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PAPUA LNG

Upstream Environmental Impact Statement

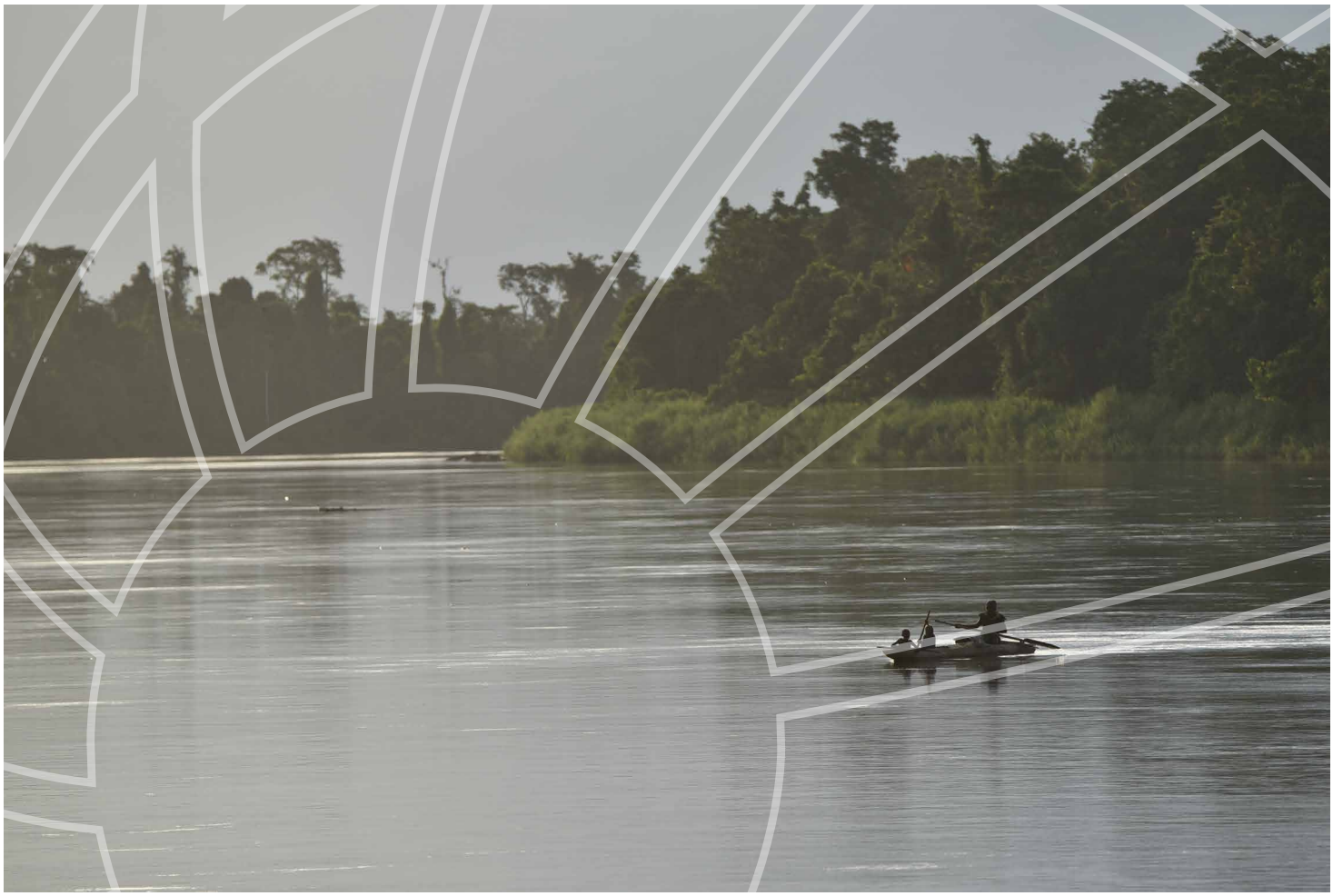
Volume 2: Environmental and Social Baseline

Part 5
Upstream Freshwater and Estuarine Biodiversity Baseline Report

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BMT WBM

"Where will our knowledge take you?"



Papua LNG Project

Upstream Freshwater and Estuarine Biodiversity Baseline Report

August 2017

Prepared for Total Exploration and Production PNG Limited

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Synopsis: **ESBS Technical Report prepared by BMT WBM for Papua LNG EIS/ESHIA for the following components: Upstream Freshwater and Estuarine Biodiversity**

TECHNICAL REPORTS SERIES

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2	***Papua LNG ESBS – Upstream Freshwater & Estuarine Biodiversity***

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Executive Summary

Background

Total E&P PNG Limited (TEP PNG), a wholly owned subsidiary of TOTAL S.A. (TOTAL) is the largest partner in a joint venture to develop the Elk-Antelope gas field, located in Petroleum Retention License 15 (PRL-15) in Gulf Province, Papua New Guinea. This project, known as the Papua LNG Project, will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to a liquefied natural gas (LNG) plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby.

This technical report provides the findings of a baseline study in relation to freshwater and estuarine biodiversity values in the study area. This technical report forms part of the Environmental and Social Baseline Study (ESBS) for the Project Environmental Impact Statement/Environmental, Social and Health Impact Assessment (EIS/ESHIA). The study area encompasses PRL-15 and the Purari River below Hathor Gorge, including the Purari delta. It also includes the Vaihua River estuary at Caution Bay.

The key objectives of the ESBS for freshwater and estuarine biodiversity are:

- Identification of the national, international and corporate regulatory and policy framework for assessment of impacts to freshwater and estuarine biodiversity, including the technical elements required to conduct an EIS/ESHIA.
- Review of previous studies relevant to freshwater and estuarine biodiversity within and adjacent to the study area.
- Collection of new data through targeted field investigations in order to fill gaps in previous studies and ensure sufficient data to meet EIS requirements.
- Description of the environmental baseline of the study area in relation to freshwater and estuarine biodiversity.

The Project is regulated under the *Environment Act 2000* and the *Oil and Gas Act 1998*. This report provides baseline ecological information which adheres to international environmental guidelines, including the International Finance Corporation (IFC) Performance Standards and TOTAL company environmental performance specifications.

Study Approach

The ESBS was prepared based on a review of desktop information, including literature associated with previous environmental studies in the study area and surrounds, together with field-based data collection to address key information gaps. The key existing information that was available consists of the following:

- Historical (1979) fish assemblage data and aquatic vegetation descriptions for Purari River catchment, focused predominantly upon the main river channel.
- Some limited information on aquatic ecology values, including flora and fauna, for small tributary streams of Purari, Pie and Era rivers within PRL-15, based on earlier studies for the Elk/Antelope gas field project.
- Limited information on aquatic ecology values for Purari River tributaries downstream of PRL-15.

- Detailed information on the Vaihua River estuary collected for the PNG LNG Project EIS.

In order to supplement information gaps, four targeted field surveys were completed between 20 June and 9 July 2016 (Purari delta and Vaihua River estuary sites, as part of marine surveys), between 18 and 29 July 2016 (freshwater sites only), between 12 and 31 January (Purari delta and Vaihua River estuary sites, as part of marine surveys) and between 13 and 22 February 2017 (freshwater sites only). The surveys involved:

(1) Aquatic biotope mapping.

(2) Characterization of the bio-physical features of aquatic biotopes.

(3) Semi-quantitative surveys of aquatic macroinvertebrate assemblages inhabiting riffle, littoral ('edge') and pool hydraulic habitat units in accordance with the AusRivAS methodology.

(4) Quantitative sampling of fish assemblages using nets, traps and electro-fishing equipment.

(5) Assessments of species listed as threatened or protected under the International Union for the Conservation of Nature (IUCN) Red List and/or *Fauna (Protection and Control Act 1966*, and species and habitats potentially relevant to a Critical Habitat assessment under IFC Performance Standard 6.

(6) Collection of fish and prawn samples for laboratory analysis of a suite of metals, metalloids and polycyclic aromatic hydrocarbons (PAHs).

Field surveys were not intended to provide a complete coverage of the entire study area but provide a representation of the likely aquatic ecological value for the study area sufficient for the purposes of the EIS/ESHIA.

This study should be read in conjunction with the Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b; Part 6 of ESBS Dossier) which provides more details on mangrove forests as well as aquatic herpetofauna (e.g. turtles, crocodiles, frogs).

Study Findings

Aquatic Biotopes and Vegetation

The study area contains a mosaic of upland, lowland and coastal landscapes. The Purari River and its catchment is in a largely undisturbed state, and encompasses a wide diversity of aquatic biotope types including tributary streams, floodplain and estuarine wetlands, and large river systems. Significant aquatic biotope features identified in the study area are as follows:

- Mangrove forests of the Purari River catchment (which are contiguous with forests of the Kikori River catchment). These forests represent the largest mangrove forest system in Papua New Guinea and are among the largest in the Asia-Pacific region. These mangrove forests contain 31 of the 33 species known from Papua New Guinea, and have among the highest number of mangrove species in the world.
- Wetlands on the floodplain of the Purari River. This floodplain wetland system contains a wide diversity of wetland types, including palustrine (marshes), lacustrine (oxbow lake) and lotic (running stream) systems. There is presently little available information on the physico-chemical and aquatic fauna characteristics of palustrine and lacustrine wetlands. It is possible that some of these wetland environments contain peat wetlands, which are highly sensitive to disturbance and whose distribution and extent are poorly documented in Papua New Guinea.

- PRL-15 plateau catchments. The southern and northern plateaus within PRL-15 support waterways that eventually flow into sub-catchments of the study area. Plateau environments that support waterbodies that are isolated over geological timescales can represent centers of local endemism (e.g. Lake Kutubu, which drains into the Kikori River). It has been conservatively assumed that isolated waterbodies containing endemic species or other features of evolutionary significance could occur on these plateaus.

In addition, the boundary of the Crater Mountain Wildlife Management Area (WMA), declared under the *Fauna (Protection and Control) Act 1966*, extends to the northern bank of the Purari River upstream of the Aure River confluence. While the part of the WMA overlapping with the study area is not expected to support aquatic biotopes or habitat types of increased sensitivity comparative to adjoining areas, it is recognized by the Government of Papua New Guinea for protection.

The key threatened aquatic flora species relevant to the Project is Haines orange mangrove *Bruguiera hainesii.* Ono et al. (2016) indicate that *B. hainesii* is a hybrid between *B. cylindrica* and *B. gymnorhiza*. Both of these species are Least Concern under the IUCN (no other categories apply) with a global decline in population. However, *B. hainesii* remains listed as a distinct species that is Critically Endangered species on the IUCN Red List of Threatened Species. *Bruguiera hainesii* has been confirmed in the study area during the terrestrial biodiversity surveys (ERIAS Group, 2017b) and is also known from the wider ecoregion and on this basis, all estuarine environments in the Purari represent potential habitat for this species. No obligate freshwater macrophytes were observed from the present field surveys but are likely to occur in palustrine wetland biotopes such as the PRL-15 oxbow wetlands.

Aquatic Macroinvertebrates

Edge and pool hydraulic habitats showed a slight difference in aquatic macroinvertebrate assemblage structure among freshwater aquatic biotope types. The macroinvertebrate assemblages in riffle and pool habitats differed across temporal scales (July 2016 and February 2017). Assemblages across both sampling periods were numerically dominated by mayfly (Ephemeroptera) families (Baetidae, Caenidae and Leptophlebiidae), which together accounted for 34% of the catch. Other abundant taxa were copepods that accounted for approximately 19% of the catch, Hemiptera (true bugs) which accounted for over 17% of the catch, while non-biting midges from the sub-family Chironominae represented approximately 17% of the catch.

Benthic macroinvertebrate assemblages in estuarine channel environments were numerically dominated by polychaete worm families Spionidae and Capitellidae, which collectively accounted for approximately 70% of the total catch. Bivalves accounted for almost 8% of the catch, while crustaceans (other than prawns) and gastropods accounted for 3 and 1% of the catch respectively. Taxonomic richness and abundance varied greatly among sites, with poorly flushed backwater environments having particularly depauperate assemblages.

The study area is expected to support two endemic aquatic insect species (*Ciliometra setosa, Iobates ivimka*). The habitat requirements of these species are not documented, but are expected to include quiescent freshwater environments (e.g. floodplain wetlands, backwaters, slow flowing streams).

Fish and Prawn Assemblages

The study area falls within the Papuan Gulf Coastal Lowlands ecoregion, which encompasses the coastal lowlands in the southern part of central New Guinea, including the Purari, Fly, Digul and Kikori Rivers. Nearly half of the ecoregion's freshwater fish species are endemic to the region, many of which are restricted to the

neighboring Fly River catchment and Lake Kutubu, located outside the study area. In addition, three aquatic insects are endemic and restricted to the ecoregion. The freshwater fauna of the ecoregion has strong affinities with that of northern Australia, reflecting the recent geological connection between these land masses. The majority of fish species within the study area also have a marine origin, and many complete part of their lifecycle within estuarine areas.

Consistent with Haines (1979), the estuarine areas of the Purari River delta were the most specious biotope (39 species identified during 2016/2017 surveys). In comparison, 15 species were found in the freshwater reaches of the Purari River delta, 18 species in the Purari River (at tributary mouths) and 24 species in the clear-water tributaries within PRL-15. Several species captured in the estuarine reaches were observed to occur in a range of biotopes. This included the archerfish (*Toxotes chatareus*), the anchovy (*Thryssa scratchleyi*), Fly River garfish (*Zenarchopterus novaeguineae*), estuarine glass perchlet (*Ambassis macrocanthus*), Day's catfish (*Nedystoma dayi*) and freshwater sole (*Aseraggodes klunzingeri*).

There were differences in fish assemblages between the Purari River main channel and those in high to moderate gradient streams (clear-water tributaries). In this regard:

- The most abundant species recorded in the Purari delta were *Ambassis macracanthus, Nedystoma novaeguineae* and *Chelon subviridis*.
- In the clear-water tributaries, fish and macrocrustacean assemblages were numerically dominated by Palaemonidae (freshwater prawns), Eleotridae (gudgeons), Gobiidae (gobies), Terapontidae (grunters) and Melanotaeniidae (rainbowfish).

Macrocrustaceans including river prawns (*Macrobrachium* spp.) and freshwater crabs (Parathelphusidae) were identified throughout the freshwater waterways and waterbodies of the study area. Estuarine features also hosted river prawns as well as marine and estuarine species such as the mud crab (*Scylla serrata*). Freshwater and estuarine macrocrustaceans are an important food resource for locals. Endangered and Critically Endangered fish species likely to occur in the study area include river sharks (*Glyphis garricki* and *G. glyphis*), sawfish (*Pristis pristis* and *P. zijsron*) and rays (*Glaucostegus typus* and *Urogymnus granulatus*).

Sensitive Species, Ecosystems and Habitat Features

Table 1 presents the sensitive species of the study area, excluding the area of the Vaihua River estuary at Caution Bay which is described separately. These consist of the following, grouped based on threatened status on the IUCN Red List:

- Four Critically Endangered species, consisting of one mangrove species (*Bruguiera hainesii*), two sawfish species (*Pristis pristis* and *P. zijsron*) and one river shark (*Glyphis garricki*).
- Two Endangered species, the narrow sawfish (*Anoxypristis cuspidata*) and speartooth shark (*Glyphis glyphis*).
- Three Vulnerable species, consisting of two ray species (*Glaucostegus typus*, *Urogymnus granulatus*) and one dolphin species (*Sousa sahulensis*).
- Three Near Threatened species, consisting of the bull shark (*Carcharhinus leucas*), orange-spotted grouper (*Epinephelus coioides*) and Australian snubfin dolphin (*Orcaella heinsohni*).

- Several freshwater aquatic insect species not considered threatened on the IUCN Red List but identified as endemic to the ecoregions of the study area by Polhemus *et al.* (2004).

Table 1 Threatened/Important Species of the Study Area, Excluding the Area of the Vaihua River estuary at Caution Bay

Species name	Common name	Relevant threatened/important status	Habitat utilized
Bruguiera hainesii	Haines orange mangrove	IUCN Critically Endangered	Estuarine wetlands
Ciliometra setosa	-	Endemic	High-to-moderate gradient tributary streams Freshwater floodplains Oxbow lakes and off-river water bodies
Iobates ivimka	-	Endemic	
Pristis pristis	Longtooth sawfish	CITES Appendix I IUCN Critically Endangered Migratory	Unconfined turbid major river systems (estuarine and freshwater) Freshwater floodplains Estuarine wetlands Oxbow lakes and off-river water bodies
Pristis zijsron	Green sawfish	CITES Appendix I ICUN Critically Endangered Migratory	Unconfined turbid major river systems (estuarine only) Estuarine wetlands
Anoxypristis cuspidata	Narrow sawfish	CITES Appendix I IUCN Endangered Migratory	
Glyphis glyphis	Speartooth shark	IUCN Endangered	Unconfined turbid major river systems (estuarine and freshwater) Estuarine wetlands
Glyphis garricki	Northern river shark	IUCN Critically Endangered	
Carcharhinus leucas	Bull shark	IUCN Near Threatened	Unconfined turbid major river systems (estuarine and freshwater) Freshwater floodplains Estuarine wetlands Oxbow lakes and off-river water bodies
Glaucostegus typus	Giant shovelnose ray	IUCN Vulnerable	Unconfined turbid major river systems (estuarine and freshwater) Freshwater floodplains Estuarine wetlands
Urogymnus granulatus	Mangrove whipray	IUCN Vulnerable	Unconfined turbid major river systems (estuarine only) Estuarine wetlands
Epinephelus coioides	Orange spotted grouper	IUCN Near Threatened	
Orcaella heinsohni	Australian snubfin dolphin	CITES Appendix I IUCN Near Threatened Migratory	Unconfined turbid major river systems (estuarine and freshwater) Estuarine wetlands
Sousa sahulensis	Australian humpback dolphin	CITES Appendix I IUCN Vulnerable Migratory	

The threatened species listed in Table 1 have a geographic distribution extending throughout southern PNG, including Caution Bay and Vaihua River estuary. The critically endangered mangrove *Bruguiera hainesii* has not been recorded in the Vaihua River estuary, therefore the estuary is not expected to represent an important habitat for this species. In the context of fauna species listed in Table 1, the Purari River estuary represents higher quality habitat than the Vaihua River estuary. The Vaihua River estuary has: (i) a small waterway area and simplified habitat structure, especially when compared to the Purari River estuary, and (ii) given its close proximity to urbanized areas, Vaihua River estuary is subject to a range of human pressures, most notably high fishing pressure and mangrove removal. All threatened estuarine fauna species listed in Table 1, but most especially sharks, rays and sawfish, are particularly vulnerable to fishing pressure. While it is possible that transient individuals (juveniles and possibly adults) of the threatened estuarine fauna species listed above could occasionally occur in the Vaihua River estuary from time to time, it is unlikely to represent an important habitat to populations of these species. Endemic aquatic insects occur in the broader ecoregion, but as these are thought to be freshwater species, they are therefore unlikely to occur in the Vaihua River estuary.

Table 2 presents a rating of habitat features based on sensitivity. Based on this rating, the higher value habitats within the study area include estuarine wetlands, used as important habitat for a number of species, as well as the PRL-15 oxbow wetlands, the northern and southern plateaus, and the Crater Mountain WMA.

Table 2 Sensitivity Rating of Study Area Habitat Features

Aquatic habitat value/area	Sensitivity rating	Comments/applicable criteria
High-to-moderate gradient tributary streams	***Low***	Habitat type does not support specific lifecycle functions of species with *moderate*, *high* or *extreme vulnerability* AND is not considered to be unique.
Low gradient slow-to-moderate flowing rivers and backwaters of large rivers	***Low***	Habitat type does not support specific lifecycle functions of species with *moderate*, *high* or *extreme vulnerability* AND is not considered to be unique.
Unconfined turbid major river systems	***Moderate***	Area potentially used by species with *high* or *extreme vulnerability* (*Pristis* and *Glyphis* spp., and *Orcaella heinsohni* and *Sousa sahulensis*) for activities other than those critical to lifecycle of species. NOTE: As the occurrence of species is currently unconfirmed, the sensitivity rating of this habitat is *moderate* rather than *high*.
Freshwater floodplain wetlands on deltaic plains	***Moderate***	Area potentially used by species with *moderate*, *high* or *extreme sensitivity* (*Pristis pristis*, *Glyphis* spp. and *Glaucostegus typus*) for activities other than those critical to lifecycle of species. NOTE: As the use of species of these habitats is currently unconfirmed, the sensitivity rating of this habitat is *moderate* rather than *high* or *extreme*.
Estuarine wetlands	***High***	Area used by species with *moderate*, *high* and *extreme vulnerability* that is critical to lifecycle functions (i.e. habitat for juveniles).
Oxbow lakes and off-river water bodies	***High***	Area potentially supports unique assemblages of aquatic species AND is a unique landscape feature within the lower Purari River catchment. NOTE: As it is uncertain whether oxbows actually support unique assemblages, sensitivity rating of this habitat is *high* rather than *extreme*.
B. hainesii stands	***Extreme***	Area supports species with *extreme* sensitivity (*B. hainesii*).
Mouth/delta of large river systems	***Moderate***	These areas represent a potential congregation point for various aquatic species that are able to move between marine and freshwater systems, including as part of lifecycle migrations. As there are not distinctive 'runs' within the study area of any species, however, it is given a *moderate* sensitivity.

Aquatic habitat value/area	Sensitivity rating	Comments/applicable criteria
Plateaus	***High***	Area potentially supports unique assemblages of species due to isolation/discontinuity. This is particularly pronounced for the northern plateau. NOTE: As it is uncertain whether plateaus actually support unique assemblages, sensitivity rating of this habitat is *high* rather than *extreme*.
Crater Mountain WMA	***High***	Protected area.

Invasive Species

There are various invasive flora and fauna species in the study area, including aquatic weeds (*Salvinia molesta*, *Eichhornia crassipes*, *Postia stratiotes*, *Hydrilla verticillata*) and introduced fish species (*Cyprinus carpio*, *Oreochromis mossambicus*, *Barbodes wynaadensis*, *Tor putitora*). These species pose a risk to the existing ecology in the study area. While invasive fish species currently occur primarily in the main river channel and (potentially) the PRL-15 oxbow wetlands, in time they are expected to spread into tributary streams and other potentially suitable habitat.

Other invasive fish species expected to occur but not recorded include alien species, mosquitofish (*Gambusia affinis*), swordtail (*Xiphophorus helleri*), guppy (*Poecilia reticulata*), snakehead murrel (*Channa striata*), walking catfish (*Claria batrachus*), climbing perch (*Anabas testudineus*), blue panchax (*Aplocheilus panchax*) and gourami (*Trichogaster pectoralis* or *T. trichopterus*), as well as the invasive natives,[1] rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*).

Contaminant Concentrations in Aquatic Fauna

All biota uptake contaminants, such as metals, metalloids and hydrocarbons, from their surrounding environment. The degree of uptake in aquatic fauna tissues depends on the pollutant type, species (and its contaminant excretion rate) and trophic level, and, the physico-chemical properties of the waters. For this reason, there is not always a strong correlation between contaminant levels in biota and the ambient environment.

Concentrations of polycyclic aromatic hydrocarbons in fish and prawn tissues were below detection limits. Metals and metalloids were detected in fish and/or prawn tissues, with copper, lead and zinc at concentrations greater than Generally Expected Levels (GELs) provided by Australian and New Zealand Food Authority (ANZFA). The ANZFA GELs does not represent a guideline for assessing health risk associated with consumption of fish and shellfish; however, it provides a benchmark for typical contaminant levels in fish and shellfish. In terms of prawns, copper and lead concentrations exceeded GELs at most sites, and was typically higher in the cephalothorax (head) than the hind body tissues. There was also one exceedance of the United States Food and Drug Administration (USFDA) Guidance Level for lead in prawns at Site 15 (Purari River near Wabo) in 2016. The cephalothorax contains most of a prawn's organs and represents a site of metal processing and storage, hence higher metal concentrations occur in this body part. In terms of fish tissue, there were exceedances of GELs for copper and zinc at most sites for most fish species. Furthermore, lead concentrations at Site 22B (Purari delta estuary – *Nedystoma novaeguineae*) in 2016 and at Site 14 (Purari River upstream of Herd Base – *Valamugil buchanani*) in 2017 exceeded the United Nations Food and Agriculture Organization (FAO)/World Health Organization (WHO) CODEX food standard. All other metal/metalloid concentrations were

[1] Native to Papua New Guinea but introduced to the Purari River catchment

below guideline values and/or guideline values were not available. No other studies to date have examined metal and metalloid pathways in aquatic fauna tissues in the study area.

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1 Introduction

1.1 Project Overview

Joint venture partners, Total E&P PNG Limited (TEP PNG) (40.13%), ExxonMobil (37.03% - through SPI (208) Limited (35.48%) and SPI Security Holdings Limited (4.55%)), and Oil Search Limited (22.84% - through PAC LNG Assets Limited (6.75%), Pac LNG International Limited (5.10%), Pac Overseas Limited (5%), Pac LNG Holdings Limited (3.49%) and Pac LNG Investments Limited (2.50%)) are planning the development of the Elk-Antelope gas fields located in Gulf Province, Papua New Guinea. The gas fields are located within Petroleum Retention License 15 (PRL-15). The Project will include infrastructure development inside PRL-15, and the construction of gas and condensate pipelines (export pipeline) to a liquefied natural gas (LNG) plant site at Caution Bay, 20 km northwest of Port Moresby.

The Project area comprises the physical footprint of the various Project components and associated infrastructure as detailed below (Figure 1-1).

- Production, processing and related facilities (within PRL-15):
  - Wellpads and the associated gathering system (including flowlines and trunkline).
  - Central processing facility (CPF).
  - Logistics base and river offloading facilities, accommodation camps, airstrip, roads and bridges.
  - Quarries, communications infrastructure.
  - Initial section of the onshore export pipeline.
- Onshore pipeline (outside PRL-15):
  - Remainder of the onshore export pipeline to landfall on the Gulf coast including valve stations.
  - Temporary laydown areas and camps.
  - Quarries, communications infrastructure.
- Transport (river) corridors:
  - River transport routes— the Purari, Urika-Ivo and Wame-Varoi rivers.
- Offshore pipeline:
  - Offshore section of the export pipeline to a LNG Plant site at Caution Bay.

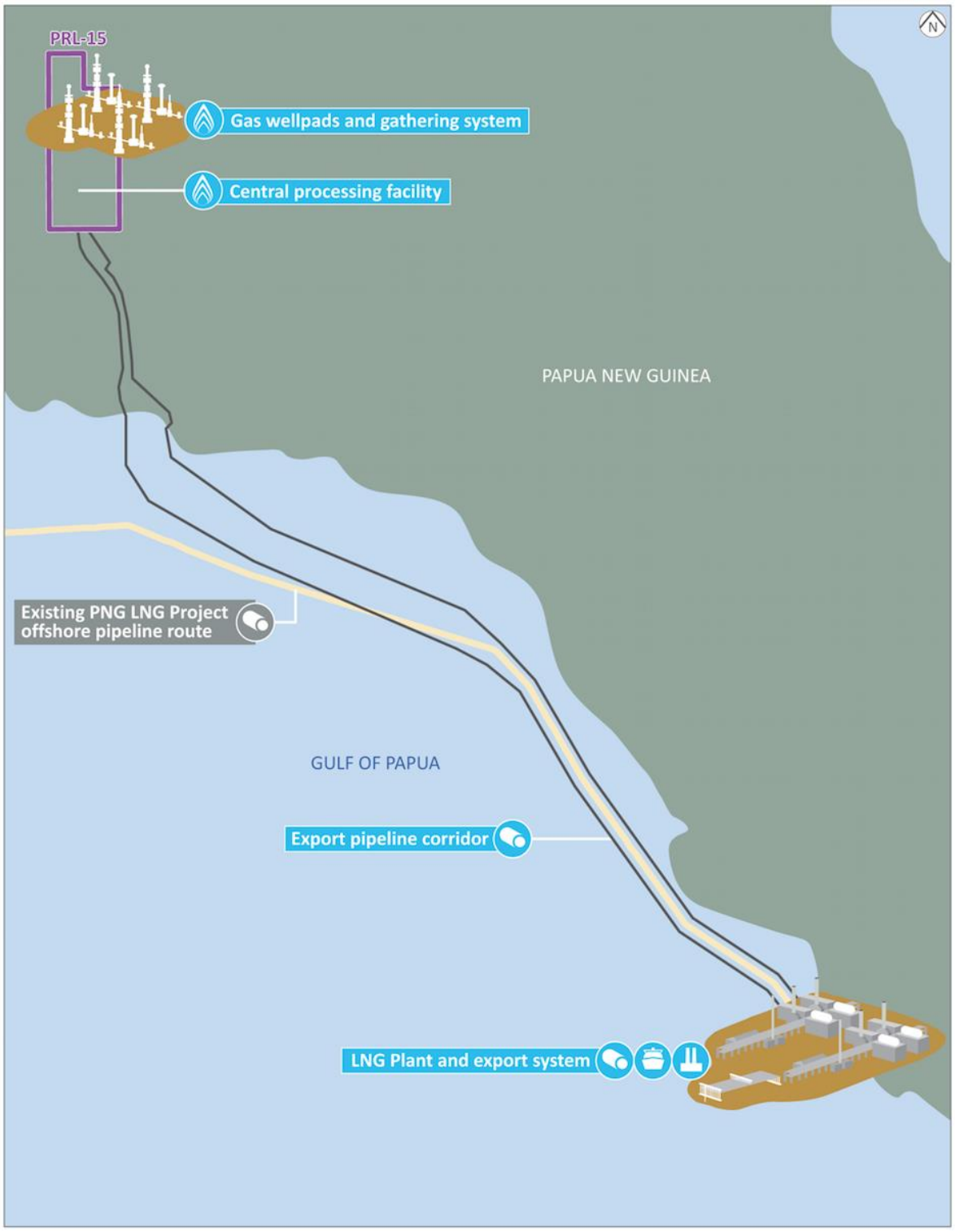


Figure 1-1 Schematic of the Project

1.2 Study and Objectives

This technical report describes the baseline freshwater and estuarine biodiversity of areas potentially affected by the Project. This report is part of the Upstream Freshwater and Estuarine Biodiversity study for the Environmental Impact Statement and the Environmental, Social and Health Impact Assessment (EIS/ESHIA) for the Project. In particular, this report forms part of the Environmental and Social Baseline Study (ESBS) component of the EIS/ESHIA.

The study objectives of the Upstream Freshwater and Estuarine Biodiversity Study are to:

- Identify aquatic fauna and flora species, communities and habitats in the study area.
- Define the structure of aquatic macroinvertebrate communities in the study area.
- Assess the presence of aquatic flora and fauna that are sensitive to increased turbidity and sediment loads and changes to natural flow regimes.
- Collect information on priority biodiversity values suitable for use in impact and critical habitat assessment, development of mitigation and management measures, and monitoring programs.
- Support assessment of project-related impacts on aquatic biological resource uses (ecosystem services).
- Plan and execute baseline studies to underpin assessment of potential Project impacts to:
    - Satisfy International Finance Corporation (IFC) environmental and social performance standards
    - Meet Papua New Guinea requirements under the *Environment Act 2000*, and
    - Meet TOTAL General Specifications, including GS EP ENV 111: Environmental Baseline and Monitoring Studies: Onshore Sites.

Within the context of these study objectives, this technical report achieves the following:

- Identifies the national, international and corporate regulatory and policy framework for assessment of impacts to freshwater and estuarine biodiversity, including the technical elements required to conduct an EIS/ESHIA.
- Reviews previous studies relevant to freshwater and estuarine biodiversity within and adjacent to the study area.
- Reports on the collection of new data through targeted field investigations in order to fill gaps in previous studies and ensure sufficient data to meet EIS requirements.
- Describes the environmental baseline of the study area in relation to freshwater and estuarine biodiversity.
- Identifies threatened, rare or otherwise noteworthy species likely to be present within the study area.

- Considers/evaluates the condition of existing freshwater and estuarine habitats to input to the identification of areas of 'critical habitat' in accordance with IFC Performance Standard (PS) 6.[2]

This report has been prepared in conjunction with the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b; Part 6 in ESBS Dossier) which provides more detail in relation to mangrove forests (mangals), aquatic reptile species (i.e. turtles, snakes and crocodiles) and bird species.

[2] NOTE: Formal assessment of critical habitat is outside the scope of this study. A separate formal critical habitat assessment in accordance with PS6 is being undertaken for the Project. The findings in this baseline study contribute to the formal assessment.

2 Regulatory Framework and Standards

The Project is regulated primarily under the *Environment Act 2000* and the *Oil and Gas Act 1998*. In addition, TEP PNG will be guided by company environmental performance specifications and international guidelines for the purposes of the EIS/ESHIA. Therefore, there are three sets of performance standards applicable to the EIS/ESHIA:

- Papua New Guinea Legislation, including Conservation and Environmental Protection Authority (CEPA) operational procedures and codes of practice under the *Environment Act 2000*.
- International environmental guidelines, including the IFC Performance Standards.
- TOTAL company standards and commitments.

2.1 Papua New Guinean Authorities and Legislation

The following Papua New Guinean legislation is considered relevant for the purposes of the Project EIS/ESHIA:

- *Environment Act 2000*, including regulations and operational procedures/information guidelines.
- *Oil and Gas Act 1998*.
- *Fauna (Protection and Control) Act 1966*.
- *International Trade (Flora and Fauna) Act 1979*.
- *Conservation Areas Act 1971*.

These instruments identify critical aspects of the EIS process, criteria for the purposes of baseline comparison and impact assessment, and/or protection to particular aspects of the Papua New Guinea environment. These are discussed in more detail below.

An EIS in Papua New Guinea is required under the *Environment Act 2000* in order to assess and understand the potential environmental impacts of significant activities prior to the issue of an Environment Permit. In particular, an EIS is required for Level 3 Activities identified under the Environment (Prescribed Activities) Regulation 2002. The Project is a Level 3 Activity in accordance with Sub-Category 18 of the Regulation. This process is administered by CEPA.

Under the *Oil and Gas Act 1998* the issue of licenses for petroleum projects, including Petroleum Development Licenses (PDLs), Pipeline Licenses (PLs) and Petroleum Processing Facility Licenses (PPFLs) require consideration of environmental aspects and management actions. A PDL can only be issued where the Minister administering the Act is satisfied that the project provides for the protection of the environment and welfare of people in the Study Area. In practice, the Minister relies on the EIS developed under the *Environment Act 2000* in making this assessment. The Minister administer the Act is the Minister of the Department of Petroleum and Energy.

In preparing an EIS and applying for an Environment Permit, a proponent is required to follow the process set out in operational procedures and guidelines prepared by CEPA. These include the following:

- Operational Procedure (2013): *Information Requirements for Permit Application & Registration of Intention to Carry Out Preparatory Works*.
- Information Guideline GL-ENV/02/2004: *Guideline for Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement*.
- Information Guideline GL-ENV/03/2004: *Guideline for Submission of an Application for an Environment Permit to Discharge Waste.*
- Technical Guideline IB-ENV/04/2004: *Water & Land Discharges*.

2.1.1 Protected Species and Areas

Species of conservation significance in Papua New Guinea consist of those listed as Restricted or Protected as declared by ministerial gazette under the *Fauna (Protection and Control) Act 1966*. The current list of species is based on a list compiled by Kula and George (1996) and primarily consists of terrestrial mammals, reptiles and birds. The list also includes some aquatic mammals, reptiles and fish.

The *Fauna (Protection and Control) Act 1966* also provides for the declaration of Wildlife Management Area (WMAs) which serve as a form of protected area in Papua New Guinea. Conservation Areas are another form of protected area declared under the *Conservation Areas Act 1971*.

Protection to the species listed under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is also provided under the *International Trade (Fauna and Flora) Act 1979*. This Act lists Schedule 1 (threatened), Schedule 2 (potentially threatened) and Schedule 3 (trade-restricted) species in accordance with the Convention.

In addition, operational procedure GL-ENV/02/2004 introduces the requirement to consider ‘special purpose areas’. While not defined under the procedure or other legislation, these areas have been interpreted as significant and/or sensitive environmental features that are not formally recognized under legislation but are still relevant to the EIS decision-making process.

2.2 International Standards and Guidelines

TEP PNG has committed to preparing an EIS/ESHIA for the Project consistent with a number of international standards and guidelines. These are:

- Equator Principles and World Bank Safeguards.
- IFC Performance Standards.
- Organization for Economic Cooperation and Development (OECD) Common Approaches.
- International Petroleum Industry Environmental Conservation Association (IPIECA) Guidelines.
- Any international convention ratified by the Government of Papua New Guinea (that has not been given effect under legislation listed above).

In addition to these instruments, a number of benchmarking guidelines exist at an international level which provide ‘generally expected’ and ‘maximum permissible’ levels of contaminants in food,

including fish and shellfish. These have been adopted for the assessment of existing levels of metals, metalloids and polycyclic aromatic hydrocarbons (PAHs) within fish tissue in the study area. The relevant guidelines (which have previously been used in Papua New Guinea EIS/ESHIA) are:

- Australian and New Zealand Food Authority (ANZFA).
- United States Food and Drug Administration (USFDA).
- United Nations Food and Agricultural Organization (FAO)/World Health Organization (WHO) CODEX Food Standards.

See Section 2.2.2 regarding international approaches for recognizing threatened species and ecosystems.

2.2.1 Environmental Impact Assessment Requirements

Preparation of an ESHIA for the purposes of environmental due diligence is required under the World Bank Safeguards, Equator Principles and OECD Common Approaches. The IFC PS provide specific guidance on the ESHIA process.

IFC PS1 establishes the framework for preparing an ESHIA in order to assess and manage the impacts from a particular activity. The remaining Performance Standards (PS2 to PS8) provide more detail on the assessment and management of impacts in particular areas, including pollution/discharges to the environment (PS3) and biodiversity conservation (PS6). The IFC PS are supplemented by Environmental, Health and Safety (EHS) guidelines which provide examples of good international industry practice (GIIP) for certain activities.

In accordance with the IFC PS an ESHIA is required to consider the risk of an activity to the environment within the activity's 'area of influence'. This includes consideration of the impacting processes in the relevant industry-specific IFC EHS Guidelines.

Under PS 3 the ESHIA is required to describe the ambient environment conditions in the area of influence, including the assimilative capacity. This then forms the basis of assessing potential pollution impacts and for the setting of impact criteria. Performance Standard 6 requires the ESHIA to include a distinction between 'modified', 'natural' and 'critical' habitat in order to appropriately quantify and manage impacts to biodiversity and ecosystems services.

The IPIECA has prepared a number of guidelines for the petroleum industry to advise proponents on best practice related to ESHIA processes. These guidelines include a focus on biodiversity and ecosystem services, oil spill preparedness, and water.

The key features of these guidelines include: locating and assessing sensitive areas (including protected areas, sensitive habitats and rare, threatened or endangered species) as part of project planning; assessing baseline ecological conditions to inform the occurrence of and vulnerability to alien invasive species; and assessing the potential impacts of abstraction of and discharge to naturally-occurring water sources, including cumulative impacts and the effects of climate change.

2.2.2 Threatened Species and Ecosystems

The IUCN has published a Red List of Threatened Species and a Red List of Ecosystems. These lists represent the most comprehensive global system for listing species and/or ecosystems that are

under threat. This system is used as the basis for designating threatened species and ecosystems under the IFC Performance Standards, especially Performance Standard 6.

Species and ecosystems are listed on the Red Lists as Least Concern, Near Threatened, Endangered, Critically Endangered and Extinct (for species) or Collapse (ecosystems). There are also categories for Not Evaluated and Data Deficient related to species that have not been sufficiently evaluated to be placed into a different category.

2.3 TOTAL Company Standards and Commitments

TOTAL has developed the following general specifications for the purpose of environmental impact assessment that are relevant to the Project EIS/ESHIA:

- GS EP ENV 120: Environmental impact assessment of E&P activities.
- GS EP ENV 111: Environmental Baseline and Monitoring Studies: Onshore Sites.
- GS EP ENV 112: Environmental Baseline and Monitoring Studies: Offshore Sites.

GS EP ENV 120 provides details on the process for undertaking an environmental impact assessment and preparing an environmental management plan. The instrument adopts the ISO14001 approach for impact assessment and management. Some relevant specific requirements of the specification include:

- Identification of the physical, biological and socio-economic context of a project, including sensitivities of the environment.
- Assessment of impacts within an ‘area of influence’.
- Use of a modelling study (if relevant) to assess liquid effluent discharges dispersion.

The specifications also identify a methodology for impact assessment and contents of an environmental management plan (including oil spill contingency plan).

GS EP ENV 111 and GS EP ENV 112 specify the type of data to be collected for baseline purposes. These include physico-chemical properties of in-stream sediment and surface water, rare and endangered species, and flora and fauna bioindicators.

3 Study Area

3.1 Study Area

The Project occurs across the northern and eastern area of the Gulf of Papua, as shown in Figure 1-1. Studies are being undertaken across much of this area as part of the EIS/ESHIA. For the purposes of this report, the study area includes the upstream components associated with:

- Freshwater and estuarine waterways in the area of PRL-15 and downstream within the Purari delta, including the Urika-Ivo and Wame-Varoi rivers.
- Estuarine waterways of the Vaihua River at Caution Bay.

NOTE: Freshwater areas of the Vaihua River are included within the 'downstream' study area and therefore not included within this report. Estuarine areas of this river have been included in this report due to its close connectivity with the Caution Bay marine environment, which is assessed as part of the Marine Biodiversity Baseline Report (BMT WBM, 2017c; Part 11 of ESBS Dossier).

The waterways in the area of PRL-15 include the Purari River downstream of Hathor Gorge and its tributaries, together with the upper parts of the Era River catchment (Mena River and Boa Creek). These areas are shown in Figure 3-1 and Figure 3-2.

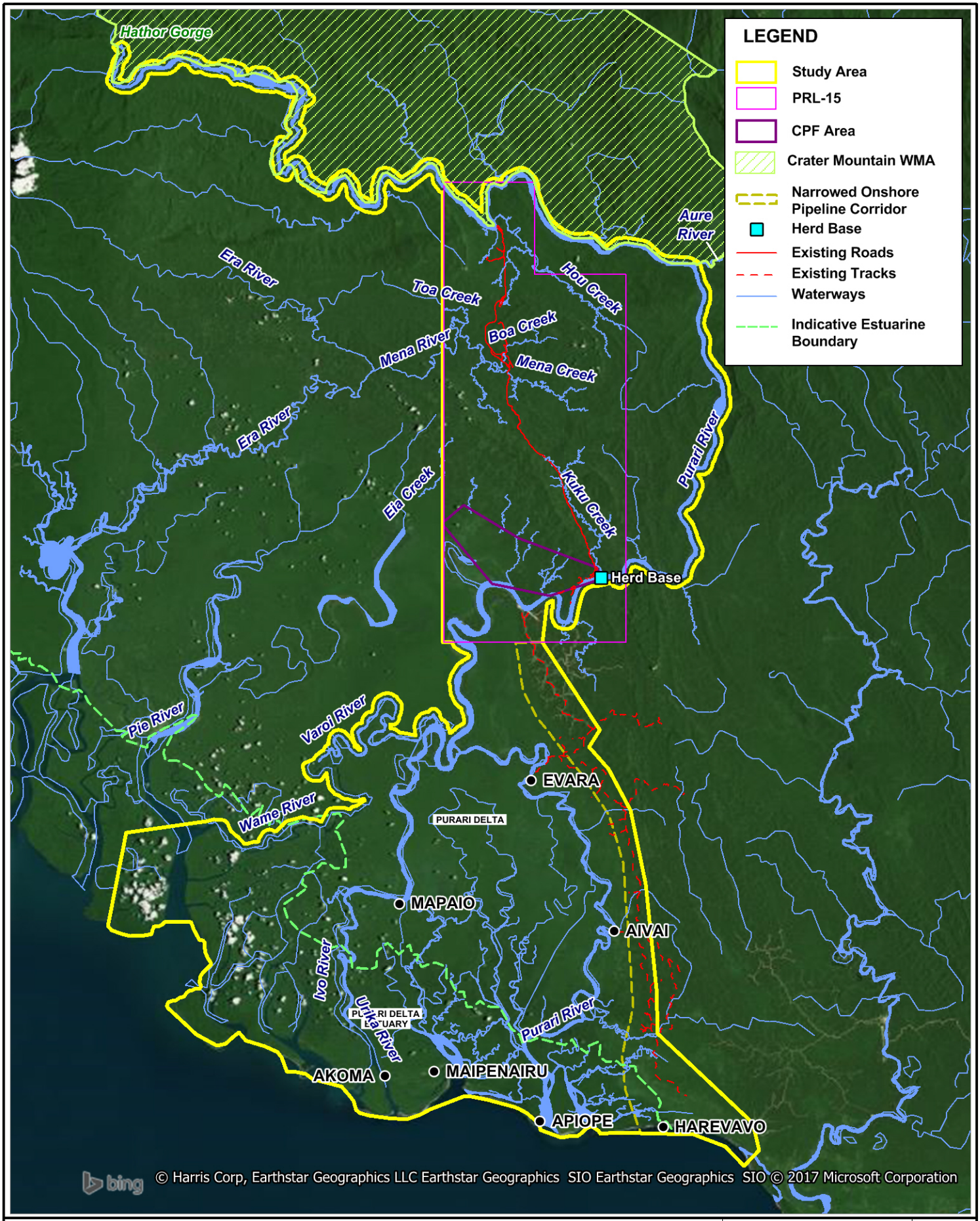
Figure 3-3 to Figure 3-6 show some of the waterways and waterbodies which occur within the study area.

In describing the study area, a distinction is made between freshwater and estuarine areas, as follows:

- All waterways and waterbodies upstream of the indicative mangrove line mapped by Shearman (2010) are considered to be freshwater while all waterways and waterbodies downstream of this line are estuarine. This indicative line is shown in Figure 3-1.
- All of the Vaihua River estuary within the study area is considered to be estuarine.

When referring to the Purari River catchment within the study area, the following terminology is used:

- Purari River – this refers to the Purari River main channel and tributaries between Hathor Gorge and the Ivo River distributary.
- Purari delta – this refers to the low, flat depositional land within the Purari River catchment where the Purari River main channel branches into distributary rivers channels, including the Urika-Ivo and Wame-Varoi rivers, before flowing into the Gulf of Papua. It refers to the freshwater section of these waterways.
- Purari delta estuary – this refers to all of the Purari, Wame-Varoi and Urika-Ivo river catchments and tributaries seaward of the indicative estuarine boundary shown in Figure 3-1.



Title:

Upstream Surface Water and Sediment Quality Study Area – PRL-15 and Purari River

Figure: 3-1

Rev: A

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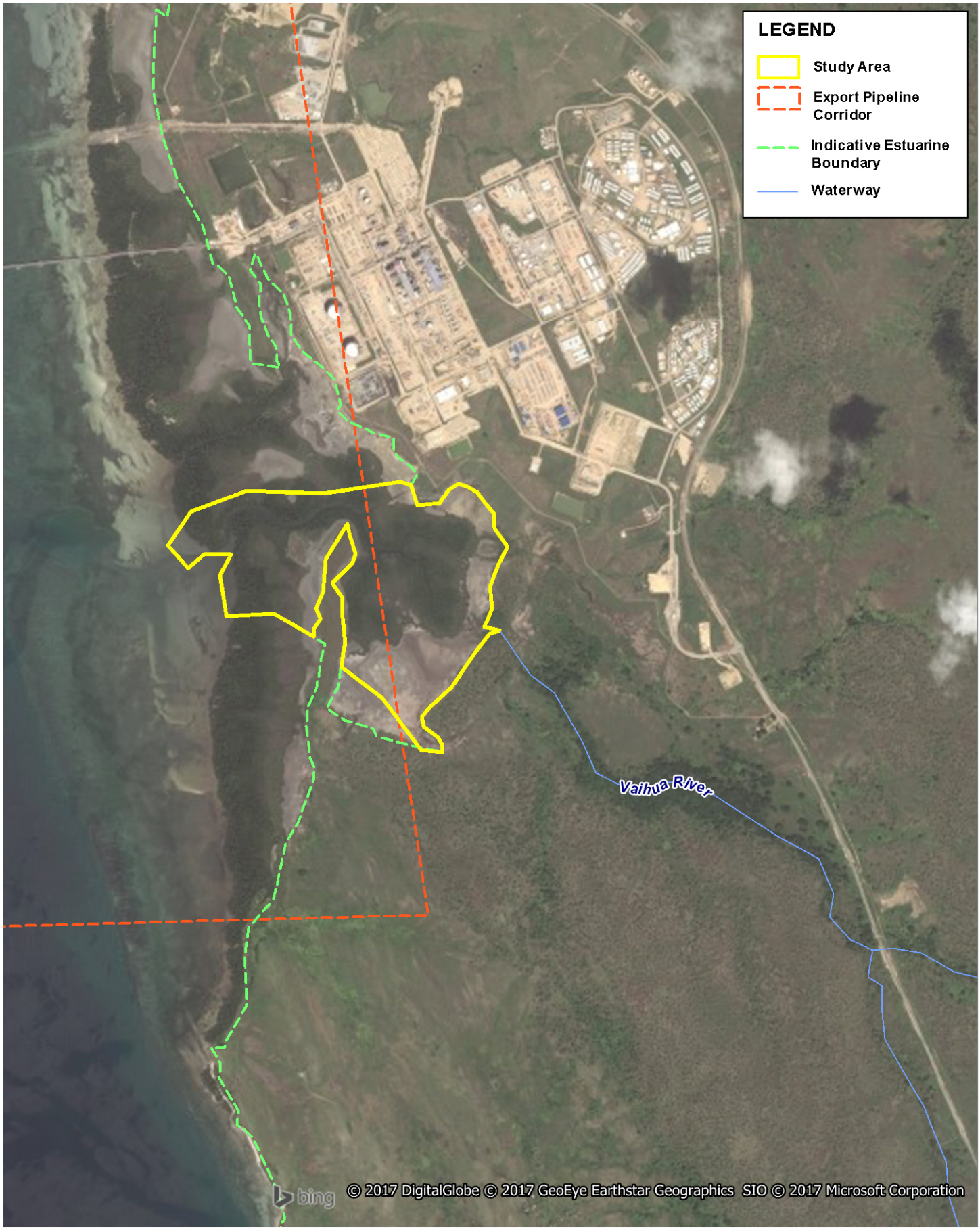
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Approx. Scale

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Title:

Upstream Freshwater and Estuarine Biodiversity Study Area – Vaihua River Estuary

Figure: 3-2

Rev: A

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Figure 3-3 Purari River Main Channel (July 2016)



Figure 3-4 Purari River Floodplain South of PRL-15 (February 2017)



Figure 3-5 Purari River Floodplain Near Delta (July 2016)



Figure 3-6 Study Area Clear Tributary Stream in PRL-15 (February 2017)

3.2 Climate

The following provides an overview of the climatic setting of the study area. More detailed climatic and meteorological information is provided in the Upstream Hydrology and Meteorology Baseline Report (BMT WBM, 2017a; Part 2 of ESBS Dossier) and the Physical Oceanography Baseline Report (BMT WBM, 2017d; Part 10 of ESBS Dossier).

3.2.1 PRL-15 and Purari Delta

Two surface pressure systems influence wind and overall climate processes in southern Papua New Guinea (McAlpine *et al.* 1983):

- Southeast trade winds – which prevail from about May to October.
- Northwest monsoon – which prevails from about December to March.

These wind streams are driven by the positioning of the subtropical high pressure belt and the inter-tropical convergence zone (ITCZ) (Evesson, 1983).

Rainfall in the Purari River catchment downstream of Hathor Gorge is driven primarily by a low-level convergence. This brings high levels of rain throughout the year, with significantly higher rain during the southeast trade wind season than during the northwest monsoon season (Evesson, 1983). This contrast to areas further inland where rainfall is highest during the monsoon due to convergence with inland mountains (Evesson, 1983; McAlpine *et al.* 1983). Mean rainfall for the entire Purari River catchment is 3,500 mm, in contrast to 8,900 mm at Wabo (Evesson, 1983). This rainfall pattern (i.e. at Wabo) is also experienced in the Pie River and Era River catchments. However, the Aure River (a tributary of the Purari River downstream of Hathor Gorge) has similar patterns to catchments further inland, with higher rainfall in the northwest monsoon season (Pickup and Chewings, 1983).

Rainfall patterns are not greatly affected by cyclones as the study area is located north of the main cyclone belt (Evesson, 1983).

Mean annual temperatures throughout the year do not fluctuate dramatically, with 1 to 2°C variation between months (McAlpine *et al.* 1983). June to September are the coolest months of the year, while November to February are the hottest (McAlpine *et al.* 1983).

3.2.2 Vaihua River Estuary

The Vaihua River estuary follows the same climatic patterns for Caution Bay. The main seasonal climatic patterns here consist of:

- Dry season from May to October, with prevailing southeast trade winds.
- Wet season from December to March, when the lighter northwest monsoon winds prevail. Approximately 80% of the mean annual rainfall of 1,200 mm occurs during the wet season.
- Transition periods during April and November, when winds are generally calmer.

The coolest months are July and August when the mean daily maximum and minimum temperatures are 28°C and 23°C respectively. The warmest months are December and January when the mean daily maximum and minimum temperatures are 32°C and 34°C respectively. There is little variation

in the mean daily minimum (±1°C) and maximum (±4°C) temperatures throughout the year (CNS, 2009).

The Vaihua River catchment is north of the main cyclone belt and occurrence of such events in the Gulf of Papua is rare, with only five named cyclones in 15 years entering the gulf, situated well south of Caution Bay. Cyclones generally occur from February to April.

3.3 Anthropogenic Setting

The following provides an overview of the anthropogenic setting of the study area, including population distribution and aquatic-based activities. More detailed information is provided in the Upstream Community and Demographics Baseline Report (Finlayson, 2017; Part 14 of ESBS Dossier) and Land and Natural Resources Use (Ecosystem Services – Provisioning) Baseline Report (Booyong Forest Science, 2017; Part 18 of ESBS Dossier).

3.3.1 PRL-15 and Purari Delta

The predominant land uses within the Purari River catchment generally fall into one of two categories: 1) undisturbed forest, broadly corresponding with the extent of the southern fold mountains, and 2) cleared rural areas, corresponding with highland valleys further inland. The inland southern fold mountains surrounding the mid reaches of the catchment are steep, highly erodible, and have a higher proportion of naturally exacerbated sediment transport. In contrast, the highland valleys are more stable and have a greater coverage of vegetation, such as anthropogenic grasslands. These land use categories contribute to sediment transport and sediment generation processes, and generally dictate the contribution of sediment from a particular sub-catchment.

The general area of PRL-15 in the Purari River catchment is characterized by low population densities. The Elk-Antelope gasfields and PRL-15 area are used by Pawaians.

Low population density in PRL-15 has meant there has been little agricultural pressure on the land, and the vast majority of Pawaian land remains covered by primary forest. Pawaian subsistence is largely practiced on the move in small mobile family or extended family groups operating from bush camps. Sago cultivation is the principal staple in the lowland areas, with production restricted to the river zones (e.g. Purari River and its tributaries). Sago is supplemented by other riverine foods, including fish and prawns.

The export pipeline corridor south of PRL-15 is largely unpopulated however has been modified by large-scale industrial logging. The Gulf Province coastal region and the onshore export pipeline corridor near the coast features a generally low inland population scattered or concentrated in small villages along riverbanks, and a much denser population in large villages and hamlets along the coastal strip. Seven of the principal villages in this area are: Evara, Mapaio, Aivai, Akoma, Aiope, Harevavo and Hororo.

The more remote inland communities rely almost entirely on native flora and fauna for their livelihoods and wellbeing. The people in this region practice a variety of subsistence activities including sago cultivation and production, swidden gardening of sweet potato, yam, taro, banana, cassava/tapioca, pawpaw and sugarcane, cultivation of trees (e.g. coconuts), pig husbandry, hunting

and trapping, and fishing. Market opportunities limit the production of cash crops at a village level and almost all colonial era copra and rubber plantations have closed.

3.3.2 Vaihua River Estuary

The catchment of the Vaihua River includes the ExxonMobil LNG facility, located immediately adjacent to the estuarine area. There are no permanent settlements in the vicinity of this facility, although residents of the coastal villages of Caution Bay may use this area. Caution Bay generally is populated by mixed populations of people from the Koita and Motu people groups. The population density across the region is 10 persons/km^2.

3.4 Protected Areas

The Crater Mountain WMA overlaps with the northwest extent of PRL-15, including part of the Purari River. This is shown in Figure 3-1.

The Paga Hill National Park Scenic Reserve is located to the east of the Vaihua River catchment, within Port Moresby, approximately 13 km southeast of Caution Bay. This is outside the study area catchment.

4 Existing Information

The following section presents the details of previous studies that are considered relevant to the study area. The actual content of this literature has been integrated, as relevant, into the findings described in Section 6.

4.1 Prior Studies within the Study Area

4.1.1 Published Reports

Table 4-1 summarizes all the significant previous environmental impact assessment studies conducted within the study area. These represent a significant body of relevant existing information which has been used in the preparation of the Freshwater and Estuarine Biodiversity Baseline Report. Some of these studies overlap with those conducted adjacent to the study area (as described in Section 4.1.2). NOTE: This section considers only published reports; unpublished reports are discussed in Section 4.1.2.

In addition to the studies listed in Table 4-1, Petr (1983) published a series of papers for the Purari River, based on the findings of the 1979 EIS for the Purari River Hydropower Project. The papers from this series considered relevant to this ESBS report are:

- Evesson, DT (1983), 'The climate of the Purari River basin' (Part I, Chapter 2).
- Pickup, G and Chewings, VH (1983), 'The hydrology of the Purari and its environmental implications' (Part I, Chapter 8).
- Paijmans, K (1983), 'The vegetation of the Purari catchment' (Part II, Chapter 1).
- Conn, BJ (1983), 'Aquatic and semi-aquatic flora of the Purari River system' (Part II, Chapter 4).
- Cragg, S (1983), 'The mangrove ecosystem of the Purari Delta' (Part II, Chapter 5).
- Haines, AK (1983), 'Fish fauna and ecology' (Part II, Chapter 9).
- Marks, EN (1983), 'Mosquitoes of the Purari River lowlands' (Part III, Chapter 7).

The survey sites from these studies that overlap with the study area are shown in the following figures. These consist of:

- Figure 4-1 – aquatic ecology in the lower Purari River (Haines, 1979).
- Figure 4-2 – aquatic ecology in the Vaihua River estuary (Hydrobiology, 2008).

Table 4-1 Summary of Previous Relevant Environmental Assessment Studies

Project/study	Year	Author	Geographic overlap	Relevance to ESBS	Relevant reports
Elk/Antelope Gasfield Project EIS (prepared for InterOil)	2008	Douglas Environmental Services (DES)	PRL-15 and adjoining areas	Detailed freshwater and estuarine biodiversity information for PRL-15 and Purari River	Elk/Antelope Gasfield Project Environmental Impact Statement (DES, 2008)
PRL-15 well pad environmental impact assessments and environmental management plans (prepared for InterOil)	2015	GHD	PRL-15	Detailed freshwater biodiversity for PRL-15 well pads	Antelope 4 Environmental Impact Assessment and Environmental Management Plan (2015) Antelope 5 Environmental Impact Assessment and Environmental Management Plan (2015) Antelope 6 Environmental Impact Assessment and Environmental Management Plan (2015) Antelope South-1 Environmental Impact Assessment and Environmental Management Plan (2015)
Purari River (Wabo) Hydroelectric Scheme Environmental Studies	1979	Papua New Guinea Government	PRL-15 and Purari River	Detailed freshwater and estuarine biodiversity information for PRL-15 and Purari River.	An Ecological Survey of Fish of the Lower Purari River System (Haines, 1979)
PNG LNG Project EIS (prepared for ExxonMobil)	2009	Coffey Natural Systems	Vaihua River estuary	Detailed freshwater and estuarine biodiversity information for Vaihua River estuary	Receiving Onshore Environment: LNG Facilities (Chapter 12) (2009) Receiving Marine Environment: Marine Facilities (Chapter 13) (2009) Aquatic Fauna Impact Assessment (Appendix 24) (Hydrobiology, 2008) Nearshore Marine Impact Assessment (Appendix 23) (2008)

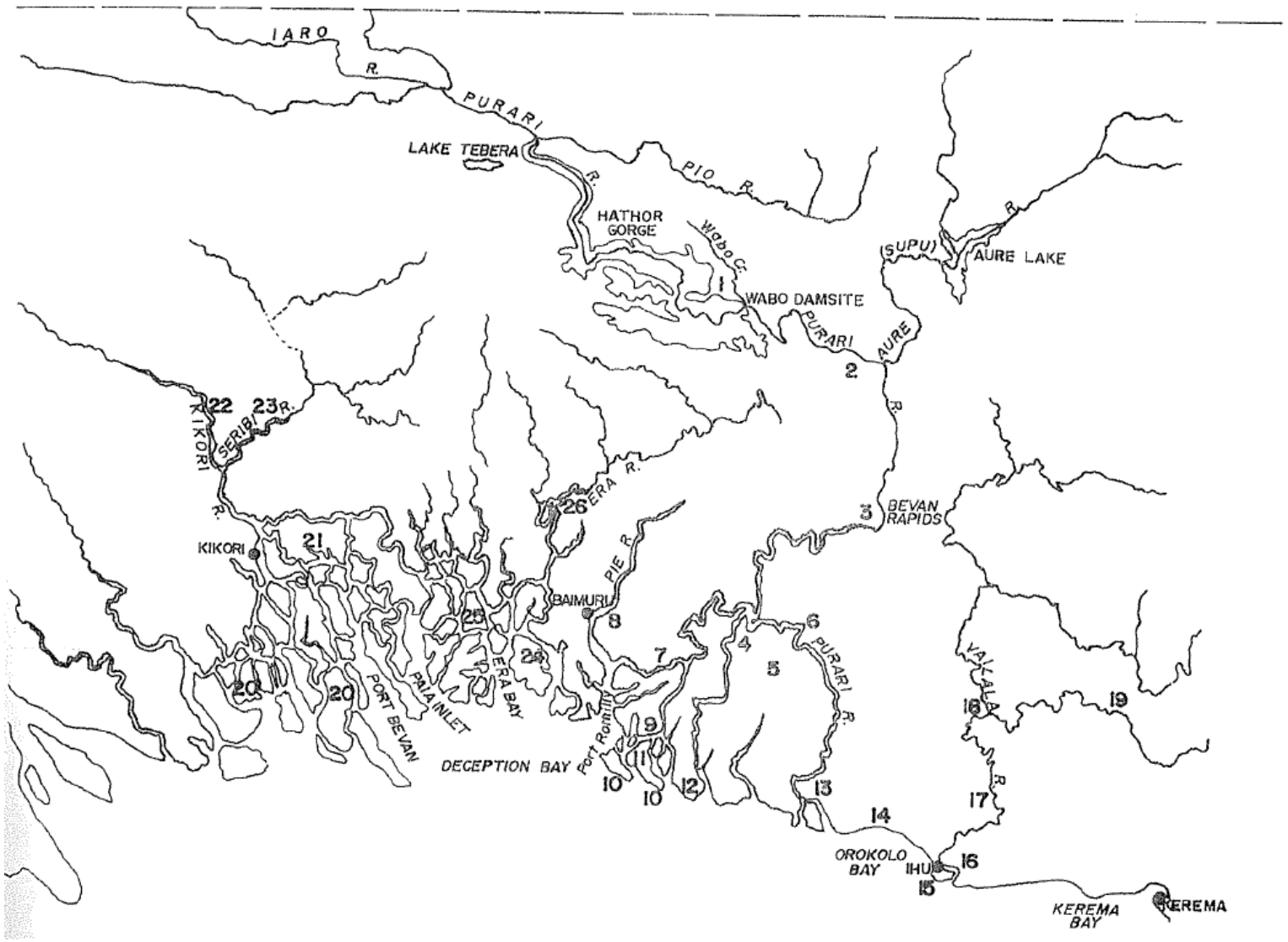


Figure 4-1 Lower Purari River Aquatic Ecology Survey Sites – Purari River (Wabo) Hydroelectric Scheme Environmental Studies (Haines, 1979)



Figure 4-2 Vaihua River Sampling Sites – PNG LNG Project EIS (Hydrobiology, 2008)

4.1.2 Unpublished Reports

In addition to the published reports discussed in Section 4.1.1, further freshwater and estuarine biodiversity studies are known to have been undertaken in PRL-15 as part of a subsequent phase of the Elk/Antelope Gasfield Project EIS. The information from these studies has been used, where relevant, in the preparation of this baseline report.

4.2 Studies in Neighboring Regions

Environmental impact statements have been prepared for two projects in catchments adjoining the study area. These are the PNG LNG Project EIS (CNS, 2009) and the P'nyang Project EIS (CNS, 2015). Both EISs provide aquatic biodiversity information from catchments adjoining the Purari River catchment, i.e. the Fly River (both studies) and Kikori River (only PNG LNG Project EIS) catchments. Both of these studies provide a contextual understanding of the aquatic biodiversity of large river systems discharging into the Gulf of Papua.

4.3 Summary

Based on the studies cited above, the following information is known to be available for the study area:

- Aquatic ecology information, including data on flora and fauna species and available habitat, from a number of sites within the study area, including in the area of PRL-15, the Purari delta, and the Vaihua River estuary.
- Limited aquatic ecology information for sites along the onshore export pipeline corridor (i.e. between Purari River and the coast), including tributaries of the Purari River within this area.

Regional/adjoining aquatic ecology information is available for multiple catchments within Western Province to the west. This provides some relevant information that can be used to contextualize the study area.

5 Approach and Methods

This section provides a summary of the approach adopted for the desktop studies and field survey data collection. A complete description is provided within the scope and methods ('rationale') report for the freshwater and estuarine studies (ERIAS Group, 2016) and addendum (ERIAS Group, 2017a).

