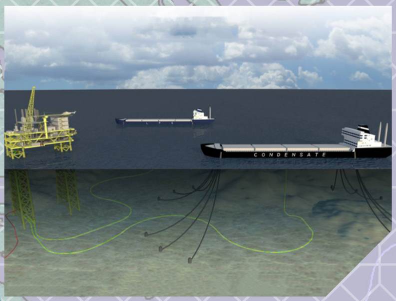
ENVIRONMENTAL IMPACT STATEMENT

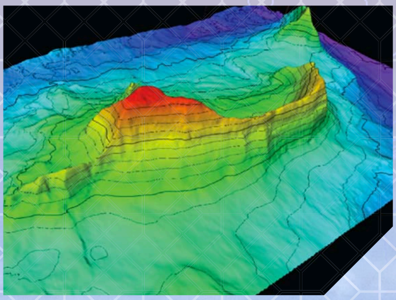
VOLUME A:
EXECUTIVE SUMMARY

PASCA A DEVELOPMENT PROJECT

TWINZA OIL (PNG) LIMITED

JANUARY 2016
Report No. 01223A_1_v1





Guide to the Environmental Impact Statement

The environmental impact statement is presented in three volumes

Volume A – Executive Summary / Sotpela Ripot

Prepared in both English and Melanesian Tok Pisin, this non-technical volume summarises the environmental impact statement

Volume B – Main Report

Prepared in English, this volume is intended to be a stand-alone document that can be read and understood without reference to the supporting studies that it draws from

Volume C – Appendices

This volume, prepared in English, comprises the specialist technical reports describing the various supporting studies, which are:

1. Marine Water and Sediment Quality Baseline Report
2. Biological Baseline Survey – Raw Data and Results
3. Qualitative Air Quality Assessment
4. Greenhouse Gas Assessment
5. Drill Cuttings and Muds Dispersion Modelling
6. Produced Formation Water Dispersion Modelling

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Twinza Oil (PNG) Limited

Pasca A Development Project

Environmental Impact Statement
Volume A – Executive Summary

January 2016
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1. Introduction

This report is the executive summary of the environmental impact statement (EIS) for the Pasca A Development Project ('the Project'), classified as a Level 3 Activity under s. 50 of the *Environment Act 2000*. Twinza Oil (PNG) Limited (Twinza) has prepared the EIS in accordance with the DEC Guideline for Conduct of Environmental Impact Assessment and Preparation of Environmental Impact Statement.

The overriding objective of the EIS is to gain government approval for the Project to proceed in an environmentally and socially acceptable manner.

1.1 Project Background

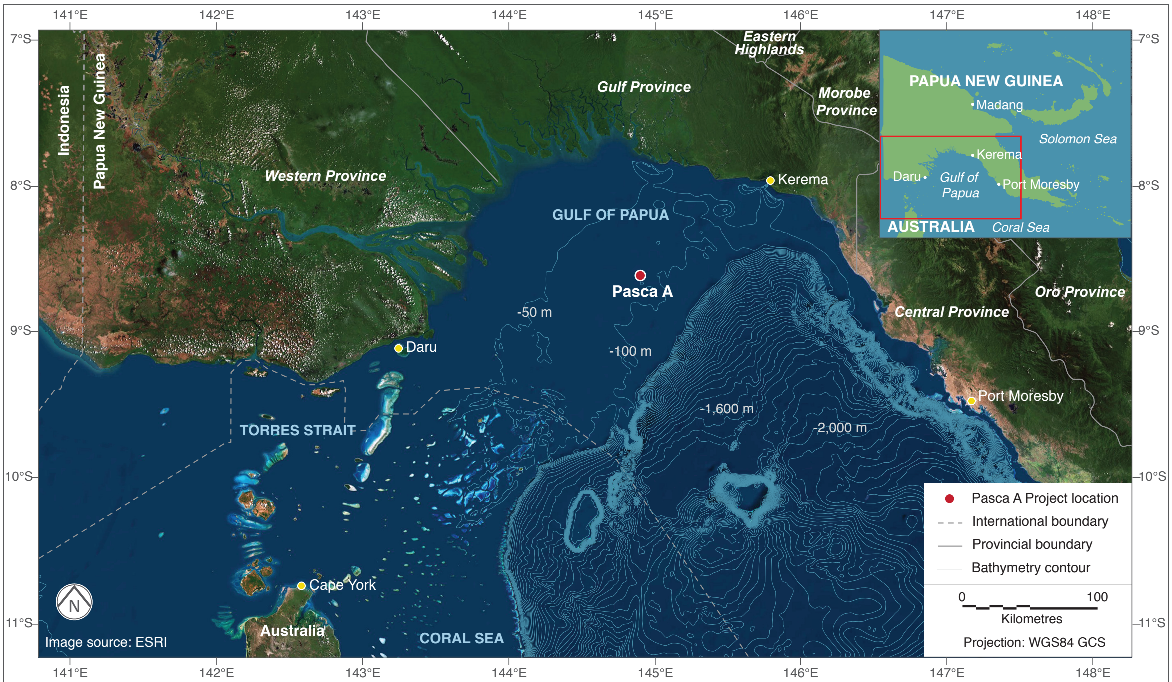
The Pasca A gas field is one of a number of undeveloped gas fields within the Papua Basin in the Gulf of Papua. The Project proposes to realise the value of this resource, providing benefits and opportunities to the people of Papua New Guinea. The Project will be Papua New Guinea's first offshore field development, bringing stranded gas resources discovered 47 years ago into production. The development also has the potential to catalyse the further gas resource potential of the gulf.

The Pasca A gas field is located approximately 85 km from the nearest coastline and 265 km west of Port Moresby in Petroleum Prospecting License 328 (Figure ES1). It is in relatively shallow water (approximately 93 m depth) with a highly productive reservoir, allowing for cost effective field development using industry standard, proven and modern technology.

The field contains a wet gas that will be extracted and processed into condensate, liquefied petroleum gas (LPG) and dehydrated gas, the latter being reinjected into the reservoir for development at a later stage. The surface processing facilities include a production platform and two floating storage and off-take vessels (FSOs) for the LPG and condensate.

These products will supply the domestic and regional energy markets with 19.1 million barrels of condensate and 20.1 million barrels of LPG (propane and butane) over a field life of 20 years. The propane stream of LPG will supply the Papua New Guinea domestic market while the condensate, butane and surplus propane fractions will be exported.

Figure ES1 – Project Location



The proponent of the Project is Twinza, a wholly owned subsidiary of Twinza Oil Limited, which is a public, unlisted Australian Company incorporated in 2004 and holding assets in Papua New Guinea, Australia and Thailand. Its partner in the Project is the Papua New Guinea state-owned Petromin PNG Holdings Limited (Petromin), which has a 10% interest via its wholly owned subsidiary Eda Energy Limited.

The total estimated capital expenditure for the Project is US$350 to US$550 million, which is equivalent to approximately K1.1 to K1.7 billion. In addition to the purely economic benefits to the national and provincial economies from the sale of hydrocarbon products, direct and indirect taxation and royalties, the Project will also bring other additional benefits to Papua New Guinea such as:

- Provision of LPG into the domestic market, delivering affordable and cleaner energy and power through substitution of other liquid fuels (kerosene, diesel and gasoline), and supporting the nation's strategic development strategy.
- Potential opportunities for LPG storage and distribution centres.
- Positioning of Papua New Guinea as a regional energy exporter, as condensate and LPG, to the Pacific Economic Community.
- Training and direct employment for Papua New Guinea citizens involved with the project at the Port Moresby office and the offshore production facility.
- Creation of new in-country industry opportunity and expertise for supply and servicing of the offshore oil and gas industry.

1.2 Project Justification

Analysis of Papua New Guinea's energy demand and supply outlook has been undertaken by the Asia Pacific Economic Cooperation (APEC) for the period 2010 to 2035. Papua New Guinea's energy demand in the 2010 to 2035 period is projected to grow at an annual rate of 3.8%. The industry sector will account for 59% of final demand in 2035, with demand projected to increase at an annual average rate of 4.4% in the outlook period. Energy demand in the transport sector is expected to increase at an average annual rate of 2.3% over the outlook period, with this demand met almost entirely by oil-derived fuels. The energy demand in other sectors, which includes residential, commercial and agricultural users, is projected to increase at an average annual rate of 4.8% over the outlook period. Energy demands in these sectors will be primarily for electricity, kerosene and LPG.

1.2.1 No-Project Option

The consequence of the Project not proceeding is that the social and economic benefits described above and in Section 4.3 will not happen. The environmental and socio-economic impacts associated with development of the gas field, identified in Chapter 4.2, would also not occur.

2. Project Description

The general arrangement for the offshore production facilities is illustrated in Figure ES2.

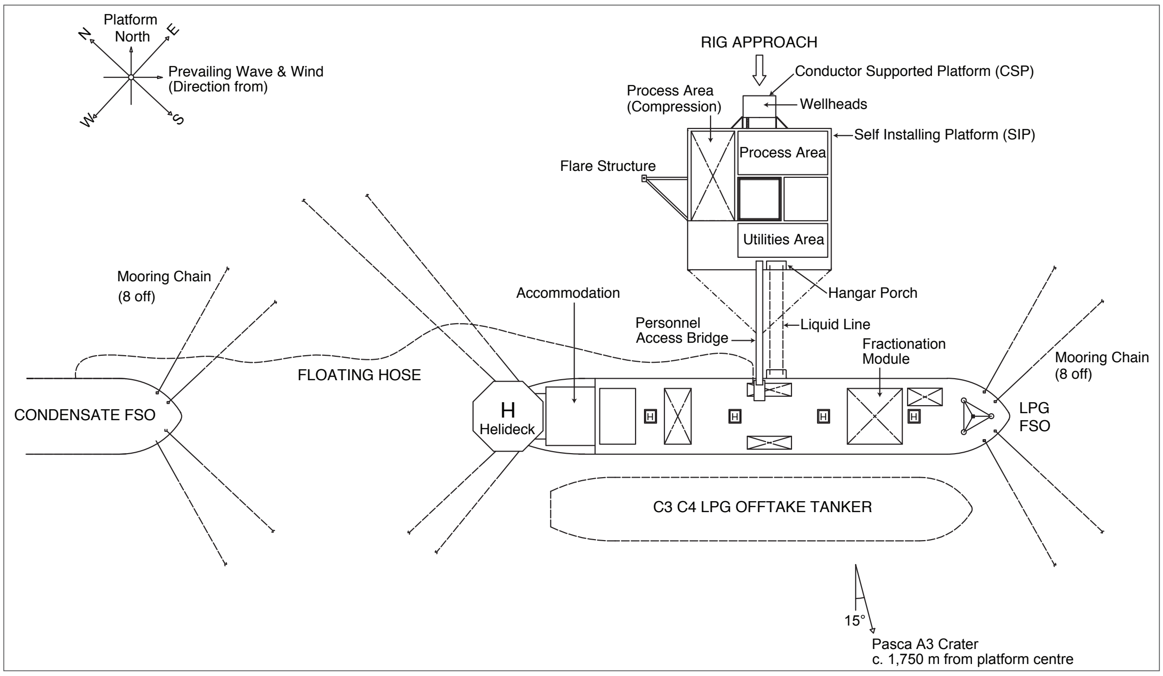
2.1 Construction Phase

The initial stage of the construction phase involves drilling of the production and injection wells and well testing, which will occur over a period of approximately four months. Activities will then cease for approximately 12 months during the fabrication of the production platform overseas. The final stage of the construction phase will be the transportation, installation and commissioning of the production platform and FSOs at the Pasca A location. These activities will occur over a period of approximately three months.

