TOTAL E&P PNG LIMITED

PAPUA LNG

Upstream Environmental Impact Statement

Volume 2: Environmental and Social Baseline

Part 4
Upstream Groundwater Baseline Report

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global environmental solutions

Papua LNG Project

Upstream Groundwater Baseline Report

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Total E&P PNG Limited

Papua LNG Project

Upstream Groundwater Baseline Report

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Executive Summary

Joint venture partners are currently planning the development of the Elk-Antelope gas field, which is located within Petroleum Retention License 15 (PRL-15) in the Gulf Province, Papua New Guinea. Total E&P PNG Limited (TEP PNG), a wholly-owned subsidiary of Total S.A. (Total) has the largest interest in the Elk-Antelope gas field and is the operator of the Papua LNG Project (the Project) on behalf of the other joint venture partners. The 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 LNG Plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby.

For the purpose of the EIS/ESHIA, a baseline groundwater study is required to assess the nature of underground water within the Project area and to assess the potential for these aspects to be impacted by Project activities. The baseline groundwater study undertaken for the upstream components of the Project has:

- Defined the study area for the groundwater baseline characterization to support impact assessment;
- Identified and assessed a number of groundwater features within the study area;
- Characterized the current groundwater quality in shallow aquifers in the coastal and inland villages; and
- Developed the conceptual understanding of the groundwater systems within the study area.

The fieldwork component of the groundwater survey was undertaken between 15 and 21 November 2016, for the “upstream” area, consisting of sites within PRL-15 and the onshore export pipeline corridor. The field survey included general observation and assessment around upstream components of the Project including the well-pad areas, central processing facility (CPF) and the proposed onshore export pipeline route. In addition, 31 groundwater features (wells, bores and springs) were assessed in the CPF area and the onshore export pipeline corridor.

Assessment of groundwater features included where possible:

- Gauging of groundwater levels;
- Measurement of field water quality parameters; and
- Collection of water samples for laboratory analysis.

The field survey identified shallow groundwater to be present and used extensively by the communities of the coastal and inland villages (near the coast) within the onshore export pipeline corridor. Groundwater usage within the study area is predominantly for washing but during dry periods there is extensive reliance on groundwater as a drinking water resource. The quality of the water encountered largely met the relevant quality criteria for intended use (drinking water standards) with respect to chemical properties. However, widespread microbiological contamination is evident. The groundwater resource targeted by coastal and inland villages is extremely shallow, generally being less than 1 m below ground level (bgl), and therefore is highly susceptible to impact from potentially contaminating activities and processes. Identified risks include overland runoff (following rainfall) entraining contaminants particularly animal waste, sewerage effluent from latrines, inundation of wells by seawater and potential spills and/or mismanagement of hydrocarbons (e.g. boat fuel).

Groundwater at Herd Base is present within the alluvium of the Purari River. The water quality in this aquifer is good and suitable for its usage at the time of survey (wash-down water at vehicle workshop). The age of the bores in use at Herd Base is unknown; anecdotal evidence suggests that the targeted groundwater is sufficient in quantity to meet the current demands. Testing of one of the bores at Herd Base has been interpreted as showing that the intersected water yielding unit is capable of yielding at least 0.8 L/sec. The depth to water bearing material (greater than 15 m) and overlying low permeability fine silts and clay materials provides some degree of protection to this resource from potentially contaminating activities.

Isolated perched, shallow (less than 10 m bgl) groundwater occurs within superficial and weathered material throughout the study area but particularly in the areas of steep slopes and incised valleys within PRL-15. This is likely to support good quality water and to act as an important recharge source for stream and creek base flow.

Little information regarding deeper groundwater within the competent geology of the Era and Orubadi beds is available. However the lithologies that occur in these formations, including mudstones and siltstones are not considered likely to support significant groundwater. In addition, were groundwater to be present in discreet horizons within these formations the occurrence of low permeability mudstones and siltstones will restrict groundwater movement and interaction. This interpretation is the basis for the conclusion that any groundwater occurrence within the Era or Orubadi beds would represent confined systems with little or no connectivity to overlying aquifers or surface water in the study area.

It is also likely that small quantities of groundwater may occur within the geology of the gas resource target, the Kapau Limestone. The depth to this geology is in excess of 1,700 m and the thickness of overlying low permeability material is understood to have contained the hydrocarbon resource and will effectively confine water occurring in this unit.

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1 INTRODUCTION

1.1 Project Overview

The following description is focused on the upstream components of the Papua LNG Project and aims to provide minimal but appropriate context for the baseline report.

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 % - though 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 an LNG Plant site at Caution Bay, 20 km northwest of Port Moresby.

The Elk-Antelope gas field is a significant gas discovery in Papua New Guinea consisting of a gas reservoir with several trillion cubic feet of gas reserves located approximately 120 km inland from the township of Kerema, and 340 km northwest of Port Moresby (**Figure 1**).

The Project area comprises the physical footprint of the various Project components and associated infrastructure as detailed below:

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

This report characterizes the baseline groundwater environment in the upstream Project area, with the offshore export pipeline and LNG Plant site at Caution Bay excluded from the scope.

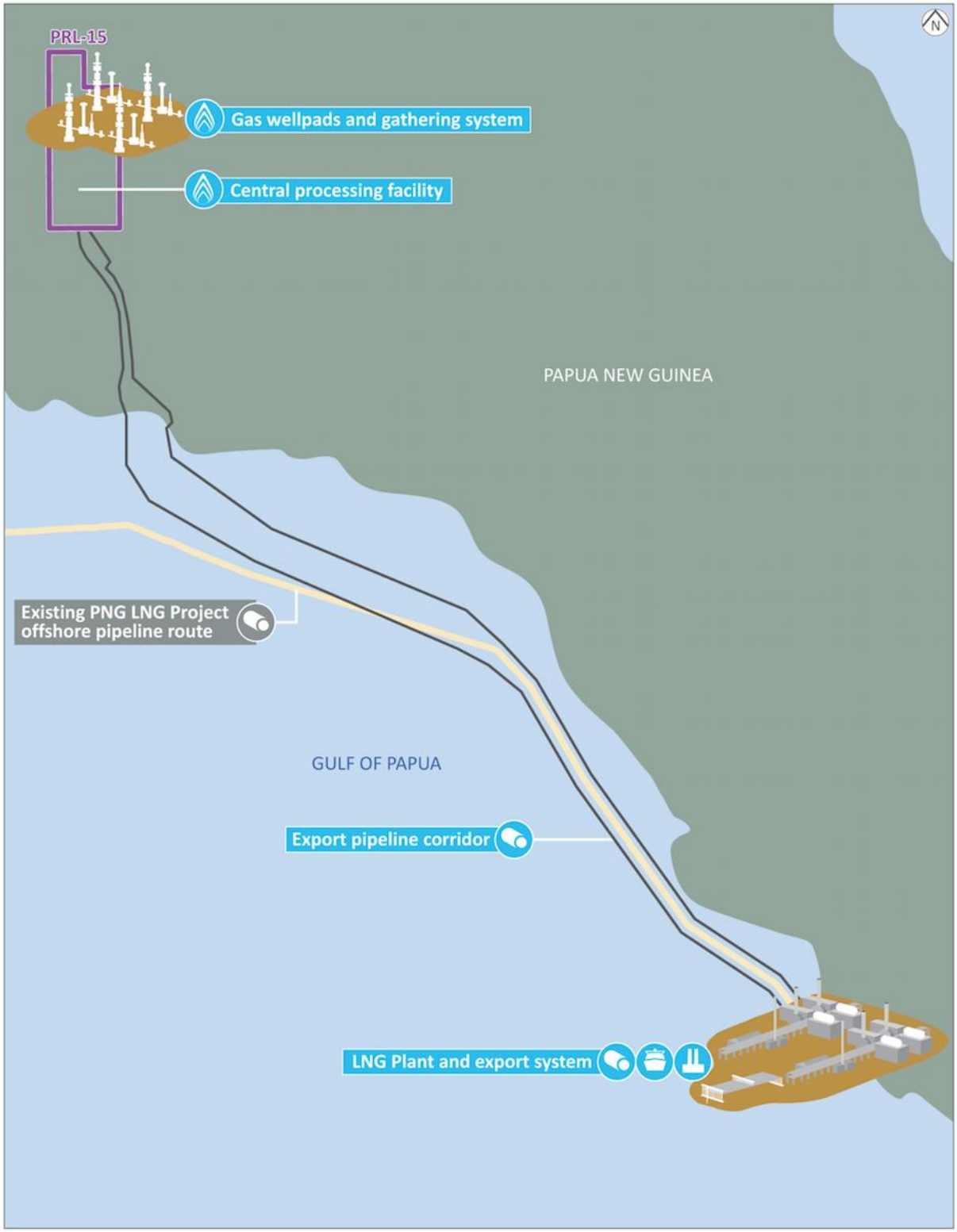


Figure 1 Project Schematic

1.2 Study and Objectives

SLR Consulting Australia Pty Ltd (SLR) has been commissioned by ERIAS Group Pty Ltd on behalf of TEP PNG to undertake this groundwater baseline study.

The objectives of the study were to assess the hydrogeology of the upstream Project area and the potential for Project activities to impact on groundwater aspects. The survey investigated the upstream area of the Project, including sites within PRL-15 and along the onshore export pipeline corridor.

