21. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES: MARINE FACILITIES

This chapter presents the environmental and resource use impact assessment of construction and operation of the LNG marine facilities; i.e., the LNG Jetty/Materials Offloading Facility and the LNG Project Gas Pipeline (in Caution Bay only). The chapter draws on information in Chapter 13 Receiving Marine Environment: Marine Facilities, which describes the existing physical, biological and resource use characteristics of the area, and Appendix 23, Nearshore Marine Impact Assessment, which provides the results and analyses of field studies and the pre-mitigation impact assessment of the construction and operation of the LNG marine facilities. This chapter completes the assessment of residual impacts after successful implementation of these mitigation measures.

The criteria for assessment of impacts are given in Section 21.1, which is followed by discussions of issues, mitigation measures and residual impacts (after implementation of mitigation), to physical coastal processes and sediment transport (Section 21.2), sea water quality (Section 21.3), coral reefs, seagrass and mangroves (Section 21.4), marine fish and other fauna (Section 21.5), subsistence fisheries and marine traffic (Section 21.6), mangrove resource utilisation (Section 21.7), and quarantine (Section 21.8).

21.1 General Approach

21.1.1 Impact Significance

The general approach and method that this EIS uses to assess environmental impact significance is described in Section 18.1.1, Impact Significance.

Definitions of the types of impacts (direct, indirect and cumulative), magnitude of impacts and sensitivity of the resource/receptor in the marine environment of Caution Bay are described in the sections below.

21.1.2 Types of Impacts

21.1.2.1 Direct and Indirect Impacts

In the marine environment, direct impacts include those that result from physical loss or removal of habitat once occupied by fauna, subsequently replaced by project infrastructure. This would apply to habitats in the areas proposed for the locations of structures such as the LNG Jetty/Materials Offloading Facility, and activities such as trenching (for the offshore pipeline) and dredging. Most of these direct effects are negative but can be positive, for example through the creation of habitat not previously present for colonisation by marine fauna and flora. Direct impacts would also apply to changes in access to resources (e.g., by people).

Indirect impacts are those arising from project facilities or activities, but with a degree of separation in time or space, for example via changes to water quality or sedimentation. They are by their nature hard to predict, and in the marine environment, rely on modelling of dispersion and dilution.

21.1.2.2 Cumulative and Associated Impacts

A step further removed are impacts arising from actions of third parties, which the presence of the project may enable or assist. Chapter 24, Cumulative and Associated Impacts characterises these impacts as scenarios based on analogous examples or speculative assumptions about the influence that the project may have on what other people may or may not do. For example, in the marine environment, this might apply to increased boating or fishing activities, or development of other projects with incremental impacts on resources or habitats.

21.1.3 Matrix Components

21.1.3.1 Impact Magnitude

The magnitude of an impact reflects:

- The intensity or severity of the impact.
- The duration of the impact.
- The spatial extent of the impact.

Criteria for assessing the magnitude of an impact (appropriate for the nearshore marine environment of Caution Bay) are provided in Table 21.1.

Table 21.1 Magnitude of impact categories and descriptions: marine facilities

Category	Description
Very High	Effect likely to have large impact on population, community or ecosystem survival and health, possibly even leading to local extinction or system collapse. Impact is widespread, affecting around 25% or more of a regional population (e.g., within all of Caution Bay). Recovery, if possible, is likely to take more than 10 years.
High	Effect likely to have severe negative impact on population, community or ecosystem survival or health. Impact is regional, affecting approximately 10% of a regional population. Recovery, if possible, is likely to take from 5 to 10 years.
Medium	Effect will be detectable but not severe; populations or the areal extent of communities may be reduced but unlikely to lead to major changes to population, community or ecosystem survival or health. Impact is local, generally occurring up to 2 km from impact site. Recovery is likely to take from 2 to 5 years.
Low	Effect may be detectable but is small and unlikely to have any material impact. Impact affects immediate surrounds of area of activity and extends for less than 1 km radius. Recovery is rapid - up to 2 years.
Minimal	Effect unlikely to be detectable.
Positive	Effect is likely to benefit the population, community or ecosystem.

21.1.3.2 Sensitivity of the Affected Receptor

The sensitivity of the environmental receptor will reflect:

- Its formal status, e.g., international conservation listing, statutory or attributed conservation status, land use zoning or environmental quality standard.
- Its vulnerability to material damage or loss by the impact in question.
- Its iconic or symbolic importance to cultural value systems.

The sensitivity of the resource or receptor that may be impacted was determined from the existing environment information (see Chapter 13, Receiving Marine Environment: Marine Facilities) and classified into categories based on Table 21.2.

Table 21.2 Sensitivity of resource or receptor categories and descriptions: marine facilities

Category	Description
Very High	A population of an ecologically or socially important species on an international level, or a site or habitat supporting such a species. A rare, threatened or vulnerable habitat or species and/or a breeding ground or feeding area that is critical to the survival of such species. Resource that provides the sole source food or income for local people.
High	A nationally designated site. A population of an ecologically or socially important species on a national level, or a site or habitat supporting such a species. Site supports 1% or more of national population. Resource upon which local people are frequently dependent for provision of food or income.
Medium	A population of an ecologically or socially important species on a regional level, or a site or habitat supporting such a species. Site supports 1% or more of regional population. Resource upon which local people are occasionally dependent for provision of food or income.
Low	Sites, populations or resources that generally enrich/maintain the local area. Resource upon which local people are rarely dependent for provision of food or income.
Minimal	No detectable ecological or social value or sensitivity.

21.1.4 Assessment of Significance

A matrix of significance was developed that combined the different definitions of magnitude of impacts with the various scales of resource or receptor sensitivity. The matrix is provided in Table 18.1 (see Section 18.1.4, Impact Significance Matrix), and assigns a significance of impact for each of the possible combinations between magnitude of impact and sensitivity of resource or receptor. Only the magnitude of an impact can be reduced by mitigation: the sensitivity, as assessed, is fixed and is not changed by project activities. The resultant significance therefore reflects the reduction in magnitude that can be achieved by the proposed mitigation.

21.2 Physical Coastal Processes and Sediment Transport

This section describes the environmental issues, mitigation measures and residual impacts to natural coastal hydrodynamic processes and sediment transport arising from construction and operation of the LNG marine facilities.

21.2.1 Issues to be Addressed

21.2.1.1 Operations

Changes to Physical Coastal Processes and Sediment Transport

Potential changes to coastal processes and sediment transport could occur once the construction of the combined LNG Jetty/Materials Offloading Facility is complete and during the operational life of the project. While there could be incremental changes during construction, all coastal process issues, their proposed mitigation measures and residual impacts are discussed under operations.

The combined LNG Jetty/Materials Offloading Facility has been designed in the light of findings of the hydrodynamic modelling study (Appendix 22, Hydrodynamic Modelling), so that the earthen causeway section does not extend offshore far enough to impede the natural coastal hydrodynamic processes, or cause blockage at the mouth of the Vaihua River estuary (see Section 7.7.4, Materials Offloading Facility). The initially proposed, longer Materials Offloading Facility would have caused closure of the Vaihua River estuary over a period of 3 to 5 years, requiring some form of management to keep the Vaihua River estuary open for the life of the project and beyond.

Shortening of the earthen causeway will require a once-off dredging program and removal of an estimated 150,000 to 200,000 m^3 of dredge spoil in order to provide the required navigable depth of 8 m below lowest astronomical tide (LAT)[1] at the Materials Offloading Facility. However, the selection of the shorter causeway option reflects the lower environmental disturbance from the once-off dredging, compared with that which would be required for permanent maintenance of the Vaihua River estuary. The impacts of dredging and spoil disposal are described in Section 21.3, Sea Water Quality.

21.2.2 Mitigation and Management Measures

21.2.2.1 Operations

Changes to Coastal Processes and Sediment Transport

During operations, there will be no need for dredging to maintain existing alongshore sediment transport patterns in the vicinity of the Vaihua River mouth [M223] (see Appendix 22, Hydrodynamic Modelling), and no requirement for maintenance dredging of access to the Materials Offloading Facility, which can be allowed to silt up naturally after its use during the construction period.

[1] Estimate based on a 90-m wide, 500-m-long channel dredged (average 3.5 to 4.5 m) to obtain a depth of 8 m LAT.

21.2.3 Residual Impact Assessment

21.2.3.1 Operations

Changes to Coastal Processes and Sediment Transport

With maintenance of normal tidal inundation of the mangroves and seasonal connectivity between the freshwater reaches of the Vaihua River and Caution Bay, species that are dependent on these ecosystems will be protected from any adverse impacts of sedimentation and blockage of the estuary.

By applying the impact significance criteria outlined above, the potential magnitude of residual impact to habitat connectivity and aquatic ecology is defined as low. The sensitivity of resource or receptor (e.g., mangroves) is high, as these habitats are important for ecological processes and as a resource upon which local people are frequently dependent. Hence, the overall residual impact significance is assessed as minor.

21.3 Sea Water Quality

This section describes the environmental issues, mitigation measures and residual impacts to water quality, including suspended sediments arising from construction and operation of the LNG marine facilities.

21.3.1 Issues to be Addressed

21.3.1.1 Construction

Increased Suspended Sediment and Sedimentation Rates

Activities that could result in increased suspended sediments and sedimentation during construction are as follows.