2.1.1 Rig Transportation and Installation

Drilling will be undertaken using a jack-up rig, which will be transported to the Pasca A location using an ocean transporter. The rig consists of a buoyant hull fitted with three movable legs. Once at location, the rig will be positioned over the well site and the legs jacked down through the water until they reach the seafloor and raise the hull above sea level. Once stabilised and secure, a conductor supported platform will be installed beside the rig to support the wellheads and permit access to the well from a surface location.

Figure ES2 – Offshore Project General Arrangement



2.1.2 Drilling, Testing and Completions

A total of five wells could be drilled over the life of the field, consisting of three producing wells and two gas injection wells. Initially, up to three wells are planned (two producers and one injector). Remaining wells are planned to maintain production levels, if necessary.

Drilling of exploration wells at Pasca by previous licence holders has identified several drilling hazards, including the presence of shallow gas, abnormal formation pressures and loss of drilling mud to the reservoir formation. Drilling mud is used during drilling to carry the drilled cuttings to the surface and to maintain borehole pressure. If the drilling mud pressure is insufficient, the greater formation pressure will force formation fluids into the wellbore. This is referred to as a 'kick', which may potentially result in uncontrolled release of gas and fluid from the well to the surface, i.e., loss of well control.

The risk of loss of well control has been significantly reduced by examining information on the historical Pasca wells and employing updated and safer drilling techniques. Proactive measures to minimise the risk of blowout include:

- Effective well and casing design, to ensure that the borehole remains stable and that the pressures from different geological formations are controlled.
- Use of the 'managed pressure drilling' technique, which provides a closed and pressurised circulating system. This allows greater control of wellbore pressures to better manage downhole formation pressures.
- Use of a downhole deployment valve system, which allows continuous mud injection to maintain downhole and annular pressure. This system uses a flapper-type seal mechanism that contains the reservoir fluid in the casing, which prevents pressure at the surface and thereby maintains safety.

In the unlikely event of loss of well control, a series of shut-in valves, known as the blowout preventer (BOP), will be closed to prevent gas and fluids from escaping and allow control of the well to be regained.

One of the production wells will be tested to evaluate reservoir productivity, fluid composition, pressures and temperatures together with other reservoir properties. The production wells will be completed with a liner across the hydrocarbon production zone and the wells will be suspended, awaiting the installation of the production platform. At this stage the drill rig will be demobilised leaving the conductor supported platform in place. The wells are expected to be suspended for approximately 12 months. During this period the conductor supported platform will have navigational aids and an established exclusion zone to ensure the safety of the wells.

2.1.3 Platform Transportation, Installation and FSO Moorings

The processing and utility modules will be constructed overseas. The modules will be assembled in the construction yard, integrated onto the deck of the platform and pre-commissioned to ensure integrity and performance. The complete structure will be transported using an ocean transporter, similar to that used for the jack-up rig. The production platform will be installed using a similar method to the jack-up rig but using a gravity-based steel structure on the seafloor to support the jacket and topside.

Two floating storage and off-loading vessels (FSOs), one for the condensate and one for the LPG, will be moored in the vicinity of the platform. The LPG FSO will also include workforce accommodation facilities and be linked by a bridge to the production platform. The FSO vessels are planned to be spread-moored given the relatively mild weather conditions, with eight anchors in total. Mooring lines will be spread from the bow and stern of the vessel in a four-group arrangement (i.e., four lines from each end of the vessel).

2.1.4 Pre-commissioning, Commissioning and Start-up

The commissioning stage will begin as the construction phase nears completion. All pre-commissioning and mechanical completion testing to confirm integrity of construction will be undertaken in the overseas fabrication yard.

Start-up of offshore production operations will be controlled under increasing loads and hydrocarbon throughput as reservoir fluids are introduced into the process stream at design capacity. Commissioning activities will involve operating the platform's topside process facilities and making adjustments necessary for satisfactory operation of the offshore production system. This includes checks to ensure all pieces of mechanical equipment and their control systems function correctly. There may be a need to briefly flare small amounts of gas to stabilise the production process.

2.2 Operations Phase

Production of LPG and condensate will occur over a period of 20 years.

2.2.1 Production, Offtake and Hydrocarbon Export

This phase consists of routine extraction of the wet gas stream that will be processed into condensate, LPG and dehydrated gas. Condensate and LPG will be temporarily stored on separate FSOs. Condensate will be exported to international markets while LPG will be sold to both the domestic and international markets. The dehydrated gas will be re-injected into the Pasca A field for development at a later stage.

The general concept for the offshore production facilities, illustrated in Figure ES2, includes the following components:

- Production platform: a self-installing production platform will stand directly on the seafloor. This platform will house the wet gas processing facilities, which extract and separate the LPG, condensate and dehydrated natural gas.
- Three producing wells: gas and condensate liquid products will be extracted from Pasca A reservoir and processed on the production platform. Initially only two production wells will be drilled and completed.
- Two gas injection wells: dehydrated gas will be injected from the production platform back into Pasca A reservoir for storage. Initially only one gas injection well will be drilled and completed.
- Condensate FSO vessel: condensate will be piped from the production platform through a flexible hose to the condensate FSO for storage.

- LPG FSO vessel: the LPG FSO is planned to be bridge-linked to the fixed production platform, with accommodation for the workforce located on the FSO. LPG product will be piped from the production platform through a flexible hose to the LPG FSO for storage.
- Shuttle offtake tankers: tankers will visit the condensate FSO and LPG FSO at least every 30 days to offtake product for transport to domestic and international markets.
- Supply vessel: a vessel will transport provisions to the fixed production platform and the two FSO vessels, and transfer waste to shore for disposal.
- Crew transfer vessel: a vessel will be used to ferry personnel between the fixed production platform, two FSO vessels and shore. Helicopters will be used to ferry crew and provisions to and from site during periods of rough weather or emergencies.

2.3 Closure Phase

Decommissioning of the offshore facilities will occur at the end of field life (approximately 20 years) over a period of approximately three months.

2.3.1 Decommissioning and Abandonment

The wells will be plugged and abandoned at the end of the field life. The production platform will be removed from site with all other infrastructure and decommissioned. The design of the offshore facilities allows all components to be easily removed without major disturbance.

2.4 Project Schedule

Commencement of drilling activities is expected to occur in 2017. Front-end engineering design (FEED), fabrication, topside module integration, transportation and installation of the production platform and FSOs is estimated to occur from June 2016 to March 2018.

Production of condensate and LPG is scheduled to commence in June 2018, with an operational life of approximately 20 years anticipated for the Project.

2.5 Alternatives Considered in Project Planning and Design

A number of options were considered in the early planning stages, including:

Wellhead location: the platform location was selected based on the requirement to be more than 1 km away from the Pasca A-3 crater (see Section 3.2.2) in an area free from shallow gas hazards. The selected location for the platform also satisfied a secondary requirement that all wells trajectories from the surface to the reservoir could be safely and technically drilled.

Choice of rig type: previous drilling at Pasca A in the 1960s and 1980s (at Pasca-1, A-2 and A-3 wells) was undertaken using a drillship, which imposed the use of a subsea BOP system. A lesson learnt from the Pasca A-3 loss of control event was that it was difficult to intervene and control the well since the BOP was not above the water surface. The Pasca A development wells will therefore be drilled using a jack-up rig, with a BOP located on the jack-up rig above sea level.

Drilling technique: the historical wells were all drilled using a floating mud cap methodology, which loses a great volume of mud and seawater into the formation. Managed pressure drilling (MPD) is a technique that has evolved considerably since the historical wells were drilled. The most appropriate MPD method for the Pasca A wellfield was determined to be pressurised mud cap drilling (PMCD). This permits greater control of the well. In addition a downhole deployment valve (DDV) is to be utilised. This valve is a new technology that allows the wellbore to be shut off downhole, thereby isolating the upper part of the well from the reservoir pressure.

Facility concept: two alternative fixed platform concepts have been considered. The first concept is a piled fixed platform jacket, on which the topsides are installed as an integrated deck using a float-over technique. This installation method requires the use of a specialist installation vessel, with high mobilisation and demobilisation costs. The second concept eliminates the requirement for an expensive installation vessel through the use of a self-installing platform design (often referred to as a 'jack-up'). The self-installing platform design was chosen as the preferred concept due to the lower costs.

Process design: a number of optimisations have been considered to improve efficiency such as gas dehydration, refrigeration, cooling systems, power generation, compression drive power and the heating process.

Mooring design: three mooring options were considered; turret-mooring, spread-mooring and calm-buoy mooring. Mild weather and sea-state conditions are expected for most of the year in the Gulf of Papua, with waves encountered predominantly from a southeasterly direction. Consequently, spread-mooring is considered suitable for both the LPG and condensate FSOs.