The major elements of the overall hydrogeological assessment were to:

- Outline the overall hydrogeological context of the upstream study area;
- Describe aquifer characteristics;
- Assess groundwater vulnerability to Project activities employing a risk management framework approach; and
- Provide information and data to support the assessment of potential Project-related impacts to groundwater and groundwater-based resource uses.

This report mainly addresses the elements of the first two bullets above in relation to the hydrogeology of the upstream Project area. The elements related to impact assessment will be the subject of future documentation.

2 REGULATORY FRAMEWORK AND STANDARDS

The Project is formally regulated under Papua New Guinea legislation. In addition to this, TEP PNG will apply international and company standards and guidance to the Papua LNG Environmental Impact Statement (EIS)/ Environmental, Social and Health Impact Assessment (ESHIA) process.

2.1 Papua New Guinean Authorities and Legislation

The primary legislative instrument regulating the potential environmental impact of development activities in Papua New Guinea is the *Environment Act, 2000*. The Act aims to legislate the sustainable development of the biological and physical components of land, air and water resources in the country. Under the definitions of the Act "water' includes surface and underground water though the Act does not include any specific requirements with respect to groundwater or aquifer protection.

Prior to 2014 the Environment Act was administered by the Department of Environment and Conservation (DEC). Following the passing of the Conservation and Environment Protection Authority Act 2014 the Conservation and Environment Protection Authority (CEPA) was established to administer the Environment Act 2000 as amended in 2014.

The following acts and regulations are considered relevant to the groundwater aspect of the EIS/ESHIA:

- *Environment Act, 2000, including Regulations and operational procedures/information guidelines;*
- *Oil and Gas Act, 1998;*
- *Environment (Prescribed Activities) Regulation, 2002;*
- *Public Health (Drinking Water) Regulation, 1984;*
- *Environment (Water Quality Criteria) Regulation, 2002; and*
- *Water and Land Discharges, DEC Publication IB-ENV/04/2004 (technical guideline).*

2.1.1 Environmental Impact Assessment Requirements

The Project is classified as a "Prescribed Activity" under the definitions of Environment (Prescribed Activities) Regulation, 2002 (Level 3 Activity – Sub-category 18 – Petroleum and gas production and processing). The Environment Act, 2000 stipulates that an EIS must be prepared for all Level 3 Activities in order to assess and understand the potential environmental impacts of the activity.

Petroleum project licenses (including: Petroleum Development Licenses (PDL); Pipeline Licenses (PL); and Petroleum Processing Facility Licenses (PPFL)) issued under the *Oil and Gas Act, 1998* must have considered environmental aspects and applied appropriate management actions. An EIS prepared as required by the *Environment Act, 1998* is typically the means by which this requirement is satisfied.

Detail regarding the specific requirements of the EIS is provided within the Guideline for Conduct of Environmental Impact Assessment & Preparation of Environmental Impact Statement, DEC Publication: GL-Env/02/2004.

2.1.2 Relevant Environmental Values

Given the Project area and the PNG legislative framework, the following environmental values are considered relevant to this groundwater baseline assessment:

- Public health – drinking water; and
- Aquatic ecosystems – surface water.

The assessment criteria (outlined in **Section 2.1.3**) are considered relevant to groundwater in the study area due to the use of groundwater by villagers to supply water for various uses including potable supply. In addition, as shallow groundwater is considered to be a significant contributor to surface water base flow, environmental standards relevant to aquatic ecosystem protection (surface water) are considered relevant and provide a conservative assessment approach as they are generally more stringent that other quality standards.

2.1.3 Environmental Assessment Criteria

Papua New Guinea legislation does not include any specific groundwater assessment criteria. Therefore, in order to comment on groundwater quality, sample results have been assessed with respect to quality standards relevant to potentially sensitive receptors. Papua New Guinea's legislation includes two regulations that define water quality standards relevant to the Project and this assessment of baseline water quality. These two regulations are:

- Public Health (Drinking Water) Regulation, 1984; and
- Environment (Water Quality Criteria) Regulation, 2002.

The drinking water quality regulations define acceptance criteria for a limited range of compounds and elements for both raw water (prior to any treatment) and drinking water at the point of consumption (i.e., 'at tap'), with the latter, more stringent, standards used in the assessment. The regulation provides standards based on health and aesthetic considerations. The Environment (Water Quality Criteria) Regulation defines water quality criteria for the protection of aquatic life in surface waters and is relevant to groundwater in this context as surface waters represent a receiving environment to groundwater discharges.

2.2 International Standards and Guidelines

Papua New Guinea's drinking water quality criteria are largely consistent with international water quality guidance, being based on World Health Organization (WHO) Guideline values. However, since the enactment of the Public Health (Drinking Water) Regulation, 1984, the WHO guidance has been revised on a number of occasions with the most recent edition of the guidelines published in 2011. Therefore, in order to provide a more comprehensive assessment of groundwater quality international standards are used to supplement the national standards in this assessment to provide additional and more recent screening criteria.

Both drinking water and discharge of groundwater to surface water are considered applicable as these are potential sensitive receptors with respect to groundwater. The application of surface water standards to groundwater is considered conservative as it does not consider mixing or dilution that occurs in potential receiving environments. The following international guidelines have been considered:

- Guidelines for Drinking-water Quality, fourth edition, World Health Organization, 2011 (WHO, 2011); and
- National Water Quality Management Strategy, Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC, 2000).

The WHO drinking water guidelines propose concentrations for common contaminants or compounds below which adverse health effects are not likely to be experienced by the consumer.

The ANZECC guidelines for fresh and marine water quality are intended to provide protection for a range of environmental values including aquatic ecosystems, primary industries, recreation and aquaculture. As a conservative approach the ANZECC guideline values for the protection of aquatic ecosystems are considered in the assessment, as these are generally protective of other values. The guideline document provides trigger concentrations, exceedances of which are intended to prompt further investigation to assess environmental impact. The use of surface water standards is considered conservative when applied to groundwater as they do not consider mixing with surface water in the receiving environment.

2.3 Total Company Standards and Commitments

Relevant groundwater baseline assessment requirements set out in Total's policy documents and General Specification documents are outlined below.

2.3.1 Environmental Baseline and Monitoring Studies: Onshore Sites

Total General Specification, GS EP ENV 111, Environmental Baseline and Monitoring Studies: Onshore Sites sets out technical instructions for the establishment of the baseline environmental status and for carrying out environmental monitoring of an onshore site, including requirements for groundwater sampling.

Appendix 9 of GS EP ENV 111 lists concerns and recommendations for various environmental issues dependent on the receiving environment for a given Project. For "tropical forest environments" and "sensitive humid environments (mangroves, etc.)", no specific issues or requirements regarding groundwater are listed.

2.4 Project Groundwater Quality Criteria

The assessment criteria presented for the Project for groundwater quality have been gathered from Papua New Guinea standards and international guidelines. Where possible both environmental and drinking water quality guideline values have been used to assess groundwater results. It should be noted that both total and dissolved metals concentrations were measured in laboratory analyzed samples. Given that no treatment of groundwater is conducted prior to use, the sampled groundwater features are considered to represent 'point of consumption'. Based on this, total metals results have been used in comparison with drinking water criteria. Environmental criteria are based on dissolved metals concentrations rather than total metals concentrations and therefore these results have been used to screen against these criteria. Relevant criteria are presented in **Table 1** and **Table 2** below.

Table 1 Groundwater Quality Criteria – Drinking Water

Analyte	Units	LOR	Public Health (Drinking Water) Regulation 1984 - Standards for Drinking Water			World Health Organization Guidelines for Drinking-water Quality	
			Health-based Standards	Aesthetic-based Standards			
			Upper Limit of Concentration	Highest desirable level	Maximum permissible level	Health	Aesthetic
Field Parameters							
Temp	°C		-	-	-	-	-
pH			-	7.0-8.5	6.5-9.2	-	6.5-8
Oxidation-Reduction Potential	mV		-	-	-	-	-
Electrical Conductivity	µS/cm		-	-	-	-	-
Turbidity	NTU		-	5	25	-	5
Dissolved Oxygen	mg/L		-	-	-	-	-
Dissolved Oxygen	%		-	-	-	-	-
Total Dissolved Solids	mg/L		-	500	1500	-	600
Alkalinity							
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	-
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	-
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	-
Total Alkalinity as $CaCO_3$	mg/L	1	-	200 *3	600 *3	-	-
Major ions							
Calcium	mg/L	1	-	75	200	-	100
Magnesium	mg/L	1	-	30 *4	150	-	-
Sodium	mg/L	1	-	-	-	-	200
Potassium	mg/L	1	-	-	-	-	-
Sulfate as SO_4	mg/L	1	-	200	400	-	250
Chloride	mg/L	1	-	200	1000	-	250
Metals							
Aluminum	mg/L	0.01	-	-	-	-	-
Arsenic	mg/L	0.001	0.05	-	-	0.01	-
Barium	mg/L	0.001	-	-	-	0.7	-
Cadmium	mg/L	0.0001	0.01	-	-	0.003	-
Chromium	mg/L	0.001	-	-	-	0.05	-
Cobalt	mg/L	0.001	-	-	-	-	-
Copper	mg/L	0.001	-	0.05	1.5	2	-
Lead	mg/L	0.001	-	0.1	-	0.01	-
Nickel	mg/L	0.001	-	-	-	0.07	-
Selenium	mg/L	0.01	0.01	-	-	0.04	-
Silver	mg/L	0.001	0.05	-	-	-	-
Zinc	mg/L	0.005	-	2	15	-	3
Iron	mg/L	0.05	-	0.1	1	-	0.3
Mercury	mg/L	0.0001	0.001	-	-	0.006	-
Fluoride							
Fluoride	mg/L	0.1	-	1	1.5	1.5	-
Nutrients							
Ammonia as N	mg/L	0.01	-	-	-	-	35
Nitrite as N	mg/L	0.01	-	-	-	3	-
Nitrate as N	mg/L	0.01	45	-	-	50	-

