4 Project Description

4 PROJECT DESCRIPTION

4.1 Introduction

This chapter of the draft environmental impact statement (Draft EIS) for the Ichthys Gas Field Development Project (the Project) describes the major infrastructure components and supporting facilities required to take the Ichthys Field to commercial production. These include the installation of subsea and processing facilities offshore, the installation of a subsea gas export pipeline, and the construction of an onshore gas-processing plant and export facilities. The construction and installation of these components are described sequentially from the Ichthys Field through to Darwin Harbour, and from the Harbour to the onshore processing plant at Blaydin Point.

Environmental, social, economic and safety criteria have been considered in the selection of technically viable design alternatives. Where applicable, these criteria are included in the descriptions of Project components in this chapter.

Many of the terms used in this chapter for equipment, processes and practices are defined in the glossary to this Draft EIS.

4.1.1 Major infrastructure

The infrastructure required for the Project will consist of offshore gas and condensate extraction, processing, storage and transportation facilities; a subsea pipeline; and onshore gas-processing and export facilities at Blaydin Point. Key considerations in the design of the offshore and onshore facilities include the following:

- ensuring the health, safety and welfare of personnel working on the Project
- minimising any negative impacts the Project might have on the environment and the Northern Territory community
- fulfilling all relevant territory and Commonwealth legislative obligations
- incorporating projected climate-change scenarios into the design, for example potential rises in sea level and/or temperature change
- developing and maintaining a culture of corporate social responsibility in respect of the community and a wide range of stakeholders
- providing a reliable long-term supply of LNG, LPGs (propane and butane) and condensate to customers.

The following represents the “base case” infrastructure proposed as part of this Draft EIS as developed in the front-end engineering design (FEED) phase. As FEED progresses and the Project moves into the detailed-design phase, the design of this infrastructure will be refined.

Subsea infrastructure at the offshore development area will consist of the following:

- approximately 50 subsea wells drilled from between 12 and 15 drill centres, developed over a period of 40 years
- control umbilicals, service lines and wet-gas, corrosion-resistant infield flowlines.

The subsea infrastructure will be tied back to a floating central processing facility (CPF) by a series of flexible risers, flowlines and umbilicals. The CPF in turn will be connected to a floating production, storage and offtake (FPSO) facility by a transfer system consisting of flexible risers and flowlines as well as by a communications umbilical. Both the CPF and FPSO, as presented in Figure 4-1, will be moored in position for the expected 40-year life of the Project.

These facilities will provide the following services:

- The CPF will be used for gas–liquid separation; gas dehydration; gas export; future inlet compression; and export of a commingled stream of condensate, monoethylene glycol (MEG) and water to the FPSO. (The MEG is used to prevent the formation of hydrates, primarily between methane and water.)
- The FPSO will be used for condensate dewatering and stabilisation, condensate storage and export, MEG regeneration, and produced-water treatment.

A subsea gas export pipeline with an outside diameter of approximately 42 inches (*c*.1.07 m) and approximate length of 852 km will be installed between the offshore development area and the entrance to Darwin Harbour. (The total length of the pipeline from the CPF to the receiving facilities at the gas-processing plant at Blaydin Point will be approximately 885 km.) The pipeline will be weight-coated with concrete for stabilisation on the seabed, but sections will also be afforded additional protection, where required, by trenching and “rock dumping” depending on depth and location.

Nearshore infrastructure will consist of the following:

- an approximately 27-km length of the subsea gas export pipeline from the mouth of Darwin Harbour parallel to the existing Bayu–Undan Gas Pipeline to the western side of Middle Arm Peninsula
- a pipeline shore crossing on the western side of Middle Arm Peninsula
- a module offloading facility on Blaydin Point for receiving prefabricated gas-processing modules and some construction materials
- a product loading jetty on the north-western end of Blaydin Point with one berth for LNG export and one for LPG and condensate export

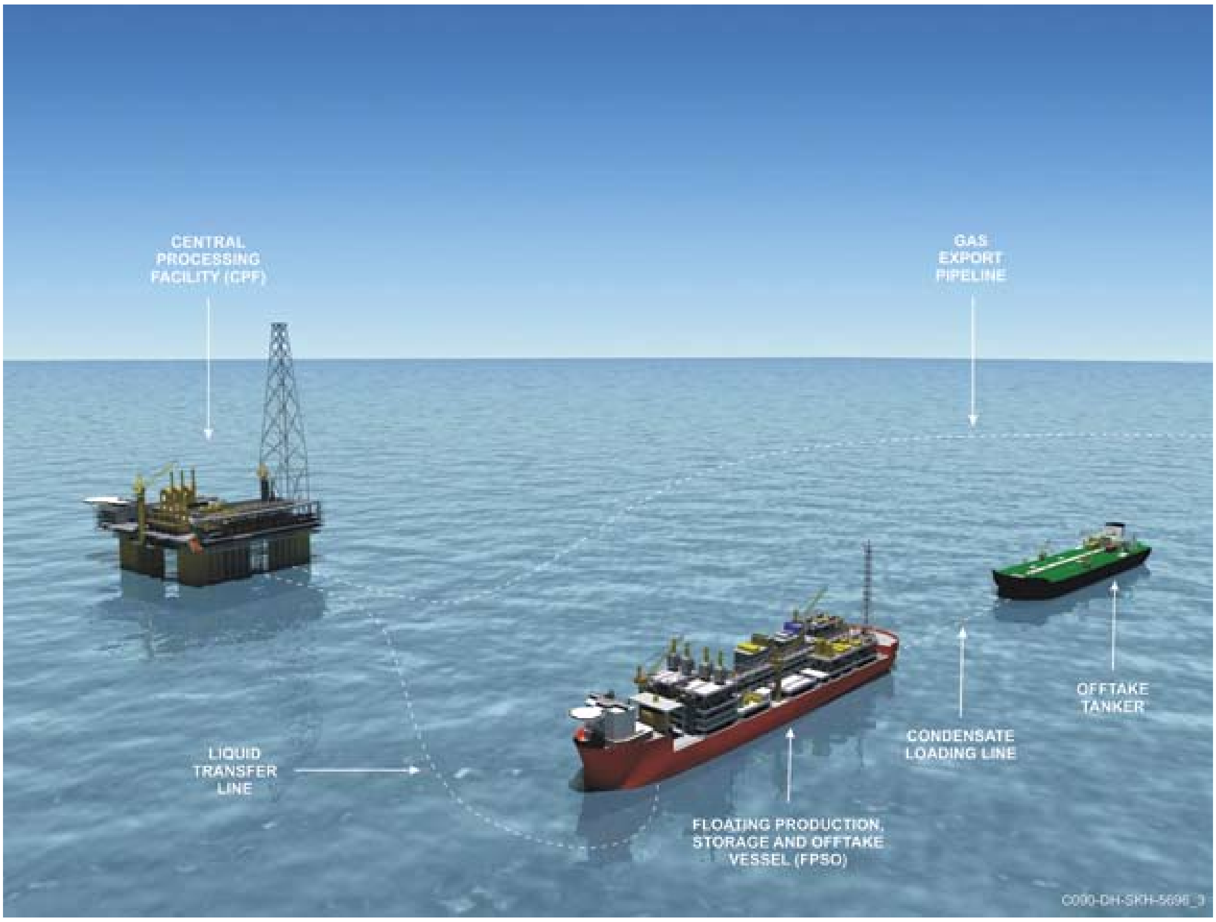

Figure 4-1: Indicative schematic of the offshore floating facilities

- a shipping channel, approach area, turning basin and berthing area for the product tankers
- a dredge spoil disposal ground outside Darwin Harbour, 12 km north-west of Lee Point.

Onshore infrastructure will consist of the following:

- a 6-km-long onshore pipeline corridor from the shore-crossing area to the Blaydin Point gas-processing plant site
- a gas reception area with a pig receiver and a slug catcher
- two gas liquefaction trains (each producing approximately 4.2 Mt/a of LNG)
- gas treatment facilities (for acid gas removal, dehydration, and mercury removal)
- a propane and butane fractionation plant
- a condensate stabilisation plant
- utilities distribution and storage (power generation, fuel, water, nitrogen, compressed air)
- storage tanks (two tanks for LNG; two large and one small tank for condensate; and one tank each for propane and butane) and LNG and LPG recovery units for boil-off gas
- an emergency gas flare system consisting of a ground flare and enclosed tankage flares
- a wastewater drainage and treatment system
- various other installations, including a warehouse, workshops, a fuel storage area, firefighting facilities, a guard room and security buildings, and a control room.

Onshore permanent supporting facilities such as communications, security and administration buildings will be located in a site administration area south of Blaydin Point in the central part of Middle Arm Peninsula.

An indicative schematic of the onshore and nearshore infrastructure is presented in Figure 4-2.

Other facilities required to support the Project that are not directly assessed in this Draft EIS include the following:

- an accommodation village for the workforce during the construction period
- quarries for the supply of fill, rock and aggregate
- a rock load-out facility and stockpile area for transferring rock for subsea pipeline stabilisation
- a maritime supply base for onshore and offshore operations
- a tug harbour
- waste disposal resources
- utility corridors (e.g. for power and water).

These facilities will either be supplied by third parties or will be subject to separate approval processes.

Figure 4-2: Indicative schematic of the onshore and nearshore infrastructure at Blaydin Point

4.1.2 Site selection

Following the appraisal of the Ichthys Field's gas and condensate reserves, INPEX investigated the options to bring the hydrocarbon products to market. Currently available technology for the processing of LNG for export involves the development of large onshore gas-processing trains with deepwater anchorages for LNG tankers. A decision was made by INPEX to pursue this proven technology for the Project.

The selection of a site for the onshore gas-processing component of the Ichthys Project commenced with studies conducted in 2002 that assessed a number of possible locations. These studies indicated that the Maret Islands in the Kimberley region of Western Australia were the most appropriate location for the onshore facility; this was based on what was understood at that time of the environmental, political, engineering and commercial constraints.

INPEX initiated an approvals process with the Commonwealth Government in May 2006 in order to pursue the Maret Islands option, referring its proposal to develop the Ichthys Field to the Commonwealth's Department of the Environment and Water Resources (DEW)[1] and Western Australia's Environmental Protection Authority (EPA). These agencies determined that the Project should be formally assessed at the EIS and the ERMP (environmental review and management program) levels respectively.

Work accordingly began on the preparation of a draft EIS/ERMP for the Maret Islands location.

By 2007, significant uncertainty relating to INPEX's ability to develop the LNG facility at the Maret Islands location in the Kimberley region became apparent. Consequently, INPEX revisited sites that were considered in earlier stages of the Project's site-selection phase and determined that it would be technologically feasible to export Ichthys gas to an onshore gas-processing location in the Darwin region, despite the considerably greater length of subsea pipeline that would have to be constructed to transport the gas. During this period, the Northern Territory Government offered INPEX the Blaydin Point site for the onshore components of the Project.

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[1] The Commonwealth's Department of the Environment and Water Resources became the Department of the Environment, Water, Heritage and the Arts (DEWHA) in December 2007.

It is the Northern Territory Government's preferred site for an LNG facility and is primarily zoned for industrial development under the Northern Territory Planning Scheme[2].

In order to facilitate the acquisition of land tenure, INPEX initiated discussions with the Northern Territory Government which led to the signing of a Project Development Agreement (PDA) on 18 July 2008 by INPEX Browse, Ltd., Total E&P Australia, and the Northern Territory Government. The PDA outlined the approximate plan for the onshore area of the Project as well as conditions that are required to be fulfilled in order to gain land tenure. The ongoing discussion regarding land tenure of the onshore development area will be based on the adjusted development area boundaries as presented in this Draft EIS.

4.1.3 Design alternatives

Consideration of environmental, social, economic and safety criteria has been included in the concepts and designs selected for the Project. Technically feasible design concepts that have been particularly influenced by these criteria include the following:

- alternative subsea pipeline routes, shore-crossing locations and onshore pipeline routes
- alternative locations for offloading the modules for the onshore gas-processing plant, that is, whether to build a new module offloading facility at Blaydin Point or to use the existing facilities at East Arm Wharf and transport the modules to site by road
- alternative concepts for the product loading jetty and navigation channels at Blaydin Point
- alternative locations for a dredge spoil disposal ground
- alternative onshore gas-processing plant layouts.

INPEX also considered a number of alternative offshore processing concepts and selected the one considered most appropriate for the scale of the Project and the location of the Ichthys Field.

Alternative locations and designs of the accommodation village for the construction workforce are subject to a series of separate approvals from the regulatory authorities that are not within the scope of this Draft EIS.

4.1.4 Consequences of adopting the "no development" option

As the permit holder and Operator of the Ichthys Project, INPEX has an obligation to undertake exploration of its permit area, to verify the nature and extent of the hydrocarbon reserves which it contains and to investigate the manner in which these reserves can be commercialised. Should the Project be commercially viable and not proceed, INPEX would not be fulfilling its obligations.

In addition, significant social and economic advantages resulting from the Project would be lost to northern Australia in general and to the Darwin region in particular. The Project has the potential to generate substantial new export income, to create numerous employment opportunities and to strengthen the Northern Territory's economic development. It would be the largest private-sector investment in the history of the Darwin region and would provide opportunities for business and employment for over four decades.

Predictions from economic modelling indicate that the gross state product (GSP) of the Northern Territory would be on average almost 18% higher each year as a result of the Project. It is also predicted that the Project will contribute A$3.5 billion (an additional 0.2%) to Australia's gross domestic product (GDP).

The economic model and other potential positive impacts are assessed in detail in Chapter 10 *Socio-economic impacts and management*.

4.1.5 Development schedule

The construction phase of the Project will cover a period of 5 to 6 years from the final investment decision (FID) to the production of first LNG cargo. Figure 4-3 presents the indicative construction schedule. As presented, construction and commissioning of the second LNG train will continue as gas is being produced from the first LNG train. From the commencement of commissioning, the aim is to run both the offshore and onshore facilities continuously for the duration of the anticipated 40-year life of the Project.

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[2] Department of Planning and Infrastructure. 2008. *Northern Territory planning scheme*. Department of Planning and Infrastructure, Darwin, Northern Territory.

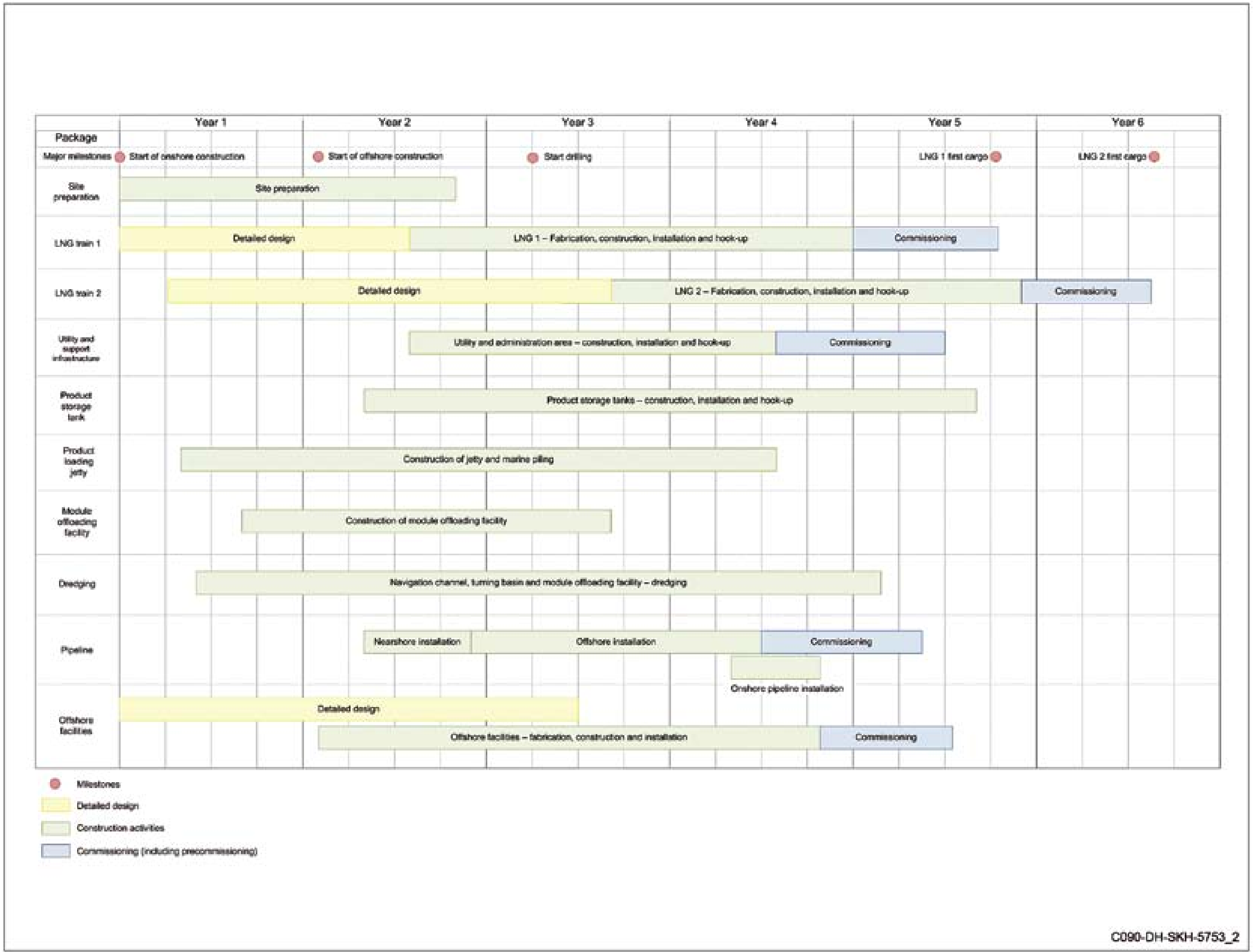

Figure 4-3: Indicative development schedule

Key steps in the development process include the following:

- *Pre-front-end engineering design (pre-FEED):* Oil and gas reserves, market opportunities, possible offshore and onshore locations, technology options and preliminary design options are evaluated. The objective is to determine if the Project is likely to be viable.
- *Front-end engineering design (FEED):* The design of the facilities is defined in more detail. No significant investments in equipment or technologies are made during this phase. The objective is to progress designs, cost estimates, schedules and approvals to a high enough level of certainty to allow for a final investment decision to be made.
- *Final investment decision (FID):* By this point, technical viability, schedule, budget, environmental approvals, land tenure and community relations have been progressed to a high enough level of accuracy and certainty to allow for a decision on whether or not to proceed with funding the Project as designed by the FEED process.
- *Detailed design:* The major engineering contractors design offshore and onshore facilities in enough detail to allow construction. Orders are placed and commitments are made for expensive equipment and off-site construction and assembly facilities (e.g. drilling-rig operators, shipyards, module yards, and the pipe mills to make 42-inch steel pipe for the gas export pipeline).
- *Construction and precommissioning:* INPEX and the major engineering contractors work to construct and install the Project infrastructure and supporting facilities (e.g. wells are drilled, the CPF and FPSO are sailed into place; LNG plant modules are brought from offshore yards; pipelay barges lay the gas export pipeline; and dredging takes place). Construction includes precommissioning activities such as hydrotesting of vessels, pipework and equipment.
- *Commissioning:* Systems are function-tested before the first hydrocarbons are introduced into the CPF from the reservoir and are directed to the onshore facilities to begin production of saleable products. Commissioning teams work to achieve steady-state operations, resolve issues, and make sure that facilities operate and perform as intended.
- *Operations:* Start-up issues have been resolved and a smaller operations team takes over operation of all facilities for the long term.
- *Decommissioning:* At the end of the useful life of the field, the wells are plugged and abandoned and the onshore and offshore facilities are decommissioned.

4.1.6 Ichthys Field reservoir characteristics

The Ichthys Field encompasses an area of approximately 800 km^2, with water depths ranging from 235 to 275 m (Figure 4-4). The field consists of two reservoirs: an upper reservoir in the Brewster Member and a lower reservoir in the Plover Formation. Notable physical characteristics of the Ichthys Field that will influence the location, design and the resulting environmental management of the proposed Project facilities include the following:

- its remote location
- the depth, pressure and temperature of the gas and liquids in the reservoirs
- the porosity and permeability of the reservoirs
- the water depth and seabed characteristics.

The percentage gas compositions for the major gas constituents in the Brewster Member and Plover Formation are presented in figures 4-5 and 4-6. In addition, traces of impurities such as hydrogen sulfide (H_2S) and mercury (Hg) also exist in the gas and liquid streams. Extraction of these impurities is expected and disposal mechanisms will be designed to suit the quantities recovered.

Produced formation water is saline water found as a liquid in a natural-gas formation along with the gas. Condensed water is produced from the processing of the gas when water vapour (evaporated into the gas) cools and condenses to a liquid. This condensed water is typically non-saline. Produced water is the combination of produced formation water and condensed water.

The peak production of produced water is expected to be approximately 3250 m^3/d in Year 23 of the Project as indicated in Figure 4-7.