3. Project Setting

3.1 General Environment

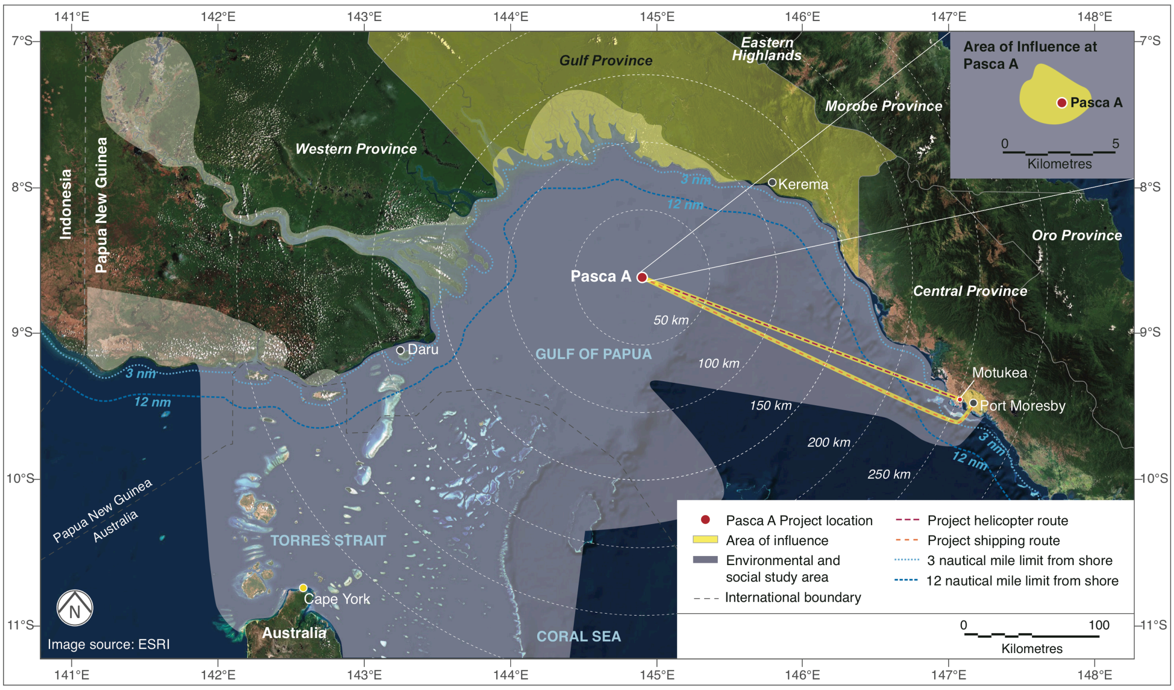
The existing environment has been characterised through relevant literature review and through primary sampling collection and analyses where data gaps were observed. Primary sampling and analyses were centred on a cruciform sampling plan with 12 nominal sampling sites (one at the proposed Pasca A well site, 10 surrounding the well site and one control site 4 km to the north). This sampling plan was used over the course of two baseline sampling campaigns (in July and November 2015). The literature review encompassed a large area of the Gulf of Papua, including the Project's area of influence and Port Moresby where the intended shore base will be located, as shown in Figure ES3.

3.1.1 Location

The Pasca A well site is located on the outer continental shelf of the Gulf of Papua and the nearest land (Ivo River delta) is 85 km to the north in Gulf Province (see Figure ES1).

The Gulf of Papua covers an area of approximately 50,000 km^2 and is crescent shaped, open to the south and bordered by Torres Strait in the west and Papua New Guinea to the north and east. The gulf shoreline is a low-lying swamp comprising the delta complexes of large rivers draining the mountainous highlands of central Papua New Guinea.

Figure ES3 – Study Areas



The northern and western regions of the Gulf of Papua contain the continental shelf waters in water depths ranging from 70 to 100 m. The outer edge of the continental shelf is defined by a sharp break at about 140 m water depth, seaward of which lies a series of ridges and terraces to 1,600 m water depth. The proposed Pasca A wellhead is located at a water depth of 93 m on the outer shelf, 44 km northwest of the shelf break at latitude 8° 35' 47.472" S, longitude 144° 54' 31.886" E (WGS 84).

Papua New Guinea's location over the converging Australian and Pacific tectonic plates means that it experiences earthquakes. The Pasca A area and the shore base in Port Moresby are, however, within Seismic Zone 4, which is the least seismically active classification in Papua New Guinea. The area also falls within Tsunami Zone 3, which is an area of least concern for tsunamis.

3.1.2 Climate

The hottest months are January and December with an average daily maximum temperature of 31°C and average daily minimum temperature of 28°C. The coolest months are July through September with the coolest average daily maximum and minimum temperatures of 28°C and 23.5°C, respectively, occurring in July. There is considerable variation in rainfall across the gulf. The average annual rainfall at Daru in the western Gulf of Papua is approximately 1,800 mm, with most rainfall occurring from December through to May. Rainfall at Kikori in the central gulf and Kerema in the eastern gulf is significantly higher at approximately 5,800 mm and 3,600 mm per year, respectively. In contrast to the western gulf, the drier season at these locations occurs from November to February.

The Gulf of Papua and Port Moresby are affected by the southeast trade and northwest monsoon wind seasons. Seasonal wind roses for the Pasca A location are shown in Figure ES4. The northwest monsoon season generally occurs from December to March. Winds are generally relatively weak during this period and from the northwest. Short-lived squalls, known locally as Gubas, are common during the northwest monsoon in the Gulf of Papua.

By April the southeast trade winds have commenced. Winds blow consistently from the southeast and are relatively strong, averaging 7.2 m/s with maximum speeds exceeding 15 m/s. Transitional periods of calm weather (doldrums) persist between the two main seasons.

The Gulf of Papua is an area of low to moderate cyclone risk. Tropical cyclones pass through Torres Strait and the Gulf of Papua offshore about twice every seven years but do not occur northward of latitude 9.5°S. Therefore there is a low probability of cyclones reaching the proposed Pasca A location, the Gulf of Papua coast or Port Moresby. Cyclones do however generate storm-force winds and long-period waves throughout the Gulf of Papua.

3.2 Physical Marine Environment

3.2.1 Physical Oceanography

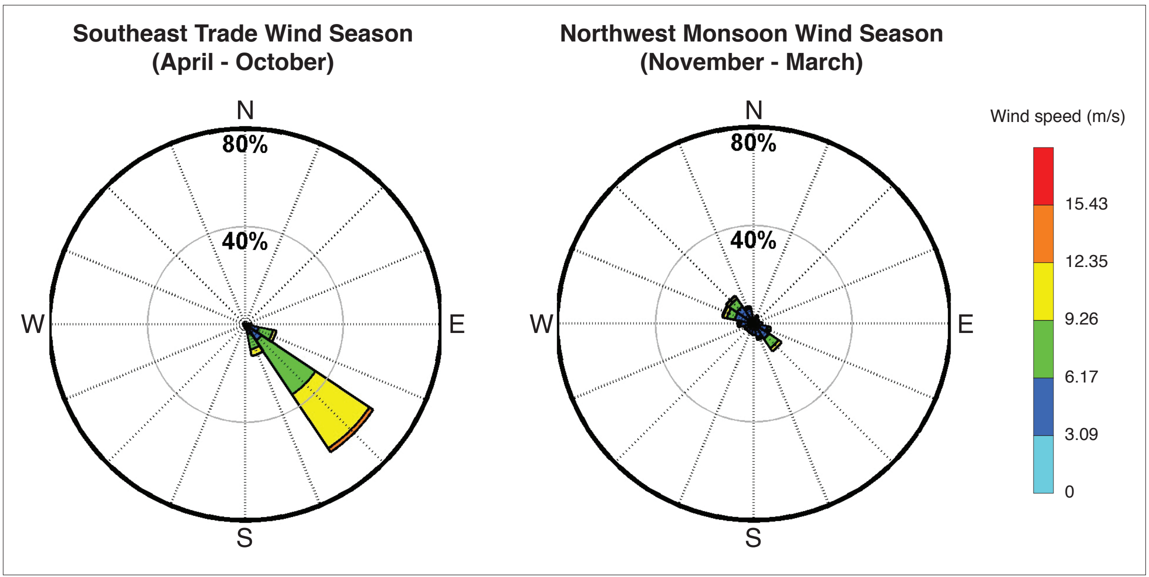
Currents

Surface currents in the Gulf of Papua tend to flow towards the east and northeast during the northwest monsoon wind season, whereas during the southeast trade wind season surface currents flow predominantly northwest. This indicates that surface currents have a wind-driven component. Oceanographic monitoring undertaken at the Pasca A location also indicates that surface currents in this area of the gulf are influenced by tides.

Bottom currents over the Gulf of Papua tend to flow to the west-southwest during the northwest monsoon season and to the coast during the southeast trade wind season. Site-specific data collected from the Pasca A well site shows near-seafloor current direction over the period of record (July to November 2015) was separated between the east-southeast to east and west-northwest to northwest sectors, with a strong tidal influence.

Wind-driven upwelling can occur along the Gulf of Papua coastline during the southeast trade wind season following several consecutive days of southeast winds. This wind-driven upwelling occurs mainly to the east of Port Moresby, and weakens further offshore to the west. Upwelling in the offshore areas of the Gulf of Papua may also possibly occur due to interactions between water movement in the Coral Sea and the Gulf of Papua. As a result, oceanic waters may be driven from the deeper parts of the Gulf of Papua and Coral Sea up over the continental shelf break into the shallower parts of the Gulf of Papua. By the time these waters reach the Pasca A location the dominant current direction is horizontal along the relatively shallow continental shelf rather than vertical. This finding is supported by the site-specific survey data.

Figure ES4 – Seasonal Wind Roses – Pasca A



Waves

Wave data collected from the Pasca A location from July to November 2015 indicates most waves to be between 0.1 to 0.2 m high (maximum height of 0.63 m), with a wave period of 6 to 8 seconds. Most waves were from the southeast, reflecting the fact that waves are dominantly wind-driven.

Tides

Tides in the Gulf of Papua are mixed semi-diurnal, meaning there are two uneven high and low tides per day. The maximum spring tidal range is 4 m occurring in the western gulf. Analysis of tidal data from the Pasca A well site indicates the maximum spring tidal range to be 3.1 m (for July to November 2015).

Solitons

Solitons are large internal waves that can cause sudden increases in current speed and rapid changes in current direction. They are generated by the deformation of the internal tide and are common in areas where there is a combination of tide, stratified water and rapid changes in bathymetry.