Analyte	Units	LOR	Public Health (Drinking Water) Regulation 1984 - Standards for Drinking Water			World Health Organization Guidelines for Drinking-water Quality	
			Health-based Standards	Aesthetic-based Standards			
			Upper Limit of Concentration	Highest desirable level	Maximum permissible level	Health	Aesthetic
PAH							
Benzo(a)pyrene	µg/L	0.5	-	-	-	0.7	-
Sum of PAH	µg/L	0.5	-	-	-	0.7 *5	-
TRH - NEPM 2013 Fractions							
C6 - C10 Fraction	µg/L	20	-	-	-	-	-
C6 - C10 Fraction minus (F1) *1	µg/L	20	-	-	-	-	-
>C10 - C16 Fraction	µg/L	100	-	-	-	-	-
>C16 - C34 Fraction	µg/L	100	-	-	-	-	-
>C34 - C40 Fraction	µg/L	100	-	-	-	-	-
>C10 - C40 Fraction (sum)	µg/L	100	-	-	-	-	-
>C10 - C16 Fraction minus (F2) *2	µg/L	100	-	-	-	-	-
BTEXN							
Benzene	µg/L	1	-	-	-	10	-
Toluene	µg/L	2	-	-	-	700	-
Ethylbenzene	µg/L	2	-	-	-	300	-
Total Xylenes	µg/L	2	-	-	-	500	-
Naphthalene	µg/L	5	-	-	-	-	-
Microbiological							
Coliforms	MPN/ 100mL		-	-	0	-	-
Fecal Streptocci (enterococci)	cfu/ 100mL		0 *6	-	-	0 *6	-

Notes
*1 - C6 - C10 Fraction minus BTEX (F1)
*2 - >C10 - C16 Fraction minus naphthalene(F2)
*3 - Based on value for total hardness ($CaCO_3$)
*4 - If sulfate >250mg/L
*5 - Based on standard for Benzo(a)Pyrene
*6 - Based on standard for E.coli
*7 - Conservatively screened against standard for Cr(VI)
*8 - Limit of detectability
*9 - Based on pH of 9 and temperature of 30°C
*10 - Based on trigger values for Tropical Australia (Upland and Lowland rivers)
*11 - pH>6.5
*12 - Conservatively screened against standard for As(V)
*13 - Chemicals for which criteria is affected by hardness. The values have been calculated using a hardness of 30 mg/L $CaCO_3$
*14 – Mercury (inorganic)
*15 - Conservatively screened against standard for p-xylene

Table 2 Groundwater Quality Criteria – Ecosystem Protection

Analyte	Units	LOR	Environment (Water Quality Criteria) Regulation 2002 - Schedule 1 Environment Act 2000	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000
			Freshwater	Trigger Values for Freshwater 95% Protection Level
Field Parameters				
Temp	°C		No change >2°C	+/-20%
pH			No change	6.0-8.0 [*10]
Oxidation-Reduction Potential (ORP)	mV		-	-
Electrical Conductivity	µS/cm		-	20-250 [*10]
Turbidity	NTU		No change >25	2-15 [*10]
Dissolved Oxygen	mg/L		>6	-
Dissolved Oxygen	%		-	85-120% [*10]
Total Dissolved Solids	mg/L		-	-
Alkalinity				
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-
Total Alkalinity as $CaCO_3$	mg/L	1	-	-
Major ions				
Calcium	mg/L	1	-	-
Magnesium	mg/L	1	-	-
Sodium	mg/L	1	-	-
Potassium	mg/L	1	5	-
Sulfate as SO_4	mg/L	1	400	-
Chloride	mg/L	1	-	-
Dissolved metals				
Aluminum	mg/L	0.01	-	0.055 [*11]
Arsenic	mg/L	0.001	0.05	0.013 [*12]
Barium	mg/L	0.001	1	-
Cadmium	mg/L	0.0001	0.01	0.0002 [*13]
Chromium	mg/L	0.001	0.05 [*7]	0.001 [*7]
Cobalt	mg/L	0.001	0.001 [*8]	-
Copper	mg/L	0.001	1	0.0014 [*13]
Lead	mg/L	0.001	0.005	0.0034 [*13]
Nickel	mg/L	0.001	1	0.011 [*13]
Selenium	mg/L	0.01	0.01	0.011
Silver	mg/L	0.001	0.05	0.00005
Zinc	mg/L	0.005	5	0.008
Iron	mg/L	0.05	1	-
Mercury	mg/L	0.0001	0.0002	0.0006 [*14]
Fluoride				
Fluoride	mg/L	0.1	1.5	-
Nutrients				
Ammonia as N	mg/L	0.01	0.05 [*9]	0.9
Nitrite as N	mg/L	0.01	-	-
Nitrate as N	mg/L	0.01	45	0.7
PAH				
Benzo(a)pyrene	µg/L	0.5	-	-
Sum of PAH	µg/L	0.5	-	-

Analyte	Units	LOR	Environment (Water Quality Criteria) Regulation 2002 - Schedule 1 Environment Act 2000	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000
			Freshwater	Trigger Values for Freshwater 95% Protection Level
TRH - NEPM 2013 Fractions				
C6 - C10 Fraction	µg/L	20	-	-
C6 - C10 Fraction minus (F1)[*1]	µg/L	20	-	-
>C10 - C16 Fraction	µg/L	100	-	-
>C16 - C34 Fraction	µg/L	100	-	-
>C34 - C40 Fraction	µg/L	100	-	-
>C10 - C40 Fraction (sum)	µg/L	100	-	-
>C10 - C16 Fraction minus (F2)[*2]	µg/L	100	-	-
BTEXN				
Benzene	µg/L	1	-	0.95
Toluene	µg/L	2	-	-
Ethylbenzene	µg/L	2	-	-
Total Xylenes	µg/L	2	-	0.2[*15]
Naphthalene	µg/L	5	-	-
Microbiological				
Coliforms	MPN/ 100mL		-	-
Fecal Streptococci (enterococci)	cfu/ 100mL		200	-

Notes
*1 - C6 - C10 Fraction minus BTEX (F1)
*2 - >C10 - C16 Fraction minus naphthalene(F2)[*2]
*3 - Based on value for total hardness ($CaCO_3$)
*4 - If sulfate >250mg/L
*5 - Based on standard for benzo(a)pyrene
*6 - Based on standard for E.coli
*7 - Conservatively screened against standard for Cr(VI)
*8 - Limit of detectability
*9 - Based on pH of 9 and temperature of 30°C
*10 - Based on trigger values for tropical Australia (upland and lowland rivers)
*11 - pH>6.5
*12 - Conservatively screened against standard for As(V)
*13 - Chemicals for which criteria is affected by hardness. The values have been calculated using a hardness of 30 mg/L $CaCO_3$
*14 – Mercury (inorganic)
*15 - Conservatively screened against standard for p-xylene

3 STUDY AREA

3.1 Study Area

The upstream Project area is located in the Gulf Province of Papua New Guinea on the southern side of the main dividing range. The study area includes the areas surrounding the upstream components of the Project, as shown in **Figure 2**. The areas assessed included:

- Petroleum Retention License 15 (PRL-15) which incorporates the Elk-Antelope gas field and associated production, processing and related facilities; and
- The onshore export pipeline corridor between PRL-15 and the coast.