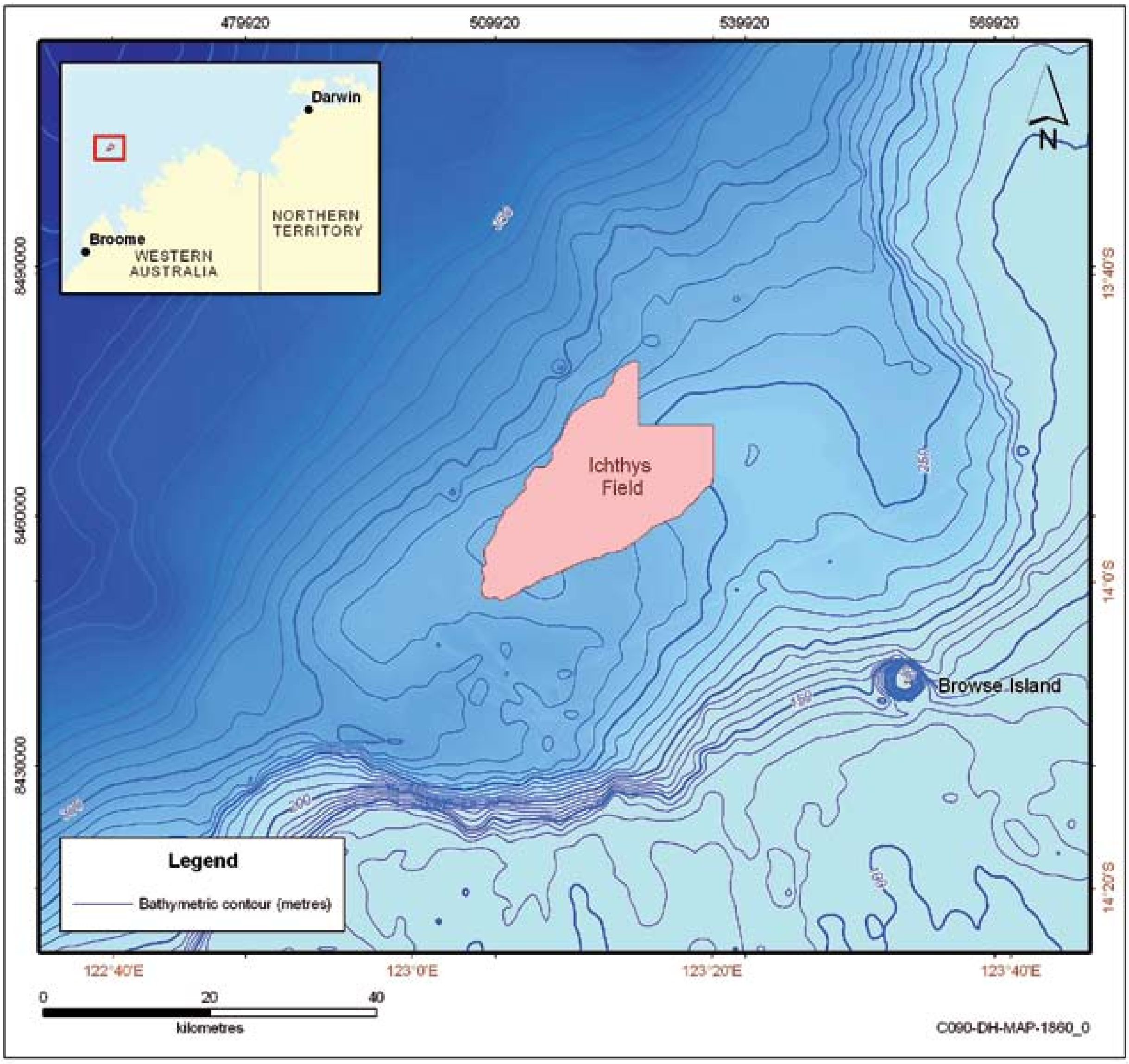

Figure 4-4: Location of the Ichthys Field

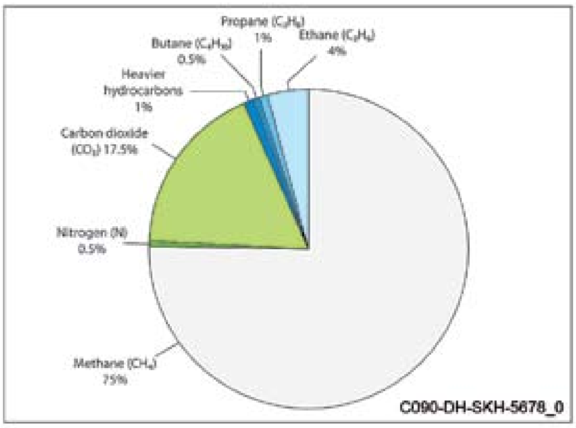

Figure 4-5: Plover Formation gas composition (mol %, excluding condensed water)

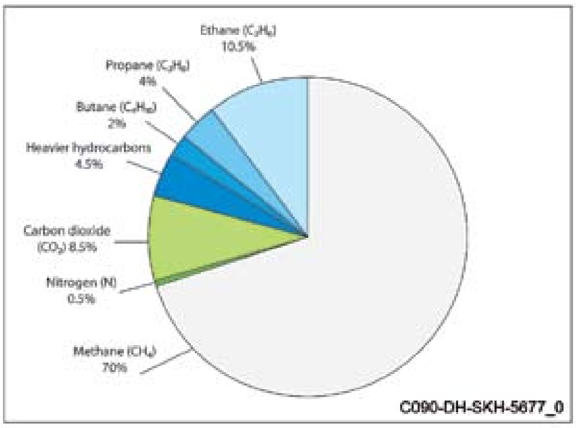

Figure 4-6: Brewster Member gas composition (mol %, excluding condensed water)

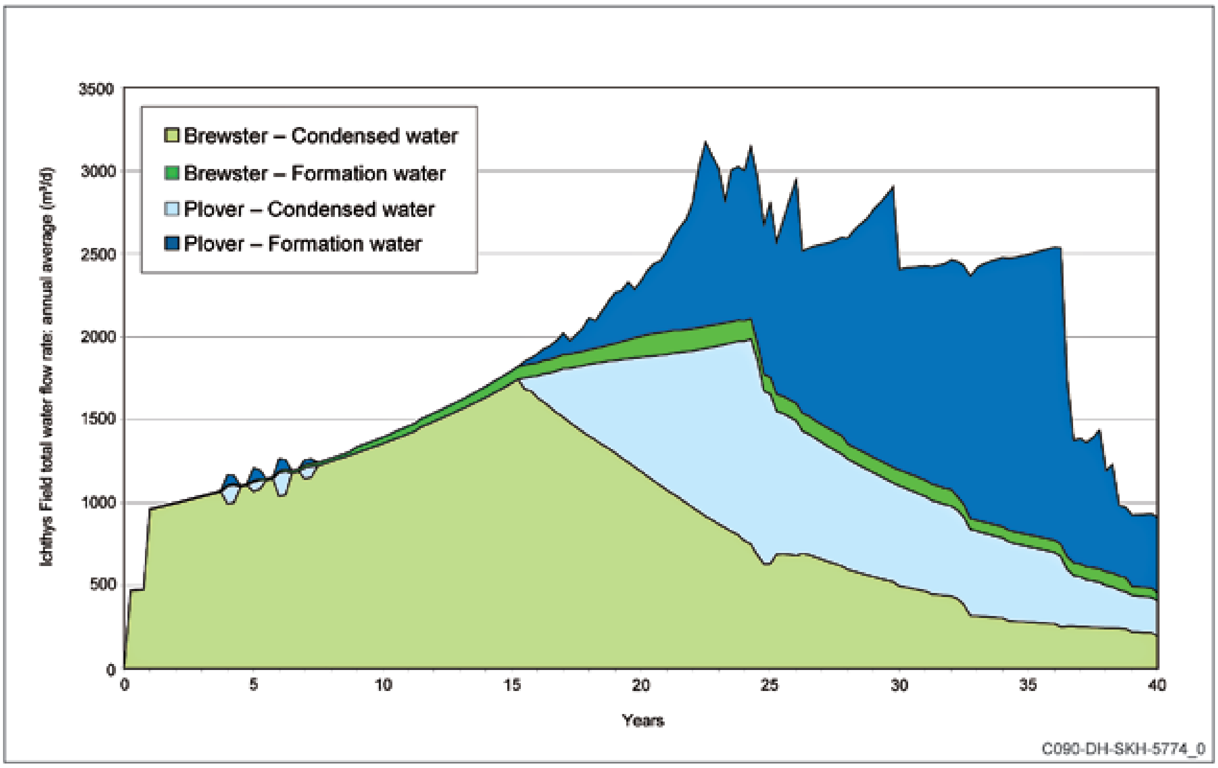

Figure 4-7: Average volumes of produced water discharged from the offshore facilities over the 40-year life of the Project

4.1.7 Products

The operating life of the Project is expected to be approximately 40 years. Over this period, hydrocarbon gas and liquids will be extracted from the Ichthys Field, processed both at the field and at Blaydin Point and then exported as the following products:

- *Liquefied natural gas:* LNG consists primarily of methane (CH_4), with some ethane (C_2H_6), that has been treated to remove almost all impurities in order to meet the buyers' gas-quality specifications. Following treatment, the natural gas is cooled by refrigeration to its liquefaction temperature of around –160 °C. LNG is approximately one six-hundredth the volume of natural gas at standard temperature and pressure, making it cost-efficient to transport over long distances. It is stored in cryogenic storage tanks at around –160 °C and is transported in custom-designed cryogenic ships to LNG reception and regasification terminals. INPEX plans to export approximately 8.4 Mt of LNG from the Blaydin Point facility each year.
- *Liquefied petroleum gas:* LPG is the general term for liquefied propane (C_3H_8) and butane (C_4H_{10}). These can be sold either as separate products or as a mixture. The Blaydin Point facility will produce and export these as separate products. Both propane and butane are gases under standard temperature and pressure and have to be refrigerated or compressed in order to be stored as liquids. INPEX plans to produce propane and butane at a rate of approximately 1.6 Mt/a.
- *Condensate:* This is essentially light oil that consists of a mixture of hydrocarbons, normally in the carbon-chain range of C_4 and above, which are liquid at standard temperature and pressure. Condensate does not require refrigeration for storage or transport. The bulk of the Project's condensate will be exported directly from the Ichthys Field at an average rate of 85 000 barrels per day (at the start of LNG production) after processing on the FPSO, with an additional 15 000 barrels per day being produced and exported by sea from the onshore processing plant at Blaydin Point.

4.2 Offshore infrastructure

The infrastructure and associated activities required in the offshore development area to manage the extraction, processing and export of hydrocarbons from the Ichthys Field are listed in Section 4.1.1 *Major infrastructure*. These are described in more detail in the following sections.

4.2.1 Drilling of subsea wells

Development of the Ichthys Field will require the drilling of approximately 50 wells over the Project's lifetime. A number of these will be drilled in the initial construction period, with remaining wells and drill centres being added to maintain gas production as the two reservoirs are depleted over time. Wells will be drilled in groups to optimise the efficiency of rig operations and to minimise the Project's footprint on the ocean floor.

Wells will be drilled using directional-drilling technology as this allows for clustering of wells and subsea facilities. Drilling will be undertaken using a semi-submersible mobile offshore drilling unit (MODU) kept in position by 8 to 12 anchors (see Figure 4-8). Drilling activities involve the boring of a sequence of holes of decreasing diameter (typically starting at 1 m) at increasing depths until the target reservoir is reached. Steel casing is then inserted into the holes and cemented into place.

In the process of drilling, the crushed and ground rock generated by the drill bit (the "drill cuttings") are continuously removed from the hole using drilling fluids. The type of drilling fluid used depends on the type of rock being drilled, with synthetic-based muds generally being used deeper in the boreholes. Drilling fluids are also important in well control.

Table 4-1 presents the types of drilling fluid used for different diameters of drill bits and hole sections. The final choice of fluids will be determined during the drilling programs.

Figure 4-8: Indicative schematic of a semi-submersible drilling rig

Table 4-1: Drilling fluid types

Drill-bit diameter (inches)*	Drilling-fluid type
42 to 26	Water-based muds (sea water and high-viscosity gel sweeps)
17½ and 16 to 17½	Water-based mud (polymer gel)
12¼	Synthetic-based muds
8½	Synthetic-based muds (with calcium carbonate ($CaCO_3$))

* 1 inch = 25.4 mm.

4.2.2 Subsea system

The subsea system will consist of wellheads, “subsea trees” and associated manifolds and flowlines, together with umbilicals to communicate with the seabed structures from the CPF. The completion of permanent production wells will enable the production of reservoir fluids. The wells will be drilled in the Brewster and Plover reservoirs over the life of the Project in cluster formations, tying back to subsea manifolds.

Indicative locations of the subsea wells and the drill centres are presented in Figure 4-9.

A subsea wellhead is installed at the top of each well and is used to support the inner casing of the well. Each subsea tree consists of a series of valves and other instruments which are connected to the CPF through umbilicals to allow control and monitoring of the production from each well. An example of a subsea system is shown in Figure 4-10.

The clusters of subsea trees will be connected to manifolds which are required to gather and commingle the produced fluids into flowlines for transport to the CPF. The control valves on the subsea system will use either an open or a closed-loop hydraulic system. The open-loop system releases a small amount of

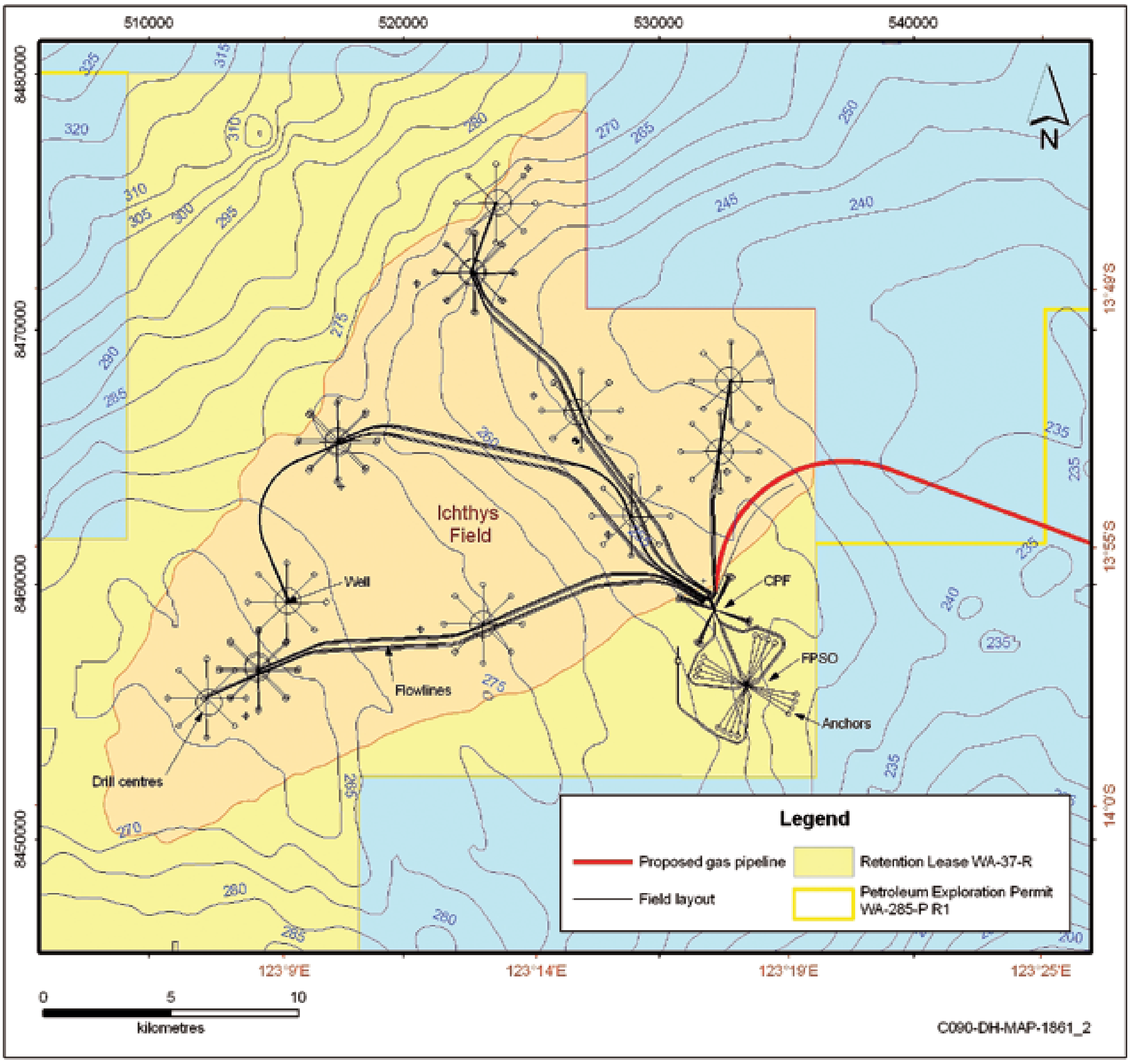

Figure 4-9: Indicative field layout showing subsea facilities

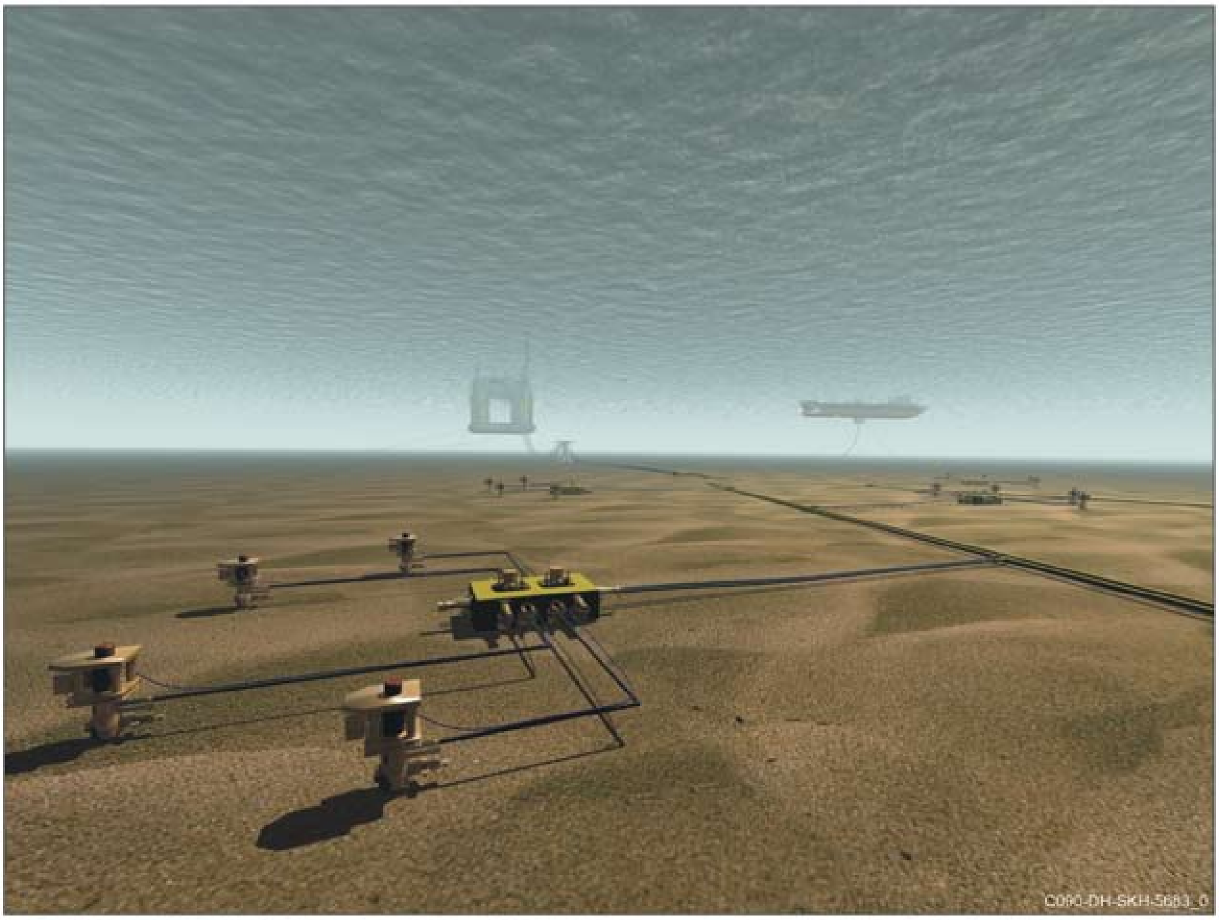

Figure 4-10: A typical layout for a subsea system

hydraulic fluid to the sea each time a valve is opened and closed, while the closed-loop system contains the fluid but has a detrimental effect on valve closure time. The final choice of system is likely to be open-loop; however, performance evaluation of these two systems will be undertaken during detailed design.

From the production manifolds, the reservoir fluids will flow towards the CPF through flowlines. The flowlines terminate at the subsea safety isolation valves. Flexible risers connected to the subsea safety isolation valves provide a conduit for reservoir fluids to reach the CPF. Umbilicals will also run from the CPF to individual wells and subsea trees to provide services, chemicals and controls. These umbilicals consist of an array of small tubes and electrical cables within a single large-diameter pipe.

The production system, infield flowlines and risers are internally corrosion-resistant and protected from produced fluids and sand particles. Production flowlines will also be insulated to maintain fluid temperature within acceptable levels and sacrificial anodes and anticorrosion paints will be used to protect each flowline against external corrosion.

Construction and installation of subsea system

The subsea trees and manifolds will be installed by the MODU or another installation vessel after the drilling process has been completed. Once the subsea trees and manifolds are in place, flowlines will be laid by pipelay vessels, flexible risers will be connected, and these risers and umbilicals will be connected to the CPF after it has been installed.

4.2.3 Offshore processing facilities

INPEX has selected a semi-submersible processing platform concept for receiving, processing, storing and exporting hydrocarbon gas and fluids from the Ichthys Field.

Hydrocarbon gas will be exported from the CPF through a subsea pipeline to the onshore facilities at Blaydin Point, Darwin. Most of the condensate will be exported from the FPSO to tandem-moored offtake tankers. A safety exclusion zone with a radius of 500 m will be put in place around surface equipment in the offshore development area. A cautionary zone will also be established, in consultation with the appropriate authorities, to protect it from potential damage from anchors, trawl nets, etc.

An indicative offshore process is presented in Figure 4-11.

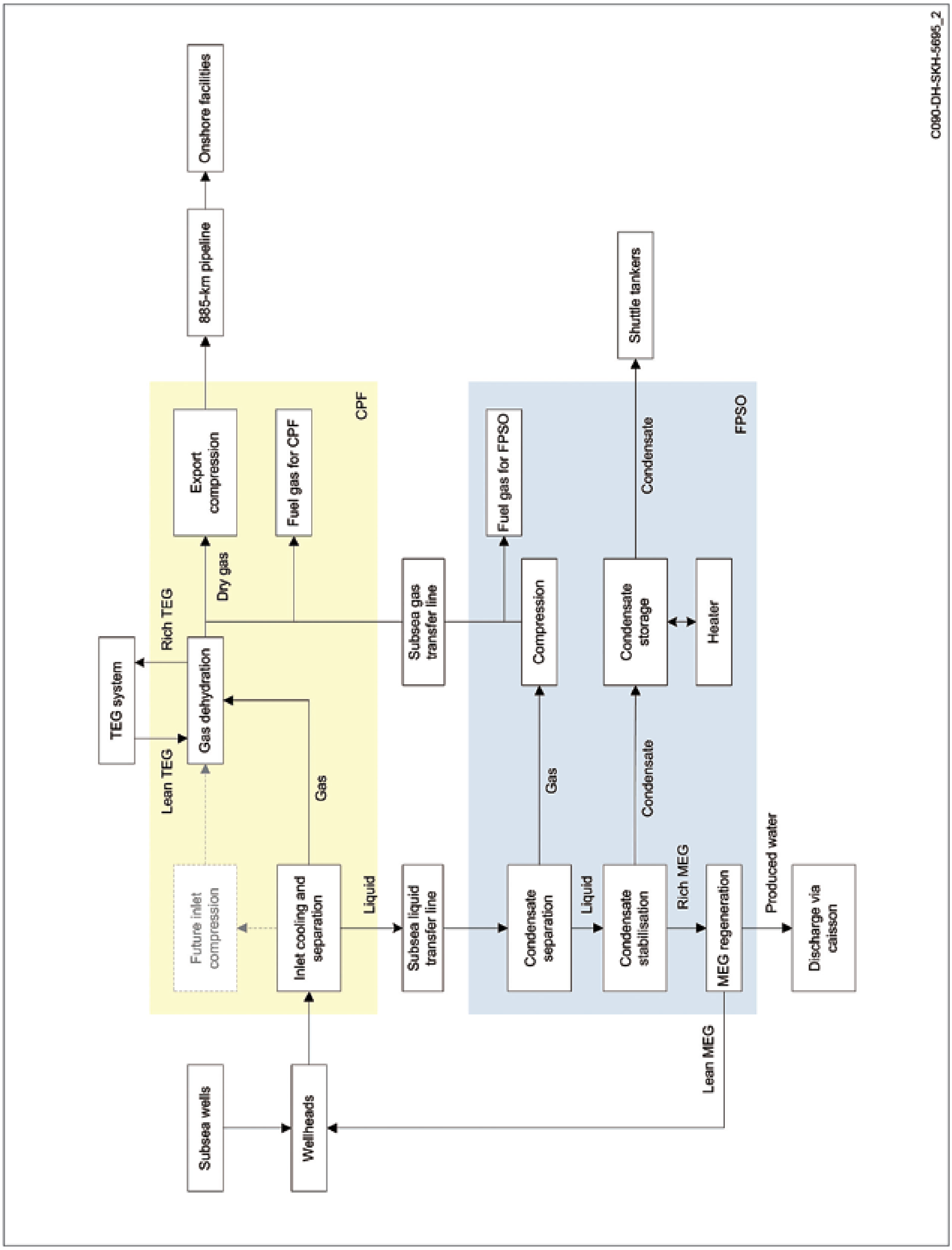

Figure 4-11: Offshore process flow diagram

Central processing facility

The CPF will be moored in a water depth of approximately 250 m and will be based on a semi-submersible floating production design that will remain at the Ichthys Field for the duration of the Project. The CPF will likely be oriented in a north-west – south-east direction to maximise ventilation from prevailing winds. This orientation provides good ventilation across the facility and supports maritime logistics operations at the facility.

The CPF will be moored in place using between 24 and 32 chain-mooring systems and suction piles. Figure 4-12 shows an example of a similar facility, the floating production unit *Asgard B*, operating in the Norwegian Sea in the North Atlantic.

Figure 4-12: Example of a semi-submersible processing platform, the *Asgard B*

The well-stream fluids will be directed to the CPF where reception facilities will separate the gas from the liquids. The gas will be dehydrated using triethylene glycol (TEG) to meet the export water dewpoint specification to prevent condensation of water and potential hydrate formation and corrosion in the gas export pipeline. A circulating TEG system will be used (along with compression and cooling). The dehydrated gas will be compressed and exported to the onshore facilities at Blaydin Point.

The liquid stream from the reception facilities, consisting of a commingled stream of condensate, water and MEG, will be routed to the FPSO for further treatment.

Gas inlet compression will be required to maintain sufficient suction pressure to the export gas compression after approximately Year 11 when the well-stream fluid's arrival pressure will decline.