- **Construction of marine facilities and offshore pipeline.** Construction of the LNG Jetty/Materials Offloading Facility will result in some increase in suspended sediments and sedimentation. This will occur mainly as the fill is progressively placed out from the shore to form the earthen causeway, and from direct disturbance to seabed from construction equipment such as jack-up barges. The extent of sediment suspension in the water will also depend on the proportion of fines in the material used for construction, and the sediment resuspension characteristics of the seabed. Activities associated with the construction of the combined LNG Jetty/Materials Offloading Facility (see Section 4.6.3. Constructing the Causeway and the Materials Offloading Facility; Section 4.9, Constructing the LNG Jetty) and installation of the offshore section of the gas pipeline (see Section 3.6, Constructing the Offshore Pipeline) will disturb the seafloor and stir up sediment leading to increased suspended sediment and turbidity in the water column.
- **Dredging.** Dredging activities will disturb the seafloor and stir up sediment leading to increased suspended sediment and turbidity in the water column within the immediate area and down current from the source. Some dredging of the turning basin adjacent to the LNG Jetty may be required to achieve uniform required depth to facilitate berthing and manoeuvring of the LNG carriers (see Figure 4.1), but if so, volumes would be small (less than 25,000 m^3). It is considered that there is sufficient existing under-keel depth within the channel for LNG

carriers to enter Caution Bay and berth at the LNG Jetty so that no dredging of the shipping access channel will be required (see Section 4.6.1.10, Dredging for the Marine Facilities). However, dredging will be required to allow vessels to unload equipment at the shortened Materials Offloading Facility. The overall volume of material to be dredged is estimated to be between 150,000 and 200,000 m^3. However, further project optimisation during FEED and detailed design may change the final estimate of volumes to be dredged and disposed.

- **Disposal of dredged material.** Disposal of the spoil will cause impacts from temporary sediment plumes in the water column and deposition on the seabed. The dredged material is likely to consist of lagoon sand, silts and clays and it is proposed that any spoil that cannot otherwise be used is disposed to very deep water off the continental shelf (i.e., in water depths greater than 450 m), which occurs within 2 to 3 km beyond the outer barrier reef system. The environmental conditions at the deposition area at approximately 450 m depth have not been studied, but continental slopes, typically include valleys of sedimentary deposits with rocky outcrops between. At these water depths, marine plants and reef-building corals do not occur, as they require high light penetration that does not reach these depths. However, other forms of corals are likely to occur on areas of hard substrate, and benthic animals inhabit areas of soft sediments. Prior to the decision to shorten the earthen causeway, the volume of dredge material was expected to be low (if any). Subsequent to this decision, there has not been the opportunity to undertake such survey work of the prospective deep water spoil disposal area, however, this will be undertaken prior to construction, and will also reflect any changes in dredging volume arising through project optimisation.
- **Marine traffic.** Project construction shipping traffic travelling within Caution Bay will potentially cause resuspension of seafloor sediments through the generation of currents from propeller action.

Discharge of Hydrotest Water

Hydrotest water will be generated during construction activities for integrity testing of the LNG storage tanks. Freshwater, sourced from desalination, will be used for the hydrotesting process and after the testing process is complete, it will be discharged offshore at a discharge point with adequate flushing for rapid dispersal. It will contain traces of biocides and oxygen scavengers used to protect the inner surface of the tanks from risks of fouling and corrosion. Therefore, there is potential for impact to the quality of receiving waters in Caution Bay resulting from the discharge of freshwater and residual levels of these chemicals.

21.3.1.2 Operations

Increased Suspended Sediment and Sedimentation Rates

The periodic movement of the LNG carriers, condensate tankers and associated tugs may resuspend sediments from the action of propellers, and suspended sediments will disperse according to particle sizes and the strength of prevailing currents.

21.3.1.3 Construction and Operations

Discharge of Brine (from Desalination) and Wastewater

The base case for a freshwater source for the LNG Facilities site is seawater desalination. Discharge of reject brine from desalination is assessed as an ongoing operational activity, as requirements during construction will extend into the longer-term operational phase. During the

early stages of construction, discharge of brine will be relatively low but will peak during years 3 and 4 at 2,500 m^3 per day, corresponding roughly to an equivalent volume of reject brine to be disposed. Initially, prior to the completion of the LNG Jetty, discharge of brine will be near to the end of the Materials Offloading Facility, at a location sufficiently far offshore to prevent stagnant hypersaline areas close inshore. Other sources of wastewater discharge into Caution Bay include treated sewage and other wastewater from the polishing pond (see Section 4.2.4.5, Wastewater Treatment Systems) and stormwater runoff.

Accidental Spillage of Hazardous Substances

Hazardous and dangerous goods that will be used on the pipelaying vessels include diesel fuel, oxyacetylene gas (for welding), solvents (for repair of corrosion coatings on the pipe), paints, hydraulic fluids, oxygen-reducing agents and X-ray sources (for radiography of pipeline welds). Accidental spillage of these substances or a large-scale spill, such as that caused by a vessel collision, could impact the marine environment. These issues have been addressed in Section 19.3, Sea Water Quality and Hydrology.

Discharge from Vessels

Discharge of sewage and other galley wastes into the coastal waters of Caution Bay has the potential to cause localised elevation of nutrients in the receiving waters, which will in turn lead to accelerated algae and plankton growth. Discharge of solids or liquid chemicals could potentially cause additional contamination.

21.3.2 Mitigation and Management Measures

21.3.2.1 Construction

The following mitigation measures will be applied to reduce impacts on seawater quality from construction activities, including the sedimentation and suspended sediments, dredging, spills and discharge-related impacts described above:

- Measures to minimise sediment release resulting from construction of the earthen causeway will include setting a lower limit of particle size for material used for LNG Jetty/Materials Offloading Facility causeway construction and/or use of a geotextile lining to minimise the release of fine sediment into the water column [M215].
- Silt curtains and/or other industry good practice management controls will be used to restrict the spread of sediment released during construction of the combined LNG Jetty/Materials Offloading Facility earthen causeway, particularly when working in mangroves, or adjacent to the reef and seagrass areas [M216].
- Selection of dredging equipment (cutter, suction/hopper, etc.) by the contractor will be appropriate to the depths and material types to be dredged and to minimise the creation of plumes [M217].
- Marine habitat or seafloor disturbance and mangrove clearing for the construction of the combined LNG Jetty/Materials Offloading Facility will be limited to the area within the perimeter fence. Works will be prohibited from exceeding the design disturbance width, and boundaries will be enforced through the use of markers or tape and distribution of worker awareness information [M208].

- Validation monitoring of sedimentation during construction will be similar in scope to that undertaken for the EIS characterisation baseline (i.e., use of settlement tubes, reef monitoring, as described in Appendix 23, Nearshore Marine Impact Assessment) [M207].
- Hydrotest water [M187, 196, M205, M214] used in the integrity testing of the LNG tanks will be reused for multiple tests whenever practicable to reduce demand for and quantities of waste hydrotest water. Typically, chemical additives such as oxygen scavengers and biocides may be used. Discharge of hydrotest water into Caution Bay will be subject to, and will comply with the required environment (waste discharge) permit from the Department of Environment and Conservation (DEC). Details of the volumes and rates of discharge into Caution Bay are not yet determined but at least 80,000 m^3 (one half the volume of one LNG storage tank) of fresh water will be required for hydrotesting. Given the once-off nature of the discharge, the dispersion potential as demonstrated for the brine would reduce salinity changes and concentrations of residual additives to benign levels rapidly. If necessary, further options to increase dispersion, such as diffusion, disposal of hydrotest water in the vicinity as the reject brine, or passing through the water treatment facility can be implemented as necessary to meet the environment (waste discharge) permit conditions, and to avoid prolonged salinity changes at the fringing reef or seagrass areas. The project will model the dispersion characteristics of the hydrotest water that will be discharged in Caution Bay prior to discharge.
- The project will adhere to Environment Australia (Commonwealth of Australia) guidelines or similar (in the absence of PNG guidelines[2]) with respect to dredging and disposal of dredged material (including protocols for investigating contamination and suitability of material for disposal, alternative options for use of material, management of dredging operations and site selection) [M211].
- Disposal of the dredge spoil will be undertaken off the continental shelf thereby presenting minimal risk of impact to the outer barrier reef [M218]. The location has been selected over 20 km from the barrier reef, in depths of 450 m and away from areas of potential upwelling (see Figure 13.4).

The dredge spoil from in front of the Materials Offloading Facility (and any smaller amount from the turning circle) will all be natural lagoon sand, which is not expected to contain any contaminants, although this will be confirmed in advance by laboratory testing.

The shipping channel from the entrance of Caution Bay to the LNG Jetty will not need to be dredged during construction as there is sufficient under-keel clearance for passage of the project-related construction vessels.

21.3.2.2 Operations

Increased Suspended Sediment and Sedimentation Rates

Within the channel from the entrance of Caution Bay to the LNG Jetty, the under-keel clearance (minimum 0.5 m) is sufficient for LNG carrier movements. On approach and leaving the berth, the

[2] The PNG Parliament is considering four new bills that, if adopted, will bring PNG law into line with international standards. The new bills are Marine Pollution (Ships and Installations) Bill, Marine Pollution (Sea Dumping) Bill, Marine Pollution (Preparedness and Response) Bill and Marine Pollution (Liability and Cost Recovery) Bill. While the bills do not yet form part of PNG legislation at the time of writing, requirements and regulations contained in the Marine Pollution (Sea Dumping) Bill include similar provisions for assessment of contamination of material to be disposed against proposed sediment quality guidelines.

LNG carrier's prop is barely turning as the propulsion is provided by the tugs, which have well over 2-m clearance. Consequently, sediment mobilisation and resuspension from propwash is low and not expected to have any significant effects on water quality. Therefore, mitigation and management measure specific to this issue are not proposed.

