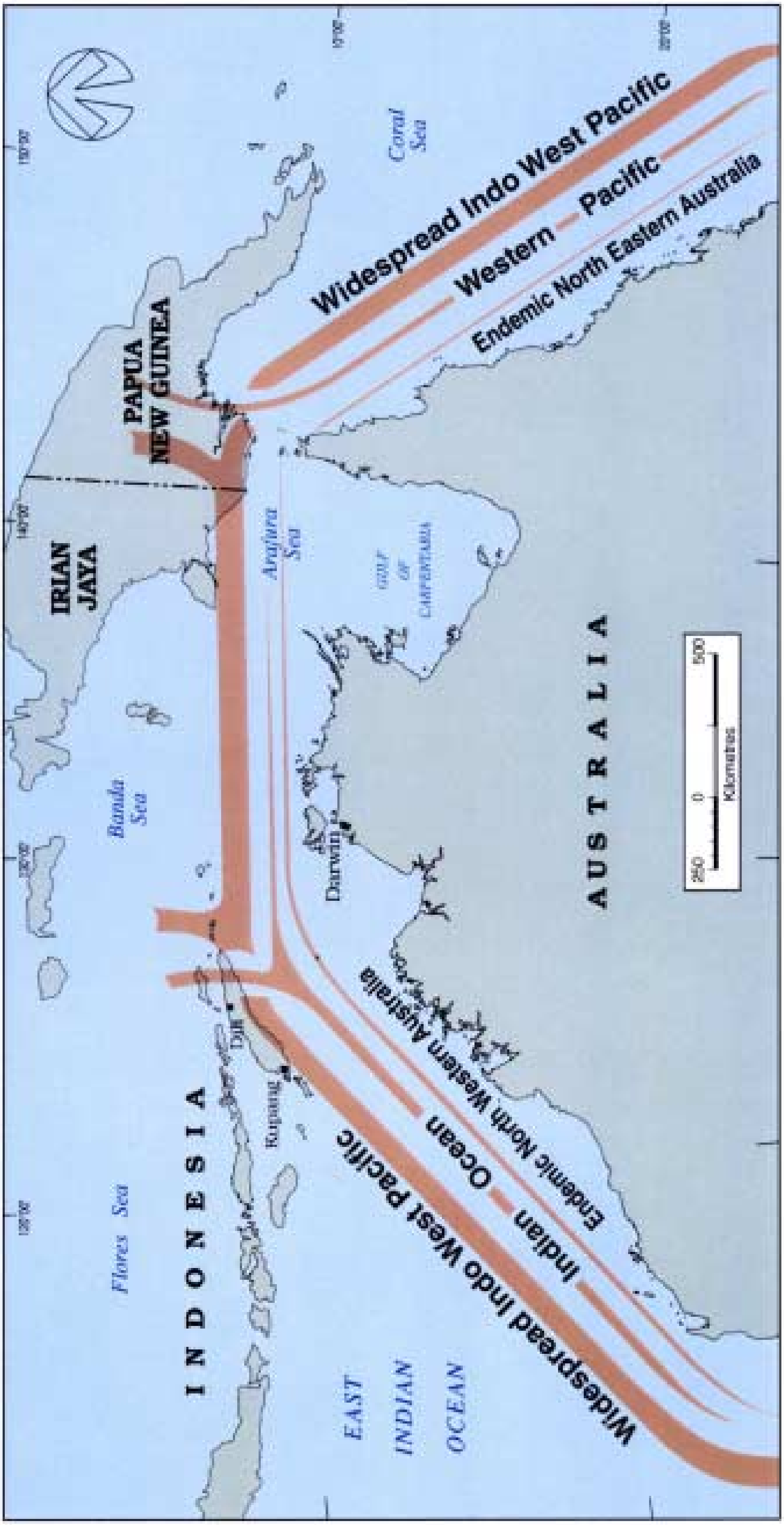
Biting insects (mosquitoes and midges) were found to be common at Wickham Point. The mosquito *Aedes vigilax* is considered to have the greatest potential as a pest and disease vector in the area. It and several other species are known to be vectors for Ross River virus, Barmah Forest virus and Murray Valley encephalitis. In addition, substantial numbers of biting midges breed in the Wickham Point area.

Salt marsh mosquito breeding sites were found to be generally absent at Wickham Point, but there is a site near the beach which could potentially be a breeding area during the high tide period at the end of the dry or after flooding early in the wet season. Mosquito breeding areas are shown on Figure 3.5.

3.3.2 Marine Biota

The marine fauna of northern Australia is part of the vast Indo-West Pacific biogeographical province (Figure 3.6). The majority of species are widely distributed in this region, with the northern part of the Australian continent being simply a small part of the wider ranges of most species. The relationships between areas within tropical Australian waters have been discussed by a number of authors, but most recent studies consider there to be one Tropical Australian Province extending from Shark Bay or North West Cape in Western Australia across the top of the continent and to the southern end of the Great Barrier Reef in Queensland. A small proportion of the species west of Cape York occur only in Australian waters, but are generally widespread within the region (D&M 1997; Wilson & Allen 1987).

The Port of Darwin Harbour has been determined to be free of introduced marine pest species, based on the outcome of a baseline study undertaken by the NT Government and CSIRO between 1998 and 2000 (Russell & Hewitt 2000). This is despite detection of an infestation of the Black-striped Mussel (*Mytilopsis sallei*) in harbour marinas in 1999, populations of which were able to be detected early and eradicated during the final stages of the port study.



Common distribution patterns of shallow water benthic animals on the Australian coast, showing approximate boundaries of the Indo-West Pacific Region, Indian Ocean, West Pacific & Endemic Zones.

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The Aquatic Pest Management Program, established in June 1999 and coordinated by the Department of Primary Industry and Fisheries, ensures active monitoring and inspection practices for the presence of marine pests.

3.3.2.1 Darwin Harbour assemblages

Darwin Harbour has a complex assemblage of habitat types, but there are large differences in the extent of each. The distribution of various habitat types in Darwin Harbour has been mapped by the DLPE and is shown in Figure 3.7. Rocky intertidal areas are found where hillsides meet the sea. Seaward of these extensive mangroves dominate in the upper intertidal, particularly in bays and other protected areas. Seaward of the mangroves, extensive flats occur in the lower intertidal. Many of these flats are mud, but some areas are basement rock which may or may not be covered with sand or mud. The sides of the channels are generally rocky, but the bottoms are similar to the intertidal in that they vary from exposed pavement, through sand veneered pavement to beds of sediment.

The biotic assemblages discussed below provide a convenient structure for examining the biological features of the marine environment. However, it should be emphasised that the environment is complex, and many of the habitats are present as small units on a single shoreline, with complex patterns of habitats such as rocky shores, mangroves and mudflats all occurring in a small area.

Rocky Shore Communities

Rocky shores occur in many areas of Darwin Harbour, particularly on headlands. Zonation patterns on the shores can be readily seen, with relatively few species occurring in the upper intertidal where organisms are exposed to variable conditions of temperature, sunlight, salinity, and other factors which can change suddenly as storms pass through the area during the wet. Diversity increases further down the shore where conditions are not as extreme. Species in the middle of the intertidal region are adapted to life in that region and do not occur subtidally. Characteristic species such as gastropods (limpets, nerites, the pulmonate slug *Onchidium*, and thaids such as *Morula*), chitons (*Acanthopleura* spp.), bivalves (oysters of the genus *Saccostrea*), barnacles (*Chthamalus* and *Tetraclita*), and others live in the midtide region. In some areas the calcareous tubes of *Galeolaria* worms (Polychaeta) are common.

Mangroves

As indicated above, mangroves occupy most of the margins of Darwin Harbour (Figure 3.7). The mangrove species present at Wickham Point and their zonation patterns are described in Section 3.3.1.1 and Figure 3.4.

Over the past five years the NT Government has spent approximately $400,000 on mangrove research (NT DLPE 2000a). A number of projects are currently nearing completion which will support management strategies for the region, ranging from productivity studies employing leaf litter and overall biomass methodologies, and ecological studies examining links between mangroves and various fauna including fish, insects and sesarmid crabs. A comprehensive report on the current status of the mangrove resources of Darwin Harbour is currently being prepared by DLPE, and is anticipated to be released later in 2001 (K. McAllister, pers. comm.).

Studies of the distribution of invertebrates in mangroves have shown that zonation patterns of the invertebrates can parallel plant zonation (D&M 1997). Hanley (1993) compared invertebrates on the seaward edge and tidal creek bank zone of mangroves in the Darwin South Project Area with sites on West Arm. A total of 131 species of invertebrates were found, including representatives of eight phyla. A variety of species are commonly found on the mud surface, or on trees. Dominant molluscs are potamidids (*Terebralia, Telescopium* and *Cerithidea*), the slug *Onchidium*, the nerite *Nerita balteata,* and several species of ellobiids. Dominant crustaceans are fiddler crabs (*Uca*), the mud lobster *Thalassina anomala,* crabs *(Perisesarma semperi),* and mudcrabs *(Scylla serrata).* The completion of a current post-graduate research program on seasonality and taxonomic composition of insects over three years in Darwin Harbour mangroves will contribute further to the knowledge base of invertebrate distribution patterns and behaviour.

Benthic Fauna

While limited studies have been undertaken on the flora and fauna of mudflats, in some areas the invertebrate fauna is known to be diverse, abundant and of a high biomass (D&M 1997). These areas are invaded by fish, mobile invertebrates, and some vertebrates during high tide for feeding, and similarly at low tide by birds.

During a field survey conducted by LDM in late 1996 (Appendix K of Draft EIS, D&M 1997), the intertidal mudflats fronting the mangroves in the vicinity of the proposed LNG plant were found to be moderately bioturbated, with fiddler crabs (*Uca* spp.), alpheid shrimp and mudskippers (*Periopthalmus* sp.) associated with many of the burrows. Sampling of subtidal sediments within the proposed vessel turning basin in November 1996 found that amphipod crustaceans were the most abundant fauna present, though their distribution was very patchy. Polychaete worms were common and more evenly distributed (Appendix K of Draft EIS).

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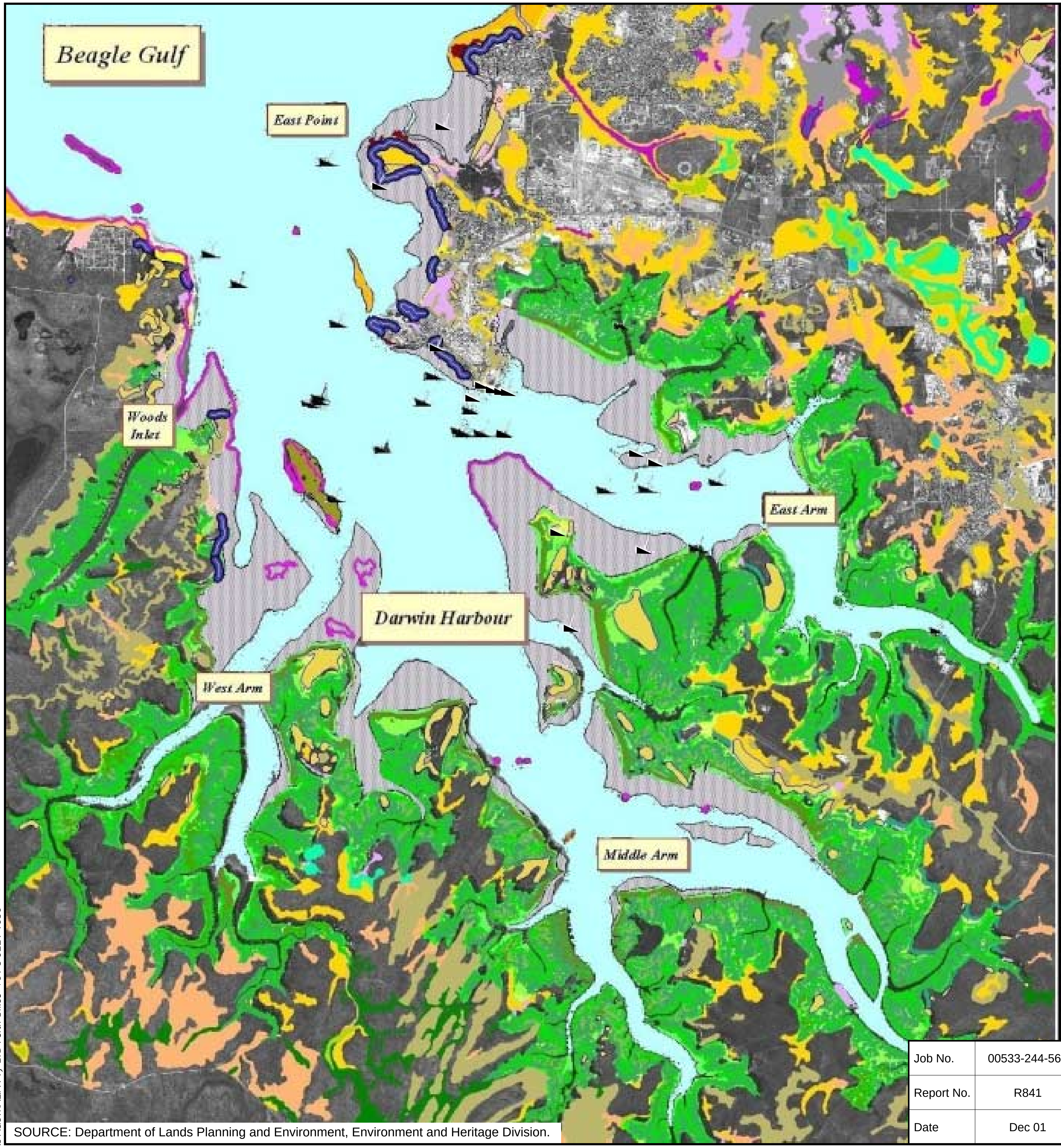

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	Figure 3.7
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Coral and Algal Communities

Corals in the harbour are scattered as individual coral heads or colonies, and do not form reefs. They are restricted to a very small vertical region extending from just above the low tide zone to a depth of 2-3 m below it (Hanley & Caswell 1995). Species living in Darwin Harbour are those which are tolerant of conditions which exclude most corals: variable salinities, which can be very low during the wet season; high turbidity which adversely affects symbiotic zooxanthellae living within the coral tissue; sedimentation; and other factors. Although the environmental tolerances of species living in Darwin Harbour are not known, it is likely that at least those individuals living well within the harbour are in suboptimal habitats and are naturally stressed.

Field surveys previously conducted by LDM as part of the investigations for the Draft EIS included sites on the rubble-covered pavements of Wickham Point, Weed Reef and West Point, a portion of the National Estate registered coral area at Channel Island and a subtidal rock pinnacle (Plater Rock). At all locations, coral cover in the intertidal zone was low (rarely >10% areal cover), predominantly comprising massive and submassive colonies of faviids, mainly *Goniastrea* and *Platygyra* but with *Favia, Oulophyllia, Barabattoia, Cyphastrea*, *Moseleya*, *Echinopora, Acanthastrea, Leptastrea* and *Montastrea* commonly present. A wide diversity of other genera were also present, including fungiids (including *Fungia, Polyphyllia*, *Herpolitha*), mussids (*Symphyllia, Lobophyllia*) and *Pectinia, Porites*, *Galaxea* and *Merulina*.

Soft corals (mainly *Sarcophyton* and *Dendronephthya* species) were abundant on the intertidal rock platforms at the southern tip of Wickham Point, and commonly occurred in similar habitats elsewhere. Sponges (including Microcionidae and Niphatidae) were generally common within this habitat, and mushroom-shaped ascidians (cf. Polycitoridae) were often encountered.

In shallow subtidal areas (1-2 m below LAT) there was no clear dominance in hard coral genera, with acroporids (encrusting and plate *Montipora*, corymbose and branching *Acropora*), poritids (*Goniopora, Alveopora*), pectinids (*Oxypora, Echinophyllia*, *Mycedium*), merulinids (Hydnophora), faviids (*Cyphastrea*) and dendrophylliids (*Turbinaria, Duncanopsammia*) present at variable abundances. Sponges, gorgonians (*Ctenocella, Junceella*), soft corals (*Clavularia, Sinularia*) and colonial anemones were also common in some of these areas.

An examination of algae on rocks and firm gravel near Channel Island in the environmental work prior to the installation of the power station (Caldwell Connell 1983, in D&M 1997) showed there to be a limited amount of favourable habitat in the area, but the limited habitat that is present provides firm attachment for algae. A total of 19 genera were recorded. *Eucheuma* was common along with the green algae *Caulerpa, Ulva,* and *Halimeda,* the browns *Padina, Taonia,* and *Sargassum*, the red *Laurencia* and unidentified encrusting corallines.

The macroalgal communities of rubble covered intertidal pavements such as Weed Reef can be diverse, and may include browns (*Sargassum*, *Padina*), foliose reds (*Laurencia*), greens (*Caulerpa, Ulva, Udotea*) and calcareous greens (*Halimeda*).

Seagrasses

Seagrasses in Darwin Harbour are known to occur off Mandorah, near the north-western entrance to the harbour, and between Channel Island and the mainland. Very sparse seagrass (thin-leafed *Halodule uninervis* and *Halophila decipiens*) is present on some of the soft sediments of the lower intertidal region at Wickham Point, but significant seagrass beds are not known to occur in the harbour.

On Weed Reef, LDM found a very sparse, patchy coverage of seagrasses where the rocky intertidal platform was covered with a thin sand veneer. These were mainly thin-leafed *Halodule uninervis* and *Halophila decipiens*, with some *Halophila ovata* and *Cymodocea serrulata* close to the reef edge.

The NT DIPE is currently pursuing a proposal to undertake an NHT funded project to identify seagrass beds and other favourable habitat locations for dugongs and sea turtles (N. Smit, pers comm).

Subtidal Pavement Biota

The areas of the harbour floor where strong currents leave only a thin veneer of gravel and coarse sand over the calcarenite substrate can support a highly diverse fauna comprising sponges, soft corals and gorgonian whips and fans, often with attendant crinoids (feather stars). These fauna rely on water currents to provide their food source and favour such high-current areas. In shallower pavement areas (3-5 m below LAT) such as offshore from West Point, brown algae such as *Sargassum* and *Padina* may also be common.

Fish

Harbour waters support a high abundance of both resident benthic and transient pelagic fish species. The most recent survey of fishes of Darwin Harbour was undertaken by Larson & Williams (1997, cited in Russell & Hewitt 2000), which documented a total of 415 species including 31 new records for the Northern Territory.

Long term monitoring of the survival and productivity of fish that live within the mangroves of Darwin Harbour is being conducted by NT DPIF and MAGNT. Preliminary results have identified 48 species from 21 families of fish, with the greatest numbers of fish caught within Charles Darwin National Park (NT DLPE 2000a). The results of this programme will facilitate the development of a basic trophic model to simulate different parts of the harbour and the contribution of mangrove ecosystems to the marine food chain.

Reptiles

Turtles tend to occur throughout the harbour, with Flatback Turtles (*Chelonia depressa*) known to nest at Channel Island and at Mica Beach near the harbour entrance. Green Turtles (*Chelonia mydas*) and Hawksbill Turtles (*Eretmochelys imbricata*) also occur in the harbour but there are no significant nesting sites in the study area (M. Guinea, cited in Dames & Moore 1993a). Saltwater (also known as Estuarine) Crocodiles (*Crocodylus porosus*) occur but are regularly removed by the Northern Territory government. Sea snakes are infrequently seen in Darwin Harbour.

Mammals

Indo-Pacific Hump-backed Dolphins (*Sousa chinensis*) and Irrawaddy River Dolphins (*Orcaella brevirostris*) are commonly observed within the harbour.

Dugongs (*Dugong dugon*) are also known to occur in East and Middle Arms except in small creeks. Three years of observations by the Northern Territory University and Biomarine International have suggested that dugongs regularly use waters around Channel Island, foraging on seasonally abundant macroalgae on rocky reef areas as a dietary supplement to the rare and small patches of seagrasses observed within the harbour (S. Whiting, pers comm.; Whiting (in press). Areas of macroalgae, including genera such as *Sargassum, Padina, Turbinaria* and *Ulva*, in the vicinity of the eastern end of Channel Island Bridge were shown to be particular foraging areas. There is also a dugong and turtle habitat project currently underway which will provide definitive mapping of favourable habitats within the harbour.

3.3.3 Ecological Function and Conservation Status of Major Biotic Groups

Wickham Point contains a good representation of coastal habitats found in the Darwin area. The area, at least on the westernmost and central islands, is relatively free of feral animals and recent human disturbance, and appears to be well protected from fire.

3.3.3.1 Rainforest vegetation

The total area of dry coastal and subcoastal rainforest vegetation in the Northern Territory is currently estimated at approximately 121,249 ha (O. Price, pers comm). The Darwin Harbour region has an estimated 1,842 ha of dry rainforest, which represents 1.5 % of the total coverage of this vegetation type in the NT. Wickham Point has approximately 60 ha of dry rainforest, while a larger area 121 ha in size exists further down Middle Arm Peninsula (Figure 3.8).

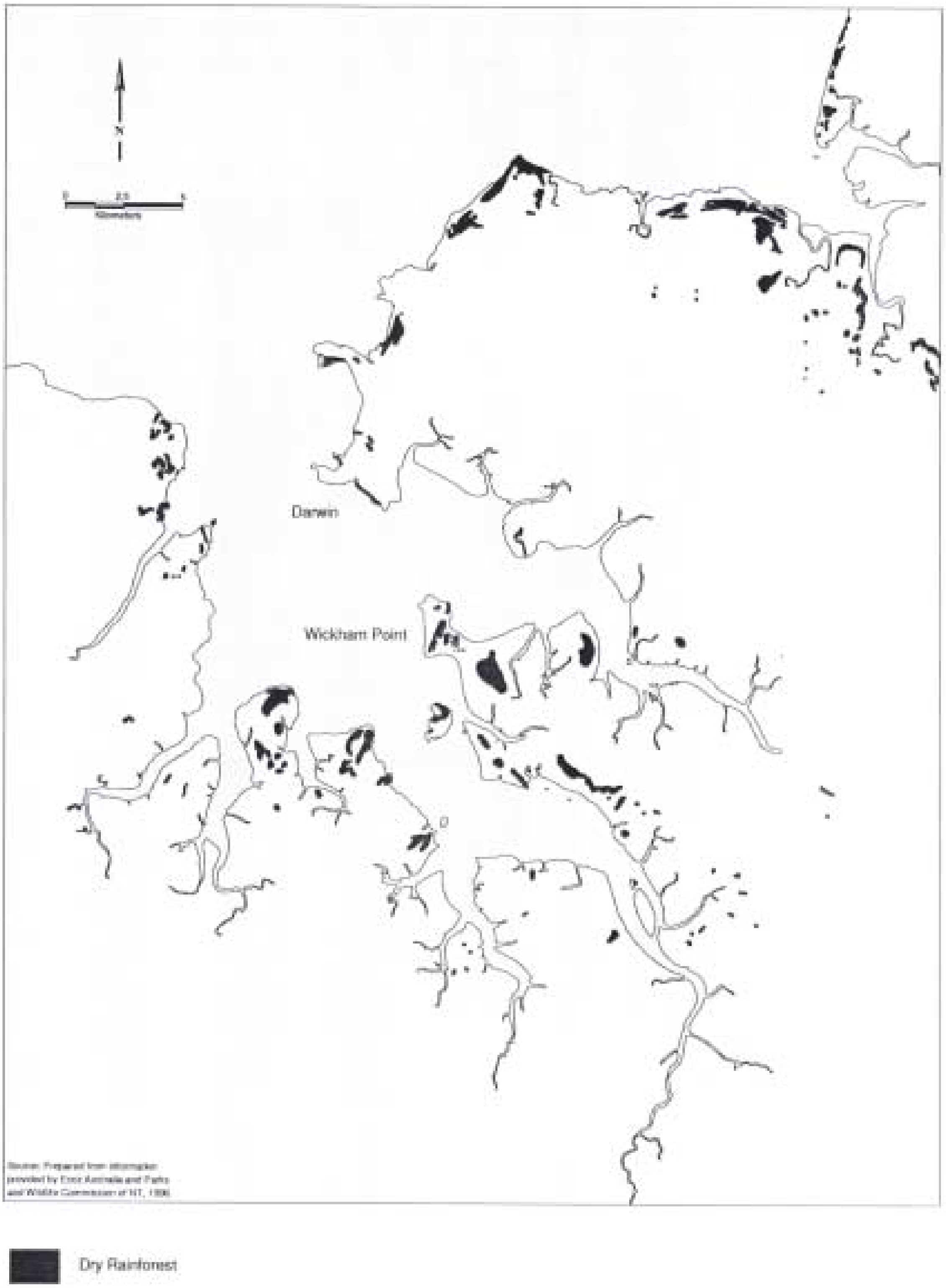
Northern Territory rainforests are typically found as small disjunct patches, scattered within a vast expanse of mostly eucalypt-dominated woodland or savanna (Russell-Smith & Lee 1992). These rainforests are characteristically less than 5 ha in extent with a maximum species richness of around 135 species per patch. The small size of most rainforest patches leaves them vulnerable to disturbance. A study over the Northern Territory as a whole noted that approximately one third of rainforest survey sites were severely disturbed by fire, 20% were severely disturbed by cattle and buffalo and 10% by pigs (Russell-Smith & Bowman 1992). Panton (1993), in evaluating the change in distribution of rainforests in the Darwin region over the 45 year period to 1993, identified 40% of dry rainforest loss as attributable to urban development in the area, while fire and cyclone damage, and weed incursion were also noted as major factors in the declining distribution.

Previous research by the NT Parks and Wildlife Commission has indicated that because these habitats are dependent on flying vectors (birds and bats such as flying foxes) for pollination and seed dispersal, they need to be considered in a regional context. Their conservation requires ensuring that they are close enough to other patches for these vectors to utilise them. When one rainforest completes its fertile phase, the resources of another rainforest or adjacent hinterland area needs to be accessible to these animals (D&M 1997).

One of the most significant threats to the integrity of rainforest vegetation is the combined threat of fire and weeds. The noxious weed *Pennisetum polystachion* is a common introduced grass found on the edges of rainforest patches, and in (at least) one patch at Wickham Point. Unlike the native annual Sorghum species, *Pennisetum* is a tall perennial grass that remains green and non-flammable until late in the dry season. If fire occurs at this time this species will support a high intensity fire with flame heights to 5 m (Panton 1993).

The vine forests of Wickham Point contain relatively few species of introduced plants and those weeds present tend to occur in very low densities. The scarcity of weeds indicates low habitat disturbance and environmental degradation, and is an indication of the high integrity of these patches at Wickham Point.

It is apparent from existing fuel loads and the almost complete absence of fire scars and charcoal that rainforest vegetation on Wickham Point and the adjacent island has not been burnt for a considerable period of time. Given the frequency of fire in the Darwin region,



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LOCATION OF REMNANT DRY RAINFORESTS IN THE DARWIN REGION

Figure 3.8

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where the great majority of savanna and woodland habitats are burnt by frequent, sometimes annual or biennial fires, an area of unburnt country represents an unusual habitat or refuge.

Previous reports have highlighted the fire protection that rainforest pockets on hinterland islets are afforded when completely surrounded by mangroves, which do not burn (Dames & Moore 1993a). This habitat represents a refuge for fire-sensitive vegetation. On these hinterland islets rainforest species which are killed by fire (including *Aidia racemosa, Cupaniopsis anacardioides, Myristica insipida, Terminalia sericocarpa* and *Strychnos lucida)* can occur (Bowman 1991). Unburnt areas provide both resources and habitat for a variety of wildlife throughout the dry season.

Monsoon rainforests such as the Wickham Point vine forests contain a large number of fruit-bearing plant species of significance to fauna. The Orange Lacewing Butterfly (*Cethosia penthsilea paksha*) is dependent on the vine-forest species *Adenia heterophylla australis* (D&M 1997). The larvae of this poorly known butterfly feed gregariously on this native vine from the passionfruit family. Other species such as the Rose-crowned Fruit Dove, Rainbow Pitta, Torres Strait Imperial Pigeon and Black Butcherbird observed at Wickham Point utilise the rainforest patches for at least part of the year.

Rainforests provide important resources to species that forage or roost in this habitat and to migratory species such as the Torres Strait Imperial Pigeon that depend on rainforests as a seasonal food resource. Over 60% of vine forest species have fleshy, brightly coloured or exposed seeds suitable for dispersal by birds (Wightman & Andrews 1989). Flying foxes (fruit bats) and birds are important pollinators and dispersers of seed and play a role in maintaining the genetic viability of rainforests generally - particularly with their typically disjunct distribution of small isolates.

Significant Flora Species

During the detailed surveys conducted for the Draft EIS, the Herbarium of the Northern Territory was consulted regarding the presence of rare plant species within the survey area. No rare, endangered or threatened species were recorded for the site, nor for nearby Channel Island (I Cowie, NT Herbarium), however the dry rainforest is recognised to be of regional conservation interest (as discussed in the previous section).

3.3.3.2 Mangroves

The mangroves of Darwin Harbour are recognised as being a key part of the marine ecosystem, providing primary production which can be used by animals higher up the foodweb. They are also a major nursery habitat for species of both vertebrates and invertebrates. The animals may be benthic species (largely marine invertebrates) which inhabit the mangroves throughout their juvenile and adult phases, or they move into the mangroves during high tide (fish, prawns, sea snakes, etc.) or alternatively low tide (birds, small mammals, etc.) to feed. Primary production may be used by animals either in the mangroves or it can be exported by tides and currents and used elsewhere.

Brocklehurst and Edmeades (1996) undertook a detailed study of the mangrove resources of Darwin Harbour, building on the knowledge base outlined in previous reports (e.g. D&M 1985, 1988; Wightman 1989). It was estimated that there are approximately 20,400 hectares of mangroves in Darwin Harbour, in relatively pristine condition.

Mangrove species diversity in Darwin Harbour is high when compared with the rest of the coastline. Approximately 48 species of plants are recognised as being regular inhabitants of the mangroves in the NT, of which approximately 36 are found in Darwin Harbour (Wightman 1989). In the course of the 1996 survey undertaken by Brocklehurst and Edmeades, 24 genera comprising 29 species were found.

Darwin Harbour was listed in the ANCA Directory of Important Wetlands in Australia in 1993 and updated in 1995. This inclusion was largely based on the harbour providing a good example of a shallow branching embayment of the Top End Region, supporting one of the largest discrete areas of mangrove forest in the Northern Territory, and also the most mangrove species of any Northern Territory embayment. The mangroves also provide a major nursery area for estuarine and offshore fish and crustacea in the Beagle Gulf Area.

The Darwin Harbour Wetlands are currently listed as an Indicative Place nominated for inclusion in the Register of the National Estate, for their extensive and well developed mangrove communities, and associated significant marine flora and fauna of the harbour. The Australian Heritage Commission is yet to make a final decision on whether the place should be entered in the Register.

3.3.3.3 Terrestrial fauna

The extensive mangrove and mudflat habitats of Darwin Harbour are listed as being of “good” quality for birdlife. The mangroves in the Wickham Point area are not considered to be as good a bird habitat as the two adjoining areas of upper Middle Arm and East Arm. Nevertheless, it is clear that the mangroves and mudflats around Wickham Point contain almost all of the more specialised mangrove bird species found in the region, including Cicadabird, Chestnut Rail, White-breasted Whistler and Mangrove Golden Whistler.

The intertidal mudflats do not appear to support large numbers of migratory waders or shorebirds, although these areas would be an important feeding resource at times. Port Darwin is listed in the above mentioned Directory of Important Wetlands as an important habitat for several (25) migratory bird species listed in the annexes to the JAMBA, CAMBA and Bonn Treaties. Most of the more significant species in this group, including Little Tern, Ruff, Eastern Curlew, White-bellied Sea Eagle and Rainbow Bee Eater, have been recorded in the area.

The best developed mangrove areas tend to have more of the rarer bird species present. In this respect, the upper reaches of the mangrove creeks are most important. The creek draining west between Wickham Point and the adjacent island had, for example, species such as Great-billed Heron, Chestnut Rail, Cicadabird and White-breasted Whistler present (see Figure 3.5).

The mangrove margin habitats, including the interface between the mangroves and landward habitats such as monsoon vine forest and paperbark woodland are particularly important for wildlife. A number of large nesting mounds used by the Orange-footed Scrubfowl occur along this interface (Figure 3.5, Plate 7). Some of these mounds are quite spectacular, being in excess of 3 m in height and 10 m across the base. All mounds seem to be active, and nesting was observed in the wet season. Some of the Aboriginal shell middens in the area have also been utilised by Orange-footed Scrubfowl as nesting mounds. The same mounds may be used by several pairs of birds. Some of these mounds may be thousands of years old and are of some scientific and public interest. The area holds a high density of these birds. They are not considered a threatened species and are generally not susceptible to human disturbance (they frequently forage in suburban gardens around Darwin) although interference with the nesting mounds would inhibit breeding.

There appear to be good populations of medium and large-sized mammals, such as Northern Brown Bandicoot, Northern Brushtailed Possum and Agile Wallaby. These populations are centred on the mangrove – paperbark interface zone, where freshwater sedge communities are developed. These species are probably more abundant in this area than in similar habitats close to Darwin as a consequence of the site being fire-protected to a large degree, and to the low levels of human disturbance.

The monsoon vine thickets on both Wickham Point and the adjacent island are amongst the most extensive found around Darwin. However, this habitat is not considered of high significance for rare or threatened fauna. Most of the resident birds known to occur in this habitat around Darwin, including Rainbow Pitta, Orange-footed Scrubfowl, Rose-crowned Fruit Dove and Emerald Dove are found at Wickham Point. This habitat appears to be an important food resource during the wet season, when increased numbers of fruit-eating birds were present.

The Eucalyptus open forest habitats, which are present mostly on the mainland peninsular contained species typical of those found throughout the Darwin area. This is a common habitat in the region.