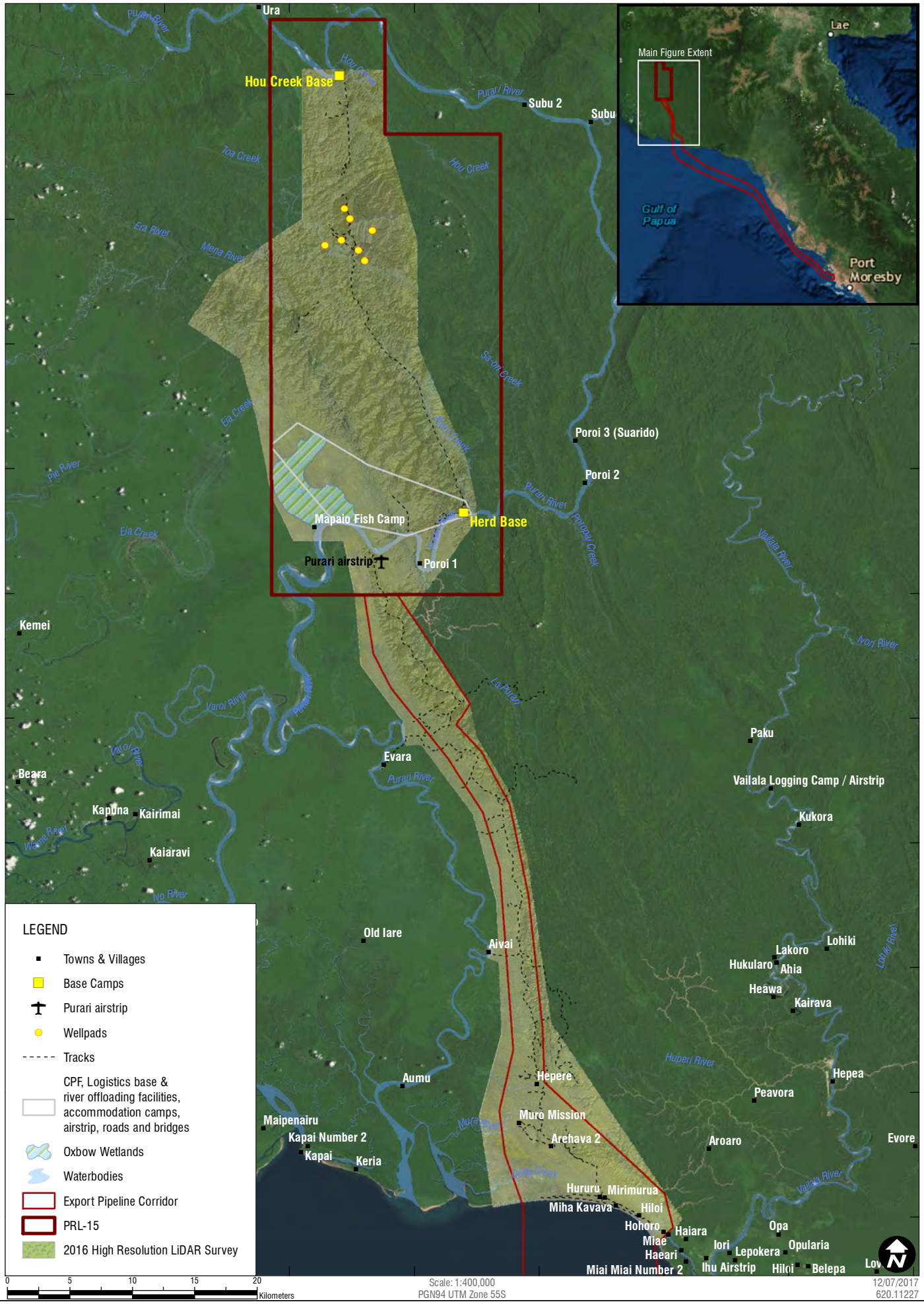
Specific focus was given to areas of existing or planned development including:

- Wellpads and upstream gathering system, within PRL-15;
- The upstream central processing facility (CPF) including supporting infrastructure, within PRL-15;
- Onshore export pipeline corridor, which will include single gas and condensate pipelines along the same route; and
- Areas where groundwater is currently accessed or used as a water source.

The upstream Project area of influence (PAOI) relevant to groundwater is expected to be limited to within close vicinity of areas of direct disturbance. Project activities with the highest potential for interaction with groundwater are likely to be associated with production wells and the central processing facility (CPF) as well as their associated support infrastructure within PRL-15. Construction, drilling and operational phases of the Project in these areas have potential to impact groundwater levels and/or quality. Pending Project design definition, the extent of potential impact to groundwater values will be refined during the impact assessment.

PRL-15 lies to the south of Wabo between two reaches of the Purari River covering an area of 750 km^2. PRL-15 is approximately 45 km from north to south and 20 km from east to west. The main areas of proposed development within PRL-15 are the gas field in the northern half of the license area and the CPF in the southern area of the license close to the Purari River.

The proposed onshore export pipeline corridor runs from the CPF area in PRL-15 in a southerly direction to the coast at Orokolo Bay. The corridor is approximately 50 km in length.



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Study Area

FIGURE 2

3.2 Physical Setting

As shown in **Figure 3**, PRL-15 is characterized by mountains, hills and levee plain landforms. The northern two-thirds of the PRL-15 is dominated by southeast to northwest trending ridges and folded terrain of the lower Eastern Highlands, up to approximately 450 m ASL in places. The existing wellpads from previous appraisal drilling within PRL-15 are mostly located on steep ridges, some up to 250 m ASL.

Terrain in the southwestern portion of PRL-15 grades to the plains of the Purari River basin that are likely to be subject to frequent inundation from overbank river flows during the wet season based on their elevation relative to the river channel.

The proposed CPF site is located on the flood plain of the Purari River bounded to the south by the Purari River main channel and to the east by its tributary, Kuku Creek. The generally flat swampy terrain of the site has a maximum elevation of about 50 m ASL, but is more generally below this elevation.

From the CPF at its northern limit, the onshore export pipeline corridor traverses extensive ranges of asymmetrical mountains and hills, which descend into alluvial plains and composite levee plains, coastal mangroves and beach ridges and beach plains along the coast.

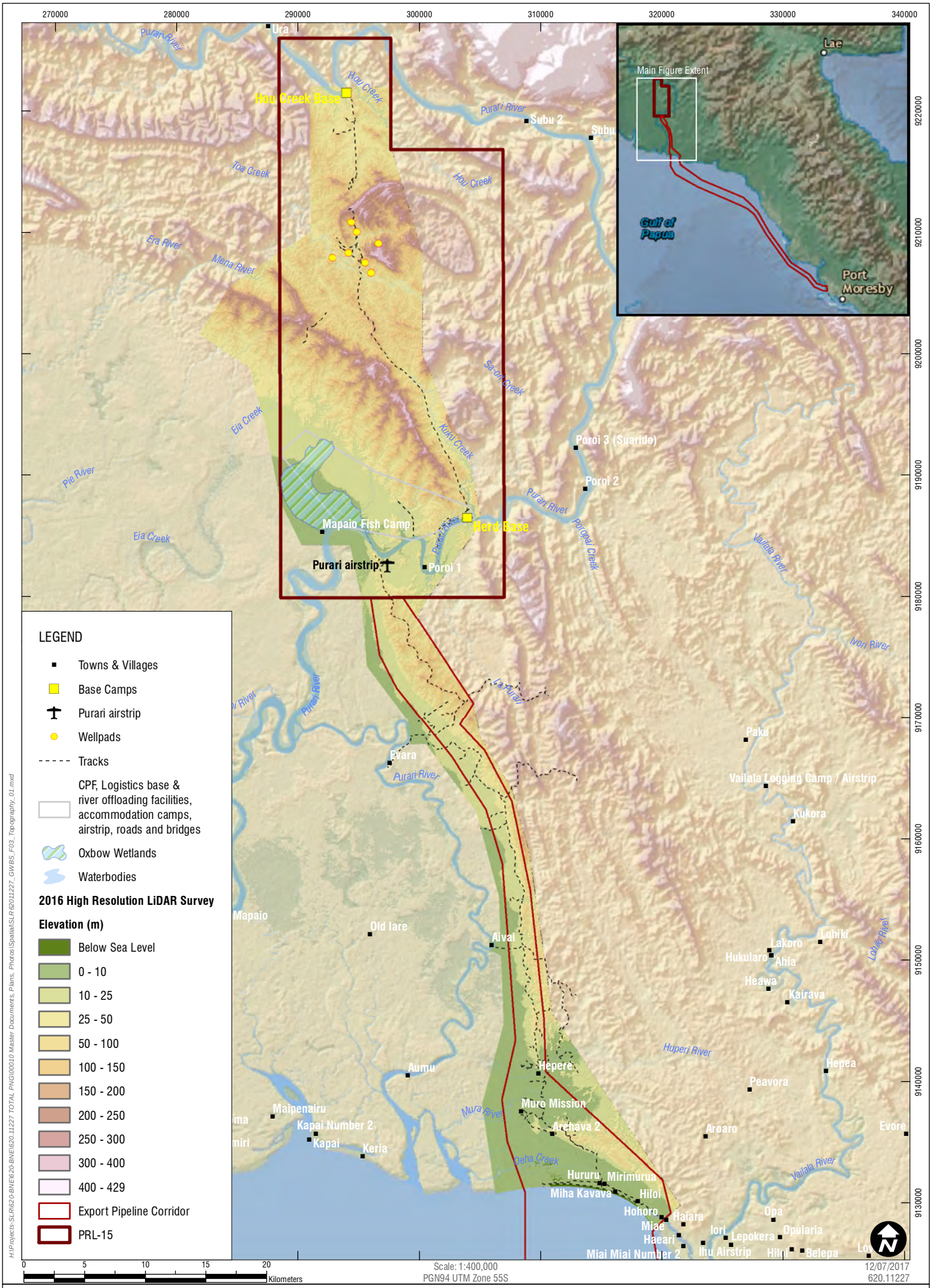
PRL-15 and the surrounding areas are densely vegetated by tropical forest. Limited clearing has been performed by the local population for subsistence farming and construction of dwellings and small villages. Commercial logging is also active in the study area. Anthropogenic activities are described in **Section 4.4** below.

3.3 Climate

Papua New Guinea has a tropical climate. The coastal and islands regions tend to be hot and humid, with temperature averages in the range 20°C to 32°C and relative humidity in the range levels ranging from 70% to 90%. Temperature is altitude dependent, with hot and humid conditions toward the coast and cooler conditions in the higher areas in the north of PRL-15.

The seasons (and rainfall patterns) in Papua New Guinea are generally dictated by the southeast trade winds that occur from May to October (dry season) and northwest monsoons winds that occur from December to March (wet season). April and November are doldrum periods between these seasons. However there is reverse seasonality in the Purari River area near PRL-15 with more rain between June and September and drier, hot weather between October and March (Evesson, 1983). In upland areas, cloud and fog are an important source of moisture for most of the year, with areas subject to the most cloud receiving the most rain. The area is one of the cloudiest and wettest places in the world with rainfall in the Wabo area being more than 8,000 mm per year (Evesson, 1983). Toward the coast, rainfall is lower and more evenly spread throughout the year (averaging around 300 mm/month) (Evesson, 1983).