It is not expected that maintenance dredging of the access to the Materials Offloading Facility or the turning circle will be required during the life of the project. In the event that sedimentation does occur to the extent that requires dredge-removal, the amounts and frequency will be low and managed as for construction dredging, with minimal impacts to adjacent habitats.

21.3.2.3 Construction and Operations

Discharge of Brine (from Desalination) and Wastewater

Reject brine from the desalination process will be discharged into Caution Bay to achieve compliance with the required environment (waste discharge) permit conditions. This will be achieved by the location of the outfall location at the end of the LNG Jetty and diffuser to maximise dispersion and dilution. While reducing the length of the earthen causeway was a design change primarily to prevent sedimentation of the Vaihua River estuary, this will also improve the flushing and dilution of the brine when discharged at the end of the LNG Jetty. The point of discharge will initially be at the end of the Materials Offloading Facility, but at a point sufficiently far offshore to avoid calm or stagnant waters, as demonstrated by modelling (see Figure 21.1, taken from Appendix 22, Hydrodynamic Modelling). Once the LNG Jetty is completed, the outfall point will be located nearer to the end of the LNG Jetty, where water depth is greater than 12 m and tidal flushing potential much higher.

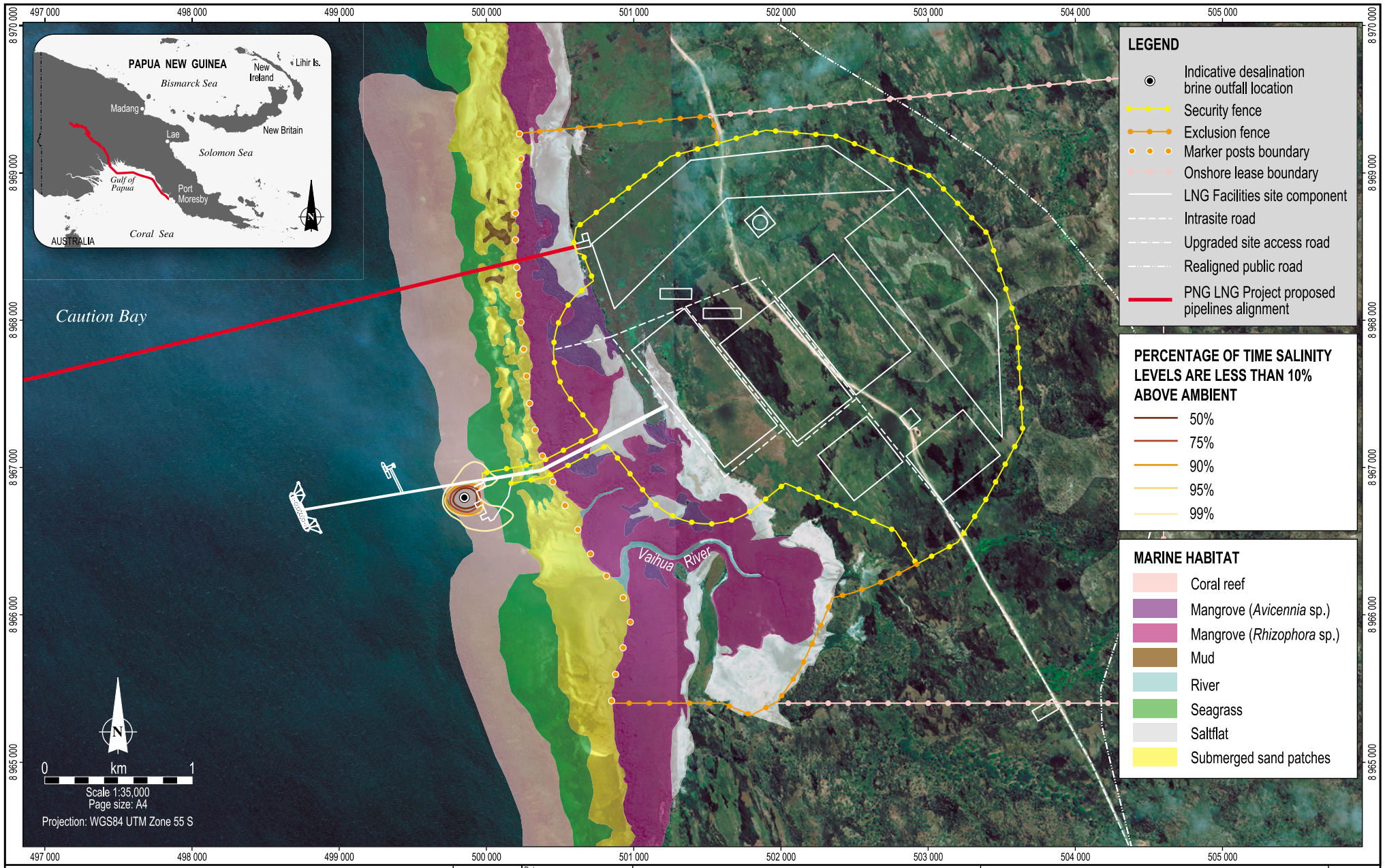
Sanitary wastewater will flow by an underground sewer network to sanitary lift stations for pumping to a treatment plant for biological oxidation, clarification and chlorination. Treated effluent will be sent to the retention pond for polishing and discharged into Caution Bay in accordance with the required environment (waste discharge) permit conditions [M219].

The chemically contaminated wastewater drains will collect effluent associated with process activities on the LNG Facilities site (see Section 4.2.4.5 Wastewater Treatment Systems). This effluent will be sent to the retention pond, where trace hydrocarbons will be separated, skimmed and sent to the oily water treatment system. Water from the retention pond will be discharged into Caution Bay in accordance with the required environment (waste discharge) permit conditions [M219].

The project will consider disposing the brine and wastewater from the wastewater treatment systems in same vicinity, which would achieve salinity similar to existing conditions at the near the discharge points [M206].

Accidental Spillage of Restricted Substances

Offshore emergency response procedures appropriate to the project phase will be established in the spill response plan and will include staff training at induction to inform workers of their responsibilities under the plan. This will include identification of all risks or sources of potential



Source: Salinity data digitised from GEMS figure, 2008. Indicative only.
Note: Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

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Brine output mixing zones and marine habitats

Figure No: **21.1**

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chemical and fuel spills and application of appropriate control or clean-up equipment appropriate for inventory volumes of restricted substances. [M209]

Discharge from Vessels

As vessels will be prohibited from discharging sewage and other wastes within Caution Bay in order to comply with MARPOL (IMO, 1973/1978) standards and international port policies and procedures [M210]. In addition, the potential application of the new (PNG) Marine Pollution (Ships and Installations) Bill, Marine Pollution (Preparedness and Response) Bill and Marine Pollution (Liability and Cost Recovery) Bill) will (when introduced) give effect to MARPOL and other conventions under PNG law and prohibit vessels discharging sewage and other wastes in nearshore areas.