Significant fauna species

Significant species known or expected to occur in the general area are listed in Table 3.1. The list includes 11 bird and two mammal species, two of which were previously listed as endangered by the Australian Nature Conservation Agency (ANCA 1996). These two species (Little Tern and Melville Cicadabird) are no longer listed as endangered or vulnerable under the EPBC Act 1999 nor the Action Plan for Australian Birds (Garnett & Crowley 2000), although the Cicadabird is listed under the migratory provisions of the Act.

Of the other species of birds and mammals recorded from the area, none are known to be restricted to Wickham Point. Fauna species previously listed as endangered and/or vulnerable under ANCA criteria include:

- *Little Tern* (Not listed – EPBC Act; Endangered – ANCA 1996; Vulnerable – Garnett 1992). The species is apparently common in the Darwin area (Garnett 1992). Wickham Point, and Darwin Harbour in general are not a recognised breeding area for the Little Tern. During surveys, individual birds were seen flying over the intertidal flats.

- *Melville Cicadabird* (Listed under migratory provisions of EPBC Act; Endangered – ANCA 1996; Special Concern – Garnett 1992). In the Northern Territory, where more habitat is available, the species can be considered secure (Garnett 1992). Cicadabirds prefer pristine tall stands of *Rhizophora* mangroves (McKean & Martin 1986), and in the Wickham Point area, were observed only along a small creek near the southern tip of the main island.

- *Beach Stone-curlew* (Not listed – EPBC Act; Vulnerable – Garnett 1992). Initial fears of declines of this species have not been born out by monitoring and much of the habitat, particularly on islands, is secure. As such, this species is classified to be of 'least concern' by Garnett & Crowley (2000). However, it is a species vulnerable to disturbance. A pair of Beach Stone-curlews were found nesting on a small beach in the vicinity of the proposed jetty site at Wickham Point during the previous fauna survey (Figure 3.5).

Table 3.1 Significant Fauna Species Known or Expected to Occut in the Wickham Point Area

Common Name	Scientific Name	Garnett (1992)	ANCA (1996)*	EPBC Act (2000)**
BIRDS				
Radjah Shelduck	*Tadorna radjah*	Special Concern		
Great-billed Heron	*Ardea sumatrana*	Special Concern		
Black-necked Stork	*Ephippiorhynchus asiaticus*	Special Concern		
Black Bittern	*Ixobrychus flavicollis*	Special Concern		
Osprey	*Pandion haliaetus*	Special Concern		
Chestnut Rail	*Eulabeornis castaneoventris*	Special Concern		
Eastern Curlew	*Numenius madagascariensis*	Special Concern		
Beach Stone-curlew	*Esacus neglectus*	Vulnerable		
Bush Stone-curlew	*Burhinus magnirostris*	Special Concern		
Little Tern	*Sterna albifrons*	Vulnerable	Endangered	
Cicadabird	*Coracina tenuirostris melvillensis*	Special Concern	Endangered	Listed in migratory provisions
MAMMALS				
Northern Quoll	*Dasyurus hallucatus*			
Common Bent-winged Bat	*Minopterus schreibersii*			

Notes: * *Endangered Species Protection Act (1992)*; Schedules 1,2, & 3 – 1996 (now repealed by *EPBC Act 1999*)
** *Environment Protection & Biodiversity Conservation Act 1999* – July 2000

Other significant species found or expected to be found at Wickham Point are listed in Appendix I of the Draft EIS. The Darwin area is recognised as being of national and international importance for migratory bird conservation. As such, the migratory provisions of the *EPBC Act* include a range of species which have been observed in the area, including the Common Sandpiper, White-Bellied Sea Eagle, Great Knot, Whimbrel and Ruddy Turnstone.

3.3.3.4 Corals

The ecological contributions of both corals and algae are similar to mangroves in that they contribute primary production to the base of the foodweb. In the case of corals the production is through symbiotic zooxanthellae within the coral tissues rather than by the corals themselves; the corals contribute secondary production. The presence of both corals and algae creates structural complexity which is used as habitat by invertebrates and small fish. Corals and some algae also contribute calcium carbonate sediments to the system.

A major examination of coral communities was conducted as part of the studies for the Darwin Port Expansion (Acer Vaughan 1993) to assess the uniqueness and importance of the Shell Island coral community. A number of sites were investigated, including Channel Island. Over 25 genera of corals were found during the survey, with most genera occurring at most sites, but proportions of the various taxa varied between areas. Acer Vaughan (1993: 80) concluded that, in addition to Shell Island and Channel Island, there are numerous sites within Darwin Harbour which have rich associations of coral and associated organisms.

The small coral community on the rocky platform at Channel Island has been considered a unique feature in Darwin Harbour, supporting a diversity of coral, fish and invertebrate species (Plate 8). The Place Report of the Register of the National Estates cites the platform as being representative of communities which have developed under conditions of high turbidity, strong tidal currents, and seasonally low salinity. The communities also have a high diversity of coral not consistent with its location, in an area of deep, fine muds, and very low salinity and high turbidity during the wet season. The high coral diversity, clear reef zonation, location of permanent coral monitoring plots, and its accessibility make the Channel Island coral community important for research and education. The location of this coral community is shown on Figure 3.9.

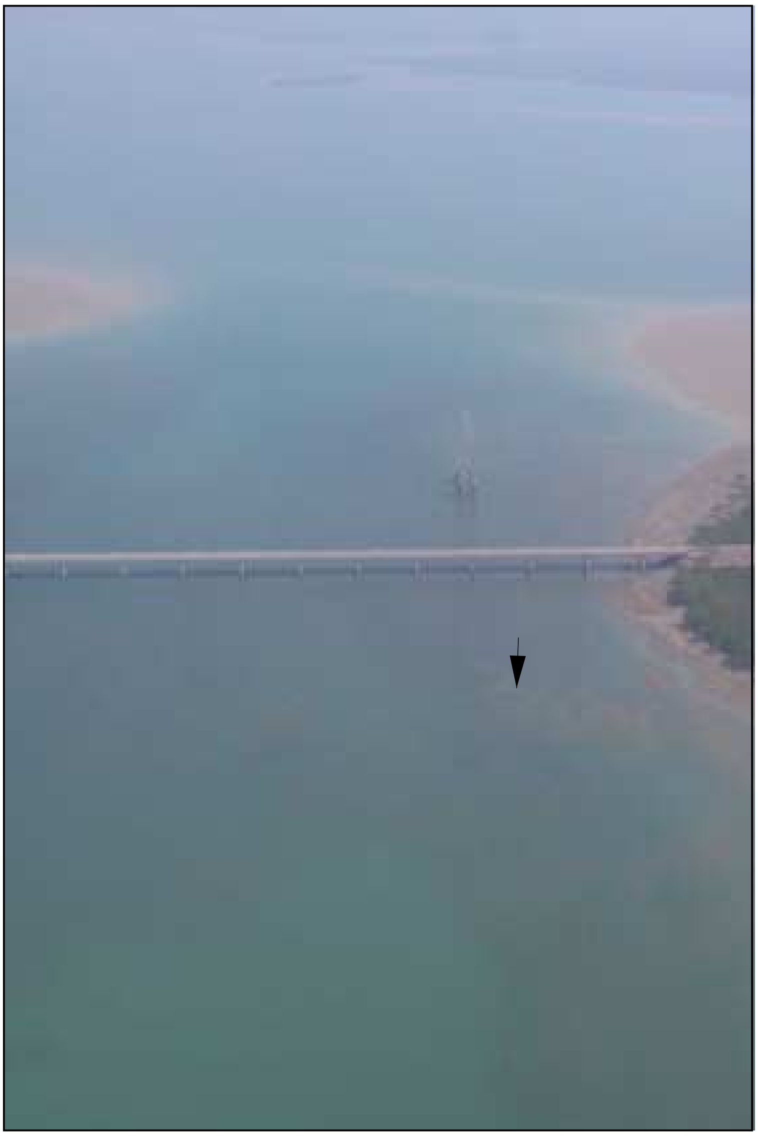

PLATE 8: Channel Island coral community.
Channel Island Power Station located to the right of photo.

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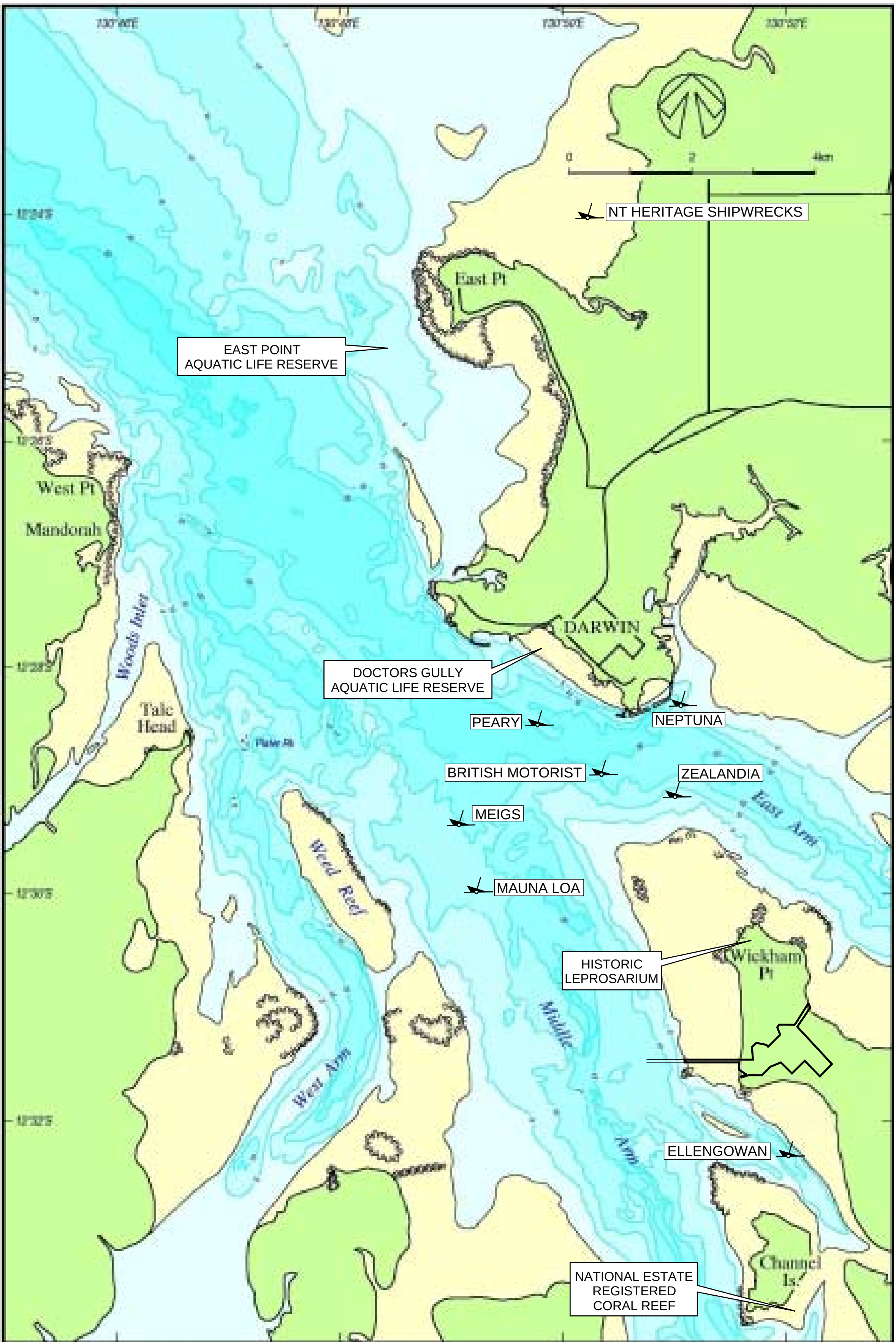

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10MTPA LNG PLANT AT WICKHAM POINT - PER

MARINE HERITAGE SITES AND CONSERVATION AREAS

Figure 3.9

URS

3.3.3.5 Marine fauna (reptiles and mammals)

Protected species known to occur within the Darwin Harbour region are:

- turtles - Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricata*), Loggerhead (*Caretta caretta*), Olive Ridley (*Lepidochelys olivacea*) and Flatback (*Natator depressus*);
- sea snakes - families Hydrophiidae and Laticaudidae;
- dugongs (*Dugong dugon*);
- dolphins - Common (*Delphinus delphis*), Striped (*Stenella coeruleoalba*), Spinner (*S. longirostris*), Bottle-nose (*Tursiops truncatus*), Irrawaddy River (*Orcaella brevirostris*) and Indo-Pacific Hump-backed (*Sousa chinensis*);

Turtles, sea snakes, dugongs and cetaceans (whales and dolphins) are protected under the Commonwealth *EPBC Act 1999*, which supersedes the previous *National Parks and Wildlife Conservation Act 1975,* the *Whale Protection Act 1980* and the *Endangered Species Protection Act 1992.*

Some of the dolphins, turtles and dugong species mentioned above have been known to feed or forage in waters within Darwin Harbour. Turtles and dugongs have also been recorded feeding on macroalgae on intertidal rocky reefs adjacent to Channel Island (Whiting, In Press).

3.4 CULTURAL ENVIRONMENT

3.4.1 Archaeology and Heritage

A detailed archaeological survey of the proposed LNG plant site was undertaken by Heritage Surveys for the Draft EIS (Appendix L, D&M 1998a). This information has been complemented by further work recently undertaken on Wickham Point which has identified a number of additional archaeological sites (Begnaze 2001a, 2001b).

Nine archaeological sites were identified on Wickham Point during the original environmental assessment, most located either within or immediately adjacent to the proposed plant area (Figure 3.10): six are prehistoric shell middens; two are historic sites dating from World War II; and one is the remains of the “Mud Island” leprosarium. A further five shell middens, and a WWII heritage site, were recently (August/September 2001) discovered and are currently subject to complete heritage surveys in consultation with the Heritage Branch of DIPE.

No Aboriginal burial grounds are known from Wickham Point, but it is likely that burials did occur near the leprosarium site and possibly in shell middens in the area. The leprosarium is located on a sandy beach ridge forming the northern extremity of Wickham Point, well away from the LNG plant site and will not be affected by the project.

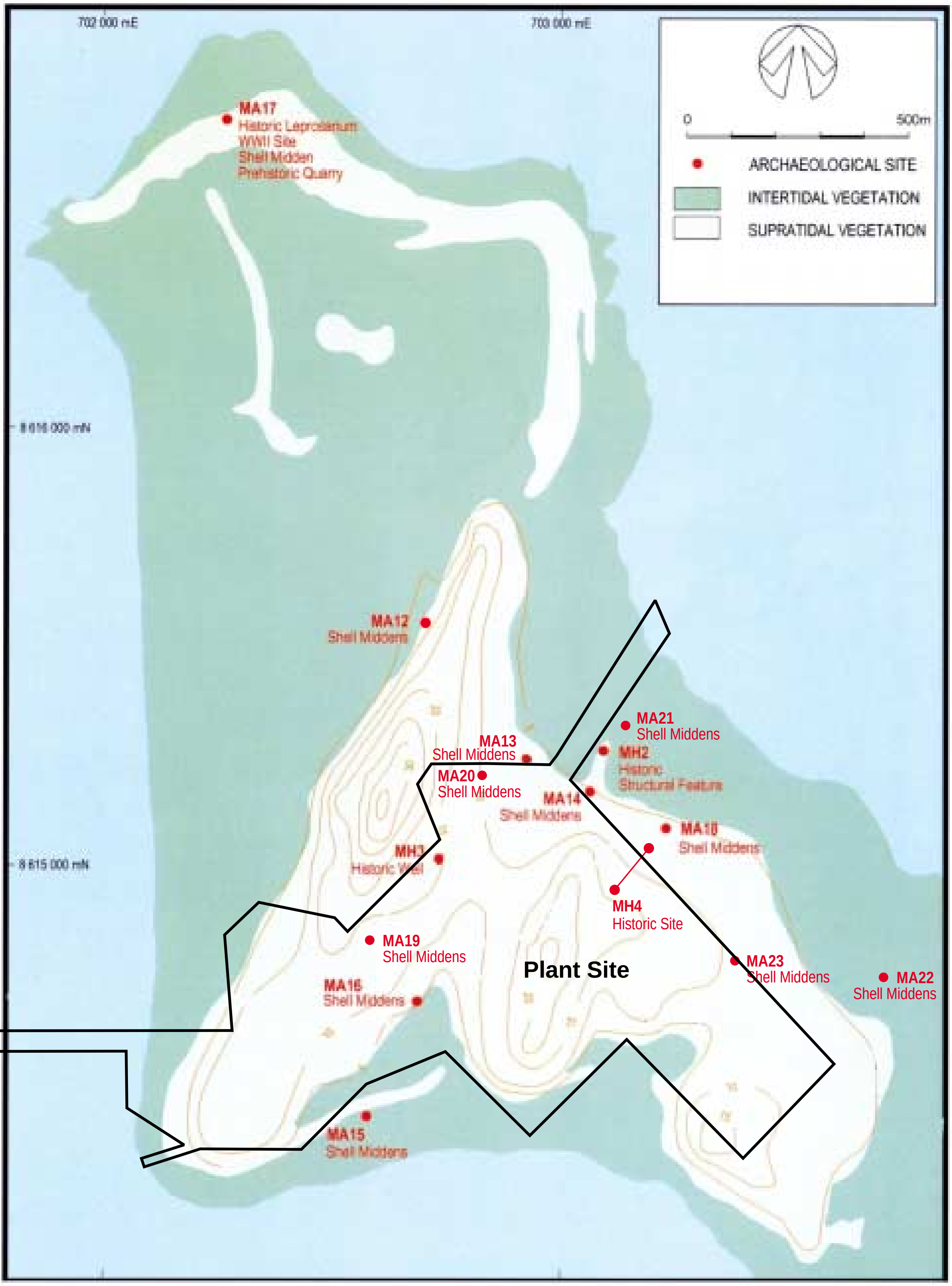
The two historic sites located during the original study (MH2 and MH3) may be associated with Second World War activities, and therefore hold some historical significance but a low level of archaeological significance. Site MH2 has a concrete floor and artefacts such as metal bolts, corrugated iron fragments, a star picket and a length of iron pipe. Site MH3 is a square well, 1.5 m on a side with a depth of 0.5 m, however no artefacts were found at this particular site.

The additional historic site (MH4), recently located on the crest of the southern hill 500 m to the south east of Peak Hill (Figure 3.10), consists of a series of concrete pads and discontinuous dry stone retaining walls on both sides of the edge of the crest. The series of concrete pads extends for approximately 200 m in a north-south direction, with each pad approximately 6 m x 5 m in dimension. Preliminary investigations indicate that the complex is again linked to World War II activities, potentially the remains of a search light camp set up during the war. This will be confirmed through further heritage surveys currently being commissioned by Phillips and DIPE.

The six prehistoric shell middens originally identified at Wickham Point for the 1997 EIS (sites MA12, MA13, MA14, MA15 and MA18, Figure 3.10) all contain a similar range of cultural materials, have similar compositions of shell taxa dominated by the bivalve *Anadara granosa*, and exhibit little or no impact from recent human activities (95%). The middens are low lying, up to 20 cm deep, and they range in area from about 30 m^2 to a midden 120 m by 15 m. However, materials at this large midden are clumped into three discrete areas of 30 m^2 or less. Stone artefacts are also present at some of the sites.

The additional five shell middens recently discovered during the geotechnical survey of Wickham Point (MA19, MA20, MA21, MA22 and MA23) have similar compositions of shell taxa to those middens previously identified, again dominated by *Anadara granosa* (95% or more) with some containing very minor presence of *Telescopium* (Begnaze 2001b). These middens range from approximately 14 to 25 m in diameter, with no stone artefacts found at these sites. The DIPE has been consulted to catalogue these additional sites and evaluate their significance.

In terms of their representativeness, the middens identified in the area are of only moderate significance. Shell middens are the most commonly recorded type of archaeological site in the Darwin region (Richardson 1996), and middens dominated by *A. granosa* have been identified at numerous other localities both at Middle



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Arm and across Darwin Harbour generally. In terms of research potential, the middens are of great archaeological interest because of the dominant shell taxon in each site, *A. granosa*. This taxon is uncommon or absent from the mangrove flats which now surround Wickham Point. The dominance of *A. granosa* in the archaeological sites suggests that a major environmental change has taken place since they were deposited. The detailed survey undertaken for the original assessment concluded that, as a result of their research potential, the six sites are regarded as possessing a high level of archaeological significance. Accordingly Phillips has made a number of management commitments to preserve the integrity of these sites (see Section 5).

3.4.2 Anthropology and Aboriginal Sites of Significance

A detailed anthropological report was prepared by Warren Murgatroyd for the Draft EIS, which was included as Appendix M (D&M 1997). A Supplementary anthropological report, outlining outcomes of further consultations with larger groups of people from the Larakia and Danggalaba families, was also provided as part of the EIS Supplement (D&M 1998a, Appendix 5). The key conclusions arising from these studies are summarised below.

Wickham Point is perceived by the Larakia and other Aboriginal people around Darwin Harbour as being of some significance to them. In 1999 an agreement was executed between the proponent and various native title parties to resolve Native Title and Aboriginal Land Rights claims previously lodged for the area.

The significance of Wickham Point to Aboriginal people flows from four sources:

- it has played a part in particular periods of Aboriginal history;
- Aboriginal people may have been buried on Wickham Point in the recent and distant past;
- adjacent marine areas are presently used as a source of food, and there is a high diversity and abundance of ethno-botanic floral species on Wickham Point; and
- Wickham Point is of spiritual significance to all Larakia people.

The Aboriginal people consulted can see that there may be some impacts on their lives as a result of the construction and use of the LNG plant. Apart from the loss of the actual project area, Aboriginal people stated that they may lose access to the marine resources around Wickham Point. They did not consider this to be a serious loss. They considered that the construction of the access road would allow people to visit areas of socio-historical, cultural, scientific, and educational value, to both Aboriginal and non-Aboriginal people – provided that resources were maintained and managed.

Wickham Point has seen intense human activity during at least three periods in the past: around 500 to 700 years ago, when the *Anadara* shell middens were formed; from 1884 to 1931 when the Mud Island leprosarium was operational; and from 1942 to 1945, during World War II when the island supported anti-aircraft gun stations. Aboriginal people consulted during the preparation of the anthropological report expressed the belief that Wickham Point has a significance to them in that it featured during particularly disruptive periods of their own and their immediate ancestors' lives.

It is likely that there were Aboriginal burials at Wickham Point, at least in the middens, but there are no known grave sites. It is also likely that some people were buried on Wickham Point during the time the leprosarium was operational. These burials may be recorded in surviving Government documents, and it is possible that Aboriginal people who died during that period, may have living relatives.

Wickham Point and the seas around it are very rich in marine, littoral zone, and terrestrial resources which were traditionally and are currently exploited by Aboriginal people. Sixty-one species of terrestrial flora which have confirmed ethno-botanical references have been recorded at Wickham Point, but the difficulty in accessing the terrestrial resources has meant that it has been little exploited in the recent past.

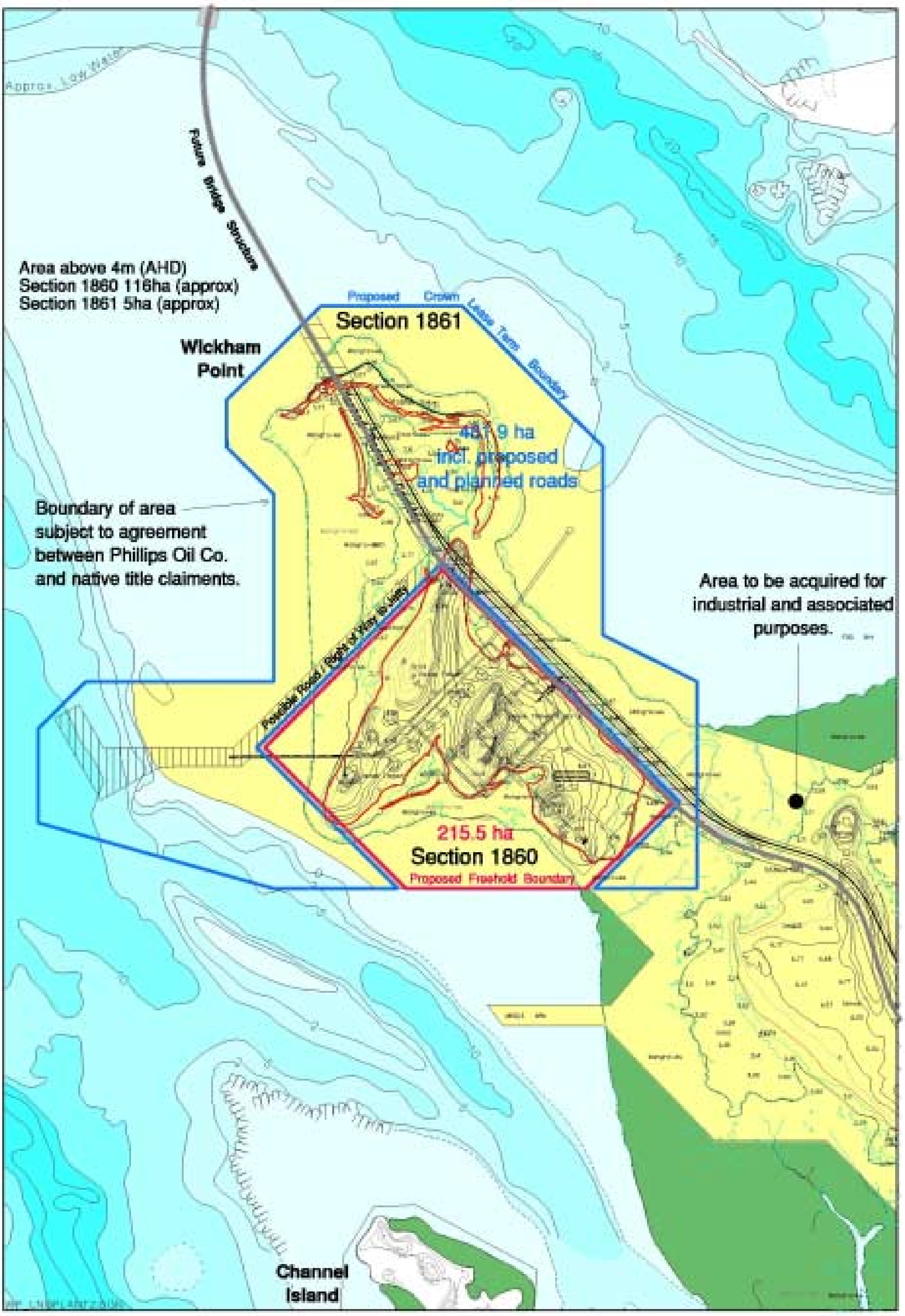
Wickham Point is of spiritual significance to Larakia people. Areas near the project area are imbued with spiritual significance as a Larakia Ancestor travelled through there to the Sacred Site, Yirra.

3.5 SOCIO-ECONOMIC ENVIRONMENT

3.5.1 Land Use and Tenure/Zoning

Wickham Point is currently undeveloped vacant crown land falling within the Litchfield Shire Council. Foreign Investment Review Board (FIRB) approval has been obtained for the project, and Phillips has reached an agreement with native title claimants. Applications have been filed for the issuance of both freehold and long-term leasehold titles over the affected area with the NT Government. Finalisation of these leases is imminent. Figure 3.11 shows the boundaries of the proposed tenure for the project area.

Middle Arm Peninsula, with its access to deep water and proximity to future urban infrastructure, has long been identified as a preferred location for major industrial development in the Darwin Region (including those industries requiring large sites and/or separation from other land uses particularly residential).



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Current land use of Middle Arm Peninsula is currently comprised of Channel Island Power Station, an LPG unloading facility adjacent to the power station, a number of aquaculture ventures and recreational activities. A mangrove boardwalk is also present on Channel Island but is currently not being utilised.

The intended future use of the peninsula for major industry, which was recognised in the Darwin Regional Land Use Structure Plan 1990, is maintained in the current proposed Litchfield Planning Concepts and Land Use Objectives (NT DLPE 2001a). The strategic land use planning concepts currently proposed for Middle Arm are shown in Figure 3.12.

3.5.2 Social Profile

3.5.2.1 Population distribution

As of June 2000 the estimated resident population of the Northern Territory was 195,500, which represents approximately 1% of Australia's total population (ABS 2000a, 2001a). The majority (over 59%) of the Northern Territory's resident population lived in the three urban centres of Darwin City, Palmerston-East Arm and Alice Springs.

The estimates of the resident population figures for Darwin and the Northern Territory as at 30 June 1999 and 30 June 2000 are presented in Table 3.2. These figures do not include Defence Force personnel. The population of Darwin grew very little in the year preceeding the last census (1999-2000), showing a growth rate of 0.57%. The satellite city of Palmerston demonstrated a much greater rate of growth at 7.37% in that same year. In terms of future projections, the Australian Bureau of Statistics (ABS) estimates that the Northern Territory population is projected to grow from 195,500 in 2000 to between 227,700 and 308,700 in 2021 (ABS 2000a).

The age structure of the population in the Northern Territory differs from that in the rest of Australia. The NT has the highest proportion of people aged 14 years and under of any State or Territory (26% compared with 20.4% nationally), the highest proportion of people aged 20-34 years (28.1% compared with 22.2% nationally), and the lowest proportion of people aged 65 years and above (3.5% compared with 12.3% nationally) (ABS 2001a).

The median age of males and females in the NT is 29.2 years and 28.7 years respectively, compared with the national median age of 34.4 years and 35.9 years (for males and females respectively).

The Aboriginal population is an integral part of the Northern Territory's history and culture. As at June 1999 it was estimated that the indigenous population of the NT was between 54,600 and 55,700 (ABS 2000a). This represents approximately 28% of the NT's population, compared with 2% nationally.

Table 3.2 Darwin Region Population Estimates, 1999 and 2000

Statistical Local Area	At 30 June 1999	At 30 June 2000	% Change
Darwin City	68, 407	68, 802	0.57
Palmerston	19, 645	21, 209	7.37
Darwin Rural Areas	17, 592	17, 797	0.03
Total Northern Territory	192, 724	195, 463	1.40

Source: ABS (2001b)

3.5.2.2 Employment

Labour force statistics for the Northern Territory and Australia are shown in Table 3.3 below. Based on current estimates, the NT unemployment rate of 5.5% is significantly lower than the national average of 6.7%. Participation rates are reported to be just under 70%, compared with 63.6% nationally.

The latest sectoral employment figures for the NT show that, as at November 2000, almost 18% of the NT workforce is employed in the area of Public Administration and Defence, compared with 3.9% nationally (Table 3.4). Other major employment sectors are Education, Health and Community Services (a combined 16.5% of the workforce), Wholesale and Retail Trade (15.4%) and Property and Business Services (7.46%). The mining sector, while employing a relatively small proportion (2%) of the NT workforce, is still significantly higher (approximately 2.2 times) than the national average of 0.9% (ABS 2001b).

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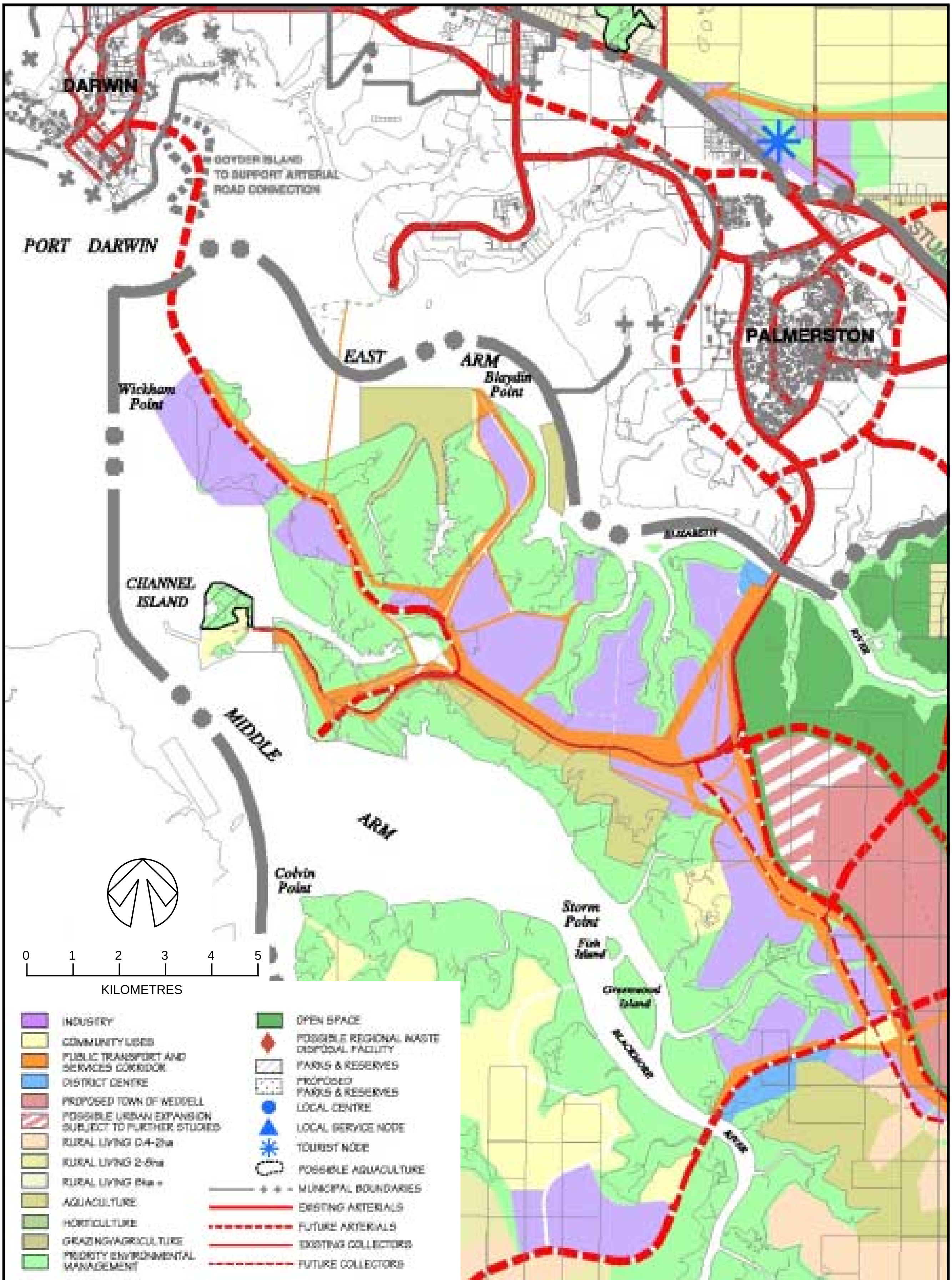

SOURCE: DLPE (2001) Proposed Litchfield Planning Concepts & Land Use Objectives

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Table 3.3 Key Labour Force Statistics for NT and Australia, 1999-2000 and 2000-2001

	Northern Territory		Australia	
	1999 - 2000	2000 – 2001e	1999 - 2000	2000 – 2001e
Total employed persons *	92,300	92,700	8,916,600	9,093,300
Unemployed persons	4,400	5,400	661,400	650,000
Unemployment rate	4.6%	5.5%	6.9%	6.7%
Participation rate	69.2%	69.4%	63.4%	63.6%

Source: NT Government 2001
* Excludes Defence personnel

Table 3.4 Employment by Industry for the NT, November 2000

Industry Type	Number	Percentage
Agriculture, Forestry and Fisheries	4,979	5.33 %
Mining	1,874	2.01 %
Manufacturing	4,580	4.91 %
Electricity, Gas and Water Supply	860	0.92 %
Construction	5,883	6.30 %
Wholesale Trade	2,388	2.56 %
Retail Trade	11,960	12.82 %
Accommodation, Cafes and Restaurants	5,908	6.33 %
Transport and Storage	4,960	5.31 %
Communication Services	1,018	1.09 %
Finance and Insurance	1,991	2.13 %
Property and Business Services	6,962	7.46 %
Government Administration and Defence	16,710	17.91 %
Education	7,781	8.34 %
Health and Community Services	7,665	8.21 %
Cultural and Recreational Services	2,783	2.98 %
Personal and Other Services	5,016	5.38 %
Total	***93,318***	***100.0 %***

Source: ABS 2001b

Recent estimates by the NT Treasury indicate that the public sector accounts for 22,000 employed wage and salary earners (excluding defence personnel) in the Territory, representing 29% of the workforce (NTT 2001). Of these public sector employees, approximately 73% are employed by the NT Government, while the remainder are employed in either Commonwealth or Local Government sectors (16% and 11% respectively). The proportion of public sector employees in the NT has decreased over the past decade as a result of substantial growth in total employment being driven by private sector employment, a reflection of the maturing Territory economy (NTT 2001).

