



Chapter 16

Nearshore Marine Environment Impact Assessment

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The information in the EIS that relates to Golpu Ore Reserves is based on information compiled by the Competent Person, Mr Pasqualino Manca, who is a member of The Australasian Institute of Mining and Metallurgy. Mr Pasqualino Manca, is a full-time employee of Newcrest Mining Limited or its relevant subsidiaries, holds options and/or shares in Newcrest Mining Limited and is entitled to participate in Newcrest's executive equity long term incentive plan, details of which are included in Newcrest's 2017 Remuneration Report. Ore Reserve growth is one of the performance measures under recent long term incentive plans. Mr Pasqualino Manca has sufficient experience which is relevant to the styles of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the JORC Code 2012. Mr Pasqualino Manca consents to the inclusion of material of the matters based on his information in the form and context in which it appears.

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These materials contain forward-looking statements within the meaning of the safe harbor provided by Section 21E of the Securities Exchange Act of 1934, as amended, and Section 27A of the Securities Act of 1933, as amended, with respect to our financial condition, results of operations, business strategies, operating efficiencies, competitive positions, growth opportunities for existing services, plans and objectives of management, markets for stock and other matters. These include all statements other than statements of historical fact, including, without limitation, any statements preceded by, followed by, or that include the words "targets", "believes", "expects", "aims", "intends", "will", "may", "anticipates", "would", "should", "could", "estimates", "forecast", "predict", "continue" or similar expressions or the negative thereof.

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Competent Person's Statement

The Wafi-Golpu Joint Venture is an unincorporated joint venture between a wholly-owned subsidiary of Harmony Gold Mining Company Limited and a wholly-owned subsidiary of Newcrest Mining Limited.

The information in the EIS that relates to Golpu Ore Reserves is based on information compiled by the Competent Person, Mr Pasqualino Manca, who is a member of The Australasian Institute of Mining and Metallurgy. Mr Pasqualino Manca, is a full-time employee of Newcrest Mining Limited or its relevant subsidiaries, holds options and/ or shares in Newcrest Mining Limited and is entitled to participate in Newcrest's executive equity long term incentive plan, details of which are included in Newcrest's 2017 Remuneration Report. Ore Reserve growth is one of the performance measures under recent long term incentive plans. Mr Pasqualino Manca has sufficient experience which is relevant to the styles of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the JORC Code 2012. Mr Pasqualino Manca consents to the inclusion of material of the matters based on his information in the form and context in which it appears.

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16. NEARSHORE MARINE ENVIRONMENT IMPACT ASSESSMENT

This chapter of the environmental impact statement (EIS) presents the method and findings of the assessment of potential Project impacts to the nearshore marine environment. The discussion considers potential impacts, proposed management measures and an assessment of residual impacts assuming the effective implementation of management measures. The chapter concludes with an outline of the proposed ongoing monitoring program for the nearshore marine environment.

16.1. Approach to Impact Assessment

As discussed in Chapter 4, Overview of Impact Assessment Methods, the nearshore marine environment impact assessment approach generally adopts one of two methods, the significance method or the compliance standard assessment method, to assess the level of residual environmental impacts of the Project on the identified receptors.

The significance assessment method has been adopted where a quantitative (or semi-quantitative) assessment is required. As detailed in Section 16.1.1, the significance assessment method examines the degree to which the existing environment is expected to change as a result of Project-related activities. This assessment method is a function of the sensitivity of an environmental value and the magnitude of impact on that particular value which, together, determine the residual significance of the impact.

The compliance standard assessment method (Section 16.1.2) has been adopted where a quantitative assessment is required. The method relies on international, national or best practice limits or guidelines to assess an impact. The compliance standard method was used for assessing the water quality effects in the Port Facilities Area.

An understanding of the existing nearshore marine environment, as described in Chapter 10, Nearshore Marine Environment Characterisation, is a key precursor to each impact assessment.

Direct and indirect potential impacts from Project activities were considered for all Project phases, i.e., construction, operations and closure as described in Chapter 6, Project Description. An overview of proposed management measures to address these potential impacts is presented and the subsequent assessment of residual impacts assumes the successful implementation of these measures. The assessment of residual impacts also includes consideration of the proposed management measures contained within the Wafi-Golpu Project (the Project) Environmental Management Plan (EMP) provided in Attachment 3.

Socioeconomic impacts with the potential to manifest as a result of the environmental impacts described in this chapter are addressed in Chapter 18, Socioeconomic Impact Assessment.

16.1.1. Significance Assessment Method

The significance assessment method examines the degree to which the existing environment is expected to change as a result of Project-related activities. This assessment method is a function of the sensitivity of an environmental value and the magnitude of impact on that particular value which, together, determine the residual significance of the impact.

Sensitivity is defined as the susceptibility of an environmental value to change, including its capacity to adapt to, or accommodate, the kinds of changes that the Project may bring about. It also considers the intrinsic importance of that value to the environment.

For each of the potential impacts identified as resulting from Project activities in the construction, operations and post-closure phases, an assessment to understand the magnitude of impact was made. This assumed successful implementation of proposed management measures, and considers the:

- Severity of the residual impact: in terms of the proportion, degree and/or rate of change of disturbance experienced by the value.
- Spatial extent of the residual impact: the size of the area which may be directly or indirectly affected by Project-related activities.
- Temporal extent of the residual impact: whether the impact will be immediate or delayed, occur during the day or at night, is seasonal, or is short or long term.

Specific definitions have been developed for sensitivity and magnitude used to derive residual impact ratings. In Table 16.1, the sensitivity of a nearshore marine value is determined if it meets one or more of the definitions in each row.