21.3.3 Residual Impact Assessment

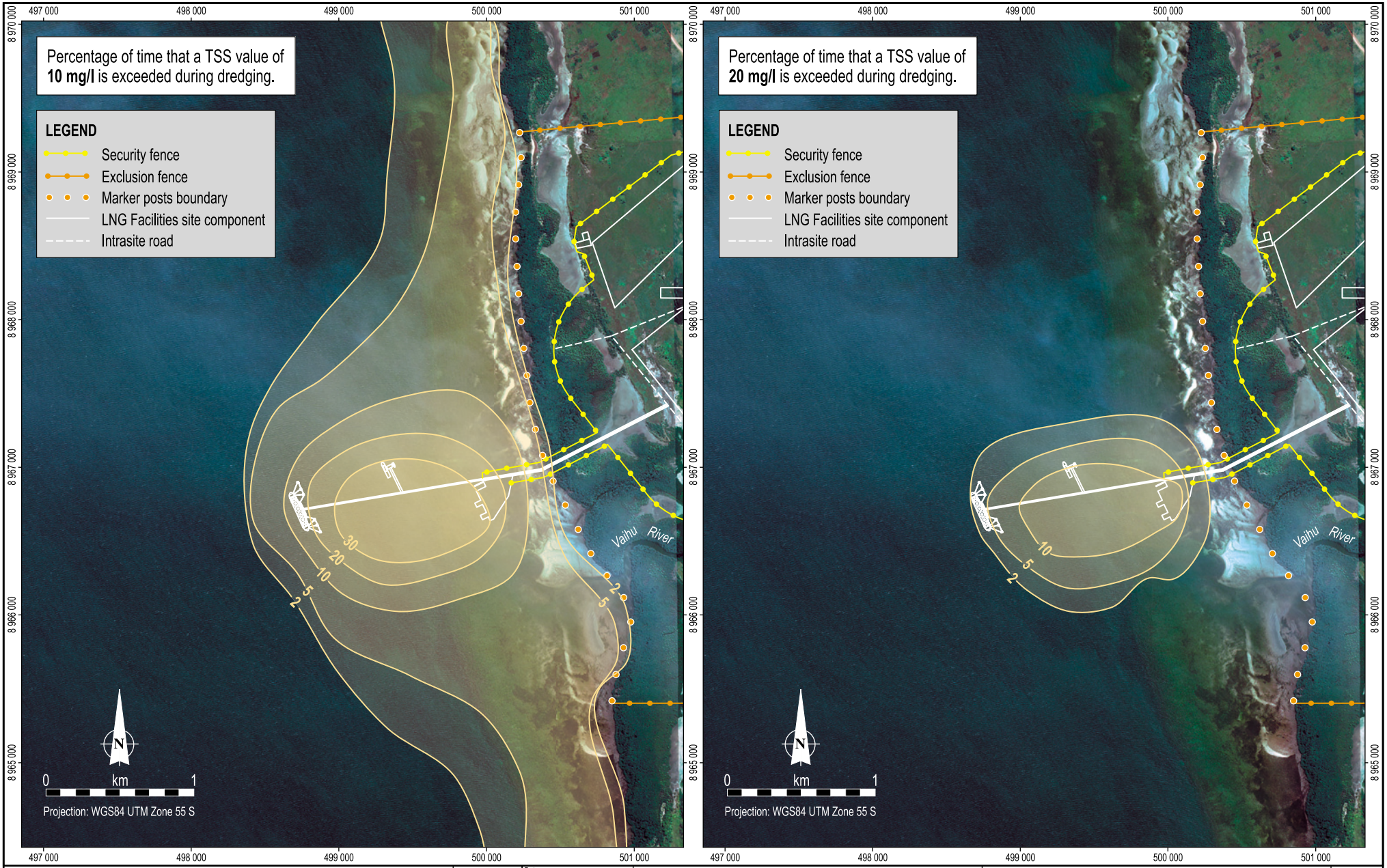
21.3.3.1 Construction

Increased Suspended Sediment and Sedimentation Rates

Use of silt curtains and other sedimentation control measures will restrict the spread of suspended sediment plumes generated from the construction of the combined LNG Jetty/Materials Offloading Facility earthen causeway to within 2 km from the impact source during the 6 to 8 months of construction. Once construction of the causeway is completed, the material of the causeway will stabilise and cease to be a source of continuing sedimentation to the surrounding coastal waters.

Assuming the maximum expected dredge spoil volume of 200,000 m^3, simulation models from the hydrodynamic studies (Appendix 22, Hydrodynamic Modelling) predicted zones of dispersion within which the percentage of time that plumes would exceed defined concentrations of 5, 10 and 20 mg/L of total suspended solids. Contours representing the proportion of time that total suspended sediment (TSS) values of 5 mg/L above ambient are exceeded show that much of the shoreline of Caution Bay will potentially be affected (see Appendix 22, Hydrodynamic Modelling); although a TSS value of 5 mg/L is not particularly high. Figure 21.2 shows the percentage of time during which TSS values of 10 mg/L and 20 mg/L are exceeded. For example, a predicted TSS value of 10 mg/L is exceeded from 1% to 5% of the time over approximately 10 km of the coast of Caution Bay, but contours of exceedence between 5% and 50% of the time are within a radius of approximately 2 km from the dredging. These levels would impact the fringing reef for up to 1 km either side of the channel as it is dredged for the Materials Offloading Facility. The predicted TSS value of 20 mg/L is not exceeded more than 30% of the time, and the extent of the impact on fringing reef correspondingly lower (see Figure 21.2). There are no PNG standards for suspended solids[3] although exposure to total suspended solid levels of 10 mg/L above ambient for the duration of dredging (i.e., approximately 2 to 3 months) could adversely affect corals. With application of the proposed mitigation measures (via a Dredging Management Plan), the distance of residual impact could be reduced to at least half of that predicted (i.e., within 2 km), depending on types of dredge gear used and weather conditions during working. Impacts of the small

[3] Standards only for turbidity, for which changes are required to be within 25 Nephelometric Turbidity Units of ambient.



Source: Sediment plume data digitised from GEMS figures, 2008. Indicative only.
Note: Layout is indicative only.
Final placement of all components is contingent upon pending soil and geological data.

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Modelling of sediment plumes from dredging

Figure No: **21.2**

amount of dredging (if any) for the LNG carrier turning basin would be substantially less than those modelled in Figure 21.2, and unlikely to be detectable in the water column or on the seabed.

If further project optimisation during FEED and detailed design results in a larger final volume of material to be dredged than has been assessed thus far, further modelling and assessment of impacts to receiving waters will be conducted in parallel with the engineering design optimisations as necessary.

Increases in suspended sediment and sedimentation rates from shipping activities during construction is not considered significant as LNG carriers will be propelled by tugs in the shipping access channel, and tugs and other vessels have adequate under-keel clearance to avoid significant propwash.

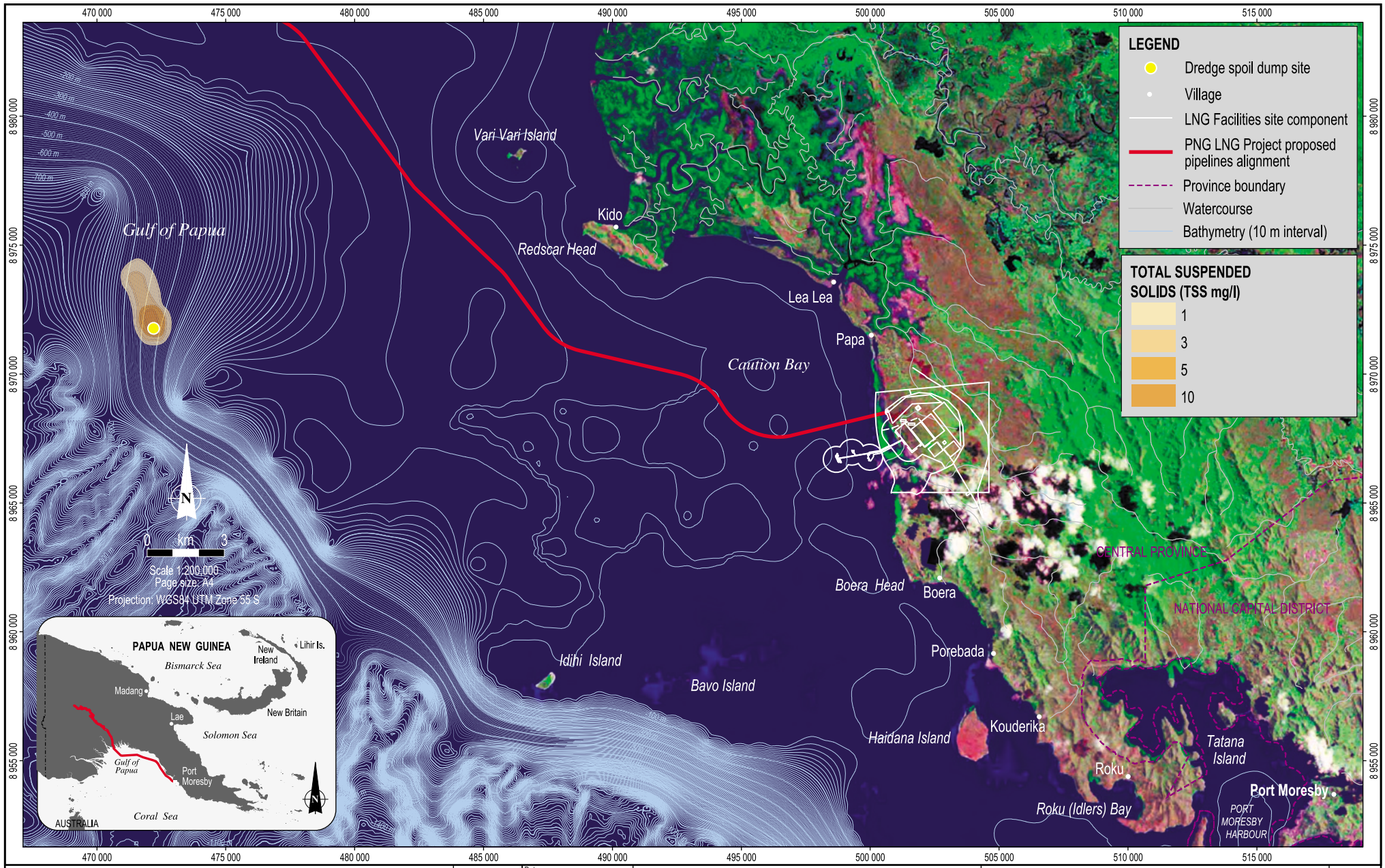
The increases in suspended sediment and sedimentation rates caused by installation of the offshore pipeline will be temporary and localised. Offshore pipelaying activities are expected to progress at a rate of 1 to 3 km per day; however, the rate of progress in nearshore Caution Bay is likely to be less (i.e., 300 to 720 m per day). The route option for shore crossing of the pipeline has been selected to avoid any need to dredge or remove bommies and to avoid areas of high value coral reef. The final shore crossing section will be trenched where the seabed is shallower than 15 m. While this will stir up some seabed sediments, this will be once off and localised to within an estimated 2 km from source of disturbance. The sediment that is disturbed will be of similar origin and particle size that naturally settle in the area and being natural lagoon sand, is unlikely to introduce any contaminants.

The marine habitats adjacent to and/or at the proposed locations for the shipping access channel, LNG Jetty/Materials Offloading Facility and offshore pipeline includes fringing-coast mangrove, seagrass beds, coral reef communities and extensive sandy seabeds. Sedimentation could affect these habitats through smothering and turbidity but sources are short-term. Sedimentation from dredging has highest potential to extend to reefs but, as discussed, with the appropriate mitigation, impacts could be restricted to within 2 km and for these reasons, the magnitude of impact is assessed as medium (Table 21.1).

The sensitivity of the receptor is high, as it supports species that are important on a regional level and provide food to local communities. Given the short temporal and localised spatial effects of the impact, the residual significance of this impact is assessed as moderate.