3.5.3 Economic base of the study area

Northern Territory Treasury figures indicate that the Territory's real Gross State Product (GSP) grew by an estimated 4.6% to $6.7 billion in the 2000/2001 fiscal year (NTT 2001). The anticipated construction of a number of major initiatives, such as the $1.3 billion Darwin to Alice Springs railway and a number of onshore gas and oil-related ‘megaprojects’, real GSP for the NT is anticipated to increase by an annual average growth rate of 6.7% over the coming 5 years, almost double the national rate (NTT 2001).

According to the latest State account figures, the mining sector is the largest single contributor to GSP at an estimated 18% (ABS 2000b), followed by Government administration and defence, wholesale and retail trade and property and business services. Relative to Australia, the NT has a dominant mining sector (3.6 times the national average), a small manufacturing sector and a large public sector.

The Northern Territory remains to be a major contributor to Australia’s export trade. In the year 2000 the Territory had the highest exports per capita of any jurisdiction at $21,472, with Western Australia second at $15,662 (NTT 2001). In comparison, the national export per capita figures show an estimated $7,426 per person. The vast majority of the NT’s exports are mineral or energy based, accounting for over 90% of total export earnings in 2000/2001, with live cattle being the other major export. An analysis of key export destinations undertaken by the NT Treasury (NTT 2001) showed that, over a five year averaging period to 2000/2001, approximately 70% of total commodity exports go to Asia (27% to South East Asia, 26% to North East Asia, and almost 18% to Japan).

Table 3.5 shows the total value of exports by commodity in the Northern Territory for 1999/2000 and 2000/2001.

Table 3.5 Northern Territory Merchandise Exports by Commodity, 1999/2000 and 2000/2001

Commodity Group	1999/2000 ($ million)	2000/2001 ($ million)	% Change
Mineral fuels	1259	2882	128.91
Crude materials	142	248	74.95
Food and live animals	162	155	-4.10
Basic manufactured goods	5	41	684.36
Chemicals and related products	14	25	78.75
Machinery/transport equipment	8	7	-14.02
Miscellaneous manufacturing	6	7	23.78
Unclassified commodities *	931	876	-5.83
Total export trade	2526	4242	67.91

Source: NT DART 2001

* Unclassified commodities include minerals (ie. bauxite, alumina, manganese, zinc, lead, gold) and uranium.

3.5.4 Infrastructure and Services

3.5.4.1 Existing facilities and service provisions

As a capital city and seat of the Northern Territory parliament, Darwin has a wide range of services and facilities and is arguably better serviced than any similarly sized city in Australia. Services include a range of modern financial, commercial, recreation, sporting, education, and health facilities.

Housing

Table 3.6 summarises housing statistics for Darwin City, Palmerston and Northern Territory gathered for the five-yearly National Population and Housing Census conducted in 1991 and 1996. Total domestic dwellings in the Territory increased from 50,542 in 1991 to 57,437 in 1996 (ABS 1998). Darwin City demonstrated only moderate growth in housing during this same period compared to Palmerston-East Arm, concomitant with the population growth statistics for this area.

Table 3.6 Housing Statistics (as Number of Dwellings) for Darwin, Palmerston, and Northern Territory, 1991 and 1996

	Family		Lone person		Group		Not classifiable		Total	
	1991	1996	1991	1996	1991	1996	1991	1996	1991	1996
Darwin City	15,104	15,536	3,722	4,375	1,802	1,675	1,530	1,837	22,158	23,423
Palmerston–East Arm	1,979	3,286	372	616	85	152	175	168	2,611	4,222
Total NT	33,659	37,127	7,678	9,599	3,279	2,876	5,926	7,835	50,542	57,437

Source: ABS 1998

The demand for housing is anticipated to increase as the Territory develops as a supply and service centre for the Defence, mining, oil and gas sectors and continues to be involved in the new nation of East Timor. Palmerston in particular, as a focal point for defence housing and commercial development, has experienced strong growth in house sales.

Education

In the year 2000, there were a total of 182 schools in the Northern Territory (ABS 2001c). Of these, 150 schools were Government-based, while the remaining 17% were non-Government from a range of backgrounds (Table 3.7). 28,925 of the 37,393 students in the Northern Territory were enrolled in Government schools in 2000 (ABS 2001c).

The Northern Territory University offers higher education degrees from bachelor level through to doctorates, at its campuses at Casuarina and Palmerston. The university also provides a large range of vocational courses (TAFE) and has 13 research centres.

Table 3.7 Northern Territory Level and Category of Schools, 2000

Level of Education	Government	Non-Government				All Schools
	Total	Anglican	Catholic	Other	Total	Total
Primary	91	-	6	9	15	106
Secondary	12	1	2	3	6	18
Primary/Secondary Combined	42	-	7	4	11	53
Special	5	-	-	-	-	5
Total	150	1	15	16	32	182

Source: ABS 2001c

Health

Health care throughout the Northern Territory is provided by the NT Government through the Department of Health and Community Services at hospitals, health centres and community care centres. This is complemented by private medical and allied health practitioners and other independent health agencies.

Two hospitals, one private (Darwin Private Hospital) with 150 beds and one public (Royal Darwin Hospital) with 257 beds provide a full range of medical and surgical services in the Darwin area. The hospital facilities are further augmented by two community care centres located in Darwin and Casuarina, and the new Palmerston Health Centre.

Community based specialist services can also be accessed through community care centres and include palliative care, paediatric services, specialist adult health services, and hearing services. Some community care centres also have visiting health professionals in the areas of: mental health services, dental services, speech pathology services, children's allied health services, dietitian services, and podiatry services. Free dental clinics are provided for all primary and pre-school children in school based clinics.

Recreation

The climate of the Top End is conducive to a wide range of recreational activities and Darwin and the surrounding region is well supplied with recreational facilities, sporting teams, and natural recreation attractions.

Religion

The culturally diverse population of the Northern Territory is well catered for with a large diversity of churches, mosques, synagogues, temples and other religious centres.

Business

Information on selected businesses in the Darwin CBD is shown in Table 3.8.

Table 3.8 Outline of Business Types in the Darwin Central Business District

Type of Business	Number of Locations
Accommodation/Hotels	28
Art Galleries	9
Bars & Nightclubs	20
Cafes	36
Car Rentals	8
Computers	15
Churches	6
Entertainment	5
Fashion	47
Hair & Beauty	29
Homeware & Gifts	11
Major Supermarket	1
Jewellers	14
Libraries	2
Medical Services, Doctors, Chemists	32
Newsagents & Book Stores	9
Optometrists	4
Photographic Services	12
Restaurants	27
Shopping & Miscellaneous	33
Souvenirs	6
Sports & Leisure	4
Takeaways	39
Travel Agents & Tour Operators	37
November 1999 Total	*434*

Source: DCC 2001b

There is also a small number of specialist and industrial manufacturing facilities and several internationally based offshore oil industry support companies in Darwin.

There are many Government offices based in the Darwin-Palmerston area, that support health, housing, primary industry and fishing and natural resource management.

Port Facilities

The main port facilities within Darwin Harbour are East Arm Port, the Iron Ore Wharf, Fort Hill Wharf, Stokes Hill Wharf and Fisherman's Wharf (Figure 3.13).

The development of East Arm Port is considered one of the most significant transport developments in the Northern Territory. The $97 million Stage One development of East Arm Port is now complete. Stage Two of the project, estimated to cost a further $100 million, will coincide with the completion of the Adelaide to Darwin railway which will link the rest of Australia to the new port. The ultimate development masterplan provides for ship repair and maintenance facilities, oil and gas supply and storage services, bulk ore exports and potential additional facilities for naval operations.

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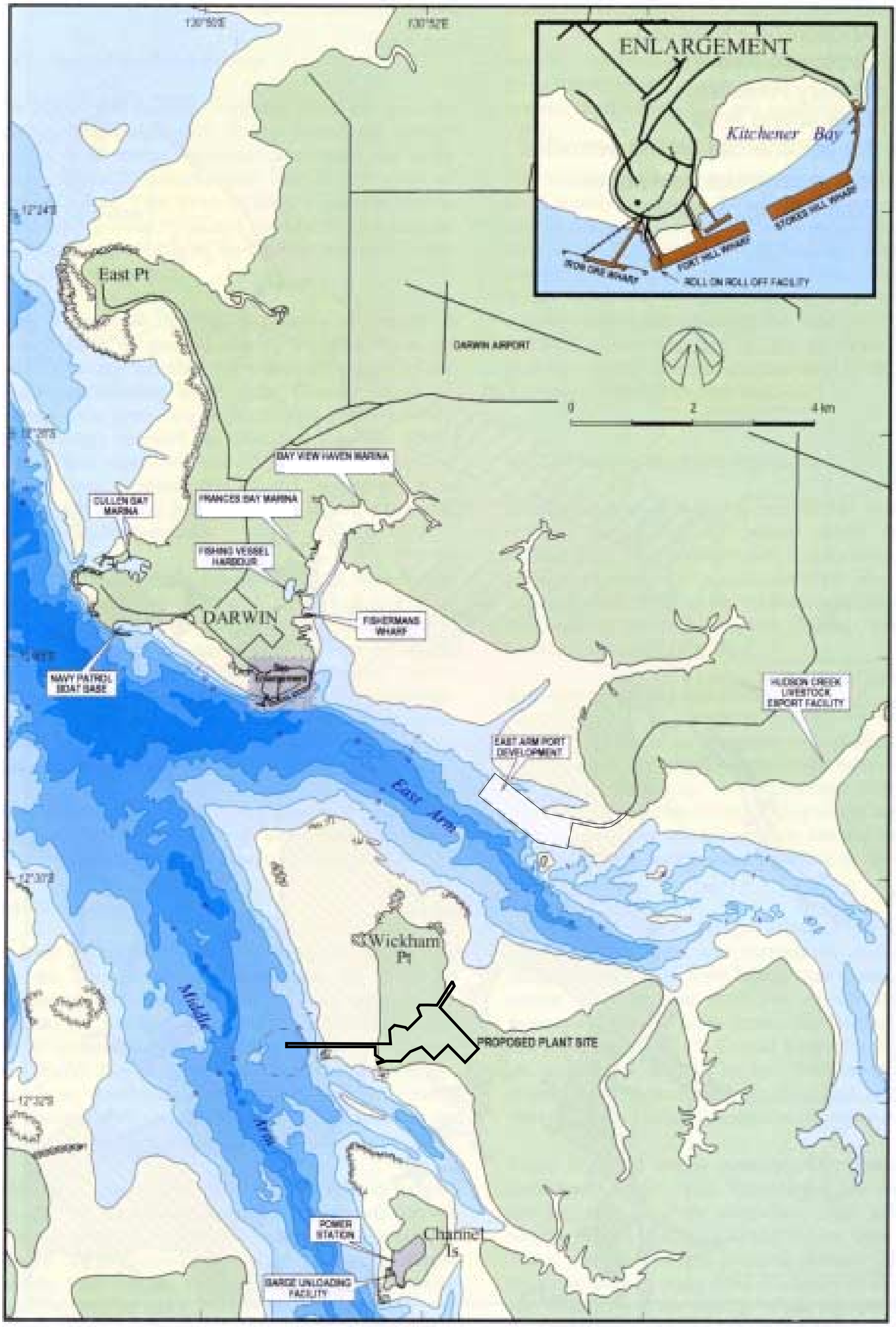

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 3.13**
Report No.	R841	**PORT FACILITIES AND MARINAS**	URS
Date	Dec 01		

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Private port facilities exist at Hudson Creek (livestock export facility) and Frances Bay (fishing vessel harbour).

Darwin Port is also strategically located to provide ship repair and engineering services to the offshore petroleum industry and defence.

Airport Facilities and Air Traffic

Darwin Airport is situated 12 km north of Wickham Point (Figure 3.1), and is a joint use facility (military and civil) which handles international, domestic, general aviation and military activity (DCC 2001b). The major Australian airlines service all parts of the country and has numerous daily services with links to all capital cities. A large number of regional and small private charter operators service all parts of the Territory. International air travel is facilitated by various carriers who fly to a range of global destinations. Darwin is increasingly becoming the hub of international travel between Australia and South East Asia. In military terms Darwin is regarded as a large airport with periods of very high usage associated with training exercises.

The proposed LNG plant site falls within the Darwin Airport Primary Control Zone and is approximately 10 km on the direct approach path for the north-south oriented Runway 36. This runway is primarily used by smaller training and passenger aircraft, with landings on runway 36 accounting for approximately 20% of annual aircraft movements (Avex 1997). The consideration of aircraft flight paths in relation to the plant location were described in detail in the Draft EIS, and have been re-assessed as part of the current PER. The results are discussed further in Section 4.6.

Road Network and Traffic

Darwin is serviced by an extensive and good quality network of roads (Figure 3.1) which is designed and maintained by the Department of Infrastructure, Planning and Environment (formerly DTW).

Road access to the Middle Arm Peninsula is provided by the Channel Island Road, an all-weather bitumen sealed road, constructed in the early 1980s to service the Channel Island power station (Plate 9).

The NT Government is responsible for construction of the arterial transport corridor through Middle Arm Peninsula, which will provide access to the proposed plant site. This is currently being progressed as part of the DIPE's works programme.

Rail

The Alice Springs to Darwin Railway involves the construction of 1410km of track between Alice Springs and Darwin. This will complete the link between the present railhead at Alice Springs and the new East Arm Port of Darwin, providing an enhanced route for trade between Australia and Asia. Financial settlement for the project took place on 20 April 2001, and construction commenced in May 2001. The railway is scheduled to be completed in mid 2003.

The rail-port project will service world-scale resource, energy and agribusiness projects from the Kimberley to Carpentaria. It will be a major infrastructure initiative for Australia and the Asia Pacific region.

3.5.5 Uses of Harbour Waters

The waters surrounding Wickham Point are used for recreational fishing, scuba diving, sailing and general boating. Pearl culture leases occur to the east at the mouth of the Elizabeth River and to the south of Channel Island, although these are currently not operational. Tour boats in Darwin Harbour tend to avoid the Wickham Point area and Middle Arm because of navigational hazards in the shallow nearshore waters.

Some subsistence fishing by Aboriginal people is undertaken in the general area of Wickham Point, but more frequently at other more accessible parts of the harbour. A landing barge visits Channel Island on average once every month to supply LPG to a depot operated by Kleenheat Gas. The Power Station currently uses fresh water for cooling purposes although it has the capacity to use sea water, and an aquaculture research facility established at Channel Island in 1998 also operates a seawater intake for its holding tanks.

Much of Middle Arm is a dedicated Naval Waters Area for fleet mooring purposes. Underwater power and communication cables extend across the harbour on the seafloor between Mandorah and Myilly Point. The waters of the harbour receive treated wastewater effluent from a number of sewage treatment plants and effluent from fish and prawn farms, as well as runoff from pastoral, residential and industrial areas which occur adjacent to the harbour.

The most intensive use of the harbour is for commercial shipping, recreational boating and military activities. Further detail on the above uses is provided below.

3.5.5.1 Shipping

Darwin has international shipping links to major ports in South East Asia and, through these, is linked to other global ports. Darwin is also served by coastal shipping routes from both the west and east coasts of Australia. Norwest Shipping operates a regular service to Darwin ex Fremantle and New Guinea Pacific Line (NGPL) provide a fortnightly service from Newcastle, Gladstone and Townsville.

PLATE 9: Aerial view of Channel Island, showing the existing Power Station (arrow in background) and the coral community (foreground).

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Plate 9**
Report No.	R841	**SITE PHOTOGRAPHS**	URS
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A recent survey of shipping movements in the Port of Darwin undertaken by Russell & Hewitt (2000) showed that, of a total of 3,515 ship visits between 1997 and 1999, approximately 48% (1,677) of these were from international last ports of call. Many international vessel operators that visit Darwin (e.g. Perkins Shipping, The Bankline, Asia World and Rooney Shipping) are scheduled services and arrive several times per year.

Shipping activity in the Port, in terms of vessel visits by type, is dominated by fishing/supply/prawning vessels, followed by pleasure/yachts, rig tenders, livestock carriers, pearling, liquid bulk/petroleum carriers and charter vessels (Russell & Hewitt 2000). More than 20 major cruise vessels visit Darwin Harbour each year.

Further development of the East Arm Port is expected to provide impetus to increase shipping services and freight volumes to and from Darwin.

3.5.5.2 Defence

The Royal Australian Navy maintains a patrol boat base at Larrakeyah, near the Darwin Port facilities, while HMAS Coonawarra, the main Navy Base in the area, is located at Berrimah, 15 km from Darwin city. During military exercises, Stokes Hill Wharf is utilised to berth visiting naval vessels. A military reserve encompassing the waters of West Arm and Middle Arm (Figure 3.14) is a designated mooring area for visiting naval fleets, although it is rarely used for this purpose.

3.5.5.3 Darwin Harbour recreation

Darwin Harbour is a prime recreational and tourism resource for the city. Dry season sunset viewing is popular with local residents and visitors alike, and the harbour provides the scenic backdrop and valuable recreation opportunities for residents and interstate and international tourists, including fishing and diving, boating, sailing and swimming.

Recreational fishing and diving

Darwin Harbour is an important recreational resource for the people of Darwin, and the city is believed to have the highest percentage of recreational fishermen in Australia. Much of the fishing takes place in the harbour. Fishing and diving activities include line and lure fishing from boats, mud-crabbing and prawning on the mudflats, and scuba diving.

Recreational fishing occurs primarily in mangrove creeks for mudcrabs and barramundi, and reef and channel areas such as Shell Island where pelagic fish are caught. Also artificial reefs are actively utilised for recreational fishing. Aside from a low level of crabbing and prawning, the DLPE Oil Spill Response Atlas shows no recreational activity in the Wickham Point area (Figure 3.15). However, 'Town Hall' hole to the south-west of Channel Island is a popular fishing spot.

Scuba diving is largely concentrated on natural coral areas such as East Point, Plater Rock and Weed Reef and on artificial reefs comprising ship and aircraft wrecks, largely dating from WWII or from Cyclone Tracy, and deliberately scuttled vessels. These dive locations are well away from Wickham Point.

Sailing, windsurfing and swimming

Sailing, sail boarding, windsurfing and water and jet skiing are all popular activities in the harbour, but mainly occur in areas near the mouth of the harbour and well away from the proposed LNG plant and existing port facilities.

The main swimming beaches are Nightcliff, Casuarina Beach and beaches at Fannie Bay through to Mindil Beach. Surfing opportunities are provided during wet season storms when waves are larger, while sailboard devotees are more active in the dry season.

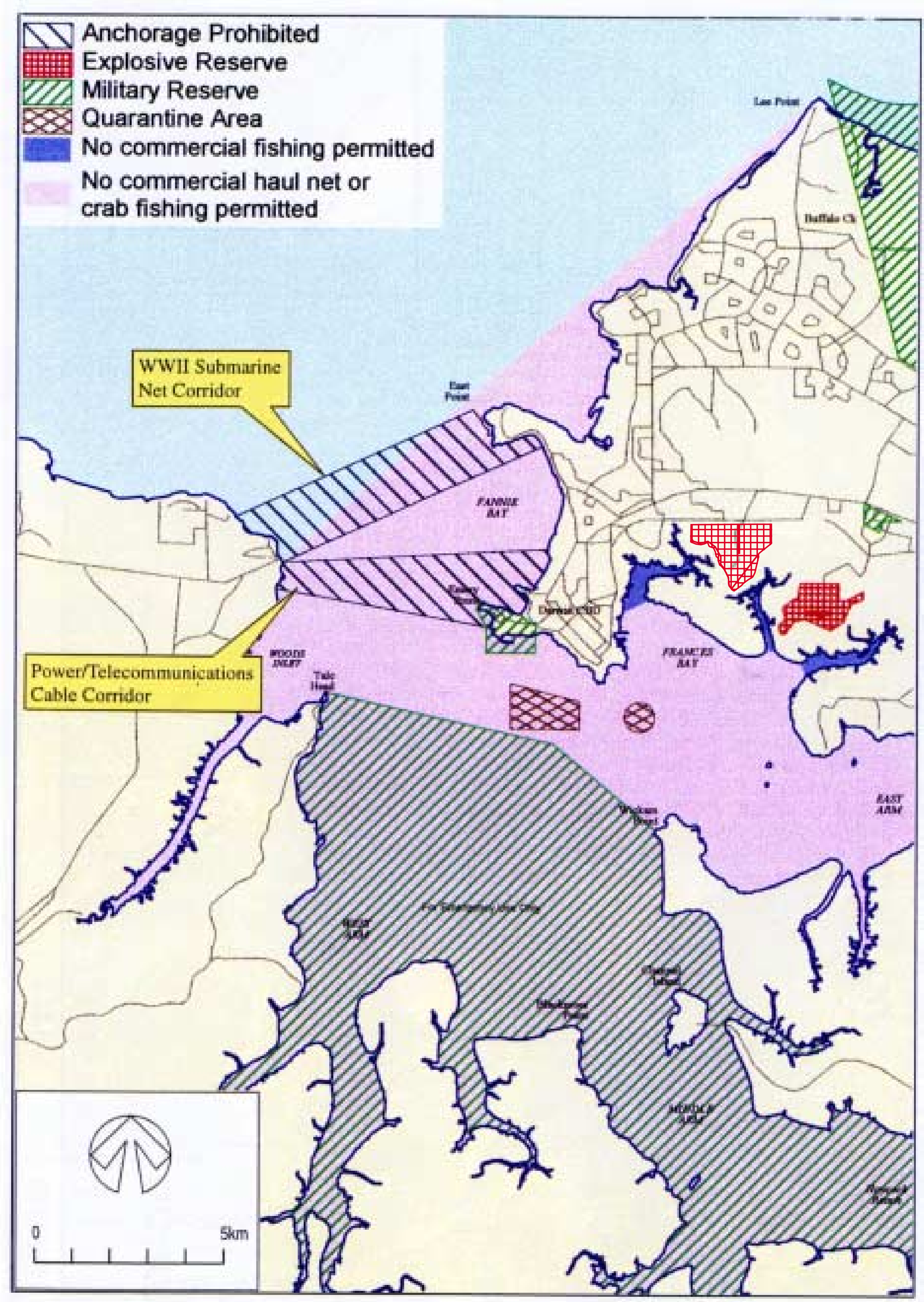
3.5.5.4 Tourism charters

Darwin Harbour supports a range of tourism charters and sightseeing operations. Daily scenic sunset cruises are offered by the *City of Darwin*, a 70', 32 passenger yacht and the *Spirit of Darwin*, a 180 passenger, motorised catamaran. The refurbished pearling lugger *Kim*, a seawing float plane and several other boats and ferries such as *Starchaser* and *Sea-Cat* also offer regular charters around the harbour.

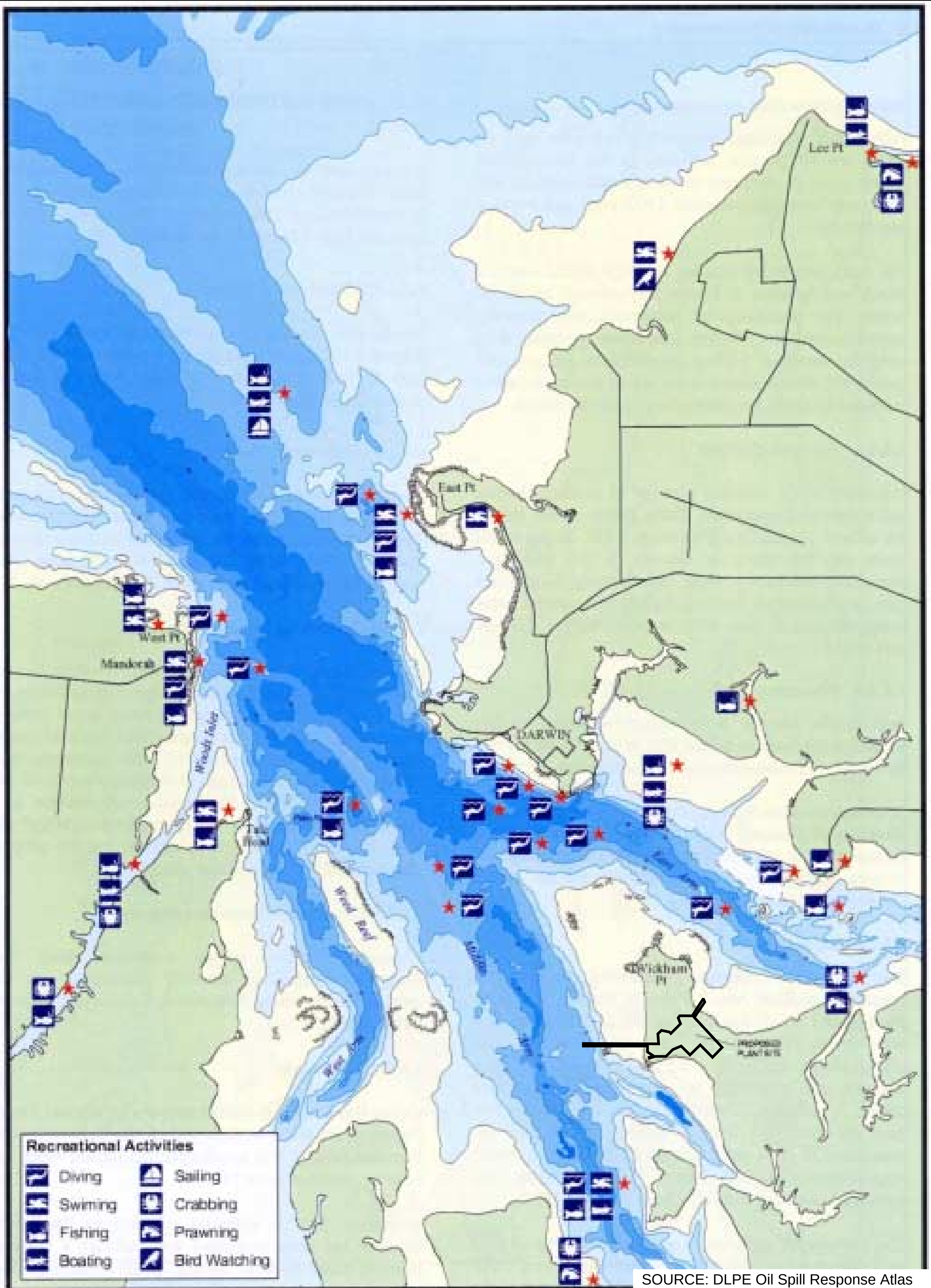
3.5.5.5 Educational

Indo-Pacific Marine is a marine aquarium facility located at the base of Stokes Hill Wharf. Water for this facility is recirculated through a closed system. The Australian Pearling Exhibition, also on Stokes Hill Wharf, utilises water from Darwin Harbour for its displays.

A mangrove boardwalk is established on the north-western shoreline of Channel Island but is currently not open to public access. A Plan of Management is currently being drafted by the Parks and Wildlife Commission to secure the future use of the boardwalk (J. Hindmarsh, pers comm).



Job No.	00533-244-562		Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 3.14**
Report No.	R810		**RESTRICTED AREAS WITHIN DARWIN HARBOUR**	URS
Prep .By	ILEP	18 Sept 01		
Office	Perth Western Australia Phone: +61 8 9221 1630			



SOURCE: DLPE Oil Spill Response Atlas

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER	**Figure 3.15**
Report No.	R841	**RECREATION ACTIVITIES WITHIN DARWIN HARBOUR**	URS
Date	Dec 01		

3.5.5.6 Aquaculture

A number of aquaculture ventures are located in the vicinity of Middle Arm (Figure 3.16). Two commercial pearl culture leases currently exist - Paspaley Pearling Company Pty Ltd to the east of Wickham Point in East Arm, and South Sea Pearling Pty Ltd on the southern side of Middle Arm – although these are not currently in operation. Two prawn farms are operational on Middle Arm, situated on the southern side of Channel Island Road ~5 km upstream from Channel Island. Another operating prawn farm exists at the upper reaches of Middle Arm near Cox Peninsula Road, with another due to be commissioned in the next dry season (C. Shelley, pers. comm..).

The DPIF Darwin Aquaculture Centre was established on the south-western side of Channel Island in late 1998. The centre has both research and commercial arms, with specific areas dedicated to fish (broodstock, hatchery), mud crab, algae, live feeds and temperature control work. The commercialisation of mudcrab aquaculture and various reef fish species represent a major focus of the research efforts currently undertaken by the centre, while Barramundi fingerlings are produced year-round on a commercial basis (C. Shelley, pers. comm..).

3.5.5.7 Commercial fishing

Darwin Harbour is closed to commercial haul net fishing and commercial mud crab fishing (Figure 3.14). Limited gill netting is permitted within the harbour, and commercial line fishing is also permitted (D&M 1997).

3.5.5.8 Subsistence fishing

Aboriginal people living in the Darwin area frequently fish and forage for food and other resources in intertidal areas at low tide. Within the harbour itself this activity is common in the Nightcliff/Coconut Grove/Kululuk area, Sadgroves Creek and Lee Point.

3.5.5.9 Industrial cooling water

Channel Island Power Station (Plate 9) currently uses evaporated town (fresh) water for the cooling towers. Chemicals such as corrosion inhibitors are added, with the water discharged to the harbour as a bleed.

A new air-cooled generating unit has recently been installed and commissioned at the Channel Island Power Station to increase the installed capacity of the power station from 204MW to 248MW. Connection of the new generating set to the inlet air-cooling plant was completed in 2000 (PAWA 2000).

3.5.5.10 Domestic wastewater disposal

The Power and Water Authority has licences under the *Water Act* to discharge treated (primary and secondary) wastewaters from its sewage treatment plants located at Berrimah, Palmerston and Ludmilla (Figure 3.1). Macerated and disinfected sewage is also discharged into the harbour via deep water outfall at the Larrakeyah plant, although there are plans to shut the macerator down and divert sewage to the Ludmilla plant for treatment to coincide with planned upgrades in accordance with the *Darwin Sewerage Strategy* (D. Jackson, pers. comm.; PAWA 2001). As part of this upgrade some of the tertiary treated wastewater will be able to be re-used through irrigation of recreation areas, parks and gardens in Darwin.

3.5.5.11 Recreational boating

Four marinas occur in Darwin Harbour at Cullen Bay Marina, Tipperary Waters Marina Estate, Bayview Marina and Frances Bay.

Frances Bay Marina is a commercial marina catering to fishing and larger vessels, while the other three cater mainly to pleasure craft and are surrounded mainly by residential dwellings (NT DLPE 2000b).

Boat ramps also occur at Adelaide River Bridge, East Arm Port, Channel Island and the above residential marinas.

3.5.5.12 Existing levels of contamination in Darwin Harbour

(i) Water

Water quality in Darwin Harbour is generally high, even though naturally turbid for most of the time. A range of previous studies have shown that many water quality parameters in the harbour are affected by seasonal, spatial and tidal factors (e.g. turbidity, total suspended solids and chlorophyll *a* dependent on location in the harbour and tidal movements). Other parameters, such as pH, total nitrogen, organic nitrogen, ammonium, dissolved oxygen and phosphorus, remain at relatively constant levels throughout the year (Padovan 1997; Russell & Hewitt 2000).