Table 16.1, the sensitivity of a nearshore marine value is determined if it meets one or more of the definitions in each row.

Table 16.2 presents the definitions for impact magnitudes.

Table 16.1: Sensitivity of nearshore marine environmental values

Sensitivity	Definition
Very high	A national or internationally recognised site of environment or conservation value. Highly restricted distribution of the environmental value. No capacity to adapt to change. Environmental value is in very good condition. Extremely rare natural resource.
High	A national or international recognised site or value. Restricted distribution. Limited capacity to adapt to change. Environmental value is in good condition. Rare natural resource.
Medium	Limited abundance and distribution of environmental value. Some resilience to change. Environmental value is in moderate to good condition. Restricted natural resource.
Low	Abundance and distribution common. Resilient to change. Environmental value is in disturbed condition. Common natural resource.
Not sensitive	Abundance and distribution are very common. Highly resilient to change. Environmental value is in poor condition. Abundant natural resource.

Table 16.2: Magnitude of nearshore marine environment impacts

Magnitude	Contributing factor	Definition
Very high	Severity of impact	Effects likely to be very large (severe) with respect to natural variability and very high with respect to effect to ecosystem function.
	Spatial extent	Effects are widespread and extend beyond the region (i.e., beyond the Huon Gulf and/or outside Morobe Province – outside a distance 180km to the southeast of Lae and 250km of coastline east of Lae). Effects may be national or international in extent.
	Duration	Effects are either long-term or permanent, i.e., changes not able to be practically or significantly rehabilitated or alleviated.
High	Severity of impact	Significant effect to ecosystem functions or other relevant environmental values.
	Spatial extent	Effects extend beyond the Project Area to a regional level (i.e., extending along the coast of the broader Huon Gulf within Morobe Province – extending up to 180km to the southeast of Lae and 250km of coastline east of Lae).
	Duration	Medium-term (one to five years)
Moderate	Severity of impact	Moderate effect to ecosystem functions or other relevant environmental values. Effect will be readily detectable with respect to natural variability.
	Spatial extent	Effects extend beyond the Project Area to the surrounding area, but are within the Upper Huon Gulf (i.e., within the coastline 10km from Lae to the south and 10km to the east).
	Duration	Effects are short-term (less than one year) and recoverable in the medium term.
Low	Severity of impact	Low-level environmental impact. Effect barely detectable with respect to natural variability.
	Spatial extent	Local effects confined within the Project Area or to a small, isolated location(s) outside the Project Area.
	Duration	Temporary or short-term (less than one year) effects that are easily recoverable.
Very low	Severity of impact	Impact within statutory limits or guidelines and no detectable change to the existing environment.
	Spatial extent	The effects are limited to areas within the Project Area.
	Duration	Temporary or short-term effects; less than one year.

For the significance assessment of predicted residual impacts, the magnitude of the residual impact was determined and considered with respect to the sensitivity of the identified values impacted using the significance matrix in Table 16.3.

Table 16.3: Matrix for assessing the level of significance of a residual impact

Magnitude of impact	Sensitivity of value				
	Very low	Low	Medium	High	Very high
Very high	Moderate	High	Major	Major	Major
High	Low	Moderate	High	Major	Major
Moderate	Low	Low	Moderate	High	High
Low	Low	Low	Low	Moderate	Moderate
Very low	Very Low	Low	Low	Low	Moderate

16.1.2. Compliance Standard Assessment Method

The compliance method was used to compare the results of modelling or other predictive techniques with statutory limits or guidelines. As described in Section 4.7, where PNG has no such published limits or thresholds then surrogate limits or thresholds from other jurisdictions or guidelines have been adopted.

To assess the potential impacts of water discharge from the Port Facilities Area, the compliance method was applied. The Port Facilities Area is proposed to contain a concentrate filtrate plant and a wastewater treatment plant. The concentrate filtrate plant is designed to extract excess water from the concentrate slurry that will be pumped from the Mine Area. This excess water will then be either reused or treated by the wastewater treatment plant prior to discharge. The compliance method was used to assess the dilutions required for the treated filtrate to meet PNG water quality standards.

The predicted water quality of the treated filtrate was compared with the compliance criteria defined in Schedule 1 of the PNG Environment (Water Quality Criteria) Regulation 2002. Reference is also made to the internationally-recognised Australian and New Zealand water quality guidelines (ANZECC/ARMCANZ, 2000) and International Finance Corporation (IFC) mining effluent guidelines for comparative purposes.

16.1.2.1. PNG Legislation

Schedule 1 of the PNG Environment (Water Quality Criteria) Regulation 2002 defines the water quality criteria for aquatic life protection in both seawater and freshwater. These regulations are hereafter referred to as PNG ambient water quality criteria.

In PNG, site-specific mixing zones are normally included as a condition a project's environment permit granted under the *Environment Act 2000*. A mixing zone is the body of water into which waste (water) is discharged and where the prescribed water quality guidelines are not required to be met. The compliance point is defined as the point where the prescribed water quality guidelines must be met.

The need for a mixing zone is typically determined by the comparison of the predicted water quality in the treated filtrate discharge with the PNG ambient water quality criteria.

16.1.2.2. ANZECC/ARMCANZ (2000) Guidelines

In addition to a comparison with PNG ambient water quality criteria, this assessment has also considered the Australian and New Zealand guidelines for marine water quality (ANZECC/ARMCANZ, 2000) for protection of aquatic ecosystems. The Australian and New Zealand guidelines for fresh and marine water quality (ANZECC/ARMCANZ, 2000) are widely regarded as one of the more robust sets of ecosystem protection guidelines

currently available internationally and have therefore been considered for the assessment of impacts to the nearshore marine environment.