Disposal of Dredged Material

The main criterion used in selecting the location for disposal of dredge spoil was to remove risk of any plumes impacting the outer barrier reef off Caution Bay. The proposed disposal area was selected based on hydrodynamic modelling (see Appendix 22, Hydrodynamic Modelling) taking into account expected particle sizes, settlement rates, ambient currents and upwelling characteristics. The proposed site for dredge spoil disposal, shown on Figure 21.3, is 28 km offshore from the LNG Facilities site and approximately 20 km from the nearest part of the barrier reef (near Idihi Island) in water depths of around 450 m off the continental shelf.



Source: Turbid plume data digitised from GEMS figure, 2008. Indicative only.
Note: Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

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Turbid plume generated at the spoil disposal site

Figure No: **21.3**

The volume of material to be disposed will be in order of 150,000 to 200,000 m^3, and the duration of the disposal is expected to be approximately two to three months, depending on the size of the dredge used and weather-induced lay days. Modelling of the turbid plume (maximum lateral extent of plume) shows no risks of transport of plumes inshore to the barrier reef (see Figure 21.3). Despite the considerable volume of dredge spoil, the plumes from each day are dispersed by the time of the next day and maximum lateral extension of TSS plumes is small, as shown in the figure. The proposed dredge spoil dump site is located so that the plume moves into deeper rather than shallower water, and is remote from any areas of possible upwelling that can occur during prolonged periods of the south-easterly trade winds (Appendix 22, Hydrodynamic Modelling). Due to the lack of any major developments or industry in the vicinity, the dredged material (lagoon sand and silts) is unlikely to contain any contaminants (to be confirmed) and will be the same sediment that is naturally (gradually) transported from the shallow to the deep slope areas. Under the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, wastes defined in Annex 1 (wastes or other matter that can be considered for dumping) include dredged material (paragraph 1.1) and inert geological material (paragraph 1.4), subject to constraints on levels of radioactivity. The dredged material from Caution Bay can be considered to meet either category and its disposal as proposed would not contravene the convention. This is also consistent with the proposed (PNG) Marine Pollution (Sea Dumping) Bill, currently under consideration by the PNG Government.

Based on the short duration of dredging, expected depositional nature of the receiving area[4] and uncontaminated nature of the material (both to be confirmed by testing prior to construction), the magnitude of impact cannot yet be assessed without further study of the receiving habitat, but provisionally assessed as medium (on the basis that these life forms are widespread, and any localised impacts from sediment smothering will be reversible). Based on the widespread nature of the resource at these depths, the sensitivity of the resource or receptor is low. The overall significance of this residual impact is therefore assessed as minor.

If further project optimisation during FEED and detailed design results in a larger final volume of material to be disposed than has been assessed thus far, further modelling and assessment of impacts to receiving waters and seafloor of the disposal area will be conducted in parallel with the engineering design optimisations as necessary.

Discharge of Hydrotest Water

As described in Section 21.3.2.1, Construction, hydrotest water will be treated as necessary to remove or denature chemical additives prior to discharge, subject to permit conditions. Hydrotest water can be disposed in the same vicinity as the brine outfall in order to reduce the extent of salinity difference (from high salinity reject brine and fresh hydrotest water) in the receiving waters, at least for the duration of discharge of hydrotest water. Details of the volumes and rates of discharge into Caution Bay are not developed sufficiently to model dispersion characteristics, which will be done as necessary to reconfirm or re-evaluate predictions. However, the dispersion capabilities (as demonstrated for brine; see Section 21.3.3.2 Operations), and further treatment options (as necessary to meet permit conditions) reduce the magnitude of impact to minimal, particularly given the short-term, once-off discharge activity that occurs only at commissioning. Sensitivity of the receiving environment is low (where corals or seagrass are not reached) and residual impact significance is therefore considered to be minimal.

[4] Characterisation of the area will be undertaken prior to construction.

21.3.3.2 Operations

Increased Suspended Sediment and Sedimentation Rates

No ongoing sources of suspended sediments are expected after completion and stabilisation of the marine facilities. During operations and for the life of the project, some mobilisation of seabed sediments may occur during movements of the LNG carriers, although propwash from the carriers themselves is expected to be minor (for reasons already outlined) and intermittent. The need for maintenance dredging of the turning circle is not anticipated, as the seabed contours are not changed substantially. In the event that some maintenance dredging is required, this will be minor and managed as for the construction dredging to minimise impacts to the water column and adjacent habitats. For these reasons, the magnitude of impact will be low. These habitats are sensitive to changes in water quality and will be impacted by increases in suspended sediment; therefore, the sensitivity of resource or receptor is medium.

Given these measures, the residual significance of this residual impact is minor.

21.3.3.3 Construction and Operations

Discharge of Brine (from Desalination) and Wastewater

The brine discharges will locally increase salinity with potential effects on habitats such as seagrasses and corals, and on the fisheries in the bay. The constant discharge of reject streams with high salinity levels can be detrimental for marine life, and can cause changes to species composition and abundance in the vicinity of discharge (Lattemann & Höpner, 2008).

Research findings from studies investigating the impacts of saline discharge from desalination plants are varied. No toxic effects of desalination plant seawater were recorded on amphipods, kelp spores or fertilised sea urchin eggs in laboratory experiments (Bay & Greenstein, 1992). Similarly, no significant variations in the macrobenthic community could be attributed to the brine discharges from the desalination plant inhabiting off the northwest Mediterranean coast of Spain (Raventos et al., 2006), and increased salinity was not found to affect the density, blade productivity and blade biomass of a seagrass meadow (*Thalassia testudinum*) after 6.5 months off Antigua, West Indies (Tomasko et al., 2000). In contrast, negative responses to increased salinity have been recorded for a number of marine organisms, such as zooxanthellate coral (*Stylophora pistillata*) (Ferrier-Pagés et al., 1999). A number of studies have also reported that some seagrass species are negatively impacted by increased salinity (Sadhwani et al., 2005; Fernández-Torquemada, 2004; Sánchez-Lizaso et al., 2008). For example, in one long-term study of more than six years, a shallow seagrass (*Posidonia oceanica*) bed was found to be very sensitive to increased salinity, and it was recommended that discharges of brine over such seagrass areas should not exceed 38.5 practical salinity units (psu) of salinity for more than 25% of the time or 40 psu for more than 5% of the time in order to reduce adverse impacts (Sánchez-Lizaso et al., 2008).

Conservative estimates based on the scientific literature suggest that that benthic environments are able to tolerate an increase in salinity of between 1 to 2 psu above ambient[5] ocean salinity (Höpner & Windelberg, 1996; Jenkins & Wasyl, 2005; Barron, 2006); and slightly higher levels for restricted periods for certain seagrass species (Sánchez-Lizaso et al., 2008). Generally, impacts are not detected where there is adequate flushing. The World Health Organization (WHO, 2007)

[5] Ambient ocean salinity is typically 35 psu.

suggests that a 10% increment above ambient ocean salinity is a conservative measure of aquatic life tolerance to increases in salinity.

In Papua New Guinea, there is no prescribed water quality guideline for salinity (e.g., from the discharge of brine to the marine environment) contained in Schedule 1 of the Environment (Water Quality Criteria) Regulation 2002. As an initial reference to determine the nature of the impact and analysis, modelling has used World Health Organization guidelines (WHO, 2007), which require that salinity variation resulting from the discharge is no greater than 10% above the ambient level for ecosystem tolerance. This salinity condition therefore would require a dilution of approximately 20 times to be achieved 99% of the time.

The hydrodynamic model (Appendix 22, Hydrodynamic Modelling) was run for a 12-month period to produce simulated hourly currents throughout the year that modelled the dilution of the saline reject waters discharged after the desalination process. Figure 21.1 shows the resultant model output showing the mixing zones required to achieve 20 dilutions to achieve less than 10% above ambient for 99%, 95%, and 90% of the time and shows that the boundary within which salinity is within 10% of ambient 99% of the time in Caution Bay is mostly within 200 m of the discharge, with no stagnant areas close to the coast.[6]

The modelling outputs reflect conservative assumptions: there are a number of factors that can be taken into consideration. These are listed as follows.

- Peak discharge rates of 2,500 m^3 per day were used.
- A single discharge point, rather than multiple diffuser outlet was used in the model.
- The effect of the earthen causeway can be seen to some extent, with slight extensions of elevated salinity to the north and south of the earthen causeway where the area is shallow. This would not be the case during operations, when discharge would be at the end of the LNG Jetty (marked on Figure 21.1).
- These areas overlap part of the fringing coral reef and seagrass beds but relatively small proportions of these habitats (Figure 21.1) most of which will have been removed by dredging to the Materials Offloading Facility, and construction of the Materials Offloading Facility itself. Once the discharge point moves close to the end of the LNG Jetty during operations, the elevated salinity contours will not reach these habitats.
- The modelling has not allowed for any dilution of the brine from other streams, such as the treated wastewater streams. Since most of the waste domestic and sewage water is sourced from desalinisation, there is the potential for achieving overall salinity balance by disposal in the same vicinity as the wastewater.

As wastewater will be treated to meet environment (waste discharge) permit conditions at the mixing zone boundary defined in the permit it will have minimal impacts to exiting water quality. Impacts will be restricted to localised increased levels of nutrients. The flushing capacity of Caution Bay has demonstrated for the brine discharge and will prevent any build-up of nutrients.

The results shown in Figure 21.1 show that even with the above conservative assumptions, dispersion modelling (see Appendix 22, Hydrodynamic Modelling) indicates that plumes of

[6] Modelling in Appendix 22, Hydrodynamic Modelling also examined other criteria that have been applied in individual cases but these are not generally applied and the WHO guidelines have been applied here.

elevated salinity would meet WHO (2007) tolerance limits within a very short distance from the discharge point and evidence from scientific literature indicates that there would be no material impact to habitats such as seagrass beds. On this basis, the magnitude of impact is low; sensitivity of receiving environment medium, and residual impact minor. Validation of the extent of elevated salinity by monitoring will be part of the marine monitoring program.