In 2000 the Natural Resources Division of the NT DIPE undertook the estimation of emissions to water in Darwin Harbour from 21 sub-catchments in the region to support the National Pollutant Inventory (NT DLPE 2000b). Four main land uses - undisturbed, rural, urban and industrial- were designated for each sub-catchment, and emissions estimates obtained for selected substances, in regard to nutrients (total nitrogen and total phosphorus) and metals (arsenic, cadmium, chromium (III), copper, lead, nickel and zinc). The study showed that undisturbed and rural catchments dominated total emissions for most pollutants, except lead and zinc compounds (Table 3.9). However, on a per hectare basis the industrial and urban catchments (such as Sadgroves Creek, Reichardt Creek and Darwin CBD) were shown

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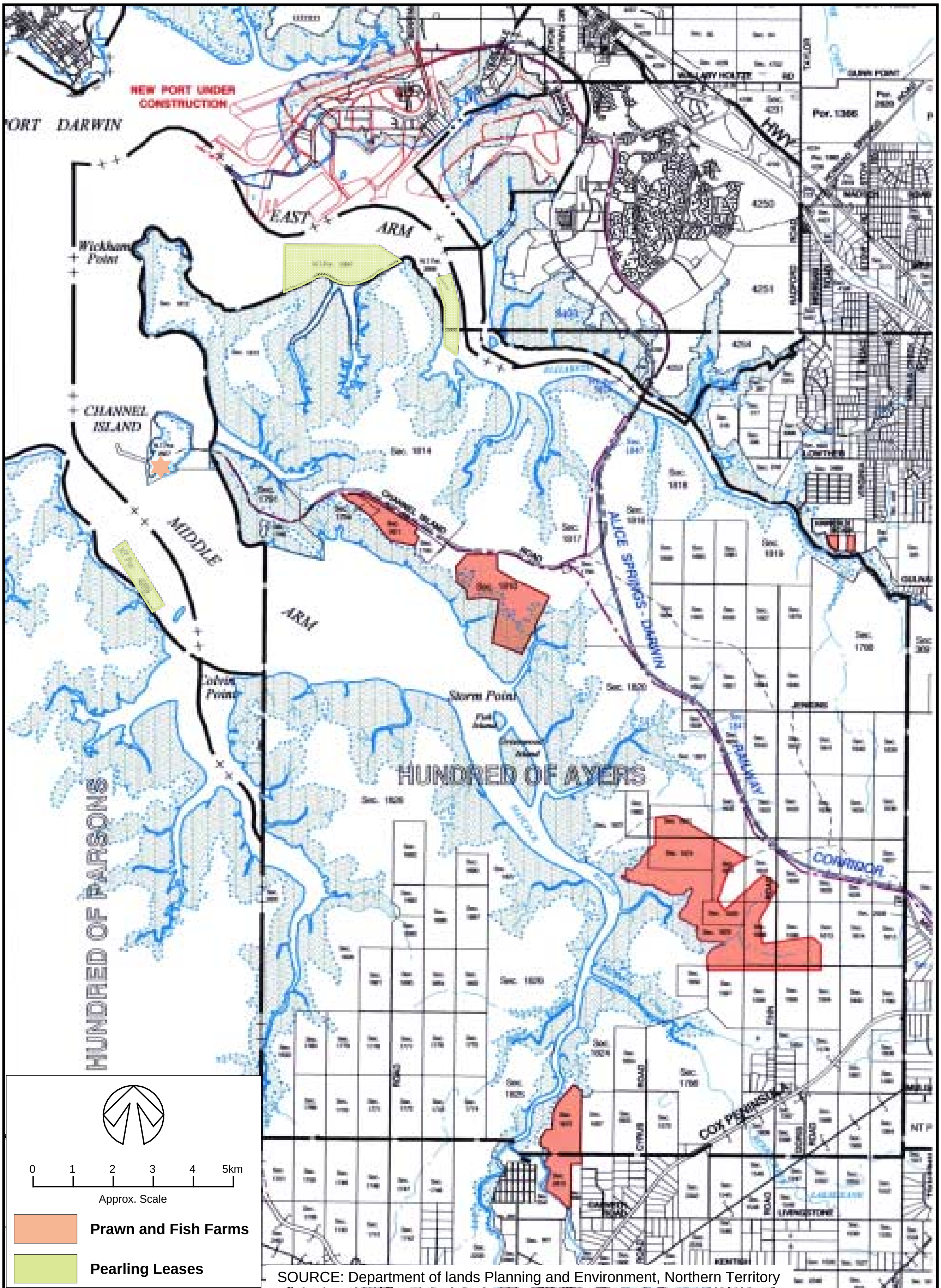

SOURCE: Department of lands Planning and Environment, Northern Territory

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Prep .By	ILEP	18 Sept 01
Office	Perth Western Australia Phone: +61 8 9221 1630	

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10MTPA LNG PLANT AT WICKHAM POINT - PER

AQUACULTURE SITES NEAR MIDDLE ARM PENINSULA

Figure 3.16

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to be significant emission sources for metal contaminants.

Contaminant loads for each of the Darwin Harbour marinas were also estimated as part of the Diffuse Water Emissions Study (NT DLPE 2000b). Cullen Bay and Frances Bay Marinas, the most established and active marinas, were shown to contribute the greatest amount of contaminants to the harbour system. Frances Bay Marina in particular exhibited notably high levels of zinc (122.2 μg/L), copper (31.3 μg/L) and total phosphorus (83.3 μg/L).

The NTU has undertaken monitoring of effluent discharges for PAWA over the past five years. It has been concluded that current levels of discharges have not greatly affected water quality in the harbour, due to the dilution factors and the harbour's strong tidal flushing (Connell Wagner 2000). Notwithstanding this, the most significant issue in relation to harbour water quality is nutrient loadings (M Lawton, pers comm).

The waters of Darwin Harbour were declared to have beneficial uses for the protection of aquatic ecosystems, recreational water quality and aesthetics under the Northern Territory *Water Act* in 1996, in accordance with the objectives and criteria defined in the ANZECC Guidelines. A draft *Darwin Harbour Strategic Plan for Beneficial Uses* was released for public comment in late 2000 (Connell Wagner 2000) as a strategic framework for the long-term maintenance of the harbour's environmental values and beneficial uses. This is expected to be finalised and submitted to Cabinet for endorsement in the near future.

Table 3.9 Annual Emissions of Key Pollutants into Darwin Harbour

Pollutant	Estimated annual emissions by land use category				
	Industrial kg/yr)	Rural (kg/yr)	Undisturbed (kg/yr)	Urban (kg/yr)	Total (kg/yr)
Arsenic & compounds	130	140	390	74	730
Cadmium & compounds	19	31	56	18	120
Chromium (III) compounds	960	350	690	220	2,200
Copper & compounds	520	680	2,500	460	4,200
Lead & compounds	700	290	590	1,800	3,400
Nickel & compounds	94	320	530	150	1,100
Total nitrogen	42,000	150,000	340,000	60,000	590,000
Total phosphorus	10,000	5,800	24,000	7,000	47,000
Zinc and compounds	6,900	4,600	1,900	4,800	18,000

<u>Source</u>: NT DLPE 2001c

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(ii) Sediments

The DIPE is currently in the process of finalising a review of the current status of contamination in Darwin Harbour sediments. Preliminary results indicate that, on the whole, sediments within the harbour environment are in relatively good condition, although 'hotspots' have been identified around the wharf areas (J. Warren, pers. comm.). Some areas, such as the upper reaches of West Arm, have naturally high levels of metals such as arsenic and chromium as a result of natural weathering of bedrock within the catchment (NT DLPE 2000a).

The Northern Territory University has also undertaken a number of research projects on Darwin Harbour sediments. The most recent of these was reported by Munksgaard & Parry (in press) who obtained baseline sediment concentrations of arsenic and selected metals and lead isotope ratios from thirteen estuaries and coastal areas along the tropical north Australian coastline between 1996 and 2000. Within Darwin Harbour, 11 sediment sampling sites, in less than 10 m water depth, were sampled twice in 1998 and again in early 2000. The observed ranges for the total arsenic and key metal concentrations (mg/kg dry weight) in the harbour were: arsenic 12.7-18.6; manganese 191-335; cobalt 9.7-13.1; nickel 19.7-27.4; copper 9.4-18.2; zinc 36.3-60.3; cadmium 0.03-0.04, and lead 12.4-16.8.

The NTU has also established a sediment database which will enable an updated dataset for sediment contamination in the region to be maintained (D. Parry, pers. comm..).

(iii) Biota

A number of marine animals have been shown to bioaccumulate heavy metals, sometimes orders of magnitude above background concentrations. Filter-feeding animals such as oysters filter food from large quantities of water, and thus integrate the concentration of heavy metals in the water column over a period of time. As the oysters *Saccostrea cuccullata* and *S. echinata* were being considered as potential species for aquaculture, heavy metal concentrations in oysters were examined by Peerzada & Dickinson (1988; 1989) in Darwin Harbour and on the open coastline of the Northern Territory. Oysters from the largely uninhabited Arnhem Land coast had extremely high levels of cadmium and zinc. As there are few people in the area and no known sources of pollution, the high levels were considered to be natural. Oysters from sites within Darwin Harbour, except from Nightcliff were fit for human consumption. Samples from Channel Island had the lowest heavy metal concentrations, but the authors cautioned that the samples were collected before the Channel Island power station became operational.

Sediment dwelling gastropods are known to bioaccumulate pollutants, and the mud snail *Telescopium* is widely eaten by Aboriginals. Again, levels obtained for most metals were lower than NHMRC recommended limits except for lead at Rapid Creek and Frances Bay. Levels from Creek H on East Arm and from Channel Island were low.

(iv) Atmosphere

The NT DIPE has recently undertaken a number of benchmark studies to quantify ambient air pollution in the Darwin area, to support jurisdictional commitments to the implementation of the National Environment Protection Measure for Ambient Air Quality (Air Quality NEPM) and the National Pollutant Inventory (NPI) (NEPC 1998a, 1998b). This information has been used to describe the current status of air quality in the area.

On a regional level the Darwin airshed is generally considered to have good air quality. Benchmark studies undertaken in the 2000 dry season indicate that particulate (as PM10) is the only pollutant of concern in the Darwin region (NT DLPE 2001b; CSIRO 2001). Of the key source categories identified for the Darwin Air Emissions Inventory for NPI reporting purposes, fires in the dry season were shown to be the most significant source of pollution, with minor point sources of pollution. Mobile (transport) sources remain a significant contributor to air pollution, characteristic of most urban airsheds in Australia. Table 3.10 summarises the annual pollutant loads estimated for the Darwin region, and the relative contribution of key source categories. The major point emission source for air pollution in the vicinity of the proposed LNG plant is the Channel Island Power Station, the major power station for Darwin. It is gas fired and only 4 km from the proposed LNG plant site (Figure 3.13, Plate 9). The major primary pollutants of concern are nitrogen oxides. The power station is also one of the major sources of greenhouse gas emissions in the area, and is an active participant in the Greenhouse Challenge Program (PAWA 1999).

The area of the LNG plant is also likely to be influenced by emissions from the East Arm Port development and surrounding residential areas. Dust levels are likely to be variable, with the highest concentrations being generally associated with natural dust emissions.

Table 3.10 Air Emissions Inventory for Key Pollutants in the Darwin Region

Pollutant	Annual emission (kg/year)	Percentage contribution of key sources						
		Bushfires (%)	Commerce (%)	Households (%)	Industry (%)	Large Industry (%)	Transport (%)	Other (%)
Oxides of Nitrogen	1.1×10^7	18	0	0	0.5	24	58	0
Particles as PM10	6.2×10^6	94	0	0	0	4	2	0
Carbon Monoxide	6.2×10^7	78	0	0.7	0	1	20	0
Sulphur Dioxide	5.5×10^5	31	0	0	0.8	4.7	63	0
Lead	8.2×10^3	7	0	0	1	0	92	0
Benzene	1.8×10^5	83	1	3	0	3	10	0
Total VOCs	6.1×10^6	46	3	2	3.5	8	22	15

Source: NT DLPE 2001d

3.5.6 Conservation Areas

The Doctors Gully Aquatic Life Reserve is a unique fish feeding area and major tourist attraction located close to the Darwin CBD (Figure 3.9).

The East Point Aquatic Life Reserve covers an area of 265 ha and has diverse coral, sponge and reef fish communities and is located on the eastern headland at the entrance to Darwin Harbour (Figure 3.9).

The newly designated Charles Darwin National Park was declared in April 1998 to protect a total area of 1,350 ha of mangrove forest and elevated forest ridge on the north side of East Arm (Figure 3.9), and Casuarina Coastal Reserve has been established adjacent to Casuarina Beach primarily for recreation purposes (NT DLPE 2000a; Connell Wagner 2000).

The intertidal platform between Channel Island and the mainland (Figure 3.9, Plates 8 & 9) is listed on the Register of the National Estate, and has been declared a Heritage Place under the *Northern Territory Heritage Conservation Act (1991).* The declaration was based upon the presence of a relatively diverse coral community, which demonstrated that a coral based community could survive in an area where most physical conditions were adverse.

The Darwin Harbour wetlands (mangroves) are listed as an Indicative Place nominated for inclusion in the National Estate register.

4. ENVIRONMENTAL EFFECTS ASSESSMENT

4.1 INTRODUCTION

This section details all the principal biophysical and socio-economic environmental effects expected to result from the proposed expansion in plant capacity. It addresses only those aspects of the expansion that have not previously been assessed. Therefore, impacts resulting from the construction and operation of those components of the plant which have not changed substantially in design since the original environmental assessment (i.e. construction dock, loading jetty) are not detailed in this section. However, the following section addresses all management commitments to mitigate impacts from all aspects of the project.

The purpose of this section is also to identify specific project activities which will require management to mitigate the potential environmental effects as a result of the proposed expansion, and briefly describe the management task proposed so that it is possible to predict the outcome of the activity. Detail on management tasks is then related to project activity in Section 5.

4.2 DIFFERENCES BETWEEN CURRENT 10 MTPA PROPOSAL, AND PREVIOUS 3 AND 9 MTPA PROJECTS

4.2.1 Previous Assessment of Potential 9 MTPA LNG Facility

Appendix 4 of the Supplement to the Draft EIS (D&M 1998a) presented an assessment of the potential environmental effects of a 9 MTPA LNG Facility located on Wickham Point. That assessment concluded that many of the terrestrial and marine environmental effects remain the same as the 3 MTPA facility because most of the construction activities (e.g. site preparation, jetty and construction dock, and dredging) will only occur once. The assessment identified that the total area of land disturbed would increase from 66.8 ha to 100 ha, that the atmospheric emissions would approximately triple in response to tripling the volume of LNG produced, that operating personnel would increase resulting in additional wastewater and solid waste disposal requirements, and shipping movements would also triple in number from 78 movements to 234 per annum.

4.2.2 Assessment of the Effects of the Proposed 10 MTPA LNG Facility

The proposed 10 MTPA LNG Facility differs from the approved 3 MTPA facility and the potential 9 MTPA Facility described in Section 4.2.1 above in a number of important ways:

- the feed stock gas will be a combination of Bayu-Undan and other gas streams, such as Greater Sunrise and Petrel-Tern, which will be processed offshore to remove LPG’s and condensate. As a result, the LNG facility is not anticipated to produce significant quantities of LPG’s or condensate for export;
- sulphur emissions are greater than previously estimated;
- the use of waste heat and ship vapor recovery equipment which will reduce atmospheric emissions including greenhouse gases from fired equipment; and
- the plant will use more efficient turbines than were available at the time of the Draft EIS, and hence lower emission factors will apply;

The main environmental effects of the new 10 MTPA Facility as compared to the approved 3 MTPA facility are primarily attributable to the increased capacity of the plant and will be as follows:

- increased area of ground disturbance from 66.8 ha to 88.3 ha;
- increased demand for power generation from 18.2 MW to 48.4 MW;
- increased operating workforce from 75 to 120 personnel;
- increased demand for process water requirements from 6 m^3/hr to 12 m^3/hr;
- increased volume of wastewater disposal requirement from 4.5 m^3/hr to 11 m^3/hr;
- increased volume of storage tank hydrotest water discharge prior to plant start-up;
- increased volume of solid waste generated (refer Table 4.1);
- potentially increased public risk environment as result of increased storage tank volumes and shipping movements associated with the larger project;
- increased product shipping movements from 78 to approximately 160 per annum and associated navigation risk using larger vessels; and
- increased atmospheric and greenhouse gas emissions (refer Table 4.2).

A clarification of the reasons behind the various changes to solid waste generation, atmospheric emissions rates and water requirements for the 10 MTPA Plant is presented below.

4.2.2.1 Solid wastes

Table 4.1 presents a comparison of the estimated solid waste generated by the approved 3 MTPA base case facility, and the potential 9 MTPA facility, and the 10 MTPA facility now proposed. Review of this table shows that the solid waste generated for the proposed 10 MTPA facility does not incrementally increase across the board. While higher than the 3 MTPA base case facility, there is a substantial reduction in volumes from that originally estimated for the 9 MTPA facility. Volume reductions are due to the efficiencies achieved by utilising a two train versus a three train operation. Reductions in the number of trains directly relates to reductions in waste generation, for instance less spent lube oil resulting from a fewer number of compressors.

Table 4.1 Estimated LNG Facility Solid Waste Quantities

Type of Solid Wastes	Quantity Kg/yr		
	3 MTPA	9 MTPA	10 MTPA
Waste Lubricating Oils	8,300	20,750	16,000
Spent Oils	950	2,375	1,500
Cellulose	1,020	2,500	2,000
Biological Sludge	4,000	6,000	5,000
Inorganic Sludge	200	500	400
Oily Sludge	40,000	80,000	60,000
Spent Solvents	100	250	200
Ceramic Balls	3,100	7,750	5,500
Molecular Sieve Waste	35,380	88,450	72,000
Trash	50,000	120,000	80,000

4.2.2.2 Atmospheric emissions

Table 4.2 presents a comparison of the atmospheric emissions estimated for the approved 3 MTPA base case facility, the potential 9 MTPA facility and the 10 MTPA facility now proposed. Review of this table shows that the emissions for the proposed 10 MTPA plant do not incrementally increase across the board and, while generally higher than the 3 MTPA facility, in most cases reflect a substantial reduction in emissions from that estimated for the 9 MTPA facility. Sections 4.3.1 and 4.3.2 further discuss the atmospheric and greenhouse emissions from the 10 MTPA facility.

In calculating the emissions from the 10 MTPA facility, new and more representative emissions factors have been used. Emission factors used for the approved base case plant were from USEPA Compilation of Air Pollutant Emission Factors (AP-42, January 1995), which are very conservative and are based on a generic natural gas composition for fuel. The emission factors used for the current 10 MTPA proposal are based on current AP-42 values adjusted to reflect the probable composition of the fuel gas for this project, which is significantly leaner than the gas composition used to calculate the emission factors for the base case. Therefore, the emission factors are generally lower than the Base Case (URS 2001).

Table 4.2 Comparison of Emissions from 3 MTPA, 9 MTPA, and 10 MTPA LNG Plants

Emissions in Tonnes per Year

Case	PM	SO_2	NOx	CO	CO_2	TOC/CH_4
3 MTPA	374	6	3,174	1,623	1,713,772	1,675
9 MTPA	1,097	18	9,244	4,800	5,070,441	5,010
10 MTPA	537	130	6,152	1,942	4,559,940	464

Note: SO_2 emissions for the 10 MTPA case are based on the expected H_2S concentration in the feed gas

Sulphur Content in the Feed Gas

In the Base Case, the estimated hydrogen sulphide concentration in the feed gas was 6 mg/Nm^3 (4.22 ppm). The current estimate of the feed H_2S composition is 4.26 mg/Nm^3 (3 ppm), potentially increasing to a maximum design concentration of 21.3 mg/Nm^3 (15 ppm). In the base case, H_2S removed by amine treatment was vented to the atmosphere and not accounted for in the emission inventory. In the current design, an acid gas incinerator has been provided to combust all of the H_2S removed by the amine unit, which will increase SO_2 emissions from the plant to a rate of 80.6 kg/hr based on the maximum design premise concentration of H_2S.

Marine Flare Operation/Addition of Vapour Recovery Equipment:

In the Base Case, the marine flare was used 624 hours per year (based on 52 LNG taker loadings per year at 12 hours each). The 9 MTPA facility therefore had a marine flare operation of 1,872 hours per year. For the current 10 MTPA facility, additional vapour recovery equipment will be installed which will lower the potential hours of operation of the flare to less than two hours of the 14 hours required to load a cold ship. On the occasion when a warm ship arrives, gas will be sent to the flare for about 12 hours as the LNG storage tanks aboard ship are cooled down. The total number of LNG ships loaded per year will be approximately 80 per train (76 of which are expected to arrive cold and four to arrive warm) or 160 for the full 10 MTPA facility. The use of the marine flare during ship loading usage for the 10 MTPA facility for ship loading will therefore be approximately 200 hours per year per train or 400 hours per year for the full 10 MTPA facility.

Addition of Waste Heat Recovery Equipment

The 10 MTPA facility will include the use of waste heat recovery equipment in the gas turbine exhaust stacks. This additional equipment will allow the plant to utilise the waste heat from the gas turbines and therefore significantly reduce the need for the use of fired equipment for heating needs within the plant. The use of fired heaters is only expected during start-up or emergency operations. This has resulted in a significant reduction in atmospheric emissions on a per tonne of LNG produced basis from the Base Case.

Additional Combustion Equipment

As noted above an acid gas incinerator has been provided in the current 10 MTPA facility design to burn the H_2S removed by amine unit. Venting of acid gas was assumed in the Base Case. This will contribute to an increase in the SO_2 emissions and a slight increase in CO_2 emissions.

Changes in the Equipment/Heat Rating

In the 3 MTPA Base Case, 6 GE Frame 5C compressor turbine drivers were proposed. In the potential 9 MTPA design this increased to 18 GE Frame 5C compressor turbine drivers. In the 10 MTPA plant design, 16 GE Frame 5D turbines are proposed. The thermal efficiency of the Frame 5D turbine is slightly higher than the Frame 5C turbine thereby reducing emissions on a per unit basis.

Carbon Dioxide in the Feed Gas

As a result of the increased capacity of the plant, there will be a corresponding increase in the CO_2 removed from the feed gas prior to liquefaction.

NO_x Emissions

In the Base Case, the emission factors for turbines were based on combustion of standard fuel gas (natural gas) and vendor guarantees (150 ppm NO_x). The fuel gas premised in the 10 MTPA case will be very lean with 30% Nitrogen, which will result in reduction in the NO_x emissions from gas turbines. For the Base Case the NO_x emissions were estimated at 1,058 tonnes per year per MTPA. For the 10 MTPA Case the NO_x emissions are estimated to be 615 tonnes per year per MTPA for a reduction of 42 % from the Base Case on an MTPA basis. Similar reductions in NO_x will occur for other fuel gas fired equipment.

TOC/CH_4 Emissions

Emission rates for TOC/CH_4 are lower in the current case than the Base Case because of elimination of venting of the acid gas. In the Base Case, the TOC/CH_4 emission rate from the vent was 135 kg/hr. In the 10 MTPA case, acid gas will be burned in an incinerator converting the TOC/CH_4 into CO_2 and water vapour. Therefore, the emission rate is lower than the Base Case.

4.2.2.3 Water requirements

Water requirements have increased from 6 m^3/hr to 12 m^3/hr from the Base Case to the 10 MTPA case. This is due to the increase in number of people required to operate the plant as a result of operating two liquefaction trains versus one (from 75 people to 120 people). Other reasons are the additional water consumption required for amine makeup, turbine wash water, and the general use of water in washdown activities. For the current case, water demand will be lower than the 9 MTPA plant as it would involve 3 LNG trains that would require additional operators, more utility stations, etc.

4.3 IMPACT ASSESSMENT STUDIES UNDERTAKEN TO ADDRESS EFFECTS OF EXPANSION

The following impact assessment studies have been undertaken to assess potential impacts associated with the expanded project:

- updated atmospheric dispersion modelling;
- a greenhouse gas emissions assessment;
- assessment of heat envelope from flares on air traffic;
- wastewater discharge analysis;
- analysis of solid and semi-liquid waste management;
- updated noise modelling;
- revised comparative visual impact assessment;
- a revised assessment of dredging and spoil disposal impacts; and
- updated ecological impact assessment;
- socio-economic and cultural impact assessment;
- a revised hazard analysis and public risk assessment for the project; and
- a sustainability assessment of the project;

Details on each of these assessments are provided in the following sections.

4.3.1 Atmospheric Emissions

Bechtel Corporation undertook air dispersion modelling on behalf of Phillips to revise the scenarios previously modelled for the 1997 EIS to take into consideration the proposed increase in plant capacity to 10 MTPA (Bechtel 2001a). The cumulative air quality impacts of the plant in combination with the Channel Island Power Station, as the nearest existing source of significant emissions, was also assessed. The complete results of the revised modelling are presented in Appendix C, with the key conclusions summarised below.

Modelling was performed using the US EPA's regulatory air dispersion model [known as the Industrial Source Complex - Short Term Version 3 (ISCST3)] to assess the impact on local air quality due to the emissions from the proposed LNG plant and the Channel Island Power Station. Meteorological data from the Darwin Airport over five years (1990, 1995, 1996, 1999 and 2000) was used as input to the ISCST3 model.

Worst case ground level concentrations were predicted for the following criteria pollutants:

- carbon monoxide (CO);
- nitrogen oxides (NO_X, modelled as 100% NO_2);
- particulate matter less than 10 μm in diameter (PM_{10}); and
- sulphur dioxide (SO_2).

The modelling used the emission sources and parameters presented in Table 2 of Appendix C. The emission rates presented in Table 4.2 were derived from the atmospheric emission inventory presented in Section 2.5.4.1.

The predicted maximum concentrations for each pollutant are presented in Table 4.3. The maximum ground level concentrations for all pollutants are predicted to be below the accepted guidelines. As such, the combined emissions of criteria pollutants from the LNG plant and the Channel Island Power Station are not expected to cause adverse short- or long-term effects on the local environment.

Table 4.3 Results of Air Dispersion Modelling

Pollutant	Averaging Period	Maximum Predicted Concentration	Ambient Standards	
			NEPM [1]	World Bank [2]
CO (ppm)	8-hour	0.07 ppm	9.0 ppm	8.7 ppm
NO_2 (ppm)	1-hour annual	0.08 ppm 0.013 ppm	0.12 ppm 0.03 ppm	- 0.05 ppm
PM_{10} (ug/m^3)	24-hour	2.9 ug/m^3	50 ug/m^3	-
SO_2 (ppm)	1-hour 24-hour annual	0.024 ppm 0.006 ppm 0.0004 ppm	0.20 ppm 0.08 ppm 0.02 ppm	- 0.19 ppm 0.04 ppm

Notes: 1. National Environment Protection Measure for Ambient Air Quality (NEPC 1998b).
2. Pollution Prevention and Abatement Handbook - Toward Cleaner Production (World Bank Group, 1999).

Appendix C (Figures 5 to 12) presents the resulting isopleth maps showing the maximum ambient concentrations expected from the proposed LNG plant and the Channel Island Power Station. The isopleth maps for NO_x are reproduced in Figures 4.1 and 4.2 to support the following discussion.

Of the criteria pollutants, the emissions of NO_x are predicted to result in ground level concentrations closest to the ambient criteria (Figures 4.1, 4.2). However, the selection of efficient technology in the current plant design, such as Frame 5D Gas Turbines serving refrigerant compressors for the LNG plant, will result in significant benefits to ensure that ambient NO_x concentrations are kept within acceptable levels.
It is recognised that alternative technology is available to control emissions of NOx, with one option being addition of dry-1ow-NOx (DLN) combustion systems on the turbines. In evaluating the use of this technology at Darwin, the following issues were considered;

(1) The feed gas to the LNG plant contains approximately 4% nitrogen. Removal of the majority of this nitrogen is required to meet LNG specifications and this is accomplished by rejecting the nitrogen to the fuel system used by the gas turbines for the refrigerant compressors. The resulting high nitrogen content of the fuel, approximately 30%, exceeds the fuel specification limitation of DLN combustors and therefore they can not be used on this fuel. The combustion of this "lean" fuel, however, results in an approximate 30.1% reduction in NOx when compared to emissions for the same turbine using other fuel sources with a higher methane content.

(2) The good dispersion characteristics of emissions from gas turbines is such that the ambient criteria for nitrogen dioxide is predicted to be easily met, even with the conservative assumption that all of the NOx is emitted as NO_2 (in fact, for conventional turbines, the emissions of NO_2 are typically only 10% of the total emissions) (Table 4.3).

(3) The use of DLN turbines would be expected to result in an approximate six percent reduction in LNG production as a result of the associated reduction in energy efficiency introduced in the liquefaction process. This reduction in energy efficiency is related to the reduction in horsepower that occurs when DLN equipment is used on a turbine and also the requirement for use of a much more inefficient process for the rejection of the nitrogen in the feed gas. Therefore, the effective unit cost of the LNG produced would be increased by the use of DLN turbines.

(4) The overall energy efficiency of the conventional turbine is greater than that of a DLN turbine in this application. The greater efficiency of the conventional turbines makes these units a more effective choice for the project and results in reduced greenhouse gas emissions.

(5) The capital cost of DLN combustors is greater than conventional turbines. There would also be an additional cost for alternative nitrogen rejection equipment.

(6) The technical risk of using DLN turbines is greater as the proposed Frame 5D turbines have not yet been commercially operated with DLN technology. In addition, controlling the DLN turbines is more difficult than conventional turbines and this could result in an increased instability in the operation of the turbine and compressors. Issues of operational reliability are important concerns for LNG customers and will have a measurable impact on any decision to incorporate technology that might undermine plant performance.

On the basis of the above points, it is considered that the use of conventional turbines operating on a lean fuel gas within the proposed LNG plant represents the selection of the best technology on environmental and technological grounds. Phillips will also continue to evaluate alternative turbine combustor technology during the detailed design of the proposed plant to ensure that the best environmental and economic choice is made for this project.

Phillips, however, does intend to use DLN technology on the power generator gas turbines. Because of the lower volumes of fuel required for the power generation system versus the refrigerant compression system, modification to the plant design are possible to provide a fuel composition that can be used with a DLN combustion system. The gas turbine used for power generation also has proven experience in DLN service therefore the technical risk in using DLN on this equipment is understood and commercially acceptable to both Phillips and LNG buyers. While the use of DLN technology and modifications to the plant design results in an additional $US2 million to the project costs, Phillips is proposing to proceed with this mitigation effort.

The conservative nature of the assumptions used in the modelling is expected to ensure that the ground level concentrations of $N0_x$ due to the combined emissions from the plant and the existing Channel Island Power Station will remain well below the ambient NEPM criteria.