5.1 General Approach

The study was based on a review and analysis of existing information, together with targeted field surveys to address identified data gaps. Both desktop review and field surveys focused on the following:

- Description of different aquatic biotope types and features in the study area, including wetlands, tributary streams and rivers – this provides context for understanding the aquatic environment of the study area and the potential values as habitat to aquatic flora and fauna.
- Characterization of spatial and temporal patterns in the structure of fish and macroinvertebrate assemblages of the study area – these provide an indication of the biodiversity values supported in the study area as well as providing a 'bioindicator' of ecosystem health (especially macroinvertebrates; see Pearson and Rosenburg, 1978; Kennedy and Jacoby, 1999; Borja *et al.* 2009; Hallock *et al.* 2003).
- Quantification of metal, metalloid and polycyclic aromatic hydrocarbon (PAH) concentrations in fish tissue – this provides an indication of 'baseline' levels of potential contaminants within aquatic fauna potentially consumed by humans.
- Identification of species listed as threatened under the IUCN Red List, threatened or protected by the *Fauna (Protection and Control) Act 1996*, or potentially relevant to a critical habitat assessment (cf. IFC Performance Standard 6), and identification of habitat otherwise relevant to a critical habitat assessment – these are high priority species and habitats for the purposes of impact assessment and management.

The study approach was the same for both estuarine and freshwater areas within the study area, subject to constraints associated with data availability, logistics and access.

5.2 Data Sources

Key data sources are referenced in the following sections, and include those outlined in Section 4. In addition, the results of village interviews conducted as part of the Upstream Land and Natural Resources Use (Ecosystem Services – Provisioning) Baseline Report (Booyong Forest Science, 2017) were also used to inform the occurrence of particular species at Orokolo Bay.

As outlined in Section 4, ecological surveys and studies have been carried out in the study areas since the 1970s. The description of the baseline environment therefore draws on this existing information from the study area, as well as broad bioregional assessments.

In addition to a review of these studies, the following databases were also reviewed:

- IUCN Red List of Threatened Species on-line database: www.iucnredlist.org (IUCN, 2017a).

- FishBase: http://www.fishbase.org/ (Froese and Pauly, 2017).
- National Fisheries Authority of Papua New Guinea (NFA) website: http://www.fisheries.gov.pg/.

Vegetation mapping data are mostly derived from Forestry Inventory Mapping System (FIMS) of Papua New Guinea version 2.1 (1998) compiled by John McAlpine and John Quigley, as updated by recent studies (e.g. Shearman, 2010) and the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b).

Aerial imagery used in figures has been based on Light Detecting and Ranging (LiDAR) imagery for PRL-15 and the onshore export pipeline corridor (where available), supplemented with Bing Aerial.

5.3 Field Surveys

5.3.1 Sampling Activities

Four field sampling events were completed on 20 June to 9 July 2016 (Purari delta and estuary and Vaihua River estuary sites), 18 to 29 July 2016 (PRL-15 and Purari River tributary sites), 12 to 31 January (Purari delta and estuary and Vaihua River estuary sites) and 13 to 22 February 2017 (PRL-15 and Purari River tributary sites).

Sampling activities consisted of the following:

- Validation of aquatic biotope mapping (see Section 5.6).
- Site-based semi-quantitative and qualitative characterization of the biophysical features of aquatic biotopes.
- Semi-quantitative surveys of aquatic macroinvertebrate assemblages inhabiting riffle, littoral (edge) and pool hydraulic habitat units in accordance with the AusRivAS methodology. Macroinvertebrate collection was undertaken using dip nets when in wadable waterways and a Van Veen grab from a vessel when in non-wadable waterways.
- Quantitative sampling of fish and macrocrustacean assemblages using nets, traps and electrofishing equipment. Electrofishing was the preferred sampling techniques for wadable waterways while all other sample techniques were used as required. Overnight deployment of gill nets occurred at some larger pool sites.
- Collection of fish and prawn samples for laboratory analysis of a suite of metals, metalloids and PAHs.

Not all activities were conducted as part of all four surveys. This is shown in Table 5-1, which provides summaries of survey activities undertaken at each survey location. A total of 26 sites were sampled across both surveys, with a summary of the rationale for site selection provided in Section 5.3.2. These are shown in Figure 5-1 to Figure 5-3. Each sampling site is described further in Table 5-2. See Appendix A for photographs of each sampling site.

Plates of sampling techniques are shown in Figure 5-4 to Figure 5-10.

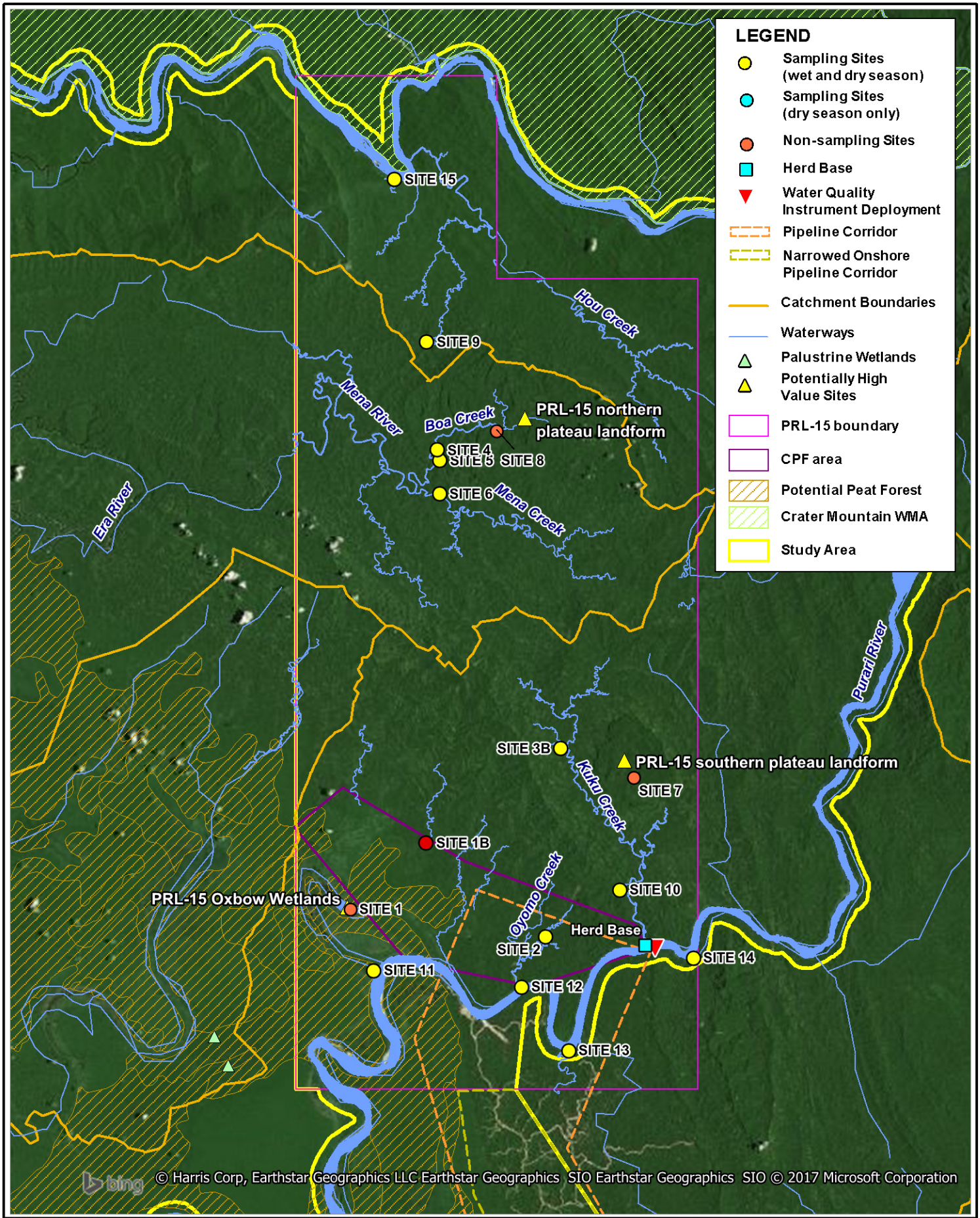
Purari delta and estuarine field surveys (June-July 2016 and January 2017) were conducted from a live-aboard research vessel, the *Browse Enterprise*, while freshwater surveys (July 2016 and February 2017) were conducted from the Herd Base and Antelope-3 field camps in PRL-15, with

travel undertaken by helicopter, light vehicle and river-going vessels (*Bereima Bullet* and *Purari Humbii*), shown in Figure 5-11 and Figure 5-12.

Table 5-1 Summary of Freshwater and Estuarine Biodiversity Sampling Activities

Sampling activity	Sites*	Survey	Notes
Biotope mapping validation	PRL-15 and Purari River	July 2017	
Characterization of aquatic biotopes	16 to 24 (Purari Delta and estuary) 28 and 26 (Vaihua River estuary)	June-July 2016	
		January 2017	
	1 to 15 (PRL-15 and Purari River)	July 2016	
		February 2017	
Macroinvertebrate sampling	16 to 24 (Purari Delta and estuary)	June-July 2016	No sampling undertaken at Vaihua River estuary (sites 28 and 29) due to risk of unexploded ordnances
	2, 3B, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15 (PRL-15 and Purari River)	July 2016	
		February 2017	
Fishing	16 to 26 (Purari Delta and estuary) 28 and 29 (Vaihua River estuary)	June-July 2016	
		January 2017	
	2, 3B, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15 (PRL-15 and Purari River)	July 2016	
		February 2017	Overnight deployment of nets was undertaken at sites 4 and 6
Tissue sampling	20, 22, 23, 24 (Purari estuary)	June-July 2016	Samples for further analysis were selected based on size of individual animals and/or catch
	18, 21, 22 (Purari Delta and estuary)	January 2017	
	1B, 2, 3B, 5, 9, 10, 11, 15 (PRL-15 and Purari River)	July 2016	
	2, 3B, 4, 5, 6, 10, 12, 14 (PRL-15 and Purari River)	February 2017	

*Sites 1, 7 and 8 were non-sampling sites due to logistical constraints and were surveyed only as part of aerial reconnaissance (i.e. helicopter flyover).



Title:

PRL-15 and Purari River Sampling Sites

Figure: 5-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Title:

Purari Delta and Estuary Sampling Sites

Figure: 5-2

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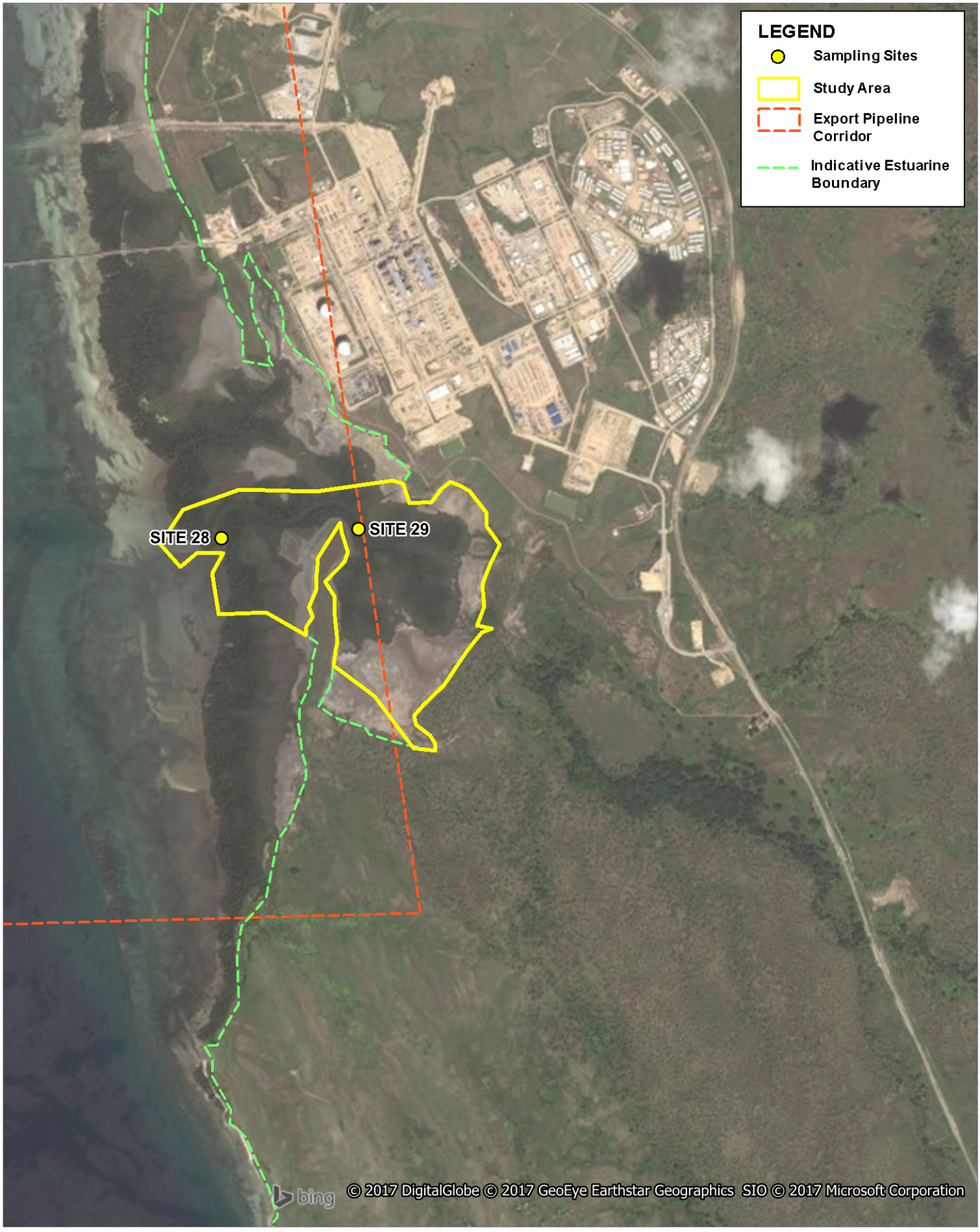
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Title:
Vaihua River Estuary Sampling Sites

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Table 5-2 Description of Sampling Sites

No.	Coordinates[1]	Description	Catchment	Waterway type
1B	-7.313214º, 145.138162º	Unnamed creek located upstream of the Purari River oxbow lake (Site 1) (Fly Camp D)	Purari River	Freshwater
2	-7.351679º, 145.187657º	Oyomo Creek, within/adjacent to the proposed footprint of the proposed CPF (Fly Camp C)	Purari River	Freshwater
3B	-7.274346º, 145.194072º	Unnamed tributary stream of Kuku Creek, upstream of access road	Purari River	Freshwater
4	-7.151558º, 145.142889º	Boa Creek, near Antelope-3 Operations Camp	Era River	Freshwater
5	-7.155956º, 145.143921º	Unnamed tributary stream of Boa Creek, near Antelope-3 Operations Camp	Era River	Freshwater
6	-7.16968º, 145.143757º	Mena River, near Antelope-3 Operations Camp	Era River	Freshwater
9	-7.107039º, 145.138461º	Unnamed tributary stream of Hou Creek	Purari River	Freshwater
10	-7.332508º, 145.218444º	Unnamed creek north of Herd Base	Purari River	Freshwater
11	-7.365724º. 145.116371º -7.36578º, 145.1164º	Mouth of downstream tie-channel (Nea Creek) to Purari River oxbow (Site 1) – adjacent to Mapaio fish camp – tributary and mouth	Purari River	Freshwater
12	-7.372452º, 145.17719º -7.37207º, 145.1778º	Mouth of unnamed creek flowing from footprint of the proposed CPF – tributary and mouth	Purari River	Freshwater
13	-7.398552º. 145.197266º -7.39893º, 145.197º	Mouth of unnamed tributary creek to Purari River, downstream of Herd Base – tributary and mouth	Purari River	Freshwater
14	-7.36044º, 145.249125º -7.36048º, 145.2491º	Mouth of unnamed tributary creek to Purari River, upstream of Herd Base – tributary and mouth	Purari River	Freshwater
15	-7.040197º, 145.125063º -7.04122º, 145.1244º	Mouth of unnamed tributary creek to Purari River, upstream of Hou Creek – tributary and mouth	Purari River	Freshwater
16	-7.503741º, 145.084094º	Urika-Ivo River main channel, downstream of split of Purari River	Urika-Ivo River	Freshwater
17	-7.517744º, 145.144975º	Purari River main channel, downstream of split of Purari River	Purari River	Freshwater
18	-7.6748675º, 145.2439989º	Mouth of unnamed tributary creek to Purari River, at Aivai	Purari River	Freshwater
19	-7.7388594º, 145.223255º	Unnamed tributary creek of Purari River	Purari River	Freshwater
20*	-7.837921º, 145.271344º	Upper Oeha Creek	Purari River	Estuarine
21	-7.827696º, 145.238810º	Unnamed tributary creek of Purari River (lower delta)	Purari River	Estuarine
22B*	-7.801099º, 145.196801º	Lower Karere Creek of Purari River (lower delta)	Purari River	Estuarine
23	-7.584074º, 144.891939º	Mouth of unnamed tributary creek to Wame-Varoi River (lower delta)	Wame-Varoi River	Estuarine

No.	Coordinates[1]	Description	Catchment	Waterway type
24	-7.595789º, 144.948395º	Unnamed tributary creek of Wame-Varoi River (lower delta)	Wame-Varoi River	Estuarine
28	-9.350952º, 147.008769º	Lower Vaihua River estuary	Vaihua River	Estuarine
29	-9.350532º, 147.015366º	Upper Vaihua River estuary	Vaihua River	Estuarine
Aerial reconnaissance sites				
1	-7.340532º, 145.106869º	Purari River oxbow	Purari River	Freshwater
7	-7.286328º, 145.224413º	PRL-15 southern plateau landform	Purari River	Freshwater
8	-7.143959º, 145.167300º	PRL-15 northern plateau landform	Era River	Freshwater

[1]Coordinates based on Papua New Guinea 1984 datum (PNG94), Universal Trans Mercator (UTM) Zone 55

*Alternatives to these sites were sampled during the June-July 2016 survey due to low dissolved oxygen in local waters leading to low fish numbers



Figure 5-4 Macroinvertebrate Collection using Dip Net in Wadable Waterways



Figure 5-5 Fishing using Electrofishing Equipment



Figure 5-6 Fishing using Gill Nets



Figure 5-7 Fishing using Cast Nets



Figure 5-8 Fishing using Fyke Nets



Figure 5-9 Fishing using Seine Nets



Figure 5-10 Fishing using Box Traps



Figure 5-11 *Bereima Bullet*, Vessel Used for River-based Sampling



Figure 5-12 *Purari Humbii*, Vessel Used for River-based Sampling

5.3.2 Site Selection

Sites were selected for the field survey to provide sufficient level of data to characterize the existing environment of the study area for the purpose of an EIS/ESHIA. The primary aims in site selection were to characterize (1) sites in the likely vicinity or sub-catchment of Project infrastructure (based on indicative alignments and locations), and/or (2) sites that represent the various biotopes within the study area. Sites were sampled for both water and sediment quality and aquatic biodiversity purposes. See further the Upstream Surface Water and Sediment Quality Baseline Report (BMT WBM, 2017b; Part 3 of ESBS Dossier).

The rationale for each of the individual sites is as follows:

- Sites 1 (oxbow lake), 7 (southern plateau) and 8 (northern plateau) were identified as potentially important habitat features within PRL-15. However, as sampling at these sites was not possible due to logistical and safety constraints, these sites were included as non-sampling sites and surveyed by helicopter flyover.
- Sites 1B-6 and 9-10 represent freshwater sites within small tributary streams which flow either into the Purari River (sites 1B, 2, 3B, 9 and 10) or into the Mena River which flows into the Era River (sites 4, 5 and 6). These sites are representative of small tributary streams within PRL-15 which may be impacted by Project activities. NOTE: Site 3B is an alternative to the original Site 3 which was located in the Pie River catchment but could not be accessed due to logistical

constraints. Site 1B was sampled to provide information to support understanding of the PRL-15 oxbow wetlands at Site 1, which was unable to be sampled, as described above.

- Sites 11-15 represent freshwater sites located at the mouths of tributary streams to the Purari River. All these sites are within PRL-15 upstream of the delta, where the Purari River splits into distributary channels including the Wame-Varoi, Urika-Ivo and Purari arms. Sites 14 and 15 are considered to provide 'reference' sites as they are upstream of likely impacts from Project activities.
- Sites 16-19 represent freshwater sites within major distributary channels of the Purari River delta, upstream of the indicative estuarine boundary. Sites 18 and 19 are located at the mouth of Purari River tributaries draining from the area in which the onshore export pipeline corridor occurs.
- Sites 20-22B represent estuarine sites within the Purari River delta, associated with the Purari River arm, including tributaries draining from the onshore export pipeline corridor. Site 22B was sampled as an alternative to the original Site 22 due to the low dissolved oxygen at the original site leading to poor fish catches during the June-July 2016 field survey.
- Sites 23 and 23 represent estuarine sites within the Purari River delta, associated with the Wame-Varoi River arm. These sites were identified to characterize an area that could potentially be used as a river transport corridor as part of Project construction and/or operational phases.
- Sites 28 and 29 represent estuarine sites within the Vaihua River estuary adjoining Caution Bay, which will be traversed by the offshore export pipeline corridor.

5.4 Laboratory Analysis

Laboratory analyses and macroinvertebrate identifications were undertaken by the following:

- National Measurement Institute (NMI) – used for fish tissue analysis. This laboratory is accredited by the National Association of Testing Authorities (NATA) and has previously been used for analysis of fish species imported from Papua New Guinea.
- Dardanus Scientific (Stephen Cook) – used for identification of benthic macroinvertebrate samples to a morph-species level, in accordance with the AusRivAS methodology (e.g. DNRM, 2001). Stephen is a former curator of invertebrates at Queensland Museum and holds AusRivAS accreditation for Module 3 – Laboratory.

5.5 Permits Obtained

The following permits were obtained for the freshwater and estuarine biodiversity surveys:

- Permit to Export – allows for the export of a scheduled group under the *International Trade (Fauna and Flora) Act 1979* (i.e. aquatic macroinvertebrates).
- Permit to Import – allows for the import of fish samples into Australia.
- Exemption to Permit to Import – a permit to import was not required to bring benthic macroinvertebrate samples into Australia as, once stored within formaldehyde, benthic macroinvertebrates are exempt from customs requirements.

The Permit to Export from Papua New Guinea is managed by the Wildlife Division of CEPA while Australian importation requirements are managed by the Australian Department of Agriculture and Fisheries.

Additional permits that were not required were 'taking' permits under the *Fauna (Protection and Control) Act 1966*. A Permit to Take protected or restricted species applies in Papua New Guinea to those species listed under Kula and George (1996). The only species 'taken' for the purposes of aquatic ecology investigations were aquatic macroinvertebrates, which are not included in Kula and George's list.

5.6 Aquatic Biotope Type Mapping

5.6.1 Biotope Types

Haines (1983) identified the following freshwater and estuarine biotope types within the Purari River catchment:

(1) Upland springs.

(2) High-to-moderate gradient tributary streams.

(3) Low gradient slow-to-moderate flowing floodplain tributary streams.

(4) Unconfined turbid major river systems, including both freshwater and estuarine reaches.

(5) Freshwater floodplains on deltaic plains.

(6) Estuarine wetlands.

(7) Oxbow lakes and off-river waterbodies (ORWBs).

(8) Upland non-floodplain lacustrine systems.

These biotopes have analogous aquatic biotopes defined by Polhemus and Allen (2006) and IUCN (2017b), as shown in Table 5-3. NOTE: Upland springs and upland non-floodplain lacustrine systems are not known to occur in the study area and, therefore, are not considered further.

Mapping of aquatic biotopes was undertaken using a variety of existing spatial data, including FIMS mapping, topographical data and stream mapping, as shown in Table 5-3.

The FIMS dataset (FIMS version 2.1 - 1998) was developed based on analysis of (i) stereo aerial photographs collected across all of Papua New Guinea between 1973 and 1974; and (ii) Landsat imagery obtained for mid-1996. The units mapped by FIMS are primarily based on vegetation community types, but also includes several non-vegetated biotope types such as rivers and lakes. Only aquatic biotope types were considered in the present study as follows:

- Swamp Forest:
  - Mixed swamp forest (Fsw).
  - Swamp forest with *Campnosperma* (FswC).
  - Swamp forest with *Melaleuca leucadendron* (FswM1).
  - Swamp forest with *Terminalia brassii* (FswTb).

- Woodland:
  - Swamp woodland (W).
  - Swamp woodland with *Melaleuca leucadendron* (WswM1).
- Grassland and Herbland:
  - Swamp grassland (Gsw).
  - Herbaceous swamp (Hsw).
- Estuarine Communities:
  - Mangrove (M).
- Other Non-vegetation and areas dominated by land use:
  - Lakes and larger rivers (E).

A digital elevation model (DEM) of the catchment was generated from 30 m Shuttle Radar Topography Mission (SRTM) DEM layers covering the study area (collected for TEP PNG 11 February 2016). Stream networks were delineated from the DEM using the output from the Flow Accumulation tool in ArcMap. Each stream was then classified according to its stream gradient class as follows:

- High to Moderate Gradient Tributary Streams (e.g. Boa and Mena creeks and other unnamed tributary streams) – stream gradient 1 to 8% (moderate gradient); stream gradient greater than 8% (high gradient).
- Low Gradient Rivers and Streams - stream gradient less than 1%. This category was further subdivided into:
  - Tributary streams (i.e. those that flow into the Purari, Era or Pie rivers), which represents the *Low Gradient Slow-to-Moderate Flowing Tributary Stream* biotope type.
  - The main channel of the Purari River and the mouths of tributary streams at the confluences with the Purari River. This represents the *Unconfined Turbid Major River Systems* biotope type.

Table 5-3 Aquatic Biotope Types Data Sources

Biotope type:*				Mapped occurrence #	Data source	Mapping confidence
Present study		Polhemus and Allen (2006)	IUCN (2017b)			
2	***High-to-Moderate Gradient Tributary Streams*** ***(a) High gradient*** ***(b) Moderate gradient***	• Lotic: Perennial stream (headwater and mid reaches) • Lotic: Intermittent stream	• 5.1 Permanent Rivers, Streams, Creeks (includes waterfalls) • 5.2 Seasonal/ Intermittent/ Irregular Rivers, Streams, Creeks	2,511 km	Stream layer from topographic data	Low to Moderate
3	***Low Gradient Slow-to-Moderate Flowing Tributary Streams***	• Lotic: Perennial stream (mid and terminal reaches)	• 5.1 Permanent Rivers, Streams, Creeks (includes waterfalls) • 5.2 Seasonal/ Intermittent/ Irregular Rivers, Streams, Creeks	1,743 km	Stream layer from topographic data FIMS: • E (Lakes and larger rivers)	High
4	***Unconfined Turbid Major River Systems (freshwater only)***	• Lotic: Perennial stream (terminal reach)	• 5.1 Permanent Rivers, Streams, Creeks (includes waterfalls)	308 km	Stream layer from topographic data FIMS: • E (Lakes and larger rivers) Mangrove mapping (Shearman, 2010) – which was used to derive the nominal boundary of estuarine waters	High

Biotope type:*				Mapped occurrence #	Data source	Mapping confidence
Present study		Polhemus and Allen (2006)	IUCN (2017b)			
5	***Freshwater Floodplain Wetlands on Deltaic Plains (including peat bogs)***	• Palustrine: Lowland marsh (non-forested) • Palustrine: Lowland swamp (forested)	• 5.3 Shrub Dominated Wetlands • 5.4 Bogs, Marshes, Swamps, Fens, Peatlands (>8 ha) • 5.7 Permanent Freshwater Marshes/ Pools (<8 ha) • 5.8 Seasonal/ Intermittent Freshwater Marshes/ Pools (<8 ha)	246 km^2	FIMS: • Fsw (Mixed swamp forest) • FswC (Swamp forest with *Campnosperma*) • FswM1 (Swamp forest with *Melaleuca leucadendron*) • FswTb (Swamp forest with *Terminalia brassii*) • Wsw (Swamp woodland) • WswM1 (Swamp woodland with *M. leucadendron*) • Hsw (Herbaceous swamp) • Gsw (Swamp grassland)	Moderate to High
6	***Estuarine Wetlands*** ***(c) Pandanus-Sonneratia*** ***(d) Nypa*** ***(e) Mangroves***	n/a	• 12.7 Mangrove Submerged Roots • I: Intertidal Forested Wetland	177 km^2 (Purari Delta estuary) 0.9 km^2 (Vaihua River estuary)	Mangrove mapping (Shearman, 2010) FIMS: • M (Mangroves)	High
7	***Oxbow Lakes/Off-River Waterbodies on Floodplains***	• Lentic: Oxbow lake; and Palustrine: Lowland marsh (non-forested)	• 5.6: Seasonal/ Intermittent/ Freshwater Lakes (>8 ha) • 5.7: Permanent Freshwater Marshes/ Pools (<8 ha)	3 km^2	Stream layer from topographic data FIMS: • E (Lakes and larger rivers)	Moderate to High

*Biotope 1, 'upland springs', and biotope 8, 'upland non-floodplain lacustrine systems', are not known to occur in the study area and are therefore not considered as part of mapping

Mapped occurrences have been calculated for the study area defined in Figure 6-3 and Figure 6-25

5.7 Protocols Used

5.7.1 Taxonomy and Nomenclature

Taxonomic arrangements and nomenclature in this report follow the IUCN Red List where available. Where nomenclature is not available from the Red List, nomenclature follows Allen (1991) for fish and Leach and Osborne (1985) for aquatic vegetation.

Where it is not possible to assign an established name to a species collected during the survey, the following system of tags and abbreviations has been adopted:

- sp. – used where single taxa can be identified to a genus level but not a species level.
- spp. – where multiple species are being referred to within a genus.
- sp. 1, sp. 2, etc. – used to distinguish between multiple taxa within the same genus that have not been identified to a genus level but are expected to be different species within the genus.

Aquatic macrophytes are defined as plants that grow in the water, are detectable with the naked eye and are located within a stream or lake area. Aquatic macrophytes are classified as submerged, emergent (herbaceous), or floating, in accordance with Sainty and Jacobs (1994). Wetland trees and shrubs (e.g. sago and pandanus) are not true aquatic macrophytes (Sainty and Jacobs, 1994) and are considered in the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b).

5.7.2 Occurrence

The occurrence of threatened/important species (see below) is described by one of the following categories:

- Known – species has been recorded in the study area as part of present surveys or similar surveys within the past 5-10 years and there is no evidence to suggest species would no longer occur in the study area.
- Likely – species was recorded in the study area more than 10 years ago but there is no evidence to suggest species would no longer occur in the study area, OR the study area supports suitable habitat for the species and is within its known or modeled distribution.
- Possible – the study area supports marginal habitat for the species but is within its known or modeled distribution.
- Unlikely – the study area does not support habitat likely to be utilized by the species, OR the study area is outside of the species known or modeled distribution.
- Does not occur – the species cannot occur within the study area due to habitat restrictions.

5.7.3 Threatened/Important Species

Within this report, the term ***threatened/important species*** is used to describe species in one of the five following categories:

(1) Species listed under the *Fauna (Protection and Control) Act 1966*.

(2) Trade-restricted under CITES and/or the *International Trade (Fauna and Flora) Act 1979*.

(3) Species with a 'threatened' status under the IUCN Red List of Threatened Species (IUCN, 2017a).

(4) Endemic and/or restricted-range species.

(5) Migratory and congregatory species.

Further details on these categories and the process of classifying species is provided below.

5.7.3.1 Nationally Listed Species

Under the *Fauna (Protection and Control) Act 1966* species can be listed as Protected or Restricted based on a gazetted list. The current list is published in Kula and George's *Protected Fauna of Papua New Guinea* (2000).

5.7.3.2 Trade-restricted Species

Trade-restricted species consist of those listed in Appendix I or Appendix II of CITES. This convention has been adopted in Papua New Guinea through the *International Trade (Fauna and Flora) Act 1979* which replicates the CITES appendices in schedules 1 and 2.

Appendix I/Schedule 1 species are those where trade is permitted only in exceptional circumstances, principally due to the threat of extinction of the species as a result of trade. Appendix II/Schedule 2 species are not necessarily threatened with extinction but trade must be controlled in order to avoid utilization which is incompatible with their survival.

5.7.3.3 IUCN Threatened Species

The IUCN Red List places all species (regardless of risk) into one of the following categories:

- Extinct.
- Extinct in the Wild.
- Critically Endangered.*
- Endangered.*
- Vulnerable.*
- Near Threatened.*
- Least Concern.
- Data Deficient.
- Not Evaluated.

Of these categories, those marked with an asterisk (*) are considered to be threatened for the purposes of this report. This does not include species already identified as extinct (Extinct and Extinct in the Wild) and those where insufficient data or existing assessments are available to evaluate threatened status (Data Deficient and Not Evaluated).

5.7.3.4 Endemic and Restricted-range Species

Endemic and restricted-range are categories for species provided under IFC Performance Standard 6 in the context of critical habitat assessments.

Endemic species are those that have equal to or greater than 95% of its global range inside the country or region of analysis. For the purposes of this assessment, the 'region of analysis' is defined as any single endemism area as defined by Polhemus *et al.* (2004) (see Section 6.1). Whether or not species are restricted to the Gulf of Papua is based on available scientific literature, including species profiles on the IUCN Red List.

Aquatic flora species are considered to be restricted-range if they are endemic. For fauna species, some species that may occur in estuarine and freshwater environments are typically marine species as adults (i.e. amphidromous species), the following two 'extent of occurrence' thresholds have been derived from IFC Performance Standard 6:

- Species occurring only in freshwater/estuarine environments – 20,000 km^2 (derived from Holland *et al.* 2012)
- Species occurring primarily in marine environments – 100,000 km^2 (derived from Edgar *et al*. 2009).

This has been determined for individual species based on the profiles on the IUCN Red List and/or any other available scientific literature.

5.7.3.5 Migratory and Congregatory Species

Migratory and congregatory are categories for species provided under IFC PS 6 in the context of critical habitat assessments.

Migratory species have been defined as species of which a significant proportion of its members cyclically and predictably move from one geographical area to another. Congregatory species are those whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis, such as the following:

- Species that form colonies, including for breeding and non-breeding purposes.
- Species that move through bottleneck sites where significant number of individuals of a species pass over a concentrated period of time.
- Species with large but clumped distributions leading to a large number of individuals being concentrated in a single or few sites.
- Source populations where certain sites hold populations of species that make an inordinate contribution to recruitment of the species elsewhere.

Whether or not species are migratory or congregatory for the purposes of these definitions has been based on an assessment of their lifecycle, as available in scientific literature. As a large number of congregatory species are also migratory species (and vice versa) a distinction is not always possible between these two definitions. Species will also be considered migratory where they are recognized

as such under an international convention, e.g. Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Many fish and other aquatic species are migratory as part of their life-cycle. This does not necessarily imply that these species are more sensitive than a non-migratory species. However, migratory species may be more difficult to protect when they move between national boundaries. For this reason, a legal definition (adapted from Bonn Convention) rather than a purely biological definition has been adopted here to define migratory species, i.e. any species or lower taxon of wild animals, in which a significant proportion of the members of the entire population or any geographically separate part of the population cyclically and predictably crosses one or more national jurisdictional boundaries.

5.7.4 Threatened/Important Ecosystems

Threatened/important ecosystems have been defined as those with a threatened status on the IUCN Red List of Ecosystems. This includes all with a status of Collapsed, Critically Endangered, Endangered, Vulnerable or Near Threatened. As no ecosystem relevant to the study area has currently been assessed under the Red List, this status has been determined based on provisional assessments using the guidelines published for the Red List (Rodriguez et al. 2011).

This guideline uses the following criteria for categorizing ecosystems:

- Short-term decline in distribution or ecological function.
- Historical decline in distribution or ecological function.
- Small current distribution and decline in distribution or ecological function.
- Very small current distribution.

5.8 Prioritization of Biodiversity Values

Within this report, biodiversity values have been prioritized for the purposes of understanding the sensitivity and/or significance of particular biotopes, ecosystems and species. This informs environmental assessment and management approaches as part of the EIS/ESHIA. Prioritization is based on the following:

- Potential critical habitat.
- Irreplaceability and vulnerability.

5.8.1 Critical Habitat

‘Critical habitat’ relates to a category of habitat under IFC Performance Standard 6 considered important for the purposes of assessment and management. Critical habitat is defined as follows:

> *Critical habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species, (ii) habitat of significant importance to endemic and/or restricted-range species, (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species, (iv) threatened and/or unique ecosystems, and/or (v) areas associated with key evolutionary processes.*

It is not the intention of this report to identify critical habitat within the study area; however, where relevant, elements that are expected to contribute to a critical habitat designation have been highlighted, such as the occurrence of threatened/important species.

5.8.2 Irreplaceability and Vulnerability

Irreplaceability relates to the spatial limitation of a particular biodiversity value. For example, a value may be considered irreplaceable where it only occurs within a limited location and therefore, once lost, cannot be substituted with an identical value elsewhere. Vulnerability relates to the likelihood of a value being lost due to its threatened status and/or sensitivity to particular kinds of impacts.

In order to determine sensitivity for a biodiversity value based on irreplaceability and vulnerability, the following steps have been taken:

For species

- Identification of the 'vulnerability rating' of the species, based on Table 5-4 (using categories for threatened/important species from Section 5.7.1); and
- Identification of a 'sensitivity rating' of habitat for the species based on the criteria in Table 5-5, which include consideration or irreplaceability.

For habitat features

- Identification of the 'sensitivity rating' of the habitat feature, based on Table 5-5 (first category, based on the IUCN Red List of Threatened Ecosystems methodology in Section 5.7.4), which is based on vulnerability and irreplaceability; or
- Identification of the 'sensitivity rating' for the habitat feature based on the criteria in Table 5-5 (second, third and fourth categories), which is based on irreplaceability.

This allows for a sensitivity rating that is linked to a spatially distributed habitat value.

Table 5-4 Vulnerability Rating for Species and Habitat Features

Category	Vulnerability rating			
	Low	Moderate	High	Extreme
Nationally listed species	n/a – the threatened status under national legislation is considered superseded by the status provided under IUCN Red List			
Trade-restricted species	Unlisted species	Appendix II	Appendix I	-
IUCN threatened species	Least Concern Data Deficient Not Evaluated	Near Threatened Least Concern species with global trend of decreasing population	Vulnerable	Critically Endangered Endangered
Endemic and restricted-range species	Species that are not endemic or restricted-range	Endemic and/or restricted to study area ecoregion	Endemic and/or restricted to local marine features across multiple areas	Endemic and/or restricted to local marine features in a single area

Table 5-5 Sensitivity Rating of Biodiversity Values in the Study Area

Category		Sensitivity rating			
		Low	Moderate	High	Extreme
IUCN threatened ecosystems		Least Concern	Near Threatened	Vulnerable	Collapsed Critically Endangered Endangered
Areas used by species of *low* or *moderate vulnerability*	Low	Area that provides 'suitable'[2] habitat for species of *low vulnerability* that is widespread and abundant through the subject and adjoining ecoregions	Area that provides 'suitable'[2] habitat for species of *low vulnerability* that only occurs within the study area ecoregion	Area that provides 'suitable'[2] habitat for a species of *low vulnerability* that is considered critical to the survival of the global population of the species.	-
	Moderate	Area that provides habitat of 'marginal'[1] value for species of *moderate vulnerability*	Area that provides 'suitable'[2] habitat for species of *moderate vulnerability* that is widespread and abundant through the subject and adjoining ecoregions	Area that provides 'suitable'[2] habitat for species of *moderate vulnerability* that only occurs within the subject ecoregion	Area that provides 'suitable'[2] habitat for a species of *moderate vulnerability* that is considered critical to the survival of the global population of the species.
	Migratory/congregatory	-	Areas within a defined migration route for migratory and/or congregatory species that is widespread and abundant through the subject and adjoining ecoregions	Area within a defined migration route for migratory and/or congregatory species that only occurs within the subject ecoregion OR Habitat that is used by a migratory and/or congregatory species for functions critical to the lifecycle of the species but which is widespread and abundant through the subject and adjoining ecoregions	Habitat that is used by a migratory and/or congregatory species for functions critical to the lifecycle of the species which is the only such area utilized by the species
Areas used by species with *high* or *extreme vulnerability*		-	Area that provides habitat of 'marginal'[1] value for species of *high* or *extreme vulnerability*	Area that provides 'suitable'[2] habitat for species of *high* or *extreme vulnerability* that is widespread and abundant through the subject and adjoining ecoregions	Area that provides 'suitable'[2] habitat for a species of *high* or *extreme vulnerability* that is considered critical to the survival of a regional or global population of the species OR

Category	Sensitivity rating			
	Low	Moderate	High	Extreme
				Area that provides 'suitable'[2] habitat for species of *high* or *extreme vulnerability* that occurs only in the subject ecoregion.
Areas with intrinsic value*	Habitat, landform or ecosystem that is not restricted to New Guinea	Habitat, landform or ecosystem that only occurs within Papua New Guinea but is well represented nationally	Habitat, landform or ecosystem feature that occurs only within the local and adjoining catchments	Habitat, landform or ecosystem feature that occurs only within the local catchment
			Area within a protected area declared under national legislation	Area expected to support a unique assemblage of species and/or be important to evolutionary processes.

*This refers to areas that have biodiversity values that are not necessarily linked to the occurrence of a single sensitive species

[1]Marginal habitat, as defined by the IUCN Habitat Classification Scheme (IUCN, 2017b), is habitat where a species occurs only irregularly or infrequently or where only a small proportion of species individuals are found in the habitat

[2]Suitable habitat, as defined by the IUCN Critical Habitat Classification Scheme (IUCN, 2017b), is habitat where a species occurs regularly or frequently

5.9 Limitations

The following limitations in study approach are noted:

- Aquatic biotope mapping is primarily based on interpretation of existing data with limited ground-truthing. The mapping is considered sufficient for EIS/ESHIA purposes.
- Logistical constraints prevented sampling of aquatic features of potential aquatic biodiversity interest, most notably a series of oxbow lakes and associated wetlands on the Purari River (PRL-15 oxbow wetlands). The characterization of this wetland environment was therefore based on a review of existing information, most notably:
  - Flood modeling – which was used to determine the degree of connectivity with the Purari River. Such information provides context regarding: (i) sensitivities to changes in water quality, most notably periodic high turbidity events; and (ii) potential for speciation (i.e. novel species or sub-species) due to isolation. This is described in the Upstream Hydrology and Meteorology Baseline Report (BMT WBM, 2017a).
  - Remote aerial imagery – to determine flow paths and vegetation structure and coverage.
- Sampling was carried out on two occasions, representing the two main seasons in the study area. The period between 2015 and early 2016 represented an El Niño event, resulting in below average rainfall across much of Papua New Guinea. Inter-annual changes in aquatic ecosystems and populations were broadly considered with reference to historical survey data. There is also great variability in aquatic ecosystems and populations in response to factors operating at finer temporal scales, such as diel changes in tidal conditions, and within-season variability in rainfall (and associated physical and physico-chemical processes). Such processes are broadly discussed where relevant.
- The threatened status of species is derived from the IUCN Red List; however, this list is limited in coverage of aquatic species with many species Data Deficient or Not Evaluated. As a result, additional species in the study area may be considered to have *moderate*, *high* or *extreme vulnerability* that have not currently been identified. It is noted, however, that the species that have been included on this list and discussed in this report (e.g. *Pristis* and *Glyphis* spp.) are considered 'keystone' species in that assessments of sensitivity related to these species will capture habitat utilized by a range of other species that may not be currently listed as threatened.

These limitations are not anticipated to impact on the ability to characterize the baseline freshwater and estuarine ecological environment suitable for the preparation of an EIS/ESHIA.

6 Baseline Characterization

This section describes the regional context and freshwater and estuarine biodiversity baseline for the study area. It focuses on the following technical areas:

- Aquatic biogeographic context of the study.
- Freshwater and estuarine biotopes and aquatic vegetation.
- Aquatic macroinvertebrates (except macrocrustaceans).
- Freshwater and estuarine fish and macrocrustaceans.[3]
- Invasive species.
- Metal, metalloid and PAH concentrations in fish and prawns.

The Vaihua River estuary (at Caution Bay) is described separately to PRL-15 and the Purari River delta due to the geographical separation of this waterway. The biodiversity baseline of the estuary is described in Section 6.9 which consolidates all of the above technical areas (rather than reporting separately).

This baseline characterization does not include a discussion of aquatic herpetofauna (e.g. turtles, crocodiles, frogs) as these are described in the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b). It is also noted that there may be some overlap in relation to ecological values described in this report and in the Upstream Marine Biodiversity Baseline Report (BMT WBM, 2017c) as many estuarine (and some diadromous[4] freshwater) species also occur within the marine environment.

6.1 Aquatic Biogeographic Overview

Polhemus *et al.* (2004) reviewed patterns in endemicity of Papua New Guineas freshwater biota (fish and macroinvertebrates) and divided Papua New Guinea into a number of ecoregions based on endemicity patterns (Figure 6-1). Abell *et al.* (2008) developed a global bioregionalization for freshwater systems, building on the Polhemus *et al.* (2004) scheme for Papua New Guinea. Figure 6-2 shows the ecoregions defined by Abell *et al.* (2008).

The study area falls within the following ecoregions:

- Papuan Gulf Foreland (Area 25) – Polhemus *et al.* (2004) (Figure 6-1).
- Papuan Gulf Coastal Lowlands (Area 28) – Polhemus *et al.* (2004) (Figure 6-1).
- Southwest New Guinea - Trans-Fly Lowland (Ecoregion 815) – Abell *et al*. (2008) (Figure 6-2).

These ecoregions encompass the coastal lowlands in the southern part of central New Guinea, including the Purari, Fly, Digul and Kikori rivers and are characterized by having a high degree of endemism, clustered around tectonic plates (Abell *et al.* 2008).

[3] Macrocrustaceans are included with fish species as the two are sampled in similar ways (i.e. by fishing techniques)
[4] Fish that migrate from the sea to freshwater to spawn, or vice versa.

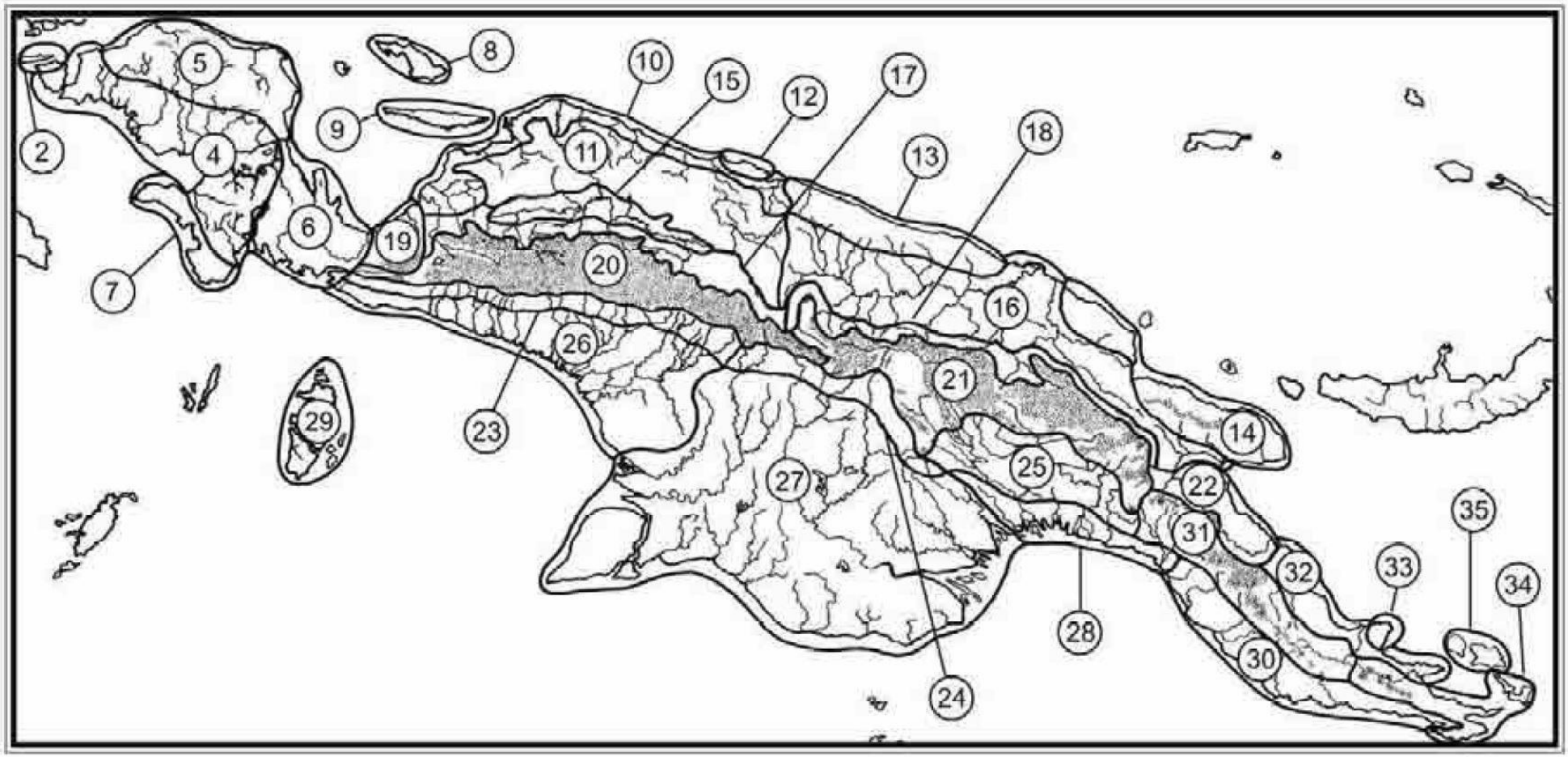
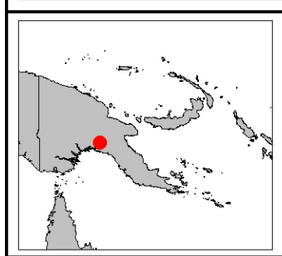


Figure 6-1 Areas of Freshwater Endemism on New Guinea and Nearby Island Groups (Polhemus *et. al.* 2004)





LEGEND

- PRL-15 Boundary
- Study Area
- Pipeline Corridor
- Narrowed Onshore Pipeline Corridor
- 815 Ecoregion

Title:

Freshwater Ecoregions of the Study Area (Abell et. al. 2008)

Figure: 6-2

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0 50 100km

Approx. Scale

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Nearly half of the freshwater fish species in these ecoregions are endemic, including several endemic genera: *Kiunga*, *Cochlefelis* and *Nedystoma*. In addition, Polhemus *et al.* (2004) recorded three aquatic insect species thought to be restricted to the ecoregion (see Section 6.3.2). The freshwater fauna of the ecoregion has strong affinities with that of northern Australia, reflecting the recent geological connection between these land masses (Allen, 1991; Abell *et al.* 2008).

For the purposes of the current freshwater and estuarine biodiversity baseline study, local endemic species are defined as those that are restricted to a single ecoregion, i.e. ecoregions 25 and 28 of Polhemus *et al.* (2004).

See Section 6.9 for discussion of the Vaihua River estuary ecoregion.

6.2 Aquatic Biotope Types

6.2.1 Description

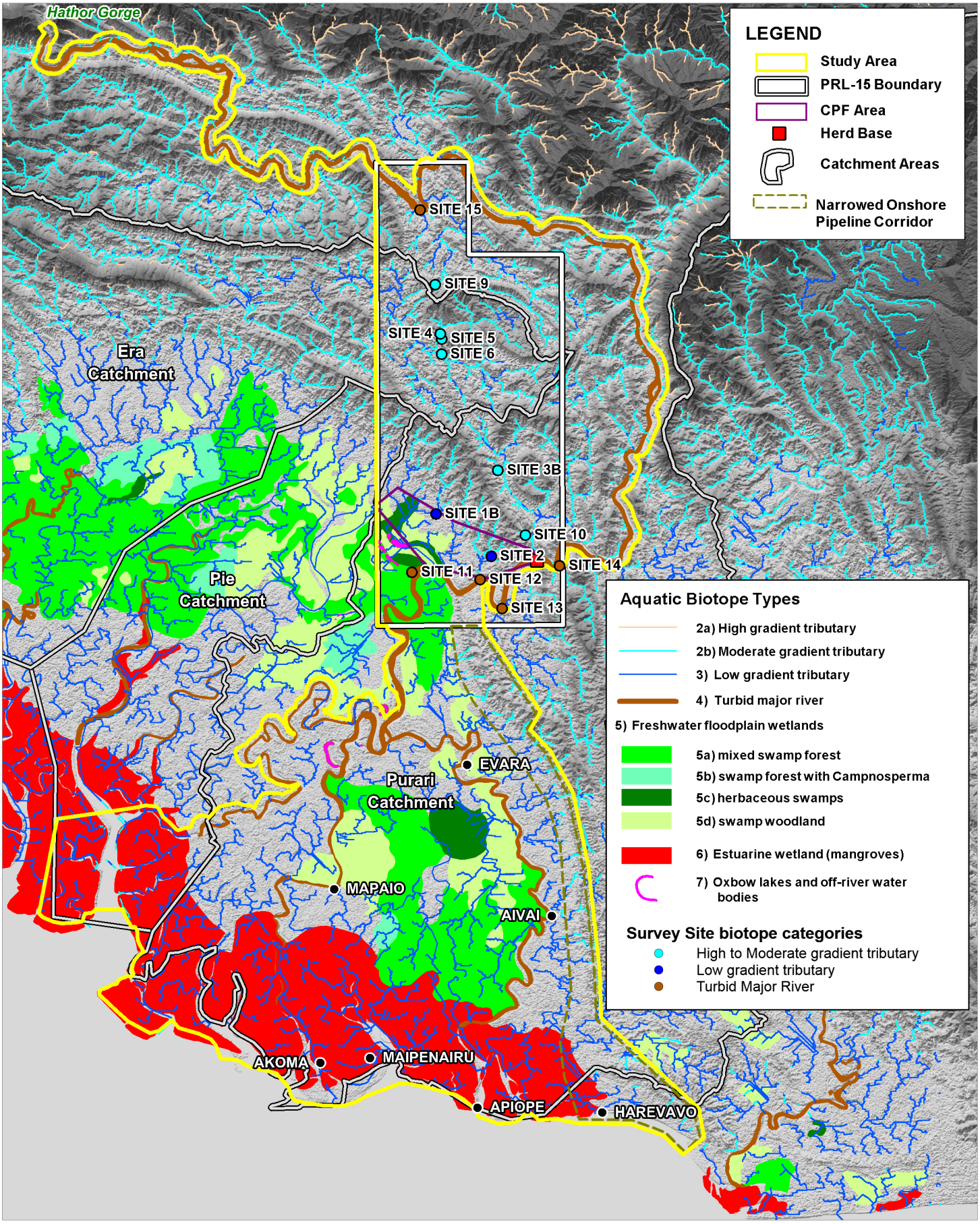
6.2.1.1 Overview

The study area encompasses the deltaic plains of the Purari River and upper reaches of the Purari, Era and Pie rivers. The portion of the study area in the Purari catchment is located downstream of Hathor Gorge (located approximately 60 km upstream of PRL-15). At a catchment-wide scale, the Hathor Gorge rapids represent a significant hydraulic and physical barrier and key control on aquatic fauna distribution patterns in the Purari River catchment (Haines, 1979).

The main channels of the Purari, Era and Pie rivers are fed by a network of high to moderate gradient tributary creeks. The deltaic plains of the Purari River consist of a broad floodplain that supports freshwater wetland systems and low gradient floodplain channels. Towards the coast, the lower deltaic plain is characterized by brackish water supporting ephemeral *Phragmites* sedgelands, *Sonneratia lanceolata*, *Pandanus* sp., *Excoecaria* sp. and *Nypa* dominated communities.

Discontinuous beach ridges occur along the delta front between distributary mouths (Haines 1979; Shearman 2010). Tidal flats, supporting a range of vegetation types depending on salinity influence, occur on low-lying terrain landward of the sand barriers. Freshwater swamps behind these barriers merge into accreting alluvial plains. Permanent swampy depressions occur in the beach ridges along the coast comprised of sago palm, pandanus, reeds and other woody and herbaceous swam plants. Tidally influenced depressions support mangroves including large stands of *Nypa* palm.

Figure 6-3 shows the aquatic biotope types within the study area. Table 6-1 summarizes the vegetation types associated with each biotope type (modified from Paijmans, 1983). The characteristics of aquatic biotopes identified in Table 5-3 are described in the following sections.



Title:

Aquatic Biotopes within the Study Area Mapped from Existing Spatial Data

Figure: 6-3

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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Table 6-1 Aquatic Vegetation Types in Different Biotopes

Biotope		Aquatic vegetation type	Habitat and location
2	High-to-Moderate Gradient Tributary Streams a) High gradient tributary b) Moderate gradient	Absent – riparian vegetation is generally rainforest and does not contain aquatic macrophytes	Steep valleys, confined or partially confined channels
3	Low Gradient Slow-to-Moderate Flowing Rivers and Backwaters of Large Rivers	Swamp forest	Poorly drained sites
		Nipa palm	Brackish tidal flats and creek edges
		Pandan scrub	Low river banks, brackish and fresh
		Saccharum robustum grasslands	Low river banks, fresh
		Sago palm	Freshwater tidal and non-tidal riverine flats
		Sonneratia caseolaris or *S. lanceolata* communities	Recent mud banks and accreting inner river curves; brackish to near fresh
4	Unconfined Turbid Major River Systems	Nipa palm	Brackish tidal flats and creek edges
		Mangroves	Saline tidal flats
		Sonneratia caseolaris or S. lanceolata communities	Recent mud banks and accreting inner river curves; brackish to near fresh
5	Freshwater Floodplain Wetlands on Deltaic Plains a) Mixed swamp forest b) Swamp forest c) Herbaceous swamps d) Swamp woodland	Mixed swamp forest	Freshwater non-tidal swamps
		Swamp forest with Campnosperma	Freshwater non-tidal swamps
		Herbaceous swamp vegetation	Freshwater non-tidal swamps
		Swamp woodland to forest	Lower freshwater reaches
6	Estuarine Wetlands	Mangroves	Saline tidal flats
		Nipa palm	Brackish tidal flats and creek edges
		Pandan scrub	Low river banks, brackish and fresh
		Sonneratia caseolaris or *S. lanceolata* communities	Recent mud banks and accreting inner river curves; brackish to near fresh
7	Oxbow Lakes/ Off-River Waterbodies on Floodplains	Herbaceous swamp vegetation	Freshwater non-tidal swamps

6.2.1.2 High-to-Moderate Gradient Tributary Streams

High-to-Moderate Gradient Tributary Streams are the main lotic biotopes in the study area, with a cumulative length of 2,511 km (Table 5-3). This biotope type occurs in steep valleys and has either confined (90% of the channel length with occasional floodplain pockets on the insides of bends) and partially confined (degree of lateral channel confinement) channels. Streams are expected to have a 'flashy' flow regime, varying greatly over time in response to rainfall and surface water runoff.

High-to-Moderate Gradient Tributary Streams were sampled at sites 3B, 4, 5, 6, 9 and 10 during the July 2016 and February 2017 surveys. Site descriptions are provided in Table 6-2, and representative photos are provided in Figure 6-4.

Higher gradient headwater streams occurred at sites 5, 9 and 10, and had the following characteristics:

- Confined channel with low sinuosity.
- No floodplain.
- Clear, swift flowing waters.
- Substrates comprised entirely of bedrock, boulders, cobble and gravel.
- Hydraulic habitat units comprised of rapids, riffles, runs and occasional off-channel backwaters.
- No trailing vegetation or aquatic macrophytes were present.
- Channel dimensions were variable, with creeks ranging from approximately 3 to 30 m wide and 0.2 to greater than 2 m deep.

Moderate gradient streams occurred at sites 3B, 4 and 6, and had the following characteristics:

- Channels were either confined or partially confined, and small floodplains were present in places.
- Clear, swift flowing waters.
- Substrates were typically comprised of bedrock and coarse material (boulders, cobble, gravel). Due to their lower gradient, sand and silt deposition was present in places, resulting in the creation of point and mid-channel bars.
- Hydraulic habitat units were comprised of rapids, runs, riffles and pools.
- No trailing vegetation or aquatic macrophytes were present.
- Channel width and depth were highly variable ranging from approximately 10 m wide and 0.5 m deep to approximately 25 m wide and greater than 1 m deep.

The general physical characteristics of sites were largely consistent between surveys. The width of the wetted stream (or low flow channel) and depth was however generally lower in February 2017 than during the July 2016 survey, reflecting seasonal changes in rainfall – see Upstream Hydrology and Meteorology Baseline Report (BMT WBM, 2017a).

Table 6-2 Site Descriptions of High-to-Moderate Gradient Tributary Stream Sites

Parameter	Site 3B		Site 4		Site 5		Site 6		Site 9		Site 10	
Aquatic ecosystems represented	Lotic: Perennial stream (high and moderate gradient)		Lotic: Perennial stream (high gradient)		Lotic: Perennial stream (high gradient)		Lotic: Perennial stream (moderate gradient)		Lotic: Perennial stream (moderate gradient)		Lotic: Perennial stream (headwater and mid reaches)	
Hydraulic habitat units	Run, riffle, glide and pool		Run, riffle cascades and pool		Run, riffle and cascades,		Run, riffle and pool		Run, riffle, glide and pool		Run, riffle, glides, cascades and pool	
Approx. elevation (m)	40		54.3		118		48.5		89.9		29.6	
Approx. mean stream width (m)*	13	5	30	30	2.5	2	26	25	3	3	10	6
Max. stream depth (m)*	1.4	1.4	>2	1.5	0.35	0.2	>2	1.6	0.3	0.3	0.5	0.3
Stream gradient (based on GIS mapping)	High		High		High		High		High		High	
Substrate types	Cobbles, pebbles, gravel and sand		Boulders, cobbles, pebbles, gravel		Boulders, cobbles, pebbles, gravel, sand, silt		Cobbles, pebbles, gravel		Bedrock, cobbles, pebbles, gravel, sand		Bedrock, cobbles, pebbles, gravel, sand	
Land use	Native forest		Native forest and cleared		Native forest		Native forest		Native forest		Native forest and cleared	
Valley shape and bank slope	Steep valley with steep concave banks		Steep valley, moderate concave banks		Steep valley with steep concave banks		Steep valley with steep concave banks		Steep valley with steep concave banks		Gorge and vertical wide lower bench banks	
Riparian vegetation cover and type	Continuous cover on both banks of lowland forest		Semi-continuous cover of lowland forest		Continuous cover on both banks of lowland forest		Continuous cover on both banks of lowland forest		Continuous cover on both banks of lowland forest		Occasional clumps of lowland forest	
Key physical characteristics	Large/small woody debris, rock faces, leaf litter, root mats, undercut banks		Rock faces, trailing vegetation, large/small woody debris		Rock faces, leaf litter, trailing vegetation, small woody debris		Rock faces, undercut banks, trailing vegetation, large/small woody debris		Rock faces, large/small woody debris, trailing vegetation, undercut banks, root mats		Rock faces, large woody debris, trailing vegetation	
Shading of waterbody (categorical visual estimate)	51-70%		<5%		51-71%		<5%		>76%		26-50%	
Trailing bank vegetation and macrophyte cover (categorical visual estimate)	No trailing vegetation and macrophytes		No trailing vegetation and sparse macrophytes (*Cyperus*)		Slight trailing vegetation and no macrophytes		Moderate trailing vegetation and no macrophytes		Slight trailing vegetation and no macrophytes		Moderate trailing vegetation in lower reaches and no macrophytes	

* Seasonal characteristics shown for each site during July 2016 (left) and February 2017 (right)



Figure 6-4 Examples of High-to-Moderate Gradient Tributary Streams: Confined Channel at Site 10 (top) and Partially Confined Channel at Site 3B (bottom)

Riverine sites located in ‘native forest’ have a riparian zone comprised of intact, continuous lowland forest (e.g. sites 9, 3B, 5, 6). Creeks located at and adjacent to roads and camp facilities have fragmented, semi-continuous to patchy riparian vegetation (e.g. sites 10 and 4). The riparian vegetation forms a dense canopy over narrow streams (less than 10 m wide).

Aquatic habitats were relatively untouched and there was little evidence of recent physical disturbance. The exception was at Site 5 where a large slug of recently deposited sediment occurred upstream of a culvert crossing (Figure 6-5). It is likely that most of this sediment originated from landslips in the upper catchment. Localized bank erosion around the culvert and road runoff may also represent a source of sediment (Figure 6-8).



Figure 6-5 Deposition of Sediments Observed Upstream of the Culvert Crossing at Site 5 (top) and Erosion Observed Downstream of Site 5 (bottom)

6.2.1.3 Low Gradient Slow-to-Moderate Flowing Tributary Streams

This biotope type had a total length of 1,743 km in the study area (Table 5-3), within the Purari River catchment. Low Gradient Slow-to-Moderate Flowing Tributary Streams represent dynamic, depositional environments that can show great variability in physical riverine characteristics, diversity, function and position over time. This biotope also represents a transitional zone between the swift flowing, clear water environments that characterize the High-to-Moderate Gradient Tributary Streams, and the slow flowing, Unconfined Turbid Major River Systems. Consequently, this biotope shares physical and physico-chemical characteristics of both, varying along its profile, as follows:

- Upper reaches – these environments typically have the following characteristics:
  - low sinuosity.
  - substrates dominated by sand, gravel and pebbles.
  - hydraulic habitats including riffle, glide and run with occasional pools.
  - high micro-habitat diversity, comprised of leaf litter, trailing vegetation, large woody debris, root mats and rock crevices.
  - common occurrence of gravel and sand bars.
  - low turbidity (less than 10 NTU).
  - continuous riparian cover from lowland forest canopies and a high degree of channel shading.
  - absence of aquatic macrophytes, likely due to channel scour and shading by riparian vegetation.
- Lower reaches (typically located on the Purari River floodplain) – these environments typically have the following characteristics:
  - high sinuosity.
  - sand and silt/clay substrates.
  - hydraulic habitats including slow moving runs, glides and pool habitats.
  - large woody debris, leaf litter, trailing vegetation and trailing roots abundant, providing a high level of micro-habitat complexity.
  - turbidity temporally variable but generally higher than upper stream reaches (greater than 10 NTU).
  - riparian vegetation composed of semi-continuous to continuous lowland and/or alluvial forest, varying depending on the local land-use (e.g. native forest or gardens).
  - sparse to absent aquatic macrophytes, most likely due to scour, high canopy shading and (in places) high turbidity.