Accidental Spillage of Restricted Substances

The magnitude of any residual impact will depend on the volume and nature of substance or substances accidentally spilled into the marine environment; and in this regard, inventories of restricted substances will be low. Development and implementation of spill prevention and emergency response procedures will be a requirement to prevent spills to the environment and limit the spread of any spills that do occur.

With application of spill prevention and emergency response procedures, and given the low volumes of restricted materials on board, the magnitude of impact is low.

Habitats in Caution Bay may be impacted in the event of a large-scale spill as mangroves or corals exposed at low tide in particular are sensitive to oil smothering. People inhabiting the coastal villages would similarly be affected by spills that impact fisheries resources, as they rely on these resources for their livelihood. For these reasons, the sensitivity of resource or receptor is high. The overall significance of this residual impact is therefore minor.

Discharge from Vessels

Adherence to MARPOL requirements will reduce the magnitude of impact to low; sensitivity of resource or receptor is reduced to medium (in this case, where nearshore habitats can be avoided); and residual impact significance to water quality will be minimal.

21.4 Coral Reef, Seagrass and Mangrove Habitats

This section describes the environmental issues, mitigation measures and residual impacts to coral reef, seagrass and mangrove habitats arising from construction and operation of the LNG marine facilities.

21.4.1 Issues to be Addressed

21.4.1.1 Construction

Direct Loss of Marine Habitat

The marine habitats presently in the areas that will be occupied by the LNG Jetty/Materials Offloading Facility will either be removed or buried during construction activities. Areas adjacent to those directly impacted will be affected by lateral spread of construction-induced increases in turbidity and sedimentation, as described in Section 21.3, Sea Water Quality. This will mainly affect marine habitats in the vicinity of the construction of the LNG Jetty/Materials Offloading Facility, dredging activities at the turning circle (if any), and pipe laying activities (see Figure 4.1). The types of the nearshore habitats affected include submerged and intertidal sandy substrates, fringing reefs, seagrass beds and mangroves (see Section 13.3, Biological Environment).

21.4.1.2 Operations

Direct Disturbance to Marine Habitat

Areas of disturbance will stabilise after construction finishes; and to some extent, the new hard structures, such as the rock armour of the causeway and jetty piles, will attract some replacement habitats and organisms (e.g., corals and other encrusting organisms and fish). Sources of ongoing potential impact to marine habitats from sedimentation will be the periodic sedimentation effects of propwash from ships. During operations, the main source of potential impact to coral reefs, seagrass beds and mangroves may be from discharges of reject brine from desalination. This has been discussed in Section 21.3, Sea Water Quality.

21.4.2 Mitigation and Management Measures

21.4.2.1 Construction

Direct Loss of Marine Habitat

The direct loss of marine habitat will occur to the extent of the areas that will be occupied by the project structures, which is unavoidable, regardless of the routes and locations of those facilities. However, considerable planning and assessment of the options has featured measures that have limited the extent of those habitats directly or indirectly impacted, taking into account other engineering and archaeological constraints. Three different options for location of the combined LNG Jetty/Materials Offloading Facility and the LNG Project Gas Pipeline shore crossing were considered. While the engineering constraints were significant, particularly the need to separate pipelaying activities from the LNG Jetty/Materials Offloading Facility construction activities, the proposed location of the marine facilities and pipeline avoids the need for removal of bommies and restricts loss of habitat to that which is unavoidably in the path of the structures themselves.

Methods to mitigate the impacts from sedimentation and turbidity in the habitats adjacent to construction are as described for sea water and sediment quality (Section 21.3.2.1, Construction) and are not repeated here. The main approach will be to limit marine habitat disturbance and mangrove clearing for the LNG Jetty/Materials Offloading Facility construction to the area within the site perimeter fence, to prohibit works from exceeding the design disturbance width and to enforce boundaries through use of markers or tape and worker awareness [M208]. The *Pavona* bommie (see Chapter 13, Receiving Marine Environment: Marine Facilities) is about 3 km to the south of the LNG Jetty/Marine Offloading Facility and will not be affected.

21.4.2.2 Operations

Direct Disturbance to Marine Habitat

Direct disturbance to marine habitats during operation, principally via ships' propwash and any maintenance dredging, (both of which are low or not predicted to occur) will be managed and mitigated as described for sea water and sediment quality in Section 21.3.2.2, Operations. Apart from monitoring the effectiveness of these, no further mitigation measures are proposed during operations.

21.4.3 Residual Impact Assessment

21.4.3.1 Construction

Direct Loss of Marine Habitat

The extent of loss of marine habitats for the LNG Jetty/Materials Offloading Facility will be limited to the width of the causeway and its immediate vicinity. The causeway is planned to pass through a relatively narrow part of the fringing mangroves, seagrass beds and fringing reef (see Figure 21.1). This is conservatively estimated at 13.7 ha or 5.3% of the mangroves within the lease area (see 'Mangroves' in Section 20.7.4.1, Significance of Impacts on Habitats and Special Areas) and substantially less than 10% of the available habitats regionally within Caution Bay. The magnitude of impact is therefore assessed as medium (local impact generally up to 2 km from impact site). The sensitivity of the habitats is high, and on this basis, the overall significance of this residual impact is therefore moderate.

The pipelaying activities will similarly directly disturb only a very narrow construction corridor where trenched from the shore to the planned depth of burial (i.e., 15 m), and disturbance to fringing reef, seagrass and mangroves would cumulatively not exceed 10% of that available. Considering just the pipeline, the magnitude of impact is low, sensitivity of resource or receptor is high, and based on the criteria set out in the matrix of significance, the significance of this potential impact is assessed as minor.

21.4.3.2 Operations

Direct Disturbance to Marine Habitat

Once construction is complete, the magnitude further disturbances to marine habitats are expected to be minimal and while the sensitivity of the resource/receptor will remain high, the residual impacts are expected to be minimal.

21.5 Marine Fish and Other Marine Fauna

This section describes the environmental issues, mitigation measures and residual impacts to marine fauna (marine mammals, turtles and fish) arising from construction and operation of the LNG marine facilities.

21.5.1 Issues to be Addressed

21.5.1.1 Collision of Vessels with Marine Mammals and Other Large Marine Fauna

The presence of the pipelaying and marine facilities construction vessels and the arrival and departure of LNG carriers and condensate tankers for loading and export present some ongoing risk of disturbances to and collision with marine mammals and turtles.

21.5.1.2 Underwater Noise

The vessels associated with construction and operations activities, including lay barges, tugs, LNG carriers and condensate carriers, will contribute to existing underwater noise levels. The lay barge is likely to use anchors but may be dynamically positioned; in which case, the underwater

noise created by dynamically positioned vessels is generally greater than from other sources. This has been discussed in Section 19.4, Marine Fauna.

Construction of the LNG Jetty/Materials Offloading Facility will require pile driving from a jack-up barge as the causeway moves progressively seawards and this will cause underwater noise and pressure waves that could affect fish and marine mammals. The effects of this on marine animals are variable, ranging from mortality (e.g., see Hastings & Popper, 2005; Nedwell et al., 2003) to avoidance or migration (Feist et al., 1992). However, mortality of fish has only been reported when exposed to high intensities of sound, close to the source and when restricted from moving away; and not when the fish were moved further from the source (Nedwell et al., 2003; Hastings & Popper, 2005). Noise from pile driving can affect marine mammals, such as dolphins: for example to their directional hearing or by masking vocalisation frequencies and amplitude (David, 2006). Depending on intensity and frequency, this may extend several kilometres, although observed behavioural modifications may simply reflect redistribution of prey (David, 2006).

Blasting may be required during dredging of the shipping turning circle and for the marine facilities, but only if rocky outcrops are encountered that cannot be removed by the dredging equipment (see Section 4.6.1.10, Dredging for the Marine Facilities). These sounds have the potential to interfere with the behaviour of nearby marine mammals that communicate using sound.

Effects of Lighting on Marine Fauna

The LNG Jetty/Materials offloading Facility will be lit for safety and security purposes during construction and operation. Increases in lighting can influence the movement and migration of marine fauna. Surface lights, such as the light of the moon, are used by some marine fauna for navigation. Sea turtles navigate to and from nesting beaches by using the light of the moon, and hatchlings migrate out to sea using the same navigational technique (see Appendix 23, Nearshore Marine Impact Assessment).

21.5.2 Mitigation and Management Measures

Specific details of the following mitigation measures for marine fish and other marine fauna will be developed in the relevant construction and operations (offshore) environment management plans.

Collision of Vessels with Marine Mammals and Other Large Marine Fauna

It is not practicable or necessary to conduct marine mammal observation procedures for all of the construction and operations activities within Caution Bay. The activities of tugs and supply vessels are not dissimilar from existing activities; and although the level of such activities will increase by project construction and operations, the low expected frequency of encounter and risks of causing physical injury to the species that might be present (dolphins and turtles) are low.

The marine fauna observation procedure (described in Section 19.4, Marine Fauna) for pipelaying operations will continue in Caution Bay [M189].

Underwater Noise

For the pipelaying operation within Caution Bay, the marine fauna observation procedure (described in Section 19.4, Marine Fauna) will continue, requiring observations of large marine animals (such as whales and turtles) to be documented in an observation log [M189].