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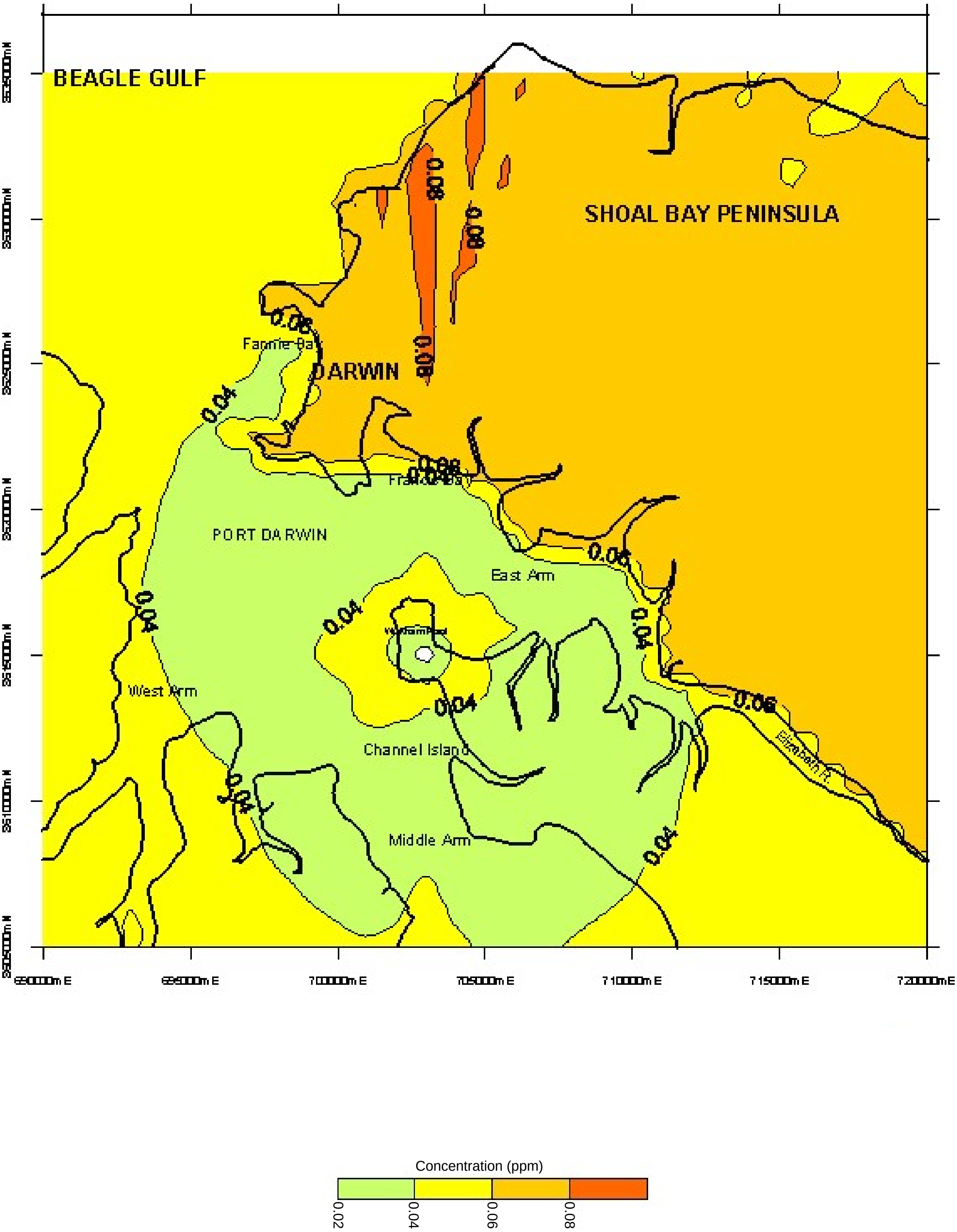

Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER **PREDICTED MAXIMUM 1 HOUR NOx CONCENTRATIONS FROM OPERATION OF THE PROPOSED LNG PLANT IN COMBINATION WITH EXISTING CHANNEL ISLAND POWER STATION**	**Figure 4.1**
Report No.	R810		URS
Date	18 Sept 01		

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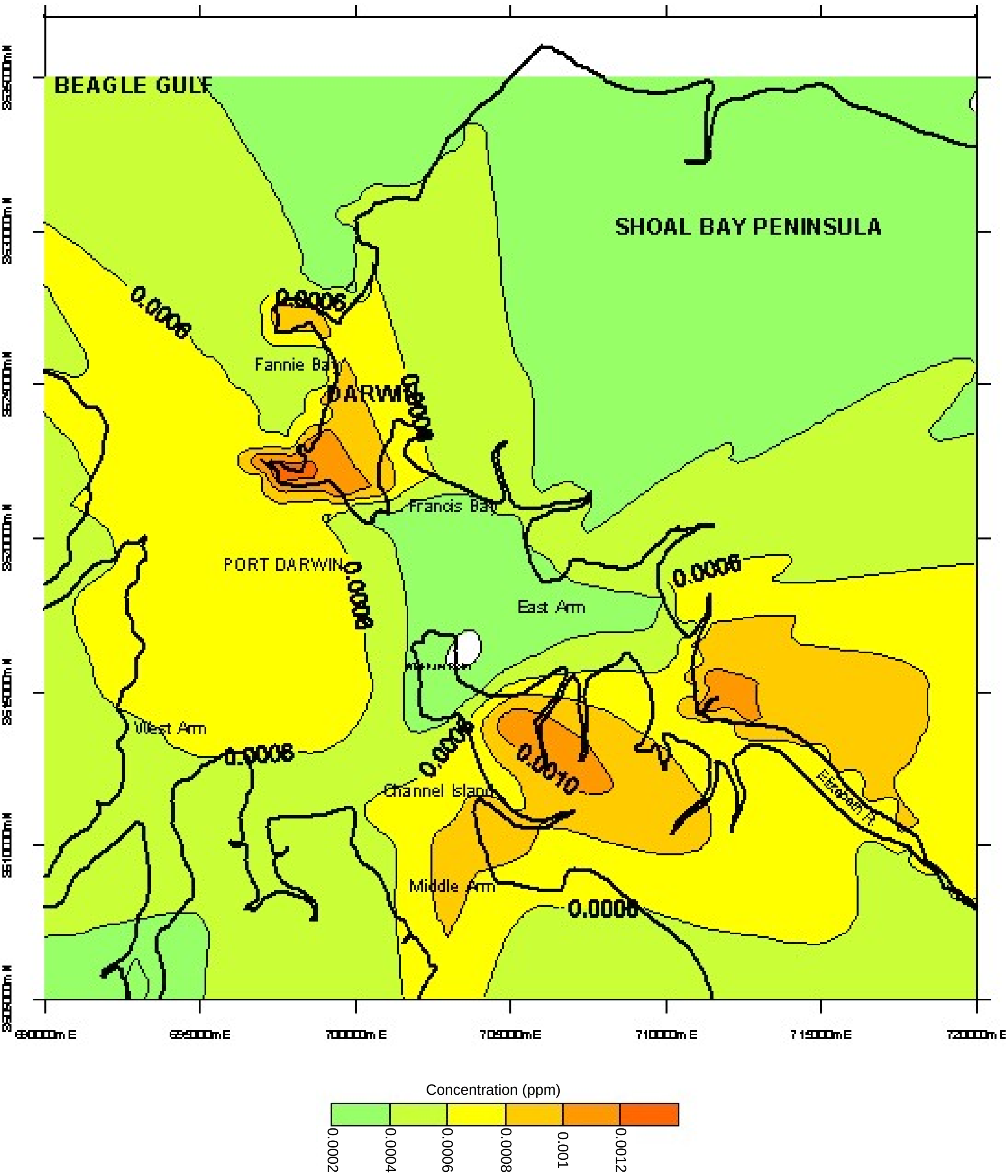


Job No.	00533-244-562
Report No.	R810
Date	18 Sept 01

Phillips Petroleum Company Australia Pty Ltd

10MTPA LNG PLANT AT WICKHAM POINT - PER

PREDICTED MAXIMUM ANNUAL NOx CONCENTRATIONS FROM OPERATION OF THE PROPOSED LNG PLANT IN COMBINATION WITH EXISTING CHANNEL ISLAND POWER STATION

Figure 4.2

URS

4.3.2 Greenhouse Emissions

This section addresses the consideration of greenhouse issues associated with the project, as detailed in the DIPE Guidelines for the PER (Appendix A).

In summary, the following sections address specific considerations in relation to:

- Greenhouse inventory;
- methodologies for greenhouse estimations;
- supporting data;
- mitigation measures;
- offset options, and
- Phillips' commitment to the Greenhouse Challenge program.

4.3.2.1 Inventory of annual emissions

Gas supplied to the LNG plant is proposed to come from the Bayu-Undan, the Greater Sunrise and other gas developments in the Timor Sea. The Bayu-Undan gas condensate field is in Area A of the Zone of Cooperation (ZOC) located in the Timor Sea between East Timor and Australia. This region will soon be known as the Joint Petroleum Development Area (JPDA) when a new treaty is executed between East Timor and Australia. The Greater Sunrise development lies partly within Area A and partly in waters under Australian jurisdiction. Annual emissions associated with the production of gas to be supplied to the LNG Plant from the Bayu-Undan field were addressed in the EIS completed on this project in 1998.

The first phase of development for Bayu-Undan, known as the Gas Recycle Project, is proceeding with a design that re-injects the lean gas after liquids (i.e. condensate and LPGs) have been extracted. The environmental impacts of this phase of development were assessed under the terms of the current Timor Gap Treaty prior to approval of a Development Plan by the Timor Gap Joint Authority in February 2000. During the second phase of development, gas re-injection will be reduced and gas will be exported from the field though a subsea pipeline to Darwin. The LNG project will be a foundation customer for this Bayu-Undan gas. CO_2 recovery and disposal has not been incorporated into the design of the gas recycle facilities due to technical and economic reasons.

Woodside Petroleum, designated operator of the Greater Sunrise Field, is currently addressing annual emissions expected from that development in a separate EIS effort. A similar but separate environmental assessment would be undertaken for any other gas field that was subsequently developed to supply gas to the LNG facility at Wickham Point. Therefore this section of the PER will contain various tables on annual emissions only for greenhouse gases expected from the LNG facility.

An estimate of annual emissions are required on the six greenhouse gases listed in the Kyoto Protocol and identified as carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. The plant will not process or emit fluoride, ie hydrofluorocarbon, perfluorocarbon, and sulphur hexafluoride, therefore these gases are not addressed in the tables that follow. Table 4.4 below shows the annual emissions expected from the 10 MTPA plant during normal operations.

Table 4.4 Annual Greenhouse Gas Emissions from Plant during Normal Operations

Annual Greenhouse Gas Emissions (tonnes/year)			
	Carbon dioxide CO_2	Methane TOC/CH_4	Nitrous Oxide N_2O
Heaters/Flares			
Inlet Gas Heaters (Metering Facility)	43,761	3.8	0.1
Acid Gas Incinerator			
Fuel	21,069	1.6	0.0
Acid Gas in Feed Gas	1,812,987	0.0	0.0
Flare Pilots & Purge Gas	740.9	0.1	0.0
Flares			
Marine Flare			
a) Warm Ship Cool-down *	5,473	6.7	0.0
b) Cold Ship Cool-down *	37,004	45.1	0.1

Table 4.4 Annual Greenhouse Gas Emissions from Plant during Normal Operations (cont'd)

Annual Greenhouse Gas Emissions (tonnes/year)			
	Carbon dioxide CO_2	**Methane TOC/CH_4**	**Nitrous Oxide N_2O**
Gas Turbines			
Refrigeration Compressor/Turbines			
(16 Frame 5D's)	2,403,455	234.1	4.9
Power Generation Turbines			
(7 Solar Mars 100S's)			
a) w/o Ship Loading	164,519	121.9	0.3
b) w/ Ship Loading	70,931	51.1	0.1
Individual Total -	**4,559,940**	**464.3**	**5.5**

Note: * The emissions shown are a result of the frequency of a warm ship versus a cold ship. See discussion of marine flare operations (Section 4.2.2.2) and ship vapour recovery (Section 4.3.2.4).

Table 4.5 shows these same emissions on a carbon dioxide equivalent basis. The "carbon dioxide equivalent" is calculated by multiplying the actual mass of emissions by the appropriate Global Warming Potential (GWP) factor. Following the convention of the United Nations Framework Convention on Climate Change (UNFCCC), carbon dioxide was used as the reference gas and assigned a GWP of 1. Methane is assigned a GWP of 21 and nitrous oxide a GWP of 310.

Table 4.5 Annual Greenhouse Gas Emissions Released Carbon Dioxide Equivalent (tonnes/year)

Carbon Dioxide Equivalent (tonnes/year)			
	CO_2	**TOC/CH_4**	**N_2O**
Heaters/Flares			
Inlet Gas Heaters (Metering Facility)	43,761	79.0	25.2
Acid Gas Incinerator			
Fuel	21,069	34.2	10.9
Acid Gas in Feed Gas	1,812,987	0.0	0.0
Flare Pilots & Purge Gas	740.9	1.5	0.5
Flares			
Marine Flare			
a) Warm Ship Cool-down *	5,473	140.1	3.4
b) Cold Ship Cool-down *	37,004	947.4	23.2
Gas Turbines			
Refrigeration Compressor/Turbines			
(16 Frame 5D's)	2,403,455	4916.0	1508.4
Power Generation Turbines			
(7 Solar Mars 100S's)			
a) w/o Ship Loading	164,519	2559.3	102.6
b) w/ Ship Loading	70,931	1073.1	44.2
Individual Total -	**4,559,940**	**9750.7**	**1718.5**
Total Emissions -	**4,571,409**		

Note: * The emissions shown are a result of the frequency of a warm ship versus a cold ship. See discussion of marine flare operations (Section 4.2.2.2) and ship vapour recovery (Section 4.3.2.4).

The project has considered and implemented several mitigation measures to lower greenhouse gas emissions. These have included the addition of waste heat recovery and additional vapor recovery for ship loading. The use of a low British Thermal Unit (btu) fuel for the refrigerant compressor gas turbines and also the use of the more efficient Frame 5D gas turbine in this service results in a reduction in greenhouse gas emissions. Additional discussion on these mitigation incentives is discussed in subsection 4.3.2.4. Air emissions without these mitigation efforts are presented in Table 4.6 below.

Table 4.7 below is a summary table that shows a comparison of greenhouse gases before and after mitigation on a carbon dioxide equivalent basis for the 10 MTPA case.

Table 4.6 Annual Greenhouse Gas Emissions Released Without Mitigation (tonnes/year)

	CO_2	TOC/CH_4	N_2O
Heaters/Flares			
Inlet Gas Heaters (Metering Facility)	43,761	3.8	0.1
Regeneration Gas Heaters	13,155	1.2	0.0
Hot Oil Heaters	485,256	45.5	1.0
Acid Gas Incinerator			
Fuel	21,069	1.6	0.0
Acid Gas in Feed Gas	1,874,075	0.0	0.0
Flare Pilots & Purge Gas	740.9	0.1	0.0
Flares			
Marine Flare			
a) Warm Ship Cool-down *	5,473	6.7	0.0
b) Warm Ship Loading *	13,633	16.6	0.0
c) Cold Ship Cool-down & Loading *	259,026	315.8	0.5
Gas Turbines			
Refrigeration Compressor/Turbines (16 Frame 5D's)	2,403,455	234.1	4.9
Power Generation Turbines			
(7 Solar Mars 100S's)			
a) w/o Ship Loading	164,519	121.9	0.3
b) w/ Ship Loading	70,931	51.1	0.1
Individual Total -	**5,355,093**	**798.4**	**7.0**
Individual CO_2 Equivalent Total	**5,355,093**	**16,766**	**2,179**
Total CO_2 Equivalent Emissions	**5,374,038**		

Note: * The emissions shown are a result of the frequency of a warm ship versus a cold ship. See discussion of marine flare operations (Section 4.2.2.2) and ship vapour recovery (Section 4.3.2.4).

Table 4.7 Annual Greenhouse Gas Emission Summary As CO_2 Equivalent (tonnes/year)

	CO_2	TOC/CH_4	N_2O	Total
Emissions Before Mitigation (tpa $CO_{2\ eq}$)	5,355,093	16766	2179	5,374,038
Emissions After Mitigation (tpa $CO_{2\ eq}$)	4,559,940	9751	1718	4,571,409
Net Reduction (tpa $CO_{2\ eq}$)	795,154	7015	461	802,629
Percent Reduction (%)	15	42	21	15

As a result of the mitigation efforts that have been pursued, cumulative greenhouse gas emissions on a carbon dioxide equivalent basis have been reduced by 15%. Subsection 4.3.2.4 provides additional discussion on the mitigation efforts that have been incorporated into this project.

4.3.2.2 Methodologies

In Section 4.3.2.1 GHG emissions for the three gases of interest are reported in terms of carbon dioxide equivalents. Phillips took the annual emissions for the greenhouse gases of interest and converted them to an equivalent basis relative to their "global warming potential" (GWP) in accordance with UNFCC protocol, as previously described in Section 4.3.2.1.

Phillips initially calculated emissions for carbon dioxide, methane and nitrous oxide as part of its overall air emission inventory (Tables 2.4.1 and 2.4.2). The calculations take into account equipment types and efficiencies, the composition of equipment-specific feed gases and their respective heating values. Phillips has utilised emission factors either predicted by the equipment vendor, or derived from the U.S. EPA AP-42 (1995) factors and updated annually through the year 2000 (USEPA 1995).

Phillips has also calculated emissions for Fuel Combustion Activities (Stationary Sources) following the procedures outlined in the National Greenhouse Gas Inventory Committee Workbook 1.1 with Supplements (NGGIC 1998). Emissions (tonnes/yr) are calculated by applying emission factors (Workbook 1.1, Tables 4 & 6) to heat inputs (Gg CO_2/PJ, Mg CH_4/PJ, Mg N_2O/PJ). The equipment/flare heat inputs are easily converted from fuel consumption rates (MMSCFD) initially calculated by Phillips. It should be noted that the generic approaches used for calculations on a national basis may not be directly transferable to calculations made for sources within an individual plant, however best attempts have been made to utilise the calculation methodologies and emission factors used by the Australian Greenhouse Office. The difference in estimates between the Phillips' total CO_2 equivalent estimated GHG emissions of 4,571,409 tonnes per year using AP-42, and calculated emissions of 4,341,020 tpa using the AGO methodology and emissions factors (NGGIC 1998, Table 6) differ by approximately 5%, with the Phillips calculations yielding slightly higher emission estimates.

4.3.2.3 Supporting data

Phillips considers that its detailed approach (described above) is equivalent (on an individual facility as opposed to a national scale) to the IPCC Detailed Technology Based Calculation or "bottom-up method" of emissions estimation, in that it incorporates anticipated operational efficiencies, detailed gas characterizations, the use of tailored emission factors and the numbers and characteristics of different equipment types.

For equipment such as heaters, flares, and compressors, Phillips has calculated individual fuel consumption rates. For heaters, the acid gas incinerator and flare pilots, hourly fuel consumptions have been calculated using equipment heat ratings, the high heating value (HHV) for each fuel source, and equipment efficiencies. For flares "fuel" consumption, the anticipated gas volumes and the fuel HHV were utilised while for the compressors the horsepower, heat rate per horsepower-hour and lower heating values for the fuel were used to calculate the individual equipment hourly fuel consumptions. Although initially expressed in millions of standard cubic feet per day (MMSCFD), fuel consumption can easily be expressed in terms of energy (GJ per hour) or mass (tonnes per hour). Emissions are calculated by estimating the number of hours/days per year that the equipment is operating and multiplying by an appropriate emission factor or by using predicted emissions based on vendors' measurements and operating parameters.

The emission factors utilised by Phillips are one of three types. Most accurate are the emission factors for carbon dioxide calculated by stoichiometry (using actual gas analyses and knowing the combustion reactions). For methane, less accurate vendor information on the emission rates of unburned hydrocarbon (UHC) for turbines and an AP-42 heater/flare emission factor for Total Organic Compounds (TOC) likely overestimate the emission of methane but are conservatively utilized by Phillips as measures of methane emissions. A nitrous oxide emission factor independent of equipment type, is derived from EPA AP-42, and as a generic factor is least accurate.

Emission factors for similar projects, whether they are Australian or international, are typically determined though a process similar to what is outlined above however these factors are typically not supplied in environmental reports provided for a project. What is provided are the emissions determined through the use of these factors. Therefore, to compare emissions from similar projects, and use this comparison for a tool to evaluate the merits of these projects, requires an understanding of the design issues that are unique to these projects that impact emissions. All of these projects will have different gas compositions, site ambient temperatures, inlet gas conditions, etc that will impact the emissions that are released at the site. For example, the lower CO_2 content in the feed gas for the North West Shelf Venture (NWSV) contributes to a lower emissions rate (higher greenhouse efficiency) than achievable with the higher CO_2 content of the feed gas at Darwin irrespective of the LNG technology used. Energy is required to remove the CO_2 from the feed stream. The feed gas to the Darwin LNG plant also contains approximately 4% nitrogen. LNG specifications require nitrogen to be less then 1%, therefore nitrogen must be removed from the LNG process. This will impact plant efficiency. The temperature at the site and of the feed gas also impacts the efficiency of any LNG process where gas is cooled to $-160\ ^0C$. The lower the ambient site and feed gas temperature, less energy is required to make the same amount of LNG with a corresponding reduction in air emissions.

Comparison of emissions between projects, therefore, requires that the unique characteristics of each project that contributes to emissions must be known. Only with this information can impacts on emissions be normalized and develop a benchmark between processes and technologies. While several LNG Plant operators and vendors of LNG technologies claim they can achieve higher fuel efficiencies then their competition, there has not been an independent benchmarking process amongst all of the various technologies that accurately accounts for the unique design characteristics of each project and therefore provides a basis for a verifiable claim of improved fuel efficiency over a competitive LNG technology.

The main reason for this lack of any accurate and meaningful benchmark process effort among technologies or projects to date has to do with the highly proprietary and competitive nature of the LNG industry. Venders of LNG technology, and the companies that have purchased these technologies for their projects, are not eager to share the various design innovations that are perceived to provide a competitive edge, or more importantly the various project economic drivers that determined the performance requirements of the technology they have selected.

Because of the above issues associated with a process by process or project by project comparison, this project reviewed the various design innovations available to any LNG technology relative to their impacts on greenhouse gas emissions and a discussion of what was considered and the resulting impact on emissions is contained in Section 4.3.2.4 below.

4.3.2.4 Mitigation

Options potentially available to Phillips to mitigate greenhouse emissions include:

- technological improvements through:
  - addition of waste heat recovery;
  - vapour recovery for ship loading;
  - high efficiency gas turbines; and
  - low BTU Fuel;
- CO_2 re-injection in offshore reservoirs; and
- downstream CO_2 utilisation.

These considerations are addressed below. Vegetation-based offset options are not considered to be economically available currently and are discussed separately in Section 4.3.2.5.

Two significant mitigation measures have been pursued for this project that have resulted in a reduction of greenhouse gas emissions. These efforts relate to the use of a waste heat recovery system and the recovery of additional vapours from the LNG ships during loading. The addition of this equipment not only reduced emissions from fired equipment or flares, they also resulted in a reduction in fuel requirements for the plant. This reduction in fuel reduced feed gas needs and carbon dioxide emissions that would have resulted from their combustion.

This section also discusses the reduction in greenhouse gases as a result of using the fuel efficient GE Frame 5D gas turbine driver versus the Frame 5C driver premised in the Base Case and also discusses the impact of using a lower btu fuel, which is possible as a result of the flexibility inherent in the Phillips Optimized Cascade LNG Process.

Waste Heat Recovery

The LNG project will incorporate the use of a waste heat recovery system that will recover heat from the gas turbine exhaust and use it for various heating requirements within the plant. The use of this system will mitigate the release of greenhouse gas emissions that would have been otherwise released if gas fired equipment was used to provide these same heating requirements. Table 4.6 shows the greenhouse gas emissions released if gas-fired equipment, specifically regeneration gas and hot oil heaters, were the sole means of providing the required process heating. The result of using waste heat recovery equipment is a reduction in greenhouse gases by approximately 500,000 tonnes per year or approximately 9.3% of the total emissions without this mitigation measure.

While the use of waste heat recovery equipment results in a reduction of greenhouse gas emissions it also results in increased project costs that must be considered in the overall economic viability of the LNG project. The waste heat equipment is designed to provide for the majority of the heat required in the process, but it requires the gas turbines to be operational to provide this need. During plant startup periods and scheduled or unscheduled maintenance, when these gas turbines may be shutdown or operating at reduced levels, the plant will still have a heat requirement. Therefore the use of waste heat recovery equipment results in a cost for the equipment itself plus the cost for gas–fired equipment required during these non-operational periods. In addition to this cost impact, the use of this equipment in the gas turbine exhaust stack impacts the performance of the gas turbine resulting in a reduction in LNG production by approximately 2%. The cost for the installation of this waste heat recovery equipment has a present value of $US9 Million. There would also be additional lifecycle costs associated with the maintenance and operation of this equipment. The economic merits of the installation of waste heat recovery (fuel cost savings versus reduced LNG, lifecycle costs, and installation costs), will be dependent on the terms of any LNG sales and feed gas purchase agreements that are eventually executed. However Phillips is presently prepared to move forward with this initiative on a “no regrets” basis.

Ship Vapour Recovery

During the loading of an LNG tanker, gas vapour displaced by the LNG must be either recovered or flared within the LNG facility. The plant design will include equipment to maximize the recovery of this vapor and therefore minimize or eliminate any flaring that may occur during LNG tanker loading and resulting greenhouse gas emissions. Table 4.6 shows the greenhouse gas emissions released if all of this gas is sent to the marine flare and Table 4.4 shows the resulting reduction in greenhouse gas emissions associated with the installation of additional ship vapour recovery equipment. The use of this equipment will result in a net reduction in greenhouse gas emissions by approximately 235,000 tonnes per year or approximately 4.4% without this mitigation measure. The cost for the installation of this vapour recovery equipment has a present value of $US7 Million. In addition the vapour recovered must be compressed in the liquefaction/fuel system that reduces gas turbine horsepower that otherwise would be used for LNG production. There would also be additional lifecycle costs associated with the maintenance and operation of this equipment. The economic merits of the installation of ship vapour recovery equipment (recovered gas savings versus reduced LNG, lifecycle costs, and installation costs), will be dependent on the terms of any LNG sales and feed gas purchase agreements that are eventually executed. However Phillips’ is presently prepared to move forward with this initiative on a “no regrets” basis.

During normal plant operations without a ship loading at the dock, any vapours that accumulate in the storage tanks, either due to normal process operations or by heat gain through the tank walls, are collected by a compressor and recovered in the LNG liquefaction process. During ship loading, the vapours displaced from the tanks on the ship are almost twice the volume handled during normal operations, therefore these vapours need to be flared or additional vapour recovery equipment is required for use during this operation. The frequency of ship loading therefore determines how often this additional equipment will be used and the economic viability of its installation.

The temperature within the ship’s cargo tank upon arrival is an important consideration in the amount of vapours released during loading and the viability of recovery of these vapours. During normal shipping operations, the ships arrive with their cargo tanks still cold but not as cold as the LNG to be loaded. Therefore during initial cargo loading some of the LNG is vaporised and is sent to the marine flare. After the cargo tanks have cooled and approach the temperature of the LNG (about two hours), the vapors generated during the rest of the loading process are significantly reduced in volume and can be effectively recovered with the equipment proposed.

If a ship arrives with its cargo tanks warm, either as a result of changes in the ship operations or as a result of arriving following a period of scheduled maintenance, the vapours generated during initial ship loading will be greater as a result of the additional LNG that is vaporised during the cooldown process and therefore the flaring will be longer than two hours. However, the frequency of a warm ship arriving at Darwin is expected to be approximately four times a year versus 76 times per year for a cold ship. As a result of the initial flaring that must occur during ship loading, Table 4.4 shows the emissions from the marine flare assuming it operates for 200 hours per train for cool down of the LNG ships (see Section 4.2.2.2).

Fuel Gas Reduction

The addition of waste heat and ship vapour recovery equipment not only reduces emissions from fired equipment or flares that otherwise would have been used, they also result in a reduction in fuel requirements for the plant. The majority of the feed gas brought into the plant is converted into LNG with the remainder consumed in the plant as fuel. Therefore a reduction in fuel requirements results in a reduction in feed gas requirements. A lower feed gas requirement results in a reduction in the carbon dioxide that must be removed from the feed gas before the gas can be used in the liquefaction process. The use of this equipment will therefore result in an additional net reduction in greenhouse gas emissions associated with a reduction in carbon dioxide removal requirements by approximately 62,000 tonnes per year or approximately 1.1% of the total emissions without this mitigation measure.

Frame 5D Gas Turbine

The original 3 MTPA project as presented in the EIS was based on the use of the GE Frame 5C Gas Turbine. Since the EIS was approved, GE has developed an upgrade to the Frame 5 gas turbine designated the 5D, which has been selected for use in the current plant design. The most noticeable improvement of the 5D over the 5C is a 15% increase in horsepower output, but the upgrade also resulted in an improvement in turbine efficiency. This improvement in efficiency results in a reduction in fuel required per horsepower generated and therefore a reduction in greenhouse gas emissions. Published information from GE show an improvement in thermal efficiency from 29.2 to 30.3%, which equates to a 3.3% reduction in fuel requirements and its corresponding reduction in greenhouse gas emissions. This 3.3% reduction in fuel equates to 82,000 tpa reduction in greenhouse gases on a carbon dioxide equivalent basis.

While the Frame 5D unit is a new upgrade and only a few units are operating at this time, there is a high level of confidence in the industry that this unit will achieve the reliability and performance equivalence to the Frame 5C unit and follow in the footsteps of the success of the performance of the overall Frame 5 industrial design gas turbine heritage. The Frame 5 industrial gas turbine is the most widely used gas turbine technology in the LNG industry and achieved this preference for selection as a result of its historical performance in an industry that demands the highest levels of reliability and long life-cycle performance.

While there are other gas turbine options that have achieved higher thermal efficiency and therefore lower greenhouse gas emissions, these options present other considerations that the plant designer and the LNG customer must consider. These include maintenance and performance characteristics that could potentially impact plant operations and therefore market reliability, and also higher life cycle costs which impact project economic viability. Maintenance characteristics to consider include the time required between inspections, which impacts maintenance costs, and therefore impacts the availability of the plant for LNG production. From a performance standpoint, a gas turbine in LNG service will see performance requirements that are different then gas turbines used in other applications, such as power or aircraft service. Therefore the selection of a gas turbine for LNG service must consider the performance history and reliability of the turbine in this type of service for acceptance in the LNG market. The economic merits of the gas turbine (fuel costs versus LNG revenue, lifecycle costs, and installation costs) will be dependent on the terms of any LNG sales and feed gas purchase agreements and also its market acceptance. Higher efficiency turbines are subject to ongoing consideration, however, and will continually be assessed as the design of the LNG facility progresses and these turbines become proven in the context of LNG operations.

Low BTU Fuel Refrigerant Compressor Drivers

As discussed in Section 4.3.1, the high nitrogen content of the fuel results in significantly reduced NOx emissions compared to emissions for the same turbine using other fuel sources available with a higher methane content. The Phillips Optimised Cascade LNG Process provides the flexibility to reject nitrogen from the feed gas into the fuel system. With nitrogen making up 4% of the feed gas composition, this results in a fuel stream that is approximately 30% nitrogen. The combustion of this “lean” fuel results in an approximate 30.1% reduction in NOx when compared to emissions for the same turbine using other fuel sources with higher methane contents.

Carbon Dioxide Mitigation Investigations

Carbon dioxide represents six percent of the anticipated feed gas composition to the LNG plant. The carbon dioxide in the feed stream must be removed prior to LNG liquefaction or it will solidify in and plug the liquefaction process. Early in the design of the gas recycle phase of development, Phillips considered the economic effects of removal of the carbon dioxide offshore at the Bayu-Undan platform instead of onshore at the LNG plant. Carbon dioxide removal offshore would reduce the amount of gas to be transported to the plant, but the volume reduction was not significant enough to allow a reduction, and associated costs savings, in pipeline size. Nor would CO_2 removal measurably reduce the corrosivity of the gas stream, lowering pipeline capital and operating costs. The study also indicated the initial cost of the offshore equipment, and the yearly expense to operate and maintain this equipment, was prohibitively high. While the costs of CO_2 removal onshore would be less that offshore, the lack of reservoir capacity to contain the gas was a fatal constraint to selecting that approach. Consequently, a decision was reached not to undertake CO_2 removal at the offshore production facility. This was revisited during the review of the development concepts being considered for the Greater Sunrise project with the same conclusion.

There have been situations in other production regions where the volume of carbon dioxide in a produced gas stream is of such a high percentage that its removal could result in a reduction in pipeline size and therefore provide an economic justification to remove the carbon dioxide offshore. An example of this application may be the proposed Natuna LNG project in Indonesia where carbon dioxide makes up 70 % of the gas produced. There are also applications where carbon dioxide removal is preferred offshore to reduce the corrosiveness of the gas (when the feed gas contains water) and therefore its impact on the pipeline integrity. However, for both the Bayu-Undan and Greater Sunrise project, water removal will be required offshore for LPG processing, therefore the corrosiveness of the gas is reduced and further reduction in corrosiveness through carbon dioxide removal cannot be justified based upon economic considerations.

Phillips also performed a preliminary review of the well logs and reservoir structure depth maps of the Bayu-Undan field in an attempt to identify subsea structures that could be used for carbon dioxide re-injection. There have not been any structures identified from this review above the main gas-bearing reservoir that could accept the injection of carbon dioxide without a potential risk of a poor reservoir seal providing the opportunity for communication with other reservoir structures. This risk to seal failure and potential contamination of adjacent reservoir structures is just as likely with the Greater Sunrise field. There may be some potential for injection into separated structures that are adjacent to the main Bayu-Undan and Greater Sunrise field, although such structures would probably be at least 10 km from potential platform sites. There is also no information available to indicate whether suitable subsurface structures exist onshore for this same purpose. Because of the uncertainty of identifying a suitable structure, and the potential risks to this structure of seal loss or communication between reservoir structures, re-injection of the carbon dioxide into a subsurface structure was not considered a viable technical or economic option (see also Appendix D).

Phillips has examined the option of using CO_2 contained in the natural gas feed for methanol production. Presently methanol is manufactured by methane reforming followed by methanol synthesis. In this process, methane gas is reacted over a catalyst to form hydrogen and carbon monoxide, which are then converted to methanol. For carbon dioxide from the feed gas to be used, it must be reacted with some of the hydrogen from the methane to form more carbon monoxide. The process is very energy intensive (i.e. additional fuel consumption) and the volume of CO_2 from the feed gas is too small to make the process economically feasible. There is no other commercially viable process for making methanol that would allow the use of the carbon dioxide contained in the feed gas and released during the LNG liquefaction process.

Worldwide there is considerable research into methods for utilising carbon dioxide in an economic and energy efficient manner. A major obstacle in this research is carbon dioxide's energy state. Carbon dioxide is a stable compound and therefore requires considerable energy to convert it to a form that can be utilised in other processes. This energy requirement is a major obstacle preventing the use of carbon dioxide waste gases being a feedstock to a commercially viable process.

The carbon dioxide in the feed to the LNG plant is discharged through the acid gas incinerator. This carbon dioxide comprises 35% of the total CO_2 released from the plant prior to mitigation efforts (Table 4.6) and 40% after mitigation (Table 4.4). The remaining carbon dioxide released from the plant is related to emissions from gas-fired equipment required for LNG liquefaction. As shown in Tables 4.4 and 4.6, Phillips has actively pursued options within the LNG plant design that can reduce carbon dioxide emissions associated with the gas fired equipment. As a result of these mitigation efforts, carbon dioxide emissions related to the liquefaction process have been reduced by 15% overall (Table 4.7) if the CO_2 in the feed gas is included, and over 21% when considering only those emissions related to the mitigation efforts pursued on gas fired equipment in the liquefaction process.

4.3.2.5 Offsets

URS, on behalf of Phillips, undertook a greenhouse offsets review for the proposed LNG plant, the full report of which is presented as Appendix D.

As part of this review, vegetation-based sequestration options both within the Northern Territory and elsewhere in Australia, were investigated, including:

- afforestation and reforestation of land within the Northern Territory;
- plantation options in temperate Australia, such as Pine, Eucalypt and Oil Mallee;
- protection of local remnant rainforest; and
- options for rehabilitation of degraded vegetation (revegetation).

Table 4.8 provides a comparison of each of the options investigated. Of the six, Bush for Greenhouse and the three plantation options offer some scope for investments in carbon sinks.

It was concluded that oil mallees may offer the greatest prospect for effective investment in ‘sink’ based offset options. The advantage of this plantation option over others is that the timber produced is used as a direct replacement of fossil fuels. This contrasts with other plantation options where the uses of timber when harvested, negate the sequestration benefit gained during its growth.

Under current guidelines for vegetation-based offsets under the Kyoto Protocol, maintaining the integrity of existing local rainforests at Middle Arm (in the vicinity of the Darwin facility) would not be considered as an offset activity as shown in the above table. However, Phillips is currently pursuing arrangements in relation to conservation of rainforest habitat to mitigate ecological impacts associated with the project (see Section 4.3.10).