Satellite observations show that the Gulf of Papua is affected by solitons, particularly on the continental shelf in water depths shallower than 100 m. Solitons occur throughout the year and most frequently occur from October to January. They are generated by various different sources in the gulf. The arrival time of solitons at a location is generally predictable, however it is complicated by the uncertainty associated with the location of the generation sites. The propagation speed of the soliton packets in the Gulf of Papua has been calculated at a maximum value of 0.82 m/s travelling from the shelf break toward the shore. These packets can be single waves or can include over 20 individual solitons.

3.2.2 Seafloor

The Pasca A field is located on the outer shelf of the Gulf of Papua in water depths of approximately 93 m. The seafloor in this area is flat and comprised of fine to coarse silty sand with broken shell and coral fragments. Anchor drag scars remain clearly visible from previous exploration activities in the area, indicating that sediment accumulation rates on the seafloor are low.

The most striking feature in the area is the crater in the seafloor created by a loss of well control event at the Pasca A-3 well during exploration activities in 1983. The crater is 290 m in length and 240 m in width, with a depth of approximately 48 m below the surrounding seabed. Small volumes of thermogenic hydrocarbon gas, interpreted as seeping from the reservoir deep below the seafloor, have also been detected escaping from the Pasca A-3 crater. These gases are formed at high temperatures and pressures deep below the seafloor.

Shallow low-pressure releases of biogenic gas are also common in the area, as shown by the numerous small pockmarks present in softer sediment. These gases, which mostly consist of methane, are formed by bacterial decomposition of organic matter in sediment at shallow depths under low temperature and pressure.

A hydrocarbon odour was evident in sediment samples collected from the Pasca A area. Laboratory analyses measured detectable levels of total petroleum hydrocarbons (TPHs) at many of the sites sampled, with the concentration at one site in the vicinity of the Pasca A well site exceeding the adopted sediment quality guideline[1]. These elevated levels of TPHs indicate the presence of thermogenic hydrocarbons in the area. This may be due to natural seepage from faults in the seabed, which have been identified in seismic surveys. It is also possible that these hydrocarbons may be due to remnant emissions from the historic Pasca A-3 well or possibly some other source of hydrocarbon contamination. Measurable concentrations of polycyclic aromatic hydrocarbon (PAH) were also present in sediment samples from many of the sites. This also indicates the presence of thermogenic hydrocarbons in the area, since fossil fuels can contain significant amounts of PAHs. However total PAH concentrations were low overall and less than sediment quality guidelines.

Concentrations of the volatile organic compounds, benzene, toluene, ethylbenzene and xylene (BTEX), were less than the analytical detection limit in all sediment samples. Metals are also not contaminants of potential concern in sediments in the vicinity of the Pasca A well site.

3.2.3 Water Column

The gulf receives freshwater and sediments from five major rivers, namely the Fly, Turama, Kikori, Bamu and Purari rivers, along with several small rivers. The combined annual freshwater discharge to the gulf is substantial (about 15,000 m^3/s) due to the high rainfall in the highlands of Papua New Guinea (about 10 to 13 m annually). This produces a buoyant fresher water plume that covers most of the gulf throughout the year, extending to a depth of 20 m and thinning with increasing distance from the coast. Discharge from the rivers is spread evenly among seasons, and with small variation between years.

These streams deliver more than 350 Mt/year of sediment to their floodplains, deltas and the gulf. Mud from the rivers is mostly deposited on the shallow inner shelf in the central region of the gulf. Sediment delivered to the gulf is dispersed by tidal and wind-driven currents, with fluid muds possibly also having a role in its distribution. This results in a high level of suspended sediment in the water column. Water quality tends to improve approximately 50 km offshore and waters are generally clearer towards the eastern side of the gulf, away from the influence of large rivers.

Water column profile measurements were undertaken at the proposed Pasca A location in July and November 2015. Salinity profiles showed the influence of the fresher water lens that covers the gulf due to riverine inflows, particularly measurements undertaken in July. Higher salinities were measured throughout the water column in November and the influence of the fresher water plume was not so evident.

[1] A 2013 revision of the ANZECC/ARMCANZ Sediment Quality Guidelines

The temperature of surface water in July was similar to bottom waters. Temperature stratification was much greater during November, when temperature in the top 30 m was almost 2 ºC higher than deeper waters. The water was well oxygenated throughout the water column.

Turbidity levels were low and constant throughout the water column during both July and November. Concentrations of suspended solids were also low but variable, and generally slightly higher in bottom water than surface water. Light penetration decreased substantially below 65 m water depth. Nutrient concentrations were less than detection limits. Concentrations of metals were also low, with most results being less than detection limits and typical of background ocean levels. Metal concentrations were less than water quality guidelines.

Concentrations of phenols and PAHs in all water samples were less than analytical detection limits. Detectable levels of TPHs were measured in water samples from two of the nine sites sampled in July 2015, indicating the possible occurrence of seepage of thermogenic hydrocarbons from deep below the seafloor to the overlying water column. As described above, it is not known whether this may be attributed to natural seepage to the surface through faults, remnant emissions from the historic Pasca A-3 well, or possibly some other source of hydrocarbon contamination. No TPHs were detected in water samples collected in the November 2015 survey.

3.3 Biological Environment

3.3.1 Marine Water Column Associated Flora and Fauna

Marine Mammals

A total of 15 marine mammal species have been confirmed or are expected to occur in the Gulf of Papua. These marine mammals include 14 species of whales and dolphins and one species of dugong. The whales include three species of large baleen whales, which have baleen plates for filtering small items of food from the water. The principal baleen whale is the humpback whale, which is an offshore species that migrates from feeding grounds in the Antarctic to breeding and calving areas off the coast of Queensland in Australia between Townsville and Gladstone. This breeding and calving area is some 1,500 km south of the Project location in the Gulf of Papua. The incidence of humpback whales in the Gulf of Papua is therefore likely to be low but stray whales could occur in the northern Coral Sea and offshore Gulf of Papua. The nearest humpback whale sighting to the Gulf of Papua is offshore of Orpheus Island, some 1,100 km south of the Project location.

The remaining 11 species of whales are the toothed whales, which include pilot whales and dolphins. Offshore dolphins such as short-beaked dolphins are frequently observed riding the bow waves of ships that pass through the Gulf of Papua. However a number of species are only found in inshore waters, such as the Australian snubfin dolphin, which prefers the turbid waters adjacent to the deltas of the Fly, Kikori and Purari rivers, where it feeds on small fish including anchovies, herring and ponyfish.

The dugong is a marine mammal that is located in nearshore waters, mainly within the Torres Strait where it breeds. It feeds on seagrass that grows in abundance in the shallow waters between the many reefs and islands of this region. A few dugongs are also found in the inshore waters of the Kikori River delta where they feed on algae that grows on the mudbanks and sandbanks of this area. However, none are expected to transit the offshore waters of the outer shelf of the Gulf of Papua.

Sea Turtles

Six of the world's seven species of sea turtles are known to occur in the Gulf of Papua. However, most sea turtles are associated with the shallow waters of the nearby Torres Strait where they breed, nest and feed. The green turtle is vegetarian and is very common in the Torres Strait where it feeds on seagrass that is abundant in the shallow waters of the Strait. All the other five turtles are omnivores and feed on a variety of marine plants and animals. Few sea turtles are expected to transit the outer shelf of the Gulf of Papua, but some may do so infrequently.

Three sea turtle species nest on the beaches of islands in the nearby Torres Strait and northern

Great Barrier Reef; the green turtle, flatback turtle and the hawksbill turtle. The hawksbill turtle has been classified as critically endangered (CR) by the International Union of Conservation and Nature (i.e., the IUCN Red List of Threatened Species) and is considered to be facing an extremely high risk of extinction in the wild.

Sea Snakes

One species of sea snake, the yellow-bellied sea snake, is found in offshore surface waters of the Gulf of Papua, where it is feeds on drifting plant material and floating organic matter. Most other sea snakes are found at or near the seafloor, where they forage for food. However, all sea snakes will be found at the sea surface from time to time, as they all need to surface to breathe.

Pelagic Fish

Pelagic fish includes those fish that live near the sea surface and includes the water column down to but not near the bottom (which is occupied by demersal fish). The pelagic fish fauna of the Gulf of Papua are poorly documented but may be expected to include fish that belong to the vast Indo-West Pacific biogeographical province.

The main pelagic fish occurring or expected to be found in the offshore waters of the Gulf of Papua are the bony fish, such as mackerels, barracuda, swordfish, black marlin, long-toms, flyingfish, sardines, anchovies, jewfish and mullet. There are also a number of cartilaginous fish, such as tiger sharks, bull sharks, silvertip sharks, hammerhead sharks, manta rays, saw-sharks, as well as the very large whale shark that feeds solely on plankton (microscopic plants and invertebrates). The sharks are all top predators in the food web of the Gulf of Papua.

Plankton

Plankton is comprised of small plants and animals, many of which are microscopic in size and are found drifting in the water column in the Gulf of Papua. The plankton of the Gulf of Papua includes microscopic plants (phytoplankton), small invertebrates and fish larvae (zooplankton) and large invertebrates (megaloplankton), which are briefly described below.

Phytoplankton

The marine phytoplankton communities of the Gulf of Papua are part of the Indo-West Pacific tropical distribution. Baseline surveys for this EIS included the collection of water samples from different depths to assess the phytoplankton present in the Gulf. A total of 15 species of phytoplankton was observed for the combined surface, mid-water and deep-water sampling sites. The phytoplankton was dominated by species of dinoflagellates (60%) and diatoms (33%), with the remainder represented by one species of cyanobacterium (7%). Phytoplankton population density was very low with many species represented by one or two to individuals per cubic metre (m^3) of seawater. The low diversity of phytoplankton is related to the low nutrient status of offshore water in the Gulf of Papua that, at the time of sampling, was mainly from the northern Coral Sea, which is a known area of low nutrients (i.e., oligotrophic).

Zooplankton

The zooplankton of the offshore Gulf of Papua includes representatives from most marine invertebrates. There are basically two major groups of zooplankton, namely holoplankton that include permanent members of the zooplankton community, and meroplankton that include temporary members, such as the larvae of fish, crustaceans and other marine animals.

The zooplankton identified during the baseline survey were diverse, with 36 groups or species of which 91.4% were copepods (small crustaceans with an elongated body and forked tail). However, their population densities were low with an average of 1,820 individuals/m^3 of seawater, which reflects the low diversity and abundance of phytoplankton upon which they feed.