The emergency flare system will be designed for blowdown of the facilities in the event of an emergency, in line with industry codes and standards. It will comprise a high-pressure flare and a low-pressure flare on a common stack with a pilot and ignition system.

Services and utilities on the CPF will include the following:

- a power generation and distribution system
- a fuel-gas supply system which will provide fuel to the power generation gas turbines
- an instrument air system to provide clean dry air and nitrogen to process units
- a chemical injection package to provide dosing chemicals such as MEG, scale inhibitors, wax inhibitors and hydraulic fluids
- a subsea control support system
- a fuel storage facility (diesel fuel will be bunkered in storage tanks within the hull of the CPF)
- open and closed drainage systems to separate deck drainage from hazardous and non-hazardous areas
- a bilge system to drain watertight compartments
- a ballast system to manage the draught of the CPF.

All non-process services and living quarters will be located in non-hazardous areas.

The CPF will have accommodation for up to 150 people on board. Its facilities will include galley units; a helicopter deck; firefighting systems; material, waste and chemical storage areas; a reverse-osmosis (RO) plant to provide potable water; and a sewage discharge system. In addition, a diesel emergency generator will provide a backup power supply for essential services and power when main power generation is unavailable. Cathodic protection of the external hull of the CPF will be provided.

Discharges from the CPF are discussed in Chapter 5 *Emissions, discharges and wastes*.

Floating, production, storage and offtake facility

The FPSO will be ship-shaped, similar to an oil trading tanker, but without propulsion, steering and navigation systems. It will be permanently moored at the designated field location for the life of the field. The facility will be equipped with hydrocarbon processing and MEG regeneration facilities. The FPSO will have a condensate storage capacity of more than 1 000 000 barrels.

The FPSO will be turret-moored, permitting 360° weathervaning. To assist in heading control and to mitigate roll movements while weathervaning, it may be fitted with ancillary thrusters. The turret connecting the FPSO to the seabed will have mooring legs with suction piles located in such a way that the distance from its stern to the CPF will be approximately 2–3 km with consideration of the prevailing winds and currents.

Figure 4-13 shows an example of an existing FPSO vessel.

Figure 4-13: Example of an FPSO

The FPSO topsides will receive liquids from the CPF. Processing of the liquids on the FPSO will include condensate stabilisation, mercury removal from the condensate, MEG regeneration and reclamation and produced-water treatment facilities.

The stabilised condensate will be stored within the hull of the FPSO prior to export to offtake tankers. Gas that comes off the liquid stream will be cooled, compressed and used for FPSO fuel gas, with any excess being sent back to the CPF where it will be commingled with the untreated gas arriving from the wells.

Waste-heat recovery systems will be installed on gas turbines to provide heat to the condensate stabilisation and MEG regeneration facilities.

The MEG regeneration facilities will remove most of the water and salt from the “rich MEG” so that “lean MEG” can be pumped back to the wellheads for reuse.

Produced water from the MEG regeneration plant will be further treated in produced-water treatment facilities to meet the required discharge standards prior to discharge to sea.

Some types of services and utilities found on the CPF will also be required on the FPSO, including accommodation quarters for up to 150 personnel, communication systems, a power generation plant, cooling and heating media, ballast and bilge systems, and flare systems. Cathodic protection of the external hull of the FPSO will be provided.

4.2.4 Construction and installation of offshore processing facilities

Both the CPF and the FPSO will be constructed at off-site fabrication yards and will be towed to the field as single units. The hull of the CPF will include pontoons, columns, the deck, hull ballast and support systems, living quarters, process and utility equipment, and the flare boom. Integrated deck modules will also be constructed in overseas fabrication yards and will most likely be installed on the CPF at the fabrication yard. As far as is practicable, all components of the CPF and FPSO will be comprehensively tested and commissioned at the fabrication yards before being transported to the Ichthys Field.

During towing to site, the CPF and FPSO will be manned and have fully functional living quarters and support systems. Once the CPF and FPSO are on location in the field they will be detached from their respective towing vessels and held in position by tugs while the permanent mooring systems are attached. Following detachment from the towing vessels, they will be de-ballasted for operation. The power generators will be started on diesel fuel.

The subsea pipeline and flowline risers will be installed between the seabed and the CPF and all the recently connected joints will be pressure-leak-tested with treated sea water. All leak- and pressure-testing of pipework offshore, similar to the process used for testing all hydrocarbon pipework, vessels and valves on the CPF and FPSO at the fabrication yards, will be undertaken using hydrotest water and/or high-pressure nitrogen containing trace quantities of helium for detection.

4.2.5 Offshore commissioning, operations and maintenance

The completion of the CPF and FPSO will coincide with the completion of the onshore plant. When all facilities are certified as ready for start-up, the first reservoir fluids will be introduced into the system. The first well will be opened on a reduced opening to permit safe pressurisation and the well-stream product will begin to flow to the CPF in the following sequence of events:

- The flare pilot and purge system will be commissioned.
- The flare pilots will be ignited and lit using bottled propane. These bottles will remain available throughout the life of the field as flare ignition backup.
- The topsides process will be pressured up and flow directed to the fuel-gas distribution system.

- The well-stream product will be introduced into the primary separation package where the liquid stream will be directed to the FPSO for treatment; as a temporary measure all the gas will be diverted to the flare on the CPF.
- A portion of the gas will be used for fuel gas to run the main power generation turbines and also to help boost the heating medium required for the gas-drying process.
- The main gas stream will be sent to the gas-treatment trains for drying using TEG. The water will then be boiled off and the TEG recycled. Once dry and to specification, the gas will be sent to the gas export pipeline to be exported to the onshore plant.

As the various systems are tuned and begin to operate at stable conditions, the flow rates will be increased up to full operational levels for proving and testing. When the systems are in steady-state operation, INPEX's operations division will be responsible for maintaining the facilities. A maintenance function will be part of the operations division's role, with prime responsibilities in the following order of importance:

- to safeguard the technical integrity of the facility and ensure a safe working environment
- to ensure that equipment and systems are maintained to a standard where they are able to satisfy environmental and regulatory-authority requirements
- to maximise the amount of time the facilities are running.

A risk-based approach will be taken to develop maintenance strategies that will be applied to different types of equipment and facilities. Preventive, predictive and corrective maintenance strategies will be developed using experience and good practice, supported when appropriate by techniques such as risk-based inspection and reliability-centred maintenance.

As personnel competence is considered key to the effectiveness of the maintenance function, appropriate selection procedures will be put in place and, where necessary, training of in-house and specialist personnel will be undertaken.

4.3 Gas export pipeline

Hydrocarbon gas will be exported from the CPF through flexible risers and a subsea manifold to the gas export pipeline and then on to the onshore processing plant at Blaydin Point. This section describes the pipeline route and associated activities through different phases of the Project.

4.3.1 Pipeline route

The gas export pipeline will run from the export pipeline manifold adjacent to the CPF to the Blaydin Point onshore processing plant. The pipeline route follows an approximately direct line from the CPF to the mouth of Darwin Harbour through the existing Northern Australia Exercise Area (administered by the Department of Defence), and then through the Harbour to Blaydin Point. The total length of the pipeline from the CPF to the gas-receiving facilities at Blaydin Point will be approximately 885 km. The pipeline route is illustrated in figures 4-14 and 4-15.

Key criteria used in determining the offshore and onshore pipeline route were:

- to achieve as direct a route as possible
- to avoid significant seabed features and obstructions such as scarps, reefs, and rough seafloor
- to minimise disturbance to potentially environmentally sensitive areas
- to avoid sensitive heritage areas such as World War II wrecks and Aboriginal sacred sites in Darwin Harbour
- to avoid existing infrastructure such as the Bayu–Undan Gas Pipeline
- to minimise any disturbance of potential acid sulfate soils which would result in the generation and release of sulfuric acid
- to minimise any disturbance to the hydrology of creek systems.

During the laying of the offshore pipeline, a detailed seabed route survey will be undertaken to ensure that the route avoids subsea obstructions and sensitive habitats.

Within Darwin Harbour, it is proposed that the pipeline will follow a similar route to, but to the west of, ConocoPhillips' existing Bayu–Undan Gas Pipeline to Wickham Point. Once onshore, the pipeline will be buried adjacent to the existing road alignment of Wickham Point Road for approximately 2.5 km, then proceed north-east to the onshore processing plant site at Blaydin Point, for a total distance of approximately 6 km (see Figure 4-16).

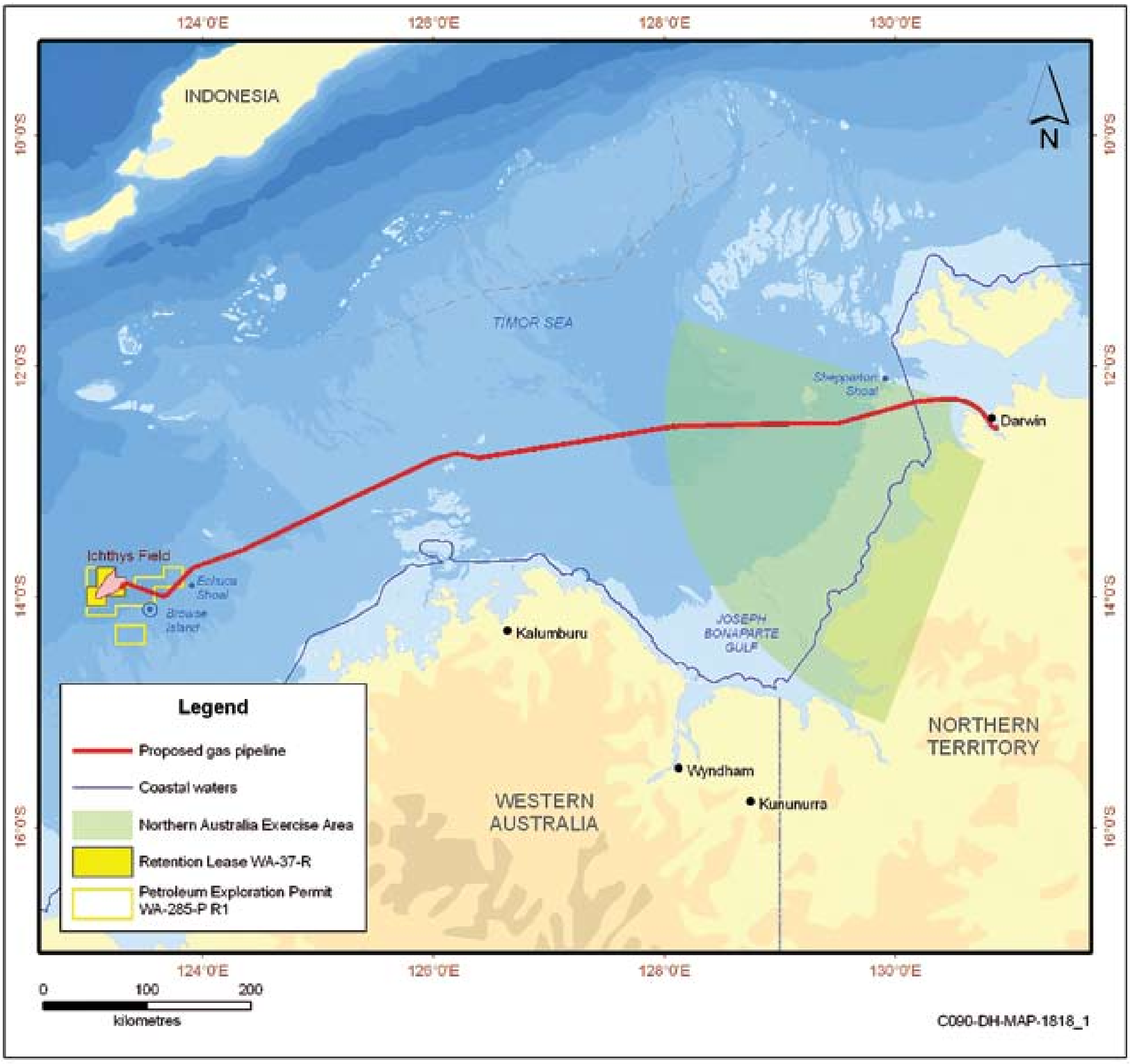

Figure 4-14: Proposed gas export pipeline route from the Ichthys Field to Darwin Harbour

4.3.2 Pipeline construction

Offshore pipeline construction

The pipeline will be constructed using conventional offshore pipeline construction methods which involve the use of many high-specification vessels sourced from around the world. The carbon-steel pipeline will be treated externally with an anticorrosion coating. In addition, sacrificial bracelet anodes will be attached at regular intervals along the pipeline for cathodic protection. A concrete coating will also be applied along the entire submerged pipeline length to provide on-bottom stability and mechanical protection.

The primary vessel used to install the pipeline will be a deepwater pipelay vessel. These vessels maintain position using either a dynamic positioning system (which controls thrusters) or an anchor system.

Vessels used to support the pipelay vessel may include pipe-supply vessels, a trailing suction hopper dredger, rock dumpers, anchor handlers, diving support vessels, hopper barges, supply vessels, ploughing support vessels and survey vessels.

Anchored barges typically have between 8 and 12 anchors. The anchors provide the reaction force to the lay tension as well as station-keeping against prevailing ocean conditions.

On the pipelay vessel, the coated segments of pipe approximately 12 m in length will be welded together in a continuous process known as “S-lay”. Once welded, the joints will be inspected for any welding defects before being “overboarded” at the back of the pipelay vessel.

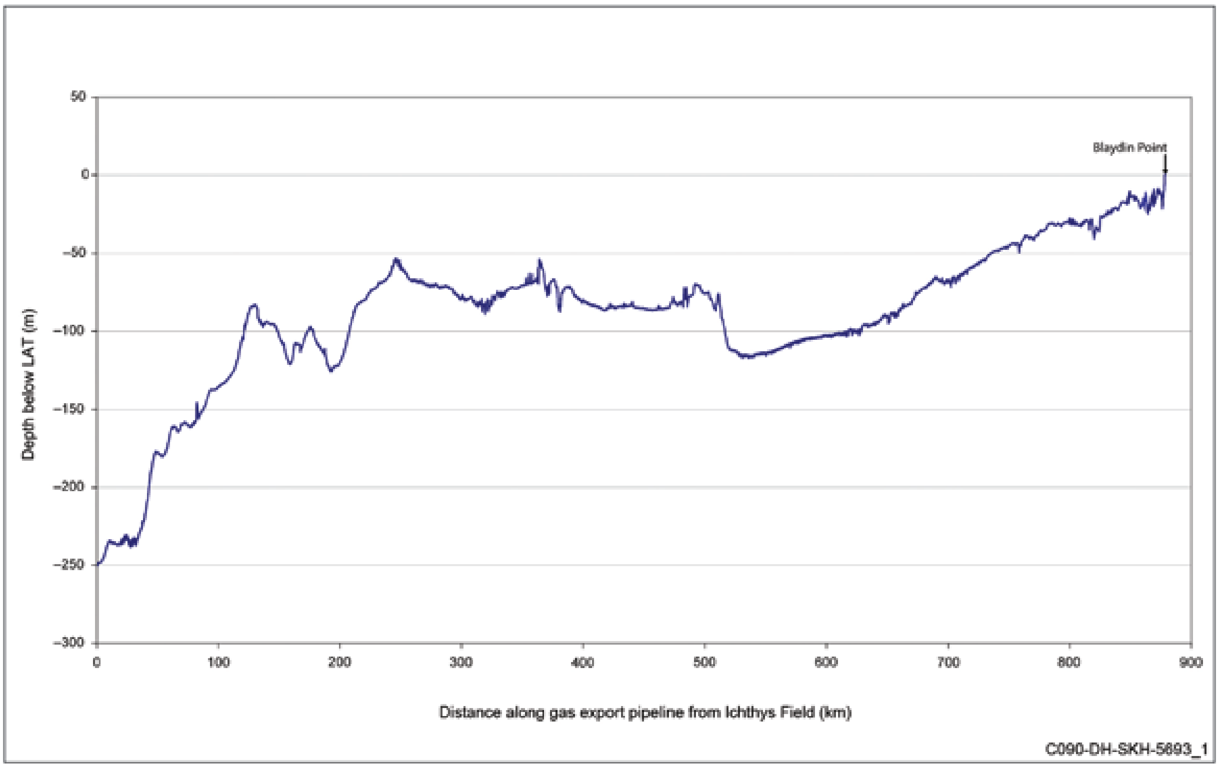

Figure 4-15: Gas export pipeline route depths in longitudinal cross-section

During construction, the pipelay vessel and support vessels will manoeuvre in a construction corridor which will be approximately 1000 m wide in Darwin Harbour and 2000 m wide offshore. The construction corridor allows room for the pipelay barge anchors and support vessel movements while also allowing for flexibility to modify the pipeline route around any local seabed obstruction.

The primary means of maintaining pipeline stability on the seabed will be through concrete weight-coating. Where stability cannot be obtained by this means alone, the pipeline may be trenched. The proposed trenching method may involve the use of underwater ploughs and/or underwater mechanical trenchers depending on the hardness of the seabed.

Where trenching is insufficient to achieve pipeline stability, rock dumping will be carried out by specialised construction vessels. Rock will most likely be sourced from an onshore quarry in the Northern Territory, such as Mount Bundy, and stored in a transfer area at East Arm Wharf prior to load-out to the pipelay operation. Typically the rock dump or berm over the pipe would be approximately 10 m wide at the base (as shown in Figure 4-17).

Nearshore pipeline and shore-crossing construction

It is anticipated that in Darwin Harbour the pipeline will be installed adjacent to the Bayu–Undan Gas Pipeline. A smaller shallow-water lay barge will be required in the Harbour for this purpose. Typical shallow-water lay barges maintain position by utilising anchors only. There are typically between 8 and 12 anchors, which are spread out from each corner of the lay barge to keep it stable.

The pipeline inside the Harbour will likely require partial burial and rock-armouring to minimise any risk of damage. Potential threats to the pipeline include damage from anchors or from ship groundings by the large vessels which use the Harbour.

The pipeline route through Darwin Harbour will be excavated using a backhoe dredger. The trench will be relatively shallow (to a depth of 3 m) and will form a gutter that will provide stability to the pipeline. The volume of dredge material generated by pipeline construction in Darwin Harbour is estimated to be approximately 600 000 m^3. The dredged material will be removed and disposed of at an approved location as discussed in Section 4.4.3 *Dredging and dredge spoil disposal.*

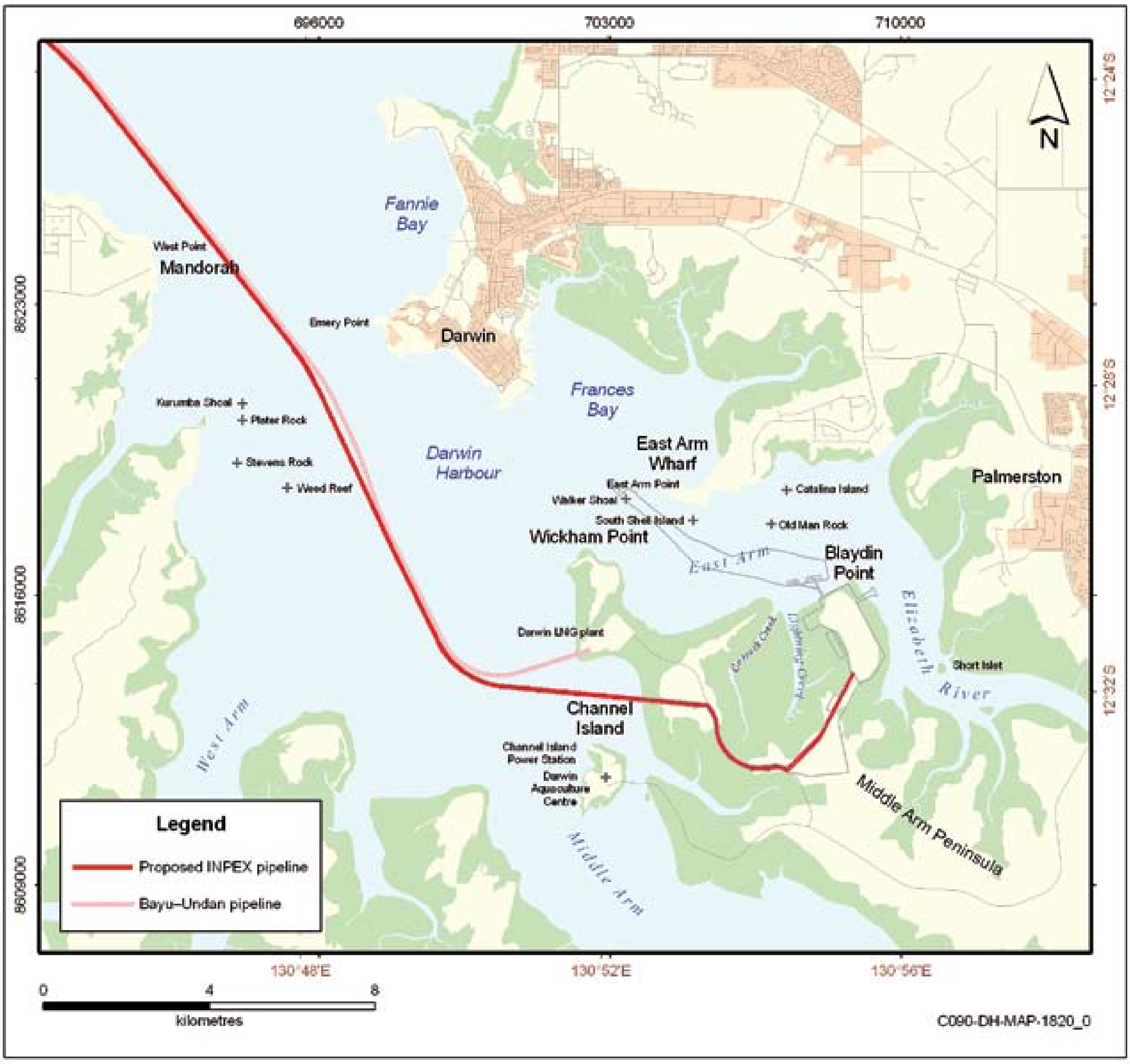

Figure 4-16: The gas export pipeline route through Darwin Harbour

Rock-armouring will be put in place over the top of the pipeline once it has been constructed on the seabed. Approximately 850 000 t of rock, which will likely be sourced from existing quarries, will be transported by road to East Arm Wharf where specialised rock-dumping vessels will take it offshore for dumping directly over the pipeline.

Pipeline shore crossing

The primary criteria used to determine a suitable location for the pipeline shore crossing were the following:

- to avoid historical sites in the Harbour, such as the wreck of the SS *Ellengowan*
- to minimise the dredging required to manoeuvre the lay barge close to shore
- to minimise the environmental footprint and disturbance by aligning the pipeline adjacent to the Bayu–Undan Gas Pipeline
- to avoid crossing over the Bayu–Undan Gas Pipeline.

The construction techniques considered for the pipeline shore crossing included open-trench excavation, micro-tunnelling and horizontal directional drilling.

The open-trench excavation method requires the construction of a trench using sea-based dredging equipment and land-based hydraulic excavators. Upon completion of the trench excavation across the shore, the pipeline would be pulled through the trench from the lay barge using an onshore winch spread. Alternatively, pipeline strings may be prefabricated onshore behind the trench and pulled through the trench with the equivalent winch spread on the pipelay vessel. This would be a robust construction technique and it was the one used in the construction of the Bayu–Undan Gas Pipeline.