Descriptions of biodiversity sampling sites classified to be Low Gradient Slow-to-Moderate Flowing Tributary Streams are provided in Table 6-3.

There was little variation between surveys for sites 1B, 2, 16, 17, 18 and 19 in relation to waterway depth and width. By contrast, there was significant change for sites 11, 12, 13, 14 and 15, with depth

and width during the February 2017 survey substantially greater for most sites than during the July 2016 survey. Higher rainfall is expected to occur at PRL-15 during July (i.e. southeast trade winds season) comparative to February (northwest monsoon); however, upstream of PRL-15, rainfall is higher within the northwest monsoon. The increased water volume at these sites during this period, therefore, is due to large volumes flowing through the Purari River from the upper catchment, causing backflow to each of these tributary sites (which were located immediately adjacent to the river).

Examples of Low Gradient Slow-to-Moderate Flowing Tributary Streams (examples in Figure 6-6) occurred at sites 1B and 2. In addition, Low Gradient Streams (lower reaches) are represented at Floodplain Stream Mouths, as described in Section 6.2.1.4. Refer to Table 6-3 for site summaries for Low Gradient Streams and Floodplain Stream Mouths, and Figure 6-7 for photos of sites 1B and 2.



Figure 6-6 Example of a Low Gradient Slow-to-Moderate Flowing Tributary Stream (Lower Reach) Transitioning to Floodplain Stream Mouth and Turbid Major River Biotope



Figure 6-7 Examples of Low Gradient Floodplain Streams: Site 2 (top) and Site 1B (bottom)

Table 6-3 Site Descriptions of Low Gradient Slow-to-Moderate Flowing Tributary Streams and Floodplain Stream Mouths

Parameter	Site 1B		Site 2		Site 11		Site 12		Site 13		Site 14		Site 15		Site 16		Site 17		Site 18		Site 19	
Aquatic ecosystems represented	Lotic: Perennial stream (lower reaches)		Lotic: Perennial stream (lower reaches)		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial Unconfined Turbid Major River Systems and Floodplain Stream Mouths		Lotic: Perennial Unconfined Turbid Major River Systems and Floodplain Stream Mouths		Lotic: Perennial stream (lower reaches) and Floodplain Stream Mouths		Lotic: Perennial stream (secondary channel) and Floodplain Stream Mouths	
Hydraulic habitat*	Run, glide and pool		Run, riffle glide and pool		Pool	Run	Pool		Pool		Run, riffle, glide and pool	Pool	Pool		Deep run		Deep run		Pool		Deep run	
Approx. elevation (m)	37.5		57.3		18		12		21		16		22		8		11		5		4	
Approx. mean stream width (m)*	11	11	1.9	1.9	12	30	31	90	10	25	3	25	12	26	360	360	60	60	5	5	30	30
Max. stream depth (m)*	2	2	0.4	0.4	>2	5	>2	2.5	>2	3	0.7	1.5	>2	4.5	2	2	5	5	1.5	1.5	10	10
Stream gradient	Low		Low		Low		Low		Low		Low		Low		Low		Low		Low		Low	
Substrate	Sand and silt		Sand, gravel and pebbles		Silt and clay		Sand and silt		Silt and clay		Sand, gravel and silt		Silt and sand		Sand and silt		Sand and silt		Silt and clay		Sand and silt	
Land use	Camp and native forest		Native forest		Village and gardens		Native forest		Native forest		Native forest and regrowth		Native forest		Native forest and gardens		Native forest and grasses		Native forest and gardens		Native forest and gardens/ village	
Valley shape and bank slope	Steep valley with steep concave banks		Steep valley with moderate to steep concave banks		Floodplain with steep to vertical banks, concave in shape		Floodplain with steep banks, concave in shape		Floodplain with moderate to steep banks, concave in shape		Floodplain with steep to vertical banks, concave in shape		Floodplain with moderate to steep banks, concave in shape		Floodplain with shallow banks convex in shape		Floodplain with shallow banks, concave in shape		Floodplain with moderate banks, concave in shape		Floodplain with shallow banks, concave in shape	
Riparian vegetation cover and type	Semi-continuous cover lowland alluvial forest		Continuous cover on both banks of lowland forest		Semi-continuous cover lowland alluvial forest		Semi-continuous cover lowland alluvial forest		Continuous cover lowland alluvial forest		Continuous cover lowland alluvial forest on downstream right bank, regrowth on downstream left bank		Continuous cover lowland alluvial forest		Continuous cover lowland alluvial forest		Continuous cover lowland alluvial forest		Semi-continuous cover lowland alluvial forest		Continuous cover lowland alluvial forest on downstream left bank. Semi-continuous on downstream right bank	
Key physical characteristics	Large/ small woody debris and trailing vegetation		Large/small woody debris, trailing vegetation and root mats		Large/small woody debris, trailing vegetation		Large/small woody debris, trailing vegetation		Large/ small woody debris, trailing vegetation		Large/small woody debris and leaf litter		Large/ small woody debris, trailing vegetation		Major river. Trailing vegetation and large woody debris		Major river. Trailing vegetation and large woody debris		Large/ small woody debris, trailing vegetation		Large/small woody debris, trailing vegetation	
Shading of waterbody (categorical visual estimate)	26-50%		>76%		<5%		<5%		6-25%		<5%		<5%		<5%		<5%		6-25%		6-25%	
Trailing bank vegetation and macrophyte cover (categorical visual estimate)	Moderate trailing vegetation, no macrophytes		Slight trailing vegetation and no macrophytes		Moderate trailing vegetation, no macrophytes		Slight trailing and no macrophytes		Slight trailing and no macrophytes		No trailing vegetation and macrophytes		Moderate trailing vegetation, no macrophytes		Trailing and submerged grasses. No macrophytes		Trailing grasses and vegetation. No macrophytes		Trailing grasses and vegetation. No macrophytes		Trailing vegetation. No macrophytes	

* Seasonal characteristics shown for each site from June-July 2016 (left) and February 2017 (right)

6.2.1.4 *Unconfined Turbid Major River Systems and Floodplain Stream Mouths*

This biotope was represented in the study area by the Purari River (Unconfined Turbid Major River Systems – sites 16, 17, 18 and 19) and the mouths of tributaries (Floodplain Stream Mouths – sites 11, 12, 13, 14 and 15). Figure 6-8 provides a representative example of Floodplain Stream Mouths.

The Purari River below Hathor Gorge has unconfined channel/s. In places the river consists of multiple braided channels that are highly unstable and subject to shifts in position of the thalweg.[5] The river can also form a continuous meandering channel that is also highly unstable, migrating across the floodplain over time. Downstream of Herd Base, the river has an extensive floodplain and in-channel sediment deposits. The river is highly turbid, deep in areas (up to 11 m), and comprised of a continuous run hydraulic habitat. Substrates vary depending on channel form, and include gravel, sands and muds.

The mouths of floodplain streams are strongly influenced by the Purari River and have similar physico-chemical and physical/hydraulic habitat characteristics. Extensive sand and cobble bars are present at most river mouth sites, which are dynamic features that vary in response to flow conditions (e.g. sites 14 and 12).

Water levels in creek mouths also vary in response to seasonal changes in rainfall, with channel width and depth higher in February 2017 than July 2016 (e.g. Site 14; Figure 6-9). The Purari River had high water levels in February 2017, resulting in backflow into adjoining floodplain streams and river waterbodies (including the PRL-15 oxbow wetlands discussed further below). This temporal pattern was inconsistent with that observed in high-to-moderate gradient streams in the PRL-15 catchment area, where water levels were generally lower in February 2017 than July 2016 (due to differences in rainfall across the catchment).

Riparian vegetation consisted of continuous alluvial forests at sites where the local land use was predominantly native forest and gardens. Semi-continuous to patchy riparian vegetation occurred at sites adjacent to villages and gardens. The sugar cane grass *Saccharum robustum* dominated banks, particularly in areas of high disturbance adjacent to creek confluences and/or inside bends.

[5] This is the deepest part of the channel where the main current flows



Figure 6-8 Examples of the Mouths of Tributary Streams at the Confluence of Purari River: Site 15 (top) and Site 14 (bottom), Showing Heavy Depositions at the Confluence



Figure 6-9 Changes in Water Depth, Hydraulic Habitat Type and Bank Structure at Site 14 Between July 2016 (top) and February 2017 (bottom)

6.2.1.5 Freshwater Floodplain Wetlands

The Purari River has an extensive floodplain containing palustrine wetlands (marshes), flooded forests and oxbow lakes and lagoons (Figure 6-10). The degree of inundation by overbank flooding of these wetland types varies seasonally in response to flooding of the Purari River – see Upstream Hydrology and Meteorology Baseline Report (BMT WBM, 2017a).

Oxbow Lakes

Oxbow lakes form where meander bends have been separated from the main channel. An oxbow lake is located approximately 18 km downstream of Herd Base on Nea Creek within PRL-15 (Figure 6-3). This is referred to as the PRL-15 oxbow wetlands for the purposes of this report. Based on helicopter reconnaissance and an inspection of aerial imagery, the oxbow wetland was observed to have the following features:

- Submerged grasses and aquatic macrophytes (floating, emergent) present along the littoral margins of the lagoon, whereas the central sections consist of open water
- Surrounding area dominated by herbaceous swamp and swamp woodland vegetation
- An outlet was identified at the downstream end of the remnant channel in which the oxbow lake is located. Anecdotal evidence provided by local fisherman indicates that the outlet channel connects to the oxbow, providing connectivity between the wetland and the Purari River main channel.

Other oxbow lakes also occur on the Purari River floodplain further than 20 km south of PRL-15.

Floodplain Forest and Palustrine Wetlands

The floodplain has large areas of floodplain forest (medium crown dense canopy of mixed swamp vegetation) containing palustrine wetlands and small off-river waterbodies. The floristic characteristics of these wetlands are described in the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b). Based on helicopter reconnaissance, the off-river waterbodies appear to be rich in tannins (i.e. tea color). Insufficient information is available to ascertain whether peat forests and wetlands are present in the floodplain forests. Such features typically have low pH and high tannin content, and can be sensitive to changes in water quality.

The low gradient of the Purari River has resulted in a gradual transition from forest to sago palm, through tidal freshwater swamp forest to mangrove vegetation on the coast. Tributaries of the Era and Pie rivers (located within and adjacent to PRL-15) primarily feature forest communities only.

Paijmans (1983) records a zone of tidal swamps in the Purari River deltaic zone, adjacent to the brackish belt of mangroves and *N. fruticans*. As these swamps are flooded regularly by upstream flows, they are primarily freshwater communities. Key vegetation types in these communities are swamp forest and woodland, sago palm and herbaceous swamp vegetation.



Figure 6-10 Examples of Floodplain Wetlands: PRL-15 Oxbow Wetlands (top) and Tannin-Stained Palustrine Wetlands (bottom) Adjacent to the Purari River

Areas of good drainage and sediment aeration are marked by a canopy of small-crowned trees with an average height of 25 m (Paijmans, 1983). In lower lying areas, swamp forest merges into open swamp woodland, marked by pandans and sagos. In some areas, adjacent to major rivers, sago forms almost mono-specific stands (Paijmans, 1983).

The deltaic plains also contain a number of lowland freshwater swamps, formed by small depressions (Conn, 1983; Paijmans, 1983). These include both permanent and semi-permanent open swamp communities, featuring the following vegetation:

- *Hanguana malayana* with sedges, gingers, sago and pandanus – occurring in small, shallow, semi-permanent depressions.
- *Leersia hexandra* and sedges – occurring in permanently swampy areas including shallow embayments and small islets.
- *Ischaemum polystachyum*, *Polygonum* sp., *Ludwigia* sp. and *Ipomoea aquatica* –occupying the fringes of swamps.
- *Phragmites karka* – occurring in slightly brackish shallow swamps.
- *Saccharum robustum* – occurring in shallow swamps with moving freshwater.
- *Coix lachrymal-jobi* – occurring on low levee banks.

Other common species in freshwater swamps are *Nymphaea nouchali, Nymphaea spp., Nymphoides indica, Ceratophyllum demersum, Lemna perpusilla, Pistia stratiotes, Azolla spp.* and *Utricularia* spp. (Conn, 1983; Paijmans, 1983).

6.2.1.6 Estuarine Wetlands

The Purari delta estuary, including the Wame-Varoi and Urika-Ivo rivers, forms the transitional zone between freshwater environments and the Gulf of Papua. The main Purari River channel, secondary channel and side channels that comprise the estuary are heavily influenced by freshwater inputs from the Purari River and small sub-catchments feeding directly into the estuarine zone. Despite the strong freshwater influence the estuary remains tidally affected. Water column profiles indicate that water quality properties are generally uniform throughout the water column at most sites, although a salt wedge was observed at Site 22B (at the mouth of the lower Karere River, adjacent to the upper estuary of Alele Passage) during the wet season. This is described in the Upstream Surface Water and Sediment Quality Baseline Report (BMT WBM, 2017b).

Small brackish water creeks were sampled at sites 20, 21 and 22c (see Figure 5-2). These creeks had narrow (10 to 40 m), deep (3 to 10 m) sinuous channels and followed a meandering course. The upper reaches of some creeks were poorly flushed and had high organic loading, resulting in moderately low dissolved oxygen concentrations in places (less than 60% saturation).

Point bars and silt deposits were observed at most creek confluences throughout the delta while mid-channel bars and islands were also observed in larger distributary channels. The main Purari channel and major distributaries tended to have variable water depth (0 to 6 m) and are hundreds of meters wide. These main channel environments typically have low sinuosity. Physical and chemical characteristics of the waterways throughout the Purari River estuary are discussed further in the

Upstream Surface Water and Sediment Quality Baseline Report (BMT WBM, 2017b), but are indicative of a well flushed, brackish water environment although with low dissolved oxygen levels in the upper reaches.

Shearman (2010) mapped the distribution and extent of mangrove forests in the Purari River delta, as shown in Figure 6-11. The distribution of mangroves shown in Figure 6-11 was verified by ERIAS Group (2017b) and the present study where vessel and helicopter based surveys generally aligned with boundaries depicted in FIMS. Mangrove forests were also observed in the present study at sites 20B, 21, 22 and 23 (June-July 2016 and January 2017 surveys) and sites 20, 22B and 22c (June-July 2016 survey only).[6] Based on these observations and previous studies (e.g. Cragg 1983) the following spatial patterns were observed:

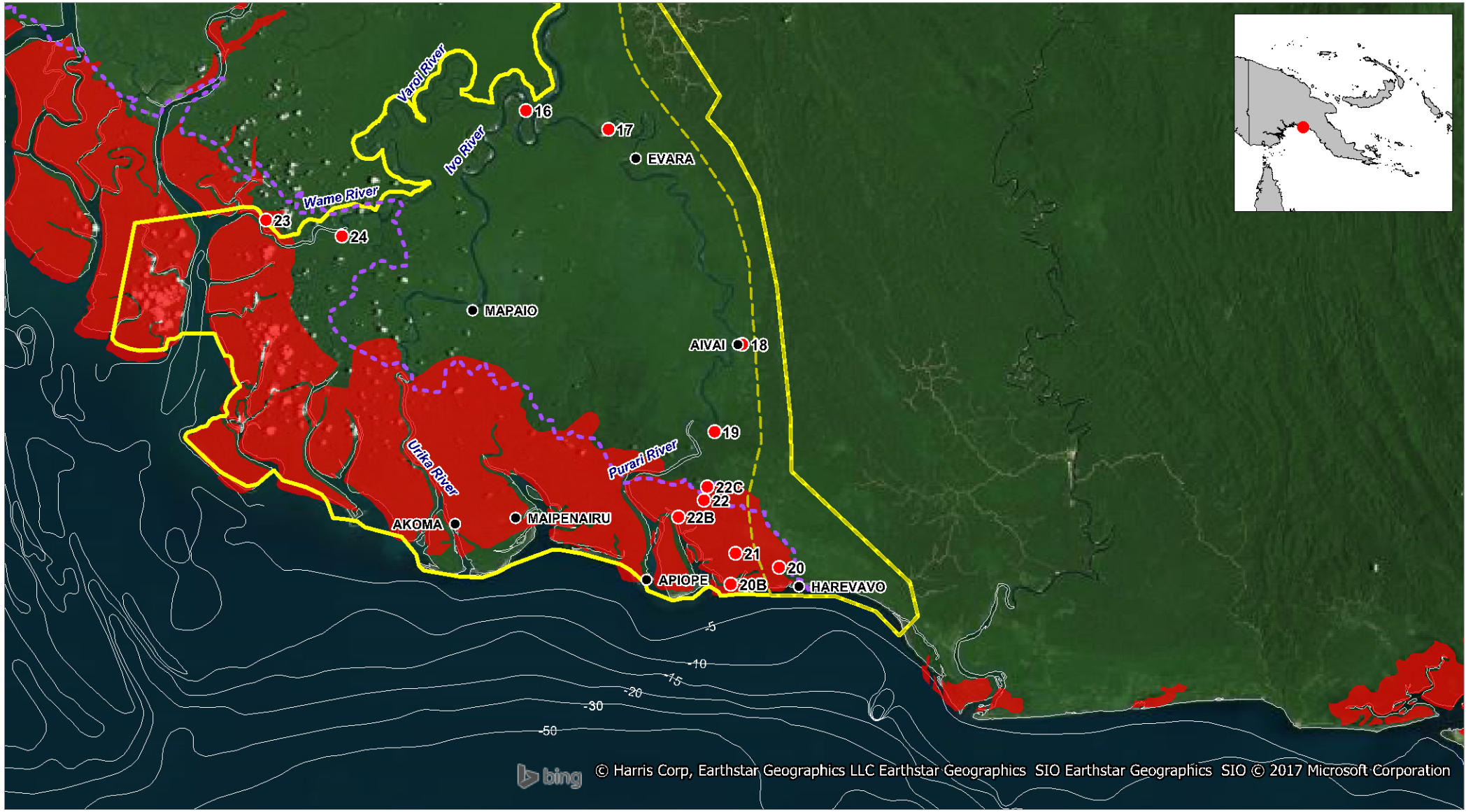
- *Sonneratia* species numerically dominated in low energy environments (i.e. inside bends) (Figure 6-12) while *Avicennia* and *Sonneratia* also tended to occur in greater abundance in more coastal environments within the estuarine zone such as sites 20, 20B (June-July 2016 survey only) and 22B (also see Cragg 1983).
- High-energy creek margins with steep cut-off banks throughout the estuarine extent of the study area have mangrove forests dominated by *Nypa fruticans* (Figure 6-12).
- *N. fruticans* was also noted in dense monospecific stands around the freshwater/estuarine boundary by Cragg (1983). In the present study, dense *Nypa* was also observed near the freshwater/estuarine boundary at Site 22 and along the main channel of the Purari River.
- Mixed mangrove communities occur along moderately quiescent creek margins in lower estuarine areas. High floral diversity occurs within these regions (sites 20, 20B, 21 and 22B), with multiple representatives from a number of genera, including *Nypa*, *Sonneratia*, *Rhizophora*, *Xylocarpus*, *Avicennia, Ceriops* and *Bruguiera*.
- High-canopy mangrove forests occur further back from creek banks and included tall varieties of *Bruguiera* spp. (40 m canopies) and mixed *Rhizophora* and *Bruguiera* forests (Cragg 1983) which abut terrestrial communities in some areas.
- Throughout much of the estuarine area, the large influence of freshwater is evident, leading to interspersion of mangrove communities with other freshwater species, especially in more landward locations.
- Although Site 24 was within the extent of mangroves mapped by Shearman (2010), ground-truthing of this mapping shows that mangroves do not occur as far upstream as this site (see Figure 6-11). This is also reflected in the salinity at this site which is more closely aligned with freshwater sites within the Purari Delta. See Upstream Surface Water and Sediment Quality (BMT WBM, 2017b).

[6] Aquatic vegetation observations were also made at other field sites but no mangroves occurred at these locations

The floristic characteristics of the estuary are summarized below and are described in detail in the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b). Mangrove and other estuarine species identified during June-July 2016 and January 2017 surveys by BMT WBM are listed in Table 6-4.

Table 6-4 Mangrove Species Observed at Survey Sites in the Purari River Estuary

Mangrove species	Site							
	20	20B	21	22	22B	22c	23	24
Nypa fruticans	✓	✓	✓	✓	✓	✓	✓	
Avicennia sp.	✓				✓			
Sonneratia lanceolata	✓	✓			✓			✓
Sonneratia sp 1	✓							
Aegiceras sp.	✓	✓			✓			
Xylocarpus granatum	✓		✓		✓			
Bruguiera parviflora	✓		✓			✓		✓
Bruguiera rhynchopetala	✓	✓						
Bruguiera sp.		✓				✓		
Ceriops decandra		✓				✓		
Cynometra sp.	✓		✓	✓				
Rhizophora apiculata			✓		✓			
Heritiera sp.			✓			✓		
Barringtonia sp.			✓		✓			
Acanthus sp.		✓						
Dolichandrone spathacea					✓		✓	✓
Campostemon sp.			✓					
Total sp. observed	**9**	**7**	**7**	**2**	**8**	**5**	**2**	**3**



LEGEND

- Town/Village
- Purari Delta Sampling Sites
- Indicative Estuarine/ Freshwater Boundary (Shearman 2010)
- FIMS Vegetation - Mangroves
- Study Area
- Narrowed Onshore Pipeline Corridor
- -5 Contours (m)

Title:

Approximate Landward Extent of Mangroves in the Purari Delta Based on Shearman (2010) and Ground-truthing

Figure: 6-11

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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0km 10 20

Approx. Scale

BMT WBM
www.bmtwbm.com.au

Filepath: I:\B21414_I_GML_Elk_Antelope_EIA_JV\DRG\ECO_045_170526_Purari mangroves.wor



Figure 6-12 Fringing Stands of *Nypa fruticans* (top) and *Sonneratia lanceolata* (bottom) in the Purari River Estuary

6.2.2 Representativeness of Biotopes

The largest rivers in Papua New Guinea are the Fly and Sepik rivers (both >1,000 km long), Purari (600 km), Kikori (320 km), Markham (170 km) and Watut rivers (157 km) (Osbourne, 1987). All of these rivers contain an extensive network of tributary streams not included in these distances. The total area of riverine systems within Papua New Guinea has not been mapped so it is not possible to determine the extent of study area streams relative to the national total.

Papua New Guinea has high rainfall (and river discharges), and due to its mountainous topography, rivers tend to have high velocities in their upper reaches (Osbourne, 1987). The types and combination of lotic (riverine) biotope types found in the study area are characteristic and representative of those found elsewhere in Papua New Guinea and worldwide: fast flowing low order streams in areas with steep topography, which widen and lose velocity at lower gradients, and eventually form large turbid lowland river system in the lowland environments.

The Purari River has a broad floodplain containing a range of wetland types. The most extensive wetland types found in the lower Purari River are lowland freshwater swamps (forested wetlands) and to lesser extent marshes and lakes. The floodplain wetland types occurring along the Purari River are well represented throughout Papua New Guinea. In 1972 and 2002 it was estimated that swamp forest extent in Papua New Guinea was approximately 3.4 million hectares, remaining stable over time (Shearman *et al.* 2008). Lowland freshwater wooded and herbaceous swamps (e.g. marshes) represent 11% of Papua New Guinea's land area and occur throughout the country, with the largest occurring in the Sepik River basin, Fly River basin and the numerous other river systems that also discharge into Gulf of Papua (Kikori, Turama, Purari, Vailala) (Paijmans, 1976).

These comparisons indicate that the aquatic biotope types found in the study area are well represented at a national scale.

6.2.3 Sensitive Species and Ecosystems

6.2.3.1 Threatened/Important Species

The only threatened aquatic flora species likely or known to occur in the study area is the Haines orange mangrove (*Bruguiera hainesii*) (Figure 6-13). The status of this species against the threatened/important species categories of Section 5.7.1 is provided below.

***Bruguiera hainesii* – Haines orange mangrove**

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	✓	Critically Endangered
Endemic and/or restricted-range	×	Species is not restricted to a single ecoregion in the study area.
Migratory and congregatory	×	n/a
Overall sensitivity	***Extreme vulnerability***	

Ono *et al.* (2016) indicate that *B. hainesii* is a hybrid between *B. cylindrica* and *B. gymnorhiza*. Both of these species are Least Concern under the IUCN (no other categories apply) with a global decline in population. However, as the IUCN Red List still includes *B. hainesii* as a distinct species, it is

treated as a Critically Endangered species for the purposes of this report, adopting a precautionary approach. Note also that, if this status did not apply, the hybrid would be considered to be of *moderate vulnerability* as its component species, although of Least Concern, have a decreasing global population.

Bruguiera hainesii is an uncommon mangrove species that has a limited and fragmented distribution within Southeast Asia, New Guinea and northern Australia. Only 120 mature individuals were known to remain in Papua New Guinea in 2010 (Duke *et al.* 2010). The study area is within the known geographic distribution of this species in Papua New Guinea. *B. hainesii* was recorded within the mangrove forests of the Purari Delta during surveys undertaken by ERIAS Group, as recorded in the Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b).



Figure 6-13 Mangrove Habitats in Study Area including *B. hainesii* (left) (ERIAS Group, 2017b)

6.2.3.2 Important or Sensitive Aquatic Biotopes

Particular aquatic biotope features in the study area are also considered to be important in their own right. For example, this includes areas that represent significant habitat features for a high diversity of species, unique aquatic biotope features in a regional or greater context, and/or areas that may promote species endemism. Significant aquatic ecosystem features are as follows:

- Contiguous mangrove forests of the Omati-Kikori-Purari delta region, which:
  - represent the largest contiguous mangrove forest system in Papua New Guinea (Shearman 2010). Extensive mangrove forests along the Gulf of Papua coastline cover 260,882 ha (Shearman 2010) and are known to be some of the largest in the Asia-Pacific region. Together

with the Kikori River mangrove system, the Purari mangrove system is one of the largest continuous areas of mangroves in Papua New Guinea.

- in a mostly pristine condition, having not been subject to large-scale clearance nor subject to land reclamation.
- have a rich mangrove flora. Southern Papua New Guinea has the highest number of mangrove species in the world, including 31 of the 33 species known from Papua New Guinea, and including the threatened *Bruguiera hainesii* (ERIAS Group, 2017b; Ellison, 1997).

- Wetlands on the western floodplain of the Purari River. This extensive floodplain wetland system contains a wide diversity of wetland types, including palustrine (marshes), lacustrine (oxbow lake) and lotic (running stream) systems. It is possible that some of these wetland environments contain peat wetlands. The distribution and extent of peat wetlands in Papua New Guinea is not well documented, and it is therefore not known whether they are well represented at a regional or national scale. Elsewhere, such environments are known to have: (i) low pH, low nutrient concentrations (typically oligotrophic) and low turbidity; (ii) support specialist aquatic fauna species that are adapted to this unique water chemistry (Yule, 2008). However, these wetlands are expected to be periodically inundated by overbank flooding by the Purari River (BMT WBM, 2017a), and therefore unlikely to support species that are highly sensitive to pulses of high turbidity and neutral pH.
- PRL-15 plateau catchments (see Figure 5-1 for location). Plateaus within PRL-15 (at sites 7 and 8) support waterways that are largely isolated from lowland environments[7]. Isolation (over geological timescales) is a key driver of speciation, and such environments can represent centers of local endemism (e.g. Lake Kutubu, which drains into the Kikori River). It has therefore been conservatively assumed that plateaus waterbodies represent features of potential biodiversity sensitivity. Of these two plateaus (discussed further below) the northern is considered to have a higher likelihood of being significant due to the presence of a significant waterway barrier.

  The northern plateau drainage and catchment area (near Site 8) appears to be separated from downstream areas by a significant barrier in the form of a large waterfall located on the main drainage flowing off the plateau (Figure 6-14). Waterbody isolation (over geological timescales) can lead to speciation and endemism, and it is therefore possible that unique species or genetically distinct sub-populations may exist above the waterfall.

  The southern plateau differed from the northern plateau in that there are no obvious barriers to fish passage along the main drainages flowing from the plateau. The main drainages flowing from the plateau area are composed of moderate gradient streams confined within steep gorges. However at least one waterfall was observed on a tributary stream on the higher plateau of the catchment, and steep cliff faces where observed elsewhere in this area. These cliff faces and waterfall represent potential significant barriers within smaller drainages in the higher catchment areas. It is therefore possible that unique species or genetically distinct sub-populations may exist within these smaller streams on the upper catchment of the southern plateau.

[7] These creeks drain to other lowland environments via waterfalls



Figure 6-14 Waterfall on Stream Flowing from the Northern Plateau Area

Crater Mountain WMA borders the northern bank of the Purari River upstream of the confluence of the Aure River. While the part of the WMA within the study area is not expected to have higher sensitivity than nearby areas outside of the WMA, it is nonetheless recognized as an area requiring protection in accordance with Papua New Guinea legislation.

Swartzendruber (1993) and Johns (1993) have identified parts of the study area as biologically sensitive areas. The Purari Basin is listed by Swartzendruber (1993) as a 'Biologically Important Area', with specific reference to the diversity of mangrove and swamp vegetation together with an expected high level of local plant endemics. Similarly, Johns (1993) places the area within the Gulf-Ihu 'Botanically Important Area' on the basis of the same features. Areas of high level plant endemism within the study area, therefore, are regarded to be sensitive ecosystems.

6.2.4 Aquatic Fauna Habitat Provisioning

Sections 6.3.2 (aquatic invertebrates), 6.4.6 (fish) and 6.5 (dolphins) discuss the potential occurrence of threatened/important species within the study area. In summary, the following aquatic biotopes are considered to provide potential habitat to threatened aquatic fauna:

- Main channel of the Purari River (including Ivo-Urika and Wame-Varoi rivers) and large, semi-confined turbid tributaries, especially within the Purari Delta – these waterways provide suitable habitat for the occurrence of threatened river sharks (*Glyphis garricki* and *G. glyphis*) rays

(*Glaucostegus typus*), sawfish (*Pristis pristis* and *P. zijsron*) and dolphins (*Orcaella heinsohni* and *Sousa sahulensis*), and these species are known or likely to occur in adjacent coastal environments (Section 6.4.6).

- Freshwater wetlands, including the PRL-15 oxbow wetlands – these areas contain potential habitat for the endemic aquatic insect species (*Ciliometra setosa*, *Iobates ivimka*). It has been conservatively assumed that they could occur in the study area.

In addition, as identified in Haines (1979) the mangroves and estuarine wetlands of the Purari River catchment are important spawning and nursery habitat for a significant proportion of the fish species occurring within the catchment as well as adjoining marine waters.

6.3 Aquatic Macroinvertebrates

6.3.1 Patterns in Assemblage Structure

A list of estuarine and freshwater macroinvertebrates families recorded in the study area in the present study is provided in Table 6-6 to Table 6-12. Semi-quantitative surveys of aquatic macroinvertebrate assemblages were conducted in three hydraulic habitat units including riffle, edge and pool habitats (in accordance with the AusRivAS methodology) and across three biotope types: Low Gradient Tributary Stream, High-to-Medium Gradient Tributary Stream and Unconfined Major River Systems and Floodplain Stream Mouths.

6.3.1.1 PRL-15 and Purari River

Aquatic macroinvertebrate sampling was undertaken within freshwater tributary streams in PRL-15 and surrounds as part of the 2008 and 2010 aquatic surveys for the Elk/Antelope Gasfield Project EIS (DES, 2008 and unpublished report, 2010) and the July 2016 and February 2017 surveys for the current Project. Table 6-5 lists the orders and families of macroinvertebrates identified in the study area as part of these surveys. At least 35 different families were identified across these surveys.

Douglas Environmental Services (2008) found that Baetidae mayflies (Ephemeroptera) were the most common taxon overall. Atyidae shrimps, Caenidae mayflies and Philopotamidae caddisfly were also widespread and abundant. Similar results were obtained during the 2010 surveys (unpublished).

In July 2016 (dry season), a total of 8,760 individuals belonging to 56 aquatic macroinvertebrates families were recorded at the 13 freshwater sites. Consistent with DES (2008) and unpublished report (2010), the aquatic macroinvertebrate fauna reported in July 2016 was numerically dominated by mayfly (Ephemeroptera) families (Baetidae, Caenidae and Leptophlebiidae; Table 6-5), which together accounted for 57% of the catch. Other abundant taxa were Hemiptera (true bugs), which accounted for almost 10% of the catch, while non-biting midges from the sub-family Chironominae represented over 14% of the catch. Other common fauna included decapod crustaceans (freshwater shrimp and prawns), oligochaete (worms), Coleoptera (Beetles), Plecoptera (Stoneflies) and Trichoptera (caddisflies). Mollusks (snails and mussels), Odonata (dragonflies), nematodes (round worms), Tricladida (flatworms), Acarina (mites), Collembola (springtails) and Nemertea (ribbon worms) were recorded in low abundance in the study area collectively representing less than 3% of the total number of individuals collected.

In February 2017 (wet season), a total of 32,988 individuals belonging to 63 aquatic macroinvertebrate families were reported at 12 freshwater sites (Table 6-5). The aquatic macroinvertebrate fauna reported was numerically dominated by copepods (Copepoda) that accounted for 23% of the catch, and Hemiptera (true bugs) family Corixidae, which accounted for 20% of the catch. Other abundant taxa were mayfly (Ephemeroptera) families (Baetidae, Caenidae and Leptophlebiidae), which together accounted for 28% of the catch, while non-biting midges from the sub-family Chironominae represented over 15% of the catch. Other common fauna included Diptera (true flies), Plecoptera (stoneflies), Oligochaeta (worms) and decapods (freshwater shrimp and prawns). Acarina (mites), Odonata (dragonflies), nematodes (round worms), Trichoptera (caddisflies) and Coleoptera (beetles and weevils) were reported in low abundance, representing approximately 2% of the total number of individuals collected.

In terms of edge habitat samples, 4,643 individuals from 32 taxa were recorded at 12 sites in July 2016. The most abundant taxa were generally also the most widespread. For example, Ephemeroptera (mayflies) families Baetidae, Caenidae and Leptophlebiidae (47%, 7% and 3% of catch respectively, recorded at 12, seven and six sites respectively), Hemiptera (true bugs) families Corixidae and Gerridae (15% and 7% of the catch respectively both at 7 sites), and Diptera (non-biting midge) sub-family Chironominae (10% of the catch at 12 sites) (Table 6-6). In February 2017, 20,354 individuals from 55 taxa were recorded at 12 sites in edge habitat samples. The most abundant taxa were copepods (38% of the catch, at seven sites), Hemiptera (true bugs) family Corixidae (31% of the catch, at 10 sites), and Ephemeroptera (mayflies) families Baetidae, Caenidae and Leptophlebiidae (9%, 3% and 2% of the catch respectively, at all 12 sites). All other taxa recorded contributed to approximately 18% of the catch (Table 6-7).

For riffle habitat samples, 3,092 individuals within 42 taxa were recorded at seven sites in July 2016. As with edge habitats, the most abundant taxa were the Ephemeroptera (mayflies) families Baetidae, Leptophlebiidae and Caenidae (40%, 13% and 6% of the catch respectively, all at seven sites) and non-biting midge sub-family Chirononminae (20% of the catch, at seven sites). The remaining taxa comprised approximately 20% of the catch (Table 6-8). In February 2017, 12,086 individuals from 43 taxa were recorded at seven sites in riffle habitat samples. Similar to riffle habitat samples recorded in July 2016, the most abundance taxa were the Ephemeroptera (mayflies) families Baetidae, Leptophlebiidae and Caenidae (28%, 20% and 5% of the catch respectively, at all seven sites), non-biting midge sub-family Chirononminae (25% of the catch, at all seven sites) and stone fly order Plecoptera (9% of the catch, at all seven sites). All other taxa recorded contributed to 12% of the overall catch (Table 6-9).

Based on pool habitat samples, 1,025 individuals from 10 taxa were recorded at nine sites in July 2016. Again, the most abundant taxa were Baetidae and Caenidae mayflies (51% and 8% of the catch respectively, at five and six sites respectively). No fauna was recorded in samples from sites 11 and 12 (likely due to survey constraints)[8]. All other taxa recorded contributed between 1% and 5% of the overall catch. In February 2017, 548 individuals from nine taxa were recorded in pool habitat samples. The most abundance taxa were oligochaete worms Oligochaeta and family Turbificidae (8% and 64% of the catch respectively, at all five sites) and non-biting midge sub-families

[8] Sites 11 and 12 were subject to high flow events immediately prior to or at the time of sampling which affects the abundance of macroinvertebrate assemblage.

Tanypodinea and Chirononminae (16% and 8% of the catch, at four sites). The remaining taxa comprised approximately 5% of the catch (Table 6-10 and Table 6-11).

Taxonomic richness (number of morpho-species) was typically less than 35 taxa per site in all habitat units (edge, riffle and pool). Richness was also similar across biotope types (Low Gradient Tributary Stream, High-to-Medium Gradient Tributary Stream and Purari River Channel sites). Shannon diversity index (morpho-species-level diversity) had an average index of 0.68 across all hydraulic habitat units. In this regard:

- Edge habitat (i.e. habitat at the littoral margins/edge of the waterway) – taxonomic richness and Shannon diversity index[9] was relatively similar among biotope types (Figure 6-15). Site 14 (Purari River Channel) had notably greater total mean abundance during July 2016 (678 ± 35 individuals) and February 2017 (4600 ± 435 individuals) than other sites, reflecting high abundance of Baetidae species.
- Riffle habitat (i.e. habitat marked by shallow flowing water with broken water surface) – taxonomic richness and Shannon diversity index was also similar among biotope types (Figure 6-16). Most High-to-Medium Gradient Stream sites sampled in February 2017 had greater total mean abundance than Site 2 (Low Gradient Tributary Stream) and Site 14 (Purari River Channel), reflecting high abundance of Baetidae species.
- Pool habitat (i.e. deep and still water habitats) – taxonomic richness, Shannon diversity index and total mean abundance of macroinvertebrates was generally lower than edge and riffles habitats (Figure 6-17). On average, Purari River Channel sites had a lower family-level richness and abundance than Low Gradient Tributary Stream and High-to-Medium Gradient Stream sites.

[9] This is a commonly used index in assessing the diversity of ecological features

Table 6-5 Freshwater Macroinvertebrate Taxa Identified by Sampling in the Study Area in Previous Studies

Order	Family	Description	2008*	2010*
Basommatophora	Ancylidae	Air-breathing snails and slugs		
Branchiobdellida	(unknown)	Branchiobdellian worms	✓	✓
Coleoptera	Elmidae	Riffle beetles	✓	✓
	Gyrinidae	Whirligig beetles	✓	✓
Decapoda	Atyidae	Atyid shrimps	✓	✓
Diptera	Simuliidae	Black flies		✓
	Chironomidae	Chironomids		✓
	Tanypodinae	n/a		
	Palaemonidae	Palaemon shrimps	✓	✓
Ephemeroptera	Baetidae	Small mayflies	✓	✓
	Leptophlebiidae	Prong-gilled mayflies	✓	
	Caenidae	Small square-gill mayflies	✓	
Haplotaxida	Naididae	Detritus worms		
Hemiptera	Nepidae	Water scorpions		✓
	Gerridae	Water striders		✓
	Veliidae	Riffle bugs		✓
	Corixidae	Water boatmen		
	Naucoridae	Creeping water bugs		
	Notonectidae	Backswimmers		
Hirundinea	-	Leeches		✓
Mollusca	Thiaridae	Gilled snails		✓
	Planorbidae	Ramshorn snails		✓
Orthoptera	Acrididae	Locusts		✓
Odonata (Anisoptera)	Aeshnidae	Hawkers (dragonfly)		✓
Odonata	Libellulidae	Skimmers (dragonfly)	✓	✓
Odonata (Zygoptera)	Platystictidae	Damselflies		✓
Trichoptera	Hydropsychidae	Net-spinning caddisflies		✓
	Philopotamidae	Finger-net caddisflies	✓	
	Calamoceratidae	n/a	✓	
Trombidiformes	Hydrachnidia	Water mites		✓
Acarina (mites and ticks)			✓	✓
Collembola (springtails)			✓	✓
Copepoda (copepods)			✓	✓
Oligochaeta (microdrile worms)			✓	✓
Plecoptera (stoneflies)			✓	✓

*Data sources: DES (2008) and unpublished report (2010)

Table 6-6 Total Abundance of the Most Abundant Aquatic Macroinvertebrates at Survey Sites – Edge Habitats (July 2016 Survey)

Order	Family or Higher Taxa	Morpho-species	Freshwater – Tributaries/Clear Water							Purari River Main Channel*					Total
			Low Gradient	High to Moderate Gradient											
			Sites							Sites					
			1B	3B	4	5	6	9	10	11	12	13	14	15	
Crustacea	Atyidae	Atyid 1	0	0	0	0	0	0	0	0	0	0	21	0	**21**
		Atyid 2	1	0	0	0	0	0	0	13	2	1	1	0	**18**
	Palaemonidae	*Macrobrachium* sp 1	13	15	3	4	6	9	0	0	0	0	16	0	**66**
	Copepoda	Copepod sp	0	0	5	0	0	5	0	0	0	5	0	0	**15**
Insecta	Baetidae	Baetidae sp	35	90	96	51	128	35	7	4	345	1	1268	51	**2,111**
	Caenidae	Caenidae sp	0	25	26	2	24	34	0	0	0	0	210	10	**331**
	Leptophlebiidae	Leptophlebiidae sp	0	1	4	8	0	17	0	1	0	0	117	0	**148**
	Hydropsychidae	Hydropsychidae sp	1	0	1	1	0	1	0	0	0	0	10	0	**14**
	Plecoptera	Plecoptera sp.	0	10	3	0	0	0	1	0	0	0	25	0	**39**
	s-f Chironominae	Chironomid 2	0	0	7	6	0	2	2	0	1	0	51	0	**69**
		Chironomid 3	2	3	3	1	4	4	0	0	0	0	43	12	**72**
		Chironomid 4	1	2	13	22	34	2	2	0	3	1	77	7	**164**
		Chironomid 5	0	0	0	8	0	0	0	0	0	0	8	2	**18**
		Chironomid pupa	0	0	0	4	5	1	0	0	0	0	10	5	**25**
	s-f Tanypodinae	Tanypodinae 2	0	0	1	4	0	7	0	0	3	1	25	3	**44**
		Tanypodinae 3	0	0	3	0	0	4	0	0	0	0	7	4	**18**
	Simuliidae	Simuliidae sp	1	0	0	1	1	7	0	0	0	0	14	0	**24**
	Corixidae	*Micronecta* sp 1	6	302	0	0	1	0	0	0	0	4	0	4	**317**
		Micronecta sp 2	4	1	0	1	83	0	1	0	0	23	0	0	**113**
		Micronecta sp juv	0	4	0	0	180	0	0	0	0	49	0	3	**236**
	Gerridae	*Tennagogerris* sp	0	112	1	1	0	1	0	2	0	0	1	2	**120**

Order	Family or Higher Taxa	Morpho-species	Freshwater – Tributaries/Clear Water							Purari River Main Channel*					Total
			Low Gradient	High to Moderate Gradient											
			Sites							Sites					
			1B	3B	4	5	6	9	10	11	12	13	14	15	
	Veliidae	Veliidae sp	7	24	0	2	9	7	0	3	0	12	4	3	**71**
Acarina	Acarina	Mite sp.	0	1	0	0	0	12	0	0	0	0	0	0	**13**
Collembola	Collembola	Collembola sp.	0	1	9	0	0	0	0	4	0	7	2	15	**38**
Oligochaeta	Oligochaete	Oligochaete sp.	21	9	25	1	15	6	7	29	8	5	2	12	**140**
	Naididae	Naididae sp.	0	0	0	0	0	0	0	0	0	0	40	0	**40**
Mollusca	Thiaridae	Thiaridae 1	0	1	0	11	0	4	0	0	0	0	0	0	**16**
		Thiaridae 2	0	0	0	21	2	6	0	0	0	0	0	0	**29**
Totals			**92**	**601**	**200**	**149**	**492**	**164**	**20**	**56**	**362**	**109**	**1,952**	**133**	**4,330**

*Sampling at the Purari River Main Channel sites was undertaken in the mouth of tributaries

Table 6-7 Total Abundance of the Most Abundant Aquatic Macroinvertebrates at Survey Sites – Edge Habitats (February 2017 Survey)

Order	Family or Higher Taxa	Morpho-species	Freshwater – Tributaries/Clear Water							Purari River Main Channel*					Total
			Low Gradient	High to Moderate Gradient											
			Sites							Sites					
			2	3B	4	5	6	9	10	11	12	13	14	15	
Acarina	Acarina	Mite sp.	0	23	0	27	0	2	5	2	0	0	0	3	**62**
Collembola	Collembola	Springtail	6	0	0	2	0	0	0	9	1	10	0	16	**44**
Copepoda	Copepoda	Copepod	1	55	5	5	0	15	0	0	0	160	7496	0	**7737**
Crustacea	Decapoda	Shrimp juv	65	4	6	5	5	1	1	3	0	0	0	0	**90**
	Palaemonidae	*Macrobrachium* sp 1	40	23	4	8	27	8	15	0	0	0	0	0	**125**
Diptera	Ceratopogonidae	Ceratopoginidae 2	5	1	16	2	0	5	1	0	0	1	7	1	**39**
		Ceratopoginidae juv	0	20	0	0	0	5	5	0	0	15	5	0	**50**
	s-f Tanypodinae	Tanypodinae 2	14	13	18	3	13	32	75	0	0	2	5	0	**175**
		Tanypodinae 3	13	6	4	3	0	2	12	0	0	0	7	1	**48**
		Tanypodinae 4	0	0	0	0	0	0	0	0	0	0	163	0	**163**
	s-f Chironominae	Chironomid 1	5	5	2	2	5	6	105	0	0	0	0	0	**130**
		Chironomid 2	9	10	19	3	3	14	175	1	1	0	2	0	**237**
		Chironomid 3	0	1	4	2	0	0	41	0	0	0	0	0	**48**
		Chironomid 4	62	97	34	94	50	38	121	0	0	3	32	0	**531**
		Chironomid other (juv/damaged)	87	123	10	227	50	114	73	0	0	0	40	0	**724**
		Chironomid pupa	0	10	7	10	4	11	20	0	0	0	0	0	**62**
	Simuliidae	Simuliidae	5	1	0	65	0	6	2	0	0	0	0	0	**79**
Ephemeroptera	Baetidae	Baetidae	157	497	197	257	396	87	187	3	8	12	3	0	**1804**
	Caenidae	Caenidae	140	35	46	37	253	22	14	0	0	0	1	0	**548**
	Leptophlebiidae	Leptophlebiidae	24	6	17	25	71	112	44	0	0	5	1	0	**305**
Hemiptera	Corixidae	*Micronecta* sp 1	0	0	0	0	0	0	0	0	15	264	0	10	**289**

Order	Family or Higher Taxa	Morpho-species	Freshwater – Tributaries/Clear Water							Purari River Main Channel*					Total
			Low Gradient	High to Moderate Gradient											
			Sites							Sites					
			2	3B	4	5	6	9	10	11	12	13	14	15	
		Micronecta sp 2	0	2	1	0	0	1	0	4	18	66	2325	1	**2,418**
		Micronecta sp juv	0	12	8	2	0	0	5	0	16	179	3665	3	**3,890**
	Gerridae	Tennagogerris sp	1	11	0	1	0	0	4	23	14	5	6	2	**67**
	Veliidae	Veliidae	1	10	0	4	0	1	1	20	39	5	0	11	**92**
	Odonata	Damsel fly juv	23	0	1	0	0	1	0	0	0	0	1	0	**26**
Oligochaeta	Naididae	Naididae	0	15	0	10	0	10	25	0	0	0	5	0	**65**
	Oligochaeta	Oligochaete	2	2	3	6	2	10	3	4	0	12	2	1	**47**
Plecoptera	Plecoptera	Stone fly	0	7	0	68	1	6	37	0	0	0	0	0	**119**
Ostracod			0	0	0	0	0	0	0	0	0	0	25	0	**25**
Totals			**660**	**989**	**402**	**868**	**880**	**509**	**971**	**69**	**112**	**739**	**13,791**	**49**	**20,039**

*Sampling at the Purari River Main Channel sites was undertaken in the mouth of tributaries

Table 6-8 Total Abundance of Most Abundant Aquatic Macroinvertebrates at Survey Sites – Riffle Habitats (July 2016 Survey)

Order	Family or Higher Taxa	Morpho- species	Freshwater- Tributaries/Clear Water						Purari River Main Channel*	Total
			Low Gradient	High to Moderate Gradient						
			Sites						Sites	
			2	3B	4	5	6	9	14	
Decapoda	Palaemonidae	Macrobrachium sp 1	34	16	7	6	12	6	1	**82**
Coleoptera	Coleoptera	Beetle 2	0	0	0	11	1	13	0	**25**
Insecta	s-f Chironominae	Chironomid 1	0	1	38	11	0	1	2	**53**
		Chironomid 2	16	5	10	49	1	7	8	**96**
		Chironomid 3	23	3	0	7	1	1	200	**235**
		Chironomid 4	37	3	8	12	1	0	13	**74**
		Chironomid other (juv/damaged)	30	1	5	6	1	0	74	**117**
	Simuliidae	Simuliidae	34	2	1	31	2	20	0	**90**
	Baetidae	Baetidae	263	175	96	144	176	12	386	**1252**
	Caenidae	Caenidae	57	23	11	10	17	13	46	**177**
	Leptophlebiidae	Leptophlebiidae	88	18	52	42	29	150	18	**397**
	Plecoptera	Stone fly	0	8	22	19	2	9	2	**62**
	Hydropsychidae	Hydropsychidae	4	0	5	10	1	38	1	**59**
	Philopotamidae	Philopotamidae	0	0	1	9	0	34	0	**44**
Oligochaeta	Oligochaeta	Oligochaete	5	2	1	6	7	2	1	**24**
Totals			**591**	**257**	**257**	**373**	**251**	**306**	**752**	**2,787**

*Sampling at the Purari River Main Channel sites was undertaken in the mouth of tributaries

Table 6-9 Total Abundance of Most Abundant Aquatic Macroinvertebrates at Survey Sites – Riffle Habitats (February 2017 Survey)

Order	Family or Higher Taxa	Morpho- species	Freshwater – Tributary/Clear Water							Total
			Low Gradient	High to Moderate Gradient						
			Sites							
			2	3B	4	5	6	9	10	
Acarina	Acarina	Mite sp.	0	7	0	21	0	1	11	**40**
Coleoptera	Elmidae	Elmid larvae 2	0	48	1	11	0	1	1	**62**
Crustacea	Atyidae	Atyid 1	0	0	23	0	40	0	0	**63**
	Palaemonidae	*Macrobrachium* sp 1	2	6	17	14	23	17	13	**92**
Diptera	s-f Tanypodinae	Tanypodinae 2	3	17	16	11	4	0	26	**77**
		Tanypodinae 3	3	7	0	3	0	2	11	**26**
	s-f Chironominae	Chironomid 1	69	79	57	16	3	112	155	**491**
		Chironomid 2	18	119	60	190	13	15	771	**1,186**
		Chironomid 3	1	8	4	11	1	0	32	**57**
		Chironomid 4	7	23	36	32	6	16	101	**221**
		Chironomid other (juv/damaged)	37	220	49	493	15	65	263	**1,142**
		Chironomid pupa	1	13	17	6	8	0	25	**70**
	Simuliidae	Simuliidae	39	24	13	117	0	37	8	**238**
	Tabanidae	Tabanidae 2	0	1	1	12	0	6	1	**21**
	Tipulidae	Tipulidae	2	6	3	3	0	2	11	**27**
	Caenidae	Caenidae	10	111	35	249	220	10	2	**637**
	Leptophlebiidae	Leptophlebiidae	10	137	163	730	320	949	149	**2,458**
Odonata	Libellulidae	Libellulidae 7	0	0	0	0	1	0	20	**21**
Oligochaeta	Naididae	Naididae	0	0	10	0	0	5	11	**26**
	Oligochaeta	Oligochaete	0	0	5	1	12	1	0	**18**
Paludicola	Dugesiidae	Dugesiidae	0	0	0	19	0	2	1	**22**

Order	Family or Higher Taxa	Morpho- species	Freshwater – Tributary/Clear Water							Total
			Low Gradient	High to Moderate Gradient						
			Sites							
			2	3B	4	5	6	9	10	
Plecoptera	Plecoptera	Stone fly	2	117	201	259	28	62	429	**1,098**
Trichoptera	Hydropsychidae	Hydropsychidae	0	45	108	43	6	61	29	**292**
	Philopotamidae	Philopotamidae	0	0	10	23	0	24	14	**71**
Totals			**204**	**988**	**829**	**2,264**	**700**	**1,388**	**2,084**	**8,457**

Table 6-10 Total Abundance of Most Abundant Aquatic Macroinvertebrates at Survey Sites – Pool Habitats (July 2016 Survey)

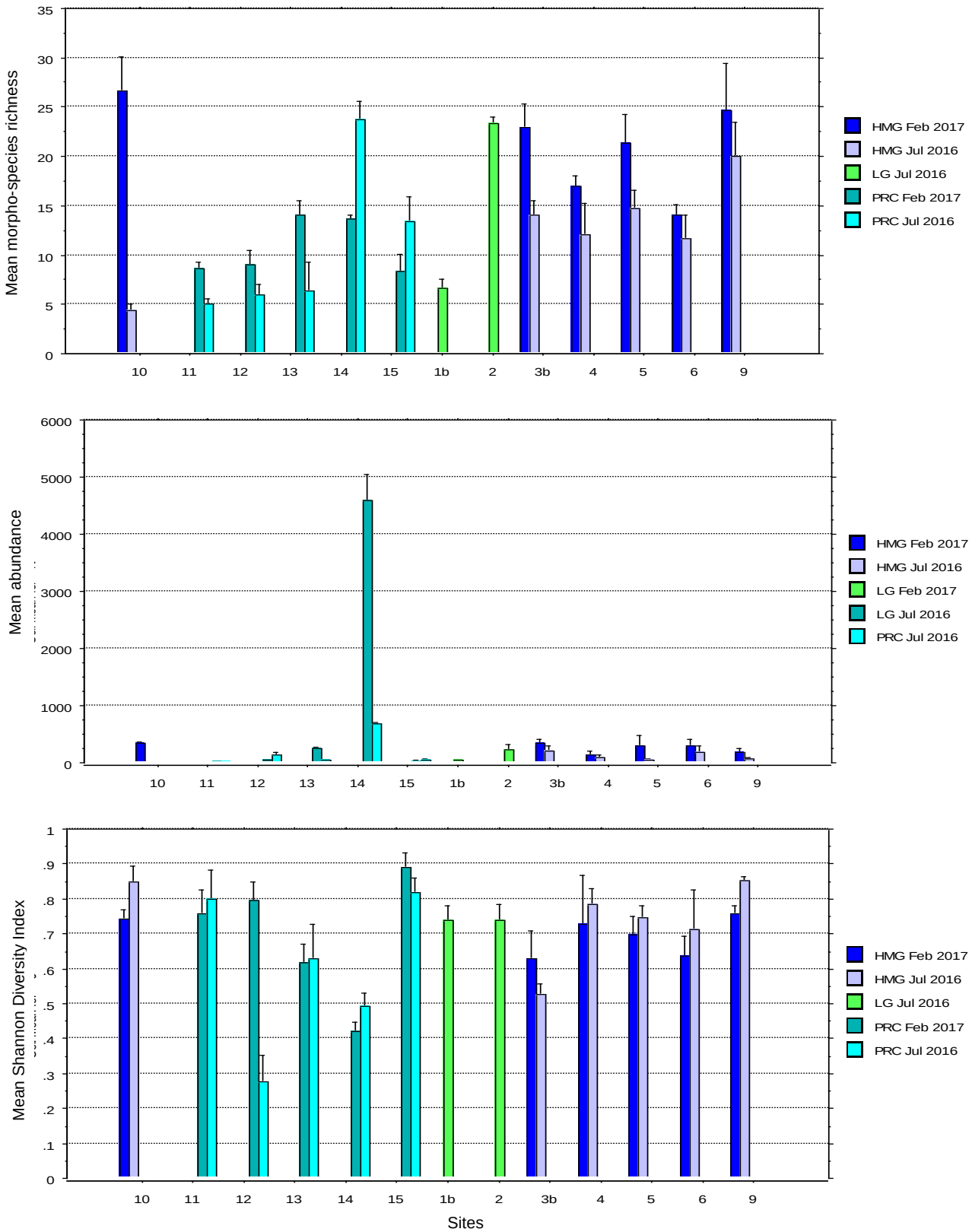
Order	Family or Higher Taxa	Genus species	Freshwater – Tributary/Clear Water			Purari River Main Channel*		Total
			Low Gradient		High to Moderate Gradient			
			Sites			Sites		
			1B	2	10	13	15	
Crustacea	Copepoda	Copepod	0	10	0	25	0	**35**
	Atyidae	Shrimp	4	13	1	0	0	**18**
	Palaemonidae	Macrobrachium sp 1	8	39	4	0	0	**51**
Insecta	Ceratopogonidae	Ceratopoginidae 2	1	0	5	6	1	**12**
	s-f Tanypodinae	Tanypodinae 1	25	0	0	0	0	**25**
		Tanypodinae 2	9	0	21	0	0	**30**
		Tanypodinae 3	0	15	1	2	0	**18**
	s-f Chironominae	Chironomid 2	1	3	14	0	0	**18**
		Chironomid 3	11	5	23	2	1	**41**
		Chironomid 4	7	12	20	0	0	**39**
		Chironomid other (juv/damaged)	1	9	21	6	1	**37**
	Baetidae	Baetidae	33	140	280	19	0	**472**
	Caenidae	Caenidae	6	12	46	11	2	**75**
	Leptophlebiidae	Leptophlebiidae	0	17	8	0	0	**25**
Oligochaeta	Oligochaeta	Oligochaete	0	8	12	10	7	**30**
Totals			**106**	**283**	**456**	**81**	**12**	**938**

*Sampling at the Purari River Main Channel sites was undertaken in the mouth of tributaries

Table 6-11 Total Abundance of Most Abundant Aquatic Macroinvertebrates at Survey Sites – Pool Habitats (February 2017 Survey)

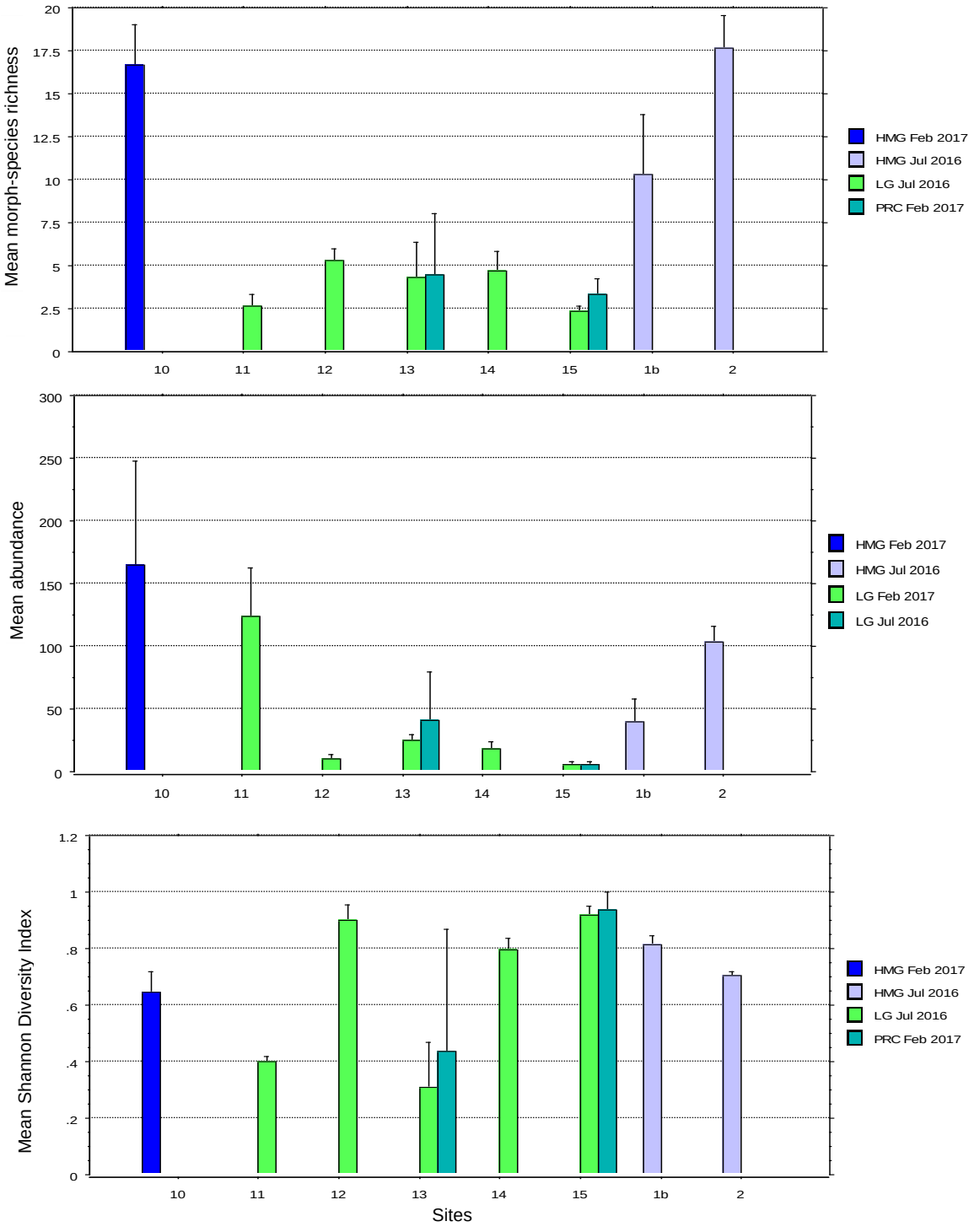
Order	Family or Higher Taxa	Genus species	Purari River Main Channel*					Total
			Sites					
			11	12	13	14	15	
Insecta	s-f Tanypodinae	Tanypodinae 4	0	0	62	12	8	**82**
	s-f Chironominae	Chironomid 4	0	2	0	24	0	**26**
	Corixidae	*Micronecta* sp juv	0	0	1	9	0	**10**
Oligochaeta	Oligochaeta	Oligochaete	37	0	3	2	0	**42**
	Naididae	Naididae	329	10	0	0	9	**348**
Totals			**366**	**12**	**66**	**47**	**17**	**508**

*Sampling at the Purari River Main Channel sites was undertaken in the mouth of tributaries



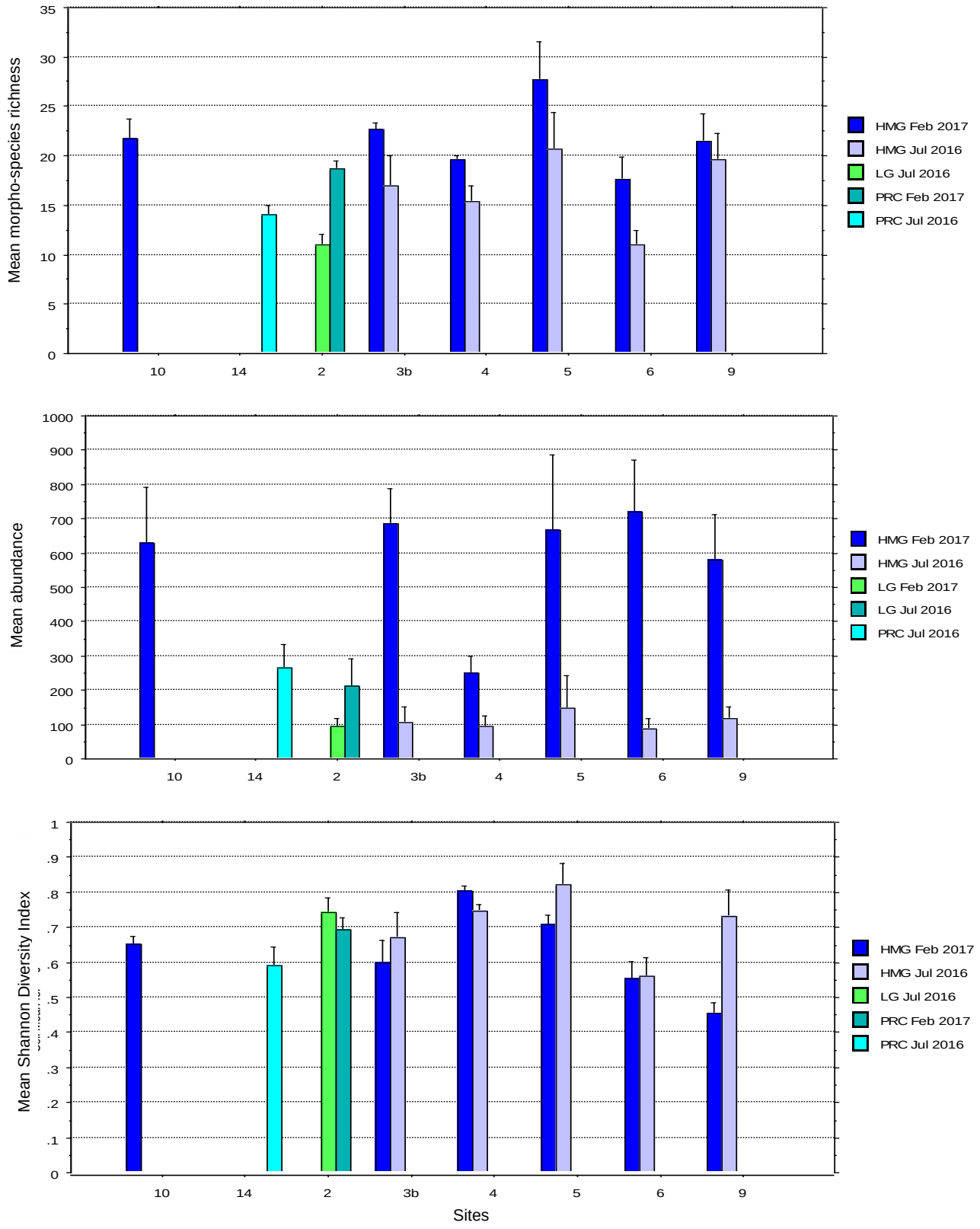
* HMG: High-to-medium gradient tributary stream, LG: Low gradient tributary stream; PRC: Purari River Main Channel

Figure 6-15 Mean (±S.E.) for Macroinvertebrate Indicators for Edge Habitats: Taxonomic Richness (top), Abundance (middle) and Shannon's Diversity (bottom)



* HMG: High-to-medium gradient tributary stream, LG: Low gradient tributary stream; PRC: Purari River Main Channel

Figure 6-16 Mean (±S.E.) for Macroinvertebrate Indicators for Riffle Habitats: Taxonomic Richness (top), Abundance (middle) and Shannon's Diversity (bottom)



* HMG: High-to-medium gradient tributary stream, LG: Low gradient tributary stream; PRC: Purari River Main Channel

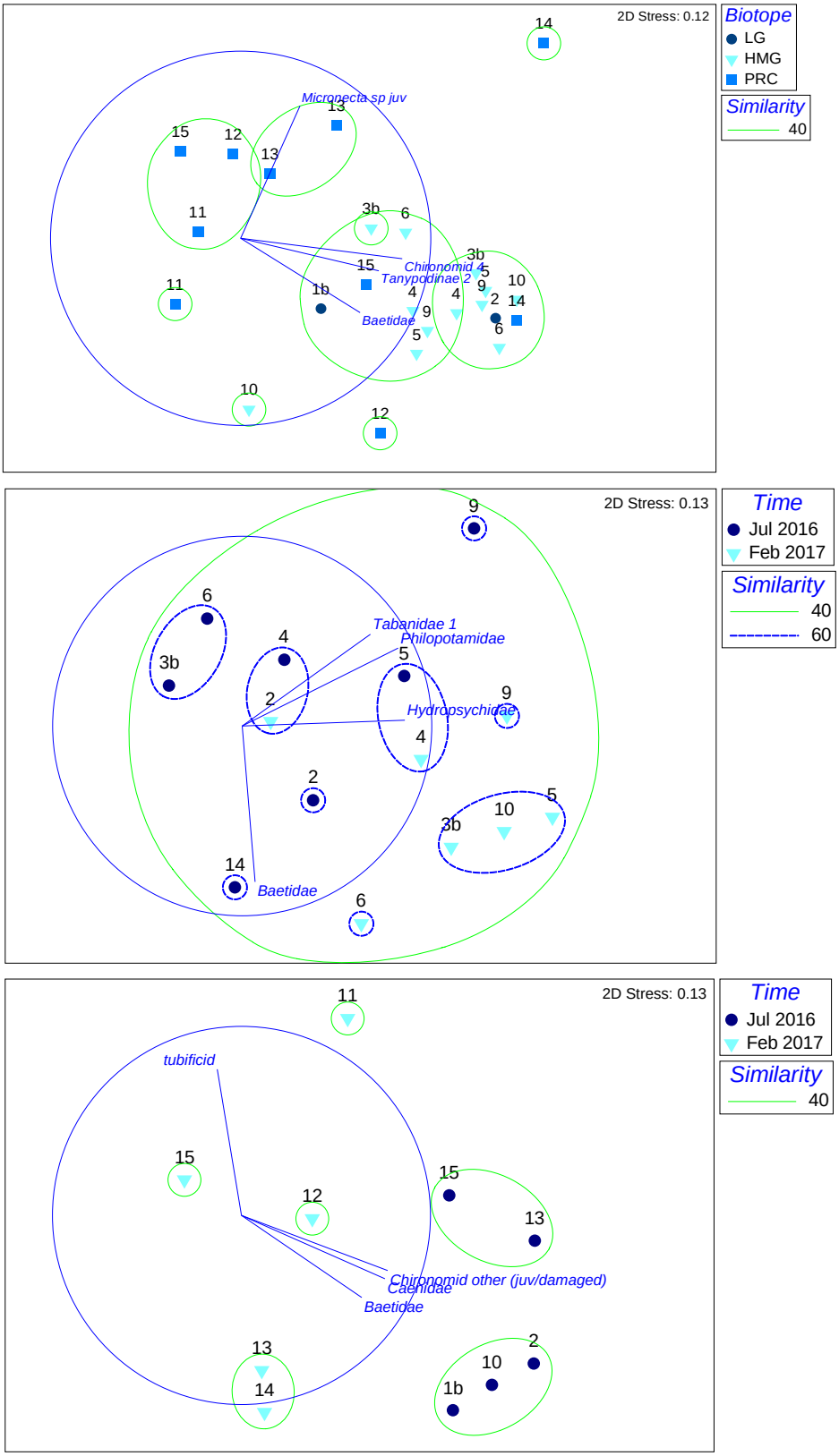
Figure 6-17 Mean (±S.E.) for Macroinvertebrate Indicators for Pool Habitats: Taxonomic Richness (top), Abundance (middle) and Shannon's Diversity (bottom)

Figure 6-18 presents non-metric multi-dimensional scaling (nMDS) ordinations showing patterns in similarity in macroinvertebrate assemblages in edge, riffle and pool hydraulic habitats.