ANZECC/ARMCANZ (2000) defines a slightly-to-moderately disturbed ecosystem as one in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. For slightly-to-moderately disturbed aquatic ecosystems the trigger value for 95% protection of species is applied for most metals, however for some metals (i.e., cadmium, mercury and nickel) the 99% protection of species is applied. A lower level of protection, such as 90% or 80%, may be justified depending on the management goals. Based on the existing environment in the Coastal Area and as a conservative approach, the ANZECC/ARMCANZ (2000) guidelines for slightly-to-moderately disturbed aquatic ecosystems have been adopted in this assessment.

The rationale of the ANZECC/ARMCANZ (2000) guidelines is that they are recommended to be used to 'trigger' further investigation if exceeded, not as primary compliance values. The guidelines are often termed 'trigger values'. A hierarchy of assessment is recommended when applying the guidelines, whereby exceedance of a guideline value does not necessarily indicate an environmental impact will occur. Instead, it indicates the need to further investigate site-specific factors. In the case of metals, the following hierarchy is recommended by ANZECC/ARMCANZ (2000):

- Compare total metal concentration to guideline value
- Compare dissolved metal concentration to guideline value
- Consider metal speciation
- Compare bioavailable metal concentration against guideline value
- Conduct a biological effects assessment (e.g., direct toxicity assessment)

The assessment described in this chapter considers the first two steps in the hierarchy above. Typically, the remaining steps are implemented where the initial steps indicate potential environmental problems due to the metal concentration.

16.1.2.3. IFC Mining Effluent Guidelines

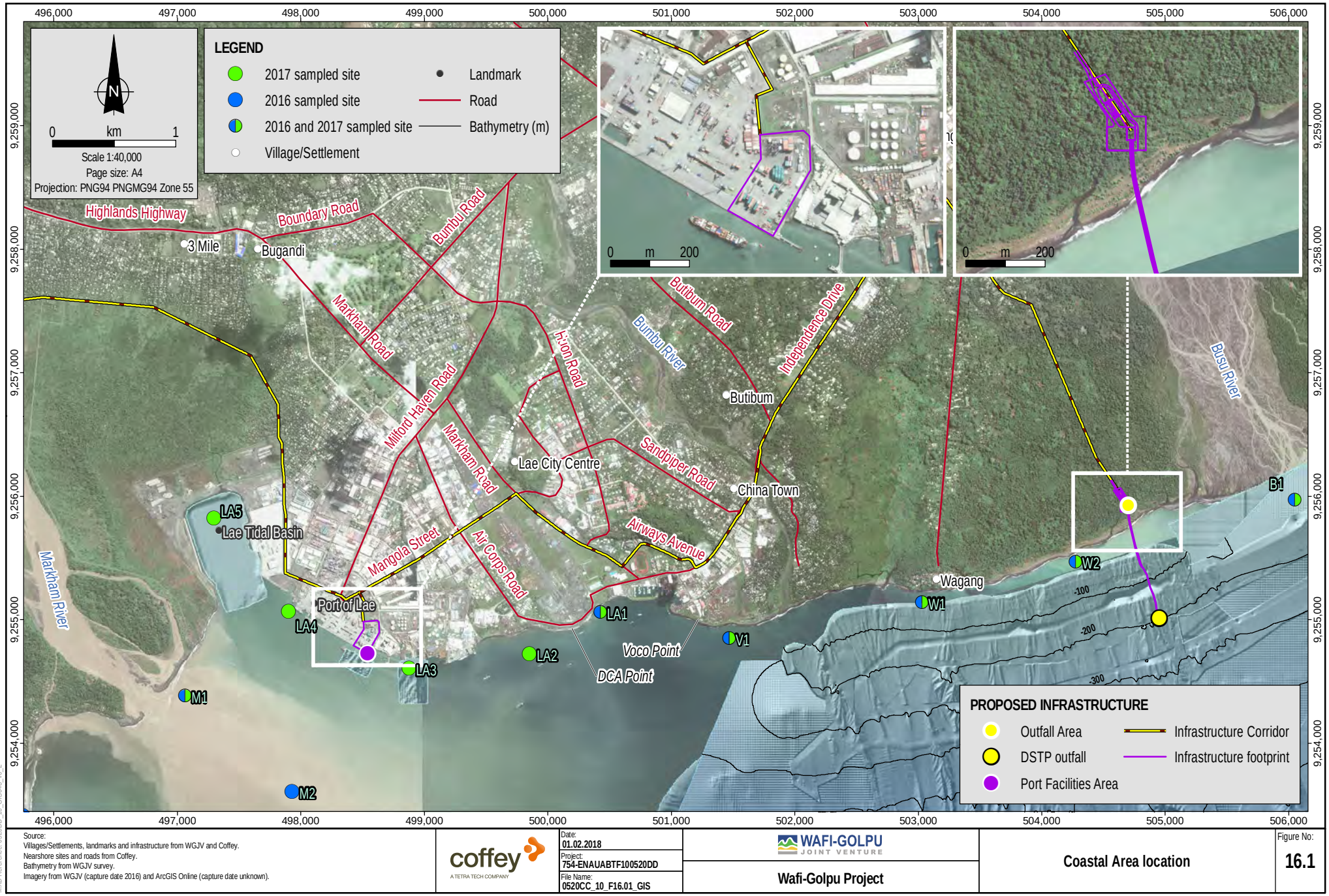
The predicted water quality of the treated filtrate was compared to the International Finance Corporation (IFC) Environmental, Health and Safety Guidelines for Mining (IFC, 2007). These guidelines are commonly adopted by mining projects in developing countries. While the PNG water quality criteria and ANZECC/ARMCANZ guidelines outlined above are for ambient waters, the IFC mining effluent guidelines are discharge (i.e., 'end of pipe') guidelines. Comparison to the IFC mining effluent guidelines provides information on potential problematic parameters in the treated effluent.