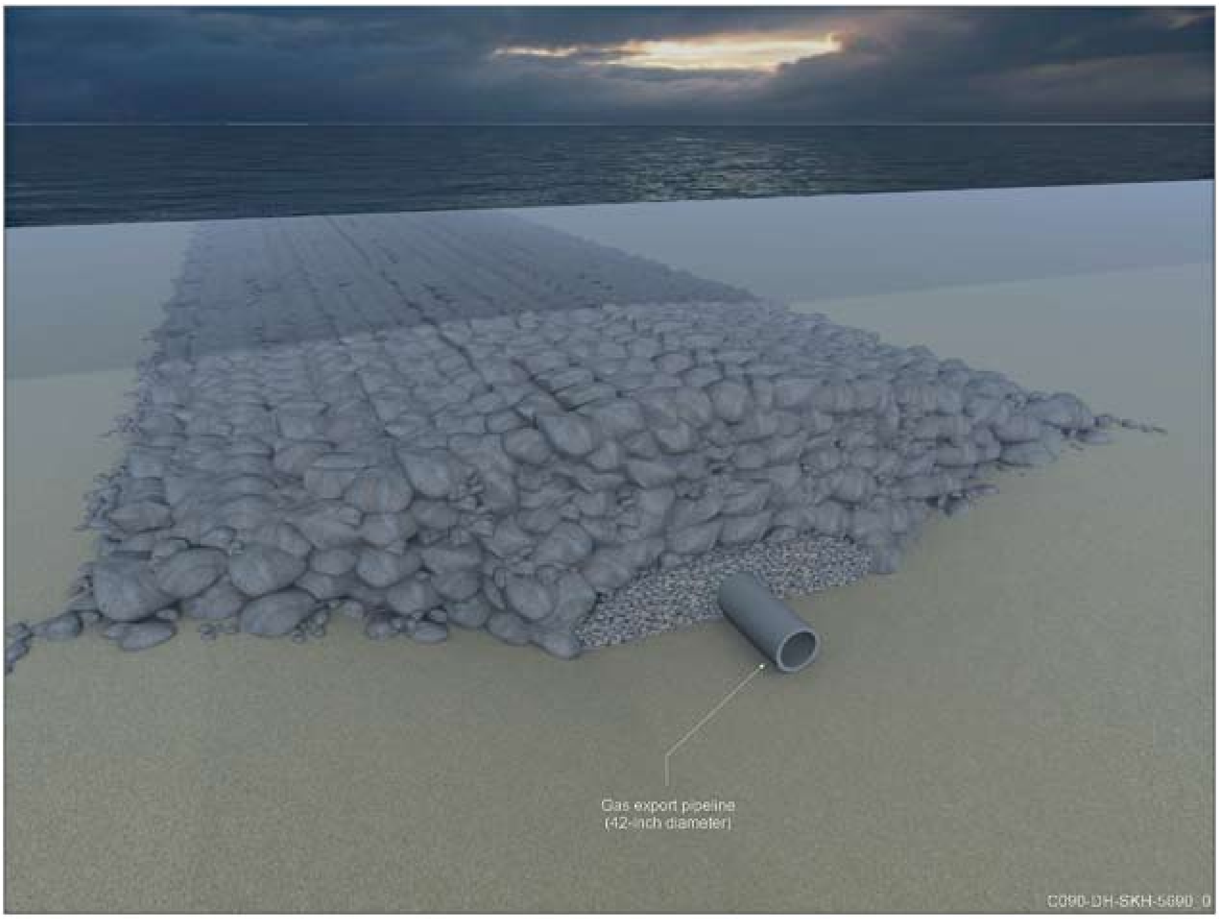

Figure 4-17: Indicative schematic of pipeline and rock-armouring

Micro-tunnelling is also considered for large-diameter pipelines when the shoreline has high steep cliffs which may preclude the application of a conventional open-trench excavation method. Micro-tunnelling to produce a shaft and tunnel uses a form of steerable pipe-jacking in which a tunnel-boring machine (TBM) is thrust forward by hydraulic rams. Steel or concrete pipe segments approximately 2 m in diameter are placed behind the TBM and are used to transfer thrust to the face of the tunnel. They are continuously added as the TBM progresses along the chosen alignment. The concept requires an onshore vertical shaft from which the TBM would be launched. The TBM bores to a location offshore where it can be recovered, and the pipeline is then installed in the tunnel.

Horizontal directional drilling is based on drilling a small pilot hole with a diameter of 10–16 inches (*c.*25–40 cm), which is subsequently opened up to a size typically 35–50% larger in diameter (depending on ground conditions) than the pipeline to be installed. The horizontally drilled boreholes are typically opened up by forward reaming as it is unlikely that continuous offshore support can be provided during back reaming. Forward reaming in soft soils places large compressive loads on the drill pipe and will consequently limit achievable reaming lengths. Upon completion of the reaming, the pipeline is pulled or pushed through the drilled hole.

The geology of the proposed shore-crossing location at Middle Arm Peninsula and the proposed diameter of the pipeline make open-trench excavation the most suitable and robust method. Neither micro-tunnelling nor horizontal directional drilling are suitable techniques for a 42-inch pipeline.

The pipeline right of way through the mangrove area to the south of Wickham Point Road will be approximately 20–25 m wide and will be dependent upon the results of geotechnical investigations. A berm (causeway) will be constructed along and within the pipeline right of way to facilitate the pipeline stringing, welding, trenching and lowering operations. The finished height of the berm will be approximately the same height as the existing road structure which it parallels. The pipeline will be laid in an open trench at the side of the berm. The excavated trench will be approximately 1.5 m deep and 2–3 m wide, depending on existing ground conditions. Once the pipeline has been laid, the trench will be backfilled with clean fill. Additional fill will be placed over the pipeline trench to a level equal to the finished height of the berm. A minimum pipeline cover depth of 1.2 m will be maintained. Drainage culverts will be installed across the width of the berm at regular intervals to ensure that drainage is maintained to the mangroves retained between the berm and Wickham Point Road.

Depending on the construction option chosen, an estimated volume of 35 000 m^3 of material in the intertidal zone may need to be excavated. One of the key considerations in undertaking the open-trenching method is to avoid the generation of sulfuric acid by disturbing potential acid sulfate soils. Management controls for this are discussed in further detail in Chapter 8 *Terrestrial impacts and management.*

Following the installation of the pipeline through the shore crossing, approximately 30 000 t of rock will likely be required for rock-armouring in the intertidal area. Reinstatement and rehabilitation of the temporarily disturbed shore-crossing location area seaward from the beach valve will be undertaken when the construction of the pipeline shore crossing is complete.

4.3.3 Pipeline precommissioning

When the pipeline has been installed, the construction process will be completed through a number of stages of precommissioning. These will typically involve the following:

- flooding, cleaning and gauging of the pipeline with treated sea water, driving a pig train from the shore with a flooding spread set up at the shore-crossing location
- hydrotesting of the pipeline with treated sea water using a pressure-testing spread set up at the shore-pull location
- dewatering of the pipeline from onshore to offshore using a dewatering spread set up at the shore-pull location
- conditioning of the pipeline in readiness for the introduction of hydrocarbons. Options under evaluation include a combination of glycol swabbing (during dewatering), purging with nitrogen, pipeline evacuation (air removal), vacuum-drying, and air-drying.

The equipment required at the shore-pull area during precommissioning will typically include water-winning pumps, pressurisation pumps, chemical injection equipment, compressors, filters, driers, coolers, generators, and storage tanks for chemicals and diesel. A typical layout of a shore-pull area is shown in Figure 4-18.

Figure 4-18: Indicative schematic of the shore-pull area

4.3.4 Pipeline commissioning, operation and maintenance

Once precommissioning has been completed, the pipeline will be ready for start-up and the introduction of hydrocarbons. The equipment at the shore-pull area will be demobilised and the pipeline will be ready to enter its operating phase.

Following commissioning, the pipeline will be continuously operated to provide gas to the onshore plant for the duration of the 40-year life of the Project. Ordinarily, maintenance will include regular internal and external inspections and monitoring with repairs as necessary to ensure the integrity of the pipeline.

4.4 Nearshore infrastructure

Infrastructure and activities in the nearshore development area that will support the construction and operations phases of the Project are listed in Section 4.1.1 *Major infrastructure*. These are described in more detail in the following sections.

4.4.1 Module offloading facility

Facilities necessary for the importation of materials, equipment and process modules are required from the outset of construction of the onshore facility.

Ports in the Darwin area have been assessed for their capacity to fulfil the requirements of the Project. The primary factor was the ability and capacity of ports to accept large prefabricated modules from ocean-going vessels. While the facilities at East Arm Wharf are capable of taking general cargo and equipment and some of the modules, it was found that most of the modules could not be accommodated.

It will therefore be necessary to design and construct a module offloading facility at Blaydin Point, the primary purpose of which will be to unload modules for the LNG plant. After completion of the construction phase, the module offloading facility will be fenced off and retained for future use, such as for major maintenance operations.

The module offloading facility will be linked with the main LNG plant area by a gently sloping embankment around 60 m wide (Figure 4-19).

Construction of the module offloading facility

The module offloading facility will be constructed with steel sheet piles, or with a concrete deck on steel piles, or using a combination of these two methods. Various design techniques are being considered for a causeway to the facility. The techniques may include use of granular fill compacted in layers sourced from the site or from a local quarry, or by a combination of these two, together with the installation of rock-armouring along the causeway for support and protection from wave action. The final construction technique will be evaluated based both on its engineering feasibility and on its associated costs.

The generation of dredge spoil and its disposal is discussed in Section 4.4.3 *Dredging and dredge spoil disposal*.

Figure 4-19: Indicative schematic of the module offloading facility

4.4.2 Product loading jetty

The ability to efficiently and safely berth tankers and load product at the product loading jetty is critical to the Project. Jetty design is based on a series of complex loading and navigation studies, geotechnical and environmental surveys, and safety quantitative risk assessments (QRAs).

Key technical criteria influencing jetty design include the following:

- The water depth and channel width in the approaches to the jetty must be sufficient for safe navigation.
- The turning basin width must be sufficient to allow tugs to safely turn and manoeuvre product tankers to the jetty head.
- The jetty alignment must take into account prevailing winds and tidal currents to facilitate safe manoeuvring for product tanker turning, berthing and departing.
- The separation distances for berthing vessels at East Arm Wharf and the product loading jetty at Blaydin Point need to be maximised for safety reasons.

In addition, during consultation with community stakeholders, a particular concern raised was that recreational fishing access should be maintained to Lightning and Cossack creeks adjacent to Blaydin Point. As a result, INPEX committed to investigating jetty design concepts which would maintain safe public access to these creeks.

Alternative jetty concepts

Based on assessment against technical criteria and in consideration of community concerns, several alternative jetty concepts were investigated. The resulting technically viable concepts fell into two categories:

- a short-jetty concept—a short jetty length, with a position and orientation as shown in Figure 4-2
- a long-jetty concept—a long jetty (approximately 3 km) with an orientation running directly across the entrance to Lightning and Cossack creeks as shown in Figure 4-20.

In addition, INPEX also explored the possibility of sharing the loading jetty at ConocoPhillips' Darwin LNG plant at Wickham Point. This option was not pursued, however, for the following reasons:

- INPEX requires export facilities for LPGs and condensate which are not available at the ConocoPhillips jetty.
- The 26 km of cryogenic-rated loading line from the Blaydin Point LNG tanks to the Wickham Point export jetty and back to Blaydin Point would be commercially unviable.
- The efficiency of INPEX's LNG plant would be reduced, as a significant proportion of the LNG would be regasified during the approximately 26-km round trip to the end of the ConocoPhillips jetty head. (The LNG is maintained in continuous circulation to keep the export pipeline in a cryogenic state.)
- There would be significant commercial and legal complications to any joint operations by the two companies at Wickham Point. Examples of possible complications would include the following:
  - questions over which company's vessels would be given preference for loading
  - the assignment of liability should damage be caused to the jetty by one party which would prevent product loading by the other party
  - the assignment of responsibility for recovery or flaring of boil-off gas at the loading berths.
- Joint use of the jetty facilities by the two companies would increase the safety risk.

Recognising that there were complex and competing environmental, social and technical issues associated with the selection of a short or long jetty, INPEX undertook a detailed evaluation of the long-jetty vs short-jetty concepts. The short-jetty option was found to be the better option.

The key advantages of the short-jetty concept include the following:

- a reduction in the risk of recreational vessels travelling into jetty safety exclusion zones and taking potentially unsafe short cuts under the jetty trestle
- a reduction in safety risks from the Project's product loading jetty because of the increased separation distances for vessels berthing at East Arm Wharf
- a reduction in the long-term impact on visual amenity from Darwin's central business district and other vantage points around Darwin Harbour
- the elimination of the need for jetty piling and jetty construction works in close proximity to the World War II Catalina flying-boat wrecks
- a reduction in leak paths for products (LNG, LPGs and condensate) from the jetty loading lines.

The disadvantage of the short-jetty concept is that larger dredge volumes are required to be removed in the shallower water closer to Blaydin Point. Overall, however, the temporary environmental and social disadvantages caused by an increased dredge volume are mitigated by improved safety outcomes, a reduction in long-term visual amenity impact, and a reduction in the extent of the area excluded by safety requirements for recreational users in East Arm.

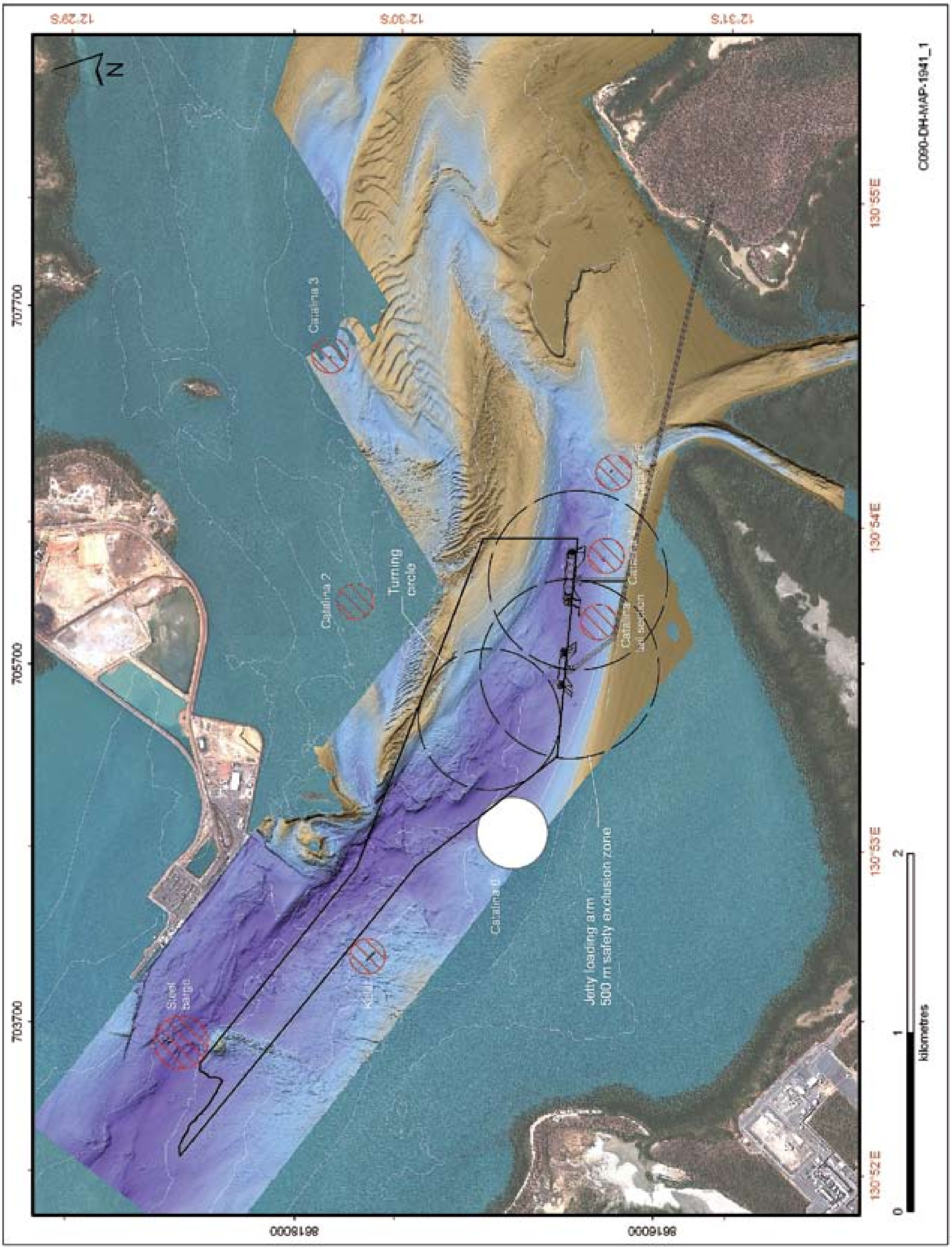

Figure 4-20: The “long-jetty” concept

INPEX has presented a comprehensive assessment of the potential marine impacts associated with the short-jetty concept in Chapter 7 *Marine impacts and management*, while the potential social impacts are presented in Chapter 10.

Design of the product loading jetty

The deck level of the product loading jetty will be approximately 16 m above Lowest Astronomical Tide (LAT). The berths will be designed to minimise the effect of wind and currents on navigation. There will be two berths along the jetty, one solely for LNG loading and the other for propane, butane and condensate loading. Based on safety assessments there will be a separation distance of 500 m between the berths.

Each berth will consist of a loading platform and berthing and mooring dolphins. A mooring dolphin is a maritime structure fixed to the seabed (and not connected to the shore or to the jetty) which extends above water level as a platform to provide a mooring point for ships.

The product flowlines from the gas-processing plant will run the length of the jetty to the loading arms and will be equipped with a leak-detection system. A wastewater discharge outfall will also be located at the end of the jetty. The outfall will be designed to maximise the dispersion of treated wastewater.

The deck of the jetty will accommodate a 4-m-wide road to allow standard truck and mobile crane access.

A security gate and access road may also be located between the berths and the product storage tank area.

Construction methods for the product loading jetty

Jetty construction methods are being investigated and will be further defined in the detailed-design phase of the Project. The most likely construction method would involve piledriving and installation of concrete prefabricated deck sections using cranes on jack-up barges. The pipe racks for the jetty trestle would be transported by self-propelled module transporters by land.

The process would continue, working out from the shore abutment until the required jetty length is reached. The piles, precast deck beams and other materials would be brought to the jack-up barge by a support barge. Rock anchors to stabilise the piles might also be required. These would be installed after the deck sections are installed.

The choice of jetty construction method will depend on the results of detailed nearshore geotechnical investigations.

4.4.3 Dredging and dredge spoil disposal

A significant amount of dredging needs to be carried out in Darwin Harbour to support the Project. The purpose of the dredging program is as follows:

- to extend the existing safe shipping access from the vicinity of East Arm Wharf to the proposed product loading jetty at Blaydin Point
- to provide a turning basin large enough to permit the safe manoeuvring of ships that are more than 350 m in length overall
- to provide a safe approach and departure area to and from the product loading jetty
- to provide two berthing pockets at the product loading jetty to accommodate two product export tankers
- to provide an approach apron with a berthing pocket capable of accommodating up to four barges at any one time at the module offloading facility area
- to provide a trench to accommodate the subsea gas export pipeline to Middle Arm Peninsula.

The primary consideration in the design of the preliminary dredging program has been the need to ensure that the environmental impact of the dredging operations in Darwin Harbour will be kept to as low a level as is reasonably practicable.

To facilitate assessment in the time frame required by the environmental approval process, a preliminary dredging program was developed by INPEX using the services of specialist dredging engineers and data obtained from environmental, geotechnical and geophysical studies. These studies provided information on the volume and nature of the material within the dredge footprint and allowed the identification of the types of dredging equipment that would be necessary, the development of a sequence and schedule of dredging activities, and the development of a cost estimate. A number of potential dredging methodologies which could have significantly reduced the dredging program costs were rejected by INPEX on the grounds that they might have resulted in significantly greater environmental impact.

Dredging depths will be determined by allowing safe under-keel clearance (based on Project-specific navigation studies and internationally recognised navigation standards) at all stages of the tide for all types of product tankers. The largest tankers will have a fully laden draught of approximately 14 m.

The dredging program will be carried out by a dredging contractor who will be engaged at a later stage. Only a limited number of specialised dredging companies having the capacity to undertake the scale of dredging required for the Project are available worldwide. Therefore, until the dredging contractor has been engaged, dredging methods can only be planned conceptually and INPEX's dredging program will only be finalised once the contractor has been appointed.

The final dredging program will be designed so that any changes in methodology do not result in any significant increases to the predicted environmental and social impacts outlined in chapters 7 and 10 of this Draft EIS. Confirmatory modelling will be undertaken if required and, if so, will be included in subsequent dredging applications made to the Northern Territory Government. These will include a detailed dredging environmental management plan required as part of a construction environmental management plan under the *Waste Management and Pollution Control Act* (NT) and an application for a waste discharge licence under the *Water Act* (NT).

A detailed description of the preliminary dredging program is provided in the following sections.

4.4.4 Preliminary dredging program

Dredge volumes, dredged materials, and footprint

Based on preliminary estimates it is expected that a total of 16.9 Mm^3 of spoil will be generated during the dredging program. This will be made up of 15.1 Mm^3 from the shipping channel, turning basin and berthing area, 1.2 Mm^3 from the module offloading facility (see Figure 4-21), and 0.6 Mm^3 from the subsea section of the gas export pipeline from the mouth of Darwin Harbour to Middle Arm Peninsula.

Dredging calculations for the shipping channel are based on the need to provide clearance for all product tankers, with appropriate allowances being made for the large tidal range experienced in the Harbour. The dredge footprint has also been designed to

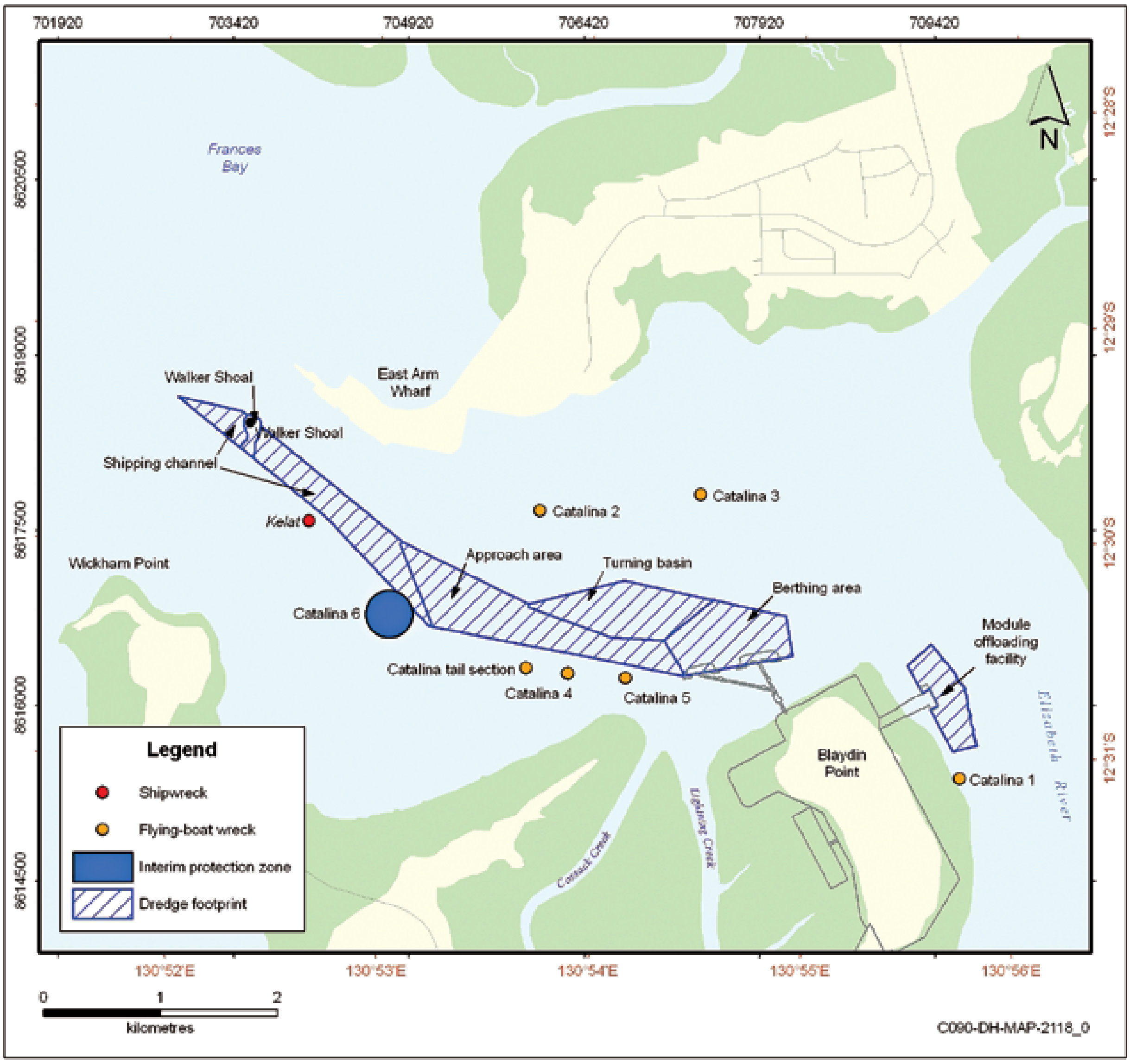

Figure 4-21: Indicative dredging footprint for the shipping channel, turning basin and module offloading facility in Darwin Harbour

avoid maritime heritage sites, while at the same time maintaining the safety buffer necessary to protect the operations of the East Arm Wharf port facilities. The largest fully laden tanker will require a 14-m-deep channel for safe navigation.