Lower noise characteristics and therefore lesser impacts are expected from underwater noise generated by other project-related vessels such as tugs and supply boats (in comparison with the dynamically positioned pipelay barge modelled). There are no practical ways to reduce the noise characteristics from these vessels and limited necessity, given the low expected frequency of encounters, extending the observer recording function to individual construction vessels and tugs in Caution Bay is not warranted.

It is not expected that blasting will be required but in the event that underwater blasting is required for construction to remove hard, undredgeable areas, a pre-blasting clearance survey will be undertaken to ensure no marine fauna or turtles are in the vicinity [M213].

Pile-driving activities will be managed so that underwater sound increases incrementally during the construction of the LNG Jetty to allow mobile marine fauna in the vicinity the opportunity to move away before sound levels reach maximum [M212].

Effects of Lighting on Marine Fauna

Turtle nesting is reported by local fishermen to occur on Idihi Island, although this is evidently an infrequent occurrence but nevertheless could occur during the life of the project. Where practicable, light spill into the marine environment during construction and operation will be managed by shielding to reduce visibility of the LNG Facilities (including the marine facilities) from Idihi Island [M220].

21.5.3 Residual Impact Assessment

Collision of Vessels with Marine Mammals and Other Large Marine Fauna

It is unlikely that collisions between marine mammals and project-related vessels will occur in Caution Bay for the following reasons:

- The pipelaying vessel will travel at slow speeds (300 to 720 m per day in Caution Bay), i.e., animals would have to collide with the vessel, not vice versa.
- While the support vessels (tugs and supply boats) will travel at greater speeds than the pipelaying vessel, they do not move at high speed and their noise characteristics enable such species as dolphins and turtles to avoid them, as with existing levels of shipping traffic (refer to Section 4.12.3.2, Operations Environmental Safety Limits, for maximum travelling speeds).
- Sounds associated with the pipeline installation activities should temporarily deter marine mammals from entering the immediate areas of activity (see ‘Underwater Noise’ below).
- Marine mammals, with the exception of dolphins, are not commonly seen in the parts of the Caution Bay traversed by the pipeline.

As discussed in Section 13.3.3.2, Marine Fauna, marine mammals are rarely encountered in Caution Bay. Although the distribution of some whale species listed as vulnerable by the IUCN

includes the Gulf of Papua, it is understood that these large species seldom enter the nearshore environment of Caution Bay, However, their presence cannot be completely discounted. Smaller marine mammals, such as bottlenose dolphins, occur in Caution Bay but are not listed by the IUCN. Dugongs are not reported to be frequently present; however, species of turtles, such as green and hawksbill, do occur in Caution Bay and are listed by IUCN. Despite the fact that the sensitivity of the resource or receptor is high, the magnitude of impact is minimal for reasons discussed above. Therefore, the overall significance of this residual impact is therefore minimal.

Underwater Noise

Levels of underwater noise from project-related vessels are not expected to be different from existing shipping activities and are insufficient to cause physiological harm, except to any animals approaching to within a few tens of metres. This assessment is based on a specialist report prepared by Curtin University of Technology, which is provided as Annex A in Appendix 11, Offshore Impact Assessment, and describes modelling that was based on the worst-case characteristics of a dynamically positioned pipelaying vessel. While this would be audible for more than 20 km, the noise is too low (i.e., less than a threshold underwater noise level of 180 dB re 1 µPa) to produce detectable physiological effects on marine fauna.

There are some differences in sound transmission and attenuation characteristics between the western (Gulf of Papua) and eastern (Caution Bay) areas of the offshore pipeline. Within Caution Bay sediments are more consolidated and less absorptive of sound than in the western parts of the offshore pipeline route, which are less consolidated and more absorptive of sound. However, Caution Bay is shallower, leading to more refraction losses as sound is reflected off the seabed and sea surface, so differences along the route are minor. The duration of sound impacts at any particular location are short, as the offshore pipelaying will likely progresses at 1 to 3 km per day, although progress may be slower in Caution Bay.

For these reasons, the magnitude of impact is assessed as low.

As discussed in Section 13.3.3.2, Marine Fauna, marine mammals are rarely encountered in Caution Bay. Some whale species listed as vulnerable by the IUCN are found in the Gulf of Papua, but these large species are not frequently observed to enter the nearshore environment of Caution Bay. Smaller marine mammals, such as bottlenose dolphins, occur in Caution Bay but are not listed by the IUCN. Dugongs are not reported to be frequently present; however, species of turtles, such as green and hawksbill, do occur in Caution Bay and are listed by IUCN. Given the presence, or potential presence of IUCN-listed species, the sensitivity of the resource or receptor is high.

The significance of this potential residual impact is therefore minor.

Effects of Lighting on Marine Fauna

LNG Facilities will be illuminated 24 hours a day during construction and operations. At night, there is likely to be some direct illumination or glare over the coast but this will be managed to reduce visibility of the LNG Facilities (including the marine facilities) from Idihi Island. For this reasons, the magnitude of impact is low.

While there are IUCN-listed species in Caution Bay, there are no beaches suitable for turtle nesting in the immediate vicinity of the proposed LNG Facilities (although turtles may nest

occasionally on Idihi Island and also may feed in the coastal waters of Caution Bay). The assessment criteria in Table 21.2 determine that the sensitivity of the resource or receptor is high because of the presence of IUCN-listed species within the vicinity of the project area.

The significance of this potential residual impact is therefore minor.

21.6 Subsistence Fisheries and Marine Traffic

21.6.1 Issues to be Addressed

21.6.1.1 Construction

Interaction with Subsistence Fisheries and Marine Traffic

Subsistence fishing within Caution bay is an important and common activity involving most adults to provide food and source of subsistence income on a daily basis. Details of fishing practices, numbers of people and boats are given Appendix 24, Resource Use Survey of Caution Bay, which examined how these resources are used in the Caution Bay area. At present, movements of shipping traffic, such as cargo ships, oil and gas tankers and lumber barges, mainly occur beyond the barrier reefs, and commercial vessels do not regularly travel through Caution Bay. For reasons of safety, non–project-related vessels, such as canoes and banana boats, will be required to keep clear of vessels involved in the construction of the offshore pipeline and marine facilities. Operators of non–project-related vessels will need to select alternative fishing areas or transit routes if at any time construction activities traverse their preferred fishing grounds or transit routes.

A safety exclusion zone of 500 m around vessels involved in the construction of the offshore pipeline and marine facilities will apply to all boats, as a safety hazard would apply if out of curiosity, operators approach too close to the construction vessels.

21.6.1.2 Operations

Impacts to Subsistence Fisheries and Marine Traffic

The project will put into effect an exclusion zone during operations that will encompass the LNG Jetty (during LNG carrier and condensate tanker loading) and the Materials Offloading Facility (during materials offloading) (see Figure 21.4). Further information on the exclusion zone is provided in Section 4.2.1.4, Fencing and Exclusion Zones.

LNG carriers will routinely cross the pipeline during passage to and from the LNG Jetty; there is a potential risk of contact with the pipeline.

21.6.2 Mitigation and Management Measures

Specific details of the following mitigation measures for subsistence fisheries and local marine traffic will be developed in consultation with local resource users and reflected in the relevant construction and operations (offshore) environment management plans.

21.6.2.1 Construction

Interaction with Subsistence Fisheries and Marine Traffic

As for construction of the marine pipeline in marine waters in the Gulf of Papua (see Section 19.5, Marine Fisheries), a community awareness program will be carried out to inform inhabitants of villages in Caution Bay regarding the offshore pipeline construction activities. Information on the timing of and the dangers associated with approaching pipelaying vessels will be passed on during the program [M183]. Local people will be requested to remain clear of the pipelaying vessels for their own safety [M185]. Consultation will include relevant aspects of access, safety and exclusion zones, and the dangers of dynamite fishing (which is an illegal activity) close to the as laid pipeline [M202].

Compensation for loss of either access to and/or marine resources as a result of marine facilities exclusion zones will be managed through consultation with relevant communities (see Section 23.9, Agriculture, Fisheries, Forestry and Subsistence, and Section 30.3.4, Social Management Plans) to determine details of how compensation measures will be implemented [M221].

The offshore pipeline route will be aligned to cross the LNG tanker shipping channel at an angle as perpendicular as practicable to the channel and the pipeline will be buried (or covered with rocks) through the shipping channel [M197]. In addition, the pipeline will be 2 to 3 m below the seabed in water depths less than 15 m LAT in Caution Bay [M191].

21.6.2.2 Operations

Impacts to Subsistence Fisheries and Marine Traffic

As described for the construction phase, community consultation will be undertaken to inform villagers in Caution Bay about the locations of the exclusion zones, the reasons for their establishment (e.g., risks to safety), how they will be implemented, and mechanisms to determine compensation for lost resources [M221].