Megaloplankton

Megaloplankton are the larger invertebrates of the sea surface and water column, and are generally included in the plankton since they are carried passively in the direction of prevailing currents. Example species include jellyfish (Medusozoa), salps (Tunicata) and comb jellies (Ctenophora). Megaloplankton were not directly sampled during the baseline surveys, owing to difficulties in sampling them.

Offshore Seabirds

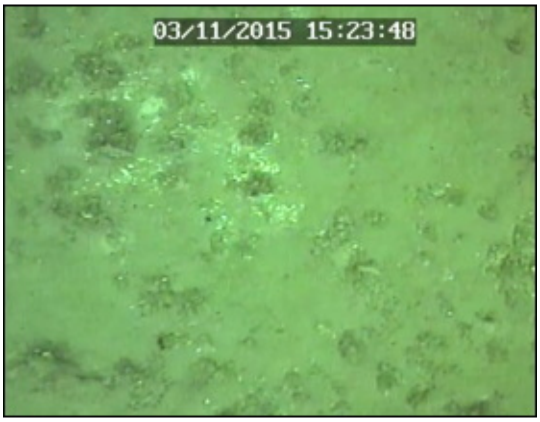
There is no reported information concerning the populations of seabirds using the open sea of the Gulf of Papua in the vicinity of the Project location. The nearest mainland seabird nesting sites are 85 km to the north at the Ivo River delta and the nearest offshore island with seabird colonies and/or nesting sites is Bramble Cay, which is 128 km southwest of the Project location. In general, the numbers of birds found over deep water are markedly lower that those found nearer shore. A search of the scientific literature, and a knowledge of the seabirds that roost on the Kumul Marine Platform about 70 km northeast of the Project location, revealed that 11 species of seabirds may occur in the offshore waters of the Gulf of Papua.

The main offshore seabirds are expected to be the brown booby, bridled tern and the common noddy. Other species likely to be present include frigatebirds, petrels, shearwaters, terns and other species of boobies. Large numbers of common noddies roost each night on the railings and other structures of the Kumul Marine Terminal, which creates a major problem with their droppings, which are hazardous to worker safety and health.

3.3.1 Seafloor Associated Flora and Fauna

Baseline surveys of seafloor habitats, flora and fauna in the Pasca A area were undertaken using beam trawls, video camera footage and drop cameras. The seafloor habitats comprised large expanses of soft sediments (e.g., coarse and fine sands with shell fragments) interspersed with soft coral and sponge communities that are firmly attached (i.e., sessile) to the seafloor (Plate ES1).

Plate ES1 – Seafloor Habitat at Pasca A



a) Drop camera photograph of seafloor habitat

b) Close-up photograph of seafloor benthos

Seafloor Flora

The low light conditions at the seafloor (93 m deep) means that there is an absence of marine flora such as seagrass or green algae. However, some of the soft corals (see below) do have internal photosynthetic algae (dinoflagellates) with which the soft corals live in a symbiotic relationship (i.e., mutually beneficial to both species). The dinoflagellates use the sun's energy to convert carbon dioxide from seawater into energy-rich sugars and fats, some of which the soft corals obtain for growth.

Seafloor Macroinvertebrates

A total of 273 individuals distributed among 59 species of benthic macroinvertebrates were found across the range of sediments sampled. The seafloor macroinvertebrates were dominated by polychaete worms (53 species), sponges (42 species), soft corals (15 species) and a variety of crustaceans such as crabs, prawns and amphipods (16 species). Other species include bivalve and gastropod molluscs. These macroinvertebrate communities provide a rich food resource for bottom-living fish.

The soft corals (e.g., sea whips and gorgonian sea fans (Plate ES2)) and sponges (Porifera (Plate ES3)) form sessile communities that prevail under low light conditions and form what is known as a mesophotic coral ecosystem (MCE). These MCEs are only now being studied due to the prevalence of deepwater sampling techniques and use of underwater videos and cameras. In the Gulf of Papua, MCEs could be distributed over a very large area of similar low light habitat (up to 15,000 km^2), so they may be much more widespread than previously thought.

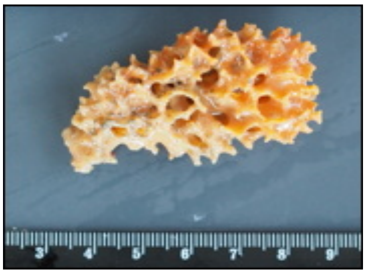
Plate ES2 – Examples of Sea Fans in the Gulf of Papua

a) Octocoral

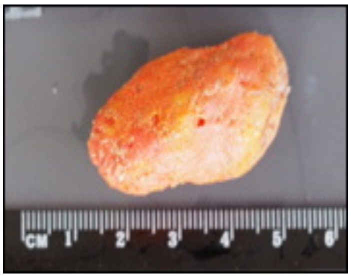
b) Octocoral

c) Octocoral

Plate ES3 – Examples of Sponges in the Gulf of Papua.



a) Ramose sponge



b) Orange ball sponge

c) Columnar sponges

Demersal and Bottom-living Fish

Baseline surveys were undertaken to characterise bottom-living (benthic) fish and fish that live near the seafloor (demersal and epibenthic). Beam trawls were used to catch benthic and epibenthic fish and baited remote underwater video (BRUV) stations were used to video and photograph fish species. A total of 122 individuals distributed among 21 species of benthic or epibenthic fish was caught by beam trawling. A noticeable feature of the catches was the small size (<10 cm long) of the fish species, which were dominated by groupers and cardinalfish. The most dominant fish caught was the saddle perch, which is a species of sandperch and was found at all the sites sampled. Other minor fish caught by beam trawl were scorpionfish and goatfish. There were no species of conservation significance.

Video observations from BRUV stations indicated that snappers (Lutjanidae) (Plate ES4) were numerically dominant in terms of numbers and biomass. The main snapper species present were gold-banded jobfish, golden-eye jobfish and red emperors. Other common fish present included groupers (Serranidae) and scavengers (Lethrinidae) and, to a lesser extent, cartilaginous fish such as white-cheek sharks and round ribbontail rays. A noticeable feature of fish at the BRUV sites was their large size, with many species up to 0.5 m long, indicating that many of these carnivorous fish species are high up in the offshore food web.

Plate ES4 – Examples of Snappers (Lutjanidae) at BRUV sites

a) Gold-banded jobfish (*P. multidens*)

b) Red emperor (*Lutjanus sebae*)

Sea Snakes

Only one or two sea snakes were observed at the seafloor BRUV sites. However most sea snakes tend to be associated with shallow-water seafloor habitats in nearshore areas, so it is not unexpected to find low sea snake species diversity or abundance in the offshore waters of the Gulf of Papua.

4. Potential Impacts

4.1 Key Environmental Aspects and Potential Impacts

Possible impacts due to planned Project activities were considered with respect to their potential to affect a sensitive environmental receptor. A summary of the key aspects and potential associated environmental impacts is provided in Table ES1 for the various phases of the Project.

Table ES1 – Environmental Aspects and Potential Impacts

Aspect	Project Phase	Project Component	Potential Impact
Marine traffic	Construction Operations Decommissioning	Ocean transporters, FSOs, shuttle tankers, supply and crew transfer vessels	♦ Collisions with marine mammals ♦ Safety exclusion zone and potential space-use conflicts
Ballast water discharges	Construction Operations Decommissioning	Ocean transporters, FSOs, shuttle tankers	♦ Introduction of non-native, exotic marine flora and fauna with the potential to become marine pests, if populations are established and viable
Noise and vibration	Construction Operations Decommissioning	Conductor installation, drilling, vertical seismic profiling, production platform, FSOs and vessels	♦ Underwater impulse noise causing acoustic damage or disturbance to marine fauna ♦ Underwater continuous broadband noise causing acoustic disturbance to sensitive marine fauna
Physical presence of marine facilities	Construction Operations	Jack-up drill rig, production platform and FSOs	♦ Loss of seabed habitat ♦ Attraction of birds, plankton and fish ♦ Space-use conflicts with mariners and fishers
Light spill	Construction Operations Decommissioning	Jack-up drill rig, production platform and FSOs	♦ Attraction of seabirds and migratory birds and potential collisions with structures ♦ Attraction of sea turtles and fish ♦ Disorientation of birds and sea turtles

Table ES1 – Environmental Aspects and Potential Impacts (cont'd)

Aspect	Project Phase	Project Component	Potential Impact
Atmospheric emissions from power generators, transport vessels and gas flaring	Construction Operations Decommissioning	Ocean transporters jack-up drill rig, production platform, FSOs, shuttle tankers, supply and crew transfer vessels	♦ Increased emissions to the atmosphere, including particulates, products of gas and diesel fuel combustion and fugitive emissions that have the potential to affect amenity and the life, health and wellbeing of humans and other forms of life ♦ Greenhouse gas emissions that will contribute to climate change
Discharge of drill cuttings, drilling fluids and cement	Construction Operations	Jack-up drill rig	♦ Decline in marine water quality due to increased suspended sediment and chemicals in drilling cuttings and fluid discharges, and excess cement ♦ Sedimentation due to discharge of drilling cuttings and fluids and cement ♦ Consequential effects on marine flora and fauna
Discharge of hydrotest water	Construction	Production platform and FSOs	♦ Decline in marine water quality due to low dissolved oxygen and chemical additives in hydrotest water discharges ♦ Consequential effects on marine flora and fauna
Discharge of produced water	Operations	Production platform	♦ Decline in marine water quality due to heat and hydrocarbons in produced water discharges ♦ Consequential effects on marine flora and fauna
Desalination plant brine discharge	Construction Operations Decommissioning	Production platform and FSOs	♦ Decline in marine water quality due to high salinity of brine discharge from desalination plant ♦ Consequential effects on marine flora and fauna
Deck drainage	Construction Operations Decommissioning	Jack-up rig, production platform and FSOs	♦ Decline in marine water quality due to deck drain discharges potentially containing oil and grease ♦ Consequential effects on marine flora and fauna
Discharge of sewage, grey water and galley waste	Construction Operations Decommissioning	Jack-up rig, production platform and FSOs	♦ Decline in marine water quality due to pathogens, nutrients and organic matter introduced through discharges of treated sewage effluent, grey water and galley waste ♦ Consequential effects on marine flora and fauna
Spills of hydrocarbons	Construction Operations Decommissioning	Jack-up rig, production platform and FSOs	♦ Contamination of marine water and sediment with hydrocarbons ♦ Consequential effects on seabirds ♦ Consequential effects on marine flora and fauna, especially air breathing and surface feeding species directly or indirectly exposed to hydrocarbons
Hazardous waste	Construction Operations Decommissioning	Jack-up rig, production platform and FSOs	♦ Decline in water or sediment quality due to exposure to potential spills of hazardous wastes generated by Project activities (e.g., waste chemicals such as solvents, lubricating oils, oily rags, filters paints, batteries, acids, empty drums, containers, gas cylinders, scrap metal, completion fluids, radioactive scale deposits)
Non-hazardous waste	Construction Operations Decommissioning	Jack-up rig, production platform and FSOs	♦ Potential for marine debris due loss of non-hazardous waste blown overboard ♦ Consequential impacts on marine fauna (e.g., entanglement or swallowing)