As specified in the previous section on pipeline construction, a dredged trench will be necessary to protect the pipeline, especially in the shallower areas of the Harbour where it would be vulnerable to damage by vessels and their anchors. In addition, however, the position of the pipeline in Darwin Harbour will be indicated on navigational charts as a prohibited area for anchoring. The buried pipeline will be covered by backfilled material which will provide additional safety to the ships passing in the area.

The spoil generated will be composed of different types of material depending on the location of the dredging activities. The material has been categorised as follows:

- sediments: high-moisture-content clays, silty sands, and gravels (estimated to be 50–70%)
- soft rock or rocklike material: fractured soft rock known as phyllite with lenses or dykes of quartz (estimated to be 30–50%)
- hard rock: metamorphic conglomerate intrusions such as those of Walker Shoal (estimated to be 1–2%).

Dredging method

The methods envisaged to be adopted for the dredging program depend on the types of material to be dredged, the water depths in which they lie and the potential impacts on the environment. The dredged spoil will be transported to the offshore spoil disposal ground outside Darwin Harbour. A number of dredging vessels will be required and these will operate for 24 hours a day and 7 days a week during specified periods. However, the final selection of equipment and sequence of operation will only be finalised after a dredging company has been selected.

Drilling and blasting will also be necessary to fracture hard rock intrusions which exist within the dredge footprint and which cannot be removed by conventional dredging methods.

Walker Shoal, which lies at the entrance to the proposed shipping channel, is the most significant of these intrusions. As the top of the shoal rises to 6 m below LAT it must be removed to allow for safe navigation. INPEX explored options to realign the shipping channel in order to avoid the shoal, but the constraints posed by the heritage-listed wreck of the coal hulk *Kelat* and the proximity of the East Arm Wharf facilities (see Figure 4-21) prevented any realignment.

The preliminary dredging program will require the following vessel types:

- a trailing suction hopper dredger (TSHD)
- a cutter-suction dredger (CSD)
- a backhoe dredger (BHD) or a grab dredger (GD)
- self-elevating drilling platforms (SDPs) for the drill-and-blast operations
- hopper barges (HBs).

A typical TSHD is shown in Figure 4-22. It is used to remove unconsolidated marine sediments using suction pipes or “drag arms” that are lowered from the vessel to the seabed. The sediments are pumped to hoppers where solids separate out; the unwanted water may be discharged at keel level. When the hoppers are full, the vessel can travel to the offshore spoil disposal ground and discharge the material to the seabed. For the preliminary dredging program, it is proposed that the TSHD be operated without overflow of excess water into the harbour. While this reduces the discharge of suspended fine material into the harbour and consequently reduces the impact on the environment, it significantly reduces the efficiency of the dredging operation and extends the duration of the dredging program.

A typical CSD is shown in Figure 4-23. This type of dredger is used primarily on consolidated sediment and weak-to-medium-strength rock which needs to be broken up before it can be recovered. To achieve this, the dredger is equipped with a cutter head which excavates the substrate before it is sucked up by the dredge pump(s). During its operations, the dredger moves around a spud pole by pulling and slacking on the two fore sideline wires. As is typical in such dredging programs, the dredged material will be redeposited on the seabed for subsequent recovery by the TSHD.

A typical BHD is shown in Figure 4-24. Such dredgers are used in substrates consisting of firm clay, soft rock and blasted rock, and when large stones can be expected. A BHD is also used where shallower waters prevent access for the larger and more efficient TSHD. The length of the boom of a BHD determines the dredging depth. These stationary dredgers are anchored by three spud poles.

The GDs (see Figure 4-25) are mechanical dredgers which use a crane with a clamshell grab. Similar to backhoes, they have the crane mounted on a floating stationary platform which is anchored by three spud poles. They are typically used to dredge sediment types such as gravels, silty sands and soft clays, but they are also useful for picking up large rocks and stones.

The environmental performance of a GD is similar to that of a BHD.

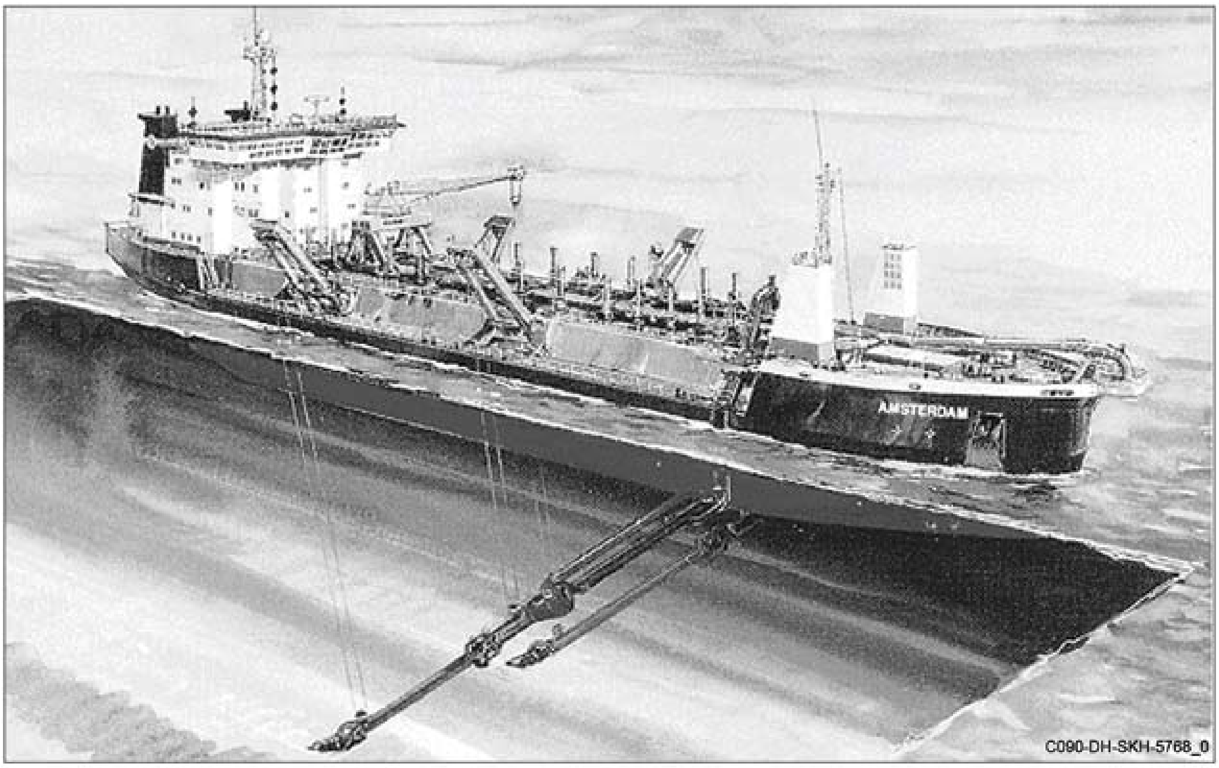

Figure 4-22: Example of a trailing suction hopper dredger

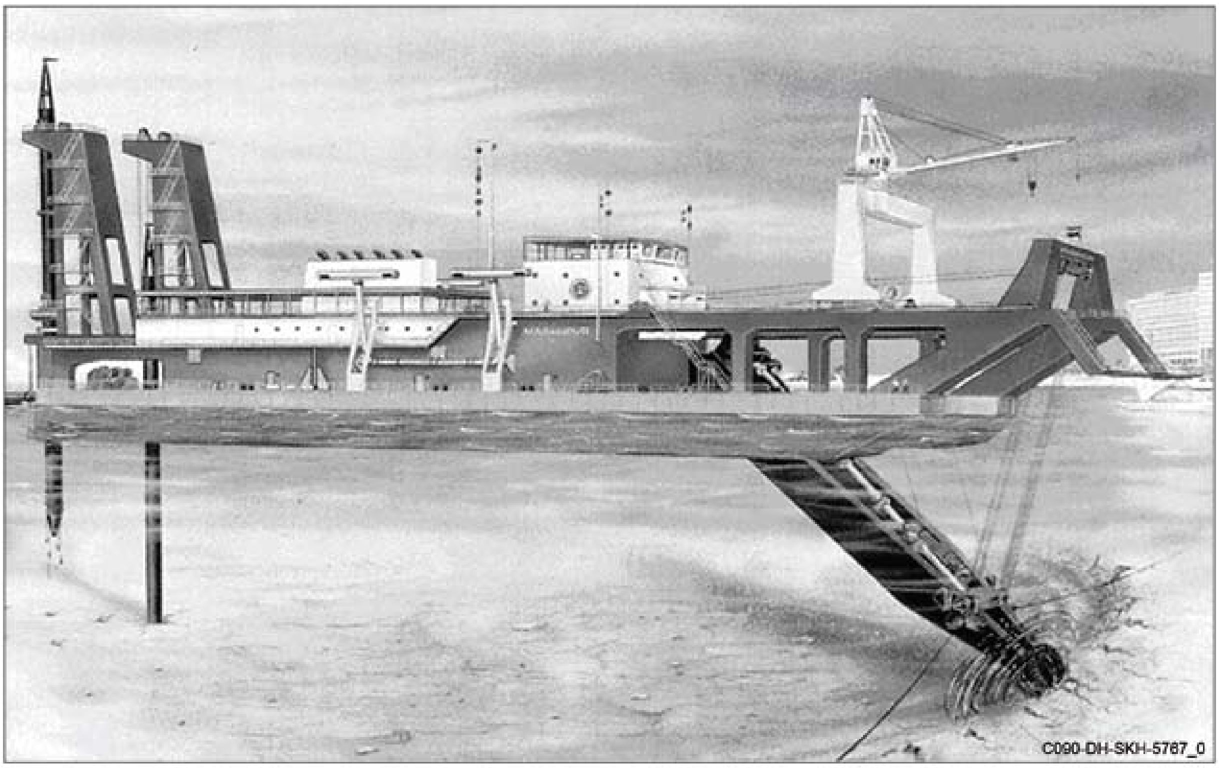

Figure 4-23: Example of a cutter-suction dredger

Figure 4-24: Example of a backhoe dredger

The BHD will excavate material of lower strengths, the CSD will excavate material of medium strengths, and the drill-and-blast operations will fragment hard rock material.

The HBs are purpose-built vessels for transporting dredge spoil to designated disposal sites. They may be self-propelled or pushed or towed by a tug. Once at the disposal site, the spoil is discharged through the keel either by hydraulically opening the hopper or by opening bottom doors. They vary in capacity from a few hundred cubic metres to several thousand cubic metres.

As noted above, the harder material, such as that on Walker Shoal, that cannot be dredged by more conventional methods, will be fragmented during a drill-and-blast program undertaken using one or more SDPs. The fragmented material will be removed by a BHD or a GD and loaded on to HBs for dumping at the offshore spoil disposal ground.

Alternative techniques to drilling and blasting are being investigated to remove the hard rock material within the shipping channel. At this stage, however, it is not possible to confirm whether there are any viable alternatives.

Dredging program

The section which follows describes the dredging methodologies, the dredging schedule and the volumes and nature of the material to be dredged under the preliminary dredging program.
This information has been used to inform the dredge modelling provided in Chapter 7.

The key features incorporated into the preliminary dredging program to reduce environmental and social impacts are as follows:

- using the BHD and/or GD in preference to the CSD wherever practicable, as the BHD and GD release significantly lower amounts of fine material than the CSD
- using the TSHD in a “no-overflow” mode which avoids the discharge of water laden with fine sediments back into Darwin Harbour. While this operating mode will reduce the release of fine sediments into the Harbour, it will result in reduced dredging efficiency and will extend the duration of the dredging program
- designing the jetty and dredge footprint in such a way that the offset distances from maritime heritage sites are maximised as far as practicable

Figure 4-25: Example of a grab dredger

- ensuring that there is an adequate buffer for the pipeline route through the Harbour in the vicinity of Aboriginal sacred sites and maritime heritage sites.

As noted previously, the final dredging program may differ from the preliminary dredging program provided that it can be demonstrated that there are no significant increases to the predicted environmental and social impacts outlined in chapters 7 and 10.

One such change, for example, could be operating the TSHD in a “minimal overflow” mode rather than a “no overflow” mode.

Table 4-2 summarises the indicative volumes of the different materials to be dredged within the dredge footprint and the methods which are proposed for their removal.

Table 4-2: Summary of dredging equipment, the type and indicative volumes of dredge material, and the sequence of operations proposed in the preliminary dredging program

Equipment	Dredge material	Volume (Mm³)	Dredge localities
TSHD	Weak	8.96	Shipping channel, approach area, turning basin, and tanker berthing area
BHD	Weak	6.60	Shipping channel, approach area, turning basin, tanker berthing area, and module offloading facility
CSD	Medium	0.57	Shipping channel, turning basin and tanker berthing area
Blasting	Strong	0.17	Shipping channel (primarily Walker Shoal)
Subtotal		**16.3**	
BHD	Weak	0.6	Gas export pipeline to shore crossing
Total		**16.9**	

In order to optimise the use of available equipment and minimise any adverse impact on the environment, it is planned to undertake the dredging program in stages. It is anticipated that dredging may start either at the area of the module offloading facility or at the pipeline trench. Alternatively the dredging at the module offloading facility and pipeline may start simultaneously provided that adequate dredging equipment is available for mobilisation. The dredging program will end in the Walker Shoal area.

At the outset of the dredging program, it is planned that only the BHD (and/or the GD) will be operating. It (or they) will be joined by the TSHD as the dredging progresses. At the peak of dredging activity it is envisaged that the TSHD, BHD (and/or the GD) and CSD will be operating simultaneously. An indicative dredging schedule is shown in Figure 4-26 and a description of the dredging operations identified for the preliminary dredge program is provided in the following sections. As mentioned above, the dredging methods to be used and the dredging schedule will be decided upon after negotiations with the selected dredging contractor.

Module offloading facility

Dredging operations for the module offloading facility will include the facility's apron and berthing area. The initial geotechnical studies and surveys indicate that the material to be dredged will consist mainly of unconsolidated sands, silts and gravels along with some clay. The operations will commence with the mobilisation of a large BHD and three HBs. All of the dredged material will be loaded into the HBs for transport to the offshore spoil disposal ground.

At the time of preparing this schedule it was believed that the selected dredging contractor would be able to provide the three HBs for this operation. These would operate simultaneously. Following the completion of dredging, the area will be handed over to an appropriate civil contractor for further work. It is expected that dredging for the module offloading facility will be completed within five months of the start of the works.

Berthing area at the product loading jetty

When dredging for the module offloading facility has been completed, the dredging equipment will be moved to the vicinity of the proposed product loading jetty where the export tankers will berth. The berthing area will consist of two berths, one for LNG tankers and the other for LPG and condensate tankers. It will be located close to the northern tip of Blaydin Point. Most of the area to be dredged in and around the product loading jetty is shallow and, based on geotechnical surveys, is expected to consist of loose sands and silts underlain by weak rock material and below that by some medium-to-hard material. The dredging around the product loading jetty is expected to last for just over two years. The sequence expected to be followed at the berthing area is as follows:

- The BHD will be transferred from the module offloading facility area to the berthing area and will dredge most of the loose material present in the shallower areas. The material dredged using the BHD will be loaded into an HB for transport to the offshore spoil disposal ground.
- Once the BHD has finished in this area it will be followed by the TSHD to remove the remaining unconsolidated material in the deeper areas. All the material dredged by the TSHD will be transported to the offshore spoil disposal ground.
- Any base material of medium strength will be dredged using the CSD. The dredged material produced by the CSD will be deposited continuously on the seabed, as is common practice, to be recovered at a later stage by the BHD.

Following dredging of the berthing area by the BHD and the TSHD, it will be handed over to the piling contractor to carry out the installation of the jetty.

Turning basin

The turning basin will be used by the incoming unladen product tankers or carriers to turn through 180° before berthing. This will allow direct seaward departure for the fully laden vessel from the product loading jetty. Geotechnical surveys indicate that the geology of the basin is similar to that of the berthing area. The sequence of operations in the basin will be similar to that followed during the dredging of the berthing area, that is, initial dredging by the BHD of the shallower areas followed by the TSHD until medium-strength material is encountered. The CSD will then be brought in to remove this. The medium-strength material will be collected in due course by the TSHD and the BHD.

The finished depth in the turning circle will be around 14 m below LAT. Dredging in the turning basin is expected to take approximately two years.

Approach area

The approach area connects the turning basin and the berthing area at the product loading jetty with the shipping channel. Geotechnical surveys indicate that its geology is similar to that of the turning basin but with a few pockets of medium-strength material located on the northern corner close to the shipping channel.

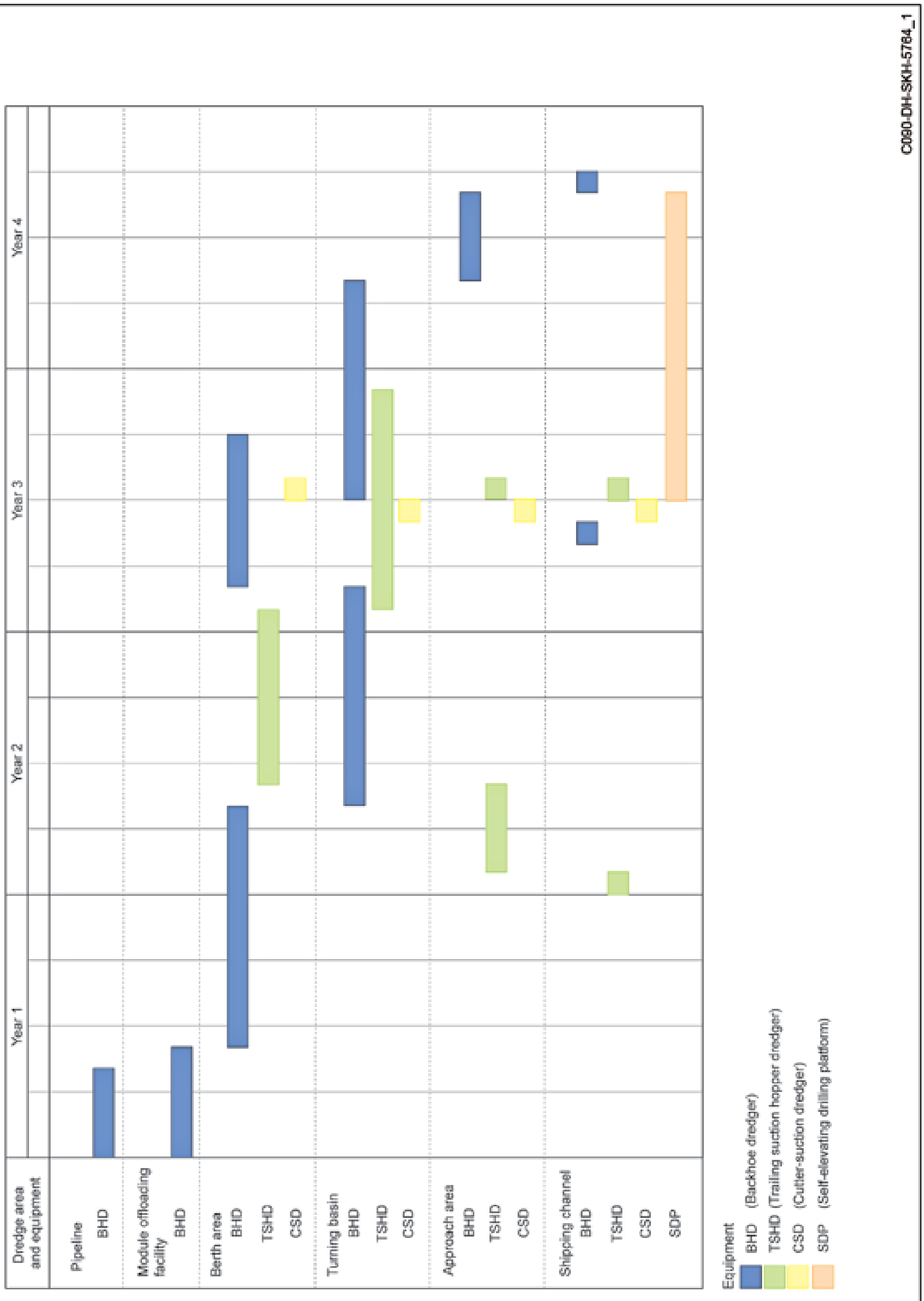

Figure 4-26: An indicative dredging schedule for Darwin Harbour

The dredging of the approach area is expected to start with the TSHD, which will recover the naturally occurring unconsolidated material on the seabed. When this material has been removed and disposed of at the offshore spoil disposal ground a CSD will dredge the medium-strength material. The TSHD and the BHD, supported by an HB, will then recover the material left on the seabed by the CSD.

Dredging in this section is likely to continue for almost a year.

Shipping channel

The shipping channel connects the approach area to the naturally deep parts of Darwin Harbour which will not require dredging. Geotechnical surveys indicate that the seabed in the shipping channel area is composed of weak through to strong material. Weak-to-medium material has been found throughout the shipping channel footprint. The strong material is found predominantly at Walker Shoal.

Dredging operations for the shipping channel are likely to occur in the following order:

- A TSHD and BHD, supported by an HB, will be used to dredge unconsolidated material in the deeper areas.
- A CSD will be used to cut potentially medium material present within the shipping channel. This material will be recovered later by a TSHD for transport to the offshore spoil disposal ground. This operation is expected to take approximately one to two months.
- Drilling and blasting will be required in the Walker Shoal area of the shipping channel where very hard rock has been found. It is planned to station one or more SDPs on Walker Shoal for the duration of the drill-and-blast program. Blasting will be limited to the daytime.
- A BHD will be used following the drill-and-blast activities to remove the fragmented hard material for transportation by HB to the offshore spoil disposal ground.

The duration of the drill-and-blast program in the shipping channel is anticipated to be up to 14 months. Details of the control measures to prevent impacts to people and infrastructure and to minimise environmental and social impacts are provided in chapters 7 and 10.

Pipeline dredging

Dredging for the pipeline in Darwin Harbour is likely to be undertaken using conventional dredging techniques that may include the following:

- excavation of soft seabed material by “mass flow excavation”. This technique uses a T-shaped tool hanging just above the seabed to draw in water laterally and direct a high-volume, low-pressure stream directly down into the seabed sediments. This effectively creates a trench into which to lay the pipeline. Mass flow excavation can be used with or without high-pressure jets to remove the material and may be required for pipelay near the entrance to the Harbour.
- excavation of soft-to-medium material by BHD. This will be required to complete a trench through the intertidal area at the shore crossing for pipeline stability and protection, and to provide sufficient access for the pipelay barge

It is expected that most of the work for preparing the pipeline trench will be carried out by the BHD. However, use of the CSD and/or the TSHD is not ruled out. It is likely that the pipeline dredging will take approximately three to four months.

Alternative dredging methodology

An increase in the amount of dredging equipment mobilised could reduce the overall duration of the program. This option remains under consideration by INPEX, but advice from dredging companies is that the availability of dredging equipment and the sourcing of Australian crews to run them are likely to be limiting factors. If the logistic and commercial constraints of engaging additional dredging equipment can be overcome, then INPEX may opt to utilise additional equipment and reduce the duration of the dredging program. The environmental and social impact assessment of the dredging program is, however, based on the base case of INPEX’s not having access to additional equipment. This provides the most conservative case for modelling and for social and environmental impact assessment.