Papua New Guinea's climate varies considerably from year to year due to the El Niño-Southern Oscillation (ENSO). This is a natural climate pattern that affects weather across the world. El Niño is a warming of the Pacific Ocean resulting in longer and cooler dry seasons (i.e., periods of drought), and a delay to the start of monsoon season. La Niña, the cold phase of ENSO, typically results in higher than average rainfall and warmer temperatures during the wet season, often leading to flooding events and landslides (PACCSAPP, 2015). Papua New Guinea also experiences neutral ENSO phases.



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Topography of the Study Area

FIGURE 3

3.4 Anthropogenic Setting

PRL-15 is largely unsettled but owned and used by the Pawaian people, who reside in villages along the Purari River. Most of these villages lie outside of but near to PRL-15 with the exception of two small villages (Poroi 1 and Mapaio Fish Camp) that are located on the Purari River within the southern part of the licence area. Aside from subsistence livelihood activities from the Pawaian people, the main anthropogenic activities in PRL-15 relate to the recent and ongoing gas exploration. These include the main operations camp at Herd Base, temporary camps at Antelope-3 Operations Camp (recently recommissioned) and Hou Creek Base (now demobilized), and activities and disturbance related to wellpads, access roads, and helipads.

The inland section of the onshore export pipeline corridor is largely unpopulated however has been modified by large-scale industrial logging. Near to and along the coast, the number and size of villages, and hence population density, increases. Anthropogenic activities include clearing of forest for settlements, subsistence agriculture (food gardens, sago planting, hunting and fishing) and historical clearing for coconut plantations.

Within approximately 10 km of Orokolo Bay the proposed onshore export pipeline corridor includes a number of village settlements. Within this assessment the villages have been divided into inland and coastal villages, and include eight inland villages and 15 coastal villages.

Along the Purari riverways, villages are predominately located on or in the vicinity of the upper reaches of the tidal influence where there is likely to be a greater availability of natural resources used to supplement subsistence agriculture activities. Commercial logging, and Project commissioned barges transporting supplies and equipment to Herd Base, regularly travel along the Purari channels.

Coastal villages are present along the beach and back beach line of Orokolo Bay. These are the largest settlements in the area, where anthropogenic activities include subsistence agriculture supplemented by extensive fishing and coastal trade. **Figure 2** includes the main settlements within the study area.

4 EXISTING GROUNDWATER INFORMATION

Groundwater assessment in the study area to date has been limited and little detail is known about the area's hydrogeology. There are few groundwater access points within the study area, with only the Project's Herd Base abstraction bores in the southern area of PRL-15 adjacent the Purari River and no known bores within the onshore export pipeline corridor. Groundwater springs are understood to be relatively common in the upper reaches of the study area particularly during and following the wet season (GHD, 2015). Hand dug village wells used for domestic water supply are common in the lower coastal areas (Finlayson, 2016). There is little quantitative data regarding groundwater levels, and flow or quality of water from these shallow groundwater features.

4.1 Prior Work Within the Study Area

Limited information regarding groundwater in the study area was available at the time of this baseline assessment. The following reports provide some information regarding groundwater within or relevant to the study area.

4.1.1 InterOil SPI (208) Ltd, Antelope-6 Environmental Impact Assessment and Environmental Management Plan, GHD, 2015

The report describes the general geology and lithology with sandstones and claystones of the Era beds (also known as the Era Formation) overlying the Orubadi bed mudstones and Tertiary limestones in the Elk-Antelope gas field area. The report states that the stratigraphy is relatively simple and that groundwater is thought to occur at various depths throughout the geological profile.

The GHD report suggests there to be three distinct types of groundwater in the gas field area, these being:

- "Shallow Groundwater" including water within permeable soils, "shallow groundwater veins" and alluvium as well as groundwater within sandstones of the upper Era beds. The report states that "at Antelope-6 the shallower groundwater table is expected to be intersected at +/-150m below surface, commensurate with the level of the closest major watercourse".
- "Formation Water" described as interstitial water occupying the pores and interstitial spaces within clay minerals of the Orubadi bed mudstones, this water is described as "sedentary" and is not considered to represent an aquifer. The report states that "low volumes of formation water have been encountered" in other Antelope and Elk gas wells.
- "Deep Groundwater". The GHD report theorizes the potential for water to be present within the carbonate geology of the hydrocarbon reservoir at depths greater than approximately 1700 m. It is suggested that water at this depth is likely to be isolated from water in overlying material due to the presence of low permeability capping materials (Orubadi bed mudstones). The report also suggests that the quality of this water may be impacted by hydrocarbons, salts and "other naturally occurring chemicals". It is also stated that deep groundwater encountered will be "generally of high quality and amount of produced water is likely to be low" based on drilling experience from Antelope-2, Antelope-3 and the Elk wells.

The GHD report further discusses groundwater movement with a suggestion of perched groundwater being "extremely shallow" and issuing from springs on the Mena escarpment with recharge from rainfall. The report states that this perched water has "little or no connection to deeper groundwater". The report also describes the permanent shallow groundwater (estimated to be present at a depth of approximately 150 m) as being in potential connectivity with surface waters, including Boa Creek. The report further states that groundwater at depths greater than 1,000 m are considered confined and not in connectivity with overlying groundwater aquifers or surface water.

It should be noted that the information presented by GHD within the Antelope-6 EIS and EMP predates the drilling at this location and therefore the stratigraphy and groundwater characteristics presented are inferred and no quantitative data regarding groundwater or geology is included.

4.1.2 Herd Base Water Bore Drilling, Water Search Ltd trading as Central Drillers, 2015 (CD, 2015) – Unpublished)

In late 2015 a drilling program to install additional groundwater abstraction bores at Herd Base was conducted. A brief report detailing these works was reviewed as part of this baseline assessment. A total of four bores were drilled. Borelogs and photographs were only included in the report for two of the bores (Bores No.3 and No.4) as the remaining two bores were dry during drilling (Bore No.5) or failed during installation (Bore No.6). In addition, interpreted data from a 10-hour constant rate pumping test for one of the bores was included.

All four bores were drilled in the Herd Base area (assumed to be within 500 m of the main camp) however the position of Bores No.5 and No.6 is unknown. All bores are understood to have encountered unconsolidated alluvial material associated with the Purari River and Kuku Creek. The total depth of Bore No.3 was 51 m and Bore No. 4 was 30 m. The logs for Bore No.3 and No.4 describe the material encountered as gray sandy clay overlying coarse to very silty sand gray to black in color with high permeability. The gray black sand is water bearing and was encountered between 32 and 39 m bgl in Bore No. 3 and between 14 and 26 m bgl in Bore No 4. Both bores were installed with 150 mm casing and stainless steel wedge wound screens targeting this sand. Neither borelog contains standing water level data. The report notes that all bores were affected by sand invasion during and following airlift development with Bore No.3 being “flooded” by sand to just below standing water level on cessation of airlifting. Sand impact at Bore No.4 was described as less severe and a 10-hour constant rate pumping test was possible (though it is noted that the pumping and drawdown data sheet is labelled with the incorrect bore number). The pumping test is reported to have shown that Bore No. 4 has a sustainable daily yield of 69,000 L/day (0.8 L/sec).

4.1.3 Liquid Niugini Gas Ltd, Gulf LNG Project Water Quality Rapid Assessment, GHD, 2012

This report provides details of a “rapid” water quality assessment undertaken during an earlier iteration of the project. The assessment study area focused on an area close to the coast of Orokolo Bay to the east of Orahuhu, approximately 25 km to the east of the study area considered in this report.

The study included the assessment of surface and groundwater through direct measurement of field water quality parameters including temperature, pH, dissolved oxygen (DO), electrical conductivity, salt, turbidity and total dissolved solids (TDS). The study identified 69 water “stations” and measured field parameters at 47 of them. Of the 47 measurement points, 33 were groundwater features (village wells). The assessment compared results of groundwater quality measurements against Australian Drinking Water Guidelines 2011 and the ANZECC guidelines.

The wells assessed in this study were all hand dug wells installed to access shallow groundwater within the upper 2 m with basic or no supporting casing. Casing materials included concrete pipes, steel drums, corrugated metal sheeting and the root balls of palm trees. The results of monitoring found that generally the water was within the limits of acceptability described within the selected assessment guidelines. This included pH measurements in the range 6.5 to 8.2 and maximum turbidity and TDS of 168 NTU and 799.5 mg/L respectively. It is noted that the usefulness of in-situ readings (i.e., field water quality parameters) alone is limited since they do not provide information on a number of water quality parameters, including potential contaminants.

4.1.4 Available Geological Information

There has been comprehensive investigation of the geology within the study area for the purpose of hydrocarbon exploration. These investigations have largely focused on the deep carbonate geology of the Kapau Limestone in which the target gas reservoir lies. The overlying mudstones, marls and shales of the Orubadi beds (also known as the Orubadi Formation act as the capping material to the hydrocarbon resource.

However, the geological information regarding the shallower (<1,000 m bgl) surface geology which is of greater relevance to the groundwater assessment is based on limited assessment localities and therefore the descriptions are considered regional. These give a basic appreciation of the likely geologies associated with certain landforms from which some interpretation of potential groundwater occurrence can be made.