Table ES1 – Environmental Aspects and Potential Impacts (cont'd)

Aspect	Project Phase	Project Component	Potential Impact
Seafloor disturbance	Construction Operations	Jack-up rig, production platform and FSOs	♦ Disturbance of seabed resulting in increased levels of suspended sediment and associated turbidity and sedimentation ♦ Consequential effects on marine flora and fauna
Decommissioning of offshore facilities	Decommissioning	Production platform and FSOs	♦ Decline in water or sediment quality due to discharge of water used to flush residual product from transfer lines and/or exposure to wastes generated during decommissioning ♦ Acoustic disturbance of sensitive marine fauna to underwater removal techniques ♦ Impacts on local flora and fauna due to removal of marine growth from subsea structures

4.2 Assessment of Environmental Impacts

Assessment of the potential impacts due to Project activities involved the following:

- Describing the existing conditions of the Project area of influence, including the sensitivity of receptors that may be affected.
- Considering potential impacts associated with the Project during all phases within the context of the existing conditions. This was based on knowledge of the existing environment, the Project description, and experience with similar operations in similar environments and issues of concern to stakeholders.
- Identifying appropriate mitigation and management measures, where the measures described are technically and economically feasible within the context of the Project.
- Assessing credible residual impacts, assuming the successful implementation of the proposed management measures.

Assessment was mostly undertaken using qualitative risk assessment methods, although semi-quantitative assessment of some discharges was undertaken based on numerical modelling (e.g., drill cuttings, drilling fluids and produced water discharges).

The key findings of the residual impact assessments are summarised below:

4.2.1 Atmospheric Emission Impacts

The key sources of atmospheric emissions associated with the Project activities are those from fugitive emissions and combustion of heavy fuel oil, diesel, gas and aviation fuel. Emissions may have a health effect on humans and other forms of life. Given the remote offshore location of Pasca A and the location of shore-based activities at existing facilities, the residual impacts to air quality have been assessed to be **'negligible'**.

During the maximum production phase, the Project may contribute between 2.4% and 3.9% of total Papua New Guinea greenhouse emissions. Within the context of Papua New Guinea's relatively small industry sector, Project-related greenhouse gas emissions have been assessed to have a **'low'** to **'moderate'** impact.

4.2.2 Marine Water Quality Impacts

Project activities that may bring about a decline in marine water quality, with consequent impacts on marine biota, included discharges of cuttings, drilling fluids, and excess cement; hydrotest water; produced water; deck drainage; sewage, grey water and galley waste; solid wastes (hazardous and non-hazardous) and product line flushing water (during decommissioning). Physical disturbance of the seafloor may also increase water turbidity. Impacts from these activities were restricted to within close proximity (less than 1 km) of the offshore facilities, and most were limited in occurrence and of short duration, or not expected to occur in the case of solid wastes. Overall, the residual impacts on water quality have been assessed to be **'low'**, based on the implementation of mitigation and management measures and the high dilution available in the receiving seawater environment.

4.2.3 Marine Sediment Quality Impacts

Discharges of cuttings, drilling fluids, and excess cement during drilling may also accumulate on the seafloor and adversely impact sediment quality. Toxic effects on benthic organisms inhabiting sediment are expected to be negligible given the low toxicity of the drilling fluids and chemical additives. The solids generated from drilling of wells are predicted to be mostly deposited within 500 m of the wells where deposition thickness is greater than 10 mm. Within 1,000 m of the wells, deposition thickness is predicted to be less than 1.5 mm. Overall, the residual impacts on marine sediment quality have been assessed to be **'low'.**

4.2.4 Marine Ecological Impacts

Seafloor Habitat Impacts

There will be a small loss of seafloor habitat (around 0.005 km^2) from Project infrastructure in direct contact with the seafloor. In addition, the discharge of drill cuttings will result in the formation of a drill cuttings pile on the seafloor that will cover an area of 0.163 km^2 (or 16 hectares). However, the total impacted area is only a small fraction of the local surrounding area of the drilling platform. Impacts will be greatest on those marine fauna within the drill cuttings pile area that are incapable of moving away, which includes sessile and low mobile species such as soft corals, sponges, starfish and sea urchins. More mobile forms, such as benthic fish and decapod crustaceans (e.g., prawns and crabs), are expected to move away from the drilling cuttings discharge point.

In areas of lighter sedimentation down current of the drill cuttings discharge point, most species are expected to be tolerant of the increased sedimentation rates, which will occur in the short term over the four-month period of the drilling program. During operations, the drill cuttings pile will gradually be recolonised by seafloor macroinvertebrate fauna and fish.

Overall, the residual impacts of sedimentation on seafloor macroinvertebrate fauna and fish habitats have been assessed to be negligible, given the large areas of seafloor habitat unaffected by the Project.

Water Quality Impacts on Marine Flora and Fauna

The principal deterioration of water quality likely to have an impact on marine flora and fauna is the turbidity plumes that will be generated as the drill cuttings fall through the water column. The extent and fate of these turbidity plumes has been modelled and they are predicted to fan out in all directions from the drill cuttings discharge point. Therefore, marine flora and fauna will only be exposed to elevated suspended sediment concentrations for short periods of time. Most species are tolerant to such short-term exposures. The residual impacts of short-lived turbidity plumes and increased suspended sediment concentrations on marine flora and fauna have therefore been assessed to be **'negligible'** and inconsequential**.**

Underwater Noise and Vibration Impacts

The Project will generate two types of underwater noise; namely, short-term high-energy impulse noise and low-energy broadband continuous noise.

Short-term but loud impulse noise will be generated during the drilling program when the production platform's supporting conductor pipes will be pile driven into the seabed to a depth of 152 m using a hydraulic hammer located on the drilling platform. Impulse noise will also be generated by operation of airguns during vertical seismic profiling (VSP), which is undertaken to assess the alignment and depths of the drilled wells. Pile driving and airgun operations have the potential to cause acoustic (i.e., noise) damage to the hearing systems of marine mammals, fish, sea turtles and other marine fauna if exposed to these loud noise sources. However, special mitigation and management measures, such as soft start procedures, will be adopted to avoid acoustic damage. Overall, acoustic damage impacts to marine fauna have been assessed to be **'negligible'**, owing to the implementation of effective mitigation and management measures.

During pile driving or airgun operations at full power, the underwater impulse noise can travel through water for considerable distances (further than 10 km) where acoustic disturbance may affect the behaviour of more distant sensitive marine mammals, such as baleen whales. However the most likely effect will be subtle changes in swimming speeds or baleen whales deviating in their paths to avoid underwater noise that they find discomforting. Therefore, the residual impact on baleen whales from acoustic disturbance has been assessed as **low** rather than negligible.

During Project operations, there will be a general continuous broadband noise that will emanate from the production platform, FSOs and visiting shuttle offtake tankers. These noise sources are less harmful than the impulse noise levels described above. Overall, the residual impacts of general Project noise on marine fauna have been assessed to be **'negligible'**.

Light Spill Impacts

Night time production platform artificial lighting and occasional flaring, as well as lighting on the jack-up drilling rig, and FSOs and visiting shuttle offtake tankers, all have the potential to attract some species of seabirds, migratory birds, sea turtles, plankton and fish.

In the case of some species of seabirds, the Project's offshore structures provide an opportunity to rest or roost overnight in what is otherwise open sea, which may be conferred as a beneficial impact. However the attraction of migratory terrestrial birds to night time light spill can have a negative impact if they become 'trapped' by the light and circle overhead until they are exhausted or use up their reserves of fat required for their migration. Notwithstanding, the offshore location of the Project is away from the main East Asia – Australasia flyway of migratory birds across the Torres Strait and the residual impacts of night time light spill on migratory terrestrial birds have been assessed to be **'negligible'**.

It is unlikely that sea turtles will be attracted to the Project's offshore structures, as night-time lighting impacts are generally associated with disorientation of sea turtle hatchlings in the nearshore environment (>85 km from the Project's location). Overall, residual impacts on marine turtles and other large marine fauna have been assessed to be **'negligible'**.

Invasive Marine Species Impacts

Non-native species of marine flora and fauna can be brought from one geographical location to another by ships in their ballast water or attached to their hulls (biofouling). In general, most marine pest invasions are located in ports or nearshore waters rather than in the offshore environment.

Overall, while ballast water discharges do have the potential to introduce exotic marine species, the likelihood of such species becoming established, thriving and becoming marine pests is assessed to be **'negligible'** due to ballast water discharges and biofouling introductions to water column plankton. In the case of marine pests being dislodged from the hull of biofouled ships and settling to the seafloor, the residual impact has been assessed to be **'low'**.

Ecosystem Services Impacts

The main ecosystem service in proximity to the Project's offshore location relate to provisioning services, which are mainly based on marine resource usage.

Gulf of Papua Prawn Fishery

The nearest prawn fishing grounds of the Gulf of Papua Prawn Fishery (GoPPF) are located between 70 and 80 km north of the Project's offshore location. The Project has been assessed to have no impacts on the GoPPF fishery.

Space-use Conflict with Navigation and Marine Traffic

The nearest shipping route to the Project's offshore location is the route taken by export oil tankers to and from the Kumul Marine Terminal that passes to the east of Port Moresby and services the East Asia market. The nearest point of this shipping route is located 27 km from the Project's location; therefore, no residual impacts on shipping lanes, or marine traffic using other routes within the Gulf of Papua, are expected.