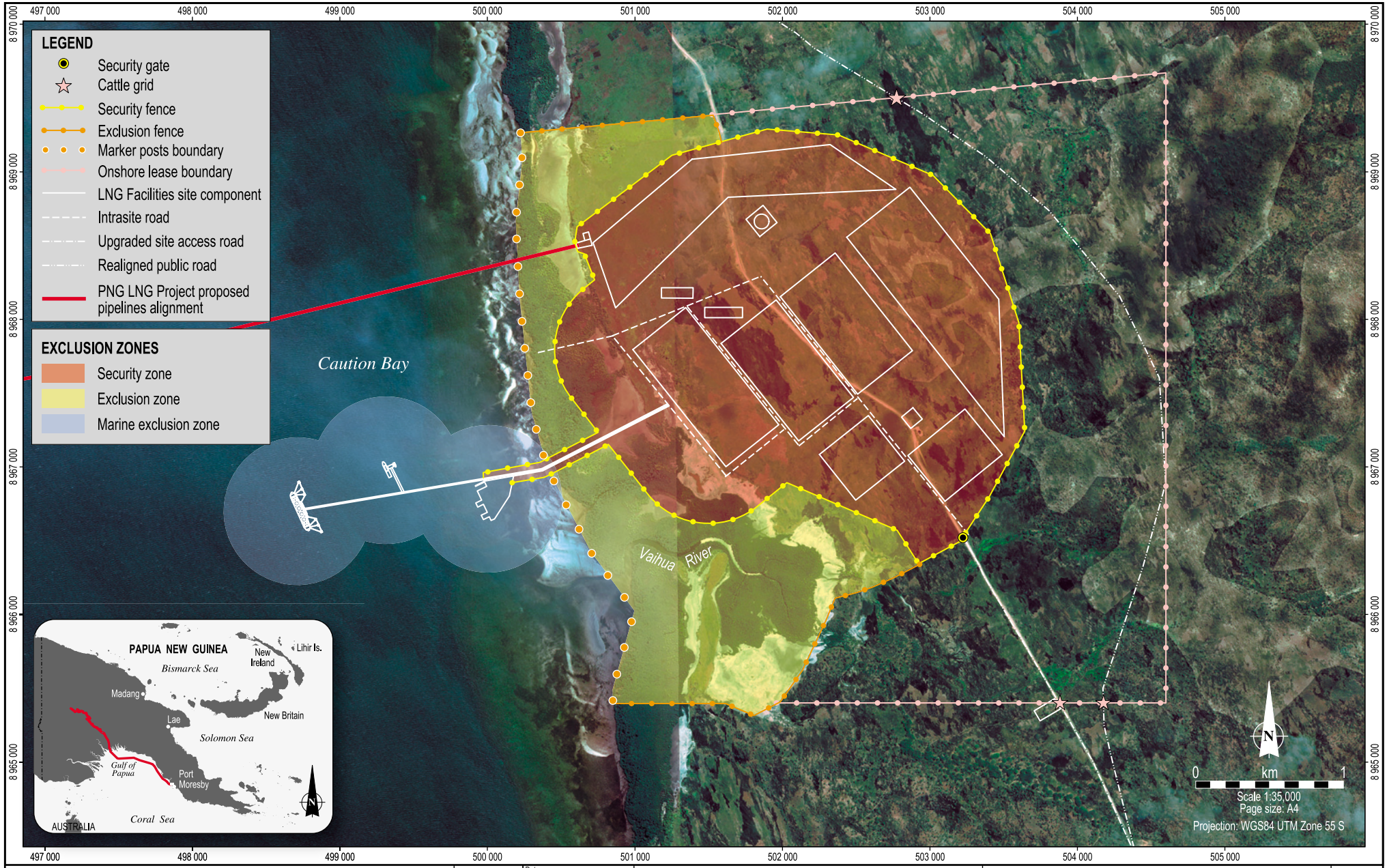
21.6.3 Residual Impact Assessment

21.6.3.1 Construction

Interaction with Subsistence Fisheries and Marine Traffic

Subsistence fishing within Caution Bay is an important activity for gathering food and income. It will be temporarily disrupted in the vicinity of the pipelaying vessel and support vessels during construction when fishing vessels will need to keep out of the exclusion zone. Given the short duration of pipelaying in the open waters of the bay and the fact that fishing vessels in the bay can move to other areas of the bay to fish (see Figure 13.11), the overall magnitude of impact will be low (impact affects immediate surrounds of area of activity and extends for less than 1 km radius). The sensitivity of fishing resource or receptor will be high; therefore, the overall significance of this residual impact will be minor for pipelaying impacts.

With an effective community awareness program, it is expected that other marine traffic using the bay can avoid or bypass the pipelaying spread for the duration of its activities with minor or minimal disruption to marine traffic movements.



Note:
Layout is indicative only.
Final placement of all components is contingent on pending soil and geological data.
Pipelines approximate the proposed alignment based on engineering data provided up to 1 October 2008.

PNG LNG

Date: 07.11.2008
MXD: PNG_LNG_Project_GIS.mxd
File Name: 1284_09_F21.04_GIS_HB

Esso Highlands Limited

PNG LNG Project

LNG Facilities exclusion zones

Figure No: 21.4

PGGP-EN-SRENV-000001-001
Rev0

The significance of impacts during construction relating to exclusion zones on subsistence fisheries and marine traffic is discussed below under operations.

21.6.3.2 Operations

Impacts to Subsistence Fisheries and Marine Traffic

The exclusion zone will provide a refuge or no-take area for fish resources; and to a certain extent, this provides a positive effect on fish stocks, depending on redistribution of fishing to other areas; however, local people will be excluded from fishing or travelling within the exclusion zones around the LNG Jetty/Materials Offloading Facility. This will increase journey time and fuel consumption for people who use the bay to travel between coastal villages, to harvest coastal marine resources or to fish offshore. This impact is unavoidable and will last for the life of the project and will cost people money, reduce their present resource-based incomes and detract from the amenity and conveniences of Caution Bay that they now enjoy. However, the PNG LNG Project, that has these effects, also brings benefits to the people affected, for which they support the project proceeding—and this implicit tradeoff rests on the local people's appreciation of what will happen especially as the effects will vary between individuals according to their age, their roles in their communities and other factors. The mitigation measures will need to make allowance and cater for these differences. Provided that the future lives up to expectations, then the mitigation effect of the project's overall benefits would be expected to bring a nominally high impact on a high sensitive resource/receptor down to one of nominally minor significance.

21.7 Mangrove Resource Utilisation

21.7.1 Issues to be Addressed

Exclusion Zone

The effect of the exclusion zone is the issue that will affect mangrove resource utilisation and will arise during both construction and operations (see Figure 21.4).

As described for subsistence fishing, local people utilise the mangrove forests for many purposes including collecting shellfish food; as a source of building materials and firewood; and exclusion from access by the boundary fence will impact on these activities. Further information on mangrove utilisation within Caution Bay is provided in Section 13.4.3, Mangrove Resource Use. Local people will need to select alternative areas away from this exclusion zone for fishing and other activities.

21.7.2 Mitigation and Management Measures

Specific details of the following mitigation measures for mangrove resource utilisation will be developed in the relevant construction and operations (offshore and onshore) environment management plans.

Exclusion Zone

As for potential loss of access to marine resources, the project will compensate for loss of either access to and/or mangrove resources as a result of the facility exclusion zone. Compensation will be managed through consultation with relevant communities (see Section 23.9, Agriculture,

Fisheries, Forestry and Subsistence, and Section 30.3.4, Social Management Plans) to determine details of how compensation measures will be implemented [M221].

21.7.3 Residual Impact Assessment

Exclusion Zone

Access to the Vaihua River and coastal mangroves in the vicinity of the LNG Facilities site will be prohibited. Local people will be excluded from fishing or travelling within the exclusion zones. Some of the local people will need to find alternative sites for collecting shellfish and other mangrove resources, and this will have a localised effect on the villages that depend on the Vaihua River. The exclusion zone will also increase travelling times for those local people who use the coastline to access villages north and south of the LNG Facilities site. For some, alternative transport methods may improve access (e.g., to markets, etc.).

The exclusion will continue for the duration of the project. Without mitigation, the magnitude of impact would likely be perceived as very high, as significant areas important for resource use locally would be alienated from normal activities of men and women. However, for the same reasons that are discussed above for subsistence fisheries, the potential for the impacts to decline from the perceived, pre-mitigation high to minor will be dependent on the fulfilment of expectations of the future benefits.

21.8 Quarantine

21.8.1 Issues to be Addressed

A potential pathway for the introduction of non-native marine flora and fauna into PNG waters is the presence of non-native organisms in ballast water discharged in waters of Caution Bay or the presence of non-native organisms on the hulls of the construction vessels, LNG carriers and condensate tankers. This issue is not unique to the project and is applicable to any vessel entering PNG waters.

Marine pests cause problems to ecosystems through competition with existing native species for resources, alteration of localised gene pools and modification of physical environments.

21.8.2 Mitigation and Management Measures

The project will establish and enforce a project-wide quarantine management protocols in the ecology, natural habitat and biodiversity management plan, which will include inspection of equipment, machinery and consumables, such as line pipe and imported rock. The protocols will follow International Maritime Organization requirements[7] and industry good practice with respect to ballast water discharge and hull cleaning to prevent unintended pest introductions [M222].

[7] It is anticipated that the (presently draft) PNG Marine Pollution (Ships and Installations) Bill is intended to give effect (i.e., have force of law) in relation to prevention of pollution by oil, noxious liquid substances, harmful packaged substances, sewage, garbage and by anti-fouling systems: the latter giving effect to provisions of the Anti Fouling Systems Convention, with respect to phasing out of tin-based anti-fouling systems.

21.8.3 Residual Impact Assessment

With the quarantine management protocols in place, it is unlikely that non-native organisms will be introduced into PNG waters either during discharge of ballast water or via the hulls of the vessels associated with the construction and operation of the project. Given the low risk of becoming established in open tropical environments such as Caution Bay, the magnitude of impact is assessed as low.

The susceptibility of tropical waters, such as Caution Bay, to the introduction of non-native marine flora and fauna is lower than temperate waters. Most tropical species have a wide distribution, so the risks of local introductions of species not already there or of temperate species becoming established is low. However, the sensitivity of the reefs and seagrass habitats within Caution Bay is high.

The significance of this potential impact is therefore is minor.