Useful reference sources include:

- The Purari – Tropical Environment of a High Rainfall River Basin (Petr, 1983); and
- The Geology of the Kikori 1:250,000 Sheet Area PNG, Record - Bureau of Mineral Resources Geology and Geophysics (Pieters, 1980).

A basic stratigraphy for the study area is included below in **Table 3**.

Table 3 Basic Stratigraphy in the Study Area

Age	Name and Thickness	Description
Holocene	Quaternary Sediments <100 m	Variable depending on parent geology and location in study area. Accumulations within river valleys and creek lines. Unconsolidated coarse sands and gravels in upper catchments with fine black to dark grey sands and silts in the Purari River basin.
Pliocene to Pleistocene	Era beds <2,000 m	Sandstone, siltstone and mudstone with rare coal and conglomerate. Commonly carbonaceous. Blue to grey and brown when weathered.
Uppermost Miocene to Pliocene	Orubadi beds <2,400 m	Mudstone, siltstone, sandstone, minor conglomerate and rare calcarenite and limestone breccia. Blues to grey and brown in more calcareous areas. Fine to medium bedded and occasionally massive.
Upper Oligocene to lower Miocene	Kapau Limestone >1,000 m	Cream to light brown; mainly thin bedded but occasionally massive limestone. Fossiliferous in places including fragments of corals, bivalves and gastropods. Reservoir rock, target of the gas exploration.

Source: Compiled from Pieters, 1980 and GHD, 2015.

Based on review of the available geological information with respect to groundwater within the study area, it is considered likely that four potential hydro-stratigraphic units (HSU) are present:

1. Perched (i.e. minor occurrences of groundwater above regional groundwater) or shallow groundwater within upper weathered material, alluvium and/or back beach deposits is considered to represent the primary source of creek discharge in their upper reaches. In the upper areas of the gas field this groundwater may not be present year round and is unlikely to be laterally continuous. Close to rivers and water bodies, alluvium may support groundwater capable of providing sustainable and valuable groundwater yields. In the lower coastal areas this groundwater may be very shallow (<1 m bgl) and is a primary water supply for a number of villages. Perched groundwater configuration is likely to be predominantly controlled by topography.
2. Shallow permanent groundwater within sandstones, siltstones, mudstones and minor conglomerates of the Era beds in certain areas of the study area (Era beds are largely absent from the gas field area) is understood to exist at depths corresponding to the levels of nearby watercourses. Beneath ridgelines and high points depth to groundwater could be greater than 200 m. Groundwater occurrence in this HSU is likely to be variable with permeability and hydraulic conductivity controlled by variation in the sediments.
3. Formation water (interstitial) within the Orubadi beds is likely to be present at various levels throughout this stratigraphy. The hydraulic conductivity of this material is likely to be low and only low volumes of water have been encountered during the drilling of exploration wells (this HSU is not considered to represent an aquifer).

4. Deep groundwater within the Kapau Limestone (>3500 m bgl) that contains the gas reservoir is expected, although only in low quantities as pore space in this geology is occupied by hydrocarbons. This HSU is considered to be confined by low permeability material of the overlying Orubadi beds and to not be in connectivity with surface water of shallower HSUs. The volume of water expected in this formation and its status as a hydrocarbon reservoir means that this HSU is not considered to represent and aquifer.

Of these potential HSUs only the perched or shallow groundwater within upper weathered material, alluvium and/or back beach deposits is accessed as a groundwater resource on the basis of observations and information collected during the field survey.

4.2 Studies in Neighboring Regions

No groundwater level or quality monitoring data is publicly available for neighboring regions from previous studies.

Appendix 6 of PNG LNG Project Environmental Impact Statement prepared by Coffey Natural Systems for ExxonMobil, PNG LNG Groundwater Impact Assessment – Upstream Facilities (SKM, 2008) prepared by Sinclair Knight Mertz (SKM) Pty Limited has been reviewed. The upstream development components of this project included the construction and recompletion of wells, and construction of a gas gathering system and gas conditioning plant in the Hides Gas Field, some 300 km northwest of the proposed CPF site. The SKM impact assessment did not include any fieldwork or sampling of groundwater and was limited to a desktop study of published information. The SKM report only makes general statements about likely occurrence and quality of groundwater. This reports key conclusions regarding groundwater included:

- [Shallow perched] groundwater systems in the area are likely to be local in extent with recharge and discharge zones in close proximity;
- [Shallow perched] groundwater systems represent an important source of base flow for creeks and streams; and
- Groundwater quality in the area is likely to be good with low salinity (due to rapid recharge and discharge) and slightly alkali conditions.

Given the similarities between the setting of the PNG LNG Project and the Total Papua LNG Project it is likely that these broad conclusions are also true within the study area, though the PNG LNG Project lies within a different drainage catchment with different parent geology.

4.3 Summary

The review of existing information outlined above shows that there is little quantitative groundwater data available in the study area. As a result, this baseline study has focused on the data collected during the field survey undertaken in November 2016. The limited existing information together with the field survey results have been used to develop a conceptual hydrogeological model, which is described in **Section 7.**

5 GROUNDWATER ASSESSMENT

5.1 General Approach

Key objectives of this upstream groundwater baseline report were to characterize the hydrogeology of the study area and describe aquifer characteristics (see Section 2.2). The survey investigated the upstream area of the Project, including sites within PRL-15 and along the onshore export pipeline corridor.

As described in **Section 4,** limited groundwater information exists for the Project area, particularly within PRL-15. As such, a groundwater field survey was instigated with the aim of collecting additional site-specific groundwater information and data to inform the groundwater assessment. Within PRL-15, groundwater fieldwork undertaken as part of this baseline assessment was limited to assessment of abstraction bores at Herd Base and general visual observations and inspection of areas around existing and proposed infrastructure. Outside the limits of PRL-15, villages using groundwater as a water source were identified by social baseline studies undertaken for the Project. In particular, the findings of village social surveys undertaken during 2016 (Finlayson, 2016) were used to identify villages where groundwater was stated to be the primary water source to aid in planning the field survey, including informing on the nature and construction of village wells and springs.

5.2 Field Surveys

The groundwater baseline assessment field survey was undertaken by John Leyland, SLR Associate Hydrogeologist, between 15 and 21 November 2016. During the survey general observations relating to geology, landform and vegetation were made within PRL-15 in order to develop a conceptual understanding of the likely groundwater conditions in the area. Where groundwater bores (Herd Base); or springs and shallow wells (coastal and low land villages) were identified, these were assessed and, where possible, gauged and sampled.

The groundwater field survey followed the methods outlined in the Groundwater, Soils & Terrain, and Geology & Geomorphology Baseline – Scope and Methods Report (ERIAS, 2016).

A summary of field survey tasks is included below:

- General observations of landform, geology and surface water to inform groundwater conceptualization;
- Measurement of groundwater level using and electronic dip meter;
- Measurement of in-situ groundwater quality parameters (temperature, electrical conductivity, pH, dissolved oxygen, oxidation and reduction potential and turbidity) using a multi-parameter water quality meter; and
- Collection of water samples for laboratory analysis. The analytical suite included the following general water quality indicators:
    - Major cations and anions;
    - Alkalinity;
    - Total organic carbon (TOC);
    - Dissolved organic carbon (DOC);
    - Total suspended solids (TSS);

  and potential contaminants of concern, including:
    - Total petroleum hydrocarbons (TPH);
    - Benzene, toluene, ethylbenzene and xylene (BTEX);
    - Polycyclic aromatic hydrocarbons (PAH);

- Total nitrogen, total phosphorous, nitrate/nitrite, ammonia and orthophosphate;
- Total and dissolved metals (Al, As, Ag, Ba, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Se, V, Zn); and
- Microbiological – total coliforms, fecal Streptococci (Enterococci).

5.3 Protocols Used

All water sampling was undertaken in accordance with the requirements of Total general specification GS EP ENV 111: Environmental Baseline and Monitoring Studies: Onshore Sites (Total, 2012). Additional detail on methods and approaches used are provided below.

5.3.1 Inspection

Identified groundwater features were assessed through visual inspection as well as measurement. Initial assessment included the recording of the following information:

- Unique location identification number and/or local identifier;
- Location (description and GPS co-ordinates);
- Location photograph;
- Owner/users – where available;
- Use – including estimation of daily abstraction;
- Installed equipment;
- Condition;
- Depth data (bores and wells):
  - Depth to water;
  - Depth to base;
  - Depth to pump intake (if available);
- Installation data:
  - Casing diameter;
  - Casing material;
  - Screened section details; and
- Any other data available.

Data was collected through both direct field measurement and observation. Where possible, liaison with bore owners/users was used as a source of information and data.

5.3.2 Groundwater Gauging

Where possible, depth to groundwater in bores and wells was measured using an electronic water level dip meter. At each bore the datum point used was recorded such that consistency with historical and future measurements can be maintained. In general the datum used was the top of bore or well casing (where not level, the highest point) or ground surface. The distance by which casing protrudes above surface (collar height) was also measured using a tape measure.

5.3.3 Groundwater Sampling

Where possible, samples were collected from groundwater features located during the field survey. Sampling was undertaken by the most appropriate means dependent on the type of groundwater feature, the nature and condition of the feature and any installed equipment present.