Clean-up dredging

It is possible that some sediment may be deposited in the main shipping channel of the Harbour adjacent to East Arm Wharf. INPEX therefore proposes that, prior to the decommissioning of the dredging equipment from the Harbour, it will carry out a survey to determine the extent of such sediment deposition, if any. In the event that significant sediment deposits are recorded during the survey, INPEX will commission a clean-up dredging program.

4.4.5 Maintenance dredging

Sediment transport modelling was undertaken in 2009 by INPEX's FEED design contractor, the JKC consortium, in order to assess the amount of maintenance dredging that may be necessary during the operations phase of the Project. JKC's model focused on the area from East Arm Wharf to Blaydin Point and was calibrated by comparing the modelled bed changes with the surveyed bed changes over the 11-year period between 1997 and 2008. The calibrated model achieved a credible representation of the primary measured erosion and accretion areas at East Arm Wharf and in the area of sand waves to the north of Blaydin Point.

The calibrated model was further modified to include the post-dredging bathymetry, the plant site reclamation works and the new module offloading facility causeway. Modelling was then carried out for ambient tide conditions, over 10- and 20-year periods, for a 100-year-ARI (average return interval) flood event in the Elizabeth River, and for a Category 3 cyclonic event consisting of a 100-year-ARI storm surge level combined with the inclusion of waves generated by cyclonic winds across critical fetches. The impacts from the flood and cyclonic events were found to be minor in comparison with the longer-term impacts from the 10- and 20-year ambient-tide modelling runs.

The modelling results were examined by INPEX engineers to determine if a product tanker approaching the product loading jetty could sail through the dredged channel without any difficulty. Based on the preliminary results of the modelling it was estimated that approximately 200 000 m^3 of sandy material might be deposited within the proposed dredge footprint after 10 years, in which case maintenance dredging might be necessary. This siltation, however, will be most intense close to the dredge batters on the northern edge of the turning basin and berthing area and is unlikely to have a major impact on ship navigation as this area will only be utilised by tankers during arrival manoeuvres, when they are unladen and have a shallower draught. These deposits were forecast to build up to a typical depth of 1.5 m, but most of it will be limited to within 100 m of the toe of the batter slope. It is therefore suggested that maintenance dredging may be necessary after approximately 10 years. Extraordinary events such as cyclones may necessitate more frequent maintenance dredging. The actual volumes of sediment to be removed will be determined through annual surveys of the shipping channel by INPEX.

4.4.6 Dredge spoil disposal ground

An appropriate disposal location for the spoil generated by the dredging program is required. Options considered include offshore disposal of acceptable material to a subsea spoil ground, and onshore disposal to settlement ponds either on Blaydin Point or on land managed by the Darwin Port Corporation (DPC), for land reclamation. It was initially considered that the existing settlement pond capacity at East Arm Wharf and the area for its proposed future expansion might provide opportunities for onshore disposal. INPEX's geotechnical and geophysical investigations have, however, demonstrated that the dredge source material is very fine and therefore unsuitable for infill and construction purposes. The results of the INPEX investigations have been made available to the Northern Territory Government. The use of dredge material for fill purposes on Blaydin Point had been previously ruled out because there is insufficient space to accommodate the necessary settlement ponds.

Therefore, for the purposes of the Draft EIS, it is assumed that all dredge spoil material will be disposed of offshore. Should the opportunity for some onshore disposal arise closer to the start of the dredging program, INPEX would explore the option in conjunction with the DPC.

In order to identify a suitable location for offshore dredge spoil disposal, key stakeholders were consulted. These included NRETAS, the Department of Planning and Infrastructure (DPI)[3], the DPC, the Amateur Fishermen's Association of the Northern Territory (AFANT) and local shipping companies. Key concerns raised during this consultation included the following:

- the possibility of impacts from sediment remobilisation on to Darwin's northern beaches, for example at Fannie Bay, and on to sensitive seagrass beds adjoining these beaches
- the possibility of creating navigation hazards for vessels entering and leaving Darwin Harbour
- the possibility of sediment remobilising back into Darwin Harbour or into the DPC-proposed Charles Point Patches navigation channel and thus interfering with safe navigation
- the possibility of sediment remobilisation adversely affecting fishing grounds in the inner Charles Point Patches and Charles Point area as well as disrupting recreational fishing boat movements between these areas and the outer fishing grounds of South Gutter and Fenton Patches

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[3] The Northern Territory's Department of Planning and Infrastructure was restructured in December 2009 and its functions were transferred to two new departments, the Department of Lands and Planning and the Department of Construction and Infrastructure.

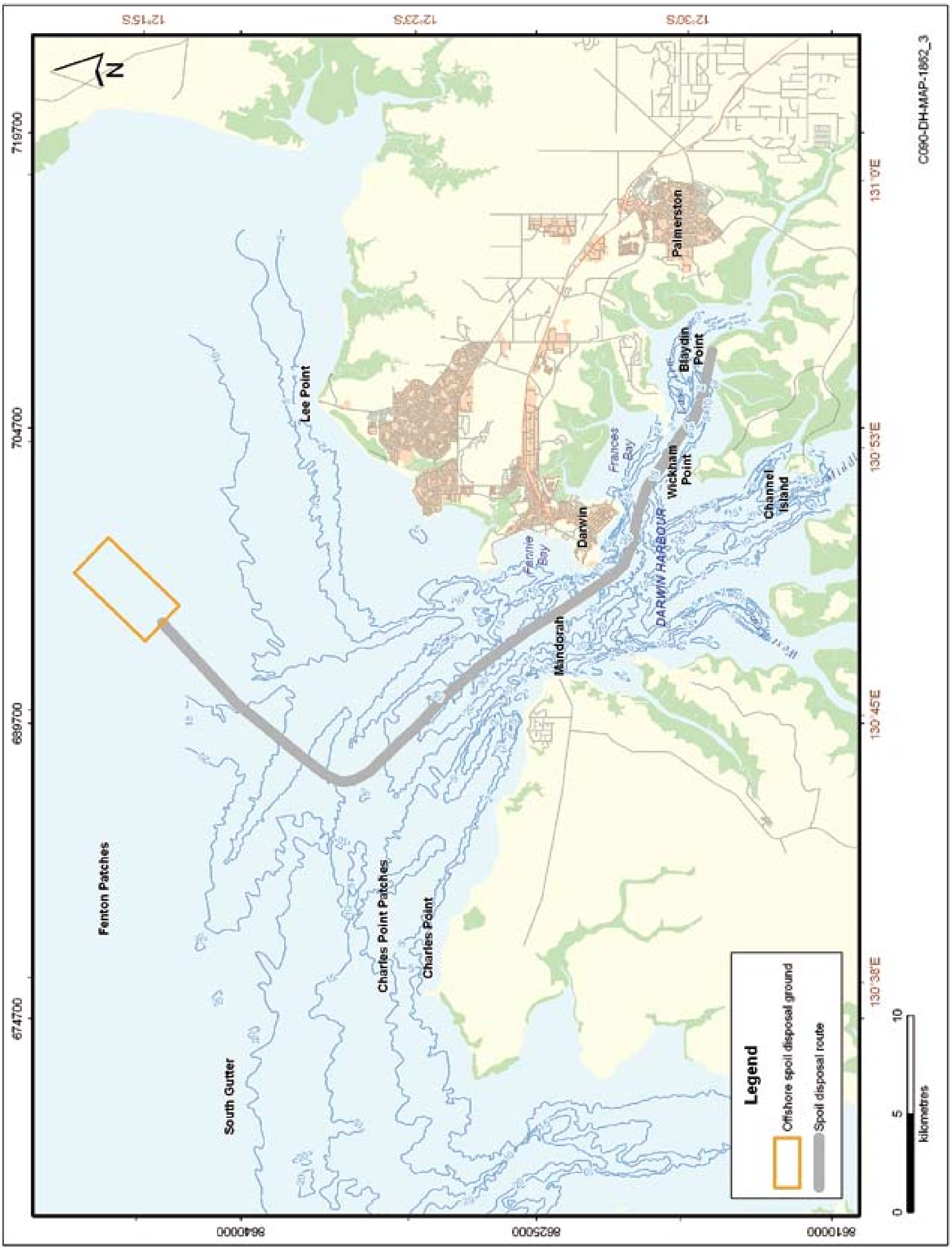

Figure 4-27: Dredge spoil disposal ground

- the possibility of sediment remobilisation adversely affecting recreational fishing activities at the series of artificial reefs off Lee Point.

In addition, the shortest possible distance to the spoil disposal ground was preferred, to minimise vessel travel times and to avoid extending the overall duration of the dredging program in Darwin Harbour.

A suitable offshore disposal ground was selected by using predictive modelling to determine the movement of dredged sediments and turbid plumes from the disposal site in ocean currents (see Appendix 14 for details). Nine sites were considered. The selected spoil disposal site is located around 12 km north-west of Lee Point (Figure 4-27).

4.4.7 Maritime traffic in Darwin Harbour

Construction maritime traffic

A number of maritime vessels will be present in the nearshore area around Blaydin Point from the commencement of construction activities. Ships carrying process modules, heavy equipment and bulk materials from the overseas fabrication yards will be unloaded at the module offloading facility. Based on an estimate that there will be more than 200 modules, it is expected that five modules will be offloaded per month at the module offloading facility. This will vary depending on the stage of the Project. Other construction vessels supplying cargo and heavy equipment for the Project will be unloaded at East Arm Wharf. Where cargoes cannot be transported by road from East Arm Wharf, they will be transferred by sea across East Arm directly to the module offloading facility.

Based on preliminary shipping studies, there will be approximately 80 maritime shipments to East Arm Wharf and around 40 maritime shipments to the module offloading facility.

Other construction-related traffic will involve movement of the following vessel types in the Harbour:

- pipelay barges
- anchor-handling vessels, supply vessels, crew-transfer vessels, and security and escort vessels
- rock-dumping barges
- dredging and support vessels including:
  - a cutter-suction dredger
  - a trailing suction hopper dredger
  - a backhoe dredger and/or grab dredger
  - hopper barges
- self-elevating drilling platforms
- jetty construction support vessels
- jack-up barges
- tug support vessels
- storage barges
- survey vessels.

A detailed discussion of the impact of increased maritime traffic in Darwin Harbour can be found in Chapter 10.

Operational traffic

Operational maritime traffic will consist of product tankers and their associated tug and support vessels. Other vessels associated with Project activities may include maintenance dredging vessels.

Product tankers range in size according to the type and volumes of product being loaded. Typically, a fleet of LNG and LPG tankers is dedicated to a particular facility, whereas condensate tankers can come from the open market. Figure 4-28 shows a typical LNG tanker.

Figure 4-28: Example of an LNG tanker in transit

Approximately 200 tankers per year (up to four tankers per week) will berth at the jetty at Blaydin Point. Table 4-3 gives the estimated frequency of shipping movements by product type.

Table 4-3: Frequency of tanker movements

Product tanker	Size of ships	Frequency of movements (average per week)
LNG	125 000 to 265 000 m^3	3
LPG (propane or butane)	35 000 to 85 000 m^3	1
Condensate	21 000 to 130 000 m^3	<1

Both the LNG and LPG–condensate berths may be occupied at the same time. The berths will be designed to be capable of berthing and loading tankers safely in most non-cyclonic weather conditions. Each loading facility will have liquid loading arms and vapour recovery arms designed for the high local tidal range. They will have proven automatic systems which will release the arms safely from the ships if wave conditions exceed design levels.

A fleet of four tugs will be required to manoeuvre the LNG, LPG and condensate tankers in and out of the Harbour. While a vessel is alongside, one of the tugs will maintain a standby role as part of the emergency response and security procedures. Currently, because of the relatively low number of shipping movements in the port, the tugs located in Darwin have surplus capacity and investigations into potential operational synergies will be undertaken with the DPC and other port users to optimise the available tug power and numbers. A secure mooring for tugs will be required, particularly with regard to cyclone management, and discussions will be undertaken with the DPC regarding options for these facilities.

Marine exclusion zones

The establishment of exclusion zones is essential to ensure that the safety of workers and Harbour users is not compromised. Their boundaries will be determined through a series of safety assessments in consultation with the DPC and the Commonwealth's Department of Infrastructure, Transport, Regional Development and Local Government (formerly the Department of Transport and Regional Services). Table 4-4 provides a preliminary assessment of the exclusion zones deemed necessary for different components of the nearshore infrastructure and activities. These zones are subject to safety confirmation through the quantitative risk assessment process (see Chapter 10).

Table 4-4: Preliminary exclusion zones around Project infrastructure and vessels in Darwin Harbour

Infrastructure or vessel type	Size of exclusion zone
General construction vessels and jack-up barges	Various, depending on vessels.
Operating dredge vessels	Various, depending on vessels.
Pipelay operation (outside and inside Darwin Harbour)	500-m radius from lay barge.
Loading arms on product loading jetty and trestles	500-m radius from loading arms when a ship is berthed.
LNG, LPG and condensate product tankers in transit	1000 m astern and 500 m around the sides of the tankers.
General security zone around Blaydin Point	Subject to safety confirmation through the quantitative risk assessment process.

Navigation aids and moorings

The Project will require new navigation aids and channel markers and the relocation of some existing navigation aids in the Harbour. Location of the navigation aids will be decided in consultation with the DPC. Temporary mooring buoys and navigation aids may also be required. Areas for the mooring of construction vessels will be allocated and will be positioned away from sensitive environmental receptors such as heritage wrecks and coral communities. Spar buoys or piled beacons are proposed for all permanent navigation aids.

4.5 Onshore infrastructure

Infrastructure and activities in the onshore development area that will support the construction and operations phases of the Project are listed in Section 4.1.1.

The Project's onshore processing plant will be located on Blaydin Point in Darwin Harbour. The onshore development area, consisting of the LNG, LPG and condensate processing plant area, the flare pad, the administration area, the construction laydown areas, borrow area and the onshore pipeline route and easement, will require approximately 406 ha of land (Figure 4-29).

Gas will be brought to the onshore processing plant from the Ichthys Field through the gas export pipeline. The gas will be processed and products recovered, stored and then exported by tanker from the product loading jetty. The gas-processing plant will be designed to produce approximately 8.4 Mt/a of LNG from two 4.2-Mt/a LNG trains which will be started up approximately 9–12 months apart. The processing plant is intended to operate for 40 years.

The design of the processing plant layout has taken the following criteria into consideration:

- The plant layout should be designed to minimise impacts on ecologically significant areas (such as the mangrove communities), to limit the environmental footprint, and to provide protection from long-term shore movement and extreme weather events.
- The plant should be established above the predicted peak combined sea levels (tides together with storm surge) for East Arm Wharf, which is the closest location to Blaydin Point with available data (a 6-m AHD (Australian Height Datum) storm surge for a 1-in-1000-year event). Adequate protection should be provided to areas exposed to tidal and storm-surge events (e.g. using rock-armouring or similar).

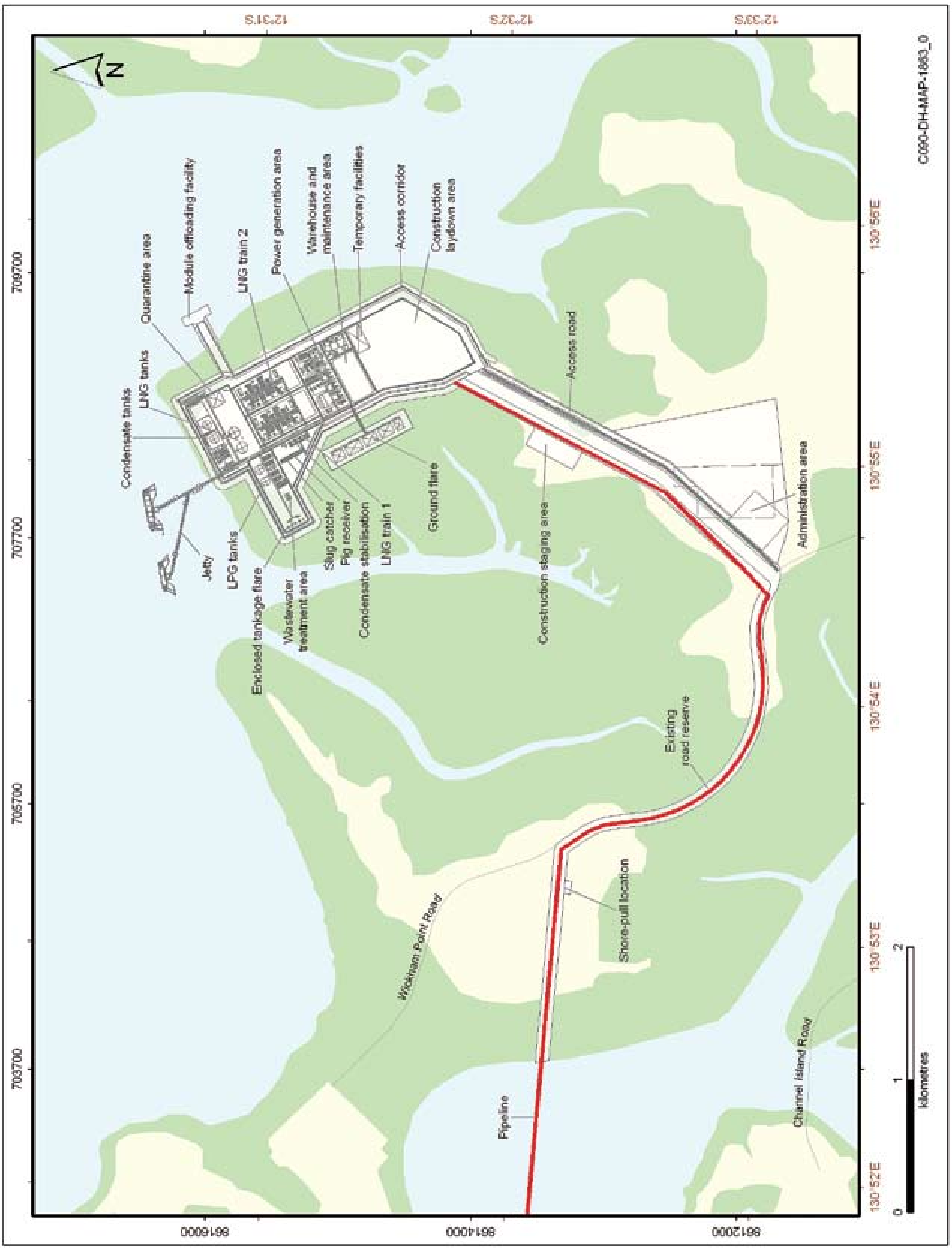

Figure 4-29: Onshore development area infrastructure

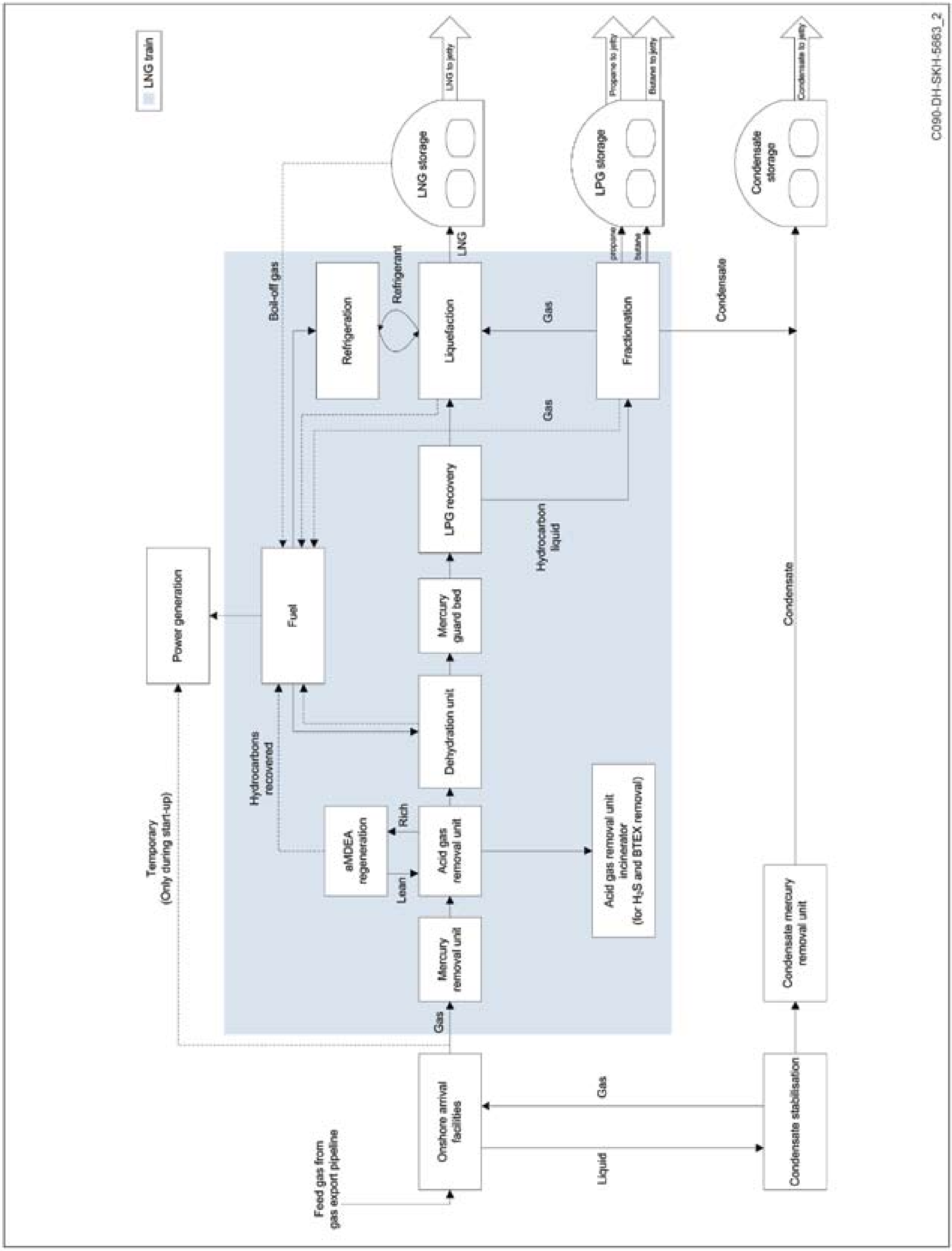

Figure 4-30: Onshore processing plant process flow diagram

- The plant should be constructed above a potential rise in sea level of 0.2 m as predicted by future climate-change scenarios for the Project's lifetime.
- Sufficient separation distances between process areas and non-process areas will be maintained, for example between the process areas and the administration building, warehouse and training centre, to minimise on-site risk.
- The road network should allow for safe emergency response and access to the process areas and the jetty.
- The plant design should take into account the prevailing wind direction to maximise natural air circulation for greater efficiency.
- The design of plant layout should position equipment to reduce off-site public risk by providing adequate separation distances.
- There should be sufficient separation between the different process areas to ensure that upset conditions in one area of the plant will not affect other areas.
- Plant layout should allow for space for future facilities, especially pipeline alignments, tanks and processing trains.

4.5.1 Onshore gas-processing facilities

Both gas-processing trains will use the same equipment and process for the cooling of the natural gas to below its liquefaction temperature of around –160 °C and for the separation of propane and butane and the stabilisation of condensate. The facility is called a "train" because the gas flows sequentially through a series of vessels that on an engineeer's process flow diagram fancifully resemble a series of railway carriages. This is shown in Figure 4-30, which presents an overview of the process.

Onshore arrival facility

The purpose of the onshore arrival facility is to separate the feed received from the offshore facilities into gas and liquid streams and to deliver these streams at a constant pressure to the LNG trains and the condensate stabilisation system respectively.

The arrival facilities will consist of pig-receiving facilities (for subsea pipeline inspection and cleaning) and a slug catcher. Pigging in the maintenance of pipelines refers to the practice of using pipeline inspection gauges or "pigs" to perform various operations on a pipeline without stopping the flow of the product in the pipeline. These operations include cleaning and inspection of the pipeline. This is accomplished by inserting the pig into a "pig launcher". The launcher is then closed and the pressure of the fluids in the pipeline is used to push the pig along the pipe until it reaches the receiving trap, the "pig receiver".