The Project's offshore production platform and FSOs will have a safety exclusion zone around them. The NMSA will issue 'Notices to Mariners', such that the captains and deck officers of all ships will be warned in advance of the location of the exclusion zone and take precautions not to enter the zone. In addition, all Project offshore structures and vessels will display internationally recognised navigation lights at night. Overall, no residual impacts of the Project on navigation and marine traffic are expected.

A summary of the residual environmental impact assessments is provided in Table ES2. Impacts associated with planned Project activities are expected to be restricted to within close proximity of the offshore facilities and manageable. Residual impacts during construction, operations and closure phases have all been assessed to be **'negligible'** to **'moderate'**.

Table ES2 – Summary of Residual Environmental Impacts

Potential Impact	Residual Impact
Air Quality and Greenhouse Gas	
Impact of air emissions on human health and marine ecosystems at:	
♦ Pasca A	Negligible
♦ Motukea shore base and Napa Napa temporary laydown area	Negligible
Impact on greenhouse gas emissions and climate change	Moderate
Marine Water Quality	
Decline in marine water quality due to:	
♦ Suspended sediment and chemicals in drill cuttings, drilling and completion fluids and excess cement discharges	Low
♦ Low dissolved oxygen and chemical additives in hydrotest water discharges	Low
♦ Heat and hydrocarbons in produced water discharges	Low
♦ High salinity of brine discharges or toxicity of biocides and anti-scaling agents	Low
♦ Deck drain discharges potentially containing oil and grease	Low
♦ Pathogens and nutrients introduced through discharges of treated sewage effluent, or discharges of greywater and galley wastes	Low
♦ Exposure to hazardous wastes generated by Project activities	Low
♦ Exposure to non-hazardous wastes generated by Project activities	Low
♦ Discharge of water used to flush residual product from transfer lines and/or exposure to wastes generated during decommissioning	Low
Platform installation (construction phase) and FSO mooring chains (operations phase) disturbing seabed resulting in increased levels of suspended sediment and associated turbidity	Low
Marine Sediment Quality	
Impacts on sediment quality due to discharge of drill cuttings, drilling fluids and excess cement during drilling, and used drilling fluids upon completion of drilling	Low
Marine Biological Impacts	
Direct alienation of seafloor by Project infrastructure (e.g., conductor support platform (CSP), anchor spreads, jack-up rig bases) and main drill cuttings pile	Negligible
Increased sedimentation impacts to seafloor benthic fauna and infauna, mesophotic coral ecosystem, and benthic fish	Negligible
Impacts of intermittent increased TSS concentrations and associated turbidity on:	
♦ Phytoplankton	Negligible
♦ Zooplankton	Negligible
♦ Megaloplankton (e.g., jellyfish and salps)	Negligible
♦ Octocorals (e.g., gorgonian fans and whips)	Negligible
♦ Sponges (Porifera)	Negligible
♦ Benthic macroinvertebrates	Negligible

Table ES2 – Summary of Residual Environmental Impacts (cont'd)

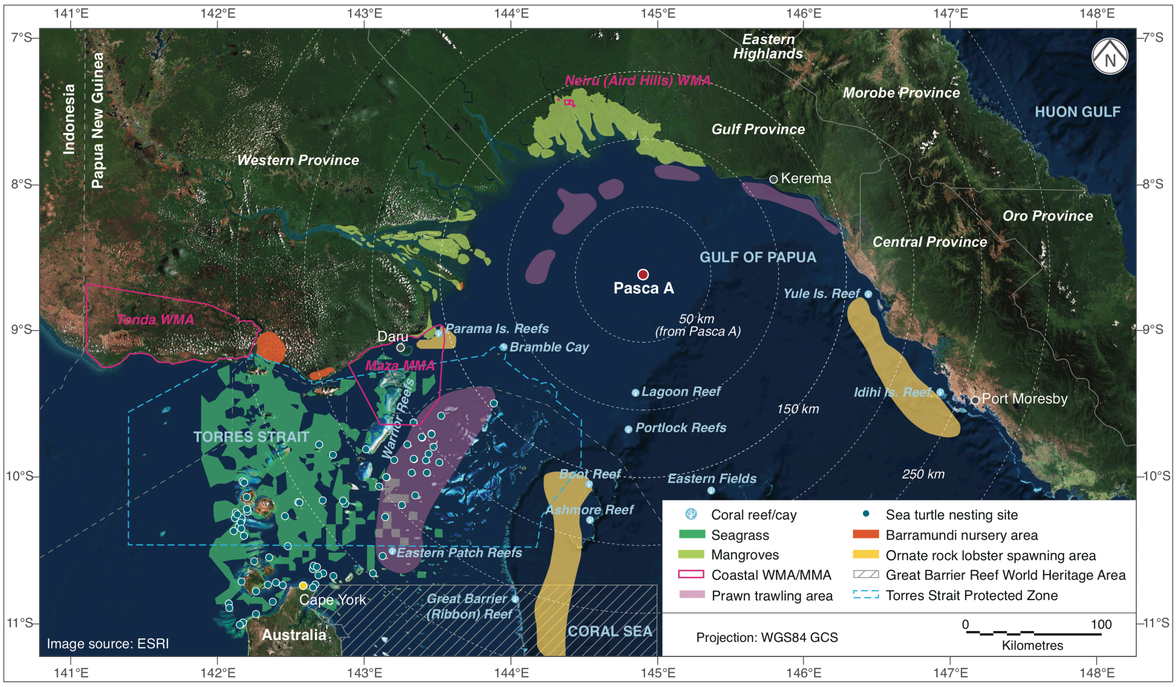
Potential Impact	Residual Impact
Marine Biological Impacts (cont'd)	
♦ Fish	Negligible
♦ Marine mammals	Negligible
Acoustic damage impacts on:	
♦ Large baleen whales (Mysticeti)	Negligible
Acoustic damage impacts on:	
♦ Small toothed whales and dolphins (Odontoceti)	Negligible
♦ Sea turtles	Negligible
♦ Sea snakes	Negligible
♦ Fish	Negligible
♦ Macroinvertebrates	Negligible
Acoustic disturbance impacts on:	
♦ Large baleen whales (Mysticeti)	Low
♦ Small toothed whales and dolphins (Odontoceti)	Negligible
♦ Sea turtles	Negligible
♦ Sea snakes	Negligible
♦ Fish	Negligible
♦ Macroinvertebrates	Negligible
Light spill impacts on:	
♦ Marine mammals	Negligible
♦ Sea turtles	Negligible
♦ Seabirds	Negligible
♦ Migratory terrestrial birds	Negligible
♦ Fish	Negligible
Ballast water marine pest introductions	Negligible
Biofouling water column marine pest introductions	Negligible
Biofouling seafloor marine pest introductions	Low
Ecosystem Services	
Exclusion zone interference of marine traffic	Negligible

Figure ES5 illustrates how the offshore Project location is remote from sensitive marine resource uses or areas of conservation significance. Only a major spill of condensate or marine diesel fuel oil would be likely to reach landfall, and only in the case where Twinza's spill response plan was not implemented or mitigation measures undertaken to reduce the volume or size of a major spill.

Transboundary Impacts

Transboundary impacts are those that extend over an international border. Potential impacts from planned Project activities are restricted to within close proximity of the offshore facilities and will not have transboundary impacts. The only possible transboundary impact could be from a major accidental event such as loss of well control or vessel collision if left unmitigated. Preventative and reactive mitigation measures will reduce the risk of such impacts to 'as low as reasonably practicable' (ALARP). Implementation of these measures would prevent the occurrence of any transboundary impacts from a major accidental event.

Figure ES5 – Environmental Sensitivity Index Map



4.3 Assessment of Socio-economic Impacts

As most of the Project activities will be undertaken a significant distance offshore, and onshore activities will be within existing commercial port facilities at Port Moresby, significant negative socio-economic impacts are not predicted to occur. Preliminary social mapping and landowner identification studies have not identified any customary landowners or subsistence fishing activity within the Project area of influence.

Potential beneficial socioeconomic impacts of the Project include but are not limited to:

- Employment and training opportunities for Papua New Guinean nationals.
- Opportunities for local contractors to provide goods and services in support of the Project.
- Indirect economic benefits arising from introduction of additional competition to the domestic LPG market. It is anticipated that further competition would reduce the price of LPG, spurring economic growth, and could also be used as a substitute fuel for power generation.
- The distribution of benefit streams to the Gulf Province, i.e., taxes and royalties, to provincial and local-level government.
- Community development through Twinza's support of community programs and social investment initiatives.
- Unlocking the gas discovered in the Papuan Basin by invigorating exploration activity, and possible gas field aggregation.

These benefits will have '**positive**' social and economic effects within Papua New Guinea. The Project involves significant investment in Papua New Guinea, with the benefits realised in the Gulf Province and nationally for at least 20 years.

Based on other projects within Papua New Guinea, negative socio-economic impacts of the Project may relate to perceived unfair distribution of benefits and/or not meeting stakeholder expectations.

The Project will operate under a Local Content Plan that will maximise, to the extent practicable, the use of local personnel, contractors, goods and services and will investigate other opportunities to contribute to the development of Gulf Province, in consultation with stakeholders.

A summary of the residual socio-economic impact assessments is provided in Table ES3.

Table ES3 – Summary of Residual Socio-economic Impacts

Potential Impact	Residual Risk
Royalties, levies, taxes and duties paid	Positive
Commercial opportunities	Positive
Skills development	Positive
Impacts on fisheries	Negligible
Impacts on maritime safety	Negligible
Impacts on tourism	Negligible
Impacts on cultural heritage	Negligible

4.4 Cumulative Impacts

Assessment of residual impacts from planned activities of the Pasca A Development Project showed that impacts are minimal, and restricted to within close proximity of the Pasca A location. Cumulative impacts due to other development gas projects, or other third party activities, are therefore not expected. Possible exceptions are impacts unrelated to the platform location, such as the increased demand for onshore waste facilities from other projects. This may present a greater risk of environmental impacts if adequate facilities are not available to cope with demand.

The Project will also increase the marine traffic using Port Moresby, and future development of other projects in the gulf would also be expected to increase marine traffic movements through this port. The existing port facility, which is managed by PNG Ports Corporation Limited (PNGPCL), is in the process of being relocated to the Port of Motukea in Fairfax Harbour. The relocation of the port has allowed the opportunity for PNGPCL to expand and develop world-class infrastructure. An increase in marine traffic from gas resource development in the Gulf of Papua is not expected to put untoward pressures on the port's operations, and is considered to represent a positive cumulative impact through the opportunities and economic benefits provided.