The size and nature of the village groundwater features, with no pumps installed and large volumes of standing water, precluded conventional purged sampling. Therefore, “grab” samples were collected using dedicated disposable bailers. This method means the field and laboratory results for certain parameters may not be entirely representative of general groundwater conditions due to factors affecting the standing water within the wells or bores. The chemistry of water standing within bores or wells may be modified by the influences of light, contact with air, biological or anthropogenic influences (e.g. plant growth, animals, and human contact). It should be noted that whilst collection of “grab” samples is not considered “best practice” all samples from village groundwater features were collected by the same method and are therefore comparable for the purposes of this assessment.

Field parameters were measured at each sampling location using an electronic multi-parameter water quality meter (WQM). The WQM probes were introduced to the well, bore or spring during sampling. Although purging could not be performed, the regular use of the village groundwater features means that the samples collected are considered to be representative of aquifer conditions. At a single location (HB BH02) an operable groundwater pump was present; three wet well volumes of water were purged prior to the collection of a groundwater sample from the pump outlet as close as possible to the bore head.

During or prior to sampling, the following field parameters were measured using the WQM:

- Temperature;
- pH;
- Salinity;
- Electrical conductivity (EC);
- Dissolved oxygen (DO);
- Turbidity; and
- Oxidation-reduction potential (ORP).

The WQM readings were closely monitored during measurement to ensure that at least three consecutive readings more than one minute apart within the stabilization criteria ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO (from USEPA, 1996) were taken prior to sample collection.

In the case where an existing bore pump was used, estimates of casing volume were made based on field measurements and pumping rates measured periodically during purging using a bucket flow test.

Laboratory supplied sample containers suitable for the specific analysis and containing the relevant preserving additive were used. Where dissolved metals analysis was required, samples were field filtered using dedicated disposable 0.45 µm filters. Sampling equipment was disposed or cleaned between sampling locations to prevent cross-contamination.

5.4 Permits Obtained

No permits were required or obtained for the groundwater assessment or sampling undertaken.

5.5 Limitations

Survey locations within the upstream Project area were restricted to locations accessible by helicopter and on foot. Within the study area bores and wells are limited to those installed by locals near to settlements in the southern portion of the onshore export pipeline corridor or Herd Base for water supply. These bores and wells are designed for water abstraction and therefore target “first water” (the shallowest water encountered, sufficient in volume and quality to meet the user’s needs) only. Therefore, no quantitative information regarding deeper groundwater systems has been available for this assessment.

Sampling was limited to wells installed in alluvium at Herd Base and wells and springs within superficial material in the coastal and southern area of the onshore export pipeline corridor. Minor seeps were observed in PRL-15 but no defined springs were identified, observed or sampled in the gas field area. Historical information regarding the detail of groundwater features identified was largely anecdotal with no records available for village wells and borelogs only available for two of the water supply bores at Herd Base (HB BH03 and HB BH04). It is likely that further springs and groundwater features exist throughout the study area, however the nature of the terrain and the vegetation make assessment of these features impractical.

The fieldwork undertaken provides preliminary assessment of groundwater quality and levels which may fluctuate or vary seasonally. Nonetheless, the findings of the assessment are considered adequate to characterize the baseline groundwater conditions in the study area for the purpose of impact assessment.

Due to the remote Project location and transport logistics, sample holding time exceedances have occurred for some water quality laboratory analytes. Holding time exceedances are discussed in **Section 6.5.** Details of all holding time breaches are provided in the laboratory certificates.

6 BASELINE CHARACTERIZATION

The baseline groundwater characterization of the study area is discussed in this section with respect to the results and findings of the field assessment undertaken.

6.1 General Groundwater Observations

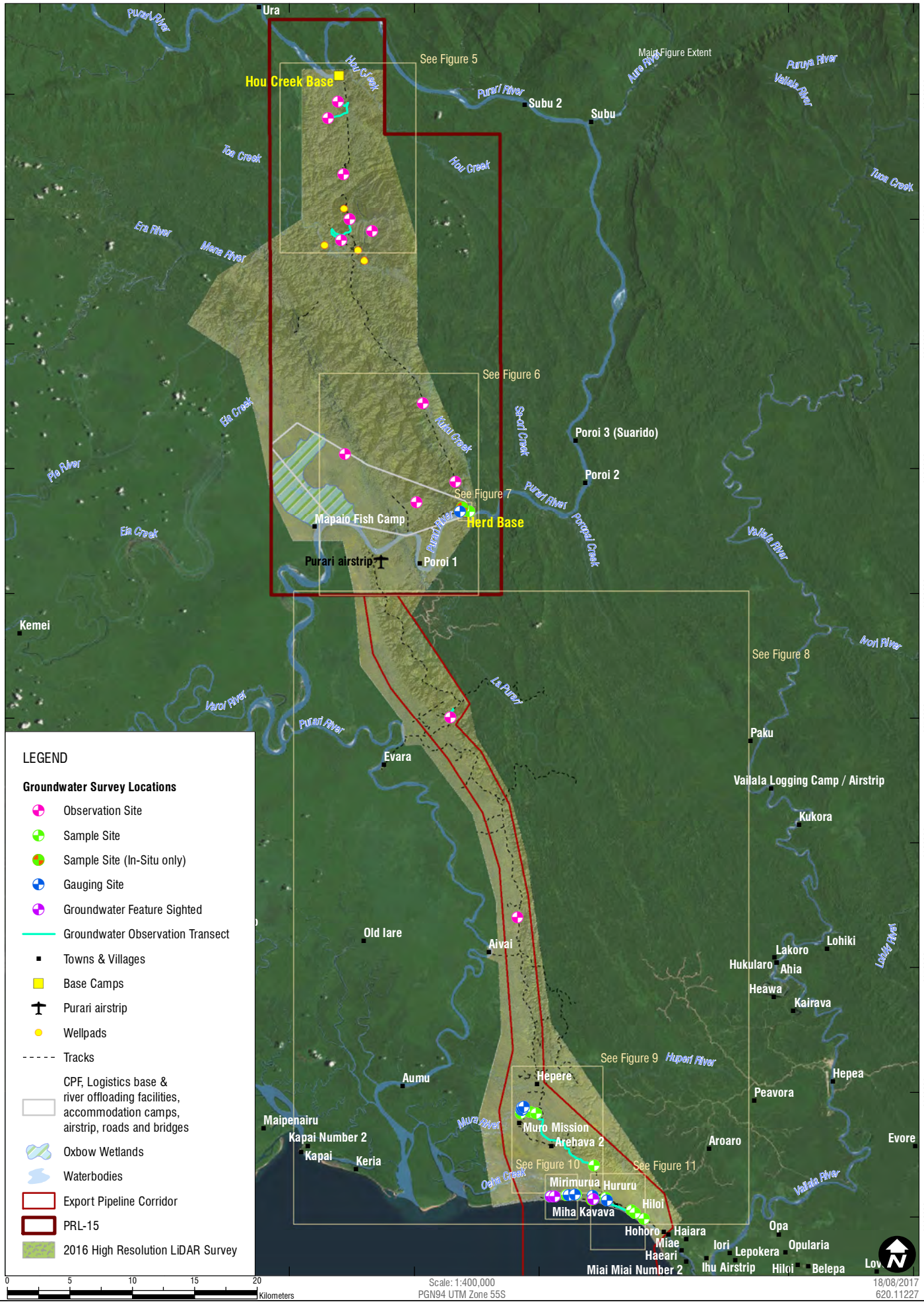
Observations to inform conceptualization of the groundwater systems within the study area were undertaken during the field survey. Observations made within PRL-15 included the identification of spring or seepage type erosional features and minor seepages on slopes and exposed faces. A number of minor groundwater seeps were observed within PRL-15 particularly in road (ANT-3 to ANT-5) or well pad bench cuttings (ANT-6), incised river channel banks (river cliffs) (ETL-2 and Fly Camp D) and at breaks in slope (CPF-01). These groundwater seeps are considered to represent minor springs indicative of features that are considered likely to be common and to have greater flows during and following rainfall events and during wetter periods. The seeps observed coincided with lower permeability material outcropping at surface such that further downward vertical movement of infiltrated water in upper weathered material is prevented and the water resurges at surface. The discharge rates at observed seeps at the time of the field work were very low, estimated to be less than a liter per minute. The observed seeps and features are described within **Appendix A** with accompanying photographs. No groundwater wells or bores were identified within PRL-15 with the exception of four bores located at Herd Base. **Figure 4** shows general observation locations in PRL-15 and along the onshore export pipeline corridor as well as sampling locations in the inland and coastal villages. **Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11** show the groundwater assessment locations in specific sections of the study area in more detail. The co-ordinates and brief descriptions of the general observation locations are provided in **Table 4**.

The groundwater observations were undertaken in the general areas marked, as well as during ground travel (by foot or motor vehicle) between locations.