The slug catcher will be of a "finger" type and its capacity will be optimised during FEED and detailed design. It will consist of two halves to allow the isolation of one half to enable the slug catcher to be cleaned and inspected as required. The slug catcher will be followed by a pressure reducing station, which will regulate gas flow to the LNG plant.

The liquid fraction recovered in the slug catcher will be reduced in pressure and directed to the condensate treatment facilities while the gases recovered will be directed to the LNG trains.

The reception facilities are also designed to provide a supply of fuel gas for at least one power generator for start-up activities.

Condensate treatment

The condensate treatment facilities include the condensate stabilisation unit and the condensate mercury removal unit. After treatment, the mercury-free condensate is directed to the storage tanks.

Condensate stabilisation

Liquids from the slug catcher are fed into a separator to separate gases and liquid. The hydrocarbon liquids will be directed to the condensate stabiliser unit where they will be heated using a hot-oil system. The purpose of heating the liquids is to drive off any hydrocarbon vapours such as ethane, propane and butane in order to stabilise the vapour pressure of the condensate. The stabilised condensate will be fed to the condensate mercury removal unit.

Gases from the tops of the stabiliser units will be compressed and mixed with the feed gas to the gas treatment system.

Mercury removal unit

Based on analyses of initial samples, the condensate could contain traces of mercury compounds, which will be removed to conform with the buyers' quality requirements for the condensate.

The mercury removal unit will be designed to keep the mercury content in the product below 30 ppb by weight. When the adsorbent beds in the unit are saturated with mercury, a specialist contractor will be engaged to remove the packaging and to transport the beds to an approved disposal facility.

Storage tanks

Following treatment, the condensate will be transferred from the mercury removal unit to the condensate storage tanks after being combined with condensate from the de-isopentaniser. The recovered condensate will be stored in two large tanks and one small tank, each fitted with a floating roof. They will be bunded to contain their full volume in case of accidental release.

LNG train

Mercury removal unit

Gas from the top of the slug catcher will be directed to the mercury removal unit. The purpose of this unit is to prevent the release of mercury to the atmosphere in the acid gas stream from the acid gas removal system and to prevent corrosion of the aluminium alloy equipment in the downstream cryogenic systems.

The maximum mercury content of the gas leaving the mercury removal unit will be 0.01 µg/Nm^3.

The mercury adsorber removes any mercury present in the feed gas using a non-regenerable adsorption bed. As the gas passes through the vessel, trace mercury reacts with the sulfur and remains chemically trapped on the adsorbent.

The bed material acts as a filter and will be replaced periodically for recycling or disposal when it becomes inactive. Specialised contractors capable of safely removing the packaging and transporting the mercury-contaminated adsorbent bed will be employed for this purpose.

The treated feed gas continues to the acid gas removal unit (AGRU).

Acid gas removal unit

The feed gas stream will enter the bottom of the absorber column and flow upwards, coming into contact with a stream of fresh (or “lean”) activated methyldiethanolamine (aMDEA) solvent flowing in the counter-current direction. The packed bed will be designed to selectively remove the “acid gases”—carbon dioxide (CO_2) and sulfur compounds such as hydrogen sulfide (H_2S). During this process these gases will be chemically adsorbed from the hydrocarbon gas stream along with small amounts of hydrocarbons. The treated feed gas will then be directed to the dehydration unit.

The CO_2 has to be removed from the gas in order to prevent it from freezing in the liquefaction process and blocking the main cryogenic heat exchanger and other equipment. The sulfur compounds have to be removed from the gas stream to meet buyers’ specifications for the gas products.

The aMDEA solvent will generally absorb the acid gases until it is saturated. The saturated or “rich” aMDEA will then flow from the bottom of the absorber column to a high-pressure “flash drum” where most of the co-absorbed hydrocarbons will be flashed off and sent to the low-pressure fuel-gas system. The solution from the bottom of the high-pressure flash drum will be sent to the low-pressure flash drum, heated by the lean–rich exchanger and then sent to the top of the regeneration column. The acid gas will first be flashed off in the low-pressure flash drum and then the remainder of the acid gas will be stripped from the rich solvent in the regenerator using a heating medium. The regenerated aMDEA will then be cooled and pumped back to the absorber. The vapour stream from the regenerator will be sent back to the low-pressure flash drum.

The vapour stream from the low-pressure flash drum will be directed to the condenser to recover water, and will then be introduced to the acid gas incinerator unit.

In the acid gas incinerator unit, the waste vapour stream will be preheated and then oxidised to destroy H_2S and aromatic hydrocarbons. The H_2S will be converted to sulfur dioxide (SO_2) and the aromatic hydrocarbons will be burned, creating CO_2 and water vapour. In the unlikely event that the AGRU incinerators are shut down, these exhaust gases will be hot-vented through gas turbine exhaust stacks.

Dehydration unit

The treated feed gas from the AGRU is now free of acid gases, but it is still saturated with water which has to be removed in the dehydration unit. Gas will enter the dehydration inlet separator where it will be cooled with propane but maintained above the hydrate formation temperature. The cooling process will condense water and some hydration liquid from the gas stream before it enters the main part of the dehydration unit. The water will be removed to prevent it from freezing and causing process vessels and pipes to be blocked by hydrate crystals in the cryogenic liquefaction unit.

Gas from the dehydration inlet separator will be passed through a molecular sieve system which will adsorb the remaining water to a level below 1 ppm by volume.

It is planned that three vessels containing molecular sieve beds will be installed. Two of the vessels will be in adsorption mode at any given time while the third vessel is being regenerated. The rich molecular sieve beds will be regenerated by waste heat recovered from the gas turbine in the refrigerant system. The heated gas will be passed through the molecular sieves to remove adsorbed water. The regeneration stream will then be air-cooled to condense water, which will be separated from the regeneration gas in the regeneration gas drum and directed to the high-pressure flash drum of the acid gas removal unit as water wash for limiting aMDEA carry-over.

The dehydrated gas will be directed to the final mercury guard bed and the cooled regeneration gas will be sent back to the fuel-gas unit.

Mercury guard bed

The mercury guard bed provides an online backup to the mercury removal unit in case of upset conditions when the mercury removal unit is unable to reduce the mercury content of the gas to below 0.01 µg/Nm^3.

The bed material will be replaced periodically for recycling or disposal during major shutdowns of the LNG train every eight years. Specialist contractors who are capable of safely removing the packaging and transporting the mercury-contaminated adsorbent bed will be employed for this purpose. During FEED, the design team will investigate if this system will be required should the efficiency of the upstream mercury removal unit be improved.

Liquefied petroleum gas recovery

The purpose of the LPG recovery system is to maximise the removal of heavy components from the gas stream in order to provide gas that meets the LNG product specification.

The LPGs (propane and butane) will be recovered from the natural gas feed through the demethaniser column and associated equipment such as a turboexpander. The demethaniser column will be designed to remove hydrocarbons by distillation through a number of trays.

The product gas stream will then be compressed by the feed recompressor of the main cryogenic heat exchanger and sent to the liquefaction unit. The heavy components will be directed to the fractionation unit.

Liquefaction and refrigeration

The gas stream from the LPG recovery unit will be compressed in the inlet gas compressor of the main cryogenic heat exchanger, cooled against air and four levels of propane chilling, then directed to the main cryogenic heat exchanger and associated refrigeration where the gas will be liquefied to create LNG.

The refrigerant compressor will provide the power for the cooling process. The configuration of the required compressor driver turbines is the subject of ongoing investigation. It is likely that two compressor driver turbines will be used per train, four in total at *c.*85 MW each. INPEX aims to optimise the use of waste-heat recovery on these systems.

The main cryogenic heat exchanger will be a large vertical vessel containing internal tubing which will provide a large surface area for the efficient transfer of heat from the main gas stream. The product stream will leave the vessel at approximately –150 °C prior to entering the end-flash-process section.

The end flash process will drop the pressure of the LNG from the cryogenic heat exchanger to near atmospheric pressure through a liquid expander, thus reducing the temperature to around –160 °C. At this temperature, and near to atmospheric pressure, the mostly methane stream will be converted to liquid form (the LNG product) and will be directed to the cryogenic storage tanks. Details of the storage tanks are provided in Section 4.5.4 *Product storage and loading facilities*.

Fractionation

The purpose of the fractionation system is to separate out the heavy hydrocarbon components from the light gas—methane with some ethane—which is destined to become LNG. The fractionation system produces ethane, propane, butane, isopentane and condensate streams.

The ethane will be used as a refrigerant. Excess ethane will be sent to the high-pressure fuel-gas system. A portion of the propane will be used as refrigerant and the greater part will be sent to the export facilities as product. Butane and condensate will be sent to the export facilities as separate products. Isopentane that does not remain in the condensate will be sent to the fuel-gas system and used as fuel gas.

The propane, butane and condensate products will be sent to storage tanks where they will be held before loading on to ships for export.

4.5.2 Utilities

Refrigerant storage

Supplies of propane refrigerant will need to be imported to start up the liquefaction process, but after a period of time the process will be self-sufficient. Once the operations stabilise following commissioning, propane produced at the plant will be used as refrigerant. The propane will be stored in a spherical storage tank.

Fuel

Fuel gas

The fuel-gas system will supply clean superheated gas at high pressure to all the compression and power generation gas turbines. A backup fuel supply will be provided to supplement the normal supply in the event of a plant upset or fuel-gas system failure. The fuel-gas system will also supply gas at low pressure for fired furnaces and incinerators as well as for pilot-light and purge purposes on flares and generators.

Diesel

Fuel storage tanks will be required at the site for the supply of diesel fuel for dual-fuel power generation turbines, vehicles and equipment during operations. These will be located on hardstands on site in the administration and processing-plant areas. During construction, a temporary fuel system with pumps, storage tanks and pipework will be required to service light vehicles, construction equipment and temporary diesel power generator sets.

Heating medium

Many of the process units in the LNG trains require heat. This heat will be provided by a hot-oil-based system, which will aim to maximise the use of waste heat from the exhaust of the main compressor's gas turbine driver on each gas-processing train. Once the heating medium has been heated, it will be circulated through the system in a closed loop.

Compressed air

Compressed air is required for three main purposes: plant air for general use, instrument air for control systems, and feed for the nitrogen plant air-separation unit. In the event that instrument air supply pressure begins to drop, the plant air system will be shed to ensure the availability of instrument air.

Plant lighting

Lighting will be required throughout the process and non-process areas to provide light for operability and plant safety. This is part of INPEX's duty-of-care obligation to its employees and contractors. A lighting system will be adopted for the gas-processing plant site with a range of lighting options dependent on the area in question and the type of operation.

Power generation and distribution

A total of nine open-cycle power generation turbines (*c*.40 MW each) will be required to service the operation of both LNG trains. However, INPEX is also investigating a combined-cycle gas turbine configuration which will reduce the required number of gas turbines and improve the efficiency of the onshore plant.

Power generation from diesel generators will also be employed for emergency power and during the initial commissioning of the facilities. These diesel generators are additional to, and independent of, the main power generation system and will be provided to supply power for those services required to ensure the safety of the installation and personnel in the event of a major incident. During the construction phase, temporary diesel power generators will be used, and power may also be imported from the Northern Territory Government's power distribution system (operated by the Power and Water Corporation (PWC)) at a point on Wickham Point Road. Distribution infrastructure, facilities and transformers may also be required.

To reduce diesel use further and to aid commissioning activities it is planned to import gas from the PWC gas transmission line. Once permanent feed gas is established from the gas export pipeline this connection to the PWC supply will be isolated (as it may be required again in the future during unforeseen events and/or emergencies).

Control of nitrogen oxides

The compressor and power generation gas turbines will be designed to achieve a low nitrogen oxides (low-NO_x) outcome. Options specific to the design of the facility are being investigated. The final selection will be determined in the detailed-design phase. Further discussion on NO_x emissions is provided in chapters 5 and 8.

Water demand and supply

Potential water demand and sources have been investigated to determine how water will be provided for the Project. These investigations have considered the requirements for the various stages of the Project's life, from the site preparation and construction phases up to and including the operations phase.

The levels of water demand can be separated by Project phase:

- *Construction:* During the construction phase, potable-water demand will gradually increase from the start of site preparation (as personnel numbers and construction activities increase) to approximately 1200 m^3/d. This includes service water and water required for concrete batching and dust suppression. It should be noted that water use is likely to be mainly during the daytime period and construction water usage will vary depending on the season (e.g. there will be reduced water demand for dust suppression in the wet season).
- *Precommissioning:* The peak water demand for the Project will be during the tank hydrotesting phase. During this period of approximately 16 months, large volumes of water will be required for the hydrotesting of storage tanks. It is anticipated that water demand could peak at approximately 7800 m^3/d, which would be required 24 hours a day intermittently for a few weeks. Where technically feasible, water demand will be minimised through reuse of tank hydrotest water.

- *Operations:* During the operations phase, water demand will be required at a consistent level over the plant's projected lifetime of approximately 40 years. Potable water required for the operation of the gas-processing facility and the site administration area would amount to approximately 2000 m^3/d. This would supply service water and water for the gas-production process.

In addition, major shutdowns are expected to occur periodically (once every 6–8 years), with each shutdown expected to last between 5 and 35 days. When one LNG train is shut down, the process-water demand will reduce; however the manning level is expected to increase to 500–600 people on site during this time and the net water demand may therefore not differ significantly from that of normal operations.

The supply of water is likely to come from the existing water main located in the road reserve of Wickham Point Road, which connects into the Darwin water supply scheme through the McMinns Water Treatment Storage Facility. Recent advice from the PWC has indicated that there will be sufficient capacity to accommodate the water demands of the Project.

Infrastructure that may be required to provide PWC water to the onshore development area includes a potential booster station near Elizabeth River Bridge and upgrading pumping capacity at the McMinns storage facility. Alternatives to using PWC water and incorporating water efficiency measures into the design of the onshore gas-processing facility are being investigated.

Sewage and grey-water treatment

Sewage and grey-water treatment will be required from the commencement of activities at Blaydin Point. As with water demand, sewage treatment capacity will be increased progressively as the Project workforce expands. The sewage management requirements for the different stages of the Project are likely to be met by packaged sewage treatment plants, self-contained septic-tank systems and ablution blocks. During construction, sewage will either be stored at site followed by disposal to existing sewage treatment facilities in the Darwin area or it will be treated and discharged to the marine environment through a temporary outfall. Ground infiltration of treated wastewater is also an option being considered; this, however, will be subject to assessment for its environmental acceptability.

A permanent sewage treatment facility will be installed to provide for operational and maintenance requirements. Separate sewage treatment and discharge facilities will be required at the process and administration areas during operations. Treated sewage from these facilities will either be used for irrigation or infiltration within a designated area or be directed to the jetty outfall.

INPEX or its subcontractors will be responsible for the operation and maintenance of the sewage and grey-water treatment facilities.

Firewater system

A firewater system will be designed with deluge and fire-monitoring systems for use in emergencies. The fire pumps will meet all statutory requirements for safety systems. During normal operations, the maintained pressure in the firewater ring main will be supplied from a freshwater tank, which can be used for testing purposes. The fire system will normally be maintained in a freshwater environment. Provision for a backup seawater supply to the firewater system is also included in the design.

Chemicals

A range of chemicals will be required for the operation of the gas-processing facilities. To ensure that chemicals are contained securely to protect underlying groundwater from accidental spills and leaks, adequate storage for all hazardous and non-hazardous liquids and chemicals will be provided at the appropriate facilities. Permanent storage areas will have the following features:

- bunded areas with drainage and adequately sized sumps
- laydown areas provided with adequate protection and lashing points
- custom-built skids with provision for spare portable tanks
- custom-built skids for transfer from portable tanks into a facility storage tank.

Temporary bunding will also be required for liquid and chemical storage in the construction phase.

Bunding and storage facilities for hazardous liquids and chemicals, including fuels, will be constructed in accordance with the relevant Australian standards and any Northern Territory requirements for dangerous goods storage.

The provision of adequate storage areas for liquids and chemicals will be critical to the effective implementation of the spill prevention and waste management plans as described in Chapter 8 *Terrestrial impacts and management* and Chapter 11 *Environmental management program*.

4.5.3 Ground flare

A flare system is required at the onshore facilities to ensure the reliable and safe collection and disposal of hydrocarbon vapour and liquid streams resulting from emergencies, process upsets, plant start-ups and shutdowns, and commissioning and maintenance activities. The flare system is the primary safety device for the facility and needs to be continuously available during commissioning and operations. The flare system must be designed to achieve the following:

- to collect vented hydrocarbon gas from the process systems and burn the gas safely at the flare tips
- to enable controlled depressurisation of systems containing hydrocarbons
- to enable safe emergency blowdown as a result of system upsets or emergencies (commonly known as “trips”).

Flare designs vary in size and complexity depending on the requirements of the facility and the environmental requirements in the Project area.

The design of the flare system will be sized to accommodate all commissioning and normal operational flaring through separate cold–dry and warm–wet systems. It will be designed to minimise smoke production and will be surrounded by noise and radiation shielding. Although the base case is for a rectangular design, the configuration of the flare pad will be finalised during detailed design. Alternatives to the configuration presented in Figure 4-31 include a square design with a similar footprint.

The flare pad will be located around 150 m west of the plant site and will cover an area of approximately 12 ha. Criteria used in determining the location of the ground flare included safety and noise impacts on the site as well as the potential visual impact and impacts on aircraft flight pathways. Safety factors include the calculation of thermal radiation zones to isolate the flare from the plant facilities and to limit the thermal radiation at the boundary of the flare area.

A causeway will connect the flare area to the main site. This will grade from 6.5 m AHD to 12 m AHD at the flare and will be designed to accommodate a 10-m-wide pipe rack, a one-way road and shoulders. Decreasing the height of the flare pad is part of ongoing investigation. The edges of the causeway will be protected by rock-armouring.

Figure 4-31: Indicative schematic of flare design

4.5.4 Product storage and loading facilities

Products from both gas-processing trains will be directed to the storage and loading facilities. The purpose of these facilities is to store products safely and to pump the stored products to their respective berths and product tankers.

Separate storage tanks are required for each of the products from the gas-processing plant, namely LNG, propane, butane and condensate.

The size and number of the LNG, LPG and condensate storage tanks are influenced by production rates, the frequency of tanker arrival, and the offtake volumes. This cycle is in turn influenced by the speed and size of the vessels; the berthing and unberthing time and the loading rates; and the state of the sea, the tide, and the weather. Storage requirements are determined based on the input of these factors into probabilistic shipping simulations. Preliminary simulations have determined that the numbers and sizes of storage tanks are as presented in Table 4-5.

The primary factor in the location of product storage tanks is distance from the loading facilities. The further away the product tanks are from the loading facility, the greater the requirement for insulated pipelines and a potential requirement for recompression and reliquefaction. These requirements would decrease the efficiency of the process, thereby increasing the volumes of emitted greenhouse gases and the cost of generating the product. The location of the tanks on Blaydin Point has therefore been designed to be as close to the product loading facilities as possible.

The storage and loading facilities are also required to manage vapours from the product tankers and storage tanks. These vapours, which are displaced when tanks and vessels are loaded, are commonly referred to as "boil-off gas" (BOG).

The BOG from LNG storage tanks and shiploading operations (ship cargo tanks) will normally be recompressed in BOG compressors and directed to the fuel-gas supply or reprocessed. BOG from propane and butane storage tanks will normally be recovered, processed and returned to the product storage tanks. LPG export tankers are fitted with their own vapour recovery systems where gases are reliquefied back to the cargo tanks. The condensate storage tanks onshore will also be fitted with floating roofs to minimise hydrocarbon vapour release.

In addition, an enclosed tankage flare will be used during loading to accommodate the BOG from storage tanks and ships that cannot be recovered. Flaring from the enclosed tankage flares may occur under the following circumstances:

- If one or more of the BOG compressors are inoperative, some or all of BOG produced may have to be sent to the enclosed tankage flare.
- If a compressor reaches capacity, excess gases will have to be flared. This can occur, for example, when large volumes of BOG are produced from tankers which have been heating up beyond normal expectation during the journey to Darwin. These ships (referred to as "hot ships") require a period of prolonged operation or flaring before bulk loading can commence, during which time a proportion of their BOG has to be flared.
- If tankers have been in dry dock for maintenance, upgrades or repairs, they will contain inert gases such as nitrogen which cannot be recompressed for reuse as fuel gas and/or reprocessed; boil-off gases from such sources will need to be flared.

4.5.5 Drainage and wastewater treatment system

The drainage and wastewater treatment systems for the onshore facility have been designed to achieve the following ends:

- to collect and treat wastewater streams
- to distribute surface water to multiple points around the onshore development area
- to minimise the erosion of landforms and the transportation of sediments
- to minimise the creation of breeding habitat for mosquitoes and other biting insects
- to minimise the impact on downstream water quality, specifically that of Darwin Harbour.

Table 4-5: Indicative product storage requirements

Product and storage type	Number of tanks	Total stored volume (m^3)	Outer dimensions of tanks	
			Width (m)	Height (m)
LNG (cryogenic)	2	330 000 m^3	85	50
Propane (refrigerated)	1	90 000 m^3	70	35
Butane (refrigerated)	1	90 000 m^3	70	35
Condensate (ambient temperature)	2	120 000 m^3	55	25
Condensate (ambient temperature)	1	*c.*7500 m^3	22	20

Plant drainage will be designed to separate contaminated from non-contaminated areas. Wastewater from potentially contaminated areas will be isolated and treated by separate drainage systems. Where wastewater is potentially contaminated by hydrocarbons, it will be routed to the oily-water treatment plant or collected locally and disposed of off site. The drainage system will also be designed to accommodate firewater in the event of an emergency. Treated wastewater streams will be commingled and directed to the jetty outfall.

Non-contaminated drainage will be directed to multiple discharge points around the perimeter of the site through open channels designed to minimise erosion. In locations where drainage cannot be captured by the main drainage system, the non-contaminated water will be discharged directly to the Harbour (e.g. the runoff from the module offloading facility access ramps).

Discussion on wastewater sources, treatment, volumes and characteristics is provided in Chapter 5. A description of the dispersion of wastewater from the combined outfall is discussed in Chapter 7.

4.5.6 Supporting facilities

Facilities that will be installed to support the production process and the logistic and administrative requirements for the workforce for the construction and operations phases are outlined in this section.

Administration area

The administration area is required to support the operation of the plant and supporting facilities. This area is 2.5 km south of the processing facility on the site access road leading to Blaydin Point. Like the plant pad, the administration area will be designed to be above storm-surge height. It is likely that the administration area pad will not require rock-armouring as it is above the Highest Astronomical Tide (HAT) datum and will not be subject to tidal inundation or wave action. During construction, the area may be used as a temporary laydown area and may house temporary buildings, utilities and facilities not required in the processing plant area.

Roads

A sealed access road will be built from Wickham Point Road past the administration area to the gas-processing plant on Blaydin Point. It will be an 11-m-wide road with two 3.5-m-wide trafficable lanes, a 1-m-wide sealed shoulder on each side and a 1-m-wide unsealed shoulder on each side. The trafficable road surface will be sealed.

Culverts will be constructed below the access road in order to allow the tide to maintain its flow through to the mangrove areas. The exact location of the culverts will be determined through detailed drainage investigations along the road. The road will be drained and drainage trenches placed alongside. The drainage trenches will remain unsealed to allow natural infiltration to occur.

A minor road from the access road to the administration area will also be required.

Communications

Internal and external communications will be required on the site. Internal communications will be supplied by a fibre-optic cable between Wickham Point Road, the administration area and the processing-plant facilities. The administration area will be connected to external communications systems through a communications tower, satellite dishes and other communications equipment. Temporary communications will also be required from the start of the construction phase, including hand-held radios and temporary communications landlines.

4.5.7 Construction of onshore infrastructure

The construction of the gas-processing facilities and supporting infrastructure in the onshore development area will take place over a period of five to six years. Onshore and nearshore construction activities will run in parallel with off-site fabrication of process modules and equipment, as well as with the installation of the offshore facilities.

The construction approach for the onshore infrastructure will be to install a combination of prefabricated gas-processing modules and facilities constructed on site, for example the product storage tanks and supporting facilities. This approach will optimise the time and resources required at the site through the concurrent construction of the process modules at overseas module yards and the preparation of the site and purpose-built facilities. Prior to installation and hook-up of the modules, significant site preparation and civil works will need to be undertaken.