The Project involves reinjection of dehydrated natural gas back into the reservoir. This natural gas may potentially be developed at a later stage. Aggregation of gas fields may also possibly occur in the future with stranded gas resources delivered by pipeline to the Pasca A platform, FLNG vessel or an onshore LNG plant. If this were to occur, the most significant impacts would be an extension of the benefits that the Project provides. Further assessment of such developments would be undertaken as part of the environmental approvals process when project details are defined.

5. Major Hazards

Discharges of environmentally hazardous substances or other impacts may potentially occur due to major hazards and extreme natural events. These events are normally associated with loss of containment leading to spills, fires, explosions and/or hazardous emissions. While rare, such events may result in significant loss of life, serious environmental harm and asset and reputation damage. These are essentially unplanned events, to be anticipated as possibilities, for which preventative action and reactive responses are required.

Preliminary analysis of major hazards and associated impacts has been undertaken for the Project, with the following hazards identified:

- Drilling hazards due to the presence of shallow gas.
- Drill rig and production platform listing or collapse, due to seismic activity, cyclones or extreme sea conditions.
- Abnormal formation pressure and reservoir mud loss zones, with potential occurrence of loss of well control and catastrophic fire and explosions.

- Possible presence of toxic hydrogen sulfide in formation gases and fluids.
- Collisions between vessels and offshore facilities.
- Fuel and product spills as a result of vessel collision, loss of containment during refuelling, breakage of an offloading hose or loss of well control.

Mitigation and management measures are proposed to prevent and reduce impacts from these hazards to 'as low as reasonably practicable'. These measures include both preventative actions and reactive responses. The hazard assessment will be progressively refined by further hazard identification (HAZID) and hazard and operability (HAZOP) studies as the Project proceeds through full FEED and detailed design. Risks will be reduced through design specifications, material selection, monitoring equipment, control and other safety systems, standard operating procedures, personnel competence and training.

A detailed spill risk assessment will also be performed for all offshore facilities and vessels following final design. This will identify specific activities where there is the potential for spills and describe mitigation measures to minimise the risk from incidents. One of the outcomes of the spill risk assessment will be the development of a Spill Response Plan.

An Emergency Response Plan shall also be developed with a systematic approach to management of incidents and emergencies.

6. Mitigation, Management and Monitoring

6.1 Mitigation

The basic strategy for impact mitigation follows a preferred hierarchy of the following groups of measures, which shall be applied as 'best management' practices:

- Engineered controls ('best available technology') – Where practicable, these are the first level of preferred mitigation because if installed and operating properly, they should provide consistent, uninterruptable mitigation for potential impacts. Examples of engineered controls include secondary containment and fail safe systems.
- Operational controls (standard operating procedures) – In instances where activities do not warrant the long-term protection provided by engineered controls, operational controls are the second preferred approach. Examples of operational controls include maintenance, cleaning, and treatment.
- Monitoring and inspection – Early detection programmes that, at best, provide advance notice of a potential problem, and at worst, discover the actual problem before it becomes unmanageable.

Many potential impacts have been avoided or substantially reduced through the site selection, proposed drilling techniques and field facilities design and construction method. The Project's residual impacts from planned activities, after mitigation and management measures have been implemented, have been assessed to be mostly negligible, or low. Proposed mitigation and management measures will be incorporated into environmental management plans.

Confirmation of predicted impacts will be verified by the Project's environmental monitoring program (see Section 6.3). Routine operational monitoring will include verification and checking of mitigation measures to ensure that performance objectives are met.

As described in Section 5, mitigation and management measures to reduce risks from major hazards to 'as low as reasonably practicable' will be progressively refined during HAZID and HAZOP studies as the Project proceeds through detailed design.

6.2 Management Plans

6.2.1 Construction Environmental Management Plan

A Construction Environmental Management Plan (CEMP) has been developed for the construction phase of the Project and submitted with the EIS. The CEMP is a live document that will be updated to reflect conditions of approval of the EIS and resultant environmental permit, and additional risk assessments undertaken as part of detailed design. It includes the following issue-specific sub-plans:

- Atmospheric Emissions Management Plan.
- Wastewater Management Plan.
- Marine Ecology Management Plan.
- Solid Wastes Management Plan (Hazardous and Non-hazardous).
- Spill Prevention Plan.
- Chemical Usage, Handling and Storage Plan.

A Project Environmental Management Plan (EMP) will be prepared for the subsequent operations phase. These EMPs will compile the mitigation and management measures, commitments and conditions applied to the Project during the EIS approvals process and describe the programs for their implementation. The specific objectives of the EMPs are to:

- Document the more general aspects of Twinza's approach to environmental management, such as the environmental management system, schedule for environmental management and organisational structure and responsibilities.
- Describe Twinza's waste management strategy and how the Project's waste management and associated environmental issues will be addressed.
- Detail the program that will monitor and report on the Project's effects and its compliance with regulatory permits and licences. In particular, this program will:
  - Describe routine operational monitoring to ensure compliance with permit conditions.
  - Validate and monitor impact predictions.
  - Identify unforeseen effects and the need for additional management, mitigation or remedial measures.

In addition to the EMPs, Twinza will develop and implement a number of social investment plans as part of its corporate social responsibility. These plans will be aimed at maximising benefits to stakeholders and minimising adverse impacts and will address community safety, business and community development, and training and localisation.

6.2.2 Waste Management Strategy

The waste management strategy follows the waste management principle of source reduction (or removal), re-use and recycling followed by environmentally responsible disposal. It is also aligned with MARPOL 73/78 Annex V. It has been incorporated into the CEMP and will evolve into waste management plans that will be developed in the Operations Environmental Management Plan. These waste management plans will feature the following:

- Waste minimisation.
- Waste identification and characterisation criteria.
- Waste segregation and storage.
- Overall waste inventory, handling, transportation and tracking requirements.
- Reuse or recycling and treatment options (if appropriate).
- Waste disposal options.

6.3 Monitoring

Monitoring will be undertaken of environmental aspects relevant to each Project-related activity. The monitoring will include:

- Routine operational monitoring of any wastewater discharges to the marine environment (such as produced water, sewage, desalination plant brine water and drill cuttings and drilling fluids). The routine monitoring will also include verification and checking of mitigation measures described in the EMPs, to ensure that performance objectives are met.

- Validation surveys that include follow-up monitoring aimed at verifying the impact predictions of the EIS. Such monitoring will include post-activity marine surveys, such as marine fauna and flora, sediment and water quality sampling.

Monitoring programs will be further developed as the Project proceeds into detailed design to take into consideration government requirements that arise from the EIS approvals process.

7. Stakeholder Consultation

Stakeholders have broadly been identified as the various individuals, groups or communities who are likely to be affected, either directly or indirectly, by the Project (affected parties); or may have an interest in the Project with the ability to influence its outcome (interested parties).

The key Project affected parties identified are the Gulf Provincial Government and the Gulf Local-level Government.

Regular consultation with interested parties, namely government departments and regulatory bodies at the national level, has been ongoing since the PPL was issued in 2011. Consultation has also been undertaken with scientific and commercial stakeholders. The affected parties of the Gulf Provincial Government in Kerema, comprising of members of the Provincial Management Team and Provincial Executive Council, have also been engaged.

Additional stakeholders with a high interest in the Project will also be invited to express their views during the public review stage. A Stakeholder Engagement Plan (SEP) is being developed to proactively manage stakeholder involvement.

The Project's consultation and disclosure program will continue to evolve through the Project, with increasingly extensive interactions with additional stakeholder groups expected. Any additional valid concerns and issues raised by stakeholders will be addressed throughout the Project life cycle and incorporated into management plans, where practicable.

The main concerns expressed to date are the safe and incident-free operation of the offshore facility, and benefit sharing to ensure fair distribution to Gulf Province stakeholders.

8. Conclusion

While the Pasca A Development Project is one of the first offshore oil or gas projects in Papua New Guinea, it is a small, technically straightforward project in a relatively unconstrained environment on the outer continental shelf of the Gulf of Papua. The Project is therefore relatively isolated and is distant from the principal nearshore areas (i.e., mainland or offshore islands), where the more sensitive marine flora and fauna of resource use and conservation value are located.

The EIS has systematically and comprehensively examined all identified aspects of the Project with the potential to give rise to environmental and socio-economic impacts. There are a limited number of impacts and, with implementation of the various mitigation measures set out in this report and the EMPs developed for the Project, these residual impacts are expected to be manageable. Many potential impacts have been avoided or substantially reduced through the site selection, proposed drilling techniques, well and facilities design and construction methods. Additional mitigation and management measures, which will be incorporated into the environmental management plans, further reduce impacts from planned Project activities.

Residual environmental impacts associated with planned Project activities are expected to be restricted to within close proximity of the offshore facilities. Residual impacts during construction, operations and closure phases were all assessed to be 'negligible' to 'moderate', with most being 'low' or 'negligible'. Confirmation of predicted impacts will be verified by the Project's environmental monitoring program. Routine operational monitoring will include verification and checking of mitigation measures to ensure that performance objectives are met.

The cumulative impact assessment has indicated that transboundary impacts on Australian offshore waters are most unlikely, given the distance of the Project's location from the international border.

Preliminary hazard assessment has been undertaken to identify possible, although rare, accidental events and natural hazards with potentially major consequences. Proposed mitigation and management measures have reduced these risks to 'as low as reasonably practicable'. The hazard assessment will be progressively refined by further hazard identification (HAZID) and hazard and operability (HAZOP) studies as the Project proceeds through full FEED and detailed design. In the unlikely event of a major spill of condensate or marine diesel fuel oil, the great distances from sensitive nearshore marine resources provide an extended time for effective implementation of response measures.

Significant negative socioeconomic impacts are not predicted to occur since most of the Project activities will be undertaken a significant distance offshore, and onshore activities will be within existing commercial port facilities at Port Moresby. The Project will bring substantial benefits in the form of royalties and taxation, improvements in the nation's balance of trade, development of a gas resource for in-country use, employment and training opportunities and potential for future offshore energy developments. These benefits will have positive social and economic effects within Papua New Guinea. The Project involves significant investment in Papua New Guinea, with the benefits realised in the Gulf Province and nationally for at least 20 years.

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