Table 4 General Observation Locations

ID	Date	Latitude	Longitude	Description
ETL-1	15/11/16	-7.334094 -7.331881	145.218153 145.218869	Linear inspection of general landform including exposed road cutting, incised erosional channels and geology exposed in creek bed
ETL-2	15/11/16	-7.275084	145.194403	Inspection of relatively high riverbank
CPF Camp	15/11/16	-7.348632 -7.351128	145.189925 145.192179	Walking transect between CPF camp and former 'sky hole' to north
ANT-6	15/11/16	-7.151674	145.158232	Area around wellpad including backbench cutting
ANT-5	15/11/16	-7.158473	145.135954	Area around wellpad and approach road (driven) from ANT-3
ANT-3	15/11/16	-7.151674	145.158232	Area around wellpad, camp terraces and laydown areas and road to northwest from camp
Fly Camp E	16/11/16	-7.649710 -7.649679	145.262084 145.262542	Area around landing zone and in undisturbed forest up slope to east
Fly Camp B	16/11/16	-7.507576 -7.498484	145.213083 145.215621	Walked transect along logging road inspecting general landform including exposed road cuttings and erosional channels
Fly Camp D	16/11/16	-7.313363	145.138153	Immediate area around landing zone including river cliff and creek
Kuku Creek	16/11/16	-7.274080 -7.278895	145.194077 145.194751	Linear inspection of general landform along road to north and south of landing zone including eroded surfaces around main creek and drainage lines
Elk-2	17/11/16	-7.058136	145.134364	Area around wellpad including backbench cuttings and along road to south to Elk-3.
Elk-3	17/11/16	-7.070037	145.128234	Approach road to Elk-3 including road cuttings and drainage channels surrounding road
Elk-4	17/11/16	-7.110567 -7.110869	145.138112 145.138494	Area around wellpad and in revegetated forest to north east of wellpad
Coastal Transect 1	19/11/16	-7.853028 -7.852986	145.282127 145.301104	Linear transect (walked) on village tracks and paths from Harevavo to Iuku
Coastal Transect 2	20/11/16	-7.854497 -7.864345	145.315189 145.343135	Linear transect (walked) on village tracks and paths from Harevavo to Iuku
Southern Transect	21/11/16	-7.791833 -7.829332	145.263667 145.317699	Linear transect (walked) on village tracks and paths from Ere/Kilavi to Paevera

Notes: Where two sets of co-ordinates are included these represent the start and end points of on-ground transects walked or driven.



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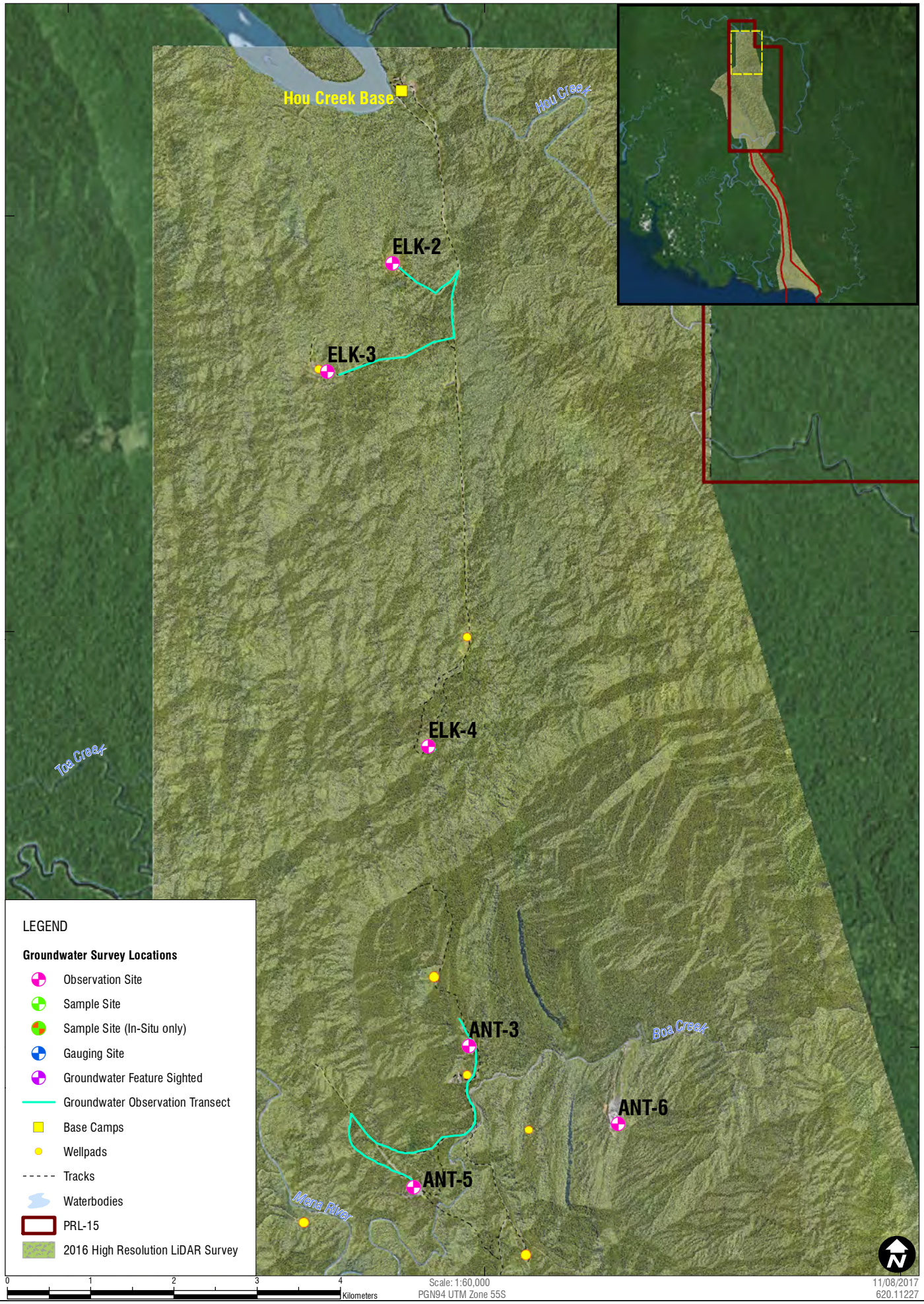
Groundwater Survey Location Overview

FIGURE 4



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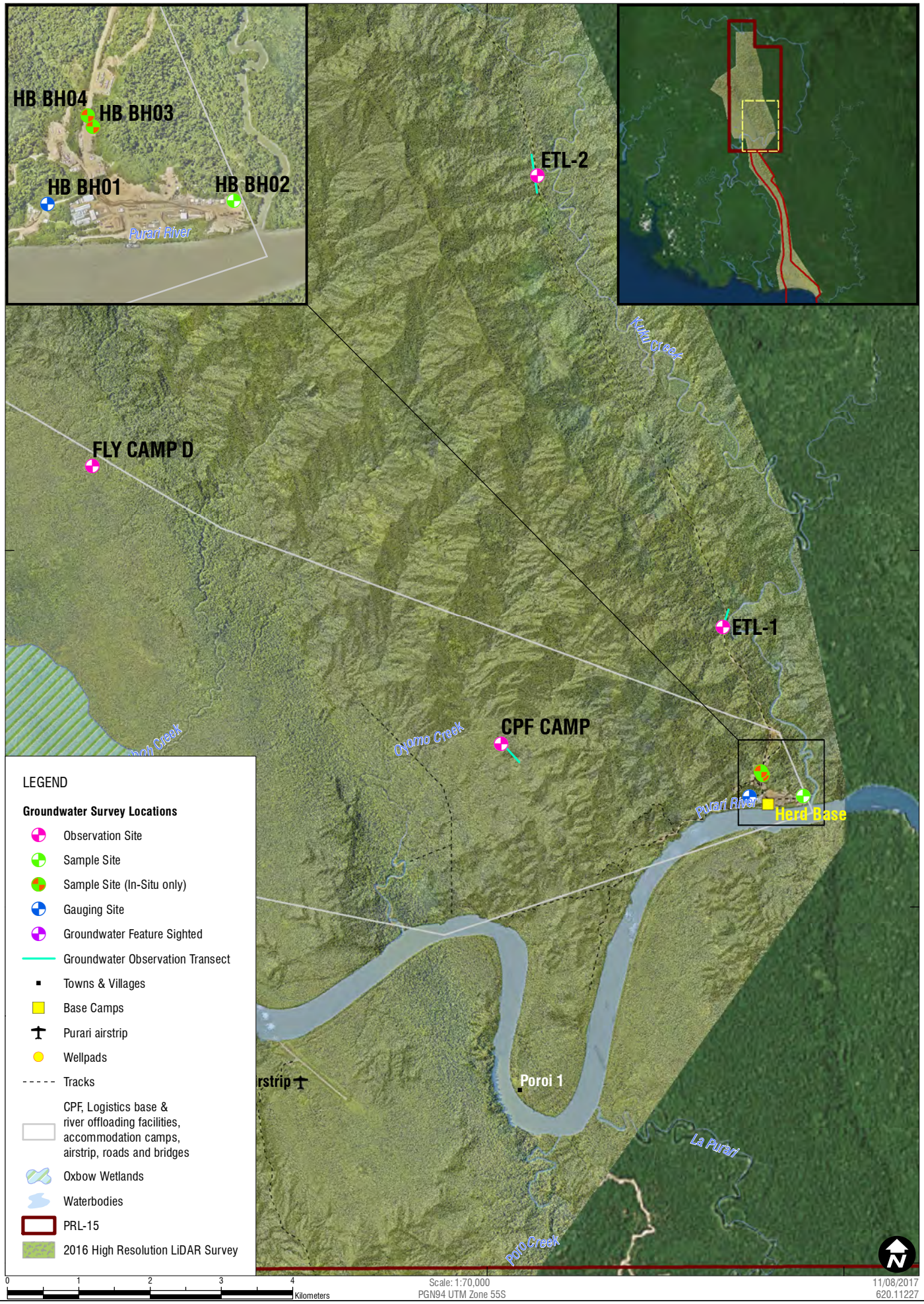
Elk & Antelope Groundwater Observation & Sampling Locations

FIGURE 5



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