16.2. Summary of Environmental Values

The environmental values associated with the nearshore marine environment are:

- Nearshore marine habitat
- Nearshore marine fauna
- West Pacific leatherback turtles

The nearshore marine environment is highly modified at the Port Facilities Area and modified to a lesser extent at the Outfall Area (Figure 16.1). This modification is due to human activities (industry and urbanisation) in and around Lae, surrounding villages and upstream along the Markham and Busu rivers (see Chapter 10, Nearshore Marine Environment Characterisation).



Source:
Villages/Settlements, landmarks and infrastructure from WGJV and Coffey.
Nearshore sites and roads from Coffey.
Bathymetry from WGJV survey.
Imagery from WGJV (capture date 2016) and ArcGIS Online (capture date unknown).

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Project: 754-ENAUABTF100520DD
File Name: 0520CC_10_F16.01_GIS

WAFI-GOLPU JOINT VENTURE

Wafi-Golpu Project

Coastal Area location

Figure No: 16.1

MXD Reference: 0520DD_10_GIS043_v0_2

The nearshore marine environment within the Coastal Area is dominated by the influx of sediment and freshwater from the Markham, Busu and Bumbu rivers. As a result of the persistent high turbidity, low salinity and steep, unstable sea floor, the area is devoid of ecologically-important habitats and there are no coral reefs or seagrass beds. The closest mangroves are located 8km south of Lae at Labu Lakes. Similarly, the nearshore marine fauna assemblage in the Coastal Area reflects these conditions.

Further to this, the long-running effects of human activity, from the large population at Lae, PNG's second most populous city, on the marine environment (such as the discharge of sewage, rubbish and the presence of derelict ships on the shorefront) mean that the habitat and fauna values of the nearshore marine environment have a low sensitivity to Project-related impacts.

The west Pacific leatherback turtle has been identified as a distinct environmental value due to it being an uncommon species with a declining population and with a restricted breeding range in PNG. For this reason, the west Pacific leatherback turtle is assessed to have a very high sensitivity to Project-related impacts.

16.3. Potential Impacts

This section presents the potential impacts that may affect nearshore marine environmental values as a result of Project activities.

Potential impacts to the nearshore marine environment relate to activities in two areas (see Figure 16.1):

- Outfall Area: construction, operations and closure of the Outfall System. The Outfall System will receive the tailings slurry from the Mine Area via the terrestrial tailings pipeline. The Outfall System will include:
  - Mix/de-aeration tank located in a dry moat set back from the shore by 120m.
  - A choke station including piping and valves.
  - Two seawater intake pipelines approximately 315m long and extending to 60m in depth to supply pre-discharge dilution water to the mix/de-aeration tank.
  - DSTP outfall pipelines.
  - An office, generators, sub-station, diesel storage, laydown and storage area, and parking and turnaround area.
- Port Facilities Area: construction, operation and closure of the Port Facilities. The Port Facilities Area will include:
  - Concentrate filtration plant which will discharge filtrate water into the adjacent marine waters at a rate of around 30 litres per second (L/s). The filtrate will be treated prior to disposal.
  - Materials handling, storage and ship loading facilities.
  - Wastewater treatment plant.
  - Containment pond.
  - Various facility buildings, generators and diesel storage.

In the nearshore marine environment these activities have the potential to lead to:

- Habitat deterioration and loss
- Disturbance to fauna
- Introduction of invasive marine species
- Waste discharge and spills

These are discussed further below.

16.3.1. Habitat Deterioration and Loss

Disturbance of nearshore benthic habitat at the Outfall Area will occur during construction of the DSTP outfall pipelines and seawater intake pipelines. Activities such as trenching have the potential to increase suspended sediment concentrations and sediment deposition rates compared to background levels, as well as remove habitat within the footprint of the trenching and other construction activities (e.g., the laying of ballast blocks and rock rip-rap protection for the pipelines).

The Outfall Area is within a section of beach known to be occasionally used by west Pacific leatherback turtles for nesting. The turtle nesting season in the region is from November to March. These turtles are listed as critically endangered on the International Union for Conservation of Nature (IUCN) Red List. Local people at nearby Wagang village indicated that about three west Pacific leatherback turtles a year are seen nesting in the section of beach from Wagang village to the Busu River (see Section 10.8.5). However, this stretch of beach appears to be used by very few turtles for nesting based on data collected to date and given the amount of human influence such as rubbish and recreational activities in the area. The nearest identified key nesting areas are more than 15km to the south of Lae (see Chapter 10, Nearshore Marine Environment Characterisation for additional details on west Pacific leatherback turtle nesting areas in the region).

The Port Facilities Area will be on existing industrial land at the Port of Lae and no infrastructure will be placed on the nearshore seabed (see Figure 16.1). Therefore, no loss of shoreline or seabed habitat will occur due to construction and closure of the Port Facilities and this has not been considered further in this assessment. The concentrate filtration plant will discharge treated filtrate to nearshore marine waters during operations and this treated filtrate will contain a maximum total suspended solids (TSS) concentration in the order of 50mg/L. This discharge has the potential to result in some minor additional deposition of sediment adjacent to the Port Facilities Area (or further along the coast depending on currents), potentially smothering habitat.

16.3.2. Disturbance to Fauna

The movement of vessels, trenching during construction of the Outfall System and loading of concentrate at the Port Facilities may be sources of increased underwater noise.