The ordination for edge habitat data showed a slight separation of assemblage among biotope type, however the assemblage did not differ across temporal scales. The High-to-Moderate Gradient Streams samples were positioned to the right side of the ordination, while Purari River Channel samples were grouped towards the left side. The vector overlay of the four strongest correlated macroinvertebrate fauna (Pearson's correlation = 0.74) showed that the High-to-Moderate Gradient Stream samples were largely characterized by a higher abundance of Diptera (non-biting midges) families Chironominae and Chironomidae, and Ephemeroptera (true bugs) family Baetidae, while *Micronecta* sp. (Corixidae) was prominent in the Purari River Channel. This indicates that littoral macroinvertebrate assemblages in the High-to-Moderate Gradient Streams were distinct from those in the Purari River channel.

The ordination for riffle habitat samples identified a slight separation of macroinvertebrate assemblages across temporal scales, however did not identify distinct groupings of assemblages by biotope type. The macroinvertebrate assemblage sampled in February 2017 were grouped towards the right side of the ordination due to the higher abundance of Hydropsychidae and Philopotamidae (caddisflies). Ephemeroptera (true bugs) families Baetidae (small minnow mayflies) and Tabanidae (horsefly) were the predominant macroinvertebrate groups across both sampling times (July 2016 and February 2017).

The ordination for pool habitat samples showed a slight separation of macroinvertebrate assemblages across temporal scales and biotope types. The assemblage sampled in July 2016 were grouped towards the right side of the ordination, while the assemblage reported in February 2017 were grouped towards the left side. Vector overlays showed that Diptera (non-biting midges) family Chironominae and Ephemeroptera (true bugs) families Baetidae and Caenidae were highly correlated (Pearson's correlation = 0.77) with the assemblage observed in July 2016, while Naididae (oligochaete worm) was the primary group observed during February 2017. Furthermore, low-gradient streams sites 1B and 2 and High-to-Moderate Gradient Stream Site 10 were grouped away from Purari River Channel sites (11 to 15), which demonstrates differences in assemblages across biotope types. Low-Gradient Streams and High-to-Moderate Gradient Streams samples were largely characterized by higher abundance of families Chironominae (non-biting midges), Baetidae and Caenidae (true bugs).



* LG: Low Gradient Tributary Stream; HMG: High-to-Moderate Gradient Tributary Stream; PRC: Purari River Main Channel

Figure 6-18 nMDS Ordinations: Edge (top), Riffle (middle) and Pool Habitat (bottom)

6.3.1.2 Purari Delta

In the present study, a total of 23 benthic macroinvertebrate and demersal fish taxa from at least 11 families were collected by grab sampler, and box traps, cast and gill nets, respectively, from seven sites in the Purari delta (Table 6-12). All these sites are considered estuarine except sites 18 and 19. No fauna was recorded in samples from sites 16 and 17 (likely due to survey constraints)[10].

The benthic macroinvertebrate fauna was comprised of representatives from a range of common estuarine fauna groups, including mollusks, crustaceans and polychaete worms. Benthic macroinvertebrate assemblages were dominated by polychaete worm families Spionidae and Capitellidae, which collectively accounted for approximately 70% of the total catch. Both families are generally comprised of deposit feeders that can proliferate in organically enriched estuarine environments (e.g. ANZECC/ARMCANZ, 2000; Dafforn *et al.* 2013), as occurs in the study area. Bivalve mollusks accounted for almost 8% of the catch, while crustaceans and gastropods accounted for 3% and 1% of the catch respectively.

Taxonomic richness ranged from zero to 11 species per site with the highest richness occurring at Site 21. Total abundance varied amongst the sites, ranging between zero and 81 individuals per site with the highest abundance occurring at Site 20. Lowest abundance and richness was at Site 24 where no macroinvertebrate fauna was observed; sites 18, 19 and 23 also had low abundance and richness scores. Sites with low abundance and richness were located furthest upstream at fresher water locations (see Figure 6-11). Upper estuarine environments typically have depauperate benthic macroinvertebrate assemblages, which is mainly a function of salinity stress (i.e. waters that vary in salinity over time), lower dissolved oxygen levels and variations in sediment properties (Saenger *et al*. 1988; Alongi, 1990).

[10] Sites 16 and 17 were deep water, fast-flowing sites in the main body of the Purari River with a highly mobile substrate, which constrained the success of benthic sampling.

Table 6-12 Benthic Macroinvertebrate (and Bottom-dwelling Fish) Families Recorded at Estuarine Sites

Class	Order	Family	Genus species	Sites							Total
				18	19	20	21	22	23	24	
Polychaeta	Phyllodocida	Nephtyidae	*Nephtys* sp	8	1	0	0	0	0	0	**9**
		Nereididae	Nereid 2	1	0	0	0	0	0	0	**1**
	Sabellida	Sabellidae	Sabellid 1	0	0	1	2	0	0	0	**3**
			Sabellid 2	0	0	0	2	0	0	0	**2**
	Scolecida	Capitellidae	Capitellid 4	0	0	54	6	2	0	0	**62**
			Capitellid 5	0	0	0	2	0	0	0	**2**
	Spionida	Spionidae	*Orthoprionospio* sp	0	0	19	20	4	0	0	**43**
			Polydora sp	0	0	0	6	0	0	0	**6**
			Pseudopolydora sp	0	0	1	4	0	0	0	**5**
	Terebellida	Cirratulidae	Cirratulid 3	0	0	0	1	0	9	0	**10**
			Cirratulid 4	0	0	0	0	5	0	0	**5**
Actinopterygii	Perciformes	Gobiidae	*Caragobius* sp	0	0	0	0	4	0	0	**4**
			Goby 1	1	0	0	0	1	0	0	**2**
Malacostraca	Amphipoda	-	Amphipod 3	1	0	0	0	0	0	0	**1**
		Oedicerotidae	Oedicerotid 2	0	0	0	1	0	0	0	**1**
	Decapoda	Penaeidae	Penaeid juv	0	0	1	0	0	0	0	**1**
	Isopoda	Anthuridae	Anthurid 3	0	0	2	0	0	0	0	**2**
Bivalvia	-	-	Bivalve 4	0	1	1	0	0	0	0	**2**
	-	-	Bivalve 5	0	0	1	0	0	0	0	**1**
	Veneroida	Tellinidae	*Tellina* sp 2	0	0	1	2	0	0	0	**3**
	-	-	Bivalves unident	0	0	0	6	1	0	0	**7**
Gastropoda	-	-	Gastropod 1	0	0	0	0	0	1	0	**1**
	Caenogastropoda	Potamididae	Potamididae sp.	0	1	0	0	0	0	0	**1**
Richness				**4**	**3**	**9**	**11**	**6**	**2**	**0**	**23**
Abundance				**11**	**3**	**81**	**52**	**17**	**10**	**0**	**174**

6.3.2 Sensitive Species

The following aquatic invertebrate species are likely to occur within parts of the study area and are also considered to be threatened/important:

- The waterstrider *Ciliometra setosa* (Family Gerridae)
- The waterstrider *Iobates ivimka* (Family Gerridae).

Each of these species are described further below and summarized in Table 6-16.

NOTE: Polhemus *et al.* (2004) also includes *Dineutes chalybeus* as an endemic species for the study area. However, subsequent findings of this species, as reported in Polhemus (2011), indicate that it occurs in the Kikori and Lakekamu river catchments, at areas which are outside of the ecoregions of the study area. For this reason, this species is not considered endemic.

Ciliometra setosa* and *Iobates ivimka

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	×	Not Evaluated
Endemic and/or restricted range	✓	Identified as endemic by Polhemus *et al.* (2004) to the Papuan Gulf Coastal Lowlands ecoregion 28.
Migratory and congregatory	×	Species not considered migratory or congregatory
Overall sensitivity	***Moderate sensitivity***	

Little is known about the ecology and distribution of these species. Polhemus *et al.* (2004) identified these species as endemic to the Papuan Gulf Coastal Lowlands, an area consisting of the freshwater and estuarine environments below the 50 m contour between the Kikori River and Kerema in ecoregion 28 (Polhemus *et al.* 2004; Figure 6-1). Congeners (related species) of the two species elsewhere can occur in a wide range of biotopes, including quiescent wetland environments, flowing streams and rivers, and the backwaters of flowing streams. This indicates that these species are likely to occur across various aquatic habitats in PRL-15 and the lower Purari River.

Based on the habitat requirement of these species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Likely*** in high-to-moderate gradient streams, based on habitat suitability, but ***Unlikely*** in low gradient streams due to higher turbidity.
- Unconfined turbid major river systems (freshwater) – ***Unlikely***, due to higher turbidity.
- Unconfined turbid major river systems (estuarine) – ***Does not occur***, as these waters are brackish.
- Freshwater floodplains – ***Likely***, based on habitat suitability.
- Estuarine wetlands – ***Does not occur***, as these waters are brackish.
- Oxbow lakes and ORWBs – ***Likely***, based on habitat suitability.

NOTE: There is a lack of information on the distribution, ecology and systematics of Papua New Guinea's macroinvertebrate fauna. With additional surveys, it is likely that other endemic species

would be found, and that some restricted-range species could occur over a much wider area than presently thought.

No threatened or near-threatened aquatic macroinvertebrates listed under other conservation schemes or legislation is known or likely to occur in PRL-15 or the Purari River and Purari River delta.

6.4 Estuarine and Freshwater Fish

6.4.1 Regional Perspective

Studies conducted by Allen (1991) and Froese and Pauly (2017), together with FishBase records (http://www.fishbase.org/) have identified the following key characteristics of freshwater fish species in New Guinea (including the study area):

- *A low degree of species richness compare to other tropical environments*. A review of FishBase records has identified a total of 347 fish species in New Guinea, 16 of which are introduced; this is known to be lower than other tropical areas in the world.
- *Strong affinities with the fish fauna of northern Australia*. Allen (1991) found that 33 fish species found in the Trans-Fly bioregion are shared with northern Australia. This reflects the relatively recent connection between these two land masses (6,000 to 8,000 years before present).
- *A high proportion of fish species with a marine larval stage*. Allen (1991) estimates that approximately 102 of Papua New Guinea's freshwater fish species have a marine larval phase and a widespread geographic distribution.
- *A high proportion of species are endemic to Papua New Guinea*. This reflects tectonic events and periods of isolation. Based on FishBase records, 58 species are thought to be restricted to Papua New Guinea.

Within the Purari River specifically, there is a notable paucity of herbivores and lack of planktonic feeders (Haines, 1983). Among the Purari fish there are more prawn-eating species than piscivores and prawns play an extremely important role in the food chain as detritivores. The role of mud-eating fishes and prawns is particularly significant, as mud is among the major sources of nutrients for the food chain of the Purari River Delta (Haines, 1983).

In addition, Haines (1979) together with Allen (1991) suggest that the majority of the species in the lower Purari River (i.e. in the area of PRL-15 and the Purari Delta) are of ancestral marine origin, providing for distribution of species across both estuarine and freshwater environments. This has been indicated by the low level of freshwater specialists recorded by Haines during his 1979 survey, though this may be partially due to survey bias.[11] This is also indicated by the fact that fish fauna above the Hathor Gorge rapids (upstream of the study area) is depauperate comparative to downstream areas, reflecting the physical barrier posed by these rapids to marine originating species (Haines, 1979).

[11] Survey methods employed by Haines (1979; e.g. gill-nets, opportunistic use of seine nets, line fishing) have a sampling bias towards large-bodied fish. Freshwater specialists are typically small-bodied fish and thus may be under-represented.

6.4.2 Taxonomic Composition of Fish Assemblages in the Study Area

Sampling undertaken in June-July 2016 and January-February 2017 captured a total of 1,123 fish (Table 6-13) and 1,151 macrocrustaceans (Table 6-14).

The fish families Ariidae (fork-tail catfish – 12 species, 17% of total individuals), Gobiidae (gobies – seven species, 6% of total individuals) and Eleotridae (sleeper gobies – seven species, 2% of total individuals) accounted for approximately 25% of all species collected. Other specious fish families were Sciaenidae (three species captured and two additional species incidentally observed); Ambassidae and Anguillidae (three species). All fish species collected were native, i.e. no introduced (non-native) fish species were captured (see Section 6.7), however one introduced species was observed (European carp - *Cyprinus carpio*).

Despite differences in sampling methodology and effort, these results are consistent with previous surveys in the study area. Haines (1979), who conducted multiple surveys in the 1970s, also found that Ariidae (19 species), Gobiidae and Eleotridae (both 10 species) were the most specious families. Furthermore, mullets (Mugilidae 12 species) were more specious than recorded in the present study, possibly reflecting the greater sampling effort in coastal and estuarine environments by Haines (1979).

6.4.3 Numerically Dominant Fish Species and their Distribution

Table 6-13 shows the total fish catch by species. Six fish species comprised 58% of the catch: Goldie River rainbowfish (*Melanotaenia goldiei*), estuarine glass perchlet (*Ambassis macracanthus*), greenback mullet (*Liza subviridis*), spoon-snouted catfish (*Doiichthyes novaeguineae*), nurseryfish (*Kurtus gulliveri*) and freshwater anchovy (*Thryssa scratchleyi*). Table 6-15 describes the distribution of these species.

Table 6-13 Total Fish Catch in Study Area Waterways

Family	Species	Purari River delta (estuarine)	Purari River delta (freshwater)	Purari River (freshwater)	PRL-15 tributaries (freshwater)	Total No. individuals	% catch	No. broad biotopes
Sites		20, 21, 22, 23, 24	16, 17, 18, 19	11, 12, 13, 14, 15	1, 2, 3, 4, 5, 6, 9, 10			
Ambassidae	*Ambassis agrammus*	0	0	9	0	9	0.8	1
Ambassidae	*Ambassis macrocanthus*	19	96	0	0	115	10.2	2
Ambassidae	*Parambassis gulliveri*	0	0	8	1	9	0.8	2
Anguillidae	*Anguilla obscura*	0	0	0	4	4	0.4	1
Anguillidae	*Anguilla* sp. (juv unid)	1	1	0	0	2	0.2	2
Anguillidae	*Anguilla reinhardti*	0	0	0	2	2	0.2	1
Apogonidae	*Glossamia sandei*	0	0	1	12	13	1.2	2
Apogonidae	*Apogon* sp. (juv unid)	1	0	0	0	1	0.1	1
Ariidae	*Nemapteryx armiger*	2	0	0	0	2	0.2	1
Ariidae	*Arius graeffei*	12	0	0	0	12	1.1	1
Ariidae	*Cochlefelis spatula*	18	1	0	0	19	1.7	2
Ariidae	*Doiichthyes novaeguineae*	88	1	0	0	89	7.9	2
Ariidae	*Nedystoma dayi*	12	0	12	1	25	2.2	3
Ariidae	*Pachyula conorynchus*	2	0	0	0	2	0.2	1
Ariidae	*Pachyula crassilabris*	0 (1)	0	0	0	0 (1)	0.0	0
Ariidae	*Potamosilurus latirostris*	4	9	1	0	14	1.2	3
Ariidae	*Sciades leptaspis*	6	1	3	0	10	0.9	3
Ariidae	*Cinetodus froggatti*	1	0	0	0	1	0.1	1
Ariidae	*Cochlefelis danielsi*	22	0	0	0	22	2.0	1
Ariidae	*Neoaris augustus*	2	3	0	0	5	0.4	2
Belonidae	*Strongylura krefti*	2	0	0	0	2	0.2	1
Carangidae	*Caranx* sp. (juv unid)	1	0	0	0	1	0.1	1
Cynoglossidae	*Cynoglossus heterolepis*	1	0	0	0	1	0.1	1
Cyprinidae	*Cyprinus carpio*	0	0 (1)	0	0	0 (1)	0.0	0
Eleotridae	*Bunaka gyrinoides*	0	0	1	2	3	0.3	2
Eleotridae	*Butis ambionensis*	1	0	0	0	1	0.1	1
Eleotridae	Gudgeon #1 (unid juv)	1	0	0	0	1	0.1	1
Eleotridae	*Mogurnda mogurnda*	0	0	0	2	2	0.2	1
Eleotridae	*Ophieleotris aporos*	0	0	2	3	5	0.4	2
Eleotridae	*Ophiocara porocephala*	0	0	0	3	3	0.3	1
Eleotridae	*Oxyeleotris fimbriata*	0	0	0	10	10	0.9	1
Engraulidae	*Thryssa hamiltonii*	4	0	0	0	4	0.4	1
Engraulidae	*Thryssa scratchleyi*	15	19	31	0	65	5.8	3
Gobiidae	*Awaous* sp1	0	0	0	9	9	0.8	1
Gobiidae	*Glossogobius concavifrons*	0	0	1	45	46	4.1	2
Gobiidae	*Glossogobius giuris*	0	5	0	1	6	0.5	2
Gobiidae	Goby sp1 (juv unid)	0	0	1	1	2	0.2	2
Gobiidae	Goby sp2 (juv unid)	0	0	0	1	1	0.1	1
Gobiidae	*Periophthalmus weberi*	1	0	0	0	1	0.1	1
Gobiidae	*Stenogobius psilosinous*	0	0	2	0	2	0.2	1
Haemulidae	*Pomadasys kaakan*	2	0	0	0	2	0.2	1
Hemiramphidae	*Zenarchopterus novaeguineae*	17	10	9	5	41	3.7	4
Hemiramphidae	Hemiramphidae (juv unid)	10	0	0	0	10	0.9	1
Kurtidae	*Kurtus gulliveri*	74	3	0	0	77	6.9	2
Latidae	*Lates calcarifer*	1	0	0	1	2	0.2	2
Lobotidae	*Lobotes surinamensis*	0 (1)	0	0	0	0	0.0	0
Lutjaidae	*Lutjanus johnii*	0 (1)	0	0	0	0	0.0	0
Melanotaeniidae	*Melanotaenia goldiei*	0	0	0	203	203	18.1	1
Melanotaeniidae	*Melanotaenia splendida rubrostriata*	0	0	1	35	36	3.2	2
Mugilidae	*Liza subviridis*	17	83	0	0	100	8.9	2
Mugilidae	*Valamugil buchanani*	1	0	5	0	6	0.5	2
Mugilidae	*Mugildae* sp1 (juv unid)	0	0	3	0	3	0.3	1
Mugilidae	*Mugilidae* sp2 (juv unid)	0	0	0	10	10	0.9	1
Mullidae	*Upeneus vittatus*	1	0	0	0	1	0.1	1
Polynemidae	*Polydactylus plebeius*	24	0	0	0	24	2.1	1
Scatophagidae	*Scatophagus argus*	1	0	0	0	1	0.1	1
Sciaenidae	*Atrobucca brevis*	15	0	0	0	15	1.3	1
Sciaenidae	*Johnius amblycephalus*	7	0	0	0	7	0.6	1
Sciaenidae	*Nibea* sp. (juv unid)	0 (1)	0	0	0	0 (1)	0.0	0
Sciaenidae	*Otolithoides pama*	5	0	0	0	5	0.4	1
Serranidae	*Epinephelus coioides*	0 (1)	0	0	0	0	0.0	0
Soleidae	*Aseraggodes klunzingeri*	1	2	4	0	7	0.6	3

Family	Species	Purari River delta (estuarine)	Purari River delta (freshwater)	Purari River (freshwater)	PRL-15 tributaries (freshwater)	Total No. individuals	% catch	No. broad biotopes
Sphyraenidae	*Sphyraena baracuda*	2	0	0	0	2	0.2	1
Synbranchidae	*Ophisternon bengalense*	0	0	0	1	1	0.1	1
Terapontidae	*Hephaestus fuliginosus*	0	0	0	1	1	0.1	1
Terapontidae	*Hephaestus lineatus*	0	0	0	17	17	1.5	1
Tetraodontidae	*Marilyna meraukensis*	6	2	0	0	8	0.7	2
Toxotidae	*Toxotes chatareus*	7	2	12	2	23	2.0	4
Richness		**39 + 4 incidental**	**15 + 1 incidental**	**18**	**24**			
Abundance		**407**	**238**	**106**	**372**	**1123**		

*Numbers in parentheses are incidental observations (not site specific)

Table 6-14 Total Macrocrustacean Catch in Study Area Waterways

Taxa	Species	Purari River delta (estuarine)	Purari River delta (freshwater)	Purari River (freshwater)	PRL-15 tributaries (freshwater)	Total No. individuals	% catch	No. broad biotopes
Sites		**20, 21, 22, 23, 24**	**16, 17, 18, 19**	**11, 12, 13, 14, 15**	**1, 2, 3, 4, 5, 6, 9, 10**			
Palaemonidae	*Macrobrachium rosenbergii*	20	20	21	75	136	11.8	4
Palaemonidae	*Macrobrachium* sp A (marine)	58	83	0	0	141	12.3	2
Palaemonidae	*Macrobrachium* sp B (stripes) (marine)	26	12	0	0	38	3.3	2
Palaemonidae	*Macrobrachium* sp C (marine)	9	0	0	0	9	0.8	1
Palaemonidae	*Macrobrachium* sp D (marine)	17	2	0	0	19	1.7	2
Palaemonidae	*Macrobrachium* sp E white (marine)	1	0	0	0	1	0.1	1
Palaemonidae	*Macrobrachium* sp 1	0	0	107	1	108	9.4	2
Palaemonidae	*Macrobrachium* sp 2	0	0	4	0	4	0.3	1
Palaemonidae	*Macrobrachium* sp 3	0	0	3	358	361	31.4	2
Palaemonidae	*Macrobrachium* sp 4	0	0	13	50	63	5.5	2
Palaemonidae	*Macrobrachium* sp 5	0	0	0	158	158	13.7	1
Palaemonidae	*Macrobrachium* sp 6	0	0	0	125	125	10.9	1
Palaemonidae	*Macrobrachium* sp 7	0	0	0	2	2	0.2	1
Penaidae	Penaidae prawn # 1	11	7	9	53	80	7.0	4
Atyidae	Atyid shrimp sp 1	0	0	0	3	3	0.3	1
Atyidae	Atyid shrimp sp 2	1	0	0	0	1	0.1	1
Stomatopoda	Mantis shrimp	24	10	0	0	34	3.0	2
Brachyura	Brachyura 1	2	0	0	0	2	0.2	1
Portunidae	*Scylla serrata*	1	0	0	0	1	0.1	1
Sundathlphusidae	Sundathlphusidae sp. 1	0	0	0	1	1	0.1	1
Richness		**10**	10	5	5	9	29	
Abundance		**150**	150	114	136	751	1151	

Table 6-15 Numerically Dominant Fish Species in the Present Study

Species	% of catch	Biotopes and Sites	Notes	Photo
Goldie River rainbowfish *(Melanotaenia goldiei)*	18%	High-Mod Gradient tributary streams (3B, 4, 5, 6, 9, 10) Low Gradient Slow-to-Moderate Flowing Tributary Streams (1B, 2)	Exclusively in tributary streams Dominant fish species at most tributary creek sites	
Estuarine glass perchlet *(Ambassis macracanthus)*	10%	Low Gradient Slow-to-Moderate Flowing Tributary Streams on the Purari River delta (18, 19) Estuarine channel (20, 22B, 23, 24)	Present in lower reaches of Purari River in estuarine and freshwater environments	
Greenback mullet *(Liza subviridis)*	9%	Low Gradient Slow-to-Moderate Flowing Tributary Streams on the Purari River delta (18, 19) Estuarine channel (23, 24)	Present in lower reaches of Purari River in estuarine and freshwater environments	

Species	% of catch	Biotopes and Sites	Notes	Photo
Spoon-snouted catfish *(Doiichthyes novaeguineae*)	8%	Low Gradient Slow-to-Moderate Flowing Tributary Streams on the Purari River delta (19) Estuarine channel (22B, 23)	Estuarine and freshwater (delta) reaches of the Purari River main channel	
Nurseryfish (*Kurtus gulliveri*)	7%	Freshwater channel (18, 19 Estuarine channel (22B, 23)	Estuarine and freshwater (delta) reaches of the Purari River main channel	
Freshwater anchovy *(Thryssa scratchleyi*)	6%	Low Gradient Slow-to-Moderate Flowing Tributary Streams near on the Purari River: a) Upstream (sites 11, 12, 13, 14, 15) b) Delta (16, 18, 19) Estuarine (20B, 21, 22B, 23, 24)	Estuarine and freshwater (delta) reaches of the Purari River main channel, and the upper reaches of the Purari River main channel (near PRL-15)	

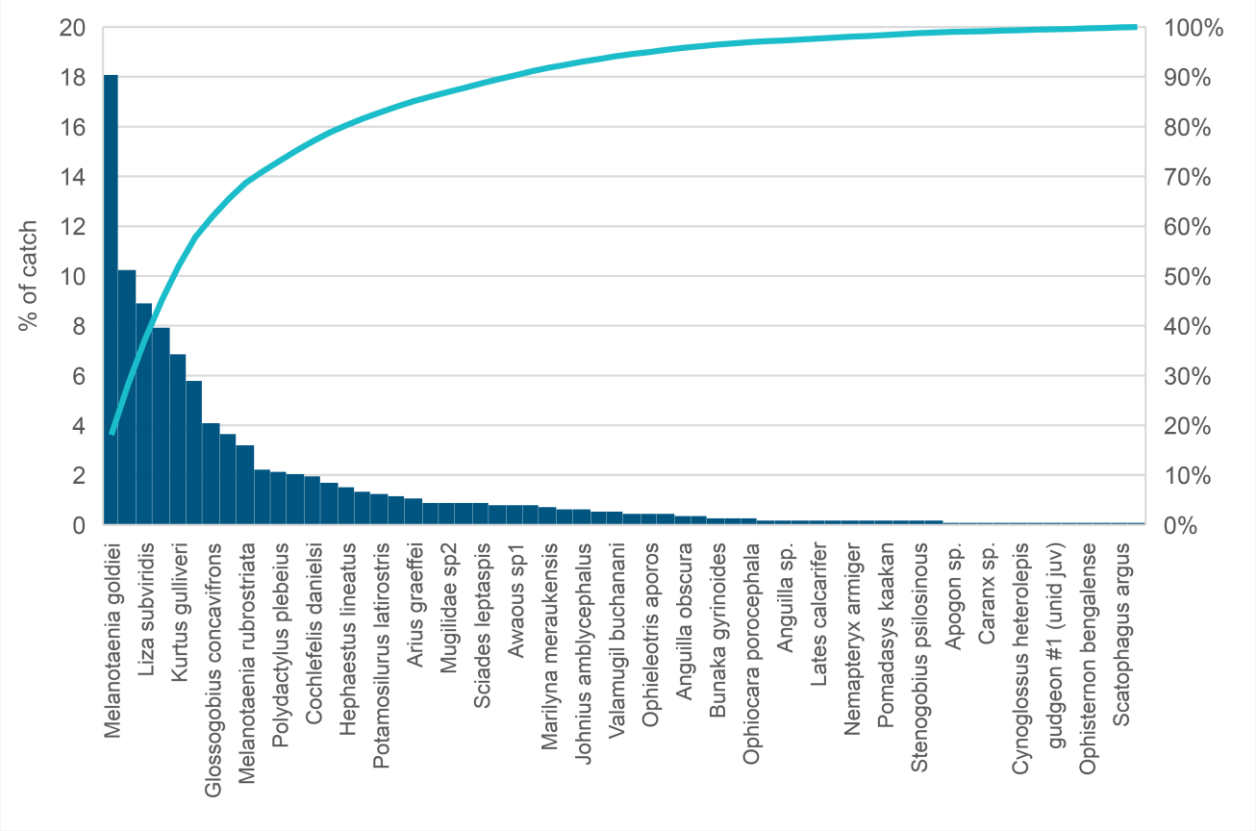


Figure 6-19 Percentage of Total Fish Catch by Species

Several species captured in the estuarine reaches were also observed to occur in a range of freshwater biotopes. These included the seven-spotted archerfish (*Toxotes chatareus),* freshwater anchovy *(Thryssa scratchleyi),* Fly River garfish *(Zenarchopterus novaeguineae),* estuarine glass perchlet *(Ambassis macracanthus),* Day's catfish *(Nedystoma dayi)* and tonguefish *(Aseraggodes klunzingeri).* The habitat types in which these species were recorded is consistent with the literature (e.g. Allen,1991 and Froese and Pauly, 2017).

The majority of the fish species identified during these surveys were either able to occur across estuarine and freshwater environments or occurred only as estuarine specialists. Only a small number of freshwater specialists were identified, including Goldie River rainbowfish (*Melanotaenia goldiei*), red-striped rainbowfish (*Melanotaenia splendida rubrostriata*), Sande's mouth almighty (*Glossamia sandei*), sooty grunter (*Hephaestus fuliginosus*), fimbriate gudgeon (*Oxyeleotris fimbriata*) and northern trout gudgeon (*Mogurnda mogurnda*). Most freshwater species were abundant and widespread throughout the freshwater environments, except:

- *Awaous* sp1 (Goby) was only recorded at Site 10. Although this species appears to be absent from other sites within the study area, it has been recorded elsewhere in southern New Guinea and north-eastern Australia.
- One individual of swamp eel *Ophisternon bengalense* was recorded at Site 2. This species has a widespread distribution but is reportedly uncommon (e.g. Pusey *et al.* 2004).

- Freshwater crabs (family Hymenosomatidae) were recorded at Site 5 only.

Wild common carp (*Cyprinus carpio)* was the only introduced species observed in the present study. This species was not captured in the surveys, but was incidentally observed in the fish catch of local villagers in the Purari River delta area (one individual). This species tends to prefer relatively quiescent waters rather than swift flowing waters, and therefore floodplain wetlands and backwaters could represent a key habitat for this species. These preferred habitats could not be fished however due to access constraints and risks from crocodiles. This species is readily caught using the fishing methods used in the present study (especially gill nets), as are other introduced species known or likely to occur in the Purari River such as tilapia (*Oreochromis mossambicus* or *Sarotherodon*) and mosquitofish (*Gambusia affinis)*. Refer to Section 6.7 for further discussion on introduced species.



Figure 6-20 Large Wild Common Carp Landed by Local Villagers (Lali village, near Site 18)

6.4.4 Patterns in Fish Species Richness and Assemblage Structure

Figure 6-21 shows the total number of fish species captured in different biotope types by Haines (1979). Estuarine and coastal areas had a richer fish fauna than freshwater environments, although different levels of sampling effort (at the site and sample scale) confound to an extent comparisons among biotope classes. Notwithstanding this, the fish fauna of coastal and estuarine environments in Papua New Guinea tend to have far higher species richness than freshwater environments, reflecting the larger species pool available in marine environments (over 3,000 species; see Allen 1991) compared to freshwaters (~340 species).

Consistent with Haines (1979), the present study found that estuarine areas of the Purari River delta were the most specious biotopes (39 fish species) in the study area. In comparison, 15 species were found in freshwater reaches of the Purari River delta, 18 species in the Purari River (at tributary mouths) and 24 species in the tributary streams within PRL-15 (see Figure 6-22).

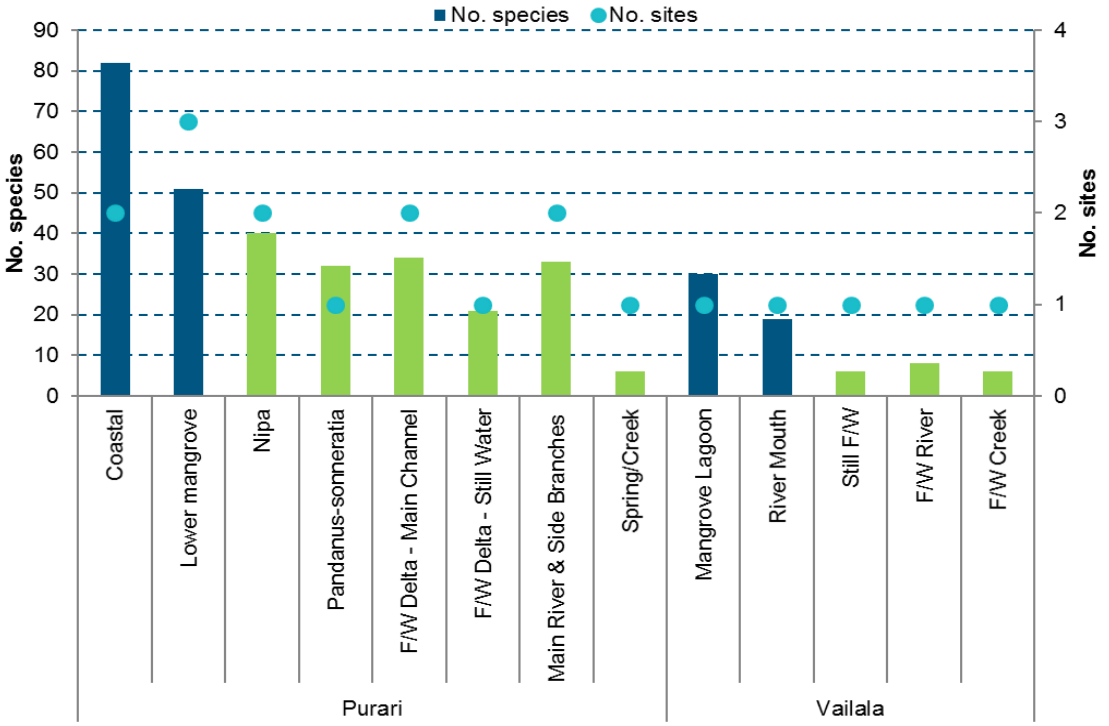


Figure 6-21 Number of Fish Species in Various Biotope Types (Haines 1979): Green is Freshwater Ecosystems; Blue is Estuarine and Coastal Ecosystems

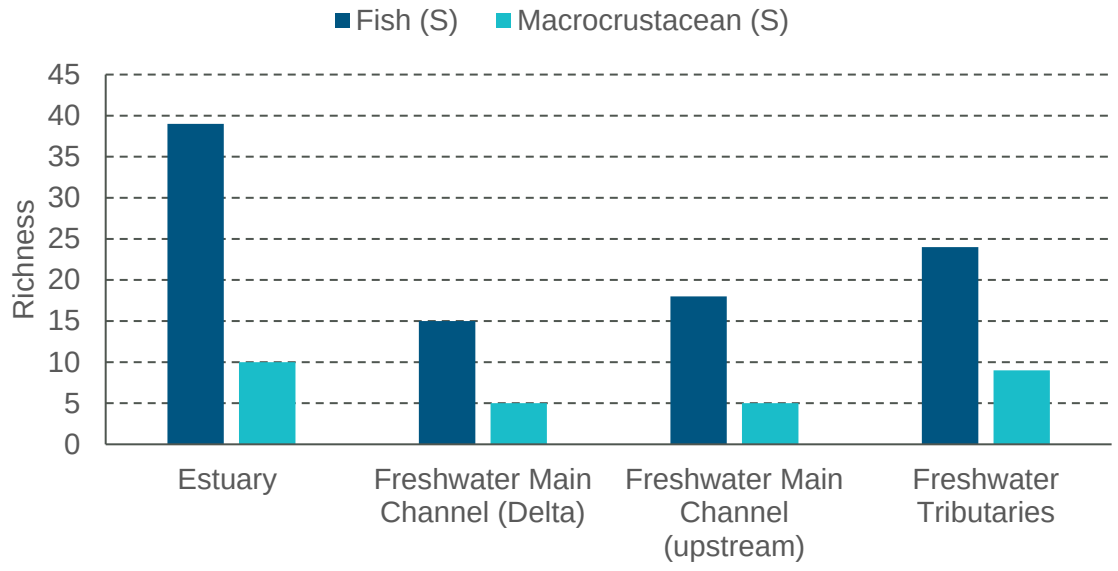


Figure 6-22 Richness (number of species) of Aquatic Fauna in Each Biotope Type – Present Study

Figure 6-23 is an ordination plot describing patterns in similarity in fish assemblages among sites. Sites that are located close together have more similar (in terms of composition and abundance) fish assemblages, and sites that have dissimilar fish assemblages are located further distant from each other. Also superimposed on the ordination are 'groupings' produced using cluster analysis – this allows classification of sites.

The ordination shows that freshwater tributaries (both high-moderate gradient and low gradient sites) had a fish fauna that differed in terms of species composition from sites in the main channel and estuary. The freshwater main channel and freshwater main channel delta fish fauna also had moderately distinct fish faunas, but were both similar to fauna in estuarine waters. There was great variability in fish assemblages in the estuarine environments, indicating that the fish fauna was not distinctive and shared elements with freshwater biotopes.

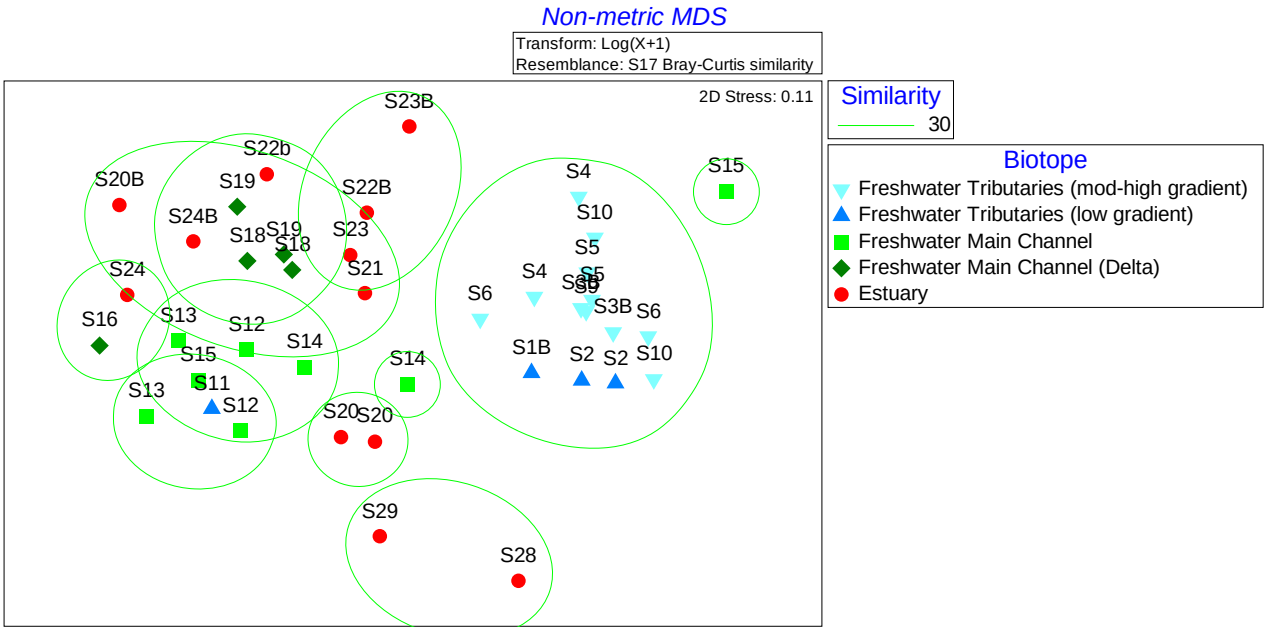


Figure 6-23 n-MDS Ordination based on Bray-Curtis Similarities using log x +1 Transformed Fish Data

The differences in fish assemblages between those in and adjacent to the Purari River main channel and those in tributary streams reflect the following:

- The most abundant species recorded in the Purari River delta (at freshwater and estuarine locations) were *Ambassis macrocanthus*, *Nedystoma novaeguineae* and *Liza subviridis*. These species are common and widespread in the broader region including the Purari River delta. As the Purari River delta is fast flowing, dynamic and turbid, fish assemblages are dominated by more sediment-tolerant species.
- In the tributaries, fish and macrocrustacean assemblages were numerically dominated by small-bodied species from the families Eleotridae (gudgeons), Gobiidae (gobies) Terapontidae (grunters) and Melanotaeniidae (rainbowfish).

Many eleotrids (gudgeons) are known to be amphidromous, i.e. fishes that migrate between freshwater and the sea. It is thought that the young of most freshwater eleotrids are swept downstream into the brackish water and that the juveniles eventually migrate back into the freshwater to complete their life cycle (Beera, 2001). The occurrence of the gudgeons *Oxyeleotris fimbriata*, *Ophieleotris aporos* and *Ophiocara porocephala* in clear-water tributaries (and the Purari River channel) suggest that there is hydraulic connectivity with lowland environments, despite the presence of shallow riffles in places.

There is a range of factors influencing spatial patterns in fish community structure within the Purari catchment:

- Hydraulic habitat conditions – hydraulic habitat conditions are likely to be a primary control on fish communities. Much of the main channel of the Purari River experiences high current velocities that would be unsuitable for many species.
- Water quality conditions – species tolerances to water quality conditions (long-section gradients in salinity, high turbidity etc.) will influence spatial patterns in fish assemblages
- Lack of backwater habitat – the Purari River does not support well-developed backwaters and floodplains compared to the Fly River catchment, and does not support extensive areas of aquatic macrophytes. Haines (1979) speculated that the low proportion of backwater and floodplain habitat was a key factor controlling the low proportion of herbivores and the absence of *Nematalosa papuensis* (an abundant herbivore in the Fly River system) in the Purari River.

6.4.5 Macrocrustacean Assemblages

As shown in Figure 6-22, macrocrustacean taxa richness was relatively similar among biotope types. However, different biotopes supported different species and assemblages. Table 6-14 shows the total catch of macrocrustaceans captured in fish surveys. The numerically dominant taxa were:

- *Macrobrachium* sp 3 – which is a prawn species that comprised 31% of the total macrocrustacean catch. This taxon was recorded only in freshwater, but not in the Purari River delta. This species appears to be a freshwater specialist species.
- *Macrobrachium* sp 5 – which is a prawn species that comprised 14% of the total macrocrustacean catch. This taxon was recorded in freshwater tributaries, but not in the Purari River. This species appears to be a freshwater tributary specialist species.
- *Macrobrachium* sp A – which is a prawn species that comprised 12% of the total macrocrustacean catch. This taxon was recorded in the estuarine and freshwater reaches of the Purari River delta.
- *Macrobrachium rosenbergii* – which is a prawn species that comprised 12% of the total macrocrustacean catch. This taxon was recorded widely throughout the study area, including estuarine and freshwater reaches of the Purari River delta, the Purari River main channel and freshwater tributary streams.
- *Macrobrachium* sp 1 – which is a prawn species that comprised 9% of the total macrocrustacean catch. This taxon was recorded in freshwater only, but not in the Purari River delta. This species appears to be a freshwater specialist species.

The mud crab *Scylla serrata* was the only other species recorded exclusively in the estuary. This species has low tolerance to freshwaters (Kailoloa *et al.* 1993). Most other species recorded in the estuary were also recorded in freshwater reaches of the Purari River.

Overall, the results of the present study show that the study area supports a rich and abundant macrocrustacean fauna. A far larger number of crab and shrimp species would also occur in mangrove environments, but were not sampled in the present study due to access and safety constraints. The macrocrustacean fauna is expected to have a critical role in maintaining ecosystem processes, especially nutrient cycling and provision of food resources to fish.

6.4.6 Sensitive Species

The prioritization of values based on freshwater and estuarine fish species includes an assessment and sensitivity rating of individual threatened/important species, based on the categories set out in Section 5.7.1, and the identification of sensitivity value of habitat features based on these species and other criteria in Section 5.8.2. A discussion of threatened/important species is provided below (and summarized in Table 6-16) while the sensitivity of habitat features is discussed in Section 6.6.

The following fish species are likely to occur in parts of the study area and are considered to be threatened/important:

- Largetooth sawfish (*Pristis pristis*).
- Green sawfish (*Pristis zijsron*).
- Narrow sawfish (*Anoxypristis cuspidata*).
- Speartooth shark (*Glyphis glyphis*).
- Northern river shark (*G. garricki*).
- Bull shark (*Carcharhinus leucas*).
- Giant shovelnose ray (*Glaucostegus typus*).
- Mangrove whipray (*Urogymnus granulatus*).
- Orange-spotted grouper (*Epinephelus coioides*).

NOTE: The following species and/or species groups that may otherwise qualify under the threatened/important species categories have been excluded from further assessment based on the reasons provided:

- Rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*). Both of these species are native to Papua New Guinea and listed as Protected under the *Fauna (Protection and Control) Act 1966* (see Kula and George, 1996). However, these species have been introduced into the Purari River catchment (i.e. do not occur naturally) and are therefore considered invasive native species (see Section 6.7). Due to this, they are not considered to be threatened/important. Note also, neither of these species are listed as threatened on the IUCN Red List or listed in the appendices to CITES, and do not meet categories for endemic, restricted-range, migratory or congregatory species.

- Similarly, the wild common carp (*Cyprinius carpio*), Mozambique tilapia (*Oreochromis mossambicus*) and mahseer species (*Barbodes wynaadensis* and *Tor putitora*) while listed as threatened on the IUCN Red List, are not considered threatened/important in the context of the study area as these are invasive alien species.
- Dwarf sawfish (*Pristis clavata*). This species is noted to have historically occurred within the study area but is now considered extinct within this area and restricted to northern Australia (Kyne *et al.* 2013b).
- Moresby mogurnda (*Mogurnda pulchra*). While this species was identified by Polhemus *et al.* (2004) to be endemic to the Papuan Gulf Coastal Lowlands (ecoregion 28) it is known to have a distribution across at least two ecoregions (Allen, 1991) and is therefore not considered to be endemic. It does not meet any other category for threatened/important species.
- Schooling species. Langhammer *et al.* (2007) defines congregatory species as 'species that gather in globally significant numbers at a particular site and at a particular time in their life cycle for feeding, breeding or resting (during migration).' Many aquatic fish species aggregate in schools but are not considered to be congregatory species in accordance with this definition.

***Pristis pristis*[12] – largetooth sawfish**

Nationally-listed	× Not listed
Trade-restricted	✓ Appendix I
IUCN threatened	✓ Critically Endangered
Endemic and/or restricted-range	× Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	✓ Juveniles expected to migrate from freshwater reaches of rivers to estuarine and marine waters at 4-5 years of age. Listed under Bonn Convention
Overall sensitivity	***Extreme vulnerability***

Haines (1979) identified *P. microdon* (a synonym for *P. pristis*) in a broad range of biotope types in estuarine areas of the Gulf of Papua. These included:

- Purari River lower mangroves (across the Purari River delta estuary) – normally present but not abundant (i.e. 1-4 individuals caught per standard catch during sampling).
- Purari River freshwater delta main channel – rare (i.e. occasional individuals).
- Purari River main body and side branches (upstream of Herd Base) – common (i.e. 5-10 individuals caught per standard catch during sampling).
- Purari River near Wabo – normally present but not abundant.
- Kikori River lower mangrove – normally present but not abundant.
- Kikori River side branches – normally present but not abundant.

[12] Previously recorded as *Pristis microdon*

The species was inferred to occur within the pandanus and nipa swamps of both the Purari and Kikori rivers but was not detected or inferred in either of the Era or Vailala rivers (Haines, 1979). The species was also noted as abundant in coastal waters offshore of the Purari River delta and Orokolo Bay.

These observations indicate the historical importance of various biotope types within the Purari River for the species. Village interviews conducted as part of the Upstream Land and Natural Resources Use Biodiversity Baseline Report (Booyong Forest Science, 2017) indicated that sawfish continue to be important to artisanal fishing at Orokolo Bay. This suggests the ongoing occurrence of sawfish species, potentially including *P. pristis*.

Freshwater rivers and estuaries represent nursery habitats for juvenile and sub-adults, whereas adults occur in coastal and offshore waters to a depth of 25 m (Stevens *et al.* 2008). Juveniles and sub-adults are usually found in turbid channels of large rivers over soft mud bottoms (Allen, 1991) more than 1 m deep. DoEE (2017b) reports that this species will move into shallow waters when travelling upstream or while hunting prey and juveniles have been recorded in ponds that have been isolated from main rivers for several years. They do not occur in small tributary streams with riparian vegetation (Wilson, 1999).

On this basis, it is unlikely that this species will occur in smaller clear-water tributary creeks within PRL-15, but it may occur in Purari River main channel (both freshwater and estuary) and floodplain ponds at and adjacent to the onshore export pipeline corridor. The principle threat to the largetooth sawfish is net fishing, particularly the use of gill nets (Kyne *et al.* 2013a; DoEE, 2017b). This is due to the long-toothed rostrums of sawfish. While gill-netting does occur within the study area, no high intensity fisheries based on gill-netting is known to occur – see Marine Fisheries and Resources Baseline Report (ERIAS Group, 2017c; Part 13 of ESBS Dossier) and Land and Natural Resources Use Baseline Report (Booyong Forest Science, 2017). Artisanal fisheries along the Orokolo Bay coast may target this species within the marine and estuarine environments.

Based on the habitat, distribution and previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Freshwater floodplains – ***Likely***, based habitat suitability.
- Estuarine wetlands – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Oxbow lakes and ORWBs – ***Likely***, based on habitat suitability.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Pristis zijsron* – green sawfish**

Nationally-listed	×	Not listed
Trade-restricted	✓	Appendix I
IUCN threatened	✓	Critically Endangered
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	✓	Listed under Bonn Convention
Overall sensitivity	***Extreme vulnerability***	

The green sawfish primarily occurs within coastal waters but is known to enter estuaries (Simpfendorfer, 2013; Stevens *et al.* 2005). Estuaries are primarily used by juveniles and smaller adults, with larger adults usually occurring in coastal waters. The species does not utilize freshwater environments (Stevens *et al.* 2005).

Green sawfish have not been confirmed within the study area but village surveys undertaken for the Upstream Land and Natural Resources Baseline Report (Booyong Forest Science, 2017) indicate the presence of sawfish species at Orokolo Bay and the Purari River delta. This may indicate individual green sawfish.

Green sawfish are long-lived but have low fecundity and late maturation, increasing the susceptibility of the species to anthropogenic mortality (Stevens *et al.* 2005). This also reduces ability of the species to recover from impacts. Similar to the largetooth sawfish, the green sawfish is highly threatened by fishing activities, particularly gill-netting and trawling. However, unlike the largetooth sawfish, the green sawfish does not utilize large river systems as adults and therefore are more likely to be impacted by the commercial fisheries operating within the Gulf of Papua – see Marine Fisheries and Resources Baseline Report (ERIAS Group, 2017c). In addition, monitoring of the species in Australia suggest a link between species decline and habitat degradation associated with anthropogenic settlements (DoEE, 2017c).

Based on the habitat, distribution and previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Does not occur***, as these are freshwater.
- Unconfined turbid major river systems (freshwater) – ***Does not occur***, as these are freshwater.
- Unconfined turbid major river systems (estuarine) – ***Possible***, but only within estuarine areas, as utilized by juveniles.
- Freshwater floodplains – ***Does not occur***, as these are freshwater.
- Estuarine wetlands – ***Possible***, as utilized by juveniles.
- Oxbow lakes and ORWBs – ***Does not occur***, as these are freshwater.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Anoxypristis cuspidata* – narrow sawfish**



Nationally-listed	×	Not listed
Trade-restricted	✓	Appendix I
IUCN threatened	✓	Endangered
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	✓	Juveniles utilize inshore and estuarine waters before moving into deeper waters offshore as adults. Listed under Bonn Convention
Overall vulnerability	***Extreme vulnerability***	

Juveniles and pupping female sawfish, as well as some individual adults, utilize estuarine waters as habitat, although most adults occur within the marine environment (D'Anastasi *et al.* 2013). Individuals do not occur within freshwater. The species is known to have a higher intrinsic rate of population increase compared to other sawfish species, allowing it to persist across most of its historical range (D'Anastasi *et al.* 2013).

Distribution mapping of the species indicates that it occurs across the coastal fringe of New Guinea, Indonesia and the Gulf of Carpentaria (Australia). Exchange of individuals between different areas does not seem to occur, suggesting that the population of New Guinea can be considered separate to those of other areas (Faria *et al.* 2013).

While the species has not been confirmed during fishing surveys as part of the current study or the Purari River (Wabo) Hydroelectric Scheme EIS, a specimen was identified based on photographs of fish catch taken during Orokolo Bay coastal village surveys in 2016. Surveys with villagers indicate that sawfish species are regularly caught in coastal and estuarine areas of Orokolo Bay, which may indicate the abundance of this species in this part of the study area. See further Upstream Land and Natural Resources Use Baseline Report (Booyong Forest Science, 2017).

As for other sawfish species, the toothed rostrum of the narrow sawfish makes them susceptible to net-based fishing activities (D'Anastasi *et al.* 2013). The species is known to be targeted by artisanal fishing in Orokolo Bay but may also be caught as by-catch in trawling activities further offshore. As juveniles of the species occur within estuarine waters, gill-netting within these areas also are a threat to the species, though as noted above, high-intensity gill-netting is not known to have occurred throughout estuarine waters of the study area. D'Anastasi (2010) suggest that localized depletions

in populations may not be replenished by adjacent stocks due to the presence of distinct genetic stocks, increasing the susceptibility of localized 'collapses' of species population.

On the basis of the above information, the following occurrence is noted for the study area:

- Tributary streams (high-to-moderate and low gradient) – ***Does not occur***, as these are freshwater.
- Unconfined turbid major river systems (freshwater) – ***Does not occur***, as these are freshwater.
- Unconfined turbid major river systems (estuarine) – ***Possible***, based on available habitat.
- Freshwater floodplains – ***Does not occur***, as these are freshwater.
- Estuarine wetlands – ***Likely***, based on habitat suitability.
- Oxbow lakes and ORWBS – ***Does not occur***, as these are freshwater.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Glyphis glyphis*[13] – speartooth shark**

Nationally-listed	× Not listed
Trade-restricted	× Not listed
IUCN threatened	✓ Endangered
Endemic and/or restricted-range	× Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	× Species does not migrate or congregate
Overall sensitivity	***Extreme vulnerability***

During surveys for the Purari River (Wabo) Hydroelectric Scheme EIS, Haines (1979) identified *Carcharhinus glyphis* (a synonym for *G. glyphis*) in the following areas:

- Era River lower mangroves (west of Port Romilly) – rare (i.e. occasional individuals).
- Era River nipa-mangrove wetlands (west of Port Romilly) – rare.
- Kikori River lower mangroves – rare.

Based on sightings by White *et al.* (2015) in coastal waters of Daru in 2014, the species still occurs within the Gulf of Papua. This was the first confirmed sighting since Haines (1979).

While the species has not been reported in the Purari River it has traditionally been sighted only within freshwater and estuarine habitats and is expected to be adapted to living in turbid waters with poor visibility (Compagno *et al.* 2009). As the species still occurs within the Gulf of Papua, it is likely that individuals utilize the river channels of the Purari River delta, both within freshwater and estuarine areas, but is less likely to use swift-flowing, clear water tributary streams. It may also occur in freshwater floodplain wetlands.

[13] Previously recorded as *Carcharhinus gylphis*

Similar to *Pristis* species, the speartooth shark is threatened by fishing activities, particularly as by-catch in gill-netting for species such as barramundi (*Lates calcarifer*) (DoEE, 2017a). Habitat degradation/modification from anthropogenic influences is also a threat to the species. Compagno *et al.* (2009) also note the tailings discharge from the Ok Tedi mine into the Fly River as a threat to the population occurring within this area.

Based on the habitat, distribution and previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Likely***, based on habitat suitability and recent records (i.e. White *et al.* 2015) in broader region.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on habitat suitability and recent records (i.e. White *et al.* 2015) in broader region.
- Freshwater floodplains – ***Possible***, based available habitat.
- Estuarine wetlands – ***Likely***, based on habitat suitability and recent records (i.e. White *et al.* 2015) in broader region.
- Oxbow lakes and ORWBs – ***Possible***, based on available habitat.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

Glyphis garricki/gangeticus [14] **– Northern river shark**

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	✓	Critically Endangered
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	×	Species does not migrate or congregate
Overall sensitivity	***Extreme vulnerability***	

Haines (1979) recorded the presence of a second *Glyphis* species during surveys for the Purari River (Wabo) Hydroelectric Scheme EIS: *Carcharhinus gangeticus* (synonym for *G. gangeticus*). As this species is known only from the lower reaches of the Ganges-Hooghli river system in India (Compagno, 2007) and as distinction between *G. gangeticus* and *G. glyphis* requires the use of x-rays of the vertebral column (see Taniuchi *et al.* 1991) it is considered more likely that this species was the northern river shark (*G. garricki*).

This species was identified in the following areas:

[14] Previously recorded as *Carcharhinus garricki/gangeticus*

- Purari River lower mangroves (across the Purari River delta estuary) – rare (i.e. occasional individuals).
- Purari River nipa wetlands (near Port Romilly and Baimuru) – rare.
- Era River lower mangroves (west of Port Romilly) – rare.
- Kikori River lower mangroves – rare.

The northern river shark has been confirmed recently within the Fly River (Compagno, 2002) and the coastal waters of Daru (White *et al.* 2015) and is considered likely to still occur within the Purari River system.

As with *G. glyphis*, this species is expected to occur within turbid waters of main river channels and large tributaries but not smaller, clear water tributaries.

Similar to *Pristis* species and *G. glyphis*, the northern river shark is threatened primarily by fishing activities, including recreational and commercial fishing using gill nets and long-lines (Pognoski and Pollard, 2003).

Based on the habitat, distribution and (potential) previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Freshwater floodplains – ***Possible***, based available habitat.
- Estuarine wetlands – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Oxbow lakes and ORWBs – ***Possible***, based on available habitat.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Carcharhinus leucas* – bull shark**

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	✓	Near Threatened
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	×	Species does not migrate or congregate
Overall vulnerability	***Moderate vulnerability***	

The bull shark occurs across the continental shelf (up to depths of 150 m), commonly within nearshore areas (Simpfendorfer and Burgess, 2009). The bull shark occurs within both freshwater and marine environments and commonly returns to estuarine areas. Typically, adults occur in offshore waters before moving into estuarine waters to give birth to their young (Simpfendorfer and Burgess, 2009). Juvenile sharks use estuarine habitats as nursery areas before travelling back out to sea.

Haines (1979) recorded bull sharks within the Purari, Vailala, Era and Kikori rivers at the following locations:

- Purari River main channel upstream of Herd Base – normally present but not abundant (i.e. 1-4 individuals caught per standard catch).
- Still water of freshwater reaches of Vailala River – only one specimen taken.
- Seribi River (tributary to Kikori River) – rare, occasional individuals.
- Lower mangrove wetlands of Era River – rare, occasional individuals.

The presence of this species was also inferred at Wabo Creek (near Wabo), the mangrove, nipa and pandanus wetlands of the Vailala, Kikori and Era rivers, and the mouth of the Kikori River (Haines, 1979).

The principle threats to bull sharks are fishing and conversion of estuarine/freshwater nursery habitat (Simpfendorfer and Burgess, 2009). However, the species is known to proliferate in some artificial waterway environments, such as canals.

On the basis of the above information, the following occurrence is noted for the study area:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on historical records (Haines, 1979) and ongoing habitat suitability.
- Freshwater floodplains – ***Likely***, based on habitat suitability.
- Estuarine wetlands – ***Likely***, based on habitat suitability.
- Oxbow lakes and ORWBS – ***Likely***, based on habitat suitability.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Glaucostegus typus* – giant shovelnose ray**

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	✓	Vulnerable
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	×	Species does not migrate or congregate
Overall sensitivity	***Moderate vulnerability***	

Giant shovelnose rays occur within mangrove systems and estuaries as juveniles, while adults occur within deeper marine waters (Last and Stevens, 1994). However, the species is also known to be able to live and breed permanently in freshwater (White and McAuley, 2016).

While the species has not been identified within the Purari River, Haines (1979) identified *G. typus* (as *Rhinobatos batillum*) within the coastal waters of Orokolo Bay and offshore of the Purari delta. This suggests that juveniles are likely to occur within the estuarine areas of the delta.

White and McAuley (2016) note the following major threats to the species:

- Market for *G. typus* fins, leading to targeted fishing as well as removal of fins of individuals caught in by-catch.
- Fishing within mangrove estuaries using gill and seine nets.