Other onshore and offshore geological sequestration options were also considered, such as CO_2 storage in depleted hydrocarbon reservoirs or deep saline reservoirs, and injection in seafloor depressions. However, these methods are still at an early stage of research and not considered viable options at the current time.

Table 4.8 Comparison of Plantation-based Offset Options

Criteria	Options					
	Pine plantation	Eucalypt plantation	Oil Mallee	Protecting local remnant rainforest	Revege-tation – bush for Greenhouse	Revege-tation – rangelands
Compliance with Protocols	✓	✓	✓	x	✓	?
Capacity to sequester carbon	H	H	H	H	M	M
Certainty of outcome:						
technical	H	H	M	N/a	M	L
legal	✓	✓	✓	N/a	✓	✓
Minimisation of risk	M	M	L	N/a	M	M
Financially positive to Phillips	?	?	?	N/a	?	?
Minimise complexity of the pathway to sequestration	H	H	H	N/a	H	H
Provides additional business benefits to Phillips	M	M	M	N/a	L	L
Provides external private and public benefits:						
environmental	L	M	H	N/a	H	H
social	M	H	H	N/a	M	M

Where: H, M, L - criteria is met and/or a positive outcome to Phillips is most likely: H = relatively strongly so; M = intermediate between between H and L; L = relatively weakly so;
✓ - criteria is met and/or a positive outcome to Phillips is most likely, but insufficient information to rate on the H, M, L scale
? - outcome maybe +ve or –ve depending on a range of factors; or too little information is available, or standards undefined
x - criteria is not met and a positive outcome for Phillips is unlikely

Phillips will continue to evaluate other offset options as part of its ongoing environmental management commitments and progress reporting to NT DIPE and the AGO, as described in the following section.

4.3.2.6 Greenhouse Challenge

The Greenhouse Challenge is a joint voluntary initiative between the Commonwealth Government and industry to abate greenhouse gas emissions, which was established in 1995. Participating organisations sign agreements with the Government that provide a framework for undertaking and reporting on actions to abate emissions.

Phillips will participate in the Commonwealth Government's Greenhouse Challenge Programme.

As part of this commitment, Phillips will develop a detailed Cooperative Agreement with the Australian Greenhouse Office (AGO) which will outline:

- an inventory of GHG emissions from the LNG facility, as detailed in the previous section;
- an action plan with specific actions to minimise emissions;
- performance indicators to measure progress; and
- a forecast of expected abatement of GHG emissions over a set time period.

Potential Greenhouse Challenge commitments/action plans include:

- a commitment to continual improvement in energy efficiency for the LNG project in accordance with Phillips' Health, Environment & Safety (HES) Policy. This will include an energy audit to be undertaken annually, and reporting results & actions to increase energy efficiency to NT DIPE and AGO;
- development and implementation of a greenhouse gas management strategy for the LNG facility;
- mitigation measures to include:
  - waste heat recovery;
  - vapour recovery for ship loading;
  - fuel efficiency gains from Frame 5D gas turbines and selection of best available technology; and
  - utilisation of Low NOx combustors for power generation.

Phillips will continue to investigate 'no regrets' and 'beyond no regrets' options for greenhouse minimisation, including:

(1) feasible CO_2 re-injection options which may develop in the future;

(2) potential plantation sequestration options which may be available to Phillips, such as oil mallee plantation investments in other parts of Australia; and

(3) investigation of appropriate carbon trading schemes in accordance with current international policy developments to meet Kyoto targets and subject to Australian participation in such schemes.

Phillips has designed its plant to maximise the project's energy efficiency and will continue to investigate ways of further improving this through the design and operational phases.

4.3.3 Heat Emissions

In the Supplement to the Draft EIS (Section 5.4.3.3), Phillips provided a summary status of efforts that were underway to address the impact of the main plant process flares on air traffic using Darwin Airport. Studies have been completed and have been shared with the Civil Aviation Safety Authority (CASA). Discussions with CASA are still ongoing. In recent correspondence from CASA to Phillips in November 2001, CASA put forth an outline of additional study efforts to be completed to allow them to finalise a determination of the impacts. This work is underway with completion expected during the first quarter of 2002. After CASA reviews the results of this latest study and makes a determination of the impact, appropriate action to manage airspace impacts may be required. Phillips will continue to work with CASA, RAAF, appropriate NT Government and Commonwealth authorities and representatives of airspace users in Darwin as necessary to bring this issue to a mutually agreeable resolution.

4.3.4 Wastewater Discharges

Phillips has undertaken an investigation of options available for wastewater discharge from the proposed LNG plant, in consultation with the DIPE.

The wastewater streams for the plant are presented in Figure 2.9. In summary, clean stormwater runoff from clean parts of the site will be discharged via drains into the intertidal zone at selected points adjacent to the site. Low volumes of process wastewater, plus low volumes of utility water from cleaning operations or testing of fire fighting equipment, and potentially contaminated stormwater runoff from the plant process area, will be routed to the CPI separator for treatment. Treated wastewater will be routed to an irrigation system for landscaping. Low volumes of treated sewage will be pumped to a sewage treatment plant and treated effluent will be routed to an irrigation system after dechlorination. Holding tanks have been provided for the treated effluent to ensure that the water quality is suitable for irrigation.

The most notable change from the original 3 MTPA plant design is in relation to direct discharge to Darwin Harbour. While the original design for the previous 3 MTPA LNG plant included an outfall for treated effluent to be located along the loading jetty, the current design reflects Phillips' commitment to re-use and recycle wastewater discharges wherever practicable in accordance with NT Government policy. As such, the project will be designed so that all treated wastewater will be used for on-site irrigation. The need may still arise on occasion to utilise direct discharge of treated wastewater via outfall in circumstances of particularly high rainfall events.

During construction of the storage tanks for LNG and condensate product on-site, there will be the requirement to discharge hydrotest water at a rate agreed with DIPE into Darwin Harbour prior to initial operation of the LNG facility. Actual volumes of such hydrotest water are not finalised as yet, however preliminary estimates indicate 90,000-100,000 m^3 of hydrotest discharge water will be released. Hydrotest water may contain an approved commercial treatment chemical that includes a bactericide, corrosion inhibitor, and an oxygen scavenger. Phillips will undertake to investigate the treatment chemical to be used and the required concentration of the treatment chemical suitable for discharge into the harbour during the preparation of the final Environmental Management Plan (EMP, see Section 5) and will secure DIPE approval prior to commencement of tank hydrotest activities.

4.3.5 Solid and Semi-liquid Wastes Disposal

As part of the revised impact assessment, Phillips re-evaluated the capacity of existing infrastructure and services available in the Darwin region to handle the increased levels of solid and semi-liquid wastes anticipated from the larger 10 MTPA plant design. The expected volumes of waste materials from operation of the originally proposed 3 MTPA plant compared with that from the 10 MTPA plant design, are shown in Table 4.1. As part of its evaluation, relevant waste management operators in the Darwin region were consulted to confirm that the range of non-hazardous and hazardous wastes can be suitably managed and disposed of safely in accordance with the provisions of the *Waste Management and Pollution Control Act 1998* and DLPE general requirements.

The following discussion describes the current capacity to handle construction and operational wastes respectively.

4.3.5.1 Construction wastes

Waste materials generated during construction of the LNG plant will be disposed of appropriately and in accordance with Northern Territory Government legislation and DIPE requirements. Disposal plans proposed for various wastes include:

- **Dryland vegetation.** Cleared vegetation will be stockpiled and used for rehabilitation. Respreading of vegetation on previously cleared areas that have been ripped or otherwise prepared for rehabilitation, provides sheltered conditions for native plant establishment as well as microhabitats for fauna recolonisation. If excess vegetation material is available, it may be chipped and used as mulch for landscaping on site. Stockpiled vegetation will only be burnt as a last resort.

- **Debris and leaf litter** from clearing operations may be utilised in rehabilitation or stockpiled for burning as soon as possible. All stripped material will be removed to the designated disposal areas in accordance with acceptable practices. It is not intended that plant debris and other non-putrescible organic matter will be required to be disposed of in a suitable landfill site.

- **Cleared mangroves** will be stored and used to assist in rehabilitation in suitable areas where practical. Unused mangrove material may be woodchipped and used in landscaping. Mangroves will be burnt only as a last resort.

- **Excess clean fill** (if any) will be sold on the local market or provided to government.

- **Spent oils**, lubricants and collected oil will be recycled or disposed of properly through a commercial waste management contractor. Waste oils from the Darwin area are generally transported for disposal to a lime kiln at Mataranka. Phillips will review waste tracking documentation provided by the waste management contractor to ensure that the spent oils are being disposed in a manner approved by DIPE.

- **Domestic garbage** generated during the construction phase will be collected by commercial waste management contractor and disposed of to landfill (either Shoal Bay Waste Disposal Facility or Humpty Doo Landfill).
- **Domestic/sanitary wastewater**. Portable toilets, provided in appropriate numbers at convenient locations, will be used during the construction phase. The toilets will be obtained through a commercial contract which will include cleaning, disinfection and maintenance at regular intervals. Sanitary wastes will be collected and disposed of off-site on a regular basis. Removal of domestic wastewater will be contracted to a local waste management company and Phillips will require waste tracking documentation to ensure disposal is to a DIPE approved facility and in accordance with PAWA requirements.

- **Drums and containers** used for non hazardous materials will be recycled or disposed of in an approved local landfill.

- **Building materials** will be disposed at an approved location such as the Palmerston Waste Disposal Facility, Shoal Bay Waste Disposal Facility or Humpty Doo Landfill. Recyclable waste such as scrap metals will be collected in a suitable disposal area and transported for commercial disposal if economically viable.

- **Hazardous materials**. At the LNG plant site, the primary contractor and subcontractors will be responsible for on-site handling and off-site disposal of hazardous materials/waste that may be generated due to construction and start-up activities. Phillips will review all proposals to bring hazardous materials onto the site, regardless of volume. The division of responsibilities for hazardous material/waste management between the contractor and Phillips is listed in Table 4.9.

Table 4.9 Responsibility for Hazardous Waste Management

Activity	Responsibility
Characterise the material/waste to decide if it is hazardous	Contractor, with input from Phillips as needed
Provide an acceptable container with label	Contractor/Subcontractor
Place waste materials in the container	Contractor/Subcontractor
Store the container in facilities approved by Work Health	Contractor/Subcontractor
Conduct regular inspections of storage facilities	Contractor/Phillips
Track the accumulation time for the waste	Contractor/Subcontractor
Prepare the required paperwork, including manifest	Contractor/Subcontractor
Haul the waste to the disposal site	Contractor/Subcontractor
Ensure waste is disposed to DIPE approved facilities	Contractor/Phillips

4.3.5.2 Operational waste

Wastes generated in the LNG plant are classified as hazardous and non-hazardous in accordance with DIPE requirements. The anticipated solid and semi-solid wastes generated at the operating LNG plant are listed in Table 2.8.

Non hazardous wastes produced during the operation of the LNG plant will be disposed of in the following ways:

- Biological sludge (sewage treatment plant) and inorganic sludge (demineralisation unit) will be removed from the site by waste management contractors. Sludges from the sewage treatment plant will be disposed to local sewage treatment plants in accordance with Northern Territory Power and Water Authority requirements. Where appropriate, inorganic sludges will be dewatered at the waste contractors premises, with the residual solids tested, as required, and disposed to landfill.

- Ceramic balls (dehydration unit), cellulose (plant area) and molecular sieve waste (dehydration unit) will be removed from site by waste management contractors. These materials are non hazardous and are suitable for disposal to domestic landfill at either Shoal Bay Waste Disposal Site or Humpty Doo Landfill. Appropriate testing of these wastes will be conducted before offsite disposal. Testing results will be provided to landfill operators and DIPE to confirm waste composition and appropriateness for disposal to local landfills.

- Domestic garbage (plant area) will be regularly removed from site by waste management contractors and disposed to landfill (Shoal Bay Waste Disposal Site or Humpty Doo Landfill).

Hazardous wastes produced during the operation of the LNG plant will be disposed of in the following ways:

- Waste lubricating oils (plant area), spent oils (hot-oil system), oily sludge (CPI separator) and spent solvents (plant area) will be removed and disposed by local waste management contractors. Standard Northern Territory practice is that local waste management companies usually transport these wastes for disposal to a lime kiln at Mataranka (approx 400km south of Darwin). Darwin based waste management companies have facilities to dewater oily sludges and provide waste tracking documentation to ensure waste is disposed to DIPE approved disposal locations. There are two international waste management companies currently operating in Darwin (Collex and Brambles) who have extensive experience in disposal of petroleum industry industrial wastes.

- Mercury-contaminated carbon beds (mercury removal unit). The carbon utilised for mercury removal has sulphur impregnated in the pores of the carbon granules. Based on preliminary testing of the Bayu-Undan gas, the amount of mercury that would accumulate over the life of the project would be approximately 3.3 kg/yr. This would equate to a 20 year life for a single carbon bed (which contains some 24,000 kg of carbon) and the current LNG plant design includes two such beds. In addition, it has been the experience of a leading carbon supplier that the carbon does not test hazardous for mercury based on the United States EPA test method for toxicity and meets current standards for disposal in industrial landfills. There are currently no industrial landfills in the Northern Territory. The carbon beds will either be processed in Darwin (encapsulated, immobilised, etc.) and disposed to a Darwin lined landfill to the satisfaction of DIPE or transported interstate to an industrial landfill.

Additionally, all Phillips operations adhere to in-house waste management procedures which ensure that waste is handled by approved contractors and is disposed in approved facilities according to applicable local regulations. Phillips' waste management procedure includes waste minimisation guidelines incorporated into the design of the LNG plant. The operations workforce will be actively encouraged to identify waste minimisation and recycling opportunities and implement waste minimisation procedures.

These management commitments are discussed further in Section 5.

4.3.6 Noise Impacts

Bechtel (2001b) completed a revised assessment of the likely noise impacts of the proposed LNG plant, in recognition of the potential increase in ambient noise levels from the expanded plant design. The complete noise report is included as Appendix E.

Noise emitted from the proposed plant will be attenuated as it radiates from the various sources. The major factors affecting noise attenuation as a function of distance are the atmospheric temperature, relative humidity, wind speed and vertical temperature gradient (or inversion strength). Rather than evaluate noise for a vast array of possible variable combinations (e.g. season, time of day, humidity, windspeed, temperature) the worst case propagation conditions (i.e. minimum attenuation with distance), that are generally associated with cool, humid nights associated with strong temperature inversions and light wind speeds, were modelled:

- temperature: 10ºC
- relative humidity: 90%
- wind speed: 2 m/s
- wind direction: southerly
- vertical temperature gradient: 2ºC per 100 m

A conservative ambient background noise level of 40 dBA was assumed for a community that theoretically might be constructed immediately south of the LNG plant fenceline. Wickham Point is currently undeveloped vacant crown land.

4.3.6.1 Construction noise

It is likely that there will be some minor impact on noise levels in the uninhabited adjacent areas during the construction phase of the project. The highest noise construction activities will tend to be relatively short duration, which will tend to reduce their overall impact on the community. It is the intention of the LNG project participants to limit primary construction activities to daytime hours.

Noise in the construction phase will be generated by construction vehicle traffic and construction equipment. Associated noise levels at the site boundary are not likely to exceed 80-90 dBA, and are not likely to be noticeable above background at nearby communities, the closest being 7 km from the proposed LNG facility.

4.3.6.2 Noise from normal operation with two trains

A preliminary noise modeling study was carried out to predict the likely noise levels during normal operation of the LNG plant with two simultaneously operating LNG Trains. This effort was based on preliminary equipment data and plant layout information.

The major noise sources in the plant proposed for the Darwin LNG facility will be the refrigerant compressors, gas turbine drivers and fin-fan air coolers. Table 4.10 shows the noise sources and anticipated individual noise levels from each major noise source. The Table 4.10 data served as model inputs; the model then calculating the attenuation of the combined noise levels as a function of distance relative to an arbitrarily selected point of origin. In comparison with the major noise sources for the original 3 MTPA plant design (shown in Table 7.5 in the Draft EIS (D&M 1997)), the maximum noise contributions from equipment are similar, and are still not anticipated to produce any unacceptable impacts beyond the plant boundary.

Table 4.10 Maximum Noise Sources for Equipment (Noise levels in dBA)

Equipment	dBA	Octave Band Center Frequency (Hz)								
		31	63	125	250	500	1000	2000	4000	8000
Fin-fan Cooler	89	100	96	92	88	85	82	80	80	80
Gas Valves	89	100	96	92	88	85	82	80	80	80
Compressor	89	100	96	92	88	85	82	80	80	80
Piping System	89	100	96	92	88	85	82	80	80	80
Electric Motor	90	100	96	92	86	83	83	83	83	83
Liquid Valve	92	100	96	92	88	85	85	85	85	85
Pump	92	100	96	92	88	85	85	85	85	85
Turbines	92	100	96	92	88	85	85	85	85	85
Others	92	100	96	92	88	85	85	85	85	85

Note: Equipment noise measured under operating conditions at full load.

4.3.6.3 Upset/emergency operating conditions

During upset and emergency operating conditions of the LNG plant other noise sources (e.g. flares, relief valves, etc.) will come into play. The noise levels associated with these noise sources will tend to be higher than those predicted for normal operating conditions. However, these sources will be of short duration and very infrequent. The wet and dry gas flares will be operated approximately 6 - 48 hours per year for each train. Additionally, it is estimated that the marine flare will typically operate for approximately two hours twice per week for each train. Therefore, the environmental impact of these infrequent intermittent sources will be small. Also, in studies put before the Civil Aviation Safety Authority, these flare releases are not expected to present any undue risks to local air traffic overflying the LNG plant.

4.3.6.4 Assessment conclusions

It was shown that the initial rate of attenuation is very rapid and that this rate of attenuation decreases as the distance from the noise source increases. Figure 1 in Appendix E indicates that the attenuation at a distance of 1,450 m, is approximately 55 dBA.

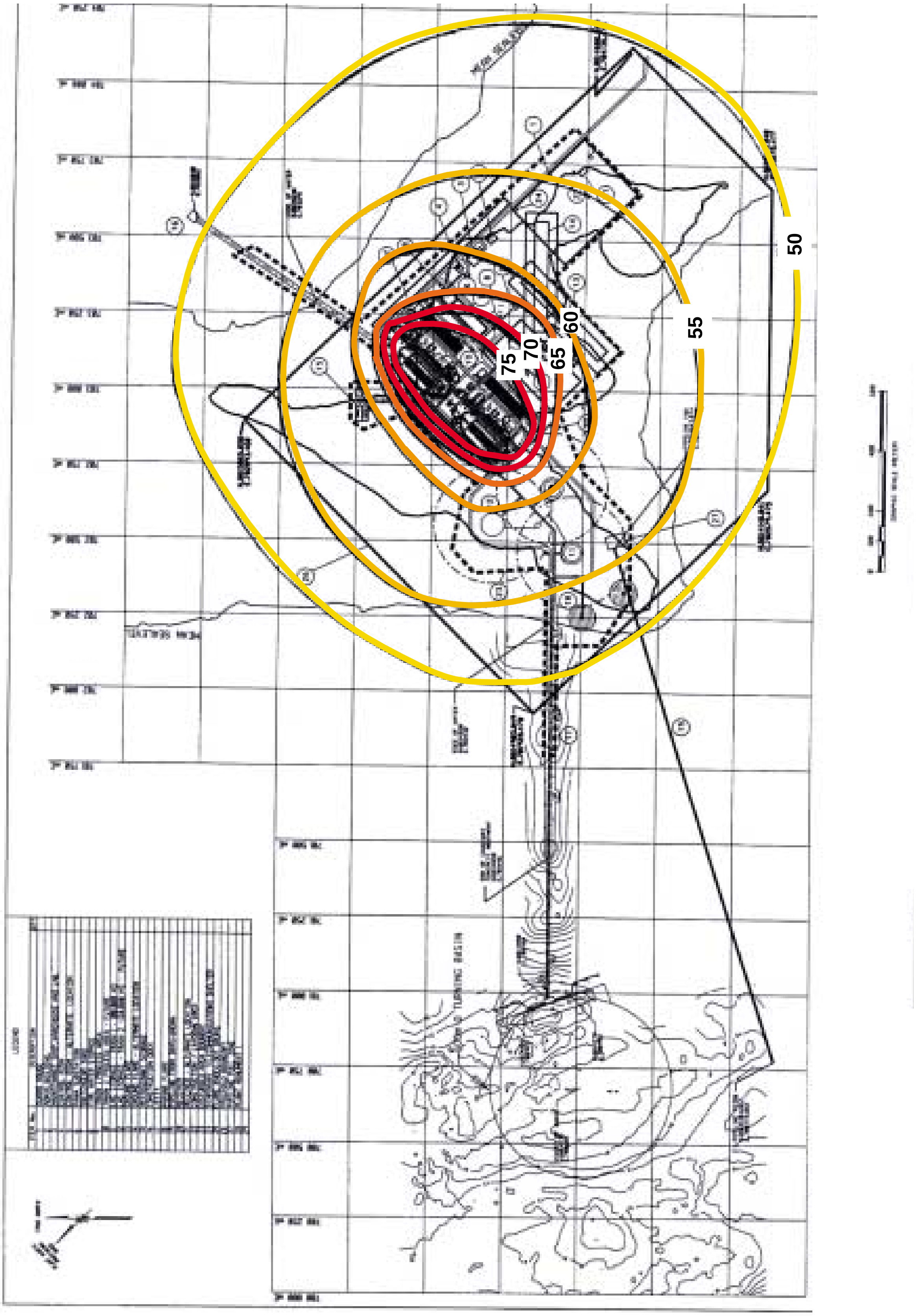
The predicted plant noise levels for normal operation of the proposed plant expansion to include two LNG Trains were used to assess the environmental impact of noise from the LNG plant utilising the guidelines given by ISO 1996, the US EPA, and the World Bank. Figure 4.3 describes the A-weighted sound level (L_{eq}) contours for two LNG Trains operating simultaneously. A sound level of approximately 50 dBA is inscribed by the southern facility boundaries.

Regarding ISO 1996 guidelines, a noise level of approximately 50 dBA at the facility boundary does not significantly exceed a conservatively estimated community ambient noise level of 40 dBA by more than 10dBA.

Regarding the U.S. EPA guidelines, the predicted L_{DN} level of 50 dBA at the facility boundary would be acceptable to residential communities under the EPA guideline since a noise level of less than 55dn is not likely to elicit community complaints.

The predicted L_{eq} level (approximately 50 dBA) at the southern facility boundaries are significantly below the World Bank industrial guidelines of 70 dBA, the most likely type of future development to occur adjacent to the southern facility boundary, below the 55 dBA day time guideline for residential areas, and not significantly above the 45 dBA night time guideline for residential areas.

Bechtel concluded that predicted noise levels from the operation of the LNG plant were found to have no impact if future industrial development occurs adjacent to the facility boundary, minimal impact on the currently uninhabited area surrounding the proposed LNG plant, and even less impact on the nearest communities under both international and US EPA guidelines for assessing industrial noise. Minimal noise impacts could occur in the unlikely event that a residential community was sited directly outside of the southern facility boundary.



Job No.	00533-244-562	Phillips Petroleum Company Australia Pty Ltd 10MTPA LNG PLANT AT WICKHAM POINT - PER **PREDICTED NOISE CONTOURS (IN dBA) FROM OPERATION OF THE PROPOSED 10 MTPA LNG PLANT**	**Figure 4.3**
Report No.	R841		URS
Date	Dec 01		

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Therefore, the proposed LNG plant is not expected to result in any unacceptable noise impacts due to the relatively low sound pressure levels associated with the proposed plant components and the relatively large distance to the closest noise sensitive receptor. A detailed modelling study will be performed after finalisation of the detailed engineering to refine the above preliminary estimates.

4.3.7 Visual Impacts

A comparative visual impact assessment was undertaken by EcoSystems to assess the potential effects on visual amenity from the revised 10 MTPA proposal, and in particular how these may have changed from the previous design for the originally proposed 3 MTPA plant. The full report is presented as Appendix F (EcoSystems 2001).

The revised visual impact assessment adopted the same methodology as previously used. A number of vantage points were selected to assess the potential visual impact of the development, using updated photographs taken in September 2001. One vantage point on land, three locations on the water and an aerial view were used as a basis for visual analysis, and enabled a comparison between:

(1) the existing landscape;

(2) the future developed landscape based on the previous 3 MTPA plant design; and

(3) the future developed landscape based on the current 10 MTPA plant design.

Two additional vantage points were selected to allow an analysis of the visual relationship between the proposed development and other development in the surrounding region, including the East Arm Port facilities and existing infrastructure on Channel Island.

In general, the visual impacts associated with both the 3 MTPA and 10 MTPA plants remain comparable, with the exception of the larger capacity LNG storage tanks, however these are not likely to significantly impinge on the landscape from Darwin Harbour (as shown in Figure 1c of Appendix F). Some components, such as the main process flares, will now have a significantly diminished visual impact due their reconfiguration to a ground design.

Given the scale and nature of the proposed development, it is anticipated that the visual impact of development, as viewed from populated areas, will be greatest during the construction phase of the project due to the limited clearing of mangroves on the north-east side of Wickham Point associated with the installation of a construction dock.

Construction works currently being undertaken at East Arm provide an example of the degree of visual impact that can be expected during the construction phase. There is not much that can be done to mitigate the visual impact of construction. However, the staged nature of construction activities proposed by Phillips should assist in keeping potential visual impacts to a minimum.

Visual impact of the development will be greater for vantage points within 500 m of Wickham Point. In this viewing range there will be clear views of the facilities, construction dock, jetty, sea walls and related infrastructure. Beyond 500 m, the visual impact of the development will gradually diminish. All nearest sensitive locations in the Darwin area are well in excess of 500 m distance from Wickham Point.

4.3.8 Public Risk Assessment

Introduction and Objectives

The NT DIPE Guidelines requested the inclusion of a Preliminary Hazard Analysis and assessment of the risks to people, the environment and adjacent facilities from potential accidents associated with the increased production and storage capacity of the LNG Plant, including increased shipping of product. In response, a Hazard and Risk Assessment report has been produced by Bechtel (Bechtel 2002, refer Appendix G) which incorporates the results of a Preliminary Siting Study for the LNG plant by Quest Consultants Inc. (international risk consultants; Quest 2002, Appendix G), and focuses on the changes in risk profile between the previously approved 3MTPA plant and the currently proposed 10 MTPA plant. The main relevant changes are that now there are two LNG trains instead of one, greater LNG storage capacity than before, and more frequent shipping movements than for the previous proposal.

The purpose of the Hazard & Risk Assessment was to identify the risk to the people and nearby facilities from the construction and operations of the proposed LNG Plant and terminal. Based on the probable incident scenarios the Hazard & Risk Assessment provides detail of strategies and procedures that will be implemented at the LNG Plant to prevent incidents and mitigate their consequences. It also identifies the responsibility of staff at the LNG Plant for prevention and mitigation of potential incidents.

The aim of the Bechtel report is to demonstrate that:

- the proponent is fully aware of the potential hazards associated with the production, storage and handling of LNG and condensate;
- the prevention and mitigation of potential hazards are being properly addressed in the LNG Plant design specifications;

- the potential hazards will be covered adequately in equipment fabrication and construction of the LNG Plant;
- the potential hazards will be managed effectively during the commissioning and operation of the LNG Plant.

For the purposes of the PER, the principal issue is the risks associated with the increased production and storage of the LNG. In this context, the main focus related to hazard assessment is to establish that the safety of the public resident in or using adjacent land areas will not be compromised.

Construction activities are not expected to create major hazards affecting the off-site areas, so these are not a significant concern in the context of establishing site suitability with regard to safety. Hence the main areas of concern in this Report relate to possible hazards arising from the commissioning and operation of the LNG Plant and shipping of product through Darwin Harbour.

The production, storage and transport of LNG and other products entail the handling of a flammable hydrocarbon fuel in large quantities, and this serves to highlight public awareness of safety and hazards. Phillips recognizes the importance of this issue; and has a long history of managing these types of operations.

The safe design of LNG installations, in order to prevent major accidents from occurring, has always been a primary consideration. The safety aspects of LNG operations are the subject of worldwide cooperation, and a number of groups have been set up to exchange information and the establishment of internationally recognized standards. Present day LNG facilities are, after many years of experience, constructed, operated and maintained to the highest standards of safety and reliability.

The principles of safe design and operation of LNG facilities are consolidated into published standards and codes of practice, of which the main reference document is NFPA (National Fire Protection Association) 59A (2001): Production, Storage and Handling of Liquefied Natural Gas (LNG). This standard has been used for LNG plant design in countries throughout the world for many years, and will be used as the basis for the design of the LNG Plant. In addition to NFPA 59A, EN 1473 (1997): Installation and Equipment for Liquefied Natural Gas – Design of Onshore Installations will be used as a guidance document for addressing inter-plant spacing issues.

Occupational safety procedures will be developed in accordance with the general principles of: the Work Health Act and associated Work Health (Occupational Health and Safety) Regulations, NT Australia; OSHA (Occupational Safety and Health Administration) guidelines; and other relevant applicable codes. Liaison will be maintained with the relevant public authority (Work Health Authority) to ensure adherence to all State and Commonwealth Government requirements.

As a minimum the following studies will be conducted and the following documents will be prepared during the detailed engineering phase of the project.

(1) <u>HAZOP: Hazard and Operability Study</u>: A critical review of Process and Instrumentation Diagrams will be conducted for "what if" analysis of the scenarios rising from failure of valves and controls or other upset conditions. Whilst HAZOPs are conducted for hazard identification and management purposes, they are also useful for pollution control purposes. This effort will be done during the detailed engineering phase of the project. The Engineering Contractor will be responsible for conducting the HAZOP and an independent team of specialists will do the comparing.

(2) <u>Quantitative Risk Assessment (QRA):</u> The principal elements of the QRA will include:
   - review of risk/accident scenarios (hazard identification);
   - assessment of initiating event frequencies;
   - consequence assessment on general basis; and
   - evaluation of severity of consequences and their impact.

   The QRA is usually conducted by a third party consultant (hired by the primary EPC contractor) specialized in Hazard and Risk Assessment of LNG facilities. The QRA will be conducted after completion of HAZOP in the detailed engineering phase of the project. As a result of HAZOP studies, the QRA usually indicates that the plant will be much safer than was determined in the preliminary risk assessment (assuming that the conservative assumptions required for preliminary risk assessment). The relevant public authority (Work Health Authority) will be consulted for a certain specific risk issues such as application of risk criteria, cumulative risk, buffer zones, etc. during the preparation of the QRA.

(3) <u>Safety Report:</u> A detailed Safety Report for the onshore facilities per requirements of the Worksafe Australia Standard "Control of Major Hazard Facilities", and guidance associated with *The Occupational Health and Safety (Major Hazardous Facilities) Regulations, State of Victoria 2000*, will be prepared after the completion of HAZOP and the QRA. This effort will be done prior to operation of the plant. Phillips will consult with the relevant public authority (Work Health Authority) for determining and agreeing on the presentation, format and detail required for the safety report.

LNG Plant

Though the plant capacity has been increased from 3 MTPA to 10 MTPA, the hazards are not significantly different from the previous proposal. The proposed facility will not have propane and butane product, therefore, hazards associated with production, storage and handling of bulk quantities of these products have been eliminated. Though propane will still be used as a refrigerant, the stored volume is significantly less than the original proposal. Similarly the design spills associated with LPG storage will be significantly smaller.

The codes and standards that govern the design of LNG plants address three potential accident consequences: radiation from fires, the extent of vapour clouds spreading from leaks, and the explosion of unconfined vapour clouds that result from leaks (refer Appendix G). The codes do not address other accident consequences such as BLEVEs, as these are not considered a significant risk in an LNG plant. Previous studies have estimated the frequency of BLEVEs at 2.5×10^{-7}/year for vessels without fireproofing, insulation, or coverage by other fire protection systems. In an LNG plant the majority of the vessels in liquid service are provided this additional protection, therefore the probability of a BLEVE is further reduced. This issue, however, will also be addressed further in the Quantitative Risk Assessment.

The overall aim in the siting, design, construction and operation of the LNG Plant is to ensure the safety and protection of persons, property and the environment. This report demonstrates that the potential hazards that could rise from the operation of the LNG Plant are being addressed in the design, and in the specification of operating procedures and contingency plans. All practicable measures both to prevent hazardous incidents and to mitigate their consequences will be adopted.

An early consideration determining the magnitude of the hazard to be managed was the location of the LNG Plant with respect to off-site population and occupied areas. The Wickham Point site was selected based upon current land-use in the immediate vicinity, and its advantages with respect to marine access.

The keystone of the safety philosophy for the LNG Plant is adherence to established international standards and codes of practice at all stages. The design of the LNG Plant is based upon the widely adopted standard NFPA 59A. LNG ships are designed to established IMO codes. Recognized international guidelines will be used in the design and construction of the LNG berth, and in the establishment of operating procedures for ship manoeuvres and cargo transfer.

The value of adherence to established international codes and guidelines is borne out by the safety record of the modern LNG industry (no injuries or fatalities to the public from over 170 facilities, and no LNG spillages from ships' cargo tanks in over 11,000 laden voyages).

The safety of the LNG Plant will be reviewed continually during detailed design engineering, fabrication, construction, testing and commissioning. The safety review process will continue through the operation of the LNG Plant and shipping.

Contingency plans will be developed in liaison with the appropriate civil and port authorities to protect the safety of employees and members of the public in the extremely unlikely event of a major unplanned emergency situation arising

Liaison will be maintained with the Energy Division, DBIRD (formerly NT DME) and other appropriate authorities, the Darwin Port Corporation and the Work Health Authority in order to ensure that all requirements of the Government of Northern Territory are met.

It is concluded, based upon all of these considerations, and an appreciation on the part of Phillips of the nature of the hazards associated with LNG production and the possible causes of hazardous incidents, that the potential hazards to the public and site personnel arising from the operation of the LNG Plant will be maintained at an acceptably low level at the plant boundary. The remote location of the Plant in relation to residential areas provides further safeguard to the public.