Marine mammals use vocalisation as a critical method of communication, facilitating organisation of activities including, but not limited to, foraging for food, courtship and reproduction and warning for the presence of predators. The impact of underwater noise on marine mammals will depend on the species affected, the specific activity of the mammal when exposed (e.g., sensitivity to noise may be higher when resting or reproducing compared with foraging), and the noise intensity, frequency, duration and distance to the receptor (Ellison et al. 2012). The impact of underwater noise on marine mammals includes altered swimming speed and depth, disorientation, displacement and the masking of biologically important acoustic signals, while long-term impacts include physical damage, permanent displacement and habitat loss (Richardson et al., 1995).

Physiological injury to marine fauna from underwater impulse noise is only likely at a very close range to such a source (tens of metres), but startle and scatter responses of fish and other species may occur over greater distances (approximately 150m) where received noise levels drop below 150 (decibel) dB to 160dB re 1 µPa root mean square (rms)[1] (Salgado-Kent et al., 2012). Animals further away may be disturbed or avoid the area.

Additionally, noise emissions or light may disturb and disorient turtles on the shoreline.

Due to the siting of the mix/de-aeration tank 120m inland from the shoreline and the use of light screening, light emissions to the nearshore zone will be of such low intensity that no disturbance to nearshore marine fauna is expected. Therefore, this potential impact has not been considered further in this assessment.

With the existing high volumes of vessel traffic (2,854 vessels per year on average) (Appendix S, Fisheries and Marine Resource Use Characterisation) and the industrial activities at the Port of Lae, the additional 18 concentrate vessel movements per year due to the Project during operations equates to less than 0.01% of annual vessel traffic. This will not be discernible from existing conditions and therefore has not been considered further in this assessment in relation to the Port Facilities Area.

At the Outfall Area, which has little nearby vessel activity, vessel movements and trenching during construction of the Outfall System and pipelaying have the potential to intermittently raise underwater noise above background levels, but only during construction.

16.3.3. Introduction of Invasive Marine Species

Like all vessel movements into and out of the Port of Lae, Project vessels have the potential to introduce invasive marine flora and fauna into the nearshore marine zone. Invasive species can compete with natural biota causing displacement, mortality or adverse physiological effects such as metabolic stress or cross breeding, resulting in changes to the genetic structure of native populations.

16.3.4. Waste Discharge and Spills

Activities at the Port Facilities Area have the potential to affect nearshore marine water quality primarily from the chemical or physiological impact associated with treated filtrate discharge and also potentially from spills of diesel and concentrate. For simplicity, the combined concentrate filtrate water and site stormwater runoff is referred to throughout this chapter as 'treated filtrate'. These potential sources of contamination may result in adverse physiological effects to nearshore marine fauna including the clogging of gills with particulate material, direct ingestion of contaminants at toxic concentrations and adsorption of contaminants to the outer surfaces of organisms. Larger spills of diesel may result in short term toxic effects to nearshore marine fauna, including ingestion of toxicants, absorption through skin and decrease in available oxygen in the waters.

During operations, spills happening during the loading of vessels with concentrate may cause potential contamination of nearshore marine waters in the vicinity of the Port Facilities Area. Furthermore, during the loading of concentrate to vessels, if not covered adequately, wind may blow particles into nearshore marine waters adjacent to the Port Facilities Area. This may result in some short term and localised elevation of copper and suspended solids in the receiving waters.

[1] The unit of 'dB re 1 µPa root mean square (rms)' is commonly used for underwater sound measurements. This unit is for sound pressures (in decibels), which are measured using a 'root-mean-square' (rms) method with reference to a relative sound pressure of 1 microPascal (µPa).

With the proposed DSTP engineering design and operational measures and the siting of the DSTP outfall at approximately 200m depth, it is expected that the potential for tailings discharge to impact the productive zone of nearshore marine waters is very low (refer to Chapter 10, Nearshore Marine Environment Characterisation for more detail on the nearshore marine environment) and this is also supported through observations of other DSTP projects operating in PNG for over 30 years, including Misima, Lihir, Simberi and Ramu. For these reasons potential impacts to the nearshore marine waters from DSTP have not been considered further in this assessment. Impacts to the primary production zones (i.e., upper water column) further from the nearshore zone are addressed in Chapter 17, Offshore Marine Environment Impact Assessment.

16.4. Management Measures

This section presents an overview of the proposed management measures to be implemented to reduce the significance level of the residual impacts. Specific measures are detailed in Attachment 3, Environmental Management Plan. The key management measures are outlined below.

To manage habitat deterioration and loss, WGJV proposes to:

- Reinstate trenched areas as soon as practicable after completion of trenching.
- Consult with a suitable local authority and define actions for protection of leatherback turtle nesting during shoreline construction. For example, install fences around turtle nests between Wagang and Busu River, where a nest is identified during shoreline construction within the nesting season (i.e., November to March).
- Employ the management measures outlined for ‘waste discharge and spills’ below.

To manage disturbance to fauna, WGJV proposes to:

- Aim to direct lighting installed for Project vessels and facilities at the Outfall Area toward the shore based facilities to meet minimum requirements for safety and security (and reduce light directed toward potential turtle nesting areas).
- Visually monitor for the presence of turtles and nests during construction on the beach and shoreline and, if they are observed, record their location, avoid them where practicable and contact the Project environmental team for guidance.
- If a west Pacific leatherback turtle is present within an area about to be disturbed by the Project, suspend construction until the turtle moves away.
- Employ soft start (or ramp up) procedures during construction in the nearshore marine environment (where practicable), to minimise startling of turtles or other marine fauna from underwater noise associated with trenching or other loud seafloor disturbing activities.