Site preparation

Site preparation is required to ensure that ground conditions are appropriate for construction. Activities will primarily consist of the following:

- establishing all-weather access roads, fencing, ablution facilities and amenities
- pegging-out the areas to be cleared and those to be protected
- mobilising clearing and earthmoving plant, temporary facilities and other equipment to site
- site-clearing and disposing of and/or storing of cleared vegetation

- engaging in major site earthworks on site and at the on-site borrow area
- installing drainage for the civil construction phase, including temporary sedimentation ponds for drainage and erosion control
- suppressing dust using potable water.

Earthworks machinery is likely to consist of drilling rigs; excavators; bulldozers; scrapers; pick-ups or light-duty vehicles; water trucks; cranes; minibuses; transit mixers; forklifts; truck-mounted concrete pumps, compressors and generators; compactors; tipper trucks and trailers; fuel and lube trucks; flat-bed trucks; and pumps.

Drainage will be put in place during site preparation for the following reasons:

- to minimise the amount of disturbed soil at any one time
- to prevent runoff from off-site areas flowing across disturbed areas
- to slow down runoff flowing across the site
- to remove sediments from on-site runoff before it is discharged to the Harbour (either by employing temporary sedimentation ponds or by building treatment structures).

The extent of the earthworks required for the site is dependent on the results of detailed geotechnical investigations and the characteristics of the soils from the borrow-pit areas. Table 4-6 presents the preliminary volumes of cut and fill required for the Project. Earthworks will involve relocating material cut from around the borrow pit at Blaydin Point to bring the site up to the required level. Use of the existing borrow pit will be maximised and additional fill will be sought from a borrow area adjacent to the administration area, which roughly follows the 7-m AHD contour, in order to allow for potential future development needs. Alternatives to using this area for borrow material are being investigated in the vicinity of Middle Arm Peninsula.

Measures will be put in place to control the flow of water across the site and in drainage channels. These measures will serve to encourage the settling of suspended solids that may be produced from stormwater drainage. Cut-off drains will intercept off-site runoff from higher ground and prevent it from flowing across the site.

During the site preparation stage, some topsoil will be stockpiled for later use in site reinstatement. Following commissioning, stable landforms will be established in the construction laydown areas and borrow pits for potential future use. Temporarily disturbed areas such as those in the vicinity of the pipeline shore crossing and onshore pipeline route will be reinstated and rehabilitated, as will any areas around the plant that do not need to remain cleared.

Temporary facilities and construction laydown

From the commencement of site preparation and throughout the construction phase, large areas will be needed for laydown to cater for a range of temporary facilities, construction materials and equipment. These will potentially include the areas and facilities listed below:

- storage areas for process modules
- storage areas for equipment and materials such as steel, piping materials, tank plates and cables
- vehicle checking and washdown areas
- temporary office and crib facilities
- ablution facilities
- parking areas and roadways for construction equipment and personnel vehicles
- fuel storage, bunded areas and distribution facilities
- water storage and distribution facilities
- a temporary sewage treatment plant
- a temporary warehouse and workshops
- liquid, chemical and waste storage and transfer areas
- evaporation and settling ponds

Table 4-6: Indicative earthworks estimates for Blaydin Point and the borrow area

Area	Cut (m^3)	Fill (m^3)	Balance (m^3)
Onshore processing plant	–1 060 000	1 350 000	290 000
Ground flare pad	n.a.	900 000	900 000
Module offloading facility	n.a.	150 000	150 000
Access road	–10 000	70 000	60 000
Administration area	–120 000	30 000	–90 000
Borrow area	–1 160 000	n.a.	–1 160 000
Total	–2 350 000	2 500 000	150 000

n.a. = not applicable.

- welding, grinding, cutting and other hot-work fabrication facilities
- industrial-cleaning, abrasive-blasting and spray-painting areas
- rock-crushing and screening plant or plants
- storage areas for soil and rock
- an acid sulfate soils neutralisation area
- a lime stockpile area for acid sulfate soil neutralisation
- a bitumen plant
- a concrete batching plant
- scaffolding and lifting-equipment storage and maintenance areas.

Construction laydown areas are required to be as close to the construction site as possible. Temporary facilities may also be located on areas which will be used later for permanent facilities.

Construction of onshore gas-processing plant

Once the site has been levelled and all access roads and drainage put in place, construction of the foundations for the processing plant will start.

The construction plan for the two LNG trains at Blaydin Point is based on a modularisation approach with a minimum of “stick-built” facilities (i.e. facilities that are constructed entirely on site with no pre-assembling of parts). A modularised construction approach is defined as a process where the plant facilities are packaged on a systems basis so that they can be fabricated off site and efficiently installed, connected and commissioned on site with as few interconnections as possible. It is planned that the process units and vessels will be built in fabrication yards overseas and transported by sea in defined modules to Blaydin Point.

The construction of any non-modularised supporting facilities, site drainage, foundations and bunded areas will run concurrently with the overseas fabrication of the processing-plant modules.

Plant foundations

The greater part of the LNG trains area will be completed with a concrete slab layer set on top of a rock-and-fill pavement layer. Where concrete is installed in areas with a potential for acid sulfate soils, a liner will be required to protect the concrete from degradation.

The process plant and equipment items are likely to be installed directly on concrete spread foundations. However, depending on the ground and load conditions of different parts of the facility, piled foundations may be adopted. Final foundation design will be determined through more detailed geotechnical investigations.

Perimeter drains and rock-armouring will be installed around the site perimeter for erosion control. Rock-armouring, crushed rock paving, and hardstand material for the construction of the bases of foundations and construction laydown areas will be sourced from the borrow area on site and from a local quarry site operated by a third party. Trucks will be required to transport the rock-armour and other materials from the quarry to the site for stockpiling prior to use.

Ground flare pad and causeway

Construction of the flare pad will require the reclamation of an area in the mangroves to provide an approach and an elevated platform made of earth fill. The fill will be obtained from the borrow pit area. Alternatives to this option, such as constructing a piling and deck structure or inserting stone or concrete columns, are being investigated.

Module offloading and installation

The installation of modules at Blaydin Point will occur sequentially so that the two LNG trains will be commissioned 9 to 12 months apart. This period is to allow module fabrication and construction activities to be scheduled without excessive overlap.

The number of modules has been minimised by making module sizes as large as possible within transportation constraints. Approximately 200 modules of varying shapes, sizes and weights will be imported through the module offloading facility. There are likely to be up to 50 modules for the main process trains and a number of smaller modules with interconnecting pipework and utilities. Offloading of the modules will be effected using hydraulic, self-propelled, multi-wheeled trailers from the delivery vessel.

Construction of LNG, propane, butane and condensate storage tanks

The onshore product storage tanks will be built on site by specialist contractors. The product storage tanks are likely to be constructed of reinforced concrete, insulation material and steel sections. The roofs of the storage tanks will either be lifted into place by a crane or by compressors that gradually lift the roofs into their required positions.

Ground improvement will be necessary prior to construction of the concrete tank foundations. The requirements for piling to support the concrete slab will be established after detailed geotechnical surveys have been conducted.

Construction and installation of supporting facilities

Construction activities associated with supporting facilities include site clearance, bulk earthworks, the construction of foundations, the erection of perimeter fencing and the provision of services such as power and water to designated interface points within each area.

The construction of the roads will be phased, with different road-surface standards being applicable at different stages. During the initial site preparation phase, the roads will take the form of earthen haul roads or access tracks and there will be a minimum of embankment earthworks prior to bituminising. The construction of the roads will require cut-and-fill activities with borrow material being used for pavement and embankment construction.

Accommodation village

The construction workforce is estimated to be between 2000 and 3000 at the peak of the five- to six-year construction period. It is proposed that an accommodation village will be constructed to house most of these people. Normal operations and periodic maintenance-campaign accommodation for personnel will also be required during the operations phase. An accommodation strategy is being developed to identify and investigate accommodation requirements and options during the operations phase. In addition, part of the accommodation village may be required during the operations phase to support accommodation requirements during maintenance shutdowns when personnel requirements increase.

A number of potential locations for the accommodation village were presented to INPEX by both the private sector and the government. The preferred location was chosen from a short list of sites with consideration of stakeholder input and the criteria listed below:

- There should be land potentially available for development.

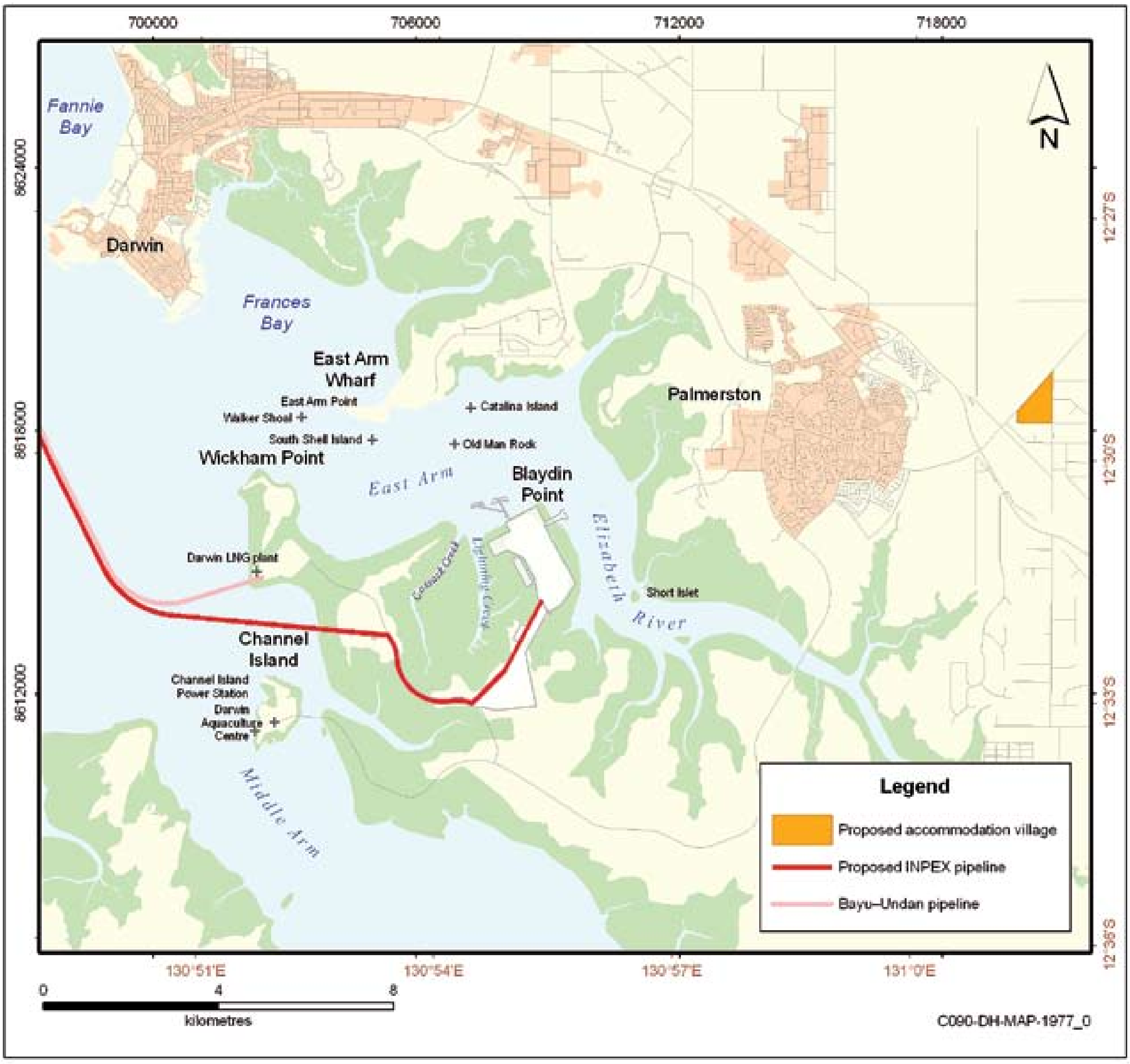

Figure 4-32: Preferred accommodation village location

- The area of available land should be sufficient to accommodate a workforce of 2000–3000 people.
- There should be access to adequate transport infrastructure.
- The location should have access to and be in close proximity to domestic utilities such as power, water and sewerage.
- The location should be in proximity to the onshore development area at Blaydin Point.

The preferred location for the accommodation village is a site on Howard Springs Road, encompassing contiguous land sections 2818, 2819 and 273 (see Figure 4-32).

As the accommodation village must be completed and available prior to the start of construction of the onshore component of the Project, a series of approvals separate from this Draft EIS are being sought. These approvals require assessment of environmental factors such as the direct impacts of vegetation clearing and sediment control on the site.

The social impacts associated with the operation of the accommodation village have been included in this Draft EIS and are detailed in Chapter 10. The issues which have been addressed include increased pressure on local infrastructure, increased traffic, and social interactions between the local community and the new workforce.

Road traffic

During the five-year construction phase, large quantities of bulk materials, other supplies, heavy equipment and plant will be brought to site. Where possible, these will be sourced from Darwin or imported by road from East Arm Wharf or directly to site across East Arm through the module offloading facility. The Project's aim is to optimise the use of the module offloading facility in order to limit the impacts on existing infrastructure. As the larger modules will be offloaded from vessels at the module offloading facility, the need for road-widening to accommodate very large vehicles is not considered necessary. Construction traffic will also include personnel commuting between the onshore development area and the accommodation village, Palmerston and Darwin.

Road traffic for the construction phase of the Project is summarised in Table 4-7 and has been the subject of a detailed traffic impact study, as described in Chapter 10.

Once the Project is fully into the operations phase, the volume of road traffic will decrease substantially. Operations road traffic will consist of light vehicles and buses carrying personnel and a range of supply and waste-transport vehicles. Volumes of personnel traffic will increase during temporary maintenance shutdowns.

Table 4-7: Assumed average peak daily road traffic generated by construction activities

Origin	Destination	Approximate number of round trips per day	Cargo
Blaydin Point	Shoal Bay landfill	30	Construction waste; domestic waste and recyclables; green waste; hazardous materials.
Blaydin Point	Shoal Bay landfill	80*	Acid sulfate soils for disposal.
Darwin	Blaydin Point	170†	Raw materials; aggregate; sand; cement; asphalt; scaffolding; tools; equipment; personnel.
East Arm Wharf	Blaydin Point	74	Fuel and cargo from maritime vessels.
East Arm Wharf	Darwin	2	Cargo from maritime vessels.
Mount Bundy quarry	Blaydin Point	60	Rock-armouring and aggregate for site construction.
Mount Bundy quarry	East Arm	102	Rock-armouring for pipeline stabilisation.
Mount Bundy quarry	Shore-crossing location	3	Rock-armouring for stabilisation of the pipeline shore-crossing location.
Accommodation village	Blaydin Point	100	Personnel from the village (bus movements).
Accommodation village	Blaydin Point	125	Personnel from the village (light-vehicle movements).
Accommodation village	Shoal Bay landfill	2	Waste and recyclables.

* Note that several methods for treatment and disposal of acid sulfate soils are being considered, including treatment in situ and disposal offshore. Depending on the final option chosen, the indicative vehicle movements shown here may not be required.

† This figure includes 100 car trips.

Mainland supply base

Logistic and supporting facilities from the mainland will be required for the offshore component of the Project. The mainland supply base will allow for the loading and refuelling of supply vessels, the storage of construction materials, the offloading of deliveries requiring transport and packaging, and the storage of fuel, chemicals and waste. The supply base will include warehouse, administrative, security and related facilities.

As INPEX has yet to decide on the location of the mainland supply base, it cannot be described in detail in this Draft EIS. Existing facilities are being investigated but a new mainland supply base may be required which would be subject to a separate governmental assessment process. Locations being investigated include Darwin, Broome, Point Torment near Derby, and Derby. The mainland supply-base location will be determined during the detailed-design phase of the Project.

4.5.8 Onshore infrastructure precommissioning

A number of steps will be involved in the precommissioning of the onshore processing plant and supporting facilities prior to the introduction of hydrocarbons during commissioning.

The option for the precommissioning of process modules at the fabrication yards prior to shipping to site is being investigated. If this can be done, it will reduce the volume of hydrotest wastewater discharged into Darwin Harbour and reduce the number of personnel required for the precommissioning process.

Three aspects that will require particular attention are as follows:

- the disposal of flushing fluids
- the dewatering of pipelines
- the dewatering of product storage tanks.

Once equipment has been installed, the major activities in the precommissioning process will be as follows:

- the pressure-testing of systems with air and/or hydrotest water
- the chemical cleaning of some systems
- the commissioning of rotating equipment (turbines and pumps)
- the loading of chemicals such as aMDEA solvent, absorbents required in the molecular sieve for dehydration, and activated carbon for the mercury removal unit
- (potentially) the carrying out of the first fill of refrigerants.

The common utilities and power generation facilities will be installed and precommissioned as a priority. This will be followed by the installation and precommissioning of the inlet facilities and condensate treatment facilities. The product loading jetty will be precommissioned in advance of the hydrotesting of the product storage tanks.

The discharges associated with hydrotesting are described in chapters 5 and 7.

4.5.9 Onshore commissioning, operations and maintenance

The gas-processing trains are likely to be commissioned nine to twelve months apart. The first three months of commissioning may be undertaken with third-party gas followed by the introduction of gas from the offshore facilities. The initial introduction of gas into the onshore facility will be undertaken in stages. These stages include the following:

- the introduction of gas into process vessels and piping
- the checking and rechecking of piping, vessels, valves and flanges
- the testing of systems
- the commissioning of the main compression and LNG process units.

Once the system has been confirmed as having no leaks and has been defrosted, it will be ready to commence cooling the equipment to the normal operating temperatures for an LNG plant. While it is cooling down, the system will initially be too warm to create LNG and the gas will be directed to the flare in line with normal practice. The system will gradually come down to normal operating temperatures and start producing LNG. Throughput can then be slowly increased until steady-state operation is achieved for the first time.

Once the plant is in steady-state operation, INPEX's operations division will be responsible for maintaining the facilities. A maintenance function will be part of the operations division's role, with prime responsibilities in the following order of importance:

- to safeguard the technical integrity of the facilities
- to ensure that equipment and systems are maintained to a standard where they are able to satisfy environmental and regulatory-authority requirements
- to maximise the amount of time the facilities are running.

A risk-based approach will be taken to develop maintenance strategies that will be applied to different types of equipment and facilities. Preventive, predictive and corrective maintenance strategies will be developed using experience and good practice, supported where appropriate by techniques such as risk-based inspection and reliability-centred maintenance.

As personnel competence is considered key to the effectiveness of the maintenance function, appropriate selection procedures will be put in place and, where necessary, training of in-house and specialist personnel will be undertaken.

4.6 Decommissioning

The estimated life of the Project is 40 years. The Project will be decommissioned at the end of its operating life when production from the gas reservoirs is predicted to reach the limit of economic viability. The final state of the site after the 40-year lifespan of the Project will be dependent on the final land use to be determined by the Northern Territory Government.

An environmental impact assessment and approval may be required to confirm that the planned decommissioning activities are the most appropriate to the prevailing circumstances. This assessment would outline management controls and aim to demonstrate that the decommissioning activities would not cause unacceptable environmental impacts.

4.6.1 Offshore decommissioning

Once the field has reached the end of its useful life, the CPF and FPSO will be decoupled from their moorings and towed from the infield location, the reservoir will be permanently isolated, necessary well equipment will be removed, and the wells will be plugged and abandoned.

The process of decommissioning the offshore facilities will necessitate the assessment of a range of options, including finding alternative uses (including recycling or onshore disposal) for the CPF and the FPSO or their component parts. The options include leaving certain subsea structures in place, such as the mooring suction piles and infield flowlines. The assessment of options will be based on a range of physical factors (e.g. water depth, ocean processes, and the physical state of the facilities) and other considerations (e.g. proximity to sensitive habitats and interference with fishing-industry activities).

The gas export pipeline will be left in place following decommissioning.

Offshore decommissioning will also be subject to assessment under the relevant legislation and international conventions and treaties. While the requirements for decommissioning will depend on the regulations prevailing nationally and internationally at the end of the useful field life of the Project, consideration of the feasibility of different decommissioning options will be incorporated into the design of the offshore facilities.

4.6.2 Onshore and nearshore decommissioning activities

The extent of onshore and nearshore decommissioning and site rehabilitation will be agreed with the Northern Territory Government prior to the commencement of decommissioning. Options for decommissioning will depend upon the anticipated future land use and the requirements of the government.

If the land is to be used for future industrial activities, it may be desirable that the module offloading facility should be left in situ along with other valuable infrastructure such as the major access road and drainage control structures. Under this scenario, non-essential aboveground infrastructure would be removed and landforms made stable to prevent erosion. If, however, it were to be decided that the onshore development area should be returned to natural habitat, all aboveground infrastructure would be removed and an active revegetation program would be initiated; the effectiveness of such a rehabilitation program would be assessed against agreed completion criteria.

Removal of onshore infrastructure

As with the offshore facility, consideration of decommissioning feasibility will be incorporated into the design of the onshore facility. The exact designs and methods for decommissioning will need to take into account the possibility of advances in technology and knowledge over the 40-year life of the Project. Limiting decommissioning options to those available during the design phase risks the Project falling well short of best practice at the time of decommissioning.

An indicative outline of the activities that may be required to remove infrastructure from the onshore site has been provided below. The exact sequence of demolition would be laid down in a detailed decommissioning management plan to be provided to, and agreed by, the Northern Territory Government before decommissioning commences.

Gas-processing plant

As most of the components of the gas-processing plant on Blaydin Point will be installed in large prefabricated modules, it may be possible to remove the same modules in the reverse sequence of the installation process.

Such a sequence for removal could involve the following steps. The pipes and cables that interconnect the common facilities and LNG processing modules could first be disconnected at the individual module and pipe-rack boundaries. The individual modules and pipe-rack sections could then in turn be disconnected from their foundations and lifted off their supports using the same type of self-propelled module transporters used during their original installation. The individual modules and pipe-rack sections could then be transported down to the module offloading facility for loading on to a transportation barge. Once on the transportation barge they could be sea-fastened and then towed to an approved location for dismantling or reuse.

Prefabricated structures of all sizes could be removed using this approach. However, while the plant will be sound for operational purposes, it may not have the structural integrity for removal in large portions.

Once the processing facilities are removed, shallow-spread foundations could be excavated and demolished. The debris and foreign materials would be loaded on to trucks for removal and disposal.

If piled foundations are utilised in construction, the support plinths and pile caps would be excavated and demolished to a depth of 1 m below existing ground level. The piles themselves would have to remain in situ as the ground disturbance involved would be significant.

All excavations resulting from the removal of foundations could be backfilled with locally sourced materials.

Product storage tanks

Onshore decommissioning of the product tanks would be likely to be undertaken by a specialist demolition subcontractor.

It is envisaged that for onshore infrastructure, controlled use of explosives could be needed during some phases of the demolition of the redundant LNG and LPG storage tanks. The storage tanks and any shallow ground-bearing spread foundations could be removed completely. All excavations resulting from the removal of foundations could be backfilled. Deep (piled) foundations that could not be removed may be managed as described above for the gas-processing facilities.

4.6.3 Decommissioning management

Notice will be given by INPEX to the Northern Territory Government at least 10 years before the end date of production, to allow discussions regarding the decommissioning management plan to begin.

It is envisaged that the process of developing detailed decommissioning management plans will be staged, initially outlining potential options and studies required for discussion with the regulatory authorities, and finally leading to agreed plans prior to the commencement of decommissioning. The content of the final plans will be dependent, for example, on the anticipated future land use determined by the Northern Territory Government for the onshore site on Middle Arm Peninsula. The plans will include methods and activities associated with the decommissioning of the offshore and onshore infrastructure, including the transportation and final disposal or reuse strategy for Project components and wastes. Completion criteria will be detailed in the management plans and will include, for example, criteria for the composition of rehabilitated vegetation communities, for erosion control measures, and for the visual amenity of the site. These completion criteria will be determined in consultation with the government.

A Provisional Decommissioning Management Plan has been outlined in this Draft EIS and is provided as Annexe 5 to Chapter 11.