Shipping

Like LNG plants, LNG carriers are designed, constructed, maintained and operated to exacting international standards, and are subject to regular survey and inspection by vessel Classification Societies. LNG carriers were the first to contain double hulls and be equipped with specialised systems (such as water sprays and dry powder) for preventing and combating LNG releases. As such they have an outstanding historical safety record (refer Appendix G).

The principal emphasis in the management of hazards from LNG carriers is on eliminating the cause of incidents. The Hazard and Risk Assessment addresses the potential for the following incidents to result in a release of cargo to the environment:

- ship collision in transit;
- LNG carrier grounding;
- LNG carrier striking fixed object;
- LNG carrier striking the jetty;
- LNG carrier struck while moored at the jetty;
- fire explosion on LNG carrier;
- escalation following cargo transfer spillage;
- sudden cargo tank failure.

In addition, local environmental influences (wind, cyclones, lightning, visibility) that need to be considered in the management of shipping hazards have been considered.

The assessment concludes that the established design, construction and operating practices of LNG vessels, combined with the Darwin Port controls and safety measures, will ensure that the likelihood of a major incident occurring and causing a hazardous release from an LNG vessel will be extremely remote. Therefore, the increased shipping movements arising from the proposed expansion do not pose substantial additional risk to the people of Darwin.

4.3.9 Dredging and Spoil Disposal Impacts

Section 2.4.3 describes the anticipated dredging volumes required for construction activities for the proposed LNG facility. Dredging of the approach channel to and the berthing pocket for the construction dock is anticipated to produce approximately 145,000 m^3 of meta-siltstone and calcareous sand. If required, dredging in the turning basin and of the berthing pocket at the head of the vessel loading facility is likely to produce limited volumes (<100,000 m^3) of similar material. These volumes represent no significant changes from the original EIS.

The proposed dredging activities for the construction dock will lead to temporarily increased water turbidity. The primary concerns related to turbid plumes is in relation to potential adverse impacts on marine habitats arising from light attenuation and sediment smothering of biota.

Hydrodynamic modelling was previously conducted by Manly Hydraulic Laboratories for the 1997 EIS (Appendix E in D&M 1997) to predict the likely dispersion of turbid plumes, based upon cutter-suction dredging of primarily meta siltstone sediments. As the anticipated sediments to be dredged for the current 10 MTPA plant are the same as those for construction of the 3 MTPA plant, the modelling outcomes remain valid and are summarised below.

The modelling undertaken by MHL predicted dredging to cause temporary and localised increases in water turbidity. Within the turning basin, dredge plume dispersion was predicted to be very rapid due to the predominant high water currents in these areas. Although lower dispersion was predicted for the construction dock approach channel, elevated turbidity remained localised. Suspended sediment concentrations within the dredge plumes were predicted to fall to background levels within a radius of ~700 m from the construction dock dredging (D&M 1997). It was shown to be highly unlikely that water turbidity in the vicinity of the Channel Island coral communities would be elevated above background levels, as they were sufficiently distant (greater than 3 km) from the construction areas for any additional sediment to have settled from the water column prior to reaching Channel Island. The predominance of water flow to the south of Channel Island, along the main Middle Arm channel, rather than to the north of the island would further reduce the chance of turbid plumes from dredging activities in Middle Arm impinging on these coral communities.

4.3.10 Ecological Impacts

4.3.10.1 Synthesis

LNG plant construction activity will permanently alter the biophysical environment and modify the topography of Wickham Point. This will result from earthworks required to level and shape the plant site. The bathymetry of adjacent waters in East Arm will also be modified as a result of dredging an approach channel to the construction dock. There may also be a minor amount of dredging within the turning basin for the loading jetty. Localised intertidal areas around Wickham Point will also be topographically modified as a result of building the construction dock and the rock-fill groyne base for the loading jetty.

The major biological impact of the construction phase of the development will be the permanent loss of the existing habitat and associated biota from the plant site, construction dock and the loading jetty. The NT Government will also complete an all-weather access road into the plant site which was generally assessed for environmental impacts during the base case EIS process in 1997/98. Marine areas affected by construction activities are likely to be recolonised by biota adapted to the new substrate conditions and hence the effect will be to replace one biotic assemblage with another.

However, a number of temporary physical effects potentially may occur during the construction period. Such effects include localised increases in water turbidity as a result of dredging, spoil disposal and construction of the loading jetty groyne and construction dock. There will be localised generation of dust, noise and vehicular exhaust emissions associated with earthmoving equipment and vibration associated with occasional blasting required to fracture hard rock.

Each of the above impacts were considered during the preparation and review of the EIS for the original 3 MTPA facility and those impacts are not markedly altered by the proposed expansion.

4.3.10.2 Loss of vegetation communities

Clearing of the plant site will result in the permanent removal of some 88.3 ha of vegetation and associated fauna currently existing within the plant site boundary as compared to 66.8 ha for the approved base case development. The plant layout has been designed to minimise the amount of mangrove habitat and dry rainforest habitat to be cleared.

The total area of each vegetation community to be thus affected has been calculated to be as follows and are displayed in comparison with the original 3 MTPA and possible 9 MTPA facilities (see Appendix 4 of the Supplement to the Draft EIS):

	3 MTPA	9 MTPA	10 MTPA
• dry rainforest	46.0 ha	70.2 ha	67.6 ha
• mangrove	11.9 ha	19.8 ha	11.9 ha
• *Melaleuca* woodland	7.6 ha	7.6 ha	7.0 ha
• samphire/salt flat	1.3 ha	2.3 ha	1.8 ha
Total	66.8 ha	99.9 ha	88.3 ha

Note: The total disturbance envelope shown in Figure 3.4 also includes offshore subtidal areas (approx. 3.4 ha) to take into account the construction dock and base of the loading jetty, to give a total disturbance area of 91.7 ha. However, this is separate from the current discussion on terrestrial vegetation impacts.

When compared to the total area of similar habitat type available in the region, the losses of the mangrove, salt flat and *Melaleuca* woodland habitat are considered of minor significance in the light of the Northern Territory Government's commitment to preserve 80% of the productivity of mangroves in Darwin Harbour in accordance with the *Darwin Regional Land Use Structure Plan 1990* (NT DLPE 2000a).

The loss of the dry rainforest habitat, however, is significant as it represents a loss of approximately 37% of this habitat existing in the immediate project area, and some 3.6% of the 1,842 ha of dry rainforest reserves in the Darwin area. The proposed 10 MTPA facility would increase the loss of dry rainforest at the plant site by 47% from 46.0 ha to 67.6 ha, however the impacts are less that originally identified for the 9 MTPA facility. The loss of good quality rainforest vegetation is recognised by the proponent as a principal environmental cost of the proposed project. In order to offset this loss, Phillips has entered into discussions with NT DIPE regarding the acquisition of another area of equivalent or better quality rainforest vegetation for conservation purposes. The location of this rainforest reserve has not been identified at this time.

4.3.10.3 Fauna impacts

Habitat loss resulting from vegetation clearance is expected to be the main impact on fauna as a result of the project. It is estimated that approximately 11.9 ha of mangroves will be cleared for construction of the LNG plant. This is no greater that the level of mangrove disturbance approved for the 3 MTPA facility and represents a decrease of 40% from that anticipated for construction of the proposed 9 MTPA LNG plant. This area of clearing is not concentrated in one location, but would take place in several areas around Wickham Point. The mangrove areas to be cleared are not regarded as particularly important mangrove stands in terms of bird diversity, although many mangrove dependent species will be affected. The reduction and fragmentation of mangrove habitats in the area is not expected to have a major impact on the more significant mangrove birds, such as Chestnut Rail, Melville Cicadabird or Great-billed Heron, as mangroves in this area are not considered to be as good a bird habitat as better quality mangrove stands found further up Middle and East Arms (Appendix I in D&M 1997).

Loss of vine forest habitat will result in a population decrease in some species, especially birds that are reliant on this habitat, including Rainbow Pitta and Rose-crowned Fruit-Dove. Since the vine thicket habitat is, by nature, a fragmented habitat type, many of the birds that use this habitat are migratory or nomadic. Thus, it is probable that all species would continue to utilise the remaining habitat patches, but that these habitats would support reduced populations.

The mangrove margin and vine forest/paperbark forest interface is used for foraging, refuge and as a dispersal route for terrestrial mammals, such as Agile Wallabies and Northern Brown Bandicoots. Tracks of these species were commonly seen in these habitats. Where these movement corridors are cleared or obstructed, then free movement of these species around the island would be limited.

Beach Stone-curlews have been observed nesting along a beach located between the proposed pipeline shore crossing and the loading jetty groyne (refer Figure 3.6). This species is highly susceptible to disturbance and is rarely seen in the more developed parts of Darwin Harbour. This species is therefore likely to be locally disturbed by the construction phase. A significant portion of beach habitat will be retained undisturbed on Wickham Point, and it is expected that the species will continue to use this habitat once the construction phase is completed.

Some of the large Scrubfowl mounds, which occur along the mangrove/vine forest interface around the island (Figure 3.6), will be lost or disturbed by developments in this habitat. Scrubfowl are not a threatened species, but they are large, conspicuous birds and their nesting mounds are of scientific and general interest. The development will result in a reduction in the local population of this species, and a reduction in the number of nest mounds.

The project is likely to have little impact on migratory wading birds that use the intertidal zone. This habitat will be largely unaffected by the development except in the area of the construction dock. Given the widespread extent of this habitat, loss of these relatively small areas of intertidal flat is considered of minor significance. Therefore it is unlikely that the project will result in a measurable reduction in populations of bird species listed in international conventions and agreements.

4.3.10.4 Fire, weeds and feral pests

Construction activity may increase the risk of occurrence of fire, weed and feral pests. The generally undisturbed condition of the vegetation on Wickham Point has been previously noted in Section 3. The lack of disturbance, either from feral animals, fire or recent cultural impact contributes to the resilience of natural habitats to weed invasion. The lack of weeds, with the exception of *Lantana* sp., within such an extensive area of rainforest greatly adds to its integrity and conservation value.

There is a need to protect the remaining areas of dry rainforest and associated fauna by minimising the potential for disturbance from fire and feral animals and by controlling the introduction of weeds. A Site Management Plan has been developed to address this issue and will include provisions for:

- cleaning and inspection of construction equipment prior to deployment on site;
- monitoring for introductions and their subsequent removal; and
- fire prevention and control.

Strict enforcement and adherence to the Site Management Plan will minimise the potential for disturbance of the remaining areas of dry rainforest and associated fauna complement on Wickham Point.

4.3.10.5 Marine impacts

The impacts predicted for the proposed LNG Plant expansion on the marine environment are not measurably different to those addressed in the previous EIS and, as such, are not addressed further here. The most sensitive marine habitats in the vicinity of the project are the Channel Island coral reef and associated seagrass beds. Modelling undertaken for the previous EIS indicated that these habitats would not be affected by turbidity plumes (see Section 4.3.9) and a Dredging Management Plan has been developed to ensure that these habitats are not adversely affected.

Phillips has reviewed recent research undertaken on feeding behaviour of dugongs in the vicinity of Channel Island (Section 3.3.2) foraging on seasonally abundant macroalgae as a dietary supplement to the rare and small patches of seagrasses observed within the harbour (Whiting in press). Phillips recognises that dugongs and sea turtles do frequent the area around Channel Island, and will ensure that LNG shipping operations remain away from the Channel Island area (approximately 4 km from the proposed loading jetty) so as to minimise potential disturbance to foraging marine species. LNG tanker speeds will also be kept at an appropriately low level within the harbour, as agreed with the NT authorities, to further minimise the potential for direct or indirect disturbance.

4.3.11 Socio-Economic and Cultural Impacts

4.3.11.1 Synthesis

The impacts of the construction phase on the socio-economic environment in and around Darwin will result from the effects of:

- loss of some archaeological sites on Wickham Point;
- accommodating and supporting a construction workforce of up to 1,600 personnel at peak periods over three to four years;
- impact on local workforce who may leave current jobs to work on LNG site;
- increased demand on public facilities such as hospitals and recreational facilities;
- increased shipping movements to the port and barge traffic to the construction dock;
- increased road traffic to the plant site;
- effect on visual amenities in the harbour; and
- potential disturbance of conservation and natural heritage assets.

Economic benefits of the project construction will mainly include increased employment opportunities, increased economic activity in Darwin and the general region, and the building of the workforce skill-base within the Darwin community.

4.3.11.2 Plant site

The socio-economic environment of Darwin will be affected by the construction phase of the plant site as follows:

- twelve archaeological heritage sites, comprising nine shell middens and three remnants of WWII sites will be disturbed;
- restriction of public access to the plant site area;
- increased road traffic to the plant site;
- the costs and benefits of supporting a large construction workforce over a three year period; and
- temporary loss of visual amenity.

Further detail on these effects is provided below.

4.3.11.3 Loss of archaeological sites and Aboriginal burial sites

Nine archaeological sites were identified on Wickham Point during the original environmental assessment, most located either within or adjacent to the proposed plant area (Figure 3.11): six are prehistoric shell middens; two are historic sites dating from World War II; and one is the remains of the "Mud Island" leprosarium. A further five shell middens, and a WWII heritage site, were recently (August 2001) discovered and are currently subject to complete heritage surveys in consultation with the Heritage Branch of DIPE.

Figure 3.11 shows the location of the archaeological sites recorded on Wickham Point in relation to the proposed plant site boundary. Ten sites are considered to be at potential risk by the proposed project. Two other sites (MA 12 and MA17) are outside the area of disturbance.

Two of these sites (MH2 and MH3) are remnants of WWII sites and are considered to be of low archaeological significance. Both have been recorded in adequate detail, and neither require protection or further investigation.

However, the remaining sites are prehistoric middens and are considered highly significant based on the criteria of representativeness and research potential. Another significant midden occurs at Site MA12, but every effort will be made to protect this site by erecting fencing around it and prohibiting entry and heavy machinery access to within 20 m. This protection strategy will also be applied to Sites MA13, MA15, MA18 and MA22 if possible.

For Sites MA14, MA16, MA19 and MA21, the proponent will obtain a permit to remove the middens under Section 29 of the *Heritage Conservation Act 1991*. Prior to the site being cleared and levelled, bulk samples of archaeological materials from each midden will be salvaged and archived by a consultant archaeologist for future research. The newly discovered site MH4 is also likely to be subject to an application for disturbance and is currently the subject of further investigation in cooperation with the NT Heritage Conservation Branch. Management tasks to address this issue are outlined in Section 5.

The most significant heritage site on Wickham Point (MA17) will not be disturbed by construction activities. This site contains remains of the 'Mud Island' Leprosarium, a WWII anti-aircraft gun battery, and prehistoric shell middens.

While there are no known grave sites in the LNG plant area, the possibility exists that there are burial sites, particularly near the old leprosarium (which is outside the area affected by the LNG plant). Information and advice will be sought from the local Aboriginal custodians of this land, the Aboriginal Areas Protection Authority, Darwin, and the Heritage Conservation Branch of DIPE if evidence of a burial site is found. It is also anticipated that a liaison committee comprising representatives from the LNG plant and the Larakia people will be involved in ensuring the protection of any newly discovered sites. Correct procedures will be followed in managing any burial sites discovered. In general, work at the particular site will cease and the appropriate authorities will be informed immediately.

4.3.11.4 Restricted public access

Construction of the proposed LNG Plant will initiate several potential changes to access by the public to Wickham Point, including:

- slightly reduced access to fishing areas; and
- changed access to terrestrial botanical resources.

The major favoured fishing area is off the northern tip of Wickham Point, which will not be affected by the LNG Plant. There will be no restriction of fishing in this area. Similarly, there will be no restriction of access to landing in the region of the old leprosarium. The only restrictions to fishing will be adjacent to the loading jetty and construction dock, both of which are well away from the area of greatest fishing interest.

Construction of the LNG plant will destroy some terrestrial vegetation, including some species which may be used by Aboriginal people for bush tucker, medicines, and other traditional purposes. Because of difficulties of access and the dense vegetation, these areas are little used by Aboriginals at the present time. Once construction commences access to the plant site will be prohibited to the general public. However, the loss of access to the plant site and associated infrastructure areas by Aboriginal people will be offset by construction of the access road which will make areas adjacent to the road much more accessible, as far as the gate to the LNG plant.

4.3.11.5 Increased road traffic

Road traffic along Channel Island Road from Palmerston to the plant site will increase during the construction period as the result of transport of workforce, materials and equipment. The original EIS mentioned that upwards of 1,000 construction personnel would be employed for the 3 MPTA facility. This number is expected to increase to 1,600 personnel to construct both phases of the currently proposed 10 MTPA plant.

Fill and some construction materials will be extracted from the Wickham Point site where feasible; however, rock suitable for armouring of the pipeline, and for use in construction of the loading jetty groyne and construction dock, will be sourced from existing quarry sites. The transport of quarry material and rock will be along main roads and highways and will be carried out in accordance with weight, noise and other requirements of the DIPE (formerly Department of Transport and Works).

During the construction phase, traffic volumes along the roads to the sites will increase in magnitude, due to workforce travel and the delivery of materials and equipment to the site. The road network in Darwin and Palmerston is of a high standard and is expected to be capable of handling the extra traffic. Potential road damage from the transport of heavy equipment will be avoided or minimised through use of barges and the construction dock to transport equipment brought in by sea. Use of the road network for transport of materials and equipment will be in keeping with DIPE regulations and is not expected to create major public concern.

4.3.11.6 Construction workforce impacts

Housing and Accommodation

Phillips does not anticipate the use of a construction camp to accommodate the non-resident workforce. The maximum workforce at peak times during construction of the plant is expected to be approximately 1,600 of which it is assumed that a minimum of 25% will be able to be recruited from the Darwin region. Accommodation for approximately 1,200 workers will therefore be required.

It is also assumed, based on the characteristics of the construction workforce in other large development projects, that there will be a significant proportion of single workers, without dependents, in the workforce. At this stage the percentage of single workers to those with dependents is not known. Single workers are more likely to choose apartment and unit accommodation, while workers with dependents may choose houses and townhouses. Some single workers may opt for shared house accommodation.

Demand for rental accommodation in Darwin and Palmerston is expected to increase during the construction phase. There is a wide range of housing available for purchase or rent, including houses, townhouses, condominiums, units/apartments, hotels, motels and caravan parks. The higher rates for hotels and motels, compared to apartments/units and houses/townhouses, may discourage longer term workers from choosing hotels and motels, and therefore there should be little competition from the construction workforce for tourist accommodation.

There is likely to be some demand for caravan accommodation, particularly by short term contract workers. There are two caravan parks that offer accommodation to long term residents, as opposed to short term tourists.

Increased demand for housing and particularly rental properties may result in an increase in housing and rental prices; however, the size of the Darwin -Palmerston market will mean that this impact is likely to be minimal and the anticipated construction workforce can be readily accommodated (S. Shearer, pers. comm.). There is currently a 12% vacancy rate in the rental market, partially due to natural seasonal fluctuations from workforce numbers, and in part due to transport-related factors such as the termination of flights by Ansett, as a major carrier in Australia, in late 2001. The Darwin market has a history of responding quickly to new demand, through the construction of new dwellings. It is therefore anticipated that rental prices would simply return to the levels that were in existence approximately 12 months ago.

It is not expected that the influx of construction workers will lead to problems in the housing market (S. Shearer, pers. comm.). A preliminary analysis of existing accommodation in the Darwin area has revealed that up to 1,200 people could be accommodated. This is consistent with the findings included in the initial 3 MTPA EIS.

Employment

Construction activities associated with the LNG plant are expected to create an estimated demand of up to approximately 1,600 skilled and unskilled workers in peak periods. It is expected that a range of specialised management positions will be filled by Phillips personnel, e.g. construction manager, business manager, field procurement supervisor, general services manager, OH&S manager.

Professional and office positions which will be filled locally if possible include civil, mechanical, electrical and instrumentation engineers; contract supervisors for tanks, welding, building, instrumentation; clerical and accounts staff; planners and cost technicians; and administrative assistants. Skilled tradespeople will include steel fixers, concrete finishers, carpenters, equipment operators, boilermakers, coded welders, pipe fitters, mechanical fitters, electricians, lagger/cladders, painters, crane operators, instrument technicians, and labourers. Contactors may be required to provide some of the above services and others such as security, waste removal, cleaning, catering, dredging, and related services.

The construction phase is expected to last for approximately three and a half years. Due to the diversity of skills required, construction workers will undertake work associated with a specific phase of development.

Phillips intends to utilise the local labour force where possible, drawing on migrant workers, transients entering the region, companies who will undertake components of the project, unemployed and trainees and people employed in the construction industry. Due to the administrative and service nature of local business, and the small proportion of construction workers in Darwin, available labor sources may be inadequately skilled to undertake the work required. This will present opportunities for further training for both skilled and unskilled workers and result in options for future employment in the region at the culmination of the project.

As a consequence of the increased demand for skilled and unskilled workers there is likely to be competition for labour and a subsequent increase in wages, which will affect the local business community. However, the project is expected to attract newcomers to the Darwin area in response to job opportunities and this will cause some levelling out of any wages increase.

Phillips will also seek to provide for diversity in the workforce to reflect local and regional demographics and the spirit of the Timor Gap Treaty. Phillips will also work closely with the Larrakia family groups and the Northern Land Council in relation to employment and business opportunities for qualified Aboriginal persons or businesses

Local Economy

The impacts of the project on the local economy will be significant, particularly during the construction phase. The project is expected to generate between A$85,000,000 to A$100,000,000 per annum in wages over the three and a half years construction time frame, based on present day average income ranges.

In addition economic benefit for the regional economy will be derived from the expenditure of wage and salary earners for goods and services. Also, in recognition of the ownership of the primary resource serving the LNG facility, Phillips will endeavour to achieve an appropriate balance in the economic benefits of the project accruing to East Timor and Australia.

Community Services

The temporary impact of the construction workforce, representing approximately less than 1% of the total Darwin - Palmerston population, and 2-2.5% of the existing workforce, would not be expected to cause an unacceptable strain on the capacity of the community infrastructure and services. However, the size of the construction workforce will place some additional demands on the existing community services and infrastructure, such as schools, health services and recreational facilities.

Schools - It is expected that the construction workforce will have minimal impact on schools, as the vast majority of the workforce will be young single contractors. Nonetheless, some families will be present, and are likely to find accommodation throughout Darwin and Palmerston. As such, the impact of the influx of the construction workforce will be spread over several schools, government and private. To minimise the negative effects on the area's education system, Phillips will liaise with the education authorities and advise on expected timing of construction activities and the likely demand for school places from construction workforce families.

Health Services - Darwin has a high standard and broad range of health services and should be able to meet the temporary increased demands placed on the health system by the construction workforce. The most significant impact may be on hospital services, given the expectation that the construction workforce will have a higher proportion of young and physically active males, who can be expected to engage in physical contact sports and more active leisure pursuits than the average population, Workers may therefore have higher injury rates and need for outpatient and emergency services. This could lead to higher demand for General Practitioners and may also stimulate demand for specialists, which would benefit the overall community.

Recreational Facilities - The area's range of facilities and the generally open and welcoming attitude to new arrivals suggests that the workforce will be able to participate in local sports and utilise existing facilities and attractions without significant detriment to the local population. Facilities in Litchfield Park and other parks in the vicinity of Darwin have been developed to cater for large numbers of tourists and are not likely to be significantly impacted by the increased visitation attributable to the construction workforce.

4.3.11.7 Loss of visual amenity

Section 4.3.7 presented the results of the revised visual impact assessment for the LNG project. Wickham Point is characterised by long low landforms, flat horizon lines and elevations of less than 50 m above sea level. The coastal edge is typically fringed with a distinct zonation of mangroves. There are numerous coastal inlets and arms. The mangrove edge reinforces the green 'natural' and undeveloped character of the harbour.

Development within Darwin Harbour is generally concentrated around Darwin City where the city buildings punctuate the skyline. The developments of Channel Island and East Arm Port have a significant visual impact particularly when viewed from the immediate surrounding environment or adjacent areas of the harbour. The proposed LNG plant and the NT Government's proposed relocation of Darwin's oil terminals to Wickham Point will be in keeping with the scale and context of this evolving industrial and maritime precinct of the harbour.

Given the scale and nature of the proposed development, it is anticipated that the visual impact of development will be greatest during the construction phase of the project due to the clearing of mangroves on the north-east side of Wickham Point. Beyond 500 m, the visual impact of the development will gradually diminish..

4.3.11.8 Operational effects on the socio-economic environment

The operational effects of the proposed 10 MTPA LNG Plant remain very similar to those identified in the 1997 Draft EIS (Section 7.5 in D&M 1997). The project will produce substantial economic benefits to the region at little cost to the local community.

The major benefits of the project are that:

- the LNG plant is compatible with the planning vision of the Northern Territory Government and will provide increased opportunities for employment while diversifying the economic base of the Territory;
- the plant will contribute substantial income to the region by way of production sharing income to the owners of the gas resource, taxes on operating profits and workforce salaries, and demand for regional goods and services; and
- it will generate export earnings which will have a positive effect on balance of trade/payments.

The socio-economic costs to the community will include:

- Localised public access restrictions.
  Public access restrictions will apply only to the plant site and within an exclusion zone around the LNG loading facility and the construction dock during periods when those facilities are in use. Both of these exclusion zones are necessary for reasons of safety during ship loading activities and when the construction dock is in use. Apart from these specified areas, public access to the intertidal flats, shores and mangroves of Wickham Point and adjacent to the access road will not be affected.

- Minimal increased demand on infrastructure and community services.
  The workforce required to operate the plant will be very small by comparison to that required for the construction phase. Up to 120 personnel will become resident in the Darwin area and therefore there will be some impact on community services such as schools, health services, and recreational facilities. However, this demand is unlikely to be noticeable above the current projections for community growth.

- Minor impact on visual amenity.
  As discussed in Section 4.3.9.7, the effects of the LNG plant and infrastructure on visual amenity are likely to be minimal. Most of the plant site is hidden behind Peak Hill, and as a result only the tops of the LNG tanks and processing trains will be visible. The loading facility groyne and jetty will be the most conspicuous reminder of the plant's presence.

- Minor effects on harbour and coastal users.
  The most noticeable operational effect of the LNG Plant will be the regular shipping movements to and from the LNG shiploading facility. All shipping movements will be coordinated by the Darwin Port Corporation, which will also provide pilotage. Contract tugs will also be required to assist in shipping movement. The increase in shipping is likely to result in increased earnings and employment opportunities for the Darwin Port Corporation. It is considered unlikely that other users of the harbour will be disadvantaged by the extra shipping movements.

- Potential public risks from operation of the larger 10 MTPA plant.
  A revised Hazard and Risk Assessment and a Preliminary Component Siting Study for the LNG project was undertaken, with a focus on the changes in risk profile between the previously approved 3MTPA plant and the currently proposed 10 MTPA plant. The main relevant changes are that now there are two LNG trains instead of one, greater LNG storage capacity than before, and more frequent shipping movements than for the previous proposal.

  Though the plant capacity has been increased from 3 MTPA to 10 MTPA, the hazards are not significantly different than those of the previous proposal. The proposed facility will not have propane and butane product, therefore, hazards associated with these products have been eliminated. The fire radiation exclusion zones associated with LNG spill impoundment areas for the LNG Plant and the LNG tanks do not extend beyond the boundaries of the facility, and the increased shipping movements arising from the proposed expansion do not pose substantial additional risk to the people of Darwin.

  All potential hazards that could rise from the operation of the LNG Plant are being addressed in the design, and practicable measures to prevent hazardous incidents will be adopted. This will be confirmed through final risk and hazard assessments to be undertaken during the final design phase.

4.3.12 Sustainability Assessment

The final guidelines provided by the NT DIPE (Appendix A) indicated that justification for the project in the manner proposed should be consistent with the principles of Ecological Sustainable Development (ESD). For the purpose of the guidelines, the principles of ESD were given as follows:

- The precautionary principle – namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- Inter- and intra- generational equity – namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations; and
- Conservation of biological diversity and ecological integrity and improved valuation and pricing of environmental resources.

This PER document has presented information to provide this justification and this section concludes with a synthesis of the environmental and social costs and benefits of the project to enable assessment of overall sustainability of the project.

The Environmental Management Plan prepared and submitted for this project will also address sustainability issues associated with the project in a "triple bottom line" approach which will integrate environmental, social/cultural and economic factors, in line with international guidelines (WBCSD 2000) for the development of sustainability practice. This approach not only meets the principles of ecologically sustainable development as defined above, but also better integrates the environmental, social and economic aspects of the project to give a truer picture of overall sustainability.

In summary, the environmental and social 'costs' of the proposed project will principally be:

- alteration of a moderate part (88.3 ha) of Wickham Point from a relatively unmodified wilderness 'island' to an industrial plant site (in accordance with community expectations as outlined in *Darwin Regional Land Use Structure Plan 1990*);
- loss of 67.6 ha of good quality dry rainforest, or monsoon thicket (and associated fauna) , which is a remnant vegetation type that is of regional conservation value. This will be offset by protection of another area of dry rainforest in the region;
- modification of intertidal pavement and sand flat in the vicinity of the construction dock and the loading jetty, and their replacement by structures which will be recolonised by various marine organisms more suited to the new habitats;
- loss of seven, and possible disturbance of three, archaeological sites on Wickham Point (seven Aboriginal middens and three World War II heritage sites);
- increased road and harbour traffic during the construction phase and increased demand on community services, infrastructure and accommodation as a result of the construction workforce;
- restricted public access to the plant site and 500 m safety exclusion zone around the loading facility and construction dock;
- modified flight path for southern approaches to the north/south runway at Darwin Airport, dependent on current discussions with CASA;
- high volume discharge of carbon dioxide into the atmosphere (4.5 MTPA). Offset options will be investigated through the Greenhouse Challenge Programme;
- low volume discharge of atmospheric emissions of NO_x, SO_2, and PM_{10} at acceptable concentrations below NEPM standards; and
- low volume disposal of a range of hazardous and non-hazardous wastes to approved onshore sites in accordance with government requirements.

The above costs will be balanced to a large extent by the following environmental and social 'benefits' of the project:

- development of new sources of energy and production of clean burning LNG for industrial fuel purposes and natural gas for domestic use;
- financial contribution to the Governments of Australia and East Timor through revenue sharing resulting from the development of the gas reserves in the Timor Sea through processing at the Darwin LNG project;
- significant contribution to the regional economies of East Timor, Northern Territory and Australia via export earnings and income sharing, taxes and salaries and purchases of goods and services during the construction and operation phase of the development;
- the use of LNG and natural gas as a preferred fuel for existing and new facilities, in place of alternative fossil fuels, will reduce global greenhouse gas emissions in accordance with the objectives of the Kyoto Protocol;
- provision of significant employment and training opportunities in Darwin during the construction phase of the development, that will result in a more diverse skilled labour for support of future long-term development of oil and gas developments in the region;
- diversification of the local economic base and the supply of infrastructure for future long term development of Timor Sea gas reserves; and
- the project will be developed with a commitment to ensure responsible management of all aspects of the project in accordance with the principles of

Ecologically Sustainable Development (ESD) in consultation with the community.

The main threat of serious or irreversible environmental damage posed by the project is the risk of a shipping accident within the harbour which results in widespread oil spillage and mortality of mangroves and associated biota. However, this risk currently exists and contingency plans are in place to minimise adverse impacts of such an event. Phillips has committed to the production of its own contingency plans, and LNG shipping has an excellent safety record.

The project will not threaten any populations of rare or endangered species, nor will it threaten currently designated conservation reserves in the Darwin area. In fact, the conservation of dry rainforest habitat in the Darwin area will increase once a suitable portion of that habitat is located, purchased and placed in reservation.

Given that the environmental risks posed by the project are minimal and manageable, and that biodiversity will not be threatened and conservation reserves will be increased, and also given the economic and social benefits that will accrue to the community of Darwin if the project proceeds, it is considered that future generations of Territorians will applaud the decision by this generation to proceed with the project.

With the exception of higher atmospheric emissions and higher economic activity, these environmental and social “costs” and “benefits” are generally the same for both the approved 3 MTPA LNG facility and the proposed 10 MTPA LNG facility.

5. ENVIRONMENTAL MANAGEMENT

5.1 INTRODUCTION

This section of the PER has two primary purposes:

(1) To confirm the environmental management commitments made by Phillips for the original EIS (D&M 1997), Supplement (D&M 1998a) and Preliminary Environmental Management Programme (EMP) (D&M 1998b) to ensure the design, construction and operation of the proposed LNG plant is undertaken in a responsible manner; and

(2) To identify additional commitments which may be required to address the potential environmental effects of the proposed expansion of the LNG plant design, taking into account the revised assessment studies outlined in Section 4.

5.1.1 Objectives

The objective of the EMP is to establish management and monitoring plans which ensure that actual and potential impacts associated with the construction, operation and decommissioning phases of the LNG plant are minimised, and that compliance with all relevant environmental regulations is achieved.

The specific objectives of the EMP are to provide a planned structure which will:

- ensure that construction activities are undertaken in an appropriate manner and that impacts on the environment are minimised and monitored;
- ensure that impacts associated with the operational phase of the development are minimised and monitored; and
- minimise the risk of potential effects from unexpected incidents, such as oil spills, and ensure that appropriate contingency plans are in place in the event of such incidents.

The EMP also identifies the timing and scope of individual components of the environmental management plan, and serves as a compliance document - recording the progress of management commitments and their conformity with requirements set by authorities and expectations of the public. An EMP is therefore a means of both documenting and auditing environmental management commitments made by the proponent

5.1.2 Previous Environmental Management Commitments

In November 1998, Phillips submitted a Preliminary EMP for the original 3 MTPA LNG Plant and associated sub-sea gas pipeline. That EMP superseded previous commitments presented in the Supplement to the Draft EIS in that it was restructured to capture comments and approval conditions provided by Commonwealth and Northern Territory (NT) governments subsequent to their review of the Supplement.