White and McAuley (2016) note that most of these impacts are occurring within eastern Indonesia (i.e. Papua) but not in Australia, due to better regulation and no target fisheries. This may indicate a lesser level of threat in the study area, as there is no known target fishery for the species (see ERIAS Group, 2017b), although there is also only limited regulation of artisanal fisheries in this area.

Based on the habitat, distribution and (potential) previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Possible***, based on available habitat.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on habitat suitability.
- Freshwater floodplains – ***Possible***, based on available habitat.
- Estuarine wetlands – ***Likely***, based on ongoing habitat suitability.
- Oxbow lakes and ORWBs – ***Possible***, based on available habitat.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Urogymnus granulatus* – mangrove whipray**

Nationally-listed	× Not listed
Trade-restricted	× Not listed
IUCN threatened	✓ Vulnerable
Endemic and/or restricted-range	× Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	× Species does not migrate or congregate
Overall sensitivity	***Moderate vulnerability***

The mangrove whipray is an inshore species, occurring in coastal waters and estuaries, including around mangroves (Manjaji Matsumoto *et al.* 2016). Whiprays typically occur as solitary individuals rather than forming aggregations.

Based on studies by Davy *et al.* (2015), juveniles (and potentially adults) appear to have high site fidelity. Mangroves are considered particularly important to this species as refuge habitat (Manjaji Matsumoto *et al.* 2016).

The whipray is often caught in by-catch of commercial fisheries, including trawl and gill-net fisheries (Manjaji Matsumoto *et al.* 2016). In addition, the reliance of the species on mangrove habitats makes it sensitive to habitat conversion and pollution within estuarine and nearshore areas.

Based on the habitat, distribution and (potential) previous records of this species, the following occurrence is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to stream flow, water quality and waterway size.
- Unconfined turbid major river systems (freshwater) – ***Unlikely***, based on lack of available habitat.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on habitat suitability.
- Freshwater floodplains – ***Unlikely***, as species tends to occur in brackish water only.
- Estuarine wetlands – ***Likely***, based on ongoing habitat suitability.
- Oxbow lakes and ORWBs – ***Unlikely***, as species tends to occur in brackish water only.

NOTE: The occurrences listed above are applicable for each of the Purari, Era and Pie river catchments.

***Epinephelus coioides* – orange-spotted grouper**

Nationally-listed	×	Not listed
Trade-restricted	×	Not listed
IUCN threatened	✓	Near Threatened
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	×	Species does not migrate or congregate
Overall vulnerability	***Moderate vulnerability***	

The orange-spotted grouper occurs within the marine environment as well as within mangroves and brackish water over mud and rubble. This species undertakes spawning activities within mangrove systems, with juveniles typically occurring within mangrove wetlands of estuaries (Cornish and Harmelin-Vivien, 2004). It is not known to occur within freshwater.

The orange-spotted grouper is known to occur in the study area based on observations made during the marine field survey.

The main threats to the species are overfishing and habitat modification (Cornish and Harmelin-Vivien, 2004), including the loss of mangrove habitats.

On the basis of the above information, the following occurrence is noted for the study area:

- Tributary streams (high-to-moderate and low gradient) – ***Does not occur***, as these are freshwater quality.
- Unconfined turbid major river systems (freshwater) – ***Does not occur***, as these are freshwater.
- Unconfined turbid major river systems (estuarine) – ***Possible***, based on available habitat.
- Freshwater floodplains – ***Does not occur***, as these are freshwater.
- Estuarine wetlands – ***Likely***, based on habitat suitability.
- Oxbow lakes and ORWBS – ***Does not occur***, as these are freshwater.

6.5 River Dolphins

While dolphins primarily occur within marine waters, two species expected to occur within the Gulf of Papua are known to utilize the deltas of large rivers:

- Australian snubfin dolphin (*O. heinsohni*).
- Australian humpback dolphin (*S. sahulensis*).

These species are discussed below.

***Orcaella heinsohni* – Australian snubfin dolphin**

Nationally-listed	✗ Not listed
Trade-restricted	✓ Appendix I
IUCN threatened	✓ Near Threatened
Endemic and/or restricted-range	✗ Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	✓ Listed under Bonn Convention
Overall vulnerability	***High vulnerability***

O. heinsohni has a geographic distribution that is restricted to tropical and subtropical zones of Australia, and southern New Guinea (Beasley *et al.* 2005). It is an uncommon nearshore coastal species in most areas, and is often found in small groups (Parra, 2005; 2006). This species inhabits riverine, estuarine and nearshore coastal waters, with a preference for very shallow areas (i.e. <2 m deep – Reeves *et al.* 2008). The species typically occurs near the mouth of rivers (Reeves *et al.* 2008).

A pod of five Australian snubfin dolphins were observed in the waters off Bluff Point, a coastal location 13 km west of Kerema as part of previous (unpublished) surveys. These surveys suggest that the pod traveled inshore to feed on resources available in association with the rocky reef areas, although this species is an opportunistic generalist and can feed in soft sediment, seagrass and reef habitats (Parra, 2006). The sighting was supported by the local community who claim that this species frequents the area on high tide. Beasley *et al*. (2016) found that *Orcaella* sp. (most likely *O. heinsohni)* was the most abundant marine mammal species recorded in boat-based surveys at the Kikori Delta between 2013 and 2015.

This species was recently separated from *O. brevirostris*, the Irrawaddy dolphin, and previous sightings of *O. brevirostris* in Papua New Guinean waters may actually be records of *O. heinsohni* as the currently recognized distribution of the former does not include Papua New Guinea. On this basis, records of the Irrawaddy dolphin in the western gulf during the PNG LNG Project EIS (CNS, 2008a) are considered to be records of the snubfin dolphin.

Based on previous counts of the species, discussed in Reeves *et al.* (2008), the total population of the species is expected to be less than 10,000 and may potentially be in decline. The key threats to the species are related to entanglement in netting set for anti-shark purposes or for fishing, including gill-nets in rivers (Reeves *et al.* 2008).

Based on the above, the following occurrence of this species is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to distance from coastal waters.
- Unconfined turbid major river systems (freshwater) – ***Possible***, based on available habitat.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on habitat suitability.
- Freshwater floodplains –***Does not occur***, as these are shallow wetlands
- Estuarine wetlands – ***Likely***, based on habitat suitability.

- Oxbow lakes and ORWBS – ***Possible***, based on available habitat.

***Sousa sahulensis* – Australian humpback dolphin**

Nationally-listed	×	Not listed
Trade-restricted	✓	Appendix I/Schedule 1 (as *S. chinensis*)
IUCN threatened	✓	Not recognized but expected to be Vulnerable (cf. Parra and Cagnazzi, 2016)
Endemic and/or restricted-range	×	Species is not restricted to the Gulf of Papua and Southeast Papua New Guinea ecoregions and has a range greater than 100,000 km^2
Migratory and congregatory	✓	Listed under Bonn Convention (as *S. chinensis*)
Overall vulnerability	***High vulnerability***	

Until recently, *S. sahulensis* was not recognized as a separate species to *S. chinensis* (see below). While the species is now accepted as taxonomically separate, the IUCN Red List still lists only *S. chinensis*. Parra and Cagnazzi (2016) consider that this species meets the criteria of Vulnerable under IUCN criterion C2a(i).

Similar to *O. heinsohni*, the geographic distribution of *S. sahulensis* encompasses the tropical and subtropical east and west coasts of northern Australia and southern New Guinea. *S. sahulensis* occurs in a broad range of coastal habitats including coastal lagoons, enclosed bays, estuaries and open coastal waters (Jefferson and Karczmarski, 2001).

Beasley *et al.* (2016) found that *S. sahulensis* was the second most abundant species recorded in boat-based marine mammal surveys of the Kikori Delta between 2013 and 2015. This species was recorded in water of low salinity and high turbidity at depths of 1.6 to 12 m. Surveys conducted in the far northern Great Barrier Reef region indicates that this species usually occurs close to the coast (within 5 km of land) in depths of less than 15 to 20 m, and usually within 20 km from the nearest river mouth (Parra *et al.* 2006). The species is an opportunistic generalist, feeding on fish and crustaceans from coastal, estuarine and nearshore reef habitats (Parra, 2006; Parra *et al.* 2006).

The principle threats to this species consist of the following (DoEE, 2017d):

- Habitat destruction and degradation, including noise pollution and harassment associated with boat use.
- Incidental capture in inshore gill-nets associated with riverine barramundi and threadfin fisheries.
- Incidental capture in shark nets.
- Competition with fisheries that target estuarine and nearshore fish species.

Based on the above, the following occurrence of this species is noted:

- Tributary streams (high-to-moderate and low gradient) – ***Unlikely***, due to distance from coastal waters.
- Unconfined turbid major river systems (freshwater) – ***Possible***, based on available habitat.
- Unconfined turbid major river systems (estuarine) – ***Likely***, based on habitat suitability.

- Freshwater floodplains –***Does not occur***, as these are shallow wetlands
- Estuarine wetlands – ***Likely***, based on habitat suitability.
- Oxbow lakes and ORWBS – ***Unlikely***, based on distance to coastal waters, depth and water quality.

Table 6-16 Threatened/Important Aquatic Flora and Fauna Species with Likely or Possible Occurrence in the Study Area*

Species name	Common name	Relevant threatened/important status	Occurrence within biotopes[1]						
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bruguiera hainesii	Haines orange mangrove	IUCN Critically Endangered						Known	
Ciliometra setosa	-	Endemic	Likely	Unlikely	Unlikely		Likely		Likely
Iobates ivimka	-	Endemic	Likely	Unlikely	Unlikely		Likely		Likely
Pristis pristis	Longtooth sawfish	CITES Appendix I IUCN Critically Endangered Migratory	Unlikely	Unlikely	Likely	Likely	Likely	Likely	Likely
Pristis zijsron	Green sawfish	CITES Appendix I ICUN Critically Endangered Migratory				Possible		Possible	
Anoxypristis cuspidata	Narrow sawfish	CITES Appendix I IUCN Endangered Migratory				Possible		Possible	
Glyphis glyphis	Speartooth shark	IUCN Endangered	Unlikely	Unlikely	Likely	Likely	Possible	Likely	Possible
Glyphis garricki	Northern river shark	IUCN Critically Endangered	Unlikely	Unlikely	Likely	Likely	Possible	Likely	Possible
Carcharhinus leucas	Bull shark	IUCN Near Threatened	Unlikely	Unlikely	Likely	Likely	Likely	Likely	Likely
Glaucostegus typus	Giant shovelnose ray	IUCN Vulnerable	Unlikely	Unlikely	Possible	Likely	Possible	Likely	Possible
Urogymnus granulatus	Mangrove whipray	IUCN Vulnerable	Unlikely	Unlikely	Unlikely	Likely	Unlikely	Likely	Unlikely
Epinephelus coioides	Orange spotted grouper	IUCN Near Threatened				Possible		Likely	
Orcaella heinsohni	Australian snubfin dolphin	CITES Appendix I IUCN Near Threatened Migratory	Unlikely	Unlikely	Possible	Likely		Likely	Unlikely
Sousa sahulensis	Australian humpback dolphin	CITES Appendix I IUCN Vulnerable Migratory	Unlikely	Unlikely	Possible	Likely		Likely	Unlikely

[1]Biotopes are listed as follows: (1) tributary streams (high-to-moderate gradient), (2) tributary streams (low gradient, (3) freshwater reaches of unconfined turbid major river systems, (3) estuarine reaches of unconfined turbid major river systems, (5) floodplain wetlands, (6) estuarine wetlands, and (7) oxbow lakes and ORWBs. Shaded cells indicate where species does not occur, e.g. where biotope is freshwater but species is restricted to brackish water

*This table does not include threatened/important species from Vaihua River estuary – these are considered in Section 6.9.

6.6 Sensitive Habitat Features

Sections 6.2.3, 6.3.2, 6.4.6 and 6.5 describe the threatened/important species of the study area and the sensitivity rating of these species. The following identifies the overall sensitivity of discrete areas of the study area based on these species and other prioritization criteria discussed in Section 5.8.2.

Based on the information in preceding sections, the following freshwater and estuarine habitat values are identified for the study area:

- High-to-moderate gradient tributary streams.
- Low gradient slow-to-moderate flowing rivers and backwaters of large rivers.
- Unconfined turbid major river systems.
- Freshwater floodplain wetlands on deltaic plains.
- Estuarine wetlands (including mangroves, nipa and pandanus wetlands).
- Oxbow lakes and off-river water bodies on floodplains.
- *B. hainesii* stands.
- Mouth/delta of large river systems.
- Plateaus discontinuous from surrounding catchment.
- Crater Mountain WMA.

Table 6-17 assesses each of these values against vulnerability and irreplaceability criteria from Section 5.8.2 and provides an overall rating of sensitivity.

Table 6-17 Sensitivity Rating of Freshwater and Estuarine Habitat Values and Areas

Aquatic habitat value/area	Sensitivity rating	Comments/applicable criteria
High-to-moderate gradient tributary streams	***Low***	Habitat type does not support specific lifecycle functions of species with *moderate*, *high* or *extreme vulnerability* AND is not considered to be unique or of high sensitivity.
Low gradient slow-to-moderate flowing rivers and backwaters of large rivers	***Low***	Habitat type does not support specific lifecycle functions of species with *moderate*, *high* or *extreme vulnerability* AND is not considered to be unique or of high sensitivity.
Unconfined turbid major river systems	***Moderate***	Area potentially used by species with *high* or *extreme vulnerability* (*Pristis* and *Glyphis* spp., and *Orcaella heinsohni* and *Sousa sahulensis*) for activities other than those critical to lifecycle of species. NOTE: As the occurrence of species is currently unconfirmed, the sensitivity rating of this habitat is *moderate* rather than *high*.
Freshwater floodplain wetlands on deltaic plains	***Moderate***	Area potentially used by species with *moderate*, *high* or *extreme sensitivity* (*Pristis pristis*, *Glyphis* spp. and *Glaucostegus typus*) for activities other than those critical to lifecycle of species. NOTE: As the use of species of these habitats is currently unconfirmed, the sensitivity rating of this habitat is *moderate* rather than *high* or *extreme*.

Aquatic habitat value/area	Sensitivity rating	Comments/applicable criteria
Estuarine wetlands	***High***	Area used by species with *moderate*, *high* and *extreme vulnerability* that is critical to lifecycle functions (i.e. habitat for juveniles).
Oxbow lakes and off-river water bodies	***High***	Area potentially supports unique assemblages of aquatic species AND is a unique landscape feature within the lower Purari River catchment. NOTE: As it is uncertain whether oxbows actually support unique assemblages, sensitivity rating of this habitat is *high* rather than *extreme*.
B. hainesii stands	***Extreme***	Area supports species with *extreme* sensitivity (*B. hainesii*).
Mouth/delta of large river systems	***Moderate***	These areas represent a potential congregation point for various aquatic species that are able to move between marine and freshwater systems, including as part of lifecycle migrations. As there are not distinctive 'runs' within the study area of any species, however, it is given a *moderate* sensitivity.
Plateaus	***High***	Area potentially supports unique assemblages of species due to isolation/discontinuity. This is particularly pronounced for the northern plateau. NOTE: As it is uncertain whether plateaus actually support unique assemblages, sensitivity rating of this habitat is *high* rather than *extreme*.
Crater Mountain WMA	***High***	Protected area.

6.7 Invasive Species

6.7.1 Flora

The main invasive aquatic plant species of concern in Papua New Guinea are:

- *Salvinia molesta* – this species has been subject to significant eradication effort in Papua New Guinea (Room and Thomas, 1986; Orapa, 2006). The species is particularly abundant in northern Papua New Guinea, but its status in the area of PRL-15 and the Purari River delta is not documented. This species was not recorded in the present study.
- *Eichhornia crassipes* – this species is widely distributed in Papua New Guinea despite management efforts (Orapa and Julien, 2001; Orapa, 2006). This species was observed floating downstream in the Purari River estuary during fieldwork in June-July 2016 and January 2017. It was also confirmed at Nea Creek, the PRL-15 oxbow wetlands and the Purari Airstrip during surveys undertaken for the terrestrial biodiversity baseline study. See Upstream Terrestrial Biodiversity Baseline Report (ERIAS Group, 2017b).
- *Pistia stratiotes* has been recorded in the Purari River catchment (Marks 1983) and may occur in the area of PRL-15 and the Purari River delta.
- *Hydrilla verticillata* - Orapa (2006) considers this species as a potential future threat in Papua New Guinea.

6.7.2 Fauna

The introduction of non-native fish species is a widespread issue throughout Papua New Guinea (Polhemus *et al.* 2004). Twenty-one species of freshwater fish representing 19 genera and 11 families have been introduced for reasons including sport, aquaculture, pest control, ornamentation and as a food resource (Enesar, 2005). Although further introductions of fish species are expected in Papua New Guinea, not all introduced species have become established and have had a significant impact (Polhemus *et al.* 2004).

While no exotic fish species were captured during the field surveys in 2016 and 2017, a number of invasive species have been identified in the study area. These include:

- European or wild common carp (*Cyprinus carpio*). This species has become established in multiple catchments in Papua New Guinea and is known to occur in the area of PRL-15 and the Purari River delta (though the population status is unknown). Whilst interviewing local fisherman at Lali Village, a common carp (*Cyprinus carpio*) was opportunistically observed as part of their catch, and while the exact location was not determined, it was in the Purari River delta region. Further consultation with local fisherman suggested that exotic species are also abundant in lacustrine and wetland environments (i.e. PRL-15 oxbow wetlands), particularly common carp (*C. carpio*) and tilapia (*Oreochromis mossambica* – see below*).* This anecdotal evidence is consistent with a survey in 2010 (unpublished report, 2010) which reported both these species in the PRL-15 oxbow wetlands.
- Tilapia (*Oreochromis mossambica* or *Sarotherodon* spp.). Native to Africa, these species were introduced to Papua New Guinea in the 1950s and has become established in many areas, either through natural dispersal or through intentional translocation by people. For example, tilapia is now a major food source for the people living in the Sepik River (northern Papua New Guinea), where it was stocked as part of the Sepik River Fish Stock Enhancement Project (SRFSEP) during 1987-1993 and FISHAID during 1993-1997. It is also one of the most abundant fish within Lake Kutubu where it is extensively farmed (Smith *et al.* 2016), but the population status of this species in the area of PRL-15 and the Purari River delta is not presently known. Due to access and safety constraints, sampling could not be conducted in the preferred habitats of this species.
- Copper mahseer (*Barbodes wynaadensis*) or Putitor mahseer (*Tor putiutora*). *B. wynaadensis* was reported to occur as part of interviews associated with the Upstream Land and Natural Resources Use (Ecosystem Services – Provisioning) Baseline Report (Booyong Forest Science, 2017) although this is considered likely to actually be *T. putitora*, consistent with previous findings of Haines (1979). Both of these species originate from south Asia (e.g. Indian, Bangladesh) and are highly constrained and threatened within their original distribution. The reason for the introduction of these species within the Purari River catchment is unknown but expected to be associated with historical fish stocking.

The presence of *Cyprinus carpio* and the tilapia species is of particular concern. Both carp and tilapia modify their environment to suit their conditions, often resulting in sub-optimal conditions for native species. This is often manifested as the destruction of aquatic plants and disturbance of sediments, which results in increased turbidity and habitat simplification (Polhemus *et al.* 2004). It is expected

that in time, these invasive species will spread into other potentially suitable habitat, such as low gradient tributary streams.

Small-bodied Poeciliidae invasive species such as the mosquitofish (*Gambusia affinis*), swordtail (*Xiphophorus helleri*) and guppy (*Poecilia reticulata*) are not known in the Purari River but could occur, especially in slower flowing streams and floodplain environments. The mosquitofish (*Gambusia affinis*) is of most concern. This species was introduced into Papua New Guinea to control mosquito populations. It has now become an established invasive species and has been reported to compete with small surface-feeding native fish and frogs, and compete with native species for food resources. There are records for this species in Lake Kutubu, but there is little existing information on the population status of this species in the study area.

Other introduced fish species known to occur in the Purari River upstream of Hathor Gorge (Haines 1983) include: snakeheads (*Channa striata*), walking catfish (*Clarias batrachus*), climbing perch (*Anabas testudineus*) (all of which compete or prey upon native fauna). Furthermore, rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), green swordtails (*Xiphophorus helleri*), blue panchax (*Aplocheilus panchax*) and gourami (*Trichogaster pectoralis* or *Trichogaster trichopterus*) are present in Papua New Guinea (Polhemus *et al.* 2004) and could in time colonize study area waterways.

6.8 Metal/Metalloid and PAH Burdens in Aquatic Fauna

6.8.1 General Context

All aquatic invertebrates and fish accumulate trace metals and metalloids (Rainbow, 2002). This accumulation of metals within aquatic biota can occur through several pathways, including (Uysal, 2011; Malik *et al*. 1998):

- Direct uptake of bioavailable metal ions from the water column through absorption and respiration.
- Ingestion of food (i.e. insects, plant/algae material, smaller fish etc.) or contaminated sediment material (i.e. benthic feeders) containing bioavailable metals/metalloids.

Bioavailability of metals is influenced by the chemical speciation of metal forms, the distribution of metals between soluble and particulate forms and chemical properties of water (e.g. hardness, pH, redox potential, organic content etc.) of the surrounding water column and sediments (Dallinger *et al*. 1987).

Some fauna are capable of rapid excretion of some metals (Rainbow, 2002). However, there are several metals/metalloids (e.g. arsenic, lead, mercury, silver and zinc) that cannot be easily excreted, and can accumulate over the life of aquatic organisms. Animals that are high in the food chain (e.g. fish, birds and humans) can accumulate these metals through the consumption of prey, resulting in metal biomagnification. The accumulation of certain metals can lead to a range of adverse health effects for the animal and/or human consumers.

Accumulation of metals varies greatly among and within aquatic species, and body concentrations can vary greatly among species and environments. The links between bioaccumulation and toxicity are also complex, and depend on species-specific partitioning of accumulated metals between metabolically active and detoxified forms (Rainbow, 2002).

6.8.2 Guideline Values

Contaminant concentrations in tissues were compared to the following food consumption guideline values:

- The ANZFA food standards code (1.4.1) and General Expected Levels (GEL) and Maximum Levels (MLs) for metal contamination (ANZFA, 2001). Results were compared to the 90th percentile GEL values for copper, selenium and zinc, and 90th percentile ML values for arsenic and mercury, in fish and crustacean food types.

  NOTE: The MLs for arsenic includes the inorganic component of arsenic only. Rainbow (2002) indicates that only about 20% of arsenic in fish tissue is inorganic.

- FAO/WHO (2006) proposed CODEX standards for the protection of human health.

- USFDA (2001) guidance values, above which decisions are made by the authority on whether consumption advisories or water closures are made.

The present assessment was intended to provide a baseline of contaminant concentrations in aquatic biota tissues, but does not represent an assessment of risks associated with human consumption of aquatic biota. It is important to note that:

- The GELs and MLs are based on trace metal concentrations recorded in biota samples collected in Australia. The GEL value does not necessarily represent a maximum level for safe human consumption while MLs do provide an indication of this level but only for arsenic and mercury. These values do not take into account local conditions, where metal burdens may be naturally higher than recorded by ANZFA. The GELs and MLs provide a benchmark against which to assess contaminant levels in organisms, but it is important to note that they are not legally enforceable.

- Comparison of data to 'human health' guideline values (USFDA, 2001; FAO/WHO, 2006) does not take into account the specific body parts of biota preferentially consumed. For example, if the prawn cephalothorax is not consumed then the comparison to these guideline levels may not be relevant.

- There are no food guidelines or similar for polycyclic aromatic hydrocarbons (PAHs).

6.8.3 Results and Discussion

Table 6-18 to Table 6-21 presents metal and metalloid concentration data for fish and *Macrobrachium* prawns collected in the 2016 and 2017 surveys. Laboratory results are provided in Appendix C.

The results indicate that several metals had concentrations that were greater than the GELs or MLs, as follows:

- Copper in fish tissue samples collected in 2016 was above the ANZFA GEL at sites 20B and 24 (in *Arius graeffei* and *Liza subviridis*), and at sites 14, 21 and 22B (in *Thryssa scratchleyi*, *Valamugil buchanani Atrobucca brevis, Polydactylus plebeius* and *Nedystoma novaeguineae*) during 2017. The highest copper concentration recorded within the fish tissue samples was at Site 22B in *N. novaeguineae* (15.39 mg/kg). However, this may be considered an outlier as the

median for *N. novaeguineae* at site 22B was much lower at 1.16 mg/kg. Copper concentrations in the prawn cephalothorax, which contains the majority of organs, exceeded the ANZFA GEL Food Standard (30 mg/kg) across all sites in both 2016 and 2017. Concentrations in hind body samples also exceeded the ANZFA GEL during 2016 at all sites, but had lower concentrations than recorded in the cephalothorax. The highest copper concentration recorded in 2016 in the cephalothorax and hind was 99.75 mg/kg and 23.86 mg/kg, respectively. The highest copper concentration recorded in 2017 was similar, with levels of 96.20 and 34.56 mg/kg measured in the cephalothorax and hind body, respectively.

- Lead was detected in fish tissue samples and exceeded the FAO/WHO CODEX food standard of 0.3 mg/kg at Site 22 in 2016 (in *Nedystoma novaeguineae*), which recorded a maximum lead concentration of 0.75 mg/kg. In 2017, lead concentrations at Site 14 (in *Valamugil buchanani*) and Site 22B (in *Nedystoma novaeguineae*) also exceeded the FAO/WHO CODEX food standard with a maximum value of 0.47 mg/kg and 0.51 mg/kg, respectively. There was only one recorded exceedance of the USFDA Guidance Level for lead (1.5 mg/kg) for prawns, which was exceeded in 2016 at Site 15 within the cephalothorax of the *Macrobrachium* sp. (1.9 mg/kg).
- Zinc concentrations in fish tissue samples frequently exceeded the ANZFA GEL (15 mg/kg) across sites in 2017, with the exception of sites 18 and 21. The highest zinc concentration (58.9 mg/kg) was recorded at Site 22B (in *N. novaeguineae*). There were also several fish species at sites 5, 10, 20B, 22 and 23 with zinc concentrations above the ANZFA GEL in 2016. The highest zinc concentration recorded over both surveys was at Site 20B (in *A. graeffe*i) with 191.84 mg/kg. Zinc exceeded the ANZFA Food Standard GEL (40 mg/kg) in prawn cephalothorax at several sites in both 2016 and 2017 surveys.
- Arsenic concentrations in fish tissue samples exceeded the MLs (2 mg/kg) at Site 20B (*Arius graeffei*) and 24 (*Liza subviridis*), both taken during the June-July 2016 survey. However, this ML represents inorganic As which is equivalent to about 10mg/kg of total As given that about 80% of As in fish tissue is present as organic arsenic (Rainbow, 2002). The concentrations of total As measured in fish tissue, including at Site 20B, were all less than this level.

All other metal/metalloid concentrations were less than guideline values and/or guideline values were not available.

On average, the bluetail mullet (*Valamugil buchanani*) at Site 14 had greater concentrations of aluminum, lead, manganese and nickel in tissues compared to other species sampled, while the tissues of the lesser salmon catfish (*Arius graeffei*) at Site 20B had greater concentrations of aluminum, arsenic, copper and zinc. All other fish species had generally similar concentrations of metals in tissues. Furthermore, the *Macrobrachium* cephalothorax, which contains the organs and is a site of contaminant accumulation, had a greater mean concentration of all metals compared to *Macrobrachium* prawn tails.

As discussed earlier, the role of the ANZFA GELs are not to provide a definitive guideline of acceptable limits for human health and safety risks, but to provide a benchmark of what levels are usually found in certain foods. Therefore, despite several exceedances of copper and zinc GELs in fish and prawn samples, this is not indicative of a threat to human health.

With the exception of lead in two fish samples exceeding the FAO/WHO CODEX Standard and lead in one prawn sample exceeding the USFDA Guidance Level, metal/metalloid concentrations in all samples of biota were below guideline levels in these food standards.

No previous studies have examined metal and metalloid pathways in aquatic fauna tissues in the study area. Case studies elsewhere indicate that metal uptake and metal burdens in tissues can be highly variable in space and time, and is dependent on numerous factors including:

- Metal bioavailability.
- The duration of exposure to contaminants (i.e. acute exposure versus prolonged exposure).
- Metabolism of different taxa.
- The age and size of a particular taxa.
- Feeding habits (i.e. dietary requirements and subsequent levels of contamination).
- The use of particular habitats and mobility.

One or more of these factors may be the cause of higher concentrations observed in some fish samples.

Concentrations of PAHs were below detection limits (0.01 mg/kg) in all samples.

Table 6-18 Whole Body Fish Trace Metal/Metalloid Concentrations (mg/kg wet weight), January and February 2017 Field Surveys

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
17-02-17	5	Goldie River rainbowfish (*Melanotaenia goldiei*)	5	Min	3.63	0.01	0.00	0.53	0.00	1.67	0.03	0.07	0.15	0.00	31.46
				Max	16.31	0.03	0.01	1.17	0.01	7.10	0.14	0.14	0.29	0.01	42.40
				Median	4.56	0.01	0.01	0.86	0.01	6.43	0.04	0.07	0.17	0.01	34.19
19-02-17	12	Triangular shield catfish (*Sciades leptaspis*)	3	Min	0.48	0.07	0.00	0.28	0.00	0.40	0.03	0.02	0.09	0.00	23.76
				Max	10.38	0.15	0.00	0.37	0.04	0.76	0.04	0.07	0.14	0.00	38.06
				Median	2.52	0.12	0.00	0.31	0.00	0.58	0.04	0.03	0.12	0.00	31.04
19-02-17	12	Freshwater anchovy (*Thryssa scratchleyi*)	5	Min	0.41	0.08	0.00	0.32	0.00	0.67	0.05	0.02	0.17	0.00	6.50
				Max	0.82	0.24	0.00	0.42	0.01	3.46	0.39	0.02	0.26	0.00	10.15
				Median	0.63	0.16	0.00	0.39	0.00	1.02	0.10	0.02	0.24	0.00	6.76
14-02-17	14	Day's catfish (*Nedystoma dayi*)	5	Min	1.66	0.03	0.00	0.34	0.00	0.38	0.08	0.03	0.13	0.00	7.97
				Max	49.14	0.14	0.01	0.64	0.03	4.04	0.12	0.17	0.22	0.00	43.68
				Median	15.90	0.05	0.01	0.43	0.03	2.46	0.08	0.08	0.18	0.00	28.05
14-02-17	14	Freshwater anchovy (*Thryssa scratchleyi*)	5	Min	2.07	0.10	0.00	0.37	0.02	1.79	0.05	0.02	0.23	0.00	8.62
				Max	4.58	0.23	0.01	2.36	0.09	4.42	0.10	0.04	0.39	0.01	15.60
				Median	3.58	0.16	0.00	0.49	0.02	2.65	0.08	0.03	0.28	0.00	11.33
14-02-17	14	Bluetail mullet (*Valamugil buchanani*)	5	Min	8.60	0.25	0.00	0.56	0.03	2.45	0.03	0.05	0.25	0.00	9.61
				Max	1139.70	0.91	0.01	2.20	0.47	34.06	0.04	1.65	0.36	0.01	15.81
				Median	252.96	0.50	0.01	1.18	0.18	15.93	0.04	0.40	0.26	0.01	12.31
14-02-17	14	Fly River garfish (*Zenarchopterus novaeguineae*)	5	Min	1.26	0.01	0.00	0.36	0.04	0.95	0.05	0.02	0.21	0.00	25.68
				Max	7.05	0.03	0.01	0.75	0.28	2.43	0.07	0.08	0.30	0.01	40.00
				Median	1.56	0.02	0.00	0.45	0.05	1.43	0.06	0.02	0.24	0.01	28.05
19-01-17	18	Greenback mullet (*Liza subviridis*)	5	Min	0.12	0.11	0.00	0.14	0.00	0.59	0.00	0.00	0.04	0.00	2.02
				Max	105.78	0.30	0.00	0.39	0.05	3.69	0.01	0.15	0.07	0.01	3.69
				Median	1.38	0.20	0.00	0.22	0.00	0.71	0.01	0.01	0.06	0.00	3.02

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
18-01-17	21	Orange jewfish (*Atrobucca brevis*)	4	Min	0.12	0.07	0.00	0.20	0.00	0.11	0.01	0.00	0.09	0.00	1.98
				Max	3.95	0.18	0.00	2.57	0.09	2.17	0.02	0.01	0.10	0.00	5.14
				Median	0.50	0.13	0.00	0.94	0.03	0.51	0.01	0.01	0.09	0.00	4.31
18-01-17	21	Striped threadfin (*Polydactylus plebeius*)	5	Min	0.46	0.06	0.00	0.11	0.00	0.18	0.01	0.00	0.07	0.00	1.00
				Max	1.94	0.12	0.00	2.06	0.06	0.75	0.01	0.02	0.09	0.00	4.16
				Median	1.00	0.11	0.00	0.13	0.01	0.64	0.01	0.01	0.08	0.00	2.08
18-01-17	22B	Spoon-snouted catfish (*Nedystoma novaeguineae*)	5	Min	1.35	0.12	0.01	0.21	0.01	0.19	0.01	0.00	0.09	0.00	17.30
				Max	6.80	0.20	0.02	15.39	**0.51**	1.02	0.03	0.03	0.19	0.00	58.90
				Median	2.48	0.15	0.01	1.16	0.04	0.63	0.02	0.01	0.11	0.00	21.45
18-01-17	22B	Nurseryfish (*Kurtus gulliveri*)	5	Min	0.38	0.09	0.00	0.04	0.00	0.17	0.00	0.00	0.05	0.00	1.93
				Max	2.80	0.16	0.00	0.12	0.00	1.09	0.01	0.01	0.06	0.00	3.62
				Median	0.62	0.12	0.00	0.09	0.00	0.37	0.01	0.00	0.05	0.00	2.10
Limit of Reporting (LOR)					**0.5**	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.02**	**0.01**
ANZFA Food Standard GEL (90th percentile value)								**2**					**2**		**15**
ANZFA Food Standard ML**						**10**					**1.5**				
FAO/WHO CODEX Standard									**0.3**		**0.5**				
USFDA Guidance - Level											**1**				

*Shaded cells indicated that the ANZFA Food Standard GEL has been exceeded, **bold yellow cells** indicate the ANZFA ML has been exceeded, and **bold blue cells** indicate the FAO/WHO CODEX Standard has been exceeded

**ANZFA MLs for As (2) mg/kg) are based on inorganic but measurements are based on organic so MLs presented have been modified based on ratio of 80% organic to 20% inorganic provided by Rainbow (2002).

Table 6-19 Prawn Trace Metal/Metalloid Concentrations (mg/kg wet weight), January and February 2017 Field Surveys

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
18-02-17	2	*Macrobrachium* sp. (Cephalothorax)	5	Min	11.62	0.05	0.25	34.30	0.01	3.52	<0.01	0.07	0.15	0.02	23.74
				Max	126.36	0.09	0.65	99.76	0.05	154.35	<0.01	0.69	0.39	0.20	87.75
				Median	65.00	0.08	0.42	38.61	0.03	52.65	<0.01	0.42	0.35	0.06	30.87
		Macrobrachium sp. (Hind)	5	Min	4.75	0.02	<0.01	7.00	0.01	1.25	<0.01	0.02	0.12	<0.02	11.76
				Max	16.69	0.05	<0.01	20.79	0.02	37.08	0.01	0.17	0.14	0.02	16.50
				Median	11.47	0.03	<0.01	9.31	0.01	12.96	<0.01	0.08	0.13	0.01	13.66
15-02-17	3B	*Macrobrachium* sp. (Cephalothorax)	5	Min	19.86	0.08	0.06	33.00	0.04	10.88	<0.01	0.11	0.23	0.05	15.83
				Max	87.00	0.11	0.30	62.56	0.09	46.15	0.01	0.26	0.35	0.14	102.95
				Median	56.80	0.09	0.19	41.04	0.08	22.61	0.00	0.18	0.29	0.05	45.00
		Macrobrachium sp. (Hind)	5	Min	8.92	0.04	<0.01	8.19	0.03	5.38	<0.01	0.05	0.15	0.01	12.32
				Max	27.06	0.07	<0.01	23.86	0.08	12.55	0.01	0.13	0.19	0.03	17.22
				Median	12.32	0.04	0.00	11.44	0.04	11.86	<0.01	0.08	0.18	0.01	13.98
16-02-17	4	*Macrobrachium* sp. (Cephalothorax)	5	Min	10.93	0.19	0.05	50.10	0.05	8.65	<0.01	0.08	0.24	0.09	19.40
				Max	56.78	0.32	0.40	75.82	0.27	23.05	<0.01	0.16	0.38	0.20	79.81
				Median	36.68	0.22	0.12	60.26	0.15	13.85	<0.01	0.12	0.31	0.12	69.25
		Macrobrachium sp. (Hind)	5	Min	3.54	0.07	<0.01	8.00	0.03	2.67	<0.01	0.03	0.18	0.01	11.48
				Max	17.92	0.14	<0.01	12.14	0.05	5.15	<0.01	0.07	0.24	0.01	16.19
				Median	5.11	0.09	<0.01	10.86	0.04	3.87	0.00	0.04	0.19	0.01	13.33
16-02-17	6	*Macrobrachium* sp. (Cephalothorax)	3	Min	69.60	0.19	0.10	50.24	0.04	29.58	0.01	0.17	0.34	0.10	31.40
				Max	155.94	0.30	0.41	81.36	0.10	108.48	0.02	0.35	0.54	0.16	80.04
				Median	106.76	0.30	0.13	52.20	0.07	37.68	0.01	0.34	0.44	0.11	54.24
		Macrobrachium sp. (Hind)	3	Min	4.86	0.06	<0.01	8.99	0.01	5.59	<0.01	0.03	0.23	0.01	13.06
				Max	32.63	0.09	0.01	10.29	0.02	77.81	0.01	0.19	0.27	0.01	14.81
				Median	20.74	0.06	<0.01	9.73	0.02	16.38	0.01	0.08	0.24	0.01	14.58

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
18-02-17	10	*Macrobrachium* sp. (Cephalothorax)	5	Min	19.18	0.08	0.09	41.16	0.02	10.06	<0.01	0.16	0.27	0.04	56.05
				Max	69.66	0.14	0.41	68.31	0.05	92.88	0.01	0.98	0.41	0.22	159.96
				Median	43.52	0.13	0.33	56.76	0.02	18.71	0.01	0.21	0.29	0.09	76.16
		Macrobrachium sp. (Hind)	5	Min	4.41	0.03	0.00	8.14	0.01	3.25	<0.01	0.06	0.12	0.01	11.88
				Max	12.98	0.12	0.00	22.25	0.02	39.60	0.01	0.42	0.18	0.06	15.92
				Median	7.00	0.06	0.00	11.75	0.02	5.80	0.01	0.07	0.15	0.01	14.50
19-01-17	18	*Macrobrachium* sp. (Cephalothorax)	4	Min	0.67	0.04	0.05	8.64	<0.01	1.27	<0.01	0.01	0.06	0.01	4.60
				Max	74.10	0.12	0.12	45.60	0.02	6.84	<0.01	0.09	0.12	0.04	37.05
				Median	6.43	0.05	0.09	22.25	<0.01	1.67	<0.01	0.02	0.07	0.03	4.73
		Macrobrachium sp. (Hind)	4	Min	0.60	0.04	<0.01	2.87	<0.01	0.79	<0.01	<0.01	0.04	<0.02	2.98
				Max	1.69	0.05	<0.01	8.70	<0.01	2.04	<0.01	0.01	0.08	0.02	5.71
				Median	1.01	0.05	<0.01	3.75	0.00	0.97	<0.01	<0.01	0.05	0.00	3.46
Limit of Reporting (LOR)					**0.5**	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.02**	**0.01**
ANZFA Food Standard GEL (90th percentile value)								**20**					**1**		**40**
ANZFA Food Standard ML**						**10**					**1.5**				
USFDA Guidance Level						**76**	**3**		**1.5**		**1**	**70**			

*Shaded cells indicated that the ANZFA Food Standard GEL has been exceeded, **bold yellow cells** indicate the ANZFA ML has been exceeded, and **bold orange cells** indicate the USFDA Guidance Level has been exceeded

**ANZFA MLs for As (2) mg/kg) are based on inorganic but measurements are based on organic so MLs presented have been modified based on ratio of 80% organic to 20% inorganic provided by Rainbow (2002).

NOTE: FAO/WHO CODEX Standard does not include standards for prawns

Table 6-20 Whole Body Fish Trace Metal/Metalloid Concentrations (mg/kg wet weight), June and July 2016 Field Surveys

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
25-07-16	5	Sande's mouth almighty (*Glossamia sandei*)	4	Min	1.34	0.03	<0.01	0.27	<0.01	1.33	0.02	0.02	0.18	<0.02	8.44
				Max	12.79	0.10	0.01	1.44	0.01	4.70	0.08	0.03	0.44	<0.02	28.71
				Median	2.59	0.03	0.01	0.51	0.00	1.88	0.05	0.02	0.20	<0.02	14.50
26-07-16	10	Lined grunter (*Hephaestus lineatus*)	2	Min	0.39	0.01	<0.01	0.43	0.01	2.41	0.17	0.02	0.21	<0.02	10.85
				Max	2.05	0.02	0.01	0.81	0.09	10.73	0.29	0.11	0.22	<0.02	22.10
				Median	1.22	0.01	<0.01	0.62	0.05	6.57	0.23	0.07	0.21	<0.02	16.47
23-07-16	11	Freshwater anchovy (*Thryssa scratchleyi*)	5	Min	0.82	0.12	<0.01	0.30	<0.01	1.04	0.05	0.01	0.15	<0.02	6.73
				Max	2.55	0.37	0.01	1.21	0.02	3.29	0.35	0.15	0.25	<0.02	11.39
				Median	2.02	0.21	0.00	0.54	0.01	2.27	0.17	0.03	0.20	<0.02	8.35
29-06-16	20B	Lesser salmon catfish (*Arius graeffei*)	5	Min	91.56	**4.13**	0.01	1.26	0.06	4.03	0.02	0.13	0.40	<0.02	67.08
				Max	180.67	**6.32**	0.03	4.67	0.08	11.14	0.03	0.28	0.55	0.04	191.84
				Median	136.32	**5.48**	0.02	2.32	0.07	7.63	0.03	0.19	0.44	<0.02	132.24
28-06-16	22	Spoon-snouted catfish (*Nedystoma novaeguineae*)	2	Min	4.43	0.58	0.01	0.51	0.05	1.82	0.02	0.02	0.40	<0.02	68.40
				Max	6.16	1.19	0.02	0.52	**0.75**	4.66	0.04	0.08	0.43	<0.02	83.88
				Median	5.29	0.88	0.01	0.52	**0.40**	3.24	0.03	0.05	0.41	<0.02	76.14
28-06-16	22	Nurseryfish (*Kurtus gulliveri*)	5	Min	0.98	0.43	0.01	0.39	0.01	1.61	0.02	0.01	0.31	<0.02	9.79
				Max	6.53	0.71	0.02	0.63	0.12	8.10	0.03	0.02	0.35	0.01	24.09
				Median	1.64	0.65	0.02	0.46	0.01	3.26	0.02	0.01	0.33	<0.02	13.87
28-06-16	22	Broad-nosed catfish (*Potamosilurus latirostris*)	5	Min	1.47	0.37	0.01	0.45	0.02	4.06	0.01	0.01	0.15	<0.02	44.65
				Max	6.09	1.36	0.05	1.65	0.12	9.17	0.01	0.03	0.23	<0.02	73.84
				Median	1.83	0.75	0.03	1.28	0.04	7.16	0.01	0.01	0.19	<0.02	63.80
02-07-16	23	Nurseryfish (*Kurtus gulliveri*)	5	Min	6.26	0.36	<0.01	0.34	0.01	2.00	0.01	0.02	0.34	<0.02	13.06
				Max	9.59	0.67	0.01	0.98	0.02	3.26	0.02	0.02	0.40	<0.02	16.77
				Median	7.00	0.43	0.01	0.50	0.01	2.80	0.02	0.02	0.37	<0.02	14.00

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
02-07-16	23	Striped threadfin (*Polydactylus plebeius*)	2	Min	2.35	0.55	<0.01	0.39	0.01	1.47	0.02	0.02	0.45	<0.02	8.31
				Max	7.24	0.68	<0.01	0.58	0.01	2.12	0.04	0.02	0.64	<0.02	10.49
				Median	4.80	0.62	<0.01	0.48	0.01	1.79	0.03	0.02	0.54	<0.02	9.40
02-07-16	24	Greenback mullet (*Liza subviridis*)	5	Min	67.62	**2.72**	0.01	1.68	0.04	6.76	<0.01	0.11	0.43	<0.02	11.28
				Max	256.62	**3.70**	0.02	4.51	0.14	12.69	0.01	0.37	0.71	0.02	14.41
				Median	129.72	**2.91**	0.01	2.72	0.07	7.07	0.01	0.18	0.52	<0.02	12.24
Limit of Reporting (LOR)					**0.5**	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.02**	**0.01**
ANZFA Food Standard GEL (90th percentile value)								**2**					**2**		**15**
ANZFA Food Standard ML**						**10**					**1.5**				
FAO/WHO CODEX Standard									**0.3**		**0.5**				
USFDA Guidance Level											**1**				

*Shaded cells indicated that the ANZFA Food Standard GEL has been exceeded, **bold yellow cells** indicate the ANZFA ML has been exceeded, and **bold blue cells** indicate the FAO/WHO CODEX Standard has been exceeded

**ANZFA MLs for As (2) mg/kg) are based on inorganic but measurements are based on organic so MLs presented have been modified based on ratio of 80% organic to 20% inorganic provided by Rainbow (2002).

Table 6-21 Prawn Trace Metal/Metalloid Concentrations (mg/kg wet weight), June and July 2016 Field Survey

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
24-07-16	1B**	*Macrobrachium* sp. (Cephalothorax)	1	-	14.57	0.08	0.28	31.00	0.16	43.40	<0.01	0.09	0.19	0.03	21.70
24-07-16	1B**	*Macrobrachium* sp. (Hind)	1	-	7.77	0.04	<0.01	10.66	0.03	19.54	<0.01	0.03	0.13	0.01	13.76
22-07-16	22	*Macrobrachium* sp. (Cephalothorax)	5	Min	16.34	0.05	0.18	29.06	0.03	38.61	<0.01	0.17	0.17	0.02	20.71
				Max	66.99	0.08	0.36	83.16	0.07	78.54	0.01	0.35	0.33	0.24	340.68
				Median	25.14	0.08	0.33	34.68	0.04	46.76	0.01	0.25	0.24	0.08	37.57
		Macrobrachium sp. (Hind)	5	Min	5.40	0.02	0.005	10.53	0.02	13.47	<0.01	0.07	0.11	0.01	13.21
				Max	25.90	0.07	0.01	18.39	0.04	32.40	0.01	0.12	0.16	0.03	19.68
				Median	13.70	0.03	0.00	12.06	0.03	17.09	0.01	0.09	0.14	0.02	14.80
24-07-16	3B	*Macrobrachium* sp. (Cephalothorax)	4	Min	14.75	0.08	0.13	35.00	0.02	5.65	0.01	0.07	0.21	0.03	22.25
				Max	31.25	0.19	0.22	66.30	0.04	40.32	0.01	0.14	0.38	0.08	33.60
				Median	18.87	0.12	0.16	47.06	0.03	18.41	0.01	0.11	0.28	0.05	28.56
		Macrobrachium sp. (Hind)	4	Min	7.07	0.05	<0.01	13.02	0.01	2.61	<0.01	0.05	0.14	0.01	16.13
				Max	33.96	0.09	<0.01	28.79	0.04	36.79	0.01	0.11	0.21	0.05	19.67
				Median	18.36	0.06	<0.01	19.84	0.03	18.47	0.01	0.08	0.16	0.02	17.82
25-07-16	5	*Macrobrachium* sp. (Cephalothorax)	2	Min	19.10	0.11	0.07	46.72	0.01	7.84	0.01	0.09	0.28	0.07	26.13
				Max	23.65	0.35	0.40	68.34	0.01	26.28	0.01	0.11	0.28	0.09	55.48
				Median	21.37	0.23	0.23	57.53	0.01	17.06	0.01	0.10	0.28	0.08	40.81
		Macrobrachium sp. (Hind)	2	Min	5.36	0.05	<0.01	10.58	0.01	4.47	<0.01	0.02	0.15	0.01	13.16
				Max	7.99	0.10	<0.01	12.50	0.01	8.16	<0.01	0.02	0.20	0.01	16.58
				Median	6.67	0.08	<0.01	11.54	0.01	6.31	<0.01	0.02	0.17	0.01	14.87
27-07-16	9	*Macrobrachium* sp. (Cephalothorax)	4	Min	9.49	0.06	0.08	32.49	0.02	3.63	<0.01	0.04	0.25	0.02	24.83
				Max	24.49	0.08	0.16	60.42	0.03	23.92	0.01	0.10	0.37	0.15	96.39
				Median	21.36	0.07	0.11	42.60	0.03	11.01	0.01	0.08	0.30	0.08	52.28
		Macrobrachium sp. (Hind)	4	Min	0.89	0.03	<0.01	8.50	<0.01	1.49	<0.01	0.01	0.17	0.01	12.75
				Max	10.00	0.04	<0.01	14.26	0.01	7.00	0.01	0.04	0.22	0.03	17.04

Date	Site	Species	No.	Parameter	Al	As	Cd	Cu	Pb	Mn	Hg	Ni	Se	Ag	Zn
				Median	4.48	0.04	<0.01	11.43	0.01	3.42	0.01	0.03	0.18	0.01	15.94
26-07-16	10	*Macrobrachium* sp. (Cephalothorax)	5	Min	6.76	0.04	0.12	40.56	0.03	5.46	0.01	0.08	0.18	0.02	21.84
				Max	120.75	0.11	0.49	96.20	0.08	32.09	0.01	0.41	0.29	0.14	41.40
				Median	11.35	0.07	0.22	44.85	0.04	8.77	0.01	0.13	0.25	0.08	29.33
		Macrobrachium sp. (Hind)	5	Min	3.51	0.03	<0.01	7.56	0.01	2.76	0.00	0.03	0.10	0.01	12.69
				Max	46.56	0.08	<0.01	34.56	0.07	12.22	0.02	0.14	0.19	0.07	20.74
				Median	10.53	0.04	0.00	16.30	0.04	4.71	0.01	0.08	0.11	0.01	15.51
20-07-16	15	*Macrobrachium* sp. (Cephalothorax)	3	Min	15.11	0.17	0.07	32.06	0.64	12.14	<0.01	0.06	0.34	0.03	21.98
				Max	140.40	0.67	0.67	42.12	**1.90**	60.16	0.01	0.29	0.88	0.07	28.20
				Median	71.44	0.56	0.17	41.36	1.28	59.67	0.01	0.15	0.37	0.05	25.97
		Macrobrachium sp. (Hind)	3	Min	12.39	0.13	<0.01	10.80	0.36	8.40	<0.01	0.07	0.21	0.01	13.44
				Max	52.80	0.19	<0.01	12.39	0.50	18.23	<0.01	0.08	0.32	0.02	15.31
				Median	23.99	0.18	<0.01	12.14	0.40	11.85	<0.01	0.07	0.26	0.01	15.03
Limit of Reporting (LOR)					**0.5**	**0.05**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.01**	**0.05**	**0.02**	**0.01**
ANZFA Food Standard GEL (90th percentile value)								**20**					**1**		**40**
ANZFA Food Standard ML* **						**10**					**1.5**				
USFDA Guidance Level						**76**	**3**		**1.5**		**1**	**70**			

*Shaded cells indicated that the ANZFA Food Standard GEL has been exceeded, **bold yellow cells** indicate the ANZFA ML has been exceeded, and **bold orange cells** indicate the USFDA Guidance Level has been exceeded

**Only one sample available

***ANZFA MLs for As (2) mg/kg) are based on inorganic but measurements are based on organic so MLs presented have been modified based on ratio of 80% organic to 20% inorganic provided by Rainbow (2002).

NOTE: FAO/WHO CODEX Standard does not include standards for prawns

6.9 Vaihua River Estuary

The Vaihua River estuary is part of the Papua Peninsula ecoregion (no. 816) defined by Abell *et al.* (2008). This ecoregion encompasses the Papuan Peninsula and offshore islands (including the Trobriand islands, D'Entrecasteaux islands and Louisiade Archipelago) along the southeast coast of New Guinea. This ecoregion is characterized by a high degree of endemism clustered around tectonic plates (Abell *et al.* 2008). The Papuan Peninsula ecoregion overlaps with Polhemus *et al.* (2004) South Papuan Peninsular Foreland (Area 30). See Figure 6-1 and Figure 6-2 for the boundaries of these regions.

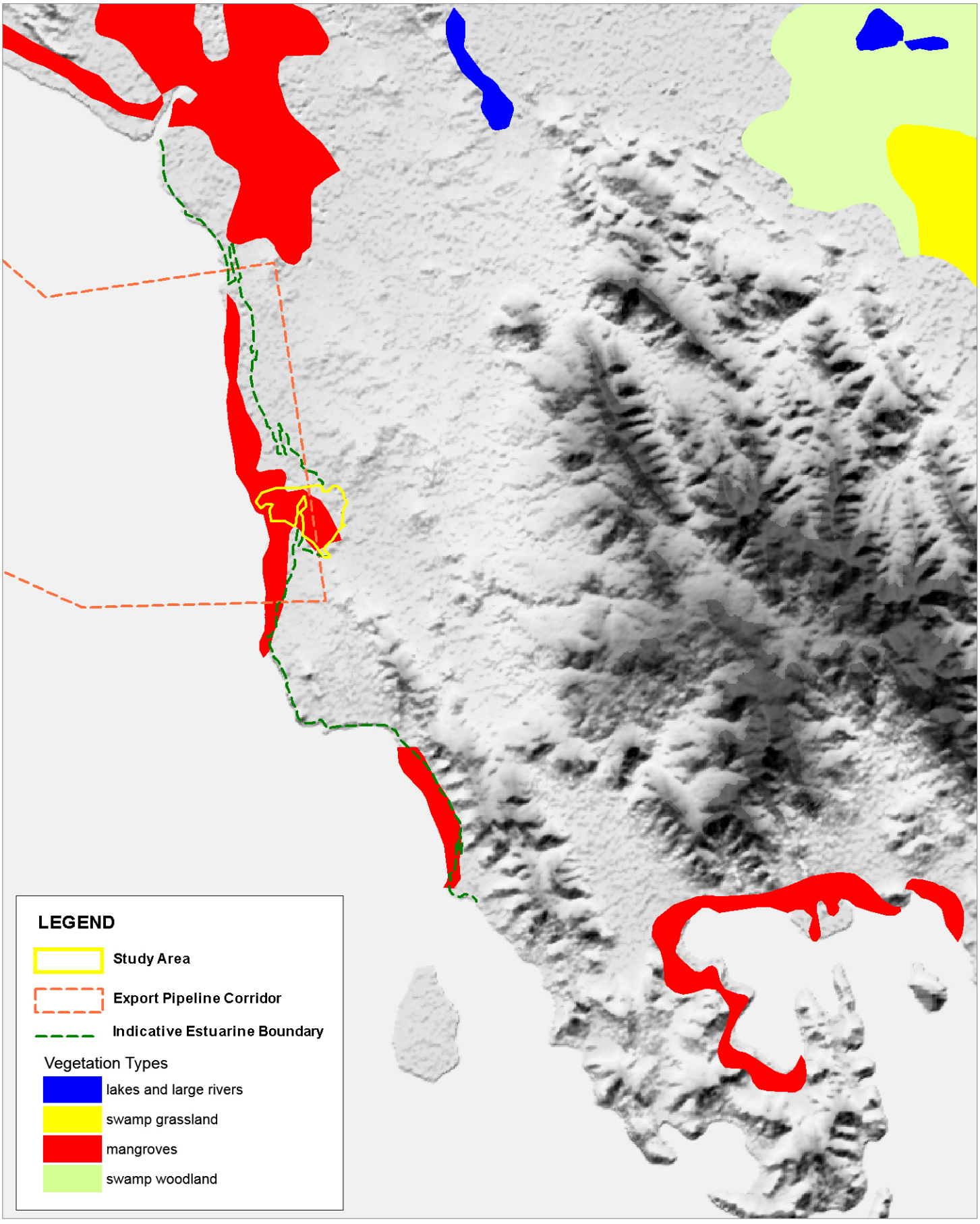
The primary aquatic biotope within this part of the study area is mangrove forests (biotope type 6 in Table 5-3), as shown in Figure 6-24. Mangroves extend along much of the coast of Caution Bay, covering an area of 335 ha (CNS, 2009). The spotted-leaved red mangrove (*Rhizophora stylosa*) is the dominant species within this area, representing more than 90% of all mangrove individuals. This mangrove community covers a distance of approximately 300 to 900 m at Caution Bay, extending from the seaward margin to the start of the landward saltflats. Other species occurring within this community include the grey mangrove (*Avicennia marina*), club mangrove (*Aegialitis annulata*) and yellow mangrove (*Ceriops* sp.) (CNS, 2009), as well as other *Rhiziphora* spp, *Bruguiera* spp. and myrtle mangrove (*Osbornia octodonta*) (observed during the BMT WBM 2016 survey). Table 6-22 describes the occurrence of mangrove species observed during the June-July 2016 survey.

Table 6-22 Mangrove Community Composition at Vaihua River Estuary (June-July 2016 Survey)

Mangrove species	Site 28	Site 29
Rhizophora apiculata		✓
Rhizophora mucronata	✓	
Spotted-leaved red mangrove (*Rhizophora stylosa*)	✓	
Bruguiera rhynchopetala	✓	
Bruguiera sp.		✓
Myrtle mangrove (*Osbornia octodonta*)	✓	
Yellow mangrove (*Ceriops tagal*)	✓	

NOTE: Site locations are shown in Figure 5-3.

Saltmarsh vegetation has been mapped within the Vaihua River estuary as part of the PNG LNG Project EIS, as shown in Figure 6-25 (CNS, 2009). This vegetation occurs on the landward margin of mangrove forests and extends landward, representing the extent of estuarine influences in the catchment. It is likely that a wide range of saltmarsh and other wetland-associated flora occurs in the area, but are not fully defined in Hydrobiology (2008).



Title:

Aquatic Biotopes within Vaihua River Estuary Mapped from Existing Spatial Data Sources

Figure: 6-24

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2 4km

Approx. Scale

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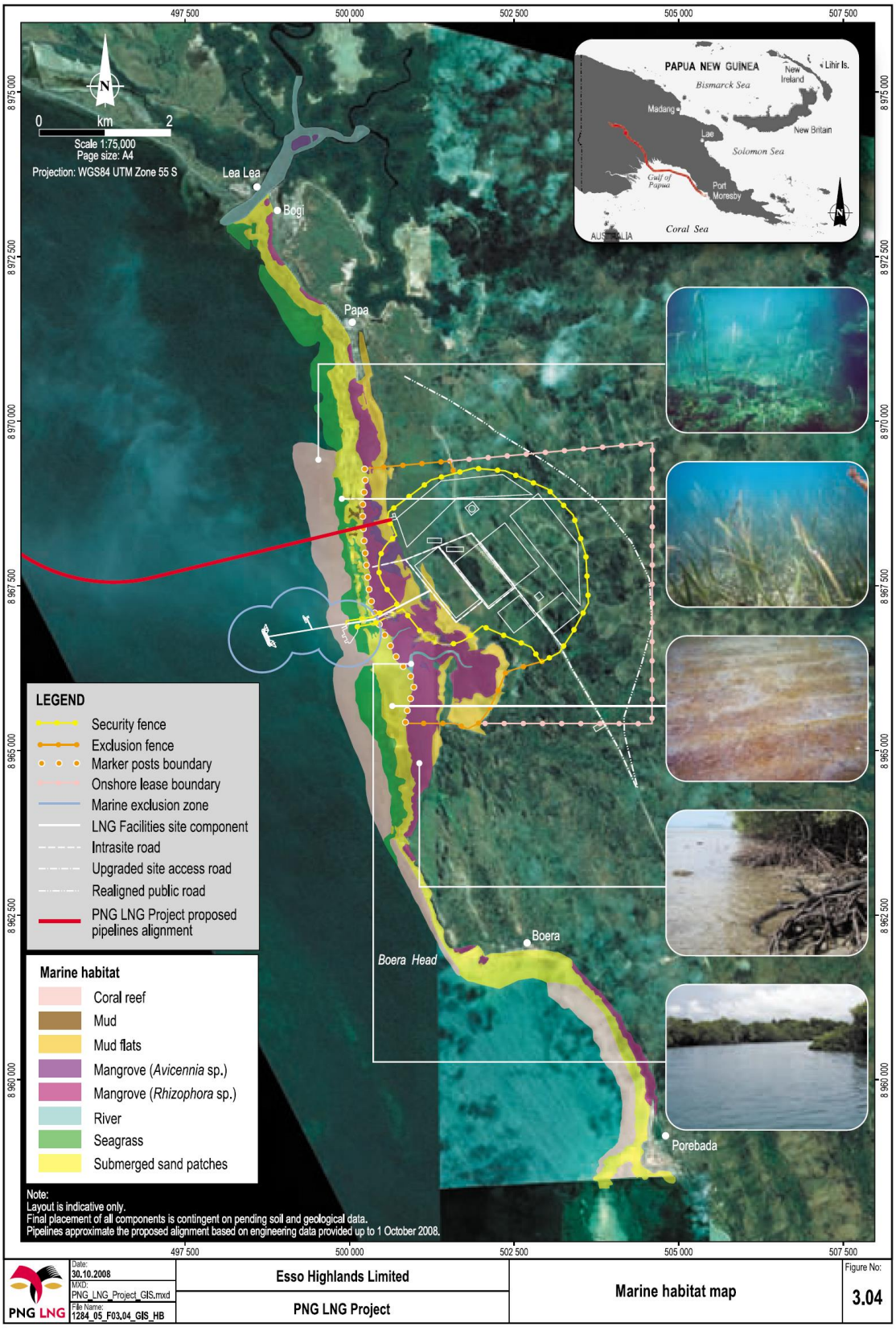


Figure 6-25 Estuarine and Marine Habitat Map of Caution Bay, including Vaihua River Estuary (CNS, 2009)

Surveys by Hydrobiology of the Vaihua River estuary and surrounding catchments as part of the PNG LNG Project EIS identified 30 species of fish and five species of macrocrustaceans within the study area and surrounds, listed in Table 6-23. Surveys undertaken by BMT WBM in January 2017 identified only one additional species, the seven-spot archerfish (*Toxotes chatareus*; this is IUCN Not Evaluated) – see Table 6-24.

These species primarily occurred within mangrove areas and primarily consistent of juveniles of marine species. The marine species that occur in Caution Bay (and potentially occur as juveniles in the Vaihua River estuary) are discussed in the Marine Biodiversity Baseline Report (BMT WBM, 2017c). The estuary cardinalfish (*Apogon hyalosoma*) was the most abundant fish species reported by Hydrobiology (2008) with the mullet (*Valamugil buchanani*) having the highest fish biomass. All species are Not Evaluated or Least Concern on the IUCN Red List with the exception of the Vulnerable mangrove whipray (*Urogymnus granulatus* and the Near Threatened orange-spotted grouper (*Epinephelus coioides*).

All of the threatened mangrove, shark, sawfish, ray, dolphin species with a known, likely or possible occurence in the Purari River estuary (see Table 6-16 in Section 6.4.6) have a geographic distribution extending throughout southern PNG, including Caution Bay and Vaihua River estuary (see the Marine Biodiversity Baseline Report, BMT WBM, 2017c). However, the Vaihua River estuary is considered to represent a low-quality habitat to these species (if they occur) given: (i) the small waterway area and simplified habitat structure, especially when compared to the Purari River estuary, and (ii) given its close proximity to urbanized areas, Vaihua River estuary is subject to numerous human pressures (CNS, 2009), most notably high fishing pressure (see the Marine Biodiversity Baseline Report, BMT WBM, 2017c) and mangrove removal (CNS, 2009). It is possible that transient individuals (juveniles and possibly adults) of the threatened estuarine fauna species listed in Table 6-16 could occasionally occur in the Vaihua River estuary from time to time, but it is unlikely that the estuary represents an important habitat to these species.

Endemic fish species associated with the South Papuan Peninsula Foreland (Polhemus *et al.* 2004, Area 30) include *Tentracentrum apagonoides*, Papuan rainbowfish (*Melanotaenia papuae*), Parkinson's rainbowfish (*M. parkinsoni*) and threespot grunter (*Hephaestus trimaculatus*). All of these species are freshwater specialists (Allen 1991), and none have been recorded, nor are they likely to occur, within the Vaihua River estuary.

Hydrobiology (2008) has also reported tilapia (*Oreochromis mossambicus*) within the Vaihua River estuary study area. This is a pest species and is considered to be a threat to native fish populations, as further discussed in Section 6.7.2.