To manage the introduction of invasive marine species, WGJV proposes to:

- Develop and implement a quarantine management plan, which will include requirements for contractor vessels to comply with PNG and relevant International Maritime Organization guidelines and standards including ballasting and hull-cleaning and antifouling requirements.

To manage waste discharge and spills, WGJV proposes to:

- Implement a waste management plan (including hazardous and non-hazardous waste) as a component of the Project EMP.
- Implement an emergency response plan and spill contingency plan as a component of the Project EMP.
- Implement a stormwater drainage and bunding system at the Port Facilites Area capable of withstanding a 1:200 year storm event.
- At the Port Facilities Area, capture contaminated runoff and combine the runoff with the concentrate filtrate prior to wastewater treatment to meet environmental permit conditions before discharge to the marine environment.
- Divert 'clean' rainwater around the Port Facilities Area into existing Port of Lae stormwater runoff infrastructure, keeping it separated from potentially contaminated runoff.
- Implement containment facilities at the Port Facilities Area capable of storing the full concentrate pipeline contents in the event of an emergency.
- Store and handle hazardous materials including fuels, oils and chemicals in accordance with AS1940-2017: The storage and handling of flammable and combustible liquids.
- Cover the concentrate storage area and ship loading conveyors in order to contain concentrate dust and equip conveyors with rain/dust covers and suitable drip/spillage trays.
- Load the ship hatch through enclosed structures such as cement hatch hoppers.
- Clean the mobile conveyors of concentrate residue after each ship loading event.
- Assign mobile equipment used to handle concentrate to designated areas.

16.5. Residual Impact Assessment

For those impacts assessed using the significance assessment method, the residual impact assessment presents the level of significance of Project impacts on the environmental values assuming successful implementation of the proposed management measures outlined in Section 16.4. The residual impact assessment for the effects on seawater quality from the treated filtrate discharge determines whether the applicable PNG ambient water quality criteria will be exceeded in the receiving marine waters. A comparison with ANZECC/ARMCANZ and IFC water quality guidelines is also made to support the assessment of effects on ambient seawater quality.

16.5.1. Habitat Deterioration and Loss

Habitat within the nearshore marine environment both at the Port Facilities Area and the Outfall Area is assessed as being of low sensitivity given that, while the Outfall Area is a natural beach, rubbish (particularly plastic bags) is common in the water and along the beach and the existing habitat is of low ecological importance. The exception is potential west Pacific leatherback turtle habitat, which has been assessed as being of **very high** sensitivity due to it being an uncommon species with a declining population and with a restricted nesting habitat range in PNG.

Trenching for the construction of the DSTP outfall and seawater intake pipelines will briefly increase the amount of sediment mobilised and depositing in the area. However, this will be localised and restricted to the construction period prior to trench re-filling and should be considered in the context of the natural sediment-laden discharges from the Busu River (see Chapter 10, Nearshore Marine Environment Characterisation). The existing benthic

biota and habitat in the area are already highly influenced by sediment deposition from surrounding rivers and are expected to recolonise any area disturbed by Project-related activities. Furthermore, wave action, currents and sedimentation from nearby rivers is expected to redistribute and/or rapidly cover any localised Project-related sediment deposition near the trench.

The removal of a small section of outcropping rock during trenching adjacent to the Outfall Area will result in the loss of potential habitat. The disturbance area due to construction of DSTP outfall pipelines and seawater intake pipelines will be a total area of approximately 0.5 square kilometres (km^2) within the nearshore zone (i.e., to depths of 20m). This represents less than 0.4% of the 140km^2 nearshore marine coast between the Busu River and Voco Point where similar habitat is likely to occur. This loss of potential habitat will therefore be highly localised and of **low** residual impact significance.

Trenching for the pipelines will cut through the beach over a 12m width. However, an impact width of 40m has been assumed, which allows for activities associated with trenching such as vehicle and machinery movements. This disturbance area equates to 0.32km^2 given the 80m long pipeline route across the beach. This does not include the approximate 40m of pipeline route further inland from the beach. This represents approximately 2% of the 2km stretch of coastline between the Busu River and Wagang that is used occasionally for nesting by west Pacific leatherback turtles. The closest regionally important turtle nesting areas are remote from the Coastal Area and extend more than 120km along the southwestern coast of the Huon Gulf from Labu Tale (15km south of Lae). Along that stretch of coast frequent and wide-spread nesting occurs yearly between November and March, with peak nesting between December and January (Kinch, 2006). If construction of the pipeline shore crossing by trenching takes place during the nesting period, the movement of west Pacific leatherback turtles could temporarily be interrupted across 2% of the stretch of coastline between the Busu River and Wagang. Once the pipes are installed and buried, the beach will be reinstated. The mix/de-aeration tank will be set back 120m from the shoreline and sufficiently far inland to avoid any interference with potential turtle nesting. The infrastructure siting and reinstatement measures are expected to pre-empt any effects on the turtle nesting activity in the Outfall Area resulting in a low magnitude of impact. However, given the **very high** sensitivity of the west Pacific leatherback turtle, the impact is of **moderate** significance. There are predicted to be no impacts to the west Pacific leatherback turtle during operations.

The discharge of treated filtrate from the concentrate filtration plant will be long-term in duration (i.e., 28 years). However, the receiving nearshore zone will continue to receive the naturally high volumes of terrigenous sediment from the Markham River and sediments will be redistributed by the variable currents in that area noted by previous studies (Renagi, 2009). Although background TSS concentrations measured in the vicinity of Port of Lae in November 2016 and February 2017 only ranged from 4 to 10mg/L TSS (see Appendix R, Nearshore Marine Characterisation), natural TSS concentrations due to Markham River sediment plumes are known to reach between 100 to 200mg/L adjacent to the Port Facilities Area (Renagi, 2009). Also, frequent dredging of the Lae Tidal Basin suggests that natural sediment deposition in the Port Facilities Area is high. It is therefore expected that discharge of 50mg/L of TSS will not result in a significant increment in seabed smothering given the habitat around the Port Facilities Area is constantly subject to the influx of riverine sediment from the Markham River and debris from the Lae stormwater system. In this context, the potential smothering of habitat due to solids in the discharged treated filtrate is expected to be of **low** residual impact significance.