In the EMP for the Wickham Point plant, Phillips agreed to undertake the following in accordance with its corporate Health, Environment and Safety (HES) Management System:

- the adoption of best practice industry standards and guidelines applicable to the construction, operation and decommissioning of the pipeline and LNG plant;
- compliance with government regulations and all legal requirements;
- production and implementation of a safety manual and an emergency response manual, including an oil spill contingency plan, for the LNG plant;
- monitoring to confirm the scale of potentially adverse environmental impacts;
- decommissioning the plant upon completion of operations; and
- rehabilitation of the plant site and infrastructure areas to a natural condition or as otherwise specified by legislative or regulatory requirements.

A summary of specific proponent commitments was included in Table 1 of the Preliminary EMP (D&M 1998b), categorised according to the key phases of the project (Detailed Design Phase, Construction Phase, Operational Phase and Project Decommissioning).

5.1.3 Conditions of Approval for Previous Project

The principal recommendations made by DLPE and EA in early 1998 were summarised previously in Section 1.4.1. Both parties committed Phillips to implement the proposed project in accordance with the undertakings outlined in the draft EIS, the Supplement to the EIS and consequent recommendations made by the NT and Commonwealth Governments.

Additional measures for environmental protection were required to be incorporated into the EMP, which requires review by DLPE and EA prior to finalisation. It was also agreed that the final version of the EMP, as a public document, shall form the basis for any approvals and licences issued under the *Waste Management and Pollution Control Act*. The reader is referred to Appendix 1 of the Preliminary EMP for full details of all specific recommendations and conditions of approval submitted by DLPE and EA at that time (D&M 1998b).

5.1.4 Preliminary EMP Prepared in 1998

The Preliminary EMP described in detail the specific management responses by the proponent to environmental impacts and issues identified during the assessment process, as a result of input by the proponent, the public and government reviewers.

The Preliminary EMP was structured according to the key project activities, and included the following components:

- **Pipeline Environment Plan** – related to the design, construction and operation of the Bayu-Undan gas pipeline. It also outlined a commitment to prepare a Pipeline Management Plan (PMP) under *Petroleum (Submerged Lands) Act* requirements. Note that the approval process for the pipeline has since been progressed separate from the LNG plant and associated infrastructure (see Section 1.4.2).
- **Dredging and Spoil Disposal Management Plan** – addressed potential effects associated with pre-construction dredging and spoil disposal in preparation for the construction dock and loading jetty, and the pipeline shore crossing.
- **LNG Plant Environment Management Plan** – to address the requirements for environmental management during the site preparation, construction, operation and decommissioning of the LNG plant. Phillips committed to prepare the LNG Plant EMP as a stand-alone document of the EMP when finalised.
- **Emergency Response Manuals** – included the proponent's commitment to prepare written emergency plans for the pipeline, plant and marine terminal to cover emergency situations that could occur, based on the results of a Quantitative Hazard and Risk Assessment. It was agreed that Emergency Response Manuals will be developed for:
  - LNG Plant Accident Response;
  - Loading Facility and LNG Carrier Accident Response;
  - Pipeline Rupture Contingency Plan; and
  - Platform Emergency Response.
- **Oil Spill Contingency Plans** – outlined commitments to prepare a series of Oil Spill Contingency Plans (OSCPs) to enable effective response during construction and operation of the LNG project, based on the results of an ecological/environmental risk assessment. Separate OSCPs are to be prepared for:
  - Pipelay Operations (integrated with the existing Darwin Harbour OSCP where appropriate);
  - Pipeline Rupture (produced as part of the Pipeline Rupture Contingency Plan); and
  - Platform OSCP (to be interfaced with the Platform Emergency Response Plan).
- **Corporate Relations Plan** – in accordance with Phillips' commitment as a good corporate citizen, a Corporate Relations Plan was proposed to ensure that the local community and other key stakeholders are kept informed of the proposed project operations. The proponent commited to implement the Plan by establishing:
  - A Corporate Relations Manager and Department;
  - Public and Community Relations Programme;
  - Larakia Liaison Committee;
  - Stakeholder Liaison Committee;
  - Internet website; and
  - CASA/Air Service Australia Liaison Link.
- **Compliance Auditing and Reporting** – Phillips assumed responsibility for undertaking regular audits and reviews of the LNG facility's environment and safety management, including both on-site compliance auditing and review of performance reports. In addition, Phillips proposed to conduct regular site internal environmental audits and Environmental Management Systems (EMS) audits as required.

For each of the components relating to the Pipeline Environment Plan, Dredging and Spoil Disposal Management Plan and LNG Plant EMP, a draft *Environmental Effects and Management Register* was outlined. These detailed the potential effects related to each activity, applicable legislation and guidelines, and the proposed implementation strategy to address those environmental effects (including management commitments, performance objectives, proposed monitoring activities to be undertaken, and performance criteria).

Monitoring Commitments

In the 1998 Preliminary EMP, Phillips committed to the production and implementation of a detailed Environmental Monitoring Programme. The environmental monitoring commitments were primarily in relation to:

- abundance of weeds and feral animals in undisturbed areas of Wickham Point;
- abundance of biting insects within the plant site;
- effects of dredging and excavation associated with construction of the loading facility turning basin, the pipeline shore crossing and the construction dock approach channel on the coral communities of Channel Island and north-east Wickham Point;
- productivity of mangroves adjacent to the plant site;
- quantity, quality and methods of disposal of construction and operational wastes;
- confirmation of the quantity and quality of atmospheric emissions;

- wastewater discharge volumes and quality, including effluent dispersal studies;
- concentrations of selected metals, tributyltin and total petroleum hydrocarbons in marine sediments and selected marine biota in the vicinity of the ship-loading facility and construction dock; and
- contribution to the Darwin Port Corporations's monitoring programme for introduced marine organisms.

More specific details on each of the above monitoring commitments were indicated in the relevant *Environmental Effects and Management Register* for each component of the Preliminary EMP (D&M, 1998) and remain valid for the revised project.

In relation to the proposed expanded 10 MTPA LNG facility, Phillips intends to build on the previous environmental commitments for managing the approved 3 MTPA plant. The finalisation of the EMP, to occur after the current Public Environmental Review period, will be focused on reviewing those original commitments for their applicability. Preparation of the final plans outlined in the Preliminary EMP will be undertaken with due regard to the additional level of risk associated with the expanded project and comments received from interested stakeholders.

5.2 REVISED ENVIRONMENTAL MANAGEMENT PLAN

The final EMP will comprise the same components as those outlined in the 1998 Preliminary EMP, as detailed in Section 5.1.4. The final EMP will provide detailed Management Plans for both construction and operational components of the project.

The following section details the additional commitments which will be made by Phillips to address the potential environmental effects associated with the expanded 10 MTPA LNG plant design.

5.2.1 Additional Environmental Management Commitments

The outcomes of the updated assessment studies undertaken for the PER and detailed in Sections 4.3.1 to 4.3.12, confirm that most of the anticipated environmental effects of the proposed 10 MTPA LNG plant essentially remain the same as those identified for the original 3 MTPA proposal. As such, the commitments detailed in the Preliminary EMP adequately address the majority of the anticipated effects of the project on biophysical, cultural and socio-economic environments.

However, evaluation of the modified project has identified a number of additional commitments to be implemented by the proponent, and one previous commitment that can no longer be sustained. These are outlined below:

5.2.1.1 Air monitoring

Phillips will quantify the major emission sources during commissioning of the project by periodic emission testing programmes (as previously agreed). Dependent on the results of this verification process, Phillips will undertake to establish a monitoring system for oxides of nitrogen (NO_x) from key emission sources. While the revised air modelling assessment clearly showed that predicted worst-case concentrations of all pollutants will meet accepted NEPM standards and no adverse effects are anticipated, when due consideration is given to cumulative effects from the existing Channel Island Power Station, NO_x is most likely to be the pollutant closest to ambient limits.

5.2.1.2 Greenhouse emissions

As part of its commitment to the Commonwealth Government's Greenhouse Challenge Programme, Phillips will develop a Cooperative Agreement with the AGO during the detailed design phase. This will include a corporate commitment to continual improvement in energy efficiency, development of a comprehensive greenhouse gas management strategy, and action plans for mitigation measures employed in the design of the revised project.

Phillips will further investigate other 'no regrets' and 'beyond no regrets' options for greenhouse minimisation. At this time plantation sequestration options, such as investment in oil mallee plantations, offer the greatest benefit as tangible offset measures. Phillips will evaluate these options further during detailed design and construction, with periodic reviews throughout the life of the project.

5.2.1.3 Wastewater discharge

As described in Section 4.3.4, Phillips has re-designed the wastewater disposal component of the project so that all treated wastewater will be used for on-site irrigation, to avoid direct discharge into Darwin Harbour. Direct discharge will only be considered as a contingency option.

During preparation of the final EMP, Phillips will undertake an evaluation of the proposed release of hydrotest water during construction of the storage tanks for LNG and condensate on-site. This will include an analysis of the additives which will be present, their fate and anticipated environmental effects. Management measures to avoid potential adverse effects on the marine environment will be agreed with the DIPE prior to construction.

5.2.1.4 Waste disposal management

The proposed management measures to handle the increased levels of solid and semi-liquid wastes anticipated from the expanded plant design have been detailed previously in Section 4.3.5. These measures have been revised to ensure compliance with the *Waste Management and Pollution Control Act 1999*, which had not been enacted at the time of the previous assessment.

Waste minimisation and recycling principles will be built into all project operations so as to reduce solid and semi-liquid waste streams where possible.

5.2.1.5 Dry rainforest mitigation

Phillips will continue to work with the NT Government to identify a suitable area of dry rainforest in the Darwin region to be acquired for conservation purposes. Protection of dry rainforest of good or better quality will offset the loss of dry rainforest required within the project area on Wickham Point.

5.2.1.6 Fauna Corridors

The restructure of major components within the plant site for the revised plant design has markedly reduced areas of natural habitat to the south of the plant. This has therefore created a physical barrier through the fauna corridor and culverts previously proposed for the southern end.

5.2.1.7 Public Risks

Section 4.3.10 detailed the outcomes of the revised Hazard Analysis and Risk Assessment undertaken to address the potential effects of the expanded 10 MTPA plant design and increased movements of LNG tankers in Darwin Harbour. It has been demonstrated that the siting, design, construction and operation of the proposed LNG plant is such that the safety and protection of persons, property and the environment will be maintained.

During the detailed engineering phase of the project, Phillips will undertake the following:

- a final HAZOP (Hazard and Operability) Study, to identify all potential scenarios arising from the failure of valves and controls or other upset conditions;
- a final QRA (Quantitative Risk Assessment), to identify, assess, evaluate and manage all potential risks associated with the project; and
- a detailed Safety Report for the LNG plant, in accordance with relevant Worksafe Australia Standards and prepared on the basis of the HAZOP and QRA studies outlined above.

5.2.1.8 Sustainability framework

Phillips has undertaken to build on a framework for assessing the design, construction and operation of the project consistent with the principles of Ecological Sustainable Development (ESD, see Section 4.3.12). Integration of the environmental, social and economic aspects of the project into a logic framework will enable Phillips to track its performance towards sustainable development of the LNG project. This will ultimately establish a tangible means to openly communicate the company's goals, objectives and performance measures through a public Sustainability Reporting process.

5.2.1.9 Proponent's environmental management commitments

Table 5.1 summarises the updated environmental management commitments for the project, taking into account the additional measures described above. Commitments which have substantially changed from the Preliminary EMP, or represent new commitments altogether, are shown in italics. Note that the commitments in relation to the Bayu-Undan to Wickham Point pipeline, being addressed in separate Environment Plans under the *Petroleum (Submerged Lands) (Management of Environment) Regulations 1999*, are not listed here.

5.3 DREDGING AND SPOIL DISPOSAL MANAGEMENT PLAN

During discussions completed during production of the Supplement to the EIS, the Darwin Port Authority and Department of Transport and Works (DTW) suggested that Phillips coordinate dredging activities with Northern Territory government plans to dredge Stage 2 for East Arm Port, thereby sharing costs of dredge mobilisation. The agencies also offered to accept for disposal at East Arm Port reclamation area all suitable fill material generated by Phillips which was not required for the LNG plant site.

Recent consultations with the DTW have confirmed that all suitable fill material generated by Phillips could be utilised for both the East Arm Port and also the preparation of the road corridor through Middle Arm Peninsula. As a result of the full evaluation of dredging and spoil disposal options as presented in Section 4, Phillips has determined that there is unlikely to be substantial volumes of excess fill once the plant construction requirements are met. Nonetheless, as part of the development of its Dredging and Spoil Disposal Management Plan, Phillips will liaise with DTW to ensure that the dredging works are undertaken in an acceptable manner, and excess dredge material will be managed and disposed of to the satisfaction of DIPE and DTW.

Table 5.1 Revised Proponent's Environmental Management Commitments

Proposed Activity	Proposed Environmental Management Commitment	PER Section(s)
Detailed Design Phase		
Pipeline shore crossing, turning basin and construction dock approach channel	Based on the detailed evaluation of all dredging, excavation and spoil disposal options, Phillips will develop a dredge and spoil disposal management plan for approval by the DIPE. Phillips will endeavour to coordinate dredging works with the Department of Transport and Works to enable the relocation of suitable fill material to East Arm Port.	**4.3.11**
Plant site	The gas flare system will be designed to eliminate risk to routine air traffic. Approval for the preferred flare design will be sought from the appropriate Commonwealth and NT Government authorities, and modelling completed to the satisfaction of CASA.	4.3.3
	An inventory of atmospheric emissions and project energy efficiency will be prepared. Mechanisms for reducing greenhouse gas emissions will be discussed with the Commonwealth Government's Australian Greenhouse Office, including further investigation of 'no regrets' and 'beyond no regrets' options.	4.3.1; 4.3.2
	Alternatives to the direct discharge of wastewater into the harbour has been pursued, to enable re-use for on-site landscape irrigation. Approval for minor volumes of direct outfall, if necessary as a contingency position, will be sought from the NT Government.	*4.3.4*
	Evaluation of the discharge of hydrotest water anticipated from construction of storage tanks will be undertaken during final EMP to identify constituents and environmental safeguards required in consultation with DIPE.	*4.3.4*
	Design measures will be implemented where practical to minimise the potential visual impact of the development.	4.3.7
	Phillips will continue to work with the NT Government to identify a suitable area of dry rainforest of equal or better quality for conservation purposes.	4.3.8
	Final Hazard and Operability (HAZOP), Quantitative Risk Assessment (QRA) and 'Safety Case' Report studies will be undertaken to address all potential hazards and risks associated with the project.	*4.3.10*
	Sustainability measures within a logic framework will be developed for environmental, social and economic aspects of the project.	*4.3.12*
Access Road	Matters relating to the planning, alignment and construction oversight of the access road are the responsibility of the NT Government.	1.5
Construction Phase		
	Any unusual, planned temporary interruptions to the activities of recreational fishermen, mariners and other users of the harbour as a result of barge movements will be notified to the Darwin Port Authority and advertised in the local media.	4.3.9
	Phillips will liaise with the Department of Transport and Works to plan the routing and timing of truck movements during construction activities so as to minimise disturbance to commuter traffic.	4.3.9

Table 5.1 Revised Proponent's Environmental Management Commitments (cont'd)

Proposed Activity	Proposed Environmental Management Commitment	PER Section(s)
Hydrotest of storage tanks	Evaluation of hydrotest water will be undertaken during final EMP to identify constituents and environmental safeguards required. Hydrotest water will be discharged into Darwin Harbour and will meet DIPE water quality requirements.	*4.3.4*
Pipeline shore crossing, turning basin and construction dock approach channel	Appropriate construction methods and timing will be adopted to minimise the potential for dispersion of turbid water plumes towards the Channel Island coral community.	4.3.11
Ship-loading facilities and construction dock	No commitments during construction.	
Plant site construction	Phillips undertakes to manage the area within the boundaries of the LNG plant in an environmentally responsible manner and will cooperate with the NT Government in management programmes as agreed in the final EMP for the site.	5.4
	Introduction of weeds and plant pathogens will be prevented through vehicle washdown and inspection procedures, to be developed in conjunction with the Department of Primary Industries and Fisheries.	5.4
	A feral animal control programme will be developed on the basis of advice from the Parks and Wildlife Commission.	5.4
	Potential soil erosion and siltation of water resources will be minimised by earthworks and by the design of drains and culverts.	5.4
	The creation of acid soil conditions will be mitigated by minimising disturbance of mangrove sediments and by disposing of any marine sediments with the potential for acid generation in a government-approved location. If necessary, an Acid Sulphate Soil Management Plan will be developed in consultation with DIPE soil conservation officers.	4.3.8; 5.4
	Construction practices will be adopted which avoid the creation of new breeding areas for biting insects, and identified breeding sites will be removed.	4.3.8; 5.4
	Phillips will establish a liaison committee, which will include indigenous interests, to assist in the management and protection of any archaeological sites which may be discovered on Wickham Point.	5.7
	An archaeological sites register will be established in consultation with DIPE Heritage Conservation Services and will be updated if any new artefacts or historic sites are discovered.	4.3.9; 5.7
	If any sites of Aboriginal significance are discovered, the areas will be protected and the AAPA will be consulted.	4.3.9; 5.7
	Areas of significant vegetation (rainforest and mangroves) to be retained will be marked by temporary fencing, with access prohibited. Fire fighting equipment will be available.	4.3.8; 5.4

Table 5.1 Revised Proponent's Environmental Management Commitments (cont'd)

Proposed Activity	Proposed Environmental Management Commitment	PER Section(s)
	Fauna habitat surrounding the plant site will be protected by fencing, with access prohibited.	5.4
	Construction activities will comply with noise abatement requirements and, where possible, will be undertaken during daylight hours. Blasting will only occur during daylight hours.	4.3.6; 5.4
	The potential for dust generation will be minimised by shaping of stockpiles, spraying of cleared areas with water and control of vehicle speeds.	5.4
Operational Phase		
Plant	*Stack emissions will meet ambient air quality guidelines, verified through periodic emission testing. Depending on the results, a continuous NO_x monitoring programme will be established.*	*4.3.1; 5.2.1*
	Improvements in project energy efficiency will be sought throughout the operational life of the plant.	4.3.2; 5.2.1
	Sewage will undergo treatment before re-use for on-site irrigation. An ICPMS scan for trace elements in wastewater will be conducted.	*4.3.4*
	All potentially contaminated stormwater leaving the process areas of the plant site will be routed through a CPI separator to ensure removal of any oil.	5.4
	AN INDUCTION PROGRAMME FOR THE OPERATIONAL WORKFORCE WILL COVER ALL ASPECTS OF HEALTH, SAFETY AND THE ENVIRONMENT. IT WILL EDUCATE WORKERS ON THE CULTURAL AND NATURAL HERITAGE VALUES OF THE PLANT SITE AND ON THE REASONS FOR THE APPLICATION OF ENVIRONMENTAL MANAGEMENT PRACTICES.	5.4
	Emergency Response Manuals will be developed for the plant. The workforce will be trained in their implementation and regularly tested to maintain necessary skills.	5.5
Shipping	Vessels serving the LNG plant will follow IMO and AQIS guidelines for ballast water discharge at sea, prior to entering Darwin Harbour. This will minimise the potential for introduction of foreign marine organisms.	5.4
	Shipping movements will be coordinated through the Darwin Port Corporation. Vessels will be escorted by tugs in the vicinity of the loading facility and will be under the control of a pilot within harbour waters, to ensure compliance with all procedures including maintenance of separation distances from other vessels.	5.5
Project Decommissioning	At the end of the project life, the plant and pipeline will be decommissioned in accordance with standard practice applicable at the time.	5.9

5.4 LNG PLANT ENVIRONMENTAL MANAGEMENT PLAN

Specific management and monitoring actions to be implemented by Phillips have been identified to achieve sound environmental management of the plant site, building on commitments made by Phillips in the Draft EIS and Supplement, and recommendations made by EA and the NT DLPE in their assessment reports on the 3 MTPA LNG plant proposal.

The LNG Plant EMP will be structured to address all effects associated with the following project phases:

1. site preparation;
2. plant construction;
3. plant operation; and
4. post-operations.

In summary, the key environmental management issues identified during the original environmental impact assessment process, and addressed in the Preliminary EMP, included:

- minimisation of environmental disturbance associated with development of the plant and protection of surrounding undisturbed areas;
- protection of remaining dry rainforest (monsoon thickets), mangroves and fauna habitat;
- management of weeds, feral animals and bushfires;
- protection of undisturbed archaeological and heritage sites;
- minimisation of mangrove mud disturbance and management of acid soil conditions that may eventuate;
- management of biting insect issues;
- management of waste and emissions resulting from construction and operation activities;
- training and education of the plant site workforce in relation to environmental management objectives; and
- minimisation of adverse socio-economic effects of the project on the Darwin region, including establishment of community liaison mechanisms.

Specific measures to manage the above environmental effects and risks are identified and addressed in detail in Table 4 (Environmental Effects and Management Register) of the Preliminary EMP (D&M 1998b). Phillips will complete this table, with performance indicators and responsibilities, during finalisation of the EMP.

5.5 EMERGENCY RESPONSE MANUALS

Phillips will prepare a written emergency plan for the plant and marine terminal to cover the conceivable emergency situations that could occur. This plan will not only address situations that occur within the operating facilities, it will also address those situations offsite that could impact these facilities. It will be Phillips' intent to liaise with the appropriate civil and port authorities in development of the overall facility emergency plan. This external liaison will facilitate the development and continual review of the plan and procedures, provide for joint participation in training and emergency exercises, and develop effective and rapid communications and response in an emergency.

5.5.1 Hazard and Risk Assessment Analysis

A revised Hazard and Risk Assessment has been undertaken for this PER, presented as Appendix G, to take into consideration the potential effects of the expanded plant design and increased shipping movements for the current revised proposal.

During the detailed engineering phase of the project, Phillips will undertake the following:

- a final HAZOP (Hazard and Operability) Study, to identify all potential scenarios arising from the failure of valves and controls or other upset conditions;

- a final QRA (Quantitative Risk Assessment), to identify, assess, evaluate and manage all potential risks associated with the project; and

- a detailed Safety Report for the LNG plant, in accordance with relevant Worksafe Australia Standards and prepared on the basis of the HAZOP and QRA studies outlined above.

5.5.2 Plant Accident Response

A site emergency plan will be produced to cover conceivable accident situations. The plan will clearly describe the emergency organisation of personnel. The responsibility for deciding when to implement an emergency plan will rest with the site manager, and a key dedicated person (probably the shift supervisor or equivalent) will be designated to coordinate on-site actions.

The emergency plan will be supported by emergency response manuals, relevant sections of which will be available to, and required reading for, all site personnel needing to work in hazardous plant areas, especially those likely to be directly involved in emergency response. The manuals will set down the procedures needed to implement the relevant part(s) of the emergency plan, and will be designed to provide instructions and advice to personnel involved in the response to an emergency on the actions to be taken. Personnel training and preparation for contingency scenarios will remain a high priority during the life of the project.

5.5.3 LNG Carrier Accident Response

Planning for emergencies on LNG carriers will be based on an understanding of the types of accident that could occur and their possible consequences, together with an effective system of communication. Written procedures will be developed in liaison with the Darwin Port Corporation (DPC). Both the NT Marine Oil Pollution Plan (NT Coastal Waters) and the National Plan to Combat Pollution of the Sea by Oil (NATPLAN-Commonwealth Waters) would be applicable to LNG carrier accident responses at sea. In Darwin Harbour the relevant plan is the Darwin Harbour Oil Spill Contingency Plan (see below).

As with the on-site plan, ship emergency procedures will be reinforced by training and exercises, and will be continually reviewed and updated in consultation with the Darwin Port Authority.

5.5.4 Emergency Response Management

Emergency response management will be provided by a small team of senior managers (the control committee) who in turn will direct all response activities through the emergency response unit, plant security, communications, public relations, safety and environmental affairs, and material procurement departments. Each of these departments will have specific responsibilities to perform in the event of an emergency.

5.6 OIL SPILL CONTINGENCY PLANS

A series of Oil Spill Contingency Plans (OSCPs) will be prepared by Phillips to enable effective response during both the construction phase and the operation phase of the project.

During the construction phase, there is potential for spillage within the harbour as a result of dredging operations, construction dock traffic and loading jetty traffic.

During operations, there is potential for spillage in the harbour as a result of LNG and LPG carrier accidents or spillages at the loading jetty.

The DPC has legal jurisdiction for dealing with oil spills in Darwin Harbour, and has developed a detailed Oil Spill Contingency Plan (OSCP) as part of the National Plan to Combat Pollution of the Sea by Oil (NATPLAN). A broader OSCP is also currently being developed for the whole of the NT, however this is yet to be finalised (B. Wilson, pers. comm.)

The Darwin Port Corporation OSCP covers all areas of the port area, including the waters adjacent to the proposed LNG plant. As such, the Phillips OSCP for the harbour will be integrated into the existing OSCP. A supplementary plan, specific to the LNG plant, will be developed in consultation with the DPC and other relevant authorities. This plan will detail the organisational responsibilities, actions, reporting requirements and resources to ensure effective and timely management of an oil spill for operations in the Darwin Harbour area. The plan will interface with the Phillips Emergency Response Plan.

5.7 CORPORATE RELATIONS MANAGEMENT PLAN

Phillips is committed to being recognised as a good corporate citizen and has incorporated appropriate practices into its HES policy to enable it to achieve this goal. Therefore, Phillips has developed a Corporate Relations Plan to ensure that the local community is informed about proposed operations and that key stakeholders have ready access to relevant information and appropriate Phillips personnel.

Phillips proposes to manage corporate relations for this project by establishing the following:

- Corporate Relations Manager and Department;
- Public and Community Relations Programme;
- Larakia Liaison Committee;
- Stakeholder Liaison Committee;
- internet web site;
- CASA/Air Service Australia Liaison Link.

Corporate Relations Manager

A senior Public Relations Manager will be employed in Darwin to manage corporate relations with key stakeholders and the community at large.

Larakia Liaison Committee

Phillips has been active in liaising with local indigenous representatives since project investigations commenced in 1996. This will continue as a formalised process. An Aboriginal Liaison Committee will be established specifically to liaise with the Larakia people regarding issues of significance to Aboriginal people along the proposed pipeline route, within Darwin Harbour and in relation to the Wickham Point plant site.

Stakeholder Liaison Committee

A committee will be established to liaise with all other stakeholders who may be affected by the construction programme and operations phase. Phillips will liaise with the NT government and the NT Chamber of Commerce and Industry regarding the establishment of this committee. Relevant NT government authorities will be represented on this committee plus private stakeholders such as recreational fishing and diving groups, ferry operators, charter boat operators and commercial fishing interests, aviation groups, etc.

CASA/Air Services Australia Liaison Link

The team currently resolving the issue of the flare being on the southern approaches to Darwin Airport with Airport and CASA authorities will remain in existence until the issue has been resolved. Phillips will advise NTDLPE when the issue has been resolved and CASA approval for the flare has been obtained.

Public and Community Relations

Information brochures will be produced for distribution to community groups, advertisements will be placed in local newspapers to inform the public of the occurrence of particular activities, and regular updates will be provided to keep the community informed of progress.

Internet Web Site

An internet wet site will be established on which a summary of this EMP will be placed, together with information on where the full EMP can be viewed, current status of the project, and a register of auditable activities which have been complied with to date.

5.8 COMPLIANCE AUDITING AND REPORTING

As confirmed in the Preliminary EMP, Phillips will be responsible for the regular audit and review of the LNG facility's environment and safety management. This will include both on-site auditing and review of performance reports. Additional onsite inspections and investigations will be undertaken in the event of significant environmental incidents. These will be undertaken in conjunction with the relevant government agencies. Plant management will participate in the audits and inspections and investigations. Plant management will also be responsible for regular review of the environmental performance of the site and site personnel, and for the reporting on the implementation of commitments made in the EMP. There is also likely to be some compliance auditing associated with the licensing of the LNG Plant under the *Waste Management and Pollution Control Act.*

Table 5 of the Preliminary EMP (D&M 1998b) presented a Compliance Audit Table which summarised, for each government recommendation and proponent commitment, the following information:

- the recommendation or proponent commitment being addressed;
- the issue to be addressed by the proponent;
- how the issue is to be addressed by the proponent;
- where the issue is addressed in the EMP;
- when the issue is to be addressed by; and
- to whose satisfaction the issue is to be addressed.

The finalisation of the EMP will see the Compliance Audit Table completed, which will record dates of compliance by the proponent with recommendations and commitments, and a reference to appropriate documentation from the relevant approving authority. It is envisaged that this table will be a live document and will be updated periodically throughout the life of the project.

Audits

In particular, there will be:

- annual audit reports to the DBIRD, DIPE and EA as required;
- a triennial review and improvement of the EMP.

Phillips recognises that periodic DBIRD external compliance audits and inspections will be made to monitor, assess and validate the level of Phillips' performance and compliance pursuant to the commitments made in the accepted Environmental Management Plan.

Phillips also proposes to conduct the following in-house audits:

- **Site Internal Environmental Audit** – to enable site management to assess the day-to-day environmental management of activities at the site. Environmental activities include all aspects of operations that result in emissions, effluent or wastes.

- **Environmental Management Systems Audit** - to assess the implementation and operational success of the EMS at the site. This is achieved by assessing the objectives, organisational structure, responsibilities, procedures, processes and resources available at the site. The EMS Audit is a systems assessment, rather than an audit of environmental compliance, which is assessed through the Site Internal Environmental Audit.

The above auditing activities will also facilitate Phillips' intention to provide annual greenhouse and energy efficiency reports as part of its Cooperative Agreement under the Greenhouse Challenge Programme and, ultimately, the framework for public sustainability reporting.

5.9 PROJECT DECOMMISSIONING

Phillips remains committed to the original position stated in the Preliminary EMP that, at the end of the project life, the plant will be decommissioned in accordance with standard practice applicable at the time.

Once all resources are exhausted and no feed is available for the LNG plant, plant equipment and piping will be purged of hydrocarbons. Plant and office equipment will be sold where possible unless the facility is sold as is. Equipment that cannot be sold will be disassembled and sold as scrap or disposed of in accordance with current regulatory guidelines. This includes the construction dock and product loading jetty.

The plant site will be rehabilitated in consultation with the Northern Territory Government as appropriate if the site is not sold and will not be utilised for other purposes.

6. INFORMATION SOURCES AND ACKNOWLEDGMENTS, REFERENCES AND GLOSSARY

6.1 INFORMATION SOURCES AND ACKNOWLEDGMENTS

6.1.1 Study Team

URS Project Team

Ian LeProvost – Project Manager and Lead Consultant
Tim Mitchell – Project Officer
Jill Regazzo – Project Coordinator
Ross Broun, Will Blackshaw and Justin Dwyer - Cartography
Peter Mueller – Darwin Project Manager
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Bechtel Corporation

Raj Kulkarni

Specialist Consultants

Bechtel	Atmospheric Emissions Modelling (Appendix C) Noise Modelling (Appendix E) Hazard and Risk Assessment (Appendix G)
EcoSystems	David Metcalfe - Visual Impact Assessment (Appendix F)
Quest	Preliminary Siting Study (Appendix G)
URS	Dr Don Burnside and Andrew Thomson Greenhouse Offsets Review (Appendix D) Peter Elliott Sustainability Indicator Development

6.1.2 Acknowledgments

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Scott Whiting	Northern Territory University
Kirsten Williams	Northern Territory Department of Infrastructure, Planning and Environment
Bruce Wilson	Darwin Port Corporation

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6.3 GLOSSARY

°C	Degrees Celsius
µg/L	Microgram per litre (essentially one part per million)
µm	Micrometre (one thousandth of a millimetre)
AAPA	Aboriginal Areas Protection Authority
AFMA	Australian Fisheries Management Authority
AFZ	Australian Fishing Zone
AGO	Australian Greenhouse Office
AHD	Australian High Datum (a tidal measurement)
ANZECC	Australia and New Zealand Environment and Conservation Council
AQIS	Australian Quarantine Inspection Service
Bcm	Billion cubic metres
CCNT	Conservation Commission of the Northern Territory
CO_2	Carbon dioxide
CPI	Corrugated plate interceptor
dB(A)	Decibels (a measuring unit for noise)
DBIRD	Northern Territory Department of Business, Industry and Resource Development (formerly DPIF, DME)
DHCS	Northern Territory Department of Health and Community Services (formerly THS)
DIPE	Northern Territory Department of Infrastructure, Planning & Environment (formerly DLPE, DTW & PWS)
DPC	Darwin Port Corporation
dwt	Dead weight tonnes
EA	Environment Australia
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMT	Emergency Management Team
ERG	Emergency Response Group
ERM	Emergency Response Manual
ERP	Emergency Response Plan
HES	Health, Environment & Safety
km	kilometre/s
LDM	LeProvost Dames & Moore
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LAT	Lowest astronomical tide
m	metre/s
MAGNT	Museums and Art Galleries of the Northern Territory
MHL	Manly Hydrographic Laboratories
Mkg	million kilograms (tonne)
mm	millimetre/s
MMBBL	million barrels
MMCFD	million cubic feet per day
mmscfd	million standard cubic feet per day
MTPA	million tonnes per annum
NGL	Natural gas liquid
NHMRC	National Health and Medical Research Council
NHT	Natural Heritage Trust
nm	mautical mile
NOI	Notice of intent
NO_X	mitrogen oxides
OH&S	Occupational Health & Safety
OSCP	Oil Spill Contingency Plan
OSRG	Oil Spill Response Group
PAWA	Northern Territory Power and Water Authority
PER	Public Environmental Review
pers comm./s	personal communication/s
ppm	parts per million
ppt	parts per thousand
ria	drowned river system
SO_2	sulphur dioxide
TBT	tributyltin (an antifoulant added to boat paints)
train	LNG processing section of the plant
VOC	volatile organic compound
v/v air	volume per volume of air
ZOC	Timor Gap Zone of Co-operation between Australia and Indonesia (to be known in future as the Joint Petroleum Development Area between Australia and East Timor)
ZOCA	Section A of the ZOC