Table 6-23 Fish and Macrocrustacean Species in Vaihua River Estuary and Surrounding Catchments (Hydrobiology, 2008)

Common name	Species name	Threatened/important status*	Invasive status
Estuarine glass perchlet	*Ambassis macrocanthus*	Not Evaluated	-
Estuary cardinalfish	*Apogon hyalosoma*	Least Concern	-
Longtom	*Strongylura krefftii*	Not Evaluated	-
Bigeye trevally	*Caranz sexfasciatus*	Not Evaluated	-
Mangrove whipray	*Himantura (Urogymnus) granulata*	Vulnerable	-
Ambon gudgeon	*Butis amboinensis*	Least Concern	-
Ebony gudgeon	*Eleotris melanosoma*	Least Concern	-
New Guinea herring	*Thyrssa scratchleyi*	Not Evaluated	-
Orange-spotted grouper	*Epinephelus coioides*	Near Threatened	-
Largetooth ponyfish	*Gazza minuta*	Least Concern	-
Threadfin silver biddy	*Gerres filamentosus*	Least Concern	-
Goby	*Goby* sp. *1*	-	-
Goby	*Goby* sp. *2*	-	-
Goby	*Goby* sp. *3*	-	-
Goby	*Goby* sp. *4*	-	-
Goby	*Goby* sp. *5*	-	-
Goby	*Goby* sp. *6*	-	-
Goby	*Goby* sp. *7*	-	-
Goby	*Goby* sp. *8*	-	-
Fly River garfish	*Zenarchopterus novaeguineae*	Not Evaluated	-
Mangrove jack	*Lutjanus argentimaculatus*	Least Concern	-
Fingermark bream	*Lutjanus johnii*	Least Concern	-
Oxeye herring	*Megalops cyprinoides*	Data Deficient	-
Mozambique tilapia	*Oreochromis mossambicus*	Near Threatened	Alien
Mullet	*Valamugil buchanani*	Not Evaluated	-
Striped threadfin	*Polydactylus plebeius*	Not Evaluated	-
Scat	*Scatophegus argus*	Not Evaluated	-
Vermiculated spinefoot	*Siganus vermiculatus*	Least Concern	-
Barracuda	*Sphyraena barracuda*	Not Evaluated	-
Pufferfish	*Arothron manillensis*	Least Concern	-
Pufferfish	*Arothron reticularis*	Least Concern	-
Archerfish	*Toxotes jaculartris*	Not Evaluated	-
Prawn	*Macrobrachium* sp. *1*	-	-
Prawn	*Macrobrachium* sp. *2*	-	-
Prawn	*Macrobrachium* sp. *3*	-	-

Common name	Species name	Threatened/important status*	Invasive status
Mud crab	*Scylla serrata*	Not Evaluated	-
Ghost shrimp	*Thalassinidean* sp.	-	-

*Threatened/important species are highlighted. The only threatened/important category applicable to these species is status on the IUCN Red List of Threatened Species. For this reason, no other columns have been provided.

Table 6-24 Fish Observations and Capture in Vaihua River Estuary during January 2017 Surveys

Site	Observations/capture
28	• Observed schools of mullet (Mugilidae) and garfish (Hemiramphidae) • Observed large schools of baitfish amongst *Rhizophora* spp. stilt roots • Captured single cardinalfish (*Apogon* sp.)
29	• Observed schools of garfish (Hemiramphidae) • Observed single seven-spot archerfish (*Toxotes chatareus*) • Observed large schools of baitfish amongst *Rhizophora* spp. stilt roots

Hydrobiology also sampled macroinvertebrate species within the Vaihua River estuary and surrounding catchments. The results of these surveys are reported in Table 6-25. Within the area sampled, 17 major taxa were identified, including at least 41 families. The most abundant families/taxa included Oligochaeta (Naididae), Polychaeta (Amphinomidae, Spionidae), Ostracoda and Cumacea (Leuconidae). No sampling of sediments to provide samples of macroinvertebrate species was undertaken by BMT WBM during the June-July 2016 or January 2017 surveys due to risks from unexploded ordnances.

High variability across the sites prevented any clear differences to be distinguished. However, a gradient between upstream and downstream sites was observed within the estuary sites, with a high degree of similarity within the downstream sites, which were different from upstream sites.

The Hydrobiology (2008) study was performed during dry conditions when freshwater reaches were not flowing, which restricted the macroinvertebrate sampling to the estuarine sites. This suggests that there may be an under-estimation of the diversity and abundance of macroinvertebrates within the area.

Polhemus *et al.* (2004) identified five freshwater invertebrate species as endemic to the South Papuan Peninsula Foreland. These are the Gerridae (water striders) *Ciliometra femorata* and *Ptilomera breddini*, and the Naucoridae (creeping water bugs) *Aptinocoris fenneri*, *A. sogeri* and *Cavocoris ismayi*. The ecology and salinity tolerance of these insect species is poorly known, but are most likely found only in freshwater habitat. Sampling by Hydrobiology (2008) did not identify any of these species in the Vaihua River estuary. On this basis, it is considered unlikely that Vaihua River estuary represents an important habitat for any of these endemic freshwater insects.

Table 6-25 Macroinvertebrate Species in the Vaihua River Estuary and Surrounding Catchments (Hydrobiology, 2008)

Major Taxon	Family	Abundance
Nematoda		22
Nemertea		1
Oligochaeta	Naididae	140
Polychaeta	Amphinomidae	131
	Ampharetidae (?)	1
	Capitellidae	17
	Cirratulidae	16
	Cossuridae	30
	Eunicidae	2
	Glyceridae	20
	Lumbrineridae	2
	Maldanidae	3
	Nephtyidae	31
	Nereididae	5
	Paraonidae	20
	Phyllodocidae	3
	Spionidae	110
	Sternasapidae	7
	Syllidae	23
	Terebellidae	1
Ostracoda		118
Cumacea	Leuconidae	68
Tanaidacea	Apseudidae	4
	Tanaidae	3
Amphipoda	Talitridae	1
	Unid.	3
Isopoda	Oniscidea	1
Caridea	Alpheidae	1
	Ogyrididae	0
	Processidae	2
	Unid.	0
Thalassinidea	Unid.	2
Anomura	Diogenidae	3
Brachyura	Ocypodidae	2
Bivalvia	Arcidae	2
	Galaeommatidae	39

Major Taxon	Family	Abundance
	Lucinidae	7
	Mactridae	4
	Solemyidae	1
	Tellinidae	3
Gastropoda	Cerithiopsidae	1
	Epitoniidae	2
	Nassariidae	4
	Neritidae	1
	Retussidae	5
	Trochidae	18
	Vitrinellidae	2
Branchiopoda	Lingulidae	3
Ophiuroidea	Unid.	7
Total		**892**

6.10 Summary

The study area supports a diversity of aquatic biotopes, including the main channels of the Purari River (freshwater and estuarine reaches), high and low gradient tributary streams, floodplain wetlands and oxbow lakes, and estuarine wetlands. The study area is considered to be part of a Biologically Important Area (Swartzendruber, 1993), supporting endemic aquatic invertebrates and threatened fish species.

The estuarine extent of the study area within the Purari River delta is dominated by mangrove forest, fringed by areas of Nipa palm and other salt-tolerant species. These mangrove forests form part of a substantial contiguous area of mangroves covering much of the Gulf of Papua, known to contain a high diversity of mangrove species. The study area is known to provide habitat for the Critically Endangered mangrove, *Bruguiera hainesii*. Within freshwater reaches, swamp and wetland vegetation communities predominate.

Most fish species in the study area are expected to complete part of their lifecycle within estuarine areas, with very few freshwater specialists identified in historical or present surveys. These fish species occur across a variety of biotope types and include a number of species that are threatened or otherwise considered to be important, including river sharks, rays, groupers, river dolphins and endemic macroinvertebrates.

In addition to threatened/important fauna and flora species, the upstream study area supports a number of key ecosystem features considered to be sensitive. These include mangrove ecosystems and estuarine wetlands, PRL-15 oxbow wetlands, and the northern and southern plateaus of PRL-15.

The Vaihua River estuary contains substantial areas of *Rhizophora* mangrove forest fringed by saltmarsh species. Most aquatic fauna within this area is associated with the mangrove forests. While no threatened/important species have been identified in the estuary, it is possible that it supports juveniles of species that occur within Caution Bay (i.e. *Pristis pristis* and *Glyphis garricki*).

There are various invasive flora and fauna species in the study area, including aquatic weeds (*Salvinia molesta*, *Eichhornia crassipes*, *Postia stratiotes*, *Hydrilla verticillata*) and introduced fish species (*Cyprinus carpio*, *Oreochromis mossambicus*, *Barbodes wynaadensis*, *Tor putitora*). These species pose a threat to the existing ecology in the study area.

7 Conclusions

The objectives of this baseline study have been successfully met. This baseline characterization provides a representation of known and likely freshwater and estuarine biodiversity values of the study area, including aspects considered important in the context of further planning and impact assessment. The key findings of the baseline characterization are as follows:

(1) The study area contains a mosaic of upland, lowland and coastal landscapes and encompasses a wide diversity of aquatic biotope types including tributary streams, floodplain and estuarine wetlands, and large river systems.

(2) Significant aquatic biotope features identified in the study area are as follows:

  (a) Contiguous mangrove forests of the Omati-Kikori-Purari delta region. These represent the largest contiguous mangrove forest system in Papua New Guinea and are among the largest in the Asia-Pacific region. These mangrove forests contain 31 of the 33 species known from Papua New Guinea, and have among the highest number of mangrove species in the world including the threatened *Bruguiera hainesii*.

  (b) Freshwater wetlands on the floodplain of the Purari River. This extensive floodplain wetland system contains a wide diversity of wetland types, including palustrine (marshes), lacustrine (oxbow lake) and lotic (running stream) systems. There is presently little available information on the physico-chemical and aquatic fauna characteristics of palustrine and lacustrine wetlands. It is possible that some of these wetland environments contain peat wetlands, which are highly sensitive environments whose distribution and extent are poorly documented in Papua New Guinea.

  (c) PRL-15 plateau catchments – the southern and northern plateaus within PRL-15 support waterways that eventually flow into sub-catchments of the study area. Plateau environments that support waterbodies that are isolated over geological timescales can represent centers of local endemism (e.g. Lake Kutubu, which drains into the Kikori River). It has been conservatively assumed that isolated waterbodies containing endemic species or other features of evolutionary importance could occur on these plateaus.

(3) The key threatened aquatic flora species relevant to the study area is *Bruguiera hainesii*. This mangrove species is listed as Critically Endangered on the IUCN Red List of Threatened Species. *Bruguiera hainesii* has been recorded within the onshore export pipeline corridor (ERIAS Group, 2017b), and is known from the wider ecoregion and on this basis, all estuarine environments in the Purari represent potential habitat for this species.

(4) Submerged, floating and emergent macrophytes are likely to occur in palustrine wetland biotopes such as the PRL-15 oxbow wetlands.

(5) Edge and pool hydraulic habitats showed a slight difference in aquatic macroinvertebrate assemblage structure among freshwater aquatic biotope types. The macroinvertebrate assemblages in riffle and pool habitats differed across temporal scales (July 2016 and February 2017). Assemblages across both sampling periods were numerically dominated by

mayfly (Ephemeroptera) families (Baetidae, Caenidae and Leptophlebiidae), which together accounted for 34% of the catch. Other abundant taxa were copepods that accounted for approximately 19% of the catch, Hemiptera (true bugs) accounted for over 17% of the catch, while non-biting midges from the sub-family Chironominae represented approximately 17% of the catch.

(6) Benthic macroinvertebrate assemblages in estuarine channel environments were numerically dominated by polychaete worm families Spionidae and Capitellidae, which collectively accounted for approximately 70% of the total catch. Bivalves accounted for almost 8% of the catch, while crustaceans and gastropods accounted for 3 and 1% of the catch respectively. Taxonomic richness and abundance varied greatly among sites, with poorly flushed backwater environments having particularly depauperate assemblages.

(7) PRL-15 and the Purari River delta falls within the Papua Gulf Foreland and the Papuan Gulf Coastal Lowlands ecoregions, which encompasses the coastal lowlands in the southern part of central New Guinea, including the Purari, Fly, Digul and Kikori Rivers. Nearly half of the ecoregion's freshwater fish species are endemic to the region, many of which are restricted to the neighboring Fly River catchment and Lake Kutubu, located outside the study area. In addition, three aquatic insects are endemic and restricted to the ecoregion.

(8) The freshwater fauna of the ecoregion has strong affinities with that of northern Australia, reflecting the recent geological connection between these land masses. The majority of fish species within the study area also have a marine origin, and many complete part of their lifecycle within estuarine areas.

(9) Consistent with Haines (1979), the estuarine areas of the Purari River delta were the most specious biotope (39 species identified during 2016/2017 surveys). In comparison, 15 species were found in the freshwater reaches of the Purari River delta, 18 species in the Purari River (at tributary mouths) and 24 species in the clear-water tributaries within PRL-15.

(10) Several species captured in the estuarine reaches were observed to occur in a range of biotopes. This included *Toxotes chatareus, Thryssa scratchleyi, Zenarchopterus novaeguineae, Ambassis macrocanthus, Nedystoma dayi and Aseraggodes klunzingeri.*

(11) There were differences in fish assemblages between the Purari River main channel and those in high to moderate gradient streams (clear water tributaries). In this regard:

(a) The most abundant species recorded in the lower Purari River were *Ambassis macrocanthus*, *Nedystoma novaeguineae* and *Liza subviridis*. The fish species found in the Purari River downstream of Hathor Gorge would need to have adaptations that allow them to persist in fast flowing, turbid waters.

(b) In the clear-water tributaries, fish and macrocrustacean assemblages were numerically dominated by Palaemonidae (freshwater prawns), Eleotridae (gudgeons), Gobiidae (Goby), Terapontidae (Grunters) and Melanotaeniidae (Rainbowfish).

(12) Macrocrustaceans including freshwater *Macrobrachium* prawns and Parathelphusidae crabs were identified throughout the freshwater reaches of the study area. Estuarine reaches also

hosted *Macrobrachium* prawns as well as marine and estuarine species such as the mud crab *Scylla serrata*.

(13) Highly threatened fish species likely to occur in the study area include river sharks and sawfish (*Glyphis garricki*, *G. glyphis*, *Pristis pristis, P. zijsron*, *Anoxypristis cuspidata*), rays (*Glaucostegus typus*), groupers (*Epinephelus coioides*). In addition, the study area is expected to support dolphins (*Orcaella heinsohni*, *Sousa sahulensis*) and endemic aquatic insect species (*Ciliometra setosa*, *Iobates ivimka*).

(14) Sensitive environments of the study area include the estuarine wetlands and mangroves, which are used by as nursery and spawning areas for a range of fish species, as well as habitat areas utilized by threatened species (e.g. turbid main channel and floodplain wetlands). The northern and southern plateaus of PRL-15 are also considered to be potential areas for endemism.

(15) In the context of threatened estuarine species, the Purari River estuary represents higher quality habitat than the Vaihua River estuary. The Vaihua River estuary has: (i) a small waterway area and simplified habitat structure, especially when compared to the Purari River estuary, and (ii) given its close proximity to urbanized areas, Vaihua River estuary is subject to a range of human pressures, most notably high fishing pressure and mangrove removal. All threatened sharks, rays and sawfish relevant to the project, are particularly vulnerable to fishing pressure. While it is possible that transient individuals (juveniles and possibly adults) of the threatened estuarine fauna species listed above could occasionally occur in the Vaihua River estuary from time to time, it is unlikely to represent an important habitat to populations of these species.

(16) Concentrations of PAHs in fish and prawn tissues were below detection limits.

(17) Metals and metalloids were detected in fish and/or prawn tissues, several of which (copper, lead, zinc and arsenic) had concentrations that were greater than the ANZFA GELs in aquatic biota. Lead concentrations in *Valamugil buchanani* at Site 14 in 2017 also exceeded the FAO/WHO CODEX food standard for fish. There were no exceedances of metals and metalloids against the USFDA food standards or ANZFA human health-based MLs.

(18) All other metal/metalloid concentrations were below guideline values and/or guideline values were not available.

(19) *Macrobrachium* prawn heads had a greater mean concentration of all metals compared to *Macrobrachium* prawn tails.

(20) Mangrove forests, dominated by *Rhizophora* spp., occur within the Vaihua River estuary, fringed by saltmarsh species. Majority of the aquatic fauna in this area is associated with mangrove forests.

(21) The Vaihua River estuary may provide habitat for juvenile *Pristis pristis* and *Glyphis garricki*.

(22) The only exotic fish species recorded in the present study was the wild common carp (*Cyprinus carpio*), although there are reports and anecdotal evidence suggesting the presence of the Mozambique tilapia (*Oreochromis mossambicus*) and mahseer species (either *Barbodes wynaadensis* or *Tor putitora*). The population status of these species in the Purari River is

undefined. Consultation with local fisherman suggested that exotic species are abundant in lacustrine and wetland environments (i.e. PRL-15 oxbow wetlands), particularly wild common carp and tilapia (Oreochromis mossambica). This anecdotal evidence is consistent with unpublished reports of previous surveys that observed both these species in the PRL-15 oxbow wetlands.

8 Study Team

The members of the study team responsible for the preparation of the Upstream Freshwater and Estuarine Biodiversity Baseline Report are listed in Table 8-1.

Table 8-1 Upstream Freshwater and Estuarine Biodiversity Study Team

Personnel	Position	Qualifications
Dr Darren Richardson	Study Director Technical Lead for Ecology	Bachelor of Applied Science (Honors) Doctor of Philosophy
Brad Hiles	Senior Aquatic Scientist	Bachelor of Applied Science, Bachelor of Education
Daniel Moran	Aquatic Ecologist	Bachelor of Science (Honors)
Jeremy Visser	Study Coordinator	Bachelor of Laws, Bachelor of Environmental Management
Lyn Leger	Study Manager	Bachelor of Laws, Bachelor of Science (Honors) Master of Laws

9 Glossary and Abbreviations

ANZECC/ARMCANZ	Australian and New Zealand Environment and Conservation Council / Agriculture and Resource Management Council of Australia and New Zealand
ANZFA	Australian and New Zealand Food Authority
AusRivAS	Australian Rivers Assessment System
Bonn Convention	Convention on the Conservation of Migratory Species of Wild Animals
CEPA	Conservation and Environment Protection Authority of Papua New Guinea
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
Congregatory	Referring to species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis
CNS	Coffey Natural Systems
CPF	Central Processing Facility
Critical Habitat	Habitat feature identified under IFC Performance Standard 6. Described as 'areas with high biodiversity value, including: (i) habitat of importance to Critically Endangered and/or Endangered species (as listed under IUCN Red List); (ii) habitat of significant importance to endemic and/or range-restricted species; (iii) habitat supporting globally significant concentrations of migratory and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes.
DEM	Digital Elevation Model
DES	Douglas Environmental Services
DNRM	Queensland (Australia) State Department of Natural Resources and Mines
DoEE	Australian Commonwealth Department of the Environment and Energy
EHS Guideline	Environment, Health and Safety Guidelines, developed by the IFC as representation of good international industry practice
EIS	Environmental Impact Statement
Elk/Antelope Gasfield Project	Gas extraction, transport and processing project proposed by InterOil. Involves operation of Elk-Antelope gasfields in Gulf Province and transport to a LNG Plant on Purari River, Gulf Province.
ESBS	Environmental and Social Baseline Study
ESHIA	Environment, Social and Health Impact Assessment
FAO	Food and Agriculture Organization of the United Nations

FIMS	Forestry Inventory Mapping System, including the following codes: • Fsw: Mixed Swamp Forest. • FswC: Swamp Forest with Campnosperma. • FswTb: Swamp Forest with *Terminalia brassi*. • W: Swamp Woodland. • WswM1: Swamp Woodland with *Melaleuca leucadendron*. • Gsw: Swamp Grassland. • Hsw: Herbaceous Swamp. • M: Mangrove. • E: Lakes and Larger Rivers.
GEL	ANZFA Food Standards Code Generally Expected Levels
GIIP	Good international industry practice
GL-ENV/02/2004	*Guideline for Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement*, prepared by (former) Department of Environment and Conservation (2004)
GS EP ENV 120	*Environmental impact assessment of E&P activities*, General Specification prepared by Total E&P (2007)
GS EP ENV 111	*Environmental Baseline and Monitoring Studies: Onshore Sites*, General Specification prepared by Total E&P (2012)
GS EP ENV 112	*Environmental Baseline and Monitoring Studies: Offshore and Nearshore Sites*, General Specification prepared by Total E&P (2012)
IFC	International Finance Corporation
ITCZ	Inter-tropical convergence zone
IUCN	International Union for the Conservation of Nature
IPIECA	International Petroleum Industry Environmental Conservation Association
LiDAR	Light Detecting and Ranging
LNG	Liquid natural gas
ML	ANZFA Food Standards Code Maximum Level
NATA	National Association of Testing Authorities, Australia
NFA	National Fisheries Authority of Papua New Guinea
nMDS	Non-metric multi-dimensional scaling
NMI	National Measurement Institute
NTU	Nephelometric turbidity units
Migratory	Any species of which a significant proportion of its members cyclically and predictably move from one geographical area to another
OECD	Organization for Economic Cooperation and Development
PAH	Polycyclic aromatic hydrocarbons
Papua LNG	Gas extraction, transport and processing project proposed by TEP PNG. Involves operation of Elk-Antelope gasfields in Gulf Province, and onshore and subsea pipeline via Orokolo Bay to LNG Plant at Caution Bay, Central Province
PDL	Petroleum Development License
PL	Pipeline License
PNG94	Papua New Guinea 1994 datum

PNG LNG	Gas extraction, transport and processing project operated by ExxonMobil. Involves operation of gasfields in Hela and Western Provinces, and onshore and subsea pipeline to LNG Plant at Caution Bay, Central Province
PPFL	Petroleum Processing Facility License
PRL	Petroleum Retention License
Project	The Papua LNG Project
Purari Delta	Low, flat depositional area within the Purari River catchment where the Purari River main channel branches into distributary rivers channels, including the Urika-Ivo and Wame-Varoi rivers, before flowing into the Gulf of Papua.
Lower Purari River	The Purari River main channel and tributaries downstream of Hathor Gorge
Purari Delta Estuary	The waterways of the Purari Delta, including Wame-Varoi and Urika-Ivo rivers, seaward of the indicative extent of mangrove forests mapped by Shearman (2010)
Red List of Threatened Ecosystems	List maintained by the IUCN that provides threatened status for a range of assessed ecosystems
Red List of Threatened Species	List maintained by the IUCN that provides threatened status for a range of assessed species
Range-restricted	A species that is known to be restricted to a limited geographic area. Within aquatic systems, this is all species with an extent of occurrence of 100,000 km^2 or less
SRFSEP	Sepik River Fish Stock Enhancement Project
SRTM	Shuttle Radar Topography Mission
Study Area	The area which is the focus of this ESBS report, consisting of the PRL-15, Lower Purari River (downstream of Hathor Gorge), Purari Delta and the Vaihua estuary at Caution Bay
TEP PNG	Total E&P Papua New Guinea
Threatened/important Species	Term used to describe species considered of key relevance to the ESBS based on listing or conservation status. Consists of the following: • species listed as Protected or Restricted under the *Fauna (Protection and Control) act 1966* as per the list in Kula and George (1996). • species listed in appendices I or II of CITES or in schedules 1 or 2 of the *International Trade (Flora and Fauna) Act 1979.* • species listed as Near Threatened, Vulnerable, Endangered or Critically Endangered on the IUCN Red List. • species that are endemic and/or restricted range based on IFC PS 6 principles. • species that are migratory or congregatory based on IFC PS 6 principles.
Upper Purari River	The Purari River main channel upstream of Hathor Gorge
USFDA	United States Food and Drug Administration
UTM	Universal Trans Mercator
WHO	World Health Organization
WMA	Wildlife Management Area

10 References

Abell, R, Thieme, ML, Revenga, C, Bryer, M, Kottelat, M, Bogutskaya, NG, Coad, B, Mandrak, N, Balderas, SC, Bussing, W, Stiassny, MLJ, Skelton, P, Allen, GR, Unmack, P, Naseka, A, Ng, R, Sindorf, N, Robertson, J, Armijo, JE, Higgins, JV, Heibe, TJ, Wikramanayake, E, Olson, D, Lopez, HL, Reis, RE, Lundberg, G, Perez, GMHS and Petry, P (2008), Freshwater ecoregions of the world: a new map of biogeographic units for freshwater biodiversity conservation, *BioScience* **58**: 403–414

Allen, GR (1991) *Field Guide to the Freshwater Fishes of New Guinea,* Publication No. 9, Christensen Research Institute, Calendar Print Pty Ltd, Singapore

Alongi, DM (1990), 'The ecology of tropical soft-bottom benthic ecosystems', *Oceanography and Marine Biology Annual Review* **28**:381-496

Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (2000), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Paper No. 4 to National Water Quality Management Strategy

Australian and New Zealand Food Authority (2001), Generally expected levels (GELs) for metal contaminants, Additional guidelines to maximum levels in Standard 1.41. – Contaminants and Natural Toxicants, available: www.foodstandards.gov.au/code/userguide/documents/GELs_0801.pdf [accessed May 2017]

Beasley, I, Jedensjö, M, Wijaya, GM, Anamiato, J, Kahn, B and Kreb, D (2016), 'Observations on Australia humpback dolphins (Sousa sahulensis) in Waters of the Pacific Islands and New Guinea', *Advanced Marine Biology* **73**:219-271

Beera, T.M. (2001) *Freshwater Fish Distribution,* University of Chicago Press Berkeley

BMT WBM (2017a), *Papua LNG Project Upstream Hydrology and Meteorology Baseline Report*, prepared for ERIAS Group Pty Ltd and Total E&P PNG Limited

BMT WBM (2017b), *Papua LNG Project Upstream Surface Water and Sediment Quality Baseline Report*, prepared for ERIAS Group Pty Ltd and Total E&P PNG Limited

BMT WBM (2017c), *Papua LNG Project Marine Biodiversity Baseline Report*, prepared for ERIAS Group Pty Ltd and Total E&P PNG Limited

BMT WBM (2017d), *Papua LNG Project Physical Oceanography Baseline Report*, prepared for ERIAS Group Pty Ltd and Total E&P PNG Limited

Booyong Forest Science (2017), *Papua LNG Project Upstream Land and Natural Resources (Ecosystem Services – Provisioning) Baseline Report*, prepared for ERIAS Group Pty Ltd and Total E&P PNG Limited

Borja, A, Alison, M, Occhipinti-Ambrogi, A and Berg, T (2009), Current status of macroinvertebrate methods used for assessing the quality of European marine waters: Implementing the Water Framework Directive, *Hydrobiologia* **633**: 181-196

Coffey Natural Systems (2008a), *Offshore Impact Assessment*, Appendix 11 to PNG LNG EIS, prepared for Esso Highlands Limited, report no. CR 1284_7

Coffey Natural Systems (2008b), *Nearshore Impact Assessment*, Appendix 23 to PNG LNG Project EIS, prepared for Esso Highlands Limited, report no. CR 1284_5

Coffey Natural Systems (2009), *PNG LNG Project Environmental Impact Statement*, prepared for Esso Highlands Limited

Coffey Natural Systems (2015), *P'nyang Development Project Environmental Impact Statement*, prepared for Esso P'nyang PNG Limited

Compagno, LJV (2002), Freshwater and estuarine elasmobranch surveys in the Indo-Pacific region: threats, distribution and speciation, in: Fowler, SL, Reed, TM and Dipper, FA (eds) *Elasmobranch Biodiversity, Conservation and Management*; Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997. IUCN SSC Shark Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK

Compagno, LJV (2007), *Glyphis gangeticus*, entry in IUCN Red List of Threatened Species 2007: e.T9281A12978210, available: http://dx.doi.org/10.2305/IUCN.UK.2007.RLTS.T9281A2978210.en [accessed 11th July 2017]

Compagno, LJV, Pogonoski, J and Pollard, D (2009), *Glyphis glyphis*, entry in IUCN Red List of Threatened Species, 2009: e.T39379A10221801, available: http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39379A10221801.en [accessed 11th July 2017].

Conn, BJ (1983), Aquatic and semi-aquatic flora of the Purari River system, Chapter 4 in Part II of Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin,* The Hague, Dr W Junk Publishers

Cornish, A and Harmelin-Vivien, M (2004), *Epinephelus coioides*, entry in IUCN Red List of Threatened Species 2004: e.T4467410934751, available: http://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4467A10934571.en. [accessed 14th July 2017]

Cragg, S (1983), The mangrove ecosystem of the Purari Delta, Chapter 5 in Part II of Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

D'Anastasi, BR (2010), *Conservation genetics of the critically endangered narrow sawfish (Anoxypristis cuspidata) in northern Australia*, James Cook University, Townsville

D'Anastasi, B, Simpfendorfer, C and van Herwerden, L (2013), *Anoxypristis cuspidata*, entry in IUCN Red List of Threatened Species 2013: e.T3989A18620409, available: http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39389A18620409.en [accessed 11th July 2017]

Dafforn, KA, Kelaher, BP, Simpson, SL, Coleman, MA, Hutchings, PA, Clark, GF, Knott, NA, Doblin, MA and Johnston, EL (2013), Polychaete Richness and Abundance Enhanced in Anthropogenically Modified Estuaries Despite High Concentrations of Toxic Contaminants, *PLoS ONE* **8**(9)

Dallinger, R. Prosi, F., Sehner, H., Back, H. 1987, Contaminated food and uptake of heavy metals by fish: a review and a proposal for further research. Oecologia, 73: 91-98.

Davy, LE, Simpfendorfer, CA and Heupel, MR (2015), Movement patterns and habitat use of juvenile mangrove whiprays (Himantura granulata), *Marine and Freshwater Research*

Department of the Environment and Energy (2017a), *Glyphis glyphis*, in Species Profile and Threats Database, Australian Government, available from http://www.environment.gov.au/sprat [accessed 14th July 2017]

Department of the Environment and Energy (2017b), *Pristis pristis*, in Species Profile and Threats Database, Australian Government, available from: http://www.environment.gov.au/sprat [accessed 11th July 2017]

Department of the Environment and Energy (2017c), *Pristis zijsron*, in Species Profile and Threats Database, Australian Government, available from http://www.environment.gov.au/sprat [accessed 14th July 2017]

Department of the Environment and Energy (2017d), *Sousa sahulensis*, in Species Profile and Threats Database, Australian Government, available from http://www.environment.gov.au/sprat [accessed 14th July 2017]

Department of Natural Resources and Mines (2001), *Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual*, Queensland Government, Brisbane

Douglas Environmental Services (DES), (2008) Elk/Antelope Gasfield Project Environmental Impact Statement. Prepared for InterOil.

Duke, N, Kathiresan, K, Salmo III, SG, Fernando, ES, Peras, JR, Sukardjo, S, Miyagi, T, Ellison, J, Koedam, NE, Wang, Y, Primavera, J, Jin Eong, O, Wan-Hong Yong, J and Ngoc Nam, V (2010), *Bruguiera hainesii*, entry on the IUCN Red List of Species 2010, e.T178834A7621565, available: http://dx.doi.org/10.2305/IUCN.UK.2010-2.RLTS.T178834A7621565.en [accessed 21st February 2017]

Edgar, GJ, Langhammer, PF, Allen, G, Brooks, TM, Brodie, J, Crosse, W, De Silva, N, Fishpool, LDC, Foster, M, Knox, DH, McCosker, JE, McManus, R, Millar, AJK and Mugo, R (2009), Key Biodiversity Areas as Globally Significant Target Sites for the Conservation of Marine Biological Diversity', *Aquatic Conservation: Marine and Freshwater Ecosystems* **18**(6):969-83

Ellison, JC (1997), Mangrove ecosystems of the Western and Gulf Provinces, Papua New Guinea, a review, *Science in New Guinea* **23**: 1–15

Enesar. (2005), *PNG Gas Project environmental impact statement. Main report*, volume 1. December. Prepared by Enesar Consulting Pty Ltd for Esso Highlands Limited. Port Moresby, Papua New Guinea

ERIAS Group (2016), *Freshwater and Estuarine Studies Scope and Methods*, Papua LNG Project, prepared for Total E&P PNG Limited, report 01215B_6-4_v4

ERIAS Group (2017a), *Addendum to Freshwater and Estuarine Studies Scope and Methods*, Papua LNG Project, prepared for Total E&P PNG Limited, report 01215B_6-13_v5

ERIAS Group (2017b), *Papua LNG Project Upstream Terrestrial Biodiversity Baseline Report*, prepared for Total E&P PNG Limited

ERIAS Group (2017c), *Papua LNG Project Marine Fisheries and Resources Baseline Report*, prepared for Total E&P PNG Limited

Evesson D.T. (1983), The Climate of the Purari River Basin, Chapter 2 in Part I of Petr, T. (ed.) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

Faria, VV, McDavitt, MT, Charvet, P, Wiley, TR, Simpfendorfer, CA and Naylor, GJP (2013), Species delineation and global population structure of Critically Endangered sawfishes (Pristidae), *Zoological Journal of the Linnean Society* **167**(1): 136-164

Finlayson, M (2017), *Papua LNG Project Upstream Community and Demographics Baseline Report*, prepared for Total E&P PNG Limited

Food and Agriculture Organization of the United Nations/World Health Organization (2006), *Codex Alimentarius*, FAO/WHO

Froese, R, Pauly, D (eds.) (2017), *FishBase*. World Wide Web electronic publication. www.fishbase.org

GHD (2015a), *Antelope-4 Environmental Impact Assessment and Environmental Management Plan*, prepared for InterOil SPI (208) Ltd

GHD (2015b), *Antelope-5 Environmental Impact Assessment and Environmental Management Plan*, prepared for InterOil SPI (208) Ltd

GHD (2015c), *Antelope-6 Environmental Impact Assessment and Environmental Management Plan*, prepared for InterOil SPI (208) Ltd

GHD (2015d), *Antelope South-1 Environmental Impact Assessment and Environmental Management Plan*, prepared for InterOil SPI (208) Ltd

Haines, A.K. (1979), *An ecological survey of fish on the lower Purari River system, Papua New Guinea*, Office of Environment and Conservation, Waigani Papua New Guinea

Haines, AK (1983), Fish Fauna and Ecology, Chapter 9 in Part II of Petr, T. (ed.) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

Hallock P, Lidz BH, Cockey-Burkhard EM, Donnelly KB (2003), Foraminifera as bioindicators in coral reef assessment and monitoring: the FORAM Index, in *Environmental Monitoring and Assessment* **81**, 221-238

Holland, RA, Darwall, WRT and Smith, K (2012), Conservation Priorities for Freshwater Biodiversity: The Key Biodiversity Approach Refined and Tested for Continental Africa, *Biological Conservation*, cited in IFC PS 6 (2012).

Hydrobiology (2008), PNG LNG Project: LNG Facilities Aquatic Fauna Impact Assessment

International Union for the Conservation of Nature (2017a), *The IUCN Red List of Threatened Species Version 2017-1*, available: http://www.iucnredlist.org/

International Union for the Conservation of Nature (2017b), *Habitats Classification Scheme Version 3.1*, available: http://www.iucnredlist.org/technical-documents/classification-schemes/habitats-classification-scheme-ver3 [accessed 12th July 2017]

Jefferson, TA and Karczmarski, L (2001), *Sousa chinensis*, *Mammalian Species* **655**:1-9

Johns, RJ (1993), Biodiversity and conservation of the native flora of Papua New Guinea, in Beehler BM (ed.) *Papua New Guinea Conservation Needs Assessment*, Washington DC, Biodiversity Support Program

Kailola PJ, Williams MJ, Stewart PC, Reichelt RE, McNee A, Grieve C (1993) 'Australian Fisheries Resources.' (Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Developement Corporation: Canberra)

Kennedy AD, Jacoby CA (1999), Biological Indicators of Marine Environmental Health: Meiofauna – A Neglected Benthic Component? Ii *Environmental Monitoring and Assessment*

Kula, GRR and George I (1996), *Protected Fauna of Papua New Guinea*, Department of Environment and Conservation, Port Moresby

Kyne, PM, Carlson, J and Smith, K (2013a), *Pristis pristis*, entry on IUCN Red List of Threatened Species 2013: e.T18584848A18620395. http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T18584848A18620395.en [accessed 5th April 2017]

Kyne, PM, Rigby, C and Simpfendorfer, C (2013b), *Pristis clavata*, entry on IUCN Red List of Threatened Species 2013: e.T39390A186203898.en, available: http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T39390A18620389.en [accessed 11th July 2017]

Langhammer PF, Bakarr MI, Bennun LA, et al (2007), Identification and gap analysis of Key Biodiversity Areas: targets for comprehensive protected area systems. IUCN, Gland, Switzerland

Last, PR and Stevens, JD (1994), *Sharks and rays of Australia*, CSIRO, Australia

Leach, JJ and Osborne, PL (1985), *Freshwater plants of Papua New Guinea*, Port Moresby: University of Papua New Guinea Press

Malik DS, Sastry KV, Hamilton DP (1998). Effects of zinc toxicity on biochemical composition of muscle and liver of murrel (*Channa punctatus*), Environmental International, 24: 433-8.

Manjaji Matsumoto, BM, White, WT, Fahmi, Ishihara, H and Morgan, DL (2016), *Urogymnus granulatus*, entry on IUCN Red List of Threatened Species 2016: e.T161431A104280437, available: http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T161431A104280437.en [accessed 14th July 2017]

Marks, EN (1983), Mosquitoes of the Purari River lowlands, Chapter 9 in Part III of Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

McAlpine J and Quigley J (1998), Forestry Inventory Mapping System (FIMS) of Papua New Guinea version 2.1

McAlpine, JR, Keig, G and Falls, R (1983), *Climate of Papua New Guinea*, Commonwealth Scientific and Industrial Research Organization in association with Australian National University Press, Canberra

Ono, J, Wong, JWH, Takayama, K, Bin Saleh, M, Wee, AKS, Asakawa, T, Wllano, OB, Salmo III, SG, Suleiman, M, Xuan Tung, N and Soe, KK (2016), *Bruguiera hainesii*, a critically endangered

mangrove species, is a hybrid between *B. cylindrica* and *B. gymnorhiza* (Rhizophoraceae), *Conservation Genetics* **17**: 1137-1144

Osborne, PL (1987), *A draft inventory of wetlands in Papua New Guinea*, Department of Environment and Conservation, Waigani, Papua New Guinea

Orapa, W (2006), Invasive weeds: impacts, prevention, detection and responses, in *Pest and disease incursions: risks, threats and management in Papua New Guinea*

Orapa, W, and Julien, M.H (2001), Insects used for biological control of the aquatic weed water hyacinth in Papua New Guinea, in *Papua New Guinea Journal of Agriculture, Forestry and Fisheries*, **44**(1-2), 49-60

Paijmans, K (1976), *New Guinea Vegetation*. Commonwealth Scientific and Industrial Research Organisation in association with the Australian National University Press, Canberra

Paijmans, K (1983), The vegetation of the Purari catchment, Chapter 1 in Part II of Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

Parra, GJ (2005), *Behavioural ecology of Irrawaddy, Orcaella brevirostris (Owen in Gray, 1866), and Indo-Pacific humpback dolphins, Sousa chinensis (Osbeck, 1765), in northeast Queensland, Australia: a comparative study*, PhD thesis, James Cook University, Townsville

Parra, GJ (2006), 'Resource partitioning in sympatric delphinids: Space use and habitat preferences of Australian snubfin and Indo-Pacific humpback dolphins', *Journal of Animal Ecology* **75**:862-874

Parra, GJ, Schick, R and Corckeron, PJ (2006), 'Spatial distribution and environmental correlates of Australian snubfin and Indo-Pacific humpback dolphins', *Ecography*, **29**:396-406

Parra, GJ and Cagnazzi, D (2016), 'Chapter seven – conservation status of the Australian humpback dolphin (*sousa sahulensis*) using the IUCN Red List Criteria', *Advances in Marine Biology*, **73**:157-192

Pearson TH and Rosenberg R (1978), Macrobenthic succession in relation to organic enrichment and pollution of the marine environment, in *Oceanographic and Marine Biology Annual Review* **16**: 229-311

Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

Pickup, G and Chewings, VH (1983), The hydrology of the Purari and its environmental implications, chapter 8 in Part I of Petr, T. (ed.) (1983) *The Purari – Tropical environment of a high rainfall river basin*, The Hague, Dr W Junk Publishers

Pogonoski, J and Pollard, D (2003), *Glyphis garricki*, entry onIUCN Red List of Threatened Species 2003: e.T42712A10746546. http://dx.doi.org/10.2305/IUCN.UK.2003.RLTS.T42712A10746546.en [accessed 11th July 2017]

Polhemus, DA (2011), New distributional records for Gyrinidae (Insecta: Coleoptera) on New Guinea and nearby islands, with a checklist of the New Guinea species, *Zootaxa* **2900**: 51-68

Polhemus, D, Englund, RA and Allen, GR (2004), *Freshwater biotas of New Guinea and nearby islands: Analysis of endemism, richness, and threats*, report for Conservation International

Polhemus, D and Allen, G (2006), Inland water ecosystems in Papua: classification, biota and threats, in Marshall, A and Beehler, B (eds.) *The Ecology of Papua*, Tuttle Publishing, Singapore

Pusey B, Kennard M, Arthington A (2004), *Freshwater Fishes of North-Eastern Australia*, CSIRO Publishing, Collingwood

Rainbow, PS (2002) Trace metal concentrations in aquatic invertebrates: why and so what? Environmental Pollution, 120: 497–507.

Reeves, RR, Jefferson, TA, Karczmarski, L, Laidre, K, O'Corry-Growe, G, Rojas-Bracho, L, Secchi, ER, Slooten, E, Smith, BD, Wang, JY and Zhou, K (2008), *Orcaella heinsohni*, entry in IUCN Red List of Threatened Species 2008:e.T136315A4273414, available: http://dx.doi/10.2305/IUCN.UK.2008.RLTS.T136315A4273414.en [accessed 15th July 2017]

Rodriguez, JP, Rodriguez-Clark, KM, Baillie, JEM, Ash, N, Benson, J, Boucher, T, Brown, C, Burgess, ND, Collen, B, Jennings, M, Keith, DA, Nicholson, E, Revenga, C, Reyers, B, Rouget, M, Smith, T, Spalding, M, Taber, A, Walpole, M, Zager, I and Zamin, T (2011), Establishing IUCN Red List Criteria for Threatened Ecosystems, *Conservation Biology* **25**(1):21-29

Room, PM and Thomas, PA (1986), Population growth of the floating weed Salvinia molesta: field observation and a global model based on temperature and nitrogen, in *Journal of Applied Ecology*, 1013-1028

Saenger, P, Moverley, J and Stephenson, W (1988), 'Seasonal and longer term patterns in the macrobenthos versus benthic stability in a subtropical estuary', *Proceedings of the Ecological Society of Australia* **15**: 229-237

Sainty, GR and Jacobs, SWL (1994), *Waterplants in Australia*. Sainty and Associates Pty Ltd, Darlinghurst

Shearman, PL, Bryan, JE, Ash, J, Hunnam, P, Mackey, B and Lokes, B (2008), *The State of the Forests of Papua New Guinea, Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972-2002*, University of Papua New Guinea, 2008

Shearman, P (2010) 'Recent Change in the Extent of Mangroves in the Northern Gulf of Papua, Papua New Guinea, AMBIO, in *A Journal of the Human Environment* **39**:181-189

Simpfendorfer, C (2013), *Pristis zijsron*, entry in IUCN Red List of Threatened Species 2013: e.T39393A18620401, available: http://dx.doi.or/10.2305/IUCN.UK.2013-1.RLTS.T3939A18620401.en [accessdd 11th July 2017]

Simpfendorfer, C and Burgess, GH (2009), *Carcharhinus leucas*, entry in IUCN Red List of Threatened Species 2009: e.T39372A1087195, available: http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T39372A1087195.en [accessed 14th July 2017]

Smith, PT, Imbun, B Y and Duarte, F (2016), Impacts of a fish kill at Lake Kutubu, Papua New Guinea, in *Pacific Science* **70**(1):21-33

Stevens, JD, McAuley, RB, Simpfendorfer, CA and Pillans, RD (2008), *Spatial distribution and habitat utilization of sawfish (*Pristis *spp) in relation to fishing in northern Australia*, report to Department of Environment, Water, Heritage and the Arts, CSIRO, Canberra

Stevens, JD, Pillans, RD and Salini, J (2005), *Conservation Assessment of* Glyphis *sp. A (Speartooth Shark),* Glyphis *sp. C (Northern River Shark),* Pristis microdon *(Freshwater Sawfish) and* Pristis *zijsron (Green Sawfish)*, Hobart, CSIRO Marine Research

Swartzendruber, JF (1993), *Papua New Guinea conservation needs assessment: synopsis report*, Biodiversity Support Program, Department of Conservation and Environment. Washington

Taniuchi, T, Shimizu, M, Sano, M, Baba, O and Last, PR (1991). Descriptions of freshwater elasmobranches collected from three rivers in northern Australia, in Shimizu, M andTaniuchi, R (eds.) *Studies on Elasmobranchs Collected from Seven River Systems in Northern Australia and Papua New Guinea*

Uysal, K (2011), Heavy Metal in Edible Portions (Muscle and Skin) and Other Organs (Gill, Liver and Intestine) of Selected Freshwater Fish Species. International Journal of Food Properties, **14**: 280-286

United States Food and Drug Administration (2001), *Fish and Fisheries Products, Hazards and Control Guidance*. Centre for Food Safety and Applied Nutrition, 3rd Edition.

White WT, Appleyard SA, Sabub B, Kyne PM, Harris M, and Lis R (2015), Rediscovery of the Threatened River Sharks, *Glyphis garricki* and *G. glyphis*, in Papua New Guinea, in *PLoS ONE* **10**(10): e0140075. doi:10.1371/journal.pone.0140075

White, WT and McAuley, RB (2016), *Glaucostegus typus*. The IUCN Red List of Threatened Species 2016: e.T41849A104018648. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T41849A104018648.en. [accessed 5th April 2017]

Wilson, D (1999), Freshwater sawfish *Pristis microdon*, Australia New Guinea Fishes Association A-Z Notebook of Native Freshwater Fish, in *Australia New Guinea Fishes Association Bulletin* **41**

Yule CM (2008), Loss of biodiversity and ecosystem functioning in Indo-Malayan peat swamp forests, in *Biodiversity and Conservation,* **19**:393–409

Appendix A Photos of Sampling Sites



Site 1B (PRL-15) (July 2016)



Site 2 (PRL-15) (July 2016)



Site 3B (PRL-15) (July 2016)



Site 4 (PRL-15) (July 2016)



Site 5 (PRL-15) (July 2016)



Site 6 (PRL-15) (July 2016)



Site 9 (PRL-15) (July 2016)



Site 10 (PRL-15) (July 2016)



Site 11 (Purari River freshwater) (July 2016)



Site 12 (Purari River freshwater) (July 2016)



Site 13 (Purari River freshwater) (July 2016)



Site 14 (Purari River freshwater) (July 2016)



Site 15 (Purari River freshwater) (July 2016)



Site 16 (Purari River freshwater) (January 2017)



Site 17 (Purari River freshwater) (January 2017)



Site 18 (Purari River freshwater) (January 2017)



Site 19 (Purari River freshwater) (January 2017)



Site 20 (Purari River estuarine) (January 2017)



Site 21 (Purari River estuarine) (June 2016)



Site 22B (Purari River estuarine) (June 2016)



Site 23 (Wame-Varoi River estuarine) (January 2017)



Site 24 (Wame-Varoi River estuarine) (January 2017)



Site 28 (Vaihua River estuarine) (January 2017)



Site 29 (Vaihua River estuarine) (January 2017)

Appendix B Freshwater and Estuarine Macroinvertebrate Data

Table B-1 Freshwater Macroinvertebrate Catch Data (number of individuals in each sample) – Sites 1B, 2 and 3B

Site						Site 1B						Site 2						Site 3B					
Hydraulic Habitat						Edge			Pool			Riffle			Pool			Edge			Riffle		
Sample Code						1B_E1	1B_E2	1B_E3	1B_P1	1B_P2	1B_P3	2_R1	2_R2	2_R3	2_P1	2_P2	2_P3	3B_E1	3B_E2	3B_E3	3B_R1	3B_R2	3B_R3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Anisocentropus sp	Calamoceratidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Anisops sp	Notonectidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Atyid 1	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 2	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baetidae	Baetidae	Ephemeroptera	Insecta	Arthropoda	PET	24	10	1	4	10	19	31	68	164	37	46	57	10	4	76	37	21	117
Beetle 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	12
Beetle 2	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beetle A (probably not aquatic)	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beetle larva 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gerridae sp.	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caddis fly	.	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Caenidae	Caenidae	Ephemeroptera	Insecta	Arthropoda	PET	0	0	0	0	5	1	10	25	22	9	2	1	2	22	1	4	4	15
Ceratopoginidae 1	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ceratopoginidae 2	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	1
Ceratopoginidae 3	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 1	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Chironomid 10	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 2	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	1	0	1	1	14	0	1	2	0	0	0	1	1	3
Chironomid 3	Chironominae	Diptera	Insecta	Arthropoda	No	0	2	0	1	1	9	5	0	18	5	0	0	0	0	3	0	0	3
Chironomid 4	Chironominae	Diptera	Insecta	Arthropoda	No	0	1	0	0	3	4	8	5	24	1	5	6	0	2	0	0	1	2
Chironomid 5	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
Chironomid 6	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0
Chironomid 7	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 8	Chironominae	Diptera	Insecta	Arthropoda	No	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 9	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Chironomid other (juv/damaged)	Chironominae	Diptera	Insecta	Arthropoda	No	20	0	0	1	0	0	13	10	7	3	6	0	0	0	5	0	1	0
chironomid pupa	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Chlorocyphidae	Chlorocyphidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	2	0	1	1	0	0	0	0
Coenagrionid 1	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0
Coenagrionid 2	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Copepod	Copepoda	Copepoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0
Crab	Sundatelphusidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly 1	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Damselfly 2	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Damselfly juv	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Diptera pupa 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Diptera larva 2	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dolichopodidae	Dolichopodidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dugesiidae	Dugesiidae	Paludicola	Tricladida	Platyhelminthes	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomidae	Ecnomidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	1	0	0	0	1	2	0	0	1	0	4	1	0
Elmid adult 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elmid adult 2	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elmid larvae 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	6	0	0	0	0	0	5	0	2	3	2

Site						Site 1B						Site 2						Site 3B					
Hydraulic Habitat						Edge			Pool			Riffle			Pool			Edge			Riffle		
Sample Code						1B_E 1	1B_E 2	1B_E 3	1B_P 1	1B_P 2	1B_P 3	2_R 1	2_R 2	2_R 3	2_P 1	2_P 2	2_P 3	3B_E 1	3B_E 2	3B_E 3	3B_R 1	3B_R 2	3B_R 3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Gastropod 1	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 2	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gyrinidae 1	Gyrinidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Hydrophylid 1	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Hydrophylid 2	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hydrophylid larva	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	Hydropsychidae	Trichoptera	Insecta	Arthropoda	PET	0	1	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0
Hydroptilidae	Hydroptilidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Leptocerid A	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	2	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
Leptophlebiidae	Leptophlebiidae	Ephemeroptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	5	14	69	6	6	5	0	0	1	2	2	14
Libellulidae 1	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0	0
Libellulidae 2	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	1	1	0	0	0	0	0	0	0	2	0	0	0	0
Libellulidae 3	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Libellulidae 4	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Libellulidae juv	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnichidae	Limnichidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limpet	Ancylidae	Basommatophora	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 1	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	10	3	0	0	6	2	0	25	9	8	10	21	2	6	7	8	5	3
Macrobrachium sp 2	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 3	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macromiidae?	Macromiidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
Micronecta sp 1	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	6	0	1	0	0	0	0	0	0	0	71	227	4	0	0	0
Micronecta sp 2	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	4	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Micronecta sp juv	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Mite sp.	Acarina	Acarina	Arachnida	Arthropoda	No	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0
Muscidae	Muscidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Naididae	Naididae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Naucoris sp 1	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naucoris sp 2	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	Nematoda	Nematoda	Nematoda	Nematoda	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Nemertean	Nemertea	Nemertea	Nemertea	Nemertea	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Nereitid 1	Nereitidae	Cycloneritimorpha	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 1	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 2	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Oligochaete	.	Oligochaeta	Oligochaeta	Annelida	No	0	0	21	0	0	0	0	0	5	2	1	5	0	2	7	1	1	0
Oniscidae	Oniscidae	Isopoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae	Philopotamidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipefish	Syngnathidae	Syngnathiformes	Actinopterygii	Chordata	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilodactylidae	Ptilodactylidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pyralidae	Pyralidae	Lepidoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Ranatra sp	Nepidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scirtidae	Scirtidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp juv	Decapoda	Decapoda	Crustacea	Arthropoda	No	0	1	0	0	4	0	0	5	0	0	8	5	0	0	0	0	11	1
Simuliidae	Simuliidae	Diptera	Insecta	Arthropoda	No	1	0	0	0	0	0	1	18	15	2	0	0	0	0	0	2	0	0
Springtail	Collembola	Collembola	Collembola	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0

Site						Site 1B						Site 2						Site 3B					
Hydraulic Habitat						Edge			Pool			Riffle			Pool			Edge			Riffle		
Sample Code						1B_E 1	1B_E 2	1B_E 3	1B_P 1	1B_P 2	1B_P 3	2_R 1	2_R 2	2_R 3	2_P 1	2_P 2	2_P 3	3B_E 1	3B_E 2	3B_E 3	3B_R 1	3B_R 2	3B_R 3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Stone fly	.	Plecoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	3	3	2
Stratiomyidae	Stratiomyidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 1	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 2	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Tanypodinae 1	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	23	2	0	0	0	0	0	0	0	0	0	1	0	0
Tanypodinae 2	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	5	4	1	0	3	0	0	0	0	0	0	0	0	1
Tanypodinae 3	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	2	1	3	8	4	0	0	0	0	0	1
Tanypodinae 4	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae X	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Tennagogerris sp	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	44	68	0	0	0	0
Thiaridae 1	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Thiaridae 2	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Tipulidae	Tipulidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	1	1	1	0	0	0	2	2	7
Tubificid	Tubificidae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Veliidae	Veliidae	Hemiptera	Insecta	Arthropoda	No	0	6	1	0	0	0	0	0	0	0	0	1	6	16	2	0	0	0
Weevil	Curculionidae	Coleoptera	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Table B-2 Freshwater Macroinvertebrate Catch Data (number of individuals in each sample) – Sites 4, 5 and 6

Site						Site 4						Site 5						Site 6					
Hydraulic Habitat						Edge			Riffle			Edge			Riffle			Edge			Riffle		
Sample Code						4_E1	4_E2	4_E3	4_R1	4_R2	4_R3	5_E1	5_E2	5_E3	5_R1	5_R2	5_R3	6_E1	6_E2	6_E3	6_R1	6_R2	6_R3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Anisocentropus sp	Calamoceratidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anisops sp	Notonectidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 1	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	3
Atyid 2	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Baetidae	Baetidae	Ephemeroptera	Insecta	Arthropoda	PET	12	6	78	8	33	55	11	23	17	5	11	128	2	46	80	19	91	66
Beetle 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beetle 2	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	1
Beetle A (probably not aquatic)	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beetle larva 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Gerridae sp.	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caddis fly	.	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	Caenidae	Ephemeroptera	Insecta	Arthropoda	PET	3	1	22	1	2	8	1	0	1	1	2	7	0	5	19	3	7	7
Ceratopoginidae 1	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0
Ceratopoginidae 2	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Ceratopoginidae 3	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 1	Chironominae	Diptera	Insecta	Arthropoda	No	0	1	1	13	13	12	1	2	0	8	2	1	0	0	0	0	0	0
Chironomid 10	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 2	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	7	0	1	9	0	6	0	1	7	41	0	0	0	0	1	0
Chironomid 3	Chironominae	Diptera	Insecta	Arthropoda	No	2	0	1	0	0	0	1	0	0	0	2	5	0	2	2	1	0	0
Chironomid 4	Chironominae	Diptera	Insecta	Arthropoda	No	1	0	12	3	0	5	3	14	5	0	5	7	0	32	2	0	1	0
Chironomid 5	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	6	2	0	0	2	14	0	0	0	0	0	0
Chironomid 6	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Chironomid 7	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	2	0	0	0	3	0	0	0	0	0	0
Chironomid 8	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Chironomid 9	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid other (juv/damaged)	Chironominae	Diptera	Insecta	Arthropoda	No	1	1	26	0	2	3	0	0	1	2	1	3	0	0	2	0	0	1
chironomid pupa	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	2	2	2	0	0	6	3	0	0	5	0	0	0
Chlorocyphidae	Chlorocyphidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionid 1	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionid 2	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Copepod	Copepoda	Copepoda	Crustacea	Arthropoda	No	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crab	Sundatelphusidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Damselfly 1	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
Damselfly 2	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly juv	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera pupa 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 2	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dolichopodidae	Dolichopodidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Dugesiidae	Dugesiidae	Paludicola	Tricladida	Platyhelminthes	No	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
Ecnomidae	Ecnomidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elmid adult 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Elmid adult 2	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Site						Site 4						Site 5						Site 6					
Hydraulic Habitat						Edge			Riffle			Edge			Riffle			Edge			Riffle		
Sample Code						4_E1	4_E2	4_E3	4_R1	4_R2	4_R3	5_E1	5_E2	5_E3	5_R1	5_R2	5_R3	6_E1	6_E2	6_E3	6_R1	6_R2	6_R3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Elmid larvae 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1
Gastropod 1	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0
Gastropod 2	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	1	0	2	2	0	0	0	0	0	0	0
Gyrinidae 1	Gyrinidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylid 1	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Hydrophylid 2	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hydrophylid larva	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	Hydropsychidae	Trichoptera	Insecta	Arthropoda	PET	1	0	0	0	2	3	0	0	1	0	0	10	0	0	0	0	1	0
Hydroptilidae	Hydroptilidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerid A	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Leptophlebiidae	Leptophlebiidae	Ephemeroptera	Insecta	Arthropoda	PET	1	3	0	4	17	31	6	1	1	5	16	21	0	0	0	3	15	11
Libellulidae 1	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 2	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Libellulidae 3	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0
Libellulidae 4	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae juv	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnichidae	Limnichidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
Limpet	Ancylidae	Basommatophora	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 1	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	1	2	0	1	2	4	3	0	1	0	0	6	1	1	4	2	3	7
Macrobrachium sp 2	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 3	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macromiidae?	Macromiidae	Odonata	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Micronecta sp 1	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Micronecta sp 2	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	0	0	0	0	0	83	0	0	0
Micronecta sp juv	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	1	0	0
Mite sp.	Acarina	Acarina	Arachnida	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
Muscidae	Muscidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Naididae	Naididae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Naucoris sp 1	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Naucoris sp 2	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	Nematoda	Nematoda	Nematoda	Nematoda	No	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nemertean	Nemertea	Nemertea	Nemertea	Nemertea	No	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Nereitid 1	Nereitidae	Cycloneritimorpha	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
Oecetis sp 1	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 2	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete	.	Oligochaeta	Oligochaeta	Annelida	No	2	0	23	0	0	1	0	1	0	4	1	1	0	1	14	0	5	2
Oniscidae	Oniscidae	Isopoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae	Philopotamidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	1	0	0	0	0	0	0	9	0	0	0	0	0	0
Pipefish	Syngnathidae	Syngnathiformes	Actinopterygii	Chordata	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ptilodactylidae	Ptilodactylidae	Coleoptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
Pyralidae	Pyralidae	Lepidoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranatra sp	Nepidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scirtidae	Scirtidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Shrimp juv	Decapoda	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	1	0	2	0	0	0	0	0	3	3	1	0	0	0

Site						Site 4						Site 5						Site 6					
Hydraulic Habitat						Edge			Riffle			Edge			Riffle			Edge			Riffle		
Sample Code						4_E1	4_E2	4_E3	4_R1	4_R2	4_R3	5_E1	5_E2	5_E3	5_R1	5_R2	5_R3	6_E1	6_E2	6_E3	6_R1	6_R2	6_R3
Genus species	Family	Order	Class	Phylum	PET taxa?																		
Simuliidae	Simuliidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	1	0	0	3	28	0	1	0	1	1	0
Springtail	Collembola	Collembola	Collembola	Arthropoda	No	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone fly	.	Plecoptera	Insecta	Arthropoda	PET	0	0	3	1	13	8	0	0	0	0	0	19	0	0	0	0	1	1
Stratiomyidae	Stratiomyidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 1	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Tabanidae 2	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Tanypodinae 1	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 2	Chironomidae	Diptera	Insecta	Arthropoda	No	1	0	0	0	1	2	2	2	0	4	1	7	0	0	0	0	0	1
Tanypodinae 3	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0
Tanypodinae 4	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae X	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Tennagogerris sp	Gerridae	Hemiptera	Insecta	Arthropoda	No	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Thiaridae 1	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	10	0	1	1	0	0	0	0	0	1	0	0
Thiaridae 2	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	21	0	0	0	0	0	0	0	2	0	0	0
Tipulidae	Tipulidae	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Tubificid	Tubificidae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Veliidae	Veliidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	2	0	0	0	0	4	5	0	0	0
Weevil	Curculionidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Table B-3 Freshwater Macroinvertebrate Catch Data (number of individuals in each sample) – Sites 9 and 10

Site						Site 9						Site 10					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						9_E1	9_E2	9_E3	9_R1	9_R2	9_R3	10_E1	10_E2	10_E3	10_P1	10_P2	10_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Anisocentropus sp	Calamoceratidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Anisops sp	Notonectidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 1	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 2	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Baetidae	Baetidae	Ephemeroptera	Insecta	Arthropoda	PET	10	15	10	3	4	5	2	2	3	57	196	27
Beetle 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	0	0	0	0	0
Beetle 2	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	11	1	1	0	0	0	0	0	0
Beetle A (probably not aquatic)	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle larva 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	3	0	0	0	0	0
Gerridae sp.	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Caddis fly	.	Trichoptera	Insecta	Arthropoda	PET	5	2	1	0	1	0	0	0	0	0	0	0
Caenidae	Caenidae	Ephemeroptera	Insecta	Arthropoda	PET	18	15	1	5	2	6	0	0	0	4	41	1
Ceratopoginidae 1	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	0	0	0
Ceratopoginidae 2	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	5
Ceratopoginidae 3	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 1	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	0	0	3	1	2
Chironomid 10	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 2	Chironominae	Diptera	Insecta	Arthropoda	No	1	1	0	2	3	2	1	1	0	2	4	8
Chironomid 3	Chironominae	Diptera	Insecta	Arthropoda	No	0	1	3	1	0	0	0	0	0	3	20	0
Chironomid 4	Chironominae	Diptera	Insecta	Arthropoda	No	2	0	0	0	0	0	0	0	2	5	13	2
Chironomid 5	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	1	0
Chironomid 6	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 7	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	2	0	0
Chironomid 8	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	1	0
Chironomid 9	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	2	0
Chironomid other (juv/damaged)	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	6	0	0	2	12	7
chironomid pupa	Chironominae	Diptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	1	0	0
Chlorocyphidae	Chlorocyphidae	Odonata	Insecta	Arthropoda	No	1	0	1	0	0	0	0	0	0	0	0	0
Coenagrionid 1	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	1	0
Coenagrionid 2	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Copepod	Copepoda	Copepoda	Crustacea	Arthropoda	No	0	5	0	0	0	0	0	0	0	0	0	0
Crab	Sundatelphusidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Damselfly 1	.	Odonata	Insecta	Arthropoda	No	0	0	0	3	0	0	0	0	0	0	0	0
Damselfly 2	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly juv	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera pupa 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 2	.	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Dolichopodidae	Dolichopodidae	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Dugesiidae	Dugesiidae	Paludicola	Tricladida	Platyhelminthes	No	1	0	0	1	4	3	0	0	0	0	0	0
Ecnomidae	Ecnomidae	Trichoptera	Insecta	Arthropoda	PET	1	1	0	0	1	0	0	0	0	1	0	0
Elmid adult 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Elmid adult 2	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0

Site						Site 9						Site 10					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						9_E1	9_E2	9_E3	9_R1	9_R2	9_R3	10_E1	10_E2	10_E3	10_P1	10_P2	10_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Elmid larvae 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	1	0	0	0	2	0	0	0	0	0	0	0
Gastropod 1	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 2	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	1	0	0	0	0	0	0
Gyrinidae 1	Gyrinidae	Coleoptera	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0
Hydrophylid 1	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylid 2	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
hydrophylid larva	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	Hydropsychidae	Trichoptera	Insecta	Arthropoda	PET	0	1	0	22	8	8	0	0	0	0	0	0
Hydroptilidae	Hydroptilidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerid A	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	2	2	0	0	0	0	0	0	0	0	0
Leptophlebiidae	Leptophlebiidae	Ephemeroptera	Insecta	Arthropoda	PET	3	14	0	78	62	10	0	0	0	3	5	0
Libellulidae 1	Libellulidae	Odonata	Insecta	Arthropoda	No	1	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 2	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 3	Libellulidae	Odonata	Insecta	Arthropoda	No	0	2	0	0	0	0	0	0	0	0	0	0
Libellulidae 4	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae juv	Libellulidae	Odonata	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	0	0	0
Limnichidae	Limnichidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Limpet	Ancylidae	Basommatophora	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 1	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	2	7	0	2	2	2	0	0	0	1	3	0
Macrobrachium sp 2	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 3	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Macromiidae?	Macromiidae	Odonata	Insecta	Arthropoda	No	0	0	3	0	0	0	0	0	0	0	0	0
Micronecta sp 1	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	1	0	0	0	0	0	0	1
Micronecta sp 2	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	1	0	0	0	0
Micronecta sp juv	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Mite sp.	Acarina	Acarina	Arachnida	Arthropoda	No	6	6	0	0	0	0	0	0	0	0	2	0
Muscidae	Muscidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Naididae	Naididae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	5	0
Naucoris sp 1	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	2	3	1	0	0	0	0	0	0
Naucoris sp 2	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	Nematoda	Nematoda	Nematoda	Nematoda	No	0	0	0	0	0	0	0	0	0	0	0	5
Nemertean	Nemertea	Nemertea	Nemertea	Nemertea	No	0	0	0	0	0	0	0	0	0	0	0	0
Nereitid 1	Nereitidae	Cycloneritimorpha	Gastropoda	Mollusca	No	0	1	0	3	2	2	0	0	0	0	0	0
Oecetis sp 1	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 2	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete	.	Oligochaeta	Oligochaeta	Annelida	No	5	0	1	1	1	0	0	7	0	1	10	1
Oniscidae	Oniscidae	Isopoda	Crustacea	Arthropoda	No	1	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae	Philopotamidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	14	19	1	0	0	0	0	0	0
Pipefish	Syngnathidae	Syngnathiformes	Actinopterygii	Chordata	No	0	0	0	0	0	0	0	0	0	0	0	0
Ptilodactylidae	Ptilodactylidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Pyralidae	Pyralidae	Lepidoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Ranatra sp	Nepidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Scirtidae	Scirtidae	Coleoptera	Insecta	Arthropoda	No	0	1	0	1	0	0	0	0	0	0	0	0
Shrimp juv	Decapoda	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	1	0