16.5.2. Disturbance to Fauna

The DSTP outfall construction and associated vessel movements at the Outfall Area will be localised and short-term (i.e., in the order of eleven months). While noise from construction activities and vessel movements could startle nearby marine fauna, such noise levels of around 150 to 160dB are within ranges of background noise sources typical of the marine environment (e.g., earthquake: 200 to 240dB re 1 µPa; toothed whale clicks: 230dB re 1 µPa; ship movements: 140 to 200dB re 1 µPa; and fish/invertebrate stridulatory sounds: 140dB re 1 µPa) (Swan, et al., 1994). In this context, the significance of residual impact to marine fauna at the Outfall Area during construction is considered to be **low**. However, given the **very high** sensitivity of the west Pacific leatherback turtle, impacts to this species are assessed to be of **moderate** significance.

16.5.3. Introduction of Invasive Marine Species

The ability of a marine pest to become established and proliferate in a different environment such as the Huon Gulf is difficult to predict, owing to the complex interaction between native and introduced exotic (i.e., non-native) species. This is further confounded by the fact that Lae is PNG's busiest port for marine traffic, handling approximately 51% of PNG cargo trading and receiving on average 2,854 vessels per year (Appendix S, Fisheries and Marine Resource Use Characterisation).

With the implementation of Project-specific quarantine management measures, it is expected that the potential for the introduction of invasive marine species due to the Project vessels will be unlikely. Furthermore, international vessels arriving at the Port Facilities Area will be required to comply with all State of PNG customs and quarantine inspection requirements in Lae.

Given the long-running use of the Port of Lae by international vessels and the potential exposure to invasive species that this brings, the lack of known significant impacts resulting from these activities to date suggests current quarantine practices are working and/or invasive species have not been able to become established in the area. With the implementation of quarantine requirements by the Project, the significance of any residual impact to the nearshore marine values is assessed as being **low**. Furthermore, the level of existing and future marine vessel traffic unrelated to the Project makes it extremely difficult to determine the cause of any introduction of invasive marine species, should it occur

16.5.4. Waste Discharge and Spills

Implementation of the design and operating measures to manage the storage of diesel and chemicals is expected to result in any impact of a spillage in the Port Facilities Area being very minor in extent (due to small volumes of diesel being stored and the runoff control measures in place), thus limiting the potential for significant residual impacts to nearshore marine fauna. This impact was assessed as being of **low** magnitude and given the **low** sensitivity of the nearshore marine fauna, the residual impact is of **low** significance.

During loading of concentrate to cargo vessels, spillage into the marine environment could result in a temporary (less than a day) and localised increase in suspended solids and turbidity. This could result in effects to fish and other marine fauna. A dangerous goods assessment by Glossop Consultancy (2015) determined that the concentrate is not environmentally hazardous. Although the concentrate contains 30% copper (as sulphides), the solubility of the copper sulphides is low and the toxic effects on marine life are therefore likely to be low. This residual impact would be of **moderate** magnitude and **low** significance.

During handling and loading of concentrate, concentrate dust could be carried into the nearshore marine environment by winds. It is unlikely that this would result in severe impacts to marine fauna given the low solubility of copper in the concentrate and that the dust would quickly disperse and become diluted to very low concentrations in nearshore waters. This residual impact would be of **low** magnitude and hence a **low** residual impact significance.

The concentrate filtration plant will discharge treated filtrate to the marine environment continuously at a rate of around 30L/s during operations. This treated filtrate will incorporate stormwater runoff from the Port Facilities Area from areas where concentrate could potentially be spilled and where vehicle washdown runoff will occur. The treated filtrate is expected to contain residual concentrations of metals, metalloids and processing reagents. Table 16.4 shows the predicted treated filtrate analyte concentrations and the dilutions required for the filtrate to meet PNG ambient water quality criteria. For comparative purposes, the table also shows international guidelines for aquatic ecosystem protection (ANZECC/ARMCANZ, 2000), where metal concentrations are dissolved metals. Also, the filtrate is compared to effluent discharge guidelines stipulated by the International Finance Corporation (IFC) mining effluent guidelines.

Residual processing reagents include xanthates, thiocarbamates, cresylic acid and sodium metabisulphite. Sodium ethyl xanthate, an organosulphur compound used as a flotation agent, has the highest potential toxicity of the processing reagents to marine life. The estimated concentration of sodium ethyl xanthate in the raw tailings liquor is 20mg/L (Watt, pers. com., 2018). As a soluble salt, sodium ethyl xanthate will also complex with the metallic ions contained in water and marine organisms and typically has a chemical half-life of 4.1 days (Boening, 1988).

Given that sodium ethyl xanthate is biodegradable and has a short half-life, it is unlikely to bioaccumulate in marine organisms. In addition, NICNAS (1995) assessed that sodium ethyl xanthate is not expected to bioaccumulate in view of its ionic character.

The remainder of this section concentrates on residual metals and metalloids in tailings liquor, which are considered the primary potential toxicants.

As shown in Table 16.4, the treated filtrate will not require any dilutions to comply with PNG ambient water quality criteria. This means that WGJV does not currently propose a mixing zone in the nearshore marine environment at the Port Facilities Area to meet PNG ambient water quality criteria.

In the treated filtrate, dissolved copper (0.024mg/L) and nickel (0.022mg/L) will each exceed their respective ANZECC/ARMCANZ guidelines of 0.0013mg/L and 0.007mg/L. Dilution factors of 18.5 and 3.1 will be required for copper and nickel respectively in order for these metals to meet the ANZECC/ARMCANZ guidelines.

During baseline water quality surveys undertaken in November 2016 and February 2017, the concentrations of dissolved copper in nearshore waters in the Coastal Area ranged from <0.001mg/L to 0.002mg/L and concentrations of dissolved nickel ranged from <0.0005mg/L to 0.0023mg/L (see Appendix R, Nearshore Marine Characterisation). While the treated filtrate copper and nickel concentrations are in the order of ten to one-hundred times higher than those detected in the receiving waters, it is expected that after dilution in the receiving waters the concentrations of dissolved copper and nickel in the discharge would rapidly reduce to concentrations within the background range.

Particulate matter in the filtrate will be removed prior to discharge such that TSS concentrations will be no higher than 50mg/L. While this concentration is greater than background concentrations measured in the vicinity of Port of Lae in November 2016 and February 2017, which ranged from 4 to 10mg/L TSS (see Appendix R, Nearshore Marine

Characterisation), the area is known to be well mixed by circulating turbid flows from the Markham River. Sediment plumes have been estimated to have TSS concentrations as high as 100 to 200mg/L adjacent to the Port Facilities Area (Renagi, 2009). Furthermore, upon discharge the concentration of 50mg/L TSS would rapidly reduce to concentrations within the lower background TSS range.

No parameters in the treated filtrate are anticipated to exceed IFC effluent guidelines for mining. However, the comparison is confounded due to the fact that the filtrate discharge metals concentrations are for dissolved metals while the IFC guidelines are for total metals.

Table 16.4: Estimated treated filtrate water quality and dilutions required to meet PNG ambient water quality criteria

Parameter	Unit	Filtrate Discharge Value	PNG Criteria[a]	ANZECC/ ARMCANZ[b]	IFC Mining Effluent Guidelines[e]	Dilutions Required to Meet PNG Criteria
pH	pH	approx. 8	no change	-	6 to 9	N/A
TSS	mg/L	50	-	-	50	N/A
K	mg/L	14	450	-	-	0
Mn	mg/L	0.009	2	-	-	0
Fe	mg/L	<0.001	1	-	2	0
As	mg/L	<0.005	0.05	-	0.1	0
Ba	mg/L	0.012	1	-	-	0
Cd	mg/L	<0.005	0.001	0.0007	0.05	0
Cr	mg/L	<0.001	0.01[c]	0.0044	0.1	0
Cu	mg/L	0.024	0.03	0.0013	0.3	0
Co	mg/L	<0.001	LOD[d]	0.001	-	0
Hg	mg/L	<0.0001	0.0002	0.0001	0.002	0
Ni	mg/L	0.022	1	0.007	0.5	0
Pb	mg/L	0.001	0.004	0.0044	0.2	0
Zn	mg/L	0.01	5	0.015	0.5	0

[a] source: PNG Environment (Water Quality Criteria) Regulation 2002, Water Quality Criteria for Aquatic Life Protection. Criteria are for dissolved metals (passing through a nominal 0.45µm membrane). Other parameters are for total (unfiltered) concentrations.
[b] source: ANZECC/ARMCANZ (2000) trigger values for protection of slightly to moderately disturbed aquatic ecosystems. Guidelines are for dissolved metals (passing through a nominal 0.45µm membrane).
[c] as hexavalent Cr^{6+}
[d] the criteria is the limit of detectability
[e] source: Environmental, Health and Safety Guidelines. Environmental, Health and Safety Guidelines for Mining (IFC, 2007). Note that these criteria are for total metals, which are not directly comparable to dissolved metals in the filtrate discharge.
- denotes no applicable criteria or guideline
N/A denotes not applicable

16.6. Monitoring

The Project will conduct a nearshore marine monitoring program to monitor environmental effects on the nearshore marine environment. This is proposed to include the following:

- Monitoring the water quality (pH, turbidity, salinity, temperature, TSS, dissolved oxygen, conductivity, oil and grease, and total and dissolved metals) of the receiving marine waters prior to discharge of treated filtrate and monthly during discharge at the following locations:
  - In the receiving marine waters at the point of discharge.
  - At reference locations.
- Monitoring sediment quality (organic and inorganic carbon, nutrients and total and bioavailable metals by standardised particle size fractions (<2,000µm and <63µm)) prior to discharge of treated filtrate and twice yearly during operations at the following locations:
  - In the receiving marine waters at the point of discharge.
  - At reference locations.
- Visually monitoring for the presence of west Pacific leatherback turtles on the beach during construction of the shoreline pipeline crossing at the Outfall Area and recording any sightings.
- Monitoring pH, turbidity, TSS, dissolved oxygen, conductivity, and total and dissolved metals in waters adjacent to the shoreline pipeline crossing at the Outfall Area prior to construction and during construction of the pipeline.
- Monitoring sediment quality (organic and inorganic carbon, nutrients and total and bioavailable metals by standardised particle size fractions (<2,000µm and <63µm)) adjacent to the shoreline pipeline crossing prior to construction of the pipeline crossing.
- Undertaking regular inspections of the integrity of infrastructure designed to manage the residual impacts (e.g., bund walls, containment pond, storage sheds and concentrate storage tanks).

Monitoring related to fugitive concentrate dust emissions is outlined in Chapter 14, Physical and Biological Environment Impact Assessment.

16.7. References

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