Site						Site 9						Site 10					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						9_E1	9_E2	9_E3	9_R1	9_R2	9_R3	10_E1	10_E2	10_E3	10_P1	10_P2	10_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Simuliidae	Simuliidae	Diptera	Insecta	Arthropoda	No	6	1	0	10	6	4	0	0	0	2	1	0
Springtail	Collembola	Collembola	Collembola	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Stone fly	.	Plecoptera	Insecta	Arthropoda	PET	0	0	0	1	7	1	0	0	1	5	1	2
Stratiomyidae	Stratiomyidae	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Tabanidae 1	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	2	0	0	0	0	0	0	0	0
Tabanidae 2	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 1	Chironomidae	Diptera	Insecta	Arthropoda	No	2	2	0	0	0	0	0	0	0	0	0	0
Tanypodinae 2	Chironomidae	Diptera	Insecta	Arthropoda	No	0	6	1	1	0	0	0	0	0	10	8	3
Tanypodinae 3	Chironomidae	Diptera	Insecta	Arthropoda	No	0	1	3	0	0	0	0	0	0	0	0	1
Tanypodinae 4	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae X	Chironomidae	Diptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	0	0	0
Tennagogerris sp	Gerridae	Hemiptera	Insecta	Arthropoda	No	1	0	0	0	0	0	0	0	0	0	0	0
Thiaridae 1	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	1	2	1	0	0	0	0	0	0	0	0	0
Thiaridae 2	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	4	2	0	0	0	0	0	0	0	0	0
Tipulidae	Tipulidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	1	0	1	0	0	1	0
Tubificid	Tubificidae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	0	0
Veliidae	Veliidae	Hemiptera	Insecta	Arthropoda	No	3	2	2	0	0	0	0	0	0	0	0	0
Weevil	Curculionidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Table B-4 Freshwater Macroinvertebrate Catch Data (number of individuals in each sample) – Sites 11, 12 and 13

Site						Site 11			Site 12			Site 13					
Hydraulic Habitat						Edge			Edge			Edge			Pool		
Sample Code						11_E1	11_E2	11_E3	12_E1	12_E2	12_E3	13_E1	13_E2	13_E3	13_P1	13_P2	13_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Anisocentropus sp	Calamoceratidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Anisops sp	Notonectidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 1	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 2	Atyidae	Decapoda	Crustacea	Arthropoda	No	9	1	3	1	0	1	1	0	0	0	0	0
Baetidae	Baetidae	Ephemeroptera	Insecta	Arthropoda	PET	2	0	2	36	208	101	1	0	0	17	2	0
Beetle 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle 2	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle A (probably not aquatic)	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	2	0	0	0	0	0	0
Beetle larva 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Gerridae sp.	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Caddis fly	.	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	Caenidae	Ephemeroptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	11	0	0
Ceratopoginidae 1	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopoginidae 2	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	5	0	0	6	0	0
Ceratopoginidae 3	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 1	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 10	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 2	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	1	0	0	0	0	0	0	0	0
Chironomid 3	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	2	0	0
Chironomid 4	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	3	0	1	0	0	0	0	0
Chironomid 5	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 6	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 7	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 8	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 9	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid other (juv/damaged)	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	6	0	0
chironomid pupa	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chlorocyphidae	Chlorocyphidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionid 1	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	0	0	0
Coenagrionid 2	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Copepod	Copepoda	Copepoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	5	0	0	25	0	0
Crab	Sundatelphusidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly 1	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly 2	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly juv	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera pupa 1	.	Diptera	Insecta	Arthropoda	No	1	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 2	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Dolichopodidae	Dolichopodidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Dugesiidae	Dugesiidae	Paludicola	Tricladida	Platyhelminthes	No	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomidae	Ecnomidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Elmid adult 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	1	0	0	0	0	0
Elmid adult 2	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	1	0	0	0	0	0	0

Site						Site 11			Site 12			Site 13					
Hydraulic Habitat						Edge			Edge			Edge			Pool		
Sample Code						11_E1	11_E2	11_E3	12_E1	12_E2	12_E3	13_E1	13_E2	13_E3	13_P1	13_P2	13_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Elmid larvae 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 1	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 2	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Gyrinidae 1	Gyrinidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylid 1	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylid 2	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	1	0	0	0	0	0	0
hydrophylid larva	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	Hydropsychidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Hydroptilidae	Hydroptilidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerid A	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	1	0	0	0	0	0
Leptophlebiidae	Leptophlebiidae	Ephemeroptera	Insecta	Arthropoda	PET	0	0	1	0	0	0	0	0	0	0	0	0
Libellulidae 1	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 2	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 3	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 4	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae juv	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Limnichidae	Limnichidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Limpet	Ancylidae	Basommatophora	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 1	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 2	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	1	0	0	0	0	0	0	0
Macrobrachium sp 3	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Macromiidae?	Macromiidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Micronecta sp 1	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	2	1	1	0	0	0
Micronecta sp 2	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	11	12	0	0	0	0
Micronecta sp juv	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	15	34	0	0	0	0
Mite sp.	Acarina	Acarina	Arachnida	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Muscidae	Muscidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Naididae	Naididae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	0	0
Naucoris sp 1	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Naucoris sp 2	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	Nematoda	Nematoda	Nematoda	Nematoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Nemertean	Nemertea	Nemertea	Nemertea	Nemertea	No	0	0	0	0	0	0	0	0	0	0	0	0
Nereitid 1	Nereitidae	Cycloneritimorpha	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 1	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 2	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete	.	Oligochaeta	Oligochaeta	Annelida	No	22	6	1	0	2	6	5	0	0	10	0	0
Oniscidae	Oniscidae	Isopoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae	Philopotamidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Pipefish	Syngnathidae	Syngnathiformes	Actinopterygii	Chordata	No	0	0	0	0	1	0	0	0	0	0	0	0
Ptilodactylidae	Ptilodactylidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Pyralidae	Pyralidae	Lepidoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Ranatra sp	Nepidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Scirtidae	Scirtidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp juv	Decapoda	Decapoda	Crustacea	Arthropoda	No	0	0	0	5	3	1	0	1	0	0	0	0

Site						Site 11			Site 12			Site 13					
Hydraulic Habitat						Edge			Edge			Edge			Pool		
Sample Code						11_E1	11_E2	11_E3	12_E1	12_E2	12_E3	13_E1	13_E2	13_E3	13_P1	13_P2	13_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Simuliidae	Simuliidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Springtail	Collembola	Collembola	Collembola	Arthropoda	No	2	2	0	0	0	0	0	0	7	0	0	0
Stone fly	.	Plecoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Stratiomyidae	Stratiomyidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 1	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 2	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 1	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 2	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	3	0	0	1	0	0	0	0
Tanypodinae 3	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	2	0	0
Tanypodinae 4	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae X	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tennagogerris sp	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	2	0	0	0	0	0	0	0	0	0
Thiaridae 1	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Thiaridae 2	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Tipulidae	Tipulidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tubificid	Tubificidae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	0	0	0	0	0	0	0	0	0
Veliidae	Veliidae	Hemiptera	Insecta	Arthropoda	No	0	0	3	0	0	0	12	0	0	0	0	0
Weevil	Curculionidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Table B-5 Freshwater Macroinvertebrate Catch Data (number of individuals in each sample) – Sites 14 and 15

Site						Site 11						Site 15					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						14_E1	14_E2	14_E3	14_R1	14_R2	14_R3	15_E1	15_E2	15_E3	15_P1	15_P2	15_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Anisocentropus sp	Calamoceratidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Anisops sp	Notonectidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Atyid 1	Atyidae	Decapoda	Crustacea	Arthropoda	No	16	3	2	0	0	0	0	0	0	0	0	0
Atyid 2	Atyidae	Decapoda	Crustacea	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0
Baetidae	Baetidae	Ephemeroptera	Insecta	Arthropoda	PET	336	499	433	41	224	121	3	12	36	0	0	0
Beetle 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle 2	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle A (probably not aquatic)	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Beetle larva 1	.	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Gerridae sp.	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Caddis fly	.	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	Caenidae	Ephemeroptera	Insecta	Arthropoda	PET	98	60	52	15	14	17	7	2	1	0	0	2
Ceratopoginidae 1	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopoginidae 2	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	1	8	0	1	0
Ceratopoginidae 3	Ceratopogonidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 1	Chironominae	Diptera	Insecta	Arthropoda	No	0	1	5	1	0	1	0	0	0	0	0	0
Chironomid 10	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 2	Chironominae	Diptera	Insecta	Arthropoda	No	15	21	15	0	6	2	0	0	0	0	0	0
Chironomid 3	Chironominae	Diptera	Insecta	Arthropoda	No	9	15	19	45	82	73	6	1	5	0	0	1
Chironomid 4	Chironominae	Diptera	Insecta	Arthropoda	No	31	25	21	2	11	0	7	0	0	0	0	0
Chironomid 5	Chironominae	Diptera	Insecta	Arthropoda	No	1	7	0	0	0	0	1	0	1	0	0	0
Chironomid 6	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 7	Chironominae	Diptera	Insecta	Arthropoda	No	1	0	0	0	1	0	0	0	0	0	0	0
Chironomid 8	Chironominae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Chironomid 9	Chironominae	Diptera	Insecta	Arthropoda	No	1	0	1	0	0	0	0	0	0	0	0	0
Chironomid other (juv/damaged)	Chironominae	Diptera	Insecta	Arthropoda	No	13	36	11	25	11	38	1	0	10	1	0	0
chironomid pupa	Chironominae	Diptera	Insecta	Arthropoda	No	3	2	5	1	2	3	5	0	0	0	0	0
Chlorocyphidae	Chlorocyphidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionid 1	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Coenagrionid 2	Coenagrionidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Copepod	Copepoda	Copepoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Crab	Sundatelphusidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly 1	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly 2	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Damselfly juv	.	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera pupa 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 1	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Diptera larva 2	.	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Dolichopodidae	Dolichopodidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Dugesiidae	Dugesiidae	Paludicola	Tricladida	Platyhelminthes	No	0	0	0	0	0	0	0	0	0	0	0	0
Ecnomidae	Ecnomidae	Trichoptera	Insecta	Arthropoda	PET	0	0	1	0	0	0	1	0	0	0	0	0
Elmid adult 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0

Site						Site 11						Site 15					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						14_E1	14_E2	14_E3	14_R1	14_R2	14_R3	15_E1	15_E2	15_E3	15_P1	15_P2	15_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Elmid adult 2	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Elmid larvae 1	Elmidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 1	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Gastropod 2	Gastropoda	Gastropoda	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Gyrinidae 1	Gyrinidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydrophylid 1	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	1	0	0	0
Hydrophylid 2	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	2	1	0	0	0	0	0	0	0	0	0
hydrophylid larva	Hydrophilidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Hydropsychidae	Hydropsychidae	Trichoptera	Insecta	Arthropoda	PET	0	7	3	0	1	0	0	0	0	0	0	0
Hydroptilidae	Hydroptilidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Leptocerid A	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	1	0	0	0	0	0	0	0	0	0	0	0
Leptophlebiidae	Leptophlebiidae	Ephemeroptera	Insecta	Arthropoda	PET	39	32	46	1	13	4	0	0	0	0	0	0
Libellulidae 1	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 2	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae 3	Libellulidae	Odonata	Insecta	Arthropoda	No	1	1	1	0	0	1	0	0	1	0	0	0
Libellulidae 4	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Libellulidae juv	Libellulidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Limnichidae	Limnichidae	Coleoptera	Insecta	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0
Limpet	Ancylidae	Basommatophora	Gastropoda	Mollusca	No	0	1	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 1	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	8	3	5	0	1	0	0	0	0	0	0	0
Macrobrachium sp 2	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Macrobrachium sp 3	Palaemonidae	Decapoda	Crustacea	Arthropoda	No	0	0	1	0	0	0	0	0	0	0	0	0
Macromiidae?	Macromiidae	Odonata	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Micronecta sp 1	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	2	0	2	0	0	0
Micronecta sp 2	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Micronecta sp juv	Corixidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	3	0	0	0
Mite sp.	Acarina	Acarina	Arachnida	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	1
Muscidae	Muscidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Naididae	Naididae	Oligochaeta	Oligochaeta	Annelida	No	20	0	20	5	0	13	0	0	0	0	0	0
Naucoris sp 1	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Naucoris sp 2	Naucoridae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Nematode	Nematoda	Nematoda	Nematoda	Nematoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Nemertean	Nemertea	Nemertea	Nemertea	Nemertea	No	0	0	0	0	0	0	0	0	0	0	0	0
Nereitid 1	Nereitidae	Cycloneritimorpha	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Oecetis sp 1	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	1	0
Oecetis sp 2	Leptoceridae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Oligochaete	.	Oligochaeta	Oligochaeta	Annelida	No	0	0	2	0	1	0	2	5	5	1	0	6
Oniscidae	Oniscidae	Isopoda	Crustacea	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Philopotamidae	Philopotamidae	Trichoptera	Insecta	Arthropoda	PET	0	0	0	0	0	0	0	0	0	0	0	0
Pipefish	Syngnathidae	Syngnathiformes	Actinopterygii	Chordata	No	0	0	0	0	0	0	0	0	0	0	0	0
Ptilodactylidae	Ptilodactylidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Pyralidae	Pyralidae	Lepidoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Ranatra sp	Nepidae	Hemiptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	1	0	0	0

Site						Site 11						Site 15					
Hydraulic Habitat						Edge			Riffle			Edge			Pool		
Sample Code						14_E1	14_E2	14_E3	14_R1	14_R2	14_R3	15_E1	15_E2	15_E3	15_P1	15_P2	15_P3
Genus species	Family	Order	Class	Phylum	PET taxa?												
Scirtidae	Scirtidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Shrimp juv	Decapoda	Decapoda	Crustacea	Arthropoda	No	0	1	0	0	0	0	0	1	6	0	0	0
Simuliidae	Simuliidae	Diptera	Insecta	Arthropoda	No	2	1	11	0	0	0	0	0	0	0	0	0
Springtail	Collembola	Collembola	Collembola	Arthropoda	No	0	2	0	0	0	0	0	5	10	0	0	0
Stone fly	.	Plecoptera	Insecta	Arthropoda	PET	1	2	22	0	1	1	0	0	0	0	0	0
Stratiomyidae	Stratiomyidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 1	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tabanidae 2	Tabanidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 1	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tanypodinae 2	Chironomidae	Diptera	Insecta	Arthropoda	No	15	4	6	1	1	1	0	1	2	0	0	0
Tanypodinae 3	Chironomidae	Diptera	Insecta	Arthropoda	No	3	4	0	1	3	5	3	0	1	0	0	0
Tanypodinae 4	Chironomidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	1	0	0
Tanypodinae X	Chironomidae	Diptera	Insecta	Arthropoda	No	0	1	0	0	0	0	0	0	0	0	0	0
Tennagogerris sp	Gerridae	Hemiptera	Insecta	Arthropoda	No	0	1	0	0	0	1	1	0	1	0	0	0
Thiaridae 1	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Thiaridae 2	Thiaridae	Neotaenioglossa	Gastropoda	Mollusca	No	0	0	0	0	0	0	0	0	0	0	0	0
Tipulidae	Tipulidae	Diptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0
Tubificid	Tubificidae	Oligochaeta	Oligochaeta	Annelida	No	0	0	0	1	0	4	0	1	0	0	0	1
Veliidae	Veliidae	Hemiptera	Insecta	Arthropoda	No	0	2	2	0	0	0	1	0	2	0	0	0
Weevil	Curculionidae	Coleoptera	Insecta	Arthropoda	No	0	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Table B-6 Freshwater (Purari River Delta) and Estuarine Macroinvertebrate Catch Data (number of individuals in each sample)

Site					Site 16			Site 17			Site 18			Site 19			Site 20			Site 21			Site 22			Site 23			Site 24		
Sample code					(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Genus/species	Family	Order	Class	Phylum																											
Amphipod 3	.	Amphipoda	Malacostraca	Crustacea	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthurid 3	Anthuridae	Isopoda	Malacostraca	Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Bivalve 4	.	.	Bivalvia	Mollusca	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Bivalve 5	.	.	Bivalvia	Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Bivalves unident	.	.	Bivalvia	Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	1	0	0	0	0	0	0	0
Capitellid 4	Capitellidae	Scolecida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	21	3	30	2	1	3	1	0	1	0	0	0	0	0	0
Capitellid 5	Capitellidae	Scolecida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Caragobius sp	Gobiidae	Perciformes	Actinopterygii	Chordata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	0	0	0	0
Cirratulid 3	Cirratulidae	Terebellida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1	5	0	0	0
Cirratulid 4	Cirratulidae	Terebellida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	0	0	0	0	0	0
Gastropod 1	.	.	Gastropoda	Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Goby 1	Gobiidae	Perciformes	Actinopterygii	Chordata	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Nephtys sp	Nephtyidae	Phyllodocida	Polychaeta	Annelida	0	0	0	0	0	0	2	5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nereid 2	Nereididae	Phyllodocida	Polychaeta	Annelida	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oedicerotid 2	Oedicerotidae	Amphipoda	Malacostraca	Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Orthoprionospio sp	Spionidae	Spionida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	3	10	6	8	7	5	3	0	1	0	0	0	0	0	0
Penaeid juv	Penaeidae	Decapoda	Malacostraca	Crustacea	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Polydora sp	Spionidae	Spionida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	1	0	0	0	0	0	0	0	0	0
Potamid	Potamididae	Caenogastropoda	Gastropoda	Mollusca	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudopolydora sp	Spionidae	Spionida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	0	0	0	0	0	0	0	0	0	0	0
Sabellid 1	Sabellidae	Sabellida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0
Sabellid 2	Sabellidae	Sabellida	Polychaeta	Annelida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Tellina sp 2	Tellinidae	Veneroida	Bivalvia	Mollusca	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0

Raw data from macroinvertebrate sampling. NOTE: '.' = lower taxonomic discrimination not achieveable

Appendix C Fish Tissue Analysis

REPORT OF ANALYSIS

Report No. RN1123340

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00909	.	BIOTA 22-1 KURTUS GULLIVERI 28/06/16 15:00
NQ16/00910	.	BIOTA 22-2 KURTUS GULLIVERI 28/06/16 15:00
NQ16/00911	.	BIOTA 22-3 KURTUS GULLIVERI 28/06/16 15:00
NQ16/00912	.	BIOTA 22-4 KURTUS GULLIVERI 28/06/16 15:00

Lab Reg No.		NQ16/00909	NQ16/00910	NQ16/00911	NQ16/00912	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	81	73	81	71	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

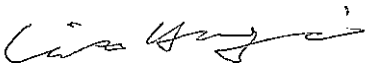
Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Lab Reg No.		NQ16/00909	NQ16/00910	NQ16/00911	NQ16/00912	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	34	7.2	4.8	5.5	NT2_46
Arsenic	mg/kg	3.7	2.6	2.1	3	NT2_46
Cadmium	mg/kg	0.12	0.1	0.07	0.08	NT2_46
Copper	mg/kg	3.3	1.7	2.4	1.9	NT2_46
Lead	mg/kg	0.64	0.03	0.03	0.05	NT2_46
Manganese	mg/kg	8.4	22	16	37	NT2_46
Mercury	mg/kg	0.10	0.07	0.15	0.07	NT2_46
Nickel	mg/kg	0.09	0.04	0.06	0.06	NT2_46
Selenium	mg/kg	1.7	1.5	1.5	1.4	NT2_46
Silver	mg/kg	0.04	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	51	66	68	110	NT2_46
Moisture Content						
Moisture	%	80.8	77.2	79.6	78.1	NT2_49

NQ16/00909
-NQ16/00937.
Results are expressed on a dry weight basis.
Moisture results were obtained from freeze-drying, please disregard the above method.



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Report No. RN1123340

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00913	.	BIOTA 22-5 KURTUS GULLIVERI 28/06/16 15:00
NQ16/00914	.	BIOTA 22-6 POTAMOSILURUS LATIROSTRIS 28/06/16 15:00
NQ16/00915	.	BIOTA 22-7 POTAMOSILURUS LATIROSTRIS 28/06/16 15:00
NQ16/00916	.	BIOTA 22-8 POTAMOSILURUS LATIROSTRIS 28/06/16 15:00

Lab Reg No.		NQ16/00913	NQ16/00914	NQ16/00915	NQ16/00916	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	75	69	73	75	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

REPORT OF ANALYSIS

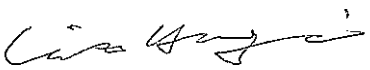
Lab Reg No.		NQ16/00913	NQ16/00914	NQ16/00915	NQ16/00916	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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Lab Reg No.		NQ16/00913	NQ16/00914	NQ16/00915	NQ16/00916	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	17	21	5.8	7.4	NT2_46
Arsenic	mg/kg	3.4	4.7	2.4	3.3	NT2_46
Cadmium	mg/kg	0.09	0.16	0.09	0.13	NT2_46
Copper	mg/kg	2.4	5.7	4	5.2	NT2_46
Lead	mg/kg	0.05	0.43	0.17	0.1	NT2_46
Manganese	mg/kg	11	15	16	29	NT2_46
Mercury	mg/kg	0.10	0.04	0.03	0.03	NT2_46
Nickel	mg/kg	0.06	0.11	0.06	0.05	NT2_46
Selenium	mg/kg	1.8	0.64	0.74	0.76	NT2_46
Silver	mg/kg	<0.02	0.04	0.03	0.04	NT2_46
Zinc	mg/kg	58	220	260	250	NT2_46
Moisture Content						
Moisture	%	80.8	71.0	74.6	75.3	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00917	.	BIOTA 22-9 POTAMOSILURUS LATIROSTRIS 28/06/16 15:00
NQ16/00918	.	BIOTA 22-10 POTAMOSILURUS LATIROSTRIS 28/06/16 15:00
NQ16/00919	.	BIOTA 22-11 DOIICHTHYS NOVAEGUINEAE 28/06/16 15:00
NQ16/00920	.	BIOTA 22-12 DOIICHTHYS NOVAEGUINEAE 28/06/16 15:00

Lab Reg No.		NQ16/00917	NQ16/00918	NQ16/00919	NQ16/00920	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	74	68	70	68	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

REPORT OF ANALYSIS

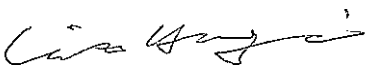
Lab Reg No.		NQ16/00917	NQ16/00918	NQ16/00919	NQ16/00920	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ16/00917	NQ16/00918	NQ16/00919	NQ16/00920	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	17	6.3	19	27	NT2_46
Arsenic	mg/kg	3.2	1.3	2.5	5.2	NT2_46
Cadmium	mg/kg	0.11	0.02	0.06	0.07	NT2_46
Copper	mg/kg	6.9	1.6	2.2	2.3	NT2_46
Lead	mg/kg	0.11	0.15	0.22	3.3	NT2_46
Manganese	mg/kg	39	32	20	8	NT2_46
Mercury	mg/kg	0.03	0.04	0.08	0.19	NT2_46
Nickel	mg/kg	0.06	0.05	0.35	0.07	NT2_46
Selenium	mg/kg	0.97	0.54	1.7	1.9	NT2_46
Silver	mg/kg	0.05	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	190	260	360	300	NT2_46
Moisture Content						
Moisture	%	76.5	71.6	76.7	77.2	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Report No. RN1123340

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00921	.	BIOTA 20B-1 ARIUS GRAEFFEI 29/06/16 14:00
NQ16/00922	.	BIOTA 20B-2 ARIUS GRAEFFEI 29/06/16 14:00
NQ16/00923	.	BIOTA 20B-3 ARIUS GRAEFFEI 29/06/16 14:00
NQ16/00924	.	BIOTA 20B-4 ARIUS GRAEFFEI 29/06/16 14:00

Lab Reg No.		NQ16/00921	NQ16/00922	NQ16/00923	NQ16/00924	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	71	71	67	76	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

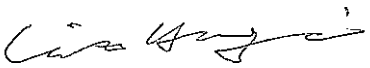


Danny Slee, Section Manager
Organic - NSW
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REPORT OF ANALYSIS

Lab Reg No.		NQ16/00921	NQ16/00922	NQ16/00923	NQ16/00924	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	420	890	550	710	NT2_46
Arsenic	mg/kg	29	27	16	26	NT2_46
Cadmium	mg/kg	0.08	0.12	0.08	0.07	NT2_46
Copper	mg/kg	9.5	23	4.9	20	NT2_46
Lead	mg/kg	0.31	0.41	0.26	0.33	NT2_46
Manganese	mg/kg	35	33	32	21	NT2_46
Mercury	mg/kg	0.12	0.13	0.07	0.15	NT2_46
Nickel	mg/kg	0.6	1.4	0.75	1.1	NT2_46
Selenium	mg/kg	1.9	2.7	1.9	2.1	NT2_46
Silver	mg/kg	0.05	0.18	0.05	0.08	NT2_46
Zinc	mg/kg	880	460	260	760	NT2_46
Moisture Content						
Moisture	%	78.2	79.7	74.2	80.8	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Report No. RN1123340

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00925	.	BIOTA 20B-5 ARIUS GRAEFFEI 29/06/16 14:00
NQ16/00926	.	BIOTA 23B-1 KURTUS GULLIVERI 02/07/16 10:00
NQ16/00927	.	BIOTA 23B-2 KURTUS GULLIVERI 02/07/16 10:00
NQ16/00928	.	BIOTA 23B-3 KURTUS GULLIVERI 02/07/16 10:00

Lab Reg No.		NQ16/00925	NQ16/00926	NQ16/00927	NQ16/00928	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	72	73	73	67	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Lab Reg No.		NQ16/00925	NQ16/00926	NQ16/00927	NQ16/00928	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	550	31	31	47	NT2_46
Arsenic	mg/kg	25	1.6	3.3	2.1	NT2_46
Cadmium	mg/kg	0.15	0.02	0.03	0.06	NT2_46
Copper	mg/kg	10	1.5	3.4	4.8	NT2_46
Lead	mg/kg	0.33	0.05	0.06	0.09	NT2_46
Manganese	mg/kg	48	14	9.9	16	NT2_46
Mercury	mg/kg	0.11	0.08	0.06	0.08	NT2_46
Nickel	mg/kg	0.81	0.09	0.08	0.11	NT2_46
Selenium	mg/kg	1.9	1.6	1.9	1.8	NT2_46
Silver	mg/kg	0.05	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	570	60	83	64	NT2_46
Moisture Content						
Moisture	%	76.8	76.9	79.8	79.6	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00929	.	BIOTA 23B-4 KURTUS GULLIVERI 02/07/16 10:00
NQ16/00930	.	BIOTA 23B-5 KURTUS GULLIVERI 02/07/16 10:00
NQ16/00931	.	BIOTA 23B-6 POLYDACTYLUS PLEBEIUS 02/07/16 10:00
NQ16/00932	.	BIOTA 23B-7 POLYDACTYLUS PLEBEIUS 02/07/16 10:00

Lab Reg No.		NQ16/00929	NQ16/00930	NQ16/00931	NQ16/00932	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	65	74	69	70	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

REPORT OF ANALYSIS

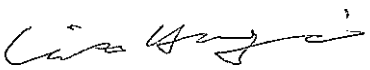
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Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

27-JUL-2016

Lab Reg No.		NQ16/00929	NQ16/00930	NQ16/00931	NQ16/00932	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	33	35	11	34	NT2_46
Arsenic	mg/kg	2.3	1.8	3.2	2.6	NT2_46
Cadmium	mg/kg	0.05	0.02	<0.01	0.01	NT2_46
Copper	mg/kg	2.5	1.7	1.8	2.7	NT2_46
Lead	mg/kg	0.06	0.06	0.04	0.04	NT2_46
Manganese	mg/kg	14	14	9.9	6.9	NT2_46
Mercury	mg/kg	0.06	0.09	0.11	0.20	NT2_46
Nickel	mg/kg	0.08	0.12	0.10	0.10	NT2_46
Selenium	mg/kg	2	1.7	2.1	3	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	75	70	49	39	NT2_46
Moisture Content						
Moisture	%	80.1	80.0	78.6	78.7	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00933	.	BIOTA 24B-1 LIZA SUBVIRIDIS 02/07/16 14:00
NQ16/00934	.	BIOTA 24B-2 LIZA SUBVIRIDIS 02/07/16 14:00
NQ16/00935	.	BIOTA 24B-3 LIZA SUBVIRIDIS 02/07/16 14:00
NQ16/00936	.	BIOTA 24B-4 LIZA SUBVIRIDIS 02/07/16 14:00

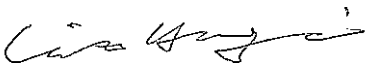
Lab Reg No.		**NQ16/00933**	**NQ16/00934**	**NQ16/00935**	**NQ16/00936**	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	70	86	91	72	NGCMS_1111
Dates						
Date extracted		20-JUL-2016	20-JUL-2016	20-JUL-2016	20-JUL-2016	
Date analysed		22-JUL-2016	22-JUL-2016	22-JUL-2016	22-JUL-2016	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Lab Reg No.		NQ16/00933	NQ16/00934	NQ16/00935	NQ16/00936	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	910	360	460	230	NT2_46
Arsenic	mg/kg	9.9	12	12	9.9	NT2_46
Cadmium	mg/kg	0.07	0.02	0.03	0.02	NT2_46
Copper	mg/kg	16	7.3	14	5.7	NT2_46
Lead	mg/kg	0.48	0.2	0.32	0.15	NT2_46
Manganese	mg/kg	45	32	24	23	NT2_46
Mercury	mg/kg	0.02	0.02	0.02	<0.01	NT2_46
Nickel	mg/kg	1.3	0.5	0.68	0.36	NT2_46
Selenium	mg/kg	2.5	1.4	2.4	1.5	NT2_46
Silver	mg/kg	0.07	0.03	0.05	0.03	NT2_46
Zinc	mg/kg	50	39	40	49	NT2_46
Moisture Content						
Moisture	%	71.8	69.2	71.8	70.6	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

27-JUL-2016

REPORT OF ANALYSIS

Report No. RN1123340

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160711
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 11-JUL-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/00937	.	BIOTA 24B-5 LIZA SUBVIRIDIS 02/07/16 14:00

Lab Reg No.		NQ16/00937				
Sample Reference	**Units**	.				**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01				NGCMS_1111
Acenaphthylene	mg/kg	<0.01				NGCMS_1111
Acenaphthene	mg/kg	<0.01				NGCMS_1111
Fluorene	mg/kg	<0.01				NGCMS_1111
Phenanthrene	mg/kg	<0.01				NGCMS_1111
Anthracene	mg/kg	<0.01				NGCMS_1111
Fluoranthene	mg/kg	<0.01				NGCMS_1111
Pyrene	mg/kg	<0.01				NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01				NGCMS_1111
Chrysene	mg/kg	<0.01				NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02				NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01				NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01				NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01				NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01				NGCMS_1111
Surrogate: TER-D14	%REC	84				NGCMS_1111
Dates						
Date extracted		20-JUL-2016				
Date analysed		22-JUL-2016				



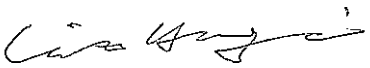
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27-JUL-2016

REPORT OF ANALYSIS

Report No. RN1123340

Lab Reg No.		NQ16/00937				
Sample Reference	Units	.				Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	480				NT2_46
Arsenic	mg/kg	10				NT2_46
Cadmium	mg/kg	0.02				NT2_46
Copper	mg/kg	10				NT2_46
Lead	mg/kg	0.27				NT2_46
Manganese	mg/kg	26				NT2_46
Mercury	mg/kg	0.02				NT2_46
Nickel	mg/kg	0.65				NT2_46
Selenium	mg/kg	1.9				NT2_46
Silver	mg/kg	0.06				NT2_46
Zinc	mg/kg	45				NT2_46
Moisture Content						
Moisture	%	72.8				NT2_49



Lisa Liu, Analyst
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27-JUL-2016

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Results relate only to the sample(s) tested.

This Report supersedes reports: *RN1122907* *RN1123330*

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01069	.	BIOTA SITE15 PRAWN TAIL 1 20/7/16 1300
NQ16/01070	.	BIOTA SITE15 PRAWN HEAD 1 20/7/16 1300
NQ16/01071	.	BIOTA SITE15 PRAWN TAIL 2 20/7/16 1300
NQ16/01072	.	BIOTA SITE15 PRAWN HEAD 2 20/7/16 1300

Lab Reg No.		NQ16/01069	NQ16/01070	NQ16/01071	NQ16/01072	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	72	188	127	101	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

NQ16/01070
Surrogate recovery outside acceptance criteria (50 to 150%).
Suggests matrix interference.

REPORT OF ANALYSIS

Lab Reg No.		NQ16/01069	NQ16/01070	NQ16/01071	NQ16/01072	
Sample Reference	Units	.	.	.	.	Method

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

22-AUG-2016

Lab Reg No.		NQ16/01069	NQ16/01070	NQ16/01071	NQ16/01072	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	83	190	51	66	NT2_46
Arsenic	mg/kg	0.61	1.5	0.53	0.75	NT2_46
Cadmium	mg/kg	<0.01	0.45	<0.01	0.31	NT2_46
Copper	mg/kg	42	110	51	140	NT2_46
Lead	mg/kg	1.4	3.4	1.5	2.8	NT2_46
Manganese	mg/kg	41	160	75	53	NT2_46
Mercury	mg/kg	<0.01	<0.01	0.01	0.02	NT2_46
Nickel	mg/kg	0.24	0.41	0.29	0.28	NT2_46
Selenium	mg/kg	1.1	0.99	0.88	1.5	NT2_46
Silver	mg/kg	0.02	0.18	0.07	0.14	NT2_46
Zinc	mg/kg	52	75	63	96	NT2_46
Moisture Content						
Moisture	%	71.1	62.4	75.7	77.1	NT2_49

NQ16/01069
NQ16/01127.
Results are expressed on a dry weight basis.
Moisture results were obtained from freeze-drying, please disregard the above method.

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01073	.	BIOTA SITE15 PRAWN TAIL 3 20/7/16 1300
NQ16/01074	.	BIOTA SITE15 PRAWN HEAD 3 20/7/16 1300
NQ16/01075	.	BIOTA SITE2 PRAWN HEAD 1 22/7/16 1200
NQ16/01076	.	BIOTA SITE2 PRAWN TAIL 1 22/7/16 1200

Lab Reg No.		NQ16/01073	NQ16/01074	NQ16/01075	NQ16/01076	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	105	120	103	104	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Lab Reg No.		NQ16/01073	NQ16/01074	NQ16/01075	NQ16/01076	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	220	400	210	50	NT2_46
Arsenic	mg/kg	0.8	1.9	0.25	0.10	NT2_46
Cadmium	mg/kg	0.01	1.9	0.96	0.01	NT2_46
Copper	mg/kg	45	120	250	44	NT2_46
Lead	mg/kg	2.1	5.4	0.21	0.14	NT2_46
Manganese	mg/kg	35	170	140	56	NT2_46
Mercury	mg/kg	<0.01	0.02	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.35	0.83	1.1	0.27	NT2_46
Selenium	mg/kg	1.1	2.5	0.76	0.47	NT2_46
Silver	mg/kg	0.03	0.13	0.38	0.05	NT2_46
Zinc	mg/kg	56	74	320	54	NT2_46
Moisture Content						
Moisture	%	76.0	64.9	68.1	72.6	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01077	.	BIOTA SITE2 PRAWN HEAD 2 22/7/16 1200
NQ16/01078	.	BIOTA SITE2 PRAWN TAIL 2 22/7/16 1200
NQ16/01079	.	BIOTA SITE2 PRAWN HEAD 3 22/7/16 1200
NQ16/01080	.	BIOTA SITE2 PRAWN TAIL 3 22/7/16 1200

Lab Reg No.		NQ16/01077	NQ16/01078	NQ16/01079	NQ16/01080	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	156	118	178	100	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

NQ16/01077

Surrogate recovery outside acceptance criteria (50 to 150%).

Suggests matrix interference.

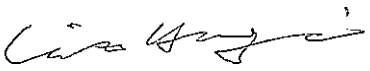
NQ16/01079
Surrogate recovery outside acceptance criteria (50 to 150%).
Suggests matrix interference.



Danny Slee, Section Manager
Organic - NSW
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22-AUG-2016

Lab Reg No.		NQ16/01077	NQ16/01078	NQ16/01079	NQ16/01080	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	55	38	65	20	NT2_46
Arsenic	mg/kg	0.26	0.22	0.22	0.12	NT2_46
Cadmium	mg/kg	1.1	<0.01	1	<0.01	NT2_46
Copper	mg/kg	280	49	82	39	NT2_46
Lead	mg/kg	0.09	0.09	0.21	0.09	NT2_46
Manganese	mg/kg	130	92	220	120	NT2_46
Mercury	mg/kg	0.02	0.01	<0.01	0.01	NT2_46
Nickel	mg/kg	0.57	0.29	0.71	0.25	NT2_46
Selenium	mg/kg	1.1	0.52	0.67	0.52	NT2_46
Silver	mg/kg	0.82	0.05	0.22	0.06	NT2_46
Zinc	mg/kg	74	51	58	54	NT2_46
Moisture Content						
Moisture	%	70.3	69.7	64.3	73.0	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01081	.	BIOTA SITE2 PRAWN HEAD 4 22/7/16 1200
NQ16/01082	.	BIOTA SITE2 PRAWN TAIL 4 22/7/16 1200
NQ16/01083	.	BIOTA SITE2 PRAWN HEAD 5 22/7/16 1200
NQ16/01084	.	BIOTA SITE2 PRAWN TAIL 5 22/7/16 1200

Lab Reg No.		NQ16/01081	NQ16/01082	NQ16/01083	NQ16/01084	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	138	77	88	104	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

NQ16/01081
Surrogate recovery outside acceptance criteria (50 to 150%).
Suggests matrix interference.

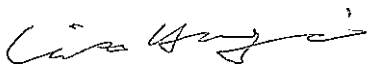
REPORT OF ANALYSIS



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

22-AUG-2016

Lab Reg No.		NQ16/01081	NQ16/01082	NQ16/01083	NQ16/01084	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	87	59	170	100	NT2_46
Arsenic	mg/kg	0.18	0.16	0.17	0.08	NT2_46
Cadmium	mg/kg	1.2	0.01	0.55	0.04	NT2_46
Copper	mg/kg	120	71	87	46	NT2_46
Lead	mg/kg	0.13	0.12	0.11	0.06	NT2_46
Manganese	mg/kg	190	66	140	52	NT2_46
Mercury	mg/kg	<0.01	<0.01	0.01	0.03	NT2_46
Nickel	mg/kg	0.7	0.45	0.77	0.42	NT2_46
Selenium	mg/kg	0.7	0.57	0.51	0.43	NT2_46
Silver	mg/kg	0.11	0.12	0.07	0.07	NT2_46
Zinc	mg/kg	130	76	1020	51	NT2_46
Moisture Content						
Moisture	%	71.1	74.1	66.6	74.1	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01085	.	BIOTA 11-1 23/7/16 1200
NQ16/01086	.	BIOTA 11-2 23/7/16 1200
NQ16/01087	.	BIOTA 11-3 23/7/16 1200
NQ16/01088	.	BIOTA 11-4 23/7/16 1200

Lab Reg No.		NQ16/01085	NQ16/01086	NQ16/01087	NQ16/01088	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	88	78	102	103	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	



Danny Slee, Section Manager
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Lab Reg No.		NQ16/01085	NQ16/01086	NQ16/01087	NQ16/01088	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	8	11	10	3.5	NT2_46
Arsenic	mg/kg	0.84	0.94	1.7	0.53	NT2_46
Cadmium	mg/kg	0.04	0.03	<0.01	<0.01	NT2_46
Copper	mg/kg	4.8	3	1.4	2.3	NT2_46
Lead	mg/kg	0.05	0.05	0.08	0.01	NT2_46
Manganese	mg/kg	13	9.8	4.8	11	NT2_46
Mercury	mg/kg	0.21	0.95	0.53	1.5	NT2_46
Nickel	mg/kg	0.13	0.64	0.31	0.03	NT2_46
Selenium	mg/kg	1	0.9	0.92	0.66	NT2_46
Silver	mg/kg	<0.02	0.03	<0.02	<0.02	NT2_46
Zinc	mg/kg	45	36	31	46	NT2_46
Moisture Content						
Moisture	%	74.7	76.8	78.3	76.7	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01089	.	BIOTA 11-5 23/7/16 1200
NQ16/01090	.	BIOTA 1B PRAWN HEAD 1 24/7/16 1000
NQ16/01091	.	BIOTA 1B PRAWN TAIL 1 24/7/16 1000
NQ16/01092	.	BIOTA 3B PRAWN HEAD 1 24/7/16 1400

Lab Reg No.		NQ16/01089	NQ16/01090	NQ16/01091	NQ16/01092	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	84	148	83	130	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

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Lab Reg No.		NQ16/01089	NQ16/01090	NQ16/01091	NQ16/01092	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	8	47	35	59	NT2_46
Arsenic	mg/kg	0.82	0.26	0.17	0.33	NT2_46
Cadmium	mg/kg	<0.01	0.9	<0.01	0.5	NT2_46
Copper	mg/kg	2	100	48	140	NT2_46
Lead	mg/kg	0.03	0.51	0.14	0.08	NT2_46
Manganese	mg/kg	7.2	140	88	43	NT2_46
Mercury	mg/kg	0.97	0.01	0.02	0.02	NT2_46
Nickel	mg/kg	0.09	0.3	0.15	0.56	NT2_46
Selenium	mg/kg	0.88	0.62	0.6	0.85	NT2_46
Silver	mg/kg	<0.02	0.09	0.05	0.14	NT2_46
Zinc	mg/kg	40	70	62	89	NT2_46
Moisture Content						
Moisture	%	82.6	69.0	77.8	75.0	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
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22-AUG-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01093	.	BIOTA 3B PRAWN TAIL 1 24/7/16 1400
NQ16/01094	.	BIOTA 3B PRAWN HEAD 2 24/7/16 1400
NQ16/01095	.	BIOTA 3B PRAWN TAIL 2 24/7/16 1400
NQ16/01096	.	BIOTA 3B PRAWN HEAD 3 24/7/16 1400

Lab Reg No.		NQ16/01093	NQ16/01094	NQ16/01095	NQ16/01096	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	104	76	82	101	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ16/01093	NQ16/01094	NQ16/01095	NQ16/01096	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	27	68	34	44	NT2_46
Arsenic	mg/kg	0.19	0.35	0.3	0.31	NT2_46
Cadmium	mg/kg	<0.01	0.47	<0.01	0.5	NT2_46
Copper	mg/kg	71	150	95	150	NT2_46
Lead	mg/kg	0.05	0.10	0.05	0.06	NT2_46
Manganese	mg/kg	23	21	8.6	59	NT2_46
Mercury	mg/kg	<0.01	0.03	0.02	0.02	NT2_46
Nickel	mg/kg	0.18	0.25	0.15	0.2	NT2_46
Selenium	mg/kg	0.61	0.86	0.68	0.85	NT2_46
Silver	mg/kg	0.12	0.1	0.15	0.18	NT2_46
Zinc	mg/kg	62	94	64	72	NT2_46
Moisture Content						
Moisture	%	73.8	73.1	69.7	55.8	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01097	.	BIOTA 3B PRAWN TAIL 3 24/7/16 1400
NQ16/01098	.	BIOTA 3B PRAWN HEAD 4 24/7/16 1400
NQ16/01099	.	BIOTA 3B PRAWN TAIL 4 24/7/16 1400
NQ16/01100	.	BIOTA 5 PRAWN HEAD 1 25/7/16 1300

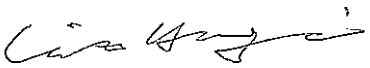
Lab Reg No.		NQ16/01097	NQ16/01098	NQ16/01099	NQ16/01100	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	79	97	99	89	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
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Lab Reg No.		NQ16/01097	NQ16/01098	NQ16/01099	NQ16/01100	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	94	93	120	81	NT2_46
Arsenic	mg/kg	0.18	0.58	0.27	1.2	NT2_46
Cadmium	mg/kg	<0.01	0.55	0.01	0.23	NT2_46
Copper	mg/kg	75	160	46	160	NT2_46
Lead	mg/kg	0.14	0.12	0.14	0.04	NT2_46
Manganese	mg/kg	110	120	130	90	NT2_46
Mercury	mg/kg	0.05	0.02	0.01	0.02	NT2_46
Nickel	mg/kg	0.39	0.41	0.39	0.38	NT2_46
Selenium	mg/kg	0.5	0.99	0.54	0.96	NT2_46
Silver	mg/kg	0.05	0.21	0.04	0.23	NT2_46
Zinc	mg/kg	70	100	57	190	NT2_46
Moisture Content						
Moisture	%	71.9	66.4	71.7	70.8	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01101	.	BIOTA 5 PRAWN TAIL 1 25/7/16 1200
NQ16/01102	.	BIOTA 5 PRAWN HEAD 2 25/7/16 1300
NQ16/01103	.	BIOTA 5 PRAWN TAIL 2 25/7/16 1300
NQ16/01104	.	BIOTA 5-1 25/7/16 1300

Lab Reg No.		NQ16/01101	NQ16/01102	NQ16/01103	NQ16/01104	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	81	100	75	82	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

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Lab Reg No.		NQ16/01101	NQ16/01102	NQ16/01103	NQ16/01104	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	21	95	34	5.3	NT2_46
Arsenic	mg/kg	0.41	0.56	0.2	0.13	NT2_46
Cadmium	mg/kg	<0.01	2	0.02	<0.01	NT2_46
Copper	mg/kg	49	340	45	2.2	NT2_46
Lead	mg/kg	0.02	0.05	0.04	0.02	NT2_46
Manganese	mg/kg	32	39	19	9.3	NT2_46
Mercury	mg/kg	<0.01	0.03	<0.01	0.25	NT2_46
Nickel	mg/kg	0.09	0.44	0.1	0.08	NT2_46
Selenium	mg/kg	0.77	1.4	0.65	0.71	NT2_46
Silver	mg/kg	0.04	0.47	0.06	<0.02	NT2_46
Zinc	mg/kg	65	130	56	62	NT2_46
Moisture Content						
Moisture	%	74.5	79.9	76.5	74.8	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01105	.	BIOTA 5-2 25/7/16 1300
NQ16/01106	.	BIOTA 5-3 25/7/16 1300
NQ16/01107	.	BIOTA 5-4 25/7/16 1300
NQ16/01108	.	BIOTA 10-1 26/7/16 1530

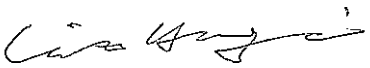
Lab Reg No.		NQ16/01105	NQ16/01106	NQ16/01107	NQ16/01108	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	102	85	91	94	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Lab Reg No.		NQ16/01105	NQ16/01106	NQ16/01107	NQ16/01108	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	13	49	11	1.6	NT2_46
Arsenic	mg/kg	0.13	0.39	0.14	<0.05	NT2_46
Cadmium	mg/kg	<0.01	0.02	<0.01	<0.01	NT2_46
Copper	mg/kg	2.1	5.5	1.3	1.8	NT2_46
Lead	mg/kg	0.01	0.05	0.02	0.04	NT2_46
Manganese	mg/kg	6	18	6.8	10	NT2_46
Mercury	mg/kg	0.37	0.07	0.2	1.2	NT2_46
Nickel	mg/kg	0.11	0.13	0.08	0.09	NT2_46
Selenium	mg/kg	0.83	1.7	1	0.87	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	38	110	64	45	NT2_46
Moisture Content						
Moisture	%	77.8	73.9	79.1	75.9	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01109	.	BIOTA 10-2 26/7/16 1530
NQ16/01110	.	BIOTA 10 PRAWN HEAD 1 26/7/16 1530
NQ16/01111	.	BIOTA 10 PRAWN TAIL 1 26/7/16 1530
NQ16/01112	.	BIOTA 10 PRAWN HEAD 2 26/7/16 1530

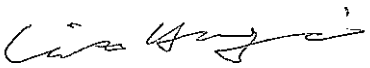
Lab Reg No.		NQ16/01109	NQ16/01110	NQ16/01111	NQ16/01112	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	67	87	77	71	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
Organic - NSW
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REPORT OF ANALYSIS

Lab Reg No.		NQ16/01109	NQ16/01110	NQ16/01111	NQ16/01112	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	6.3	44	13	33	NT2_46
Arsenic	mg/kg	0.07	0.3	0.16	0.18	NT2_46
Cadmium	mg/kg	0.02	0.49	<0.01	0.49	NT2_46
Copper	mg/kg	2.5	180	28	180	NT2_46
Lead	mg/kg	0.28	0.16	0.04	0.16	NT2_46
Manganese	mg/kg	33	34	23	30	NT2_46
Mercury	mg/kg	0.53	0.02	0.03	0.04	NT2_46
Nickel	mg/kg	0.34	0.32	0.11	0.59	NT2_46
Selenium	mg/kg	0.67	0.83	0.41	0.75	NT2_46
Silver	mg/kg	<0.02	0.32	0.04	0.1	NT2_46
Zinc	mg/kg	68	130	47	96	NT2_46
Moisture Content						
Moisture	%	67.5	74.2	73.0	76.2	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01113	.	BIOTA 10 PRAWN TAIL 2 26/7/16 1530
NQ16/01114	.	BIOTA 10 PRAWN HEAD 3 26/7/16 1530
NQ16/01115	.	BIOTA 10 PRAWN TAIL 3 26/7/16 1530
NQ16/01116	.	BIOTA 10 PRAWN HEAD 4 26/7/16 1530

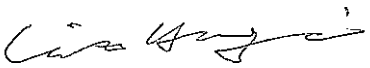
Lab Reg No.		NQ16/01113	NQ16/01114	NQ16/01115	NQ16/01116	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	77	92	66	85	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

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Organic - NSW
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REPORT OF ANALYSIS

Lab Reg No.		NQ16/01113	NQ16/01114	NQ16/01115	NQ16/01116	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	160	26	41	350	NT2_46
Arsenic	mg/kg	0.15	0.27	0.28	0.32	NT2_46
Cadmium	mg/kg	<0.01	1.9	<0.01	1	NT2_46
Copper	mg/kg	56	370	120	130	NT2_46
Lead	mg/kg	0.19	0.13	0.24	0.24	NT2_46
Manganese	mg/kg	42	21	9.6	93	NT2_46
Mercury	mg/kg	0.03	0.04	0.02	0.03	NT2_46
Nickel	mg/kg	0.49	0.31	0.34	1.2	NT2_46
Selenium	mg/kg	0.33	1	0.66	0.83	NT2_46
Silver	mg/kg	0.04	0.52	0.24	0.16	NT2_46
Zinc	mg/kg	50	84	72	120	NT2_46
Moisture Content						
Moisture	%	70.9	74.0	71.2	65.5	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01117	.	BIOTA 10 PRAWN TAIL 4 26/7/16 1530
NQ16/01118	.	BIOTA 10 PRAWN HEAD 5 26/7/16 1530
NQ16/01119	.	BIOTA 10 PRAWN TAIL 5 26/7/16 1530
NQ16/01120	.	BIOTA 9 PRAWN HEAD 1 27/7/16 1130

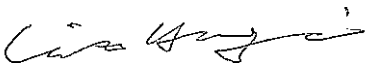
Lab Reg No.		NQ16/01117	NQ16/01118	NQ16/01119	NQ16/01120	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	84	117	76	111	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ16/01117	NQ16/01118	NQ16/01119	NQ16/01120	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	38	61	22	60	NT2_46
Arsenic	mg/kg	0.1	0.24	0.2	0.18	NT2_46
Cadmium	mg/kg	<0.01	0.71	<0.01	0.32	NT2_46
Copper	mg/kg	45	130	86	91	NT2_46
Lead	mg/kg	0.07	0.26	0.15	0.08	NT2_46
Manganese	mg/kg	17	29	12	67	NT2_46
Mercury	mg/kg	0.06	0.03	0.01	<0.01	NT2_46
Nickel	mg/kg	0.22	0.41	0.3	0.29	NT2_46
Selenium	mg/kg	0.38	0.81	0.56	0.7	NT2_46
Silver	mg/kg	0.03	0.35	0.18	0.06	NT2_46
Zinc	mg/kg	56	94	65	270	NT2_46
Moisture Content						
Moisture	%	72.3	68.8	73.8	64.3	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01121	.	BIOTA 9 PRAWN TAIL 1 27/7/16 1130
NQ16/01122	.	BIOTA 9 PRAWN HEAD 2 27/7/16 1130
NQ16/01123	.	BIOTA 9 PRAWN TAIL 2 27/7/16 1130
NQ16/01124	.	BIOTA 9 PRAWN HEAD 3 27/7/16 1130

Lab Reg No.		NQ16/01121	NQ16/01122	NQ16/01123	NQ16/01124	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.1	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.05	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	72	153	109	130	NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016	11-AUG-2016	

NQ16/01122
Sample diluted prior to analysis due to matrix interferences.
PAH LORs raised.
Surrogate recovery outside acceptance criteria (50 to 150%).

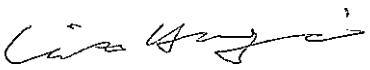
Suggests matrix interference.



Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ16/01121	NQ16/01122	NQ16/01123	NQ16/01124	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	40	77	3.7	34	NT2_46
Arsenic	mg/kg	0.15	0.25	0.18	0.22	NT2_46
Cadmium	mg/kg	<0.01	0.5	<0.01	0.4	NT2_46
Copper	mg/kg	34	190	43	160	NT2_46
Lead	mg/kg	0.03	0.09	0.02	0.06	NT2_46
Manganese	mg/kg	28	31	6.2	13	NT2_46
Mercury	mg/kg	<0.01	<0.01	<0.01	0.02	NT2_46
Nickel	mg/kg	0.14	0.26	0.08	0.13	NT2_46
Selenium	mg/kg	0.67	1	0.8	0.99	NT2_46
Silver	mg/kg	0.03	0.38	0.07	0.54	NT2_46
Zinc	mg/kg	51	180	71	89	NT2_46
Moisture Content						
Moisture	%	75.0	68.2	76.0	72.1	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Report No. RN1126737

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/160801
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-AUG-2016
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ16/01125	.	BIOTA 9 PRAWN TAIL 3 27/7/16 1130
NQ16/01126	.	BIOTA 9 PRAWN HEAD 4 27/7/16 1130
NQ16/01127	.	BIOTA 9 PRAWN TAIL 4 27/7/16 1130

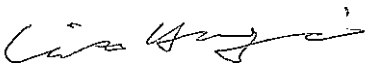
Lab Reg No.		NQ16/01125	NQ16/01126	NQ16/01127		
Sample Reference	Units	.	.	.		Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02		NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Surrogate: TER-D14	%REC	92	92	94		NGCMS_1111
Dates						
Date extracted		11-AUG-2016	11-AUG-2016	11-AUG-2016		
Date analysed		11-AUG-2016	11-AUG-2016	11-AUG-2016		

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

22-AUG-2016

REPORT OF ANALYSIS

Lab Reg No.		NQ16/01125	NQ16/01126	NQ16/01127		
Sample Reference	Units	.	.	.		Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	16	63	19		NT2_46
Arsenic	mg/kg	0.15	0.22	0.11		NT2_46
Cadmium	mg/kg	<0.01	0.24	<0.01		NT2_46
Copper	mg/kg	51	120	54		NT2_46
Lead	mg/kg	0.03	0.09	0.04		NT2_46
Manganese	mg/kg	9.6	36	17		NT2_46
Mercury	mg/kg	<0.01	0.02	0.02		NT2_46
Nickel	mg/kg	0.05	0.25	0.15		NT2_46
Selenium	mg/kg	0.7	1.1	0.82		NT2_46
Silver	mg/kg	0.11	0.13	0.03		NT2_46
Zinc	mg/kg	62	140	63		NT2_46
Moisture Content						
Moisture	%	75.4	66.2	73.6		NT2_49



Lisa Liu, Analyst
Inorganics - NSW
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22-AUG-2016

ACCREDITED FOR TECHNICAL COMPETENCE

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This report shall not be reproduced except in full.
Results relate only to the sample(s) tested.

This Report supersedes reports: *RN1126578* *RN1126713*

REPORT OF ANALYSIS

Report No. RN1148459

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00219	.	BIOTA SITE 21-1 ATROBUCCA BREVIS 18/01/2017
NQ17/00220	.	BIOTA SITE 21-2 ATROBUCCA BREVIS 18/01/2017
NQ17/00221	.	BIOTA SITE 21-3 ATROBUCCA BREVIS 18/01/2017
NQ17/00222	.	BIOTA SITE 21-4 ATROBUCCA BREVIS 18/01/2017

Lab Reg No.		NQ17/00219	NQ17/00220	NQ17/00221	NQ17/00222	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	65	70	69	65	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

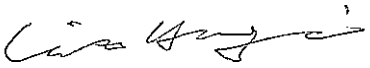
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Organic - NSW
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21-FEB-2017

REPORT OF ANALYSIS

Lab Reg No.		NQ17/00219	NQ17/00220	NQ17/00221	NQ17/00222	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	16	0.6	1.4	3.3	NT2_46
Arsenic	mg/kg	0.59	0.37	0.52	0.83	NT2_46
Cadmium	mg/kg	<0.01	<0.01	0.01	<0.01	NT2_46
Copper	mg/kg	0.8	3.5	5.7	12	NT2_46
Lead	mg/kg	0.01	0.08	0.18	0.44	NT2_46
Manganese	mg/kg	8.8	0.58	1.4	3.4	NT2_46
Mercury	mg/kg	0.05	0.11	0.06	0.08	NT2_46
Nickel	mg/kg	0.04	0.02	0.03	0.04	NT2_46
Selenium	mg/kg	0.4	0.43	0.5	0.41	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	18	10	20	24	NT2_46
Moisture Content						
Moisture	%	75.3	80.2	79.1	78.6	NT2_49

NQ17/00219
-NQ17/00250.
Results are expressed on a dry weight basis.
Moisture results were obtained from freeze-drying, please disregard the above method.



Lisa Liu, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Report No. RN1148459

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00223	.	BIOTA SITE 21-5 POLYDACTYLUS PLEBIUS 18/01/2017
NQ17/00224	.	BIOTA SITE 21-6 POLYDACTYLUS PLEBIUS 18/01/2017
NQ17/00225	.	BIOTA SITE 21-7 POLYDACTYLUS PLEBIUS 18/01/2017
NQ17/00226	.	BIOTA SITE 21-8 POLYDACTYLUS PLEBIUS 18/01/2017

Lab Reg No.		NQ17/00223	NQ17/00224	NQ17/00225	NQ17/00226	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	72	64	106	68	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

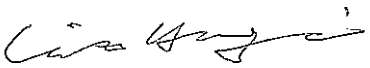
Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-FEB-2017

REPORT OF ANALYSIS

Report No. RN1148459

Lab Reg No.		NQ17/00223	NQ17/00224	NQ17/00225	NQ17/00226	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	8.3	4.8	9.1	2.4	NT2_46
Arsenic	mg/kg	0.5	0.27	0.57	0.55	NT2_46
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Copper	mg/kg	0.62	9.9	1.1	0.59	NT2_46
Lead	mg/kg	0.04	0.29	0.26	<0.01	NT2_46
Manganese	mg/kg	3.1	3.6	3.3	0.94	NT2_46
Mercury	mg/kg	0.04	0.04	0.04	0.04	NT2_46
Nickel	mg/kg	0.02	0.07	0.04	0.04	NT2_46
Selenium	mg/kg	0.35	0.35	0.42	0.39	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	10	20	12	5.2	NT2_46
Moisture Content						
Moisture	%	79.2	79.2	78.7	80.7	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

21-FEB-2017

REPORT OF ANALYSIS

Report No. RN1148459

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00227	.	BIOTA SITE 21-9 POLYDACTYLUS PLEBIUS 18/01/2017
NQ17/00228	.	BIOTA SITE 22B-1 DOIICHTHYS NOVAEGUINEAE 18/01/2017
NQ17/00229	.	BIOTA SITE 22B-2 DOIICHTHYS NOVAEGUINEAE 18/01/2017
NQ17/00230	.	BIOTA SITE 22B-3 DOIICHTHYS NOVAEGUINEAE 18/01/2017

Lab Reg No.		NQ17/00227	NQ17/00228	NQ17/00229	NQ17/00230	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	62	69	83	77	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	20-FEB-2017	14-FEB-2017	

REPORT OF ANALYSIS

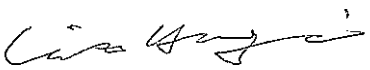
Lab Reg No.		NQ17/00227	NQ17/00228	NQ17/00229	NQ17/00230	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-FEB-2017

Lab Reg No.		NQ17/00227	NQ17/00228	NQ17/00229	NQ17/00230	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	3.9	7.8	34	19	NT2_46
Arsenic	mg/kg	0.57	0.7	1	0.82	NT2_46
Cadmium	mg/kg	<0.01	0.03	0.07	0.11	NT2_46
Copper	mg/kg	0.58	6.7	33	81	NT2_46
Lead	mg/kg	0.02	0.26	1.2	2.7	NT2_46
Manganese	mg/kg	1.9	1.1	5.1	3.3	NT2_46
Mercury	mg/kg	0.05	0.11	0.11	0.08	NT2_46
Nickel	mg/kg	0.08	0.03	0.13	0.14	NT2_46
Selenium	mg/kg	0.38	0.5	0.53	1	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	8.3	100	180	310	NT2_46
Moisture Content						
Moisture	%	79.6	82.7	80.0	81.0	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

21-FEB-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00231	.	BIOTA SITE 22B-4 DOIICHTHYS NOVAEGUINEAE 18/01/2017
NQ17/00232	.	BIOTA SITE 22B-5 DOIICHTHYS NOVAEGUINEAE 18/01/2017
NQ17/00233	.	BIOTA SITE 22B-6 KURTAS GOLLIVEVI 18/01/2017
NQ17/00234	.	BIOTA SITE 22B-7 KURTAS GOLLIVEVI 18/01/2017

Lab Reg No.		NQ17/00231	NQ17/00232	NQ17/00233	NQ17/00234	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	84	60	56	66	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

REPORT OF ANALYSIS

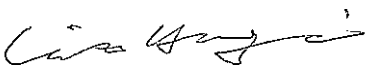
Lab Reg No.		NQ17/00231	NQ17/00232	NQ17/00233	NQ17/00234	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-FEB-2017

Lab Reg No.		NQ17/00231	NQ17/00232	NQ17/00233	NQ17/00234	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	6.3	15	5.3	3.5	NT2_46
Arsenic	mg/kg	0.66	0.78	0.68	0.74	NT2_46
Cadmium	mg/kg	0.03	0.07	0.01	<0.01	NT2_46
Copper	mg/kg	0.9	3.2	0.54	0.68	NT2_46
Lead	mg/kg	0.05	0.1	0.02	0.02	NT2_46
Manganese	mg/kg	3.9	1.6	0.98	2.1	NT2_46
Mercury	mg/kg	0.11	0.07	0.03	0.02	NT2_46
Nickel	mg/kg	0.02	0.04	0.02	0.01	NT2_46
Selenium	mg/kg	0.53	0.55	0.29	0.34	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	94	130	11	12	NT2_46
Moisture Content						
Moisture	%	77.2	83.5	82.5	82.3	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

21-FEB-2017

REPORT OF ANALYSIS

Report No. RN1148459

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00235	.	BIOTA SITE 22B-8 KURTAS GOLLIVEVI 18/01/2017
NQ17/00236	.	BIOTA SITE 22B-9 KURTAS GOLLIVEVI 18/01/2017
NQ17/00237	.	BIOTA SITE 22B-10 KURTAS GOLLIVEVI 18/01/2017
NQ17/00238	.	BIOTA 18 - SPL- R1 TAIL M. ROSENBERGII 19/01/2017 1430

Lab Reg No.		NQ17/00235	NQ17/00236	NQ17/00237	NQ17/00238	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	75	69	63	58	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

REPORT OF ANALYSIS

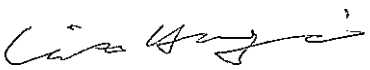
Lab Reg No.		NQ17/00235	NQ17/00236	NQ17/00237	NQ17/00238	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ17/00235	NQ17/00236	NQ17/00237	NQ17/00238	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	1.8	2.5	16	6.3	NT2_46
Arsenic	mg/kg	0.45	0.51	0.91	0.21	NT2_46
Cadmium	mg/kg	<0.01	<0.01	0.02	<0.01	NT2_46
Copper	mg/kg	0.49	0.23	0.44	13	NT2_46
Lead	mg/kg	0.01	0.01	0.02	<0.01	NT2_46
Manganese	mg/kg	5.1	1.8	2.4	4.6	NT2_46
Mercury	mg/kg	0.03	0.02	0.04	<0.01	NT2_46
Nickel	mg/kg	0.01	0.06	0.03	0.02	NT2_46
Selenium	mg/kg	0.25	0.29	0.31	0.2	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	17	11	12	14	NT2_46
Moisture Content						
Moisture	%	78.7	81.4	82.5	77.9	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

21-FEB-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00239	.	BIOTA 18 - SPL- R1 HEAD M. ROSENBERGII 19/01/2017 1430
NQ17/00240	.	BIOTA 18 - SPL- R2 TAIL M. ROSENBERGII 19/01/2017 1430
NQ17/00241	.	BIOTA 18 - SPL- R2 HEAD M. ROSENBERGII 19/01/2017 1430
NQ17/00242	.	BIOTA 18 - SPL- R3 TAIL M. ROSENBERGII 19/01/2017 1430

Lab Reg No.		NQ17/00239	NQ17/00240	NQ17/00241	NQ17/00242	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	0.012	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	67	50	88	86	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

REPORT OF ANALYSIS

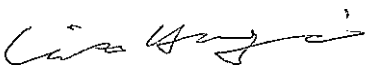
Lab Reg No.		NQ17/00239	NQ17/00240	NQ17/00241	NQ17/00242	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ17/00239	NQ17/00240	NQ17/00241	NQ17/00242	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	260	6.2	3.2	2.5	NT2_46
Arsenic	mg/kg	0.43	0.19	0.15	0.19	NT2_46
Cadmium	mg/kg	0.42	<0.01	0.18	<0.01	NT2_46
Copper	mg/kg	160	32	32	18	NT2_46
Lead	mg/kg	0.08	0.01	<0.01	<0.01	NT2_46
Manganese	mg/kg	24	7.5	6.4	3.9	NT2_46
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.33	0.03	0.02	0.02	NT2_46
Selenium	mg/kg	0.41	0.29	0.27	0.23	NT2_46
Silver	mg/kg	0.13	0.08	0.04	<0.02	NT2_46
Zinc	mg/kg	130	21	18	16	NT2_46
Moisture Content						
Moisture	%	71.5	72.8	73.0	76.1	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00243	.	BIOTA 18 - SPL- R3 HEAD M. ROSENBERGII 19/01/2017 1430
NQ17/00244	.	BIOTA 18 - SPL- R4 TAIL M. ROSENBERGII 19/01/2017 1430
NQ17/00245	.	BIOTA 18 - SPL- R4 HEAD M. ROSENBERGII 19/01/2017 1430
NQ17/00246	.	BIOTA SITE 18-1 LIZA SUBVIRIDIS 19/01/2017 1430

Lab Reg No.		NQ17/00243	NQ17/00244	NQ17/00245	NQ17/00246	
Sample Reference	Units	.	.	.	.	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	82	80	135	76	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

REPORT OF ANALYSIS

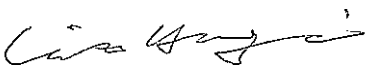
Lab Reg No.		NQ17/00243	NQ17/00244	NQ17/00245	NQ17/00246	
Sample Reference	Units	.	.	.	.	Method



Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ17/00243	NQ17/00244	NQ17/00245	NQ17/00246	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	2.9	2.9	60	7.3	NT2_46
Arsenic	mg/kg	0.22	0.21	0.25	0.45	NT2_46
Cadmium	mg/kg	0.47	<0.01	0.36	<0.01	NT2_46
Copper	mg/kg	110	15	96	0.91	NT2_46
Lead	mg/kg	<0.01	<0.01	0.02	0.02	NT2_46
Manganese	mg/kg	5.5	3.7	8.1	2.6	NT2_46
Mercury	mg/kg	0.01	0.01	0.02	0.03	NT2_46
Nickel	mg/kg	0.06	0.01	0.09	0.03	NT2_46
Selenium	mg/kg	0.31	0.2	0.29	0.24	NT2_46
Silver	mg/kg	0.11	<0.02	0.16	<0.02	NT2_46
Zinc	mg/kg	20	14	23	8.4	NT2_46
Moisture Content						
Moisture	%	77.0	78.7	80.0	76.0	NT2_49



Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170102
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 1-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00247	.	BIOTA SITE 18-2 LIZA SUBVIRIDIS 19/01/2017 1430
NQ17/00248	.	BIOTA SITE 18-3 LIZA SUBVIRIDIS 19/01/2017 1430
NQ17/00249	.	BIOTA SITE 18-4 LIZA SUBVIRIDIS 19/01/2017 1430
NQ17/00250	.	BIOTA SITE 18-5 LIZA SUBVIRIDIS 19/01/2017 1430

Lab Reg No.		NQ17/00247	NQ17/00248	NQ17/00249	NQ17/00250	
Sample Reference	**Units**	.	.	.	.	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	0.06	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	0.07	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	0.08	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	64	55	54	55	NGCMS_1111
Dates						
Date extracted		13-FEB-2017	13-FEB-2017	13-FEB-2017	13-FEB-2017	
Date analysed		14-FEB-2017	14-FEB-2017	14-FEB-2017	14-FEB-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Lab Reg No.		NQ17/00247	NQ17/00248	NQ17/00249	NQ17/00250	
Sample Reference	Units	.	.	.	.	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	1.2	430	5.6	<0.5	NT2_46
Arsenic	mg/kg	0.59	1.2	0.8	0.96	NT2_46
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Copper	mg/kg	0.98	1.6	0.57	0.73	NT2_46
Lead	mg/kg	0.03	0.2	0.01	0.01	NT2_46
Manganese	mg/kg	2.8	15	2.4	3.1	NT2_46
Mercury	mg/kg	0.03	0.02	0.04	0.03	NT2_46
Nickel	mg/kg	0.03	0.6	0.02	0.05	NT2_46
Selenium	mg/kg	0.22	0.28	0.16	0.22	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	12	15	13	8.7	NT2_46
Moisture Content						
Moisture	%	74.8	75.4	75.4	76.7	NT2_49

Lisa Liu, Analyst
Inorganics - NSW
Accreditation No. 198

21-FEB-2017

ACCREDITED FOR TECHNICAL COMPETENCE

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This Report supersedes reports: *RN1147606* *RN1148377*

REPORT OF ANALYSIS

105 Delhi Road, North Ryde NSW 2113 Tel: +61 2 9449 0111 Fax: +61 2 9449 1653 www.measurement.gov.au

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00296	14-1	BIOTA 14/02/2017 N.DAYI
NQ17/00297	14-2	BIOTA 14/02/2017 N.DAYI
NQ17/00298	14-3	BIOTA 14/02/2017 N.DAYI
NQ17/00299	14-4	BIOTA 14/02/2017 N.DAYI

Lab Reg No.		NQ17/00296	NQ17/00297	NQ17/00298	NQ17/00299	
Sample Reference	Units	14-1	14-2	14-3	14-4	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	108	129	98	118	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2001	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

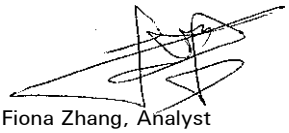
Report No. RN1151989

Lab Reg No.		NQ17/00296	NQ17/00297	NQ17/00298	NQ17/00299	
Sample Reference	Units	14-1	14-2	14-3	14-4	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	80	85	270	220	NT2_46
Arsenic	mg/kg	0.18	0.38	0.29	0.68	NT2_46
Cadmium	mg/kg	0.02	0.03	0.03	0.04	NT2_46
Copper	mg/kg	1.8	2.3	3.5	2.5	NT2_46
Lead	mg/kg	0.16	0.10	0.15	0.15	NT2_46
Manganese	mg/kg	13	7.8	22	20	NT2_46
Mercury	mg/kg	0.42	0.63	0.42	0.44	NT2_46
Nickel	mg/kg	0.18	0.2	0.92	0.38	NT2_46
Selenium	mg/kg	0.89	1	1.0	1.1	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	75	150	240	200	NT2_46
Moisture Content						
Moisture	%	81.1	81.3	81.8	79.8	NT2_49

NQ17/00296

-NQ17/00374

Results are expressed on a dry weight basis. Moisture results were obtained from freeze-drying, please disregard the above method.



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00300	14-5	BIOTA 14/02/2017 N.DAYI
NQ17/00301	14-6	BIOTA 14/02/2017 T.SCRATCHLEYI
NQ17/00302	14-7	BIOTA 14/02/2017 T.SCRATCHLEYI
NQ17/00303	14-8	BIOTA 14/02/2017 T.SCRATCHLEYI

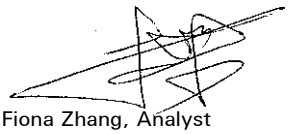
Lab Reg No.		NQ17/00300	NQ17/00301	NQ17/00302	NQ17/00303	
Sample Reference	**Units**	**14-5**	**14-6**	**14-7**	**14-8**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	150	142	82	81	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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Lab Reg No.		NQ17/00300	NQ17/00301	NQ17/00302	NQ17/00303	
Sample Reference	Units	14-5	14-6	14-7	14-8	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	10	16	8.9	16	NT2_46
Arsenic	mg/kg	0.27	0.56	0.98	0.45	NT2_46
Cadmium	mg/kg	<0.01	0.06	0.01	0.02	NT2_46
Copper	mg/kg	2.1	10	1.6	2.2	NT2_46
Lead	mg/kg	0.03	0.07	0.26	0.07	NT2_46
Manganese	mg/kg	2.3	8.2	7.7	12	NT2_46
Mercury	mg/kg	0.51	0.42	0.23	0.37	NT2_46
Nickel	mg/kg	0.59	0.15	0.11	0.11	NT2_46
Selenium	mg/kg	0.76	1.2	1	1.3	NT2_46
Silver	mg/kg	<0.02	0.03	<0.02	<0.02	NT2_46
Zinc	mg/kg	48	49	37	45	NT2_46
Moisture Content						
Moisture	%	83.4	76.4	76.7	77.6	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00304	14-9	BIOTA 14/02/2017 T.SCRATCHLEYI
NQ17/00305	14-10	BIOTA 14/02/2017 T.SCRATCHLEYI
NQ17/00306	14-11	BIOTA 14/02/2017 Z.NOVAEGUINEAE
NQ17/00307	14-12	BIOTA 14/02/2017 Z.NOVAEGUINEAE

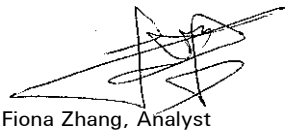
Lab Reg No.		NQ17/00304	NQ17/00305	NQ17/00306	NQ17/00307	
Sample Reference	Units	14-9	14-10	14-11	14-12	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	80	92	102	91	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ17/00304	NQ17/00305	NQ17/00306	NQ17/00307	
Sample Reference	Units	14-9	14-10	14-11	14-12	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	9.6	19	5.1	6.1	NT2_46
Arsenic	mg/kg	0.61	0.73	0.10	0.06	NT2_46
Cadmium	mg/kg	0.02	0.02	<0.01	<0.01	NT2_46
Copper	mg/kg	2.4	1.6	1.7	1.4	NT2_46
Lead	mg/kg	0.34	0.09	0.19	1.1	NT2_46
Manganese	mg/kg	17	11	5.9	5.6	NT2_46
Mercury	mg/kg	0.32	0.41	0.24	0.26	NT2_46
Nickel	mg/kg	0.1	0.1	0.07	0.07	NT2_46
Selenium	mg/kg	0.98	1.6	0.98	0.84	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	60	47	110	110	NT2_46
Moisture Content						
Moisture	%	74.0	75.9	75.2	74.5	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00308	14-13	BIOTA 14/02/2017 Z.NOVAEGUINEAE
NQ17/00309	14-14	BIOTA 14/02/2017 Z.NOVAEGUINEAE
NQ17/00310	14-15	BIOTA 14/02/2017 Z.NOVAEGUINEAE
NQ17/00311	14-16	BIOTA 14/02/2017 V.BUCHANANI

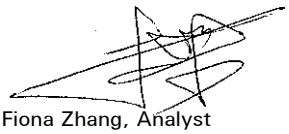
Lab Reg No.		NQ17/00308	NQ17/00309	NQ17/00310	NQ17/00311	
Sample Reference	**Units**	**14-13**	**14-14**	**14-15**	**14-16**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	69	50	101	72	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
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Lab Reg No.		NQ17/00308	NQ17/00309	NQ17/00310	NQ17/00311	
Sample Reference	Units	14-13	14-14	14-15	14-16	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	5.7	11	29	4350	NT2_46
Arsenic	mg/kg	<0.05	0.09	0.11	1.9	NT2_46
Cadmium	mg/kg	0.01	0.01	0.03	0.03	NT2_46
Copper	mg/kg	1.7	2.1	3.1	8.4	NT2_46
Lead	mg/kg	0.17	0.14	0.26	1.8	NT2_46
Manganese	mg/kg	4.1	3.8	10	130	NT2_46
Mercury	mg/kg	0.22	0.21	0.26	0.15	NT2_46
Nickel	mg/kg	0.07	0.10	0.33	6.3	NT2_46
Selenium	mg/kg	0.9	1.2	1.2	1	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	98	160	140	47	NT2_46
Moisture Content						
Moisture	%	73.8	75.0	75.7	73.8	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00312	14-17	BIOTA 14/02/2017 V.BUCHANANI
NQ17/00313	14-18	BIOTA 14/02/2017 V.BUCHANANI
NQ17/00314	14-19	BIOTA 14/02/2017 V.BUCHANANI
NQ17/00315	14-20	BIOTA 14/02/2017 V.BUCHANANI

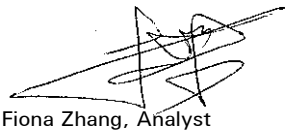
Lab Reg No.		NQ17/00312	NQ17/00313	NQ17/00314	NQ17/00315	
Sample Reference	Units	14-17	14-18	14-19	14-20	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	57	56	64	144	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
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Lab Reg No.		NQ17/00312	NQ17/00313	NQ17/00314	NQ17/00315	
Sample Reference	Units	14-17	14-18	14-19	14-20	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	1020	34	1440	440	NT2_46
Arsenic	mg/kg	1.4	1	3.1	2.5	NT2_46
Cadmium	mg/kg	0.01	<0.01	0.02	0.02	NT2_46
Copper	mg/kg	3.5	2.2	4	4	NT2_46
Lead	mg/kg	0.74	0.13	0.74	0.42	NT2_46
Manganese	mg/kg	36	9.7	54	60	NT2_46
Mercury	mg/kg	0.18	0.14	0.11	0.09	NT2_46
Nickel	mg/kg	1.6	0.18	2	0.63	NT2_46
Selenium	mg/kg	1	1	1.1	1.2	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	40	38	43	52	NT2_46
Moisture Content						
Moisture	%	75.2	74.7	70.5	69.6	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00316	3B-1 HEAD	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00317	3B-1 TAIL	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00318	3B-2 HEAD	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00319	3B-2 TAIL	BIOTA 15/02/2017 MACROBRACHIUM SP

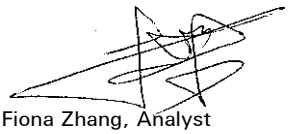
Lab Reg No.		NQ17/00316	NQ17/00317	NQ17/00318	NQ17/00319	
Sample Reference	Units	3B-1 HEAD	3B-1 TAIL	3B-2 HEAD	3B-2 TAIL	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	56	101	78	99	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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Lab Reg No.		NQ17/00316	NQ17/00317	NQ17/00318	NQ17/00319	
Sample Reference	Units	3B-1 HEAD	3B-1 TAIL	3B-2 HEAD	3B-2 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	73	37	220	71	NT2_46
Arsenic	mg/kg	0.39	0.31	0.28	0.18	NT2_46
Cadmium	mg/kg	1.1	<0.01	0.35	<0.01	NT2_46
Copper	mg/kg	230	34	120	56	NT2_46
Lead	mg/kg	0.15	0.12	0.24	0.28	NT2_46
Manganese	mg/kg	40	23	70	52	NT2_46
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.39	0.2	0.57	0.36	NT2_46
Selenium	mg/kg	1.1	0.63	0.74	0.84	NT2_46
Silver	mg/kg	0.5	0.05	0.19	0.08	NT2_46
Zinc	mg/kg	290	58	49	58	NT2_46
Moisture Content						
Moisture	%	72.8	75.9	67.7	77.2	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00320	3B-3 HEAD	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00321	3B-3 TAIL	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00322	3B-4 HEAD	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00323	3B-4 TAIL	BIOTA 15/02/2017 MACROBRACHIUM SP

Lab Reg No.		NQ17/00320	NQ17/00321	NQ17/00322	NQ17/00323	
Sample Reference	**Units**	**3B-3 HEAD**	**3B-3 TAIL**	**3B-4 HEAD**	**3B-4 TAIL**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	88	96	77	97	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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Lab Reg No.		NQ17/00320	NQ17/00321	NQ17/00322	NQ17/00323	
Sample Reference	Units	3B-3 HEAD	3B-3 TAIL	3B-4 HEAD	3B-4 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	160	45	63	110	NT2_46
Arsenic	mg/kg	0.25	0.14	0.22	0.24	NT2_46
Cadmium	mg/kg	0.53	<0.01	0.82	<0.01	NT2_46
Copper	mg/kg	160	44	120	97	NT2_46
Lead	mg/kg	0.25	0.16	0.22	0.34	NT2_46
Manganese	mg/kg	130	47	43	51	NT2_46
Mercury	mg/kg	0.02	0.02	0.01	<0.01	NT2_46
Nickel	mg/kg	0.61	0.33	0.51	0.54	NT2_46
Selenium	mg/kg	0.98	0.62	0.86	0.72	NT2_46
Silver	mg/kg	0.14	0.03	0.14	0.12	NT2_46
Zinc	mg/kg	290	59	70	70	NT2_46
Moisture Content						
Moisture	%	64.5	74.0	65.8	75.4	NT2_49

Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00324	3B-5 HEAD	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00325	3B-5 TAIL	BIOTA 15/02/2017 MACROBRACHIUM SP
NQ17/00326	6-1 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00327	6-1 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP

Lab Reg No.		NQ17/00324	NQ17/00325	NQ17/00326	NQ17/00327	
Sample Reference	**Units**	**3B-5 HEAD**	**3B-5 TAIL**	**6-1 HEAD**	**6-1 TAIL**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	69	104	103	98	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
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Lab Reg No.		NQ17/00324	NQ17/00325	NQ17/00326	NQ17/00327	
Sample Reference	Units	3B-5 HEAD	3B-5 TAIL	6-1 HEAD	6-1 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	290	55	460	130	NT2_46
Arsenic	mg/kg	0.32	0.16	0.89	0.37	NT2_46
Cadmium	mg/kg	0.21	<0.01	1.2	0.02	NT2_46
Copper	mg/kg	110	48	240	41	NT2_46
Lead	mg/kg	0.24	0.15	0.2	0.07	NT2_46
Manganese	mg/kg	76	24	320	310	NT2_46
Mercury	mg/kg	<0.01	<0.01	0.03	0.02	NT2_46
Nickel	mg/kg	0.86	0.29	1	0.77	NT2_46
Selenium	mg/kg	0.78	0.87	1.6	0.91	NT2_46
Silver	mg/kg	0.16	0.04	0.47	0.04	NT2_46
Zinc	mg/kg	150	55	160	59	NT2_46
Moisture Content						
Moisture	%	70.0	77.6	66.1	74.9	NT2_49

Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00328	6-2 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00329	6-2 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00330	6-3 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00331	6-3 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP

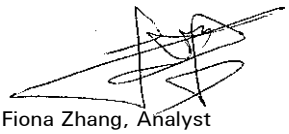
Lab Reg No.		NQ17/00328	NQ17/00329	NQ17/00330	NQ17/00331	
Sample Reference	**Units**	**6-2 HEAD**	**6-2 TAIL**	**6-3 HEAD**	**6-3 TAIL**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	80	95	92	99	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
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Lab Reg No.		NQ17/00328	NQ17/00329	NQ17/00330	NQ17/00331	
Sample Reference	Units	6-2 HEAD	6-2 TAIL	6-3 HEAD	6-3 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	340	81	200	20	NT2_46
Arsenic	mg/kg	0.6	0.25	0.87	0.26	NT2_46
Cadmium	mg/kg	0.32	<0.01	0.38	<0.01	NT2_46
Copper	mg/kg	160	38	150	37	NT2_46
Lead	mg/kg	0.32	0.08	0.12	0.04	NT2_46
Manganese	mg/kg	120	64	85	23	NT2_46
Mercury	mg/kg	0.05	0.02	0.02	0.01	NT2_46
Nickel	mg/kg	1.1	0.3	0.49	0.13	NT2_46
Selenium	mg/kg	1.4	0.95	0.99	1.1	NT2_46
Silver	mg/kg	0.31	0.05	0.32	0.05	NT2_46
Zinc	mg/kg	100	51	230	60	NT2_46
Moisture Content						
Moisture	%	68.6	74.4	65.2	75.7	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00332	4-1 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00333	4-1 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00334	4-2 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00335	4-2 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP

Lab Reg No.		NQ17/00332	NQ17/00333	NQ17/00334	NQ17/00335	
Sample Reference	Units	4-1 HEAD	4-1 TAIL	4-2 HEAD	4-2 TAIL	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	95	88	90	94	NGCMS_1111
Dates						
Date extracted		10-MAR-2017	10-MAR-2017	10-MAR-2017	10-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

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Lab Reg No.		NQ17/00332	NQ17/00333	NQ17/00334	NQ17/00335	
Sample Reference	Units	4-1 HEAD	4-1 TAIL	4-2 HEAD	4-2 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	49	87	140	27	NT2_46
Arsenic	mg/kg	0.92	0.44	0.87	0.48	NT2_46
Cadmium	mg/kg	1.8	<0.01	0.51	<0.01	NT2_46
Copper	mg/kg	340	56	230	39	NT2_46
Lead	mg/kg	0.26	0.2	0.58	0.14	NT2_46
Manganese	mg/kg	41	25	33	13	NT2_46
Mercury	mg/kg	0.02	<0.01	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.37	0.33	0.47	0.17	NT2_46
Selenium	mg/kg	1.3	0.9	0.9	0.97	NT2_46
Silver	mg/kg	0.88	0.04	0.44	0.03	NT2_46
Zinc	mg/kg	87	58	140	56	NT2_46
Moisture Content						
Moisture	%	77.7	79.4	73.8	79.5	NT2_49

Fiona Zhang, Analyst
Inorganics - NSW
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REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00336	4-3 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00337	4-3 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00338	4-4 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00339	4-4 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP

Lab Reg No.		NQ17/00336	NQ17/00337	NQ17/00338	NQ17/00339	
Sample Reference	Units	4-3 HEAD	4-3 TAIL	4-4 HEAD	4-4 TAIL	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	52	99	127	104	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
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Lab Reg No.		NQ17/00336	NQ17/00337	NQ17/00338	NQ17/00339	
Sample Reference	Units	4-3 HEAD	4-3 TAIL	4-4 HEAD	4-4 TAIL	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	130	14	120	24	NT2_46
Arsenic	mg/kg	0.93	0.56	0.79	0.38	NT2_46
Cadmium	mg/kg	0.34	<0.01	0.27	<0.01	NT2_46
Copper	mg/kg	200	48	200	51	NT2_46
Lead	mg/kg	0.14	0.10	0.81	0.21	NT2_46
Manganese	mg/kg	57	17	50	14	NT2_46
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.47	0.13	0.38	0.17	NT2_46
Selenium	mg/kg	1.1	0.95	1.2	0.84	NT2_46
Silver	mg/kg	0.34	0.02	0.35	0.04	NT2_46
Zinc	mg/kg	230	64	250	66	NT2_46
Moisture Content						
Moisture	%	65.3	74.7	72.3	78.7	NT2_49

Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00340	4-5 HEAD	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00341	4-5 TAIL	BIOTA 16/02/2017 MACROBRACHIUM SP
NQ17/00342	5-1	BIOTA 17/02/2017 M.GOLDIEI
NQ17/00343	5-2	BIOTA 17/02/2017 M.GOLDIEI

Lab Reg No.		NQ17/00340	NQ17/00341	NQ17/00342	NQ17/00343	
Sample Reference	**Units**	**4-5 HEAD**	**4-5 TAIL**	**5-1**	**5-2**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	54	91	124	130	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

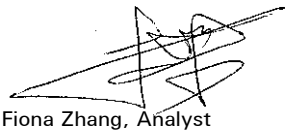


Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Lab Reg No.		NQ17/00340	NQ17/00341	NQ17/00342	NQ17/00343	
Sample Reference	Units	4-5 HEAD	4-5 TAIL	5-1	5-2	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	170	18	17	32	NT2_46
Arsenic	mg/kg	0.57	0.33	0.12	0.05	NT2_46
Cadmium	mg/kg	0.14	<0.01	0.02	0.03	NT2_46
Copper	mg/kg	150	47	3.2	5	NT2_46
Lead	mg/kg	0.81	0.21	0.04	0.04	NT2_46
Manganese	mg/kg	69	18	24	28	NT2_46
Mercury	mg/kg	<0.01	<0.01	0.52	0.17	NT2_46
Nickel	mg/kg	0.46	0.17	0.26	0.58	NT2_46
Selenium	mg/kg	0.93	0.83	1.1	0.65	NT2_46
Silver	mg/kg	0.26	0.05	<0.02	<0.02	NT2_46
Zinc	mg/kg	210	62	140	140	NT2_46
Moisture Content						
Moisture	%	66.6	78.5	73.2	76.7	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00344	5-3	BIOTA 17/02/2017 M.GOLDIEI
NQ17/00345	5-4	BIOTA 17/02/2017 M.GOLDIEI
NQ17/00346	5-5	BIOTA 17/02/2017 M.GOLDIEI
NQ17/00347	2-1 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP

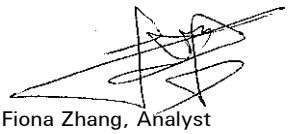
Lab Reg No.		NQ17/00344	NQ17/00345	NQ17/00346	NQ17/00347	
Sample Reference	**Units**	**5-3**	**5-4**	**5-5**	**2-1 HEAD**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	118	115	124	99	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

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REPORT OF ANALYSIS

Lab Reg No.		NQ17/00344	NQ17/00345	NQ17/00346	NQ17/00347	
Sample Reference	Units	5-3	5-4	5-5	2-1 HEAD	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	15	14	62	290	NT2_46
Arsenic	mg/kg	<0.05	<0.05	0.11	0.23	NT2_46
Cadmium	mg/kg	0.01	<0.01	0.02	0.72	NT2_46
Copper	mg/kg	2.2	2.5	3.4	100	NT2_46
Lead	mg/kg	0.02	0.02	0.04	0.13	NT2_46
Manganese	mg/kg	6.9	8.7	27	450	NT2_46
Mercury	mg/kg	0.18	0.22	0.11	0.01	NT2_46
Nickel	mg/kg	0.29	0.26	0.4	2	NT2_46
Selenium	mg/kg	0.72	0.64	1	0.43	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	0.24	NT2_46
Zinc	mg/kg	130	160	130	90	NT2_46
Moisture Content						
Moisture	%	75.8	73.5	73.7	65.7	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00348	2-1 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00349	2-2 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00350	2-2 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00351	2-3 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP

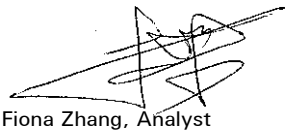
Lab Reg No.		NQ17/00348	NQ17/00349	NQ17/00350	NQ17/00351	
Sample Reference	Units	2-1 TAIL	2-2 HEAD	2-2 TAIL	2-3 HEAD	Method
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	93	50	98	85	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
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REPORT OF ANALYSIS

Lab Reg No.		NQ17/00348	NQ17/00349	NQ17/00350	NQ17/00351	
Sample Reference	Units	2-1 TAIL	2-2 HEAD	2-2 TAIL	2-3 HEAD	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	81	200	67	33	NT2_46
Arsenic	mg/kg	0.2	0.28	0.21	0.14	NT2_46
Cadmium	mg/kg	<0.01	2	<0.01	0.91	NT2_46
Copper	mg/kg	34	110	92	110	NT2_46
Lead	mg/kg	0.04	0.09	0.07	0.03	NT2_46
Manganese	mg/kg	180	340	60	10	NT2_46
Mercury	mg/kg	0.03	0.01	0.02	<0.01	NT2_46
Nickel	mg/kg	0.81	1.5	0.47	0.19	NT2_46
Selenium	mg/kg	0.58	0.79	0.6	1.1	NT2_46
Silver	mg/kg	0.05	0.06	0.11	0.18	NT2_46
Zinc	mg/kg	58	270	73	190	NT2_46
Moisture Content						
Moisture	%	79.4	67.5	77.4	64.8	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00352	2-3 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00353	2-4 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00354	2-4 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00355	2-5 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP

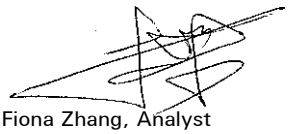
Lab Reg No.		NQ17/00352	NQ17/00353	NQ17/00354	NQ17/00355	
Sample Reference	**Units**	**2-3 TAIL**	**2-4 HEAD**	**2-4 TAIL**	**2-5 HEAD**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	94	84	88	99	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
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REPORT OF ANALYSIS

Lab Reg No.		NQ17/00352	NQ17/00353	NQ17/00354	NQ17/00355	
Sample Reference	Units	2-3 TAIL	2-4 HEAD	2-4 TAIL	2-5 HEAD	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	24	89	31	360	NT2_46
Arsenic	mg/kg	0.11	0.21	0.12	0.26	NT2_46
Cadmium	mg/kg	0.01	1.3	<0.01	1.2	NT2_46
Copper	mg/kg	47	290	35	110	NT2_46
Lead	mg/kg	0.04	0.06	0.03	0.13	NT2_46
Manganese	mg/kg	6.3	150	54	150	NT2_46
Mercury	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Nickel	mg/kg	0.11	0.61	0.31	1.2	NT2_46
Selenium	mg/kg	0.66	1.1	0.52	1	NT2_46
Silver	mg/kg	<0.02	0.59	0.03	0.09	NT2_46
Zinc	mg/kg	69	69	49	72	NT2_46
Moisture Content						
Moisture	%	80.2	65.6	76.0	64.9	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00356	2-5 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00357	10-1 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00358	10-1 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00359	10-2 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP

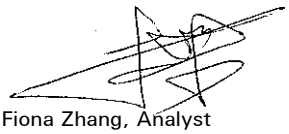
Lab Reg No.		NQ17/00356	NQ17/00357	NQ17/00358	NQ17/00359	
Sample Reference	**Units**	**2-5 TAIL**	**10-1 HEAD**	**10-1 TAIL**	**10-2 HEAD**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	99	120	100	89	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

Danny Slee, Section Manager
Organic - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Lab Reg No.		NQ17/00356	NQ17/00357	NQ17/00358	NQ17/00359	
Sample Reference	Units	2-5 TAIL	10-1 HEAD	10-1 TAIL	10-2 HEAD	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	48	160	28	140	NT2_46
Arsenic	mg/kg	0.13	0.53	0.46	0.33	NT2_46
Cadmium	mg/kg	<0.01	1.2	<0.01	0.73	NT2_46
Copper	mg/kg	53	230	89	120	NT2_46
Lead	mg/kg	0.03	0.08	0.04	0.16	NT2_46
Manganese	mg/kg	32	37	13	64	NT2_46
Mercury	mg/kg	0.03	0.03	0.02	0.02	NT2_46
Nickel	mg/kg	0.32	0.78	0.27	0.67	NT2_46
Selenium	mg/kg	0.58	1.5	0.72	1	NT2_46
Silver	mg/kg	0.07	0.33	0.22	0.13	NT2_46
Zinc	mg/kg	58	280	58	310	NT2_46
Moisture Content						
Moisture	%	76.1	72.8	75.0	65.7	NT2_49



Fiona Zhang, Analyst
Inorganics - NSW
Accreditation No. 198

21-MAR-2017

REPORT OF ANALYSIS

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00360	10-2 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00361	10-3 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00362	10-3 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00363	10-4 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP

Lab Reg No.		NQ17/00360	NQ17/00361	NQ17/00362	NQ17/00363	
Sample Reference	**Units**	**10-2 TAIL**	**10-3 HEAD**	**10-3 TAIL**	**10-4 HEAD**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	99	108	92	144	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	



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Lab Reg No.		NQ17/00360	NQ17/00361	NQ17/00362	NQ17/00363	
Sample Reference	Units	10-2 TAIL	10-3 HEAD	10-3 TAIL	10-4 HEAD	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	31	270	59	87	NT2_46
Arsenic	mg/kg	0.16	0.31	0.14	0.45	NT2_46
Cadmium	mg/kg	<0.01	1.6	<0.01	1.3	NT2_46
Copper	mg/kg	45	220	37	230	NT2_46
Lead	mg/kg	0.06	0.09	0.08	0.10	NT2_46
Manganese	mg/kg	42	360	180	63	NT2_46
Mercury	mg/kg	0.02	0.03	0.04	<0.01	NT2_46
Nickel	mg/kg	0.36	3.8	1.9	0.55	NT2_46
Selenium	mg/kg	0.58	1.1	0.53	0.96	NT2_46
Silver	mg/kg	0.03	0.86	0.05	0.51	NT2_46
Zinc	mg/kg	61	620	54	220	NT2_46
Moisture Content						
Moisture	%	73.9	74.2	78.0	70.3	NT2_49

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Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00364	10-4 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00365	10-5 HEAD	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00366	10-5 TAIL	BIOTA 18/02/2017 MACROBRACHIUM SP
NQ17/00367	12-1	BIOTA 19/02/2017 T.SCRATCHLEYI

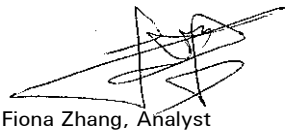
Lab Reg No.		NQ17/00364	NQ17/00365	NQ17/00366	NQ17/00367	
Sample Reference	**Units**	**10-4 TAIL**	**10-5 HEAD**	**10-5 TAIL**	**12-1**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	94	105	95	98	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

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Lab Reg No.		NQ17/00364	NQ17/00365	NQ17/00366	NQ17/00367	
Sample Reference	Units	10-4 TAIL	10-5 HEAD	10-5 TAIL	12-1	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	19	65	27	4.1	NT2_46
Arsenic	mg/kg	0.27	0.46	0.32	1.2	NT2_46
Cadmium	mg/kg	<0.01	0.29	<0.01	<0.01	NT2_46
Copper	mg/kg	45	140	68	2.1	NT2_46
Lead	mg/kg	0.04	0.08	0.1	0.02	NT2_46
Manganese	mg/kg	25	61	17	4.8	NT2_46
Mercury	mg/kg	<0.01	0.02	0.02	0.33	NT2_46
Nickel	mg/kg	0.28	0.6	0.28	0.08	NT2_46
Selenium	mg/kg	0.68	0.91	0.67	1.2	NT2_46
Silver	mg/kg	0.03	0.21	0.12	<0.02	NT2_46
Zinc	mg/kg	65	190	60	33	NT2_46
Moisture Content						
Moisture	%	76.8	70.5	79.2	80.1	NT2_49



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Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00368	12-2	BIOTA 19/02/2017 T.SCRATCHLEYI
NQ17/00369	12-3	BIOTA 19/02/2017 T.SCRATCHLEYI
NQ17/00370	12-4	BIOTA 19/02/2017 T.SCRATCHLEYI
NQ17/00371	12-5	BIOTA 19/02/2017 T.SCRATCHLEYI

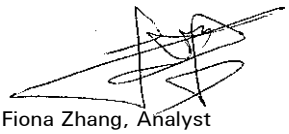
Lab Reg No.		NQ17/00368	NQ17/00369	NQ17/00370	NQ17/00371	
Sample Reference	**Units**	**12-2**	**12-3**	**12-4**	**12-5**	**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02	<0.02	NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01	<0.01	NGCMS_1111
Surrogate: TER-D14	%REC	104	93	103	101	NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017	15-MAR-2017	
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017	16-MAR-2017	

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Lab Reg No.		NQ17/00368	NQ17/00369	NQ17/00370	NQ17/00371	
Sample Reference	Units	12-2	12-3	12-4	12-5	Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	3.6	2.9	1.9	2.7	NT2_46
Arsenic	mg/kg	0.78	0.94	0.36	0.51	NT2_46
Cadmium	mg/kg	<0.01	<0.01	<0.01	<0.01	NT2_46
Copper	mg/kg	1.9	1.6	1.9	1.5	NT2_46
Lead	mg/kg	0.01	0.02	0.03	0.02	NT2_46
Manganese	mg/kg	3.3	4.7	16	5.8	NT2_46
Mercury	mg/kg	0.52	0.24	1.8	0.45	NT2_46
Nickel	mg/kg	0.09	0.08	0.11	0.07	NT2_46
Selenium	mg/kg	1.3	1.1	0.79	0.94	NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02	<0.02	NT2_46
Zinc	mg/kg	32	31	47	37	NT2_46
Moisture Content						
Moisture	%	79.7	78.2	78.4	78.5	NT2_49



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Report No. RN1151989

Client	: BMT WBM PTY LTD	**Job No.**	: BMTW01/170228/1
	PO BOX 203	**Quote No.**	: QT-02027
	SPRING HILL QLD 4004	**Order No.**	:
		Date Sampled	:
		Date Received	: 28-FEB-2017
Attention	: JEREMY VISSER	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: RICHARD COGHLAN	**Phone**	: (02) 94490161

Lab Reg No.	Sample Ref	Sample Description
NQ17/00372	12-6	BIOTA 19/02/2017 S.LEPTASPIS
NQ17/00373	12-7	BIOTA 19/02/2017 S.LEPTASPIS
NQ17/00374	12-8	BIOTA 19/02/2017 S.LEPTASPIS

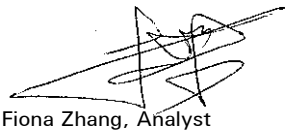
Lab Reg No.		NQ17/00372	NQ17/00373	NQ17/00374		
Sample Reference	**Units**	**12-6**	**12-7**	**12-8**		**Method**
Polycyclic Aromatic Hydrocarbons						
Naphthalene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Acenaphthylene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Acenaphthene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Fluorene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Phenanthrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Fluoranthene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benz(a)anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Chrysene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benzo(b)&(k)fluoranthene	mg/kg	<0.02	<0.02	<0.02		NGCMS_1111
Benzo(a)pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Indeno(1,2,3-cd)pyrene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Dibenzo(a,h)anthracene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Benzo(g,h,i)perylene	mg/kg	<0.01	<0.01	<0.01		NGCMS_1111
Surrogate: TER-D14	%REC	99	102	93		NGCMS_1111
Dates						
Date extracted		15-MAR-2017	15-MAR-2017	15-MAR-2017		
Date analysed		16-MAR-2017	16-MAR-2017	16-MAR-2017		

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Lab Reg No.		NQ17/00372	NQ17/00373	NQ17/00374		
Sample Reference	Units	12-6	12-7	12-8		Method
Total Recoverable Trace Elements by ICP						
Aluminium	mg/kg	2.4	13	60		NT2_46
Arsenic	mg/kg	0.75	0.38	0.7		NT2_46
Cadmium	mg/kg	<0.01	<0.01	0.02		NT2_46
Copper	mg/kg	1.4	1.9	1.8		NT2_46
Lead	mg/kg	0.02	0.02	0.26		NT2_46
Manganese	mg/kg	2	3	4.4		NT2_46
Mercury	mg/kg	0.21	0.22	0.2		NT2_46
Nickel	mg/kg	0.1	0.37	0.18		NT2_46
Selenium	mg/kg	0.47	0.64	0.83		NT2_46
Silver	mg/kg	<0.02	<0.02	<0.02		NT2_46
Zinc	mg/kg	120	160	220		NT2_46
Moisture Content						
Moisture	%	80.2	80.6	82.7		NT2_49



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21-MAR-2017

All results are expressed on a dry weight basis.

ACCREDITED FOR TECHNICAL COMPETENCE

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This report shall not be reproduced except in full.
Results relate only to the sample(s) tested.

This Report supersedes reports: *RN1151681* *RN1151976*

Appendix D Freshwater and Estuarine Fish Species

The following provides a list of the fauna families identified within the study area, excluding the Vaihua River estuary (discussed in Section 6.9). Individual species, where identified, have been listed as ***Known*** or ***Possible/Likely*** to occur. The sources used for identifying occurrence are:

Known

1) Estuarine and freshwater surveys conducted in June-July 2016 and January 2017 (estuarine) and July 2016 and February 2017 (freshwater).
2) Village interviews conducted as part of the Upstream Land and Natural Resources (Ecosystem Services – Provisioning) Baseline Report (Booyong Forest Science, 2017).
3) Surveys conducted for the Elk/Antelope Gasfields Development Project EIS (DES, 2008).
4) Various other sources (as described in main body of this report) that allow for attribution of species presence in past 10 years.

Possible/Likely

5) Catch data from Haines (1979), collected as part of surveys for the Purari River (Wabo) Hydroelectric Scheme EIS.
6) Various other sources (as described in main body of this report) that allow for assessments to be made on likely species occurrence.

For each species, information has also been provided on status with regards the following:

A. *Fauna (Protection and Control) Act 1966*, i.e. Protected or Restricted.
B. Trade-restricted status under CITES Appendices (I or II) and/or *International trade (Fauna and Flora) Act 1979* schedules (1 or 2).
C. IUCN Red List of Threatened species, i.e. Not Evaluated, Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered.
D. Endemism or restricted-range status.
E. Migratory or congregatory status.
F. Invasive species, including invasive alien and invasive native species.

NOTE: Table D-1 does not include flora or benthic macroinvertebrate families or species which are reported elsewhere.

Table D-1 List of Estuary and Freshwater Species Likely to Occur in the Study Area

Family	Accepted name	Common name	Occurrence[1]						Waters[2]	Status[3]					
			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
Anguilliforms															
Anguillidae	*Anguilla interioris*	Highlands long-finned eel					✓		Fresh	-	-	DD	×	×	-
	Anguilla reinhardti	Long-finned eel	✓						Fresh	-	-	NE	×	×	-
	Anguilla obscura	Pacific short-finned eel	✓						Fresh	-	-	DD	×	×	-
Carcharhiniformes															
Carcharhinidae	*Glyphis garricki*	New Guinea River Shark					✓		Brackish	-	-	CE	×	×	-
	Glyphis glyphis	Speartooth Shark					✓		Brackish	-	-	EN	×	×	-
	Carcharhinus leucas	Bull shark					✓		Both	-	-	NT	×	×	-
	Rhizoprionodon acutus	Milk shark		✓					Brackish	-	-	LC	×	×	-
Cetartiodactyla															
Delphinidae	*Orcaella heihsohni*	Australian snubfin dolphin						✓	Brackish	-	I	NT	×	✓	-
	Sousa sahulensis	Australian humpback dolphin						✓	Brackish	-	I	VU	×	✓	-
Cyprinodontiformes															
Aplocheilidae	*Aplocheilus panchax*	Blue panchax					✓		Fresh	-	-	LC	×	×	A
Cyprinidae	*Barbodes wynaadensis*	-								-	-	CE	×	×	A
	Tor putitora	Putitor mahseer					✓		Fresh	-	-	EN	×	×	A
Poeciliidae	*Gambusia affinis*	Western mosquitofish					✓		Fresh	-	-	LC	×	×	A
	Xiphophorus helleri	Green swordtail					✓		Fresh	-	-	NE	×	×	A
Decapoda															
Portunidae	*Scylla serrata*	Mud crab	✓						Brackish	-	-	NE	×	×	-
Palaemonidae	*Macrobrachium rosenbergii*	Giant river prawn	✓						Both	-	-	NE	×	×	-
Penaeidae	*Penaeus merguiensis*	Banana prawn				✓			Brackish	-	-	NE	×	×	-

Family	Accepted name	Common name	Occurrence[1]						Waters[2]	Status[3]					
			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
	Penaeus indicus	Indian prawn				✓			Brackish	-	-	NE	×	×	-
	Penaeus monodon	Giant tiger prawn				✓			Brackish	-	-	NE	×	×	-
	Penaeus semisulcatus	Green tiger prawn				✓			Brackish	-	-	NE	×	×	-
	Metapenaeus ensis	Greasyback prawn				✓			Brackish	-	-	NE	×	×	-
	Metapenaeus demani	-				✓			Brackish	-	-	NE	×	×	-
	Metapenaeus eboracensis	-				✓			Brackish	-	-	NE	×	×	-
Elopiformes															
Megalopidae	*Megalops cyprinoides*	Indo-Pacific tarpon					✓		Both	-	-	DD	×	×	-
Mugiliformes															
Mugilidae	*Cestraeus goldiei*	Goldie River Mullet					✓		Fresh	-	-	DD	×	×	-
	Chelon macrolepis	Largescale mullet					✓		Fresh	-	-	LC	×	×	-
	Chelon planiceps	Tade gray mullet					✓		Fresh	-	-	NE	×	×	-
	Chelon subviridis	Greenback mullet	✓				✓		Fresh	-	-	NE	×	×	-
	Ellochelon vaigiensis	Squaretail mullet			✓		✓		Fresh	-	-	LC	×	×	-
	Moolgarda engeli	Kanda					✓		Fresh	-	-	NE	×	×	-
	Moolgarda seheli	Bluespot mullet					✓		Fresh	-	-	NE	×	×	-
	Mugil cephalus	Flathead grey mullet		✓					Fresh	-	-	LC	×	×	-
	Oedalechilus labiosus	Hornlip mullet					✓		Fresh	-	-	NE	×	×	-
	Paramugil parmatus	Broad-mouthed mullet					✓		Fresh	-	-	NE	×	×	-
	Rhinomugil nasutus	Shark mullet					✓		Fresh	-	-	NE	×	×	-
	Valamugil buchanani	Bluetail mullet		✓			✓		Fresh	-	-	NE	×	×	-
Perciformes															
Ambassidae	*Ambassis agrammus*	Sailfin glass perchlet	✓						Both	-	-	NE	×	×	-

Family	Accepted name	Common name	Occurrence[1]						Waters[2]	Status[3]					
			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
	Ambassis buruensis	Buru glass perchlet					✓		Both	-	-	NE	×	×	-
	Ambassis interrupta	Long-spined glassfish					✓		Both	-	-	LC	×	×	-
	Ambassis macracanthus	Estuarine glass perchlet	✓				✓		Both	-	-	DD	×	×	-
	Ambassis nalua	Scalloped perchlet					✓		Both	-	-	LC	×	×	-
	Parambassis gulliveri	Giant glassfish	✓		✓		✓		Fresh	--	-	NE	×	×	-
	Tentracentrum apagonoides	-						✓	Both	-	-	NE	×	×	-
Anabantidae	*Anabas testudineus*	Climbing perch					✓		Fresh	-	-	DD	×	×	A
Apogonidae	*Apogon* sp.	Cardinalfish	✓						Brackish	-	-	-	-	-	-
	Apogon hyalaspma	Mangrove cardinalfish						✓	Brackish	-	-	LC	×	×	-
	Glossamia sandei	Sande's mouth almighty	✓		✓		✓		Brackish	-	-	NE	×	×	-
Ariidae	*Arius* sp.	Catfish sp.					✓		Both	-	-	-	-	-	-
	Arius latirostris	Broad-snouted catfish	✓						Both	-	-	NE	×	×	-
	Arius microcephalus	Granular-toothed catfish					✓		Both	-	-	NE	×	×	-
	Cinetodus sp.	Long ridged catfish					✓		Brackish	-	-	-	-	-	-
	Cinetodus conorhynchus	Lorentz catfish	✓						Brackish	-	-	NE	×	×	-
	Cinetodus carinatus	Lesser thick-lipped catfish			✓		✓		Brackish	-	-	NE	×	×	-
	Cinetodus crassilabris	Greater thick-lipped catfish	✓		✓		✓		Brackish	-	-	NE	×	×	-
	Cinetodus froggatti	High-nose catfish	✓				✓		Brackish	-	-	DD	×	×	-
	Cochlefelis danielsi	Daniel's catfish	✓						Brackish	-	-	NE	×	×	-
	Cochlefelis spatula	Duckbill catfish	✓				✓		Brackish	-	-	NE	×	×	-
	Hemiarius/Cochlefelis dioctes	Yellow catfish			✓		✓		Brackish	-	-	NE	×	×	-
	Hemipimelodus sp.	Flesh-lipped catfish						✓	Brackish	-	-	-	-	-	-
	Hexanematichthys mastersi	Beach catfish					✓		Brackish	-	-	NE	×	×	-

Family	Accepted name	Common name	Occurrence[1]						Waters[2]	Status[3]					
			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
	Hexanematichthys proximus	Grey catfish						✓	Brackish	-	-	NE	×	×	-
	Nedystoma dayi	Day's catfish	✓				✓		Brackish	-	-	NE	×	×	-
	Nedystoma/Doiichthyes novaeguineae	Spoon snouted catfish	✓				✓		Brackish	-	-	NE	×	×	-
	Nemapteryx armiger	Threadfin catfish	✓				✓		Brackish	-	-	NE	×	×	-
	Neoarius augustus	Short-barbel catfish	✓						Both	-	-	NE	×	×	-
	Neoarius graeffei	Ridge-backed catfish					✓		Both	-	-	NE	×	×	-
	Neoarius leptaspis	Goldspot catfish	✓				✓		Both	-	-	NE	×	×	-
	Neoarius taylori	Taylor's catfish						✓	Both	-	-	DD	×	×	-
	Potamosilurus macrorhynchus	Sharp-nosed catfish					✓		Brackish	-	-	NE	×	×	-
	Sciades leptaspis	Triangular shield catfish	✓		✓		✓		Brackish	-	-	NE	×	×	-
Atherinidae	*Craterocephalus pimatuae*	Pima hardyhead						✓	Both	-	-	DD	×	×	-
Belonidae	*Strongylura krefftii*	Freshwater longtom	✓		✓		✓		Fresh	-	-	NE	×	×	-
	Strongylura strongylura	Spottailed needlefish					✓		Fresh	-	-	NE	×	×	-
Callionymidae	*Eleutherochir opercularis*	-					✓		Brackish	-	-	NE	×	×	-
	Callionymus sagitta	Arrow-headed darter dragonet					✓		Brackish	-	-	LC	×	×	-
Carangidae	*Caranx sp*	Trevally sp.	✓						Brackish	-	-	-	-	-	-
	Caranx ignobilis	Giant trevally					✓		Brackish	-	-	LC	×	×	-
	Caranx sexfasciatus	Bigeye trevally						✓	Brackish	-	-	LC	×	×	-
	Pantolabus radiatus	Fringefin trevally		✓					Brackish	-	-	LC	×	×	-
	Scomberoides sp. *Juv*	Queenfish sp.					✓		Brackish	-	-	-	-	-	-
	Scomberoides lysan	Doublespotted queenfish					✓		Brackish	-	-	LC	×	×	-
Channidae	*Channa striata*	Snakehead murrel					✓		Fresh	-	-	LC	×	×	A
Chirocentridae	*Chirocentrus dorab*	Dorab wolf herring		✓					Brackish	-	-	NE	×	×	-

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Clupeidae	*Sardinella gibbosa*	Goldstripe sardinella		✓					Brackish	-	-	NE	×	×	-
	Kowala macrolepis	Sprat, deep-bodied herring						✓	Brackish	-	-	NE	×	×	-
	Hilsa kelee	Kelee shad					✓		Brackish	-	-	NE	×	×	-
Cyprinidae	*Cyprinus carpio*	Wild common carp	✓		✓				Fresh	-	-	VU	×	×	A
Datnioididae	*Datnioides polota*	Four-banded tiger perch					✓		Fresh	-	-	LC	×	×	-
Drepaneidae	*Drepane punctata*	Spotted sicklefish						✓	Brackish	-	-	NE	×	×	-
Cichlidae	*Oreochromis mossambicus*	Tilapia			✓				Fresh	-	-	NT	×	×	A
	Saretherodon spp.	Tilapia spp.						✓	Fresh	-	-	-	-	-	A
Eleotridae	*Bunaka gyrinoides*	Greenback gauvina	✓				✓		Both	-	-	LC	×	×	-
	Butis amboinensis	Olive flathead-gudgeon	✓				✓		Both	-	-	LC	×	×	-
	Eleotris melanosoma	Ebony gudgeon						✓	Both	-	-	LC	×	×	-
	Lagocephalus lunaris	Lunartail Puffer						✓	Both	-	-	LC	×	×	-
	Mogurnda mogurnda	Northern purple-spot gudgeon	✓				✓		Both	-	-	NE	×	×	-
	Mogurnga pulchra	Moresby mogurnda						✓	Both	-	-	NE	×	×	-
	Ophieleotris aporos/Giuris margaritacea	Snakehead gudgeon	✓						Both	-	-	NE	×	×	-
	Ophiocara porocephala	Northern mud gudgeon	✓				✓		Both	-	-	NE	×	×	-
	Oxyeleotris fimbriata	Fimbriate gudgeon	✓				✓		Both	-	-	NE	×	×	-
	Oxyeleotris herwerdenii	Papuan gauvina					✓		Both	-	-	NE	×	×	-
	Oxyeleotris lineolata	Sleepy cod					✓		Both	-	-	NE	×	×	-
	Oxyeleotris urophthalmus	Sleeper sp.					✓		Both	-	-	DD	×	×	-
	Prionobutis microps	Small-eyed loter					✓		Both	-	-	NE	×	×	-
Engraulidae	*Stolephorus commersonnii*	Commerson's anchovy					✓		Brackish	-	-	NE	×	×	-
	Stolephorus indicus	Indian Anchovy					✓		Brackish	-	-	NE	×	×	-

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	Stolephorus waitei	Whitebait					✓		Brackish	-	-	NE	×	×	-
	Thryssa hamiltonii	Hamilton's thryssa	✓				✓		Brackish	-	-	NE	×	×	-
	Thryssa rastrosa	Fly River thryssa			✓				Brackish	-	-	NE	×	×	-
	Thryssa scratchleyi	Freshwater anchovy	✓				✓		Brackish	-	-	DD	×	×	-
Ephinephelidae	*Epinephelus coioides*	Orange-spotted grouper	✓						Brackish	-	-	NT	×	×	-
	Epinephelus tauvina	Greasy grouper						✓	Brackish	-	-	DD	×	×	-
Ephippidae	*Rhinoprenes pentanemus*	Threadfin scat		✓					Brackish	-	-	LC	×	×	-
Gerreidae	*Gerres filamentosus*	Threadfin silver biddy						✓	Brackish	-	-	NE	×	×	-
Gobiidae	*Awaous sp1*	Roman's nose goby	✓						Both	-	-	-	-	-	--
	Glossogobius celebius	Celebes goby						✓	Both	-	-	DD	×	×	-
	Glossogobius concavifrons	Concave goby	✓						Both	-	-	NE	×	×	-
	Glossogobius giuris	Tank goby					✓		Both	-	-	NE	×	×	-
	Oligolepis jaarmani	-					✓		Both	-	-	NE	×	×	-
	Oxyurichthys tentacularis	Redspot arrowfin goby					✓		Both	-	-	DD	×	×	-
	Periophthalmodon schlosseri	Giant mudskipper					✓		Both	-	-	NE	×	×	-
	Periophthalmus argentilineatus	Barred mudskipper							Both	-	-	NE	×	×	-
	Periophthalmus barbarus	Atlantic mudskipper					✓		Both	-	-	LC	×	×	-
	Periophthalmus weberi	Weber’s mudskipper					✓		Both	-	-	NE	×	×	-
	Stenogobius gymnopomus	-					✓		Both	-	-	NE	×	×	-
	Scartelaos histophorus	Walking goby	✓				✓		Both	-	-	LC	×	×	-
	Strenogobius psilosinous	Barcheek goby	✓						Both	-	-	DD	×	×	-
Haemulidae	*Pomadasys argenteus*	Silver grunt					✓		Brackish	-	-	LC	×	×	-
	Pomadasys kaakan	Spotted javelinfish	✓						Brackish	-	-	NE	×	×	-

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			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
Kuhliidae	*Kuhlia marginata*	Dark-margined flagtail						✓	Brackish	-	-	LC	×	×	-
Kurtidae	*Kurtus gulliveri*	Nurseryfish	✓				✓		Both	-	-	NE	×	×	-
Latidae	*Lates calcarifer*	Barramundi	✓				✓		Both	-	-	NE	×	×	-
Leiognathidae	*Gazza achlamys*	Smalltoothed ponyfish						✓	Brackish	-	-	LC	×	×	-
	Gazza minuta	Largetooth ponyfish						✓	Brackish	-	-	LC	×	×	-
	Leiognathus berbis	Berber ponyfish					✓		Brackish	-	-	NE	×	×	-
	Leiognathus equula	Common ponyfish		✓			✓		Brackish	-	-	LC	×	×	-
	Secutor sp	Ponyfish sp.					✓		Brackish	-	-	-	-	-	-
Leptobramidae	*Leptobrama muelleri*	Beach salmon		✓			✓		Brackish	-	-	NE	×	×	-
Lobotidae	*Lobotes surinamensis*	Tripletail	✓						Brackish	-	-	LC	×	×	-
Lutjanidae	*Lutjanus* sp.	Snapper sp.					✓		Brackish	-	-	-	-	-	-
	Lutjanus argentimaculatus	Mangrove red snapper			✓		✓		Brackish	-	-	LC	×	×	-
	Lutjanus johnii	Golden snapper	✓						Brackish	-	-	LC	×	×	-
Malacanthidae	*Malacanthidae juv.*	Tilefish sp.					✓		Brackish	-	-	-	-	-	-
Melanotaeniidae	*Chilatherina campsi*	Highlands rainbowfish						✓	Fresh	-	-	NE	×	×	-
	Iriatherina werneri	Threadfin rainbowfish						✓	Fresh	-	-	NE	×	×	-
	Melanotaenia goldiei	Goldie River rainbowfish	✓						Fresh	-	-	NE	×	×	-
	Melanotaenia herbetaxelrodi	Lake Tebera rainbowfish						✓	Fresh	-	-	DD	×	×	-
	Melanotaenia maccullochi	Dwarf rainbowfish						✓	Fresh	-	-	NE	×	×	-
	Melanotaenia monticola	Mountain rainbowfish						✓	Fresh	-	-	DD	×	×	-
	Melanotaenia papuae	Papuan rainbowfish						✓	Fresh	-	-	LC	×	×	-
	Melanotaenia parkinsoni	Parkinson's rainbowfish						✓	Fresh	-	-	NE	×	×	-
	Melanotaenia splendida rubrostriata	Red-striped rainbowfish	✓				✓		Fresh	-	-	NE	×	×	-

Family	Accepted name	Common name	Occurrence[1]						Waters[2]	Status[3]					
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Mullidae	*Upeneus sulphureus*	Sulphur goatfish					✓		Brackish	-	-	LC	×	×	-
	Upeneus vittatus	Striped goatfish	✓						Brackish	-	-	LC	×	×	-
Muraenidae	*Gymnothorax polyuranodon*	Freshwater moray						✓	Both	-	-	LC	×	×	-
Osphronemidae	*Trichopodus pectoralis OR trichopterus*	Gourami					✓		Fresh	-	-	LC	×	×	A
Pholidichthyidae	*Pholidichthys* sp.	-					✓		Brackish	-	-	-	-	-	-
Plotosidae	*Plotosus canius*	Gray eel-catfish					✓		Fresh	-	-	LC	×	×	-
Polynemidae	*Eleutheronema tetradactylum*	Fourfinger threadfin		✓			✓		Both	-	-	NE	×	×	-
	Polydactylus macrochir	King threadfin				✓	✓		Both	-	-	NE	×	×	-
	Polydactylus plebeius	Striped threadfin	✓						Both	-	-	NE	×	×	-
Scatophagidae	*Scatophagus argus*	Spotted scat	✓				✓		Both	-	-	LC	×	×	-
	Selenotoca multifasciata	Spotbanded scat					✓		Both	-	-	NE	×	×	-
Sciaenidae	*Atrobucca brevis*	Orange jewfish	✓						Both	-	-	NE	×	×	-
	Atrobucca nibe	Black mouth croaker		✓					Both	-	-	NE	×	×	-
	Johnius amblycephalus	Bearded jewfish	✓						Both	-	-	NE	×	×	-
	Johnius coitor	Coitor croaker		✓					Both	-	-	LC	×	×	-
	Johnius macrorhynus	Big-snout croaker					✓		Both	-	-	NE	×	×	-
	Johnius novaeguineae	Paperhead croaker						✓	Both	-	-	LC	×	×	-
	Nibea sp.	Sharp-nosed jewfish	✓						Both	-	-	-	-	-	-
	Nibea soldado	Soldier croaker					✓		Both	-	-	NE	×	×	-
	Nibea semifasciata	Sharpnose croaker					✓		Both	-	-	NE	×	×	-
Siganidae	*Siganus vermiculatus*	Vermiculated spinefoot						✓	Brackish	-	-	LC	×	×	-
Sillaginidae	*Sillago sihama*	Silver sillago						✓	Brackish	-	-	LC	×	×	-
	Sillago sillago	Northern whiting					✓		Brackish	-	-	NE	×	×	-

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			1)	2)	3)	4)	5)	P/L		A	B	C	D	E	F
Sparidae	*Acanthopagrus berda*	Goldsilk seabream						✓	Brackish	-	-	LC	×	×	-
Sphyraenidae	*Sphyraena barracuda*	Great barracuda	✓						Brackish	-	-	LC	×	×	-
Terapontidae	*Hephaestus fuliginosus*	Black bream	✓				✓		Both	-	-	NE	×	×	-
	Hephaestus lineatus	Lined grunter	✓						Both	-	-	NE	×	×	-
	Hephaestus raymondi	Raymond's grunter						✓	Both	-	-	NE	×	×	-
	Hephaestus trimaculatus	Threespot grunter						✓	Both	-	-	DD	×	×	-
	Terapon jarbua	Tiger perch					✓		Both	-	-	LC	×	×	-
Toxotidae	*Toxotes chatareus*	Spotted archerfish	✓		✓		✓		Both	-	-	NE	×	×	-
	Toxotes jaculatrix	Banded archerfish						✓	Both	-	-	LC	×	×	-
Zenarchopteridae	*Zenarchopterus* sp.	-	✓						Both	-	-	-	-	-	-
	Zenarchopterus caudovittatus	Long-jawed river garfish					✓		Both	-	-	DD	×	×	-
	Zenarchopterus dunckeri	Duncker's river garfish					✓		Both	-	-	NE	×	×	-
	Zenarchopterus gilli	Viviparous halfbeak					✓		Both	-	-	LC	×	×	-
	Zenarchopterus novaeguineae	Fly River garfish	✓				✓		Both	-	-	NE	×	×	-
Pleuronectiformes															
Cynoglossidae	*Cynoglossus heterolepis*	Freshwater tonguesole					✓		Brackish	-	-	NE	×	×	-
	Cynoglossus punticeps	Speckled tonguesole					✓		Brackish	-	-	NE	×	×	-
	Paraplagusia bilineata	Doublelined tonguesole					✓		Brackish	-	-	NE	×	×	-
Paralichthyidae	*Pseudorhombus elevatus*	Deep flounder						✓	Brackish	-	-	NE	×	×	-
Soleidae	*Leptachirus* sp.	Sole sp.						✓	Both	-	-	-	-	-	-
	Leptachirus klunzingeri	Tailed sole					✓		Both	-	-	NE	×	×	-
Rajiformes															
Dasyatidae	*Dasyatis sephen*	Cowtail stingray					✓		Brackish	-	-	NE	×	×	-

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	Glaucostegus typus	Giant shovelnose ray					✓		Brackish	-	-	VU	×	×	-
	Urogymnus granulata	Mangrove whipray						✓	Brackish	-	-	VU	×	×	-
Pristidae	*Anoxypristis cuspidatus*	Narrow sawfish		✓					Brackish	-	I	EN	×	×	-
	Pristis pristis	Largetooth sawfish					✓		Both	-	I	CE	×	×	-
	Pristis zijsron	Green sawfish						✓	Brackish	-	I	EN	×	×	-
Salmoniformes															
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout					✓		Fresh	P	-	NE	×	×	N
	Salmo trutta	Brown trou					✓		Fresh	P	-	LC	×	×	N
Scorpaeniformes															
Platycephalidae	*Platycephalus indicus*	Bartail flathead					✓		Brackish	-	-	DD	×	×	-
Siluriformes															
Clariidae	*Clarias batrachus*	Walking catfish					✓		Fresh	-	-	LC	×	×	A
Syngnathiformes															
Syngnathidae	*Hippichthys heptagonus*	Belly pipefish					✓		Brackish	-	-	NE	×	×	-
	Hippichthys spicifer	Bellybarred pipefish					✓		Brackish	-	-	LC	×	×	-
	Microphis brachyurus brachyurus	Opossum Pipefish					✓		Brackish	-	-	LC	×	×	-
Synbracnhiformes															
Synbranchidae	*Ophisternon bengalense*	Bengal mudeel	✓						Both	-	-	LC	×	×	-
Tetraodontiformes															
Tetraodontidae	*Arothron manillensis*	Narrow-lined pufferfish						✓	Brackish	-	-	LC	×	×	-
	Arothron reticularis	Reticulated pufferfish					✓		Brackish	-	-	LC	×	×	-
	Chelonodon patoca	Milkspotted puffer					✓		Brackish	-	-	LC	×	×	-
	Marilyna meraukensis	Merauke toadfish	✓				✓		Brackish	-	-	NE	×	×	-

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	Marilyna pleurosticta	Banded toadfish					✓		Brackish	-	-	LC	×	×	-
Triacanthidae	*Triacanthus biaculeatus*	Short-nosed tripodfish					✓		Brackish	-	-	NE	×	×	-
Triacanthodidae	*Triacanthodes indicus*	Spikefish					✓		Brackish	-	-	NE	×	×	-

[1]Occurrence is grouped into Known ((1)-(4)) and Possible/Likely ((5) and P/L) based on the following sources: (1) current field survey, (2) Orokolo Bay coastal village surveys, (3) records from Elk/Antelope Gasfields Project EIS (DES, 2008), (4) other sources allow attribution of species presence in past 10 years, and (5) surveys by Haines (1979) for the Wabo Hydroelectric Scheme Project. P/L is based on assessment of habitat availability and historical records, as described in the main body of the report.

[2]'Waters' refers to the type of waters in which the species principally occurs: Fresh, Brackish or Both (i.e. no preference)

[3]Status is based on threatened/important status, consisting of the following categories: A. Protected (P) or Restricted (R) under *Fauna (Protection and Control) Act 1966*; B. trade-restricted status in Appendix I or Appendix II of CITES; C. Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN) or Critically Endangered (CE) on IUCN Red List of Threatened Species; D. considered to be endemic and/or restricted range; and E. considered to be migratory and/or congregatory. The invasive status of species has also been included in the following categories: F. invasive alien (A) or invasive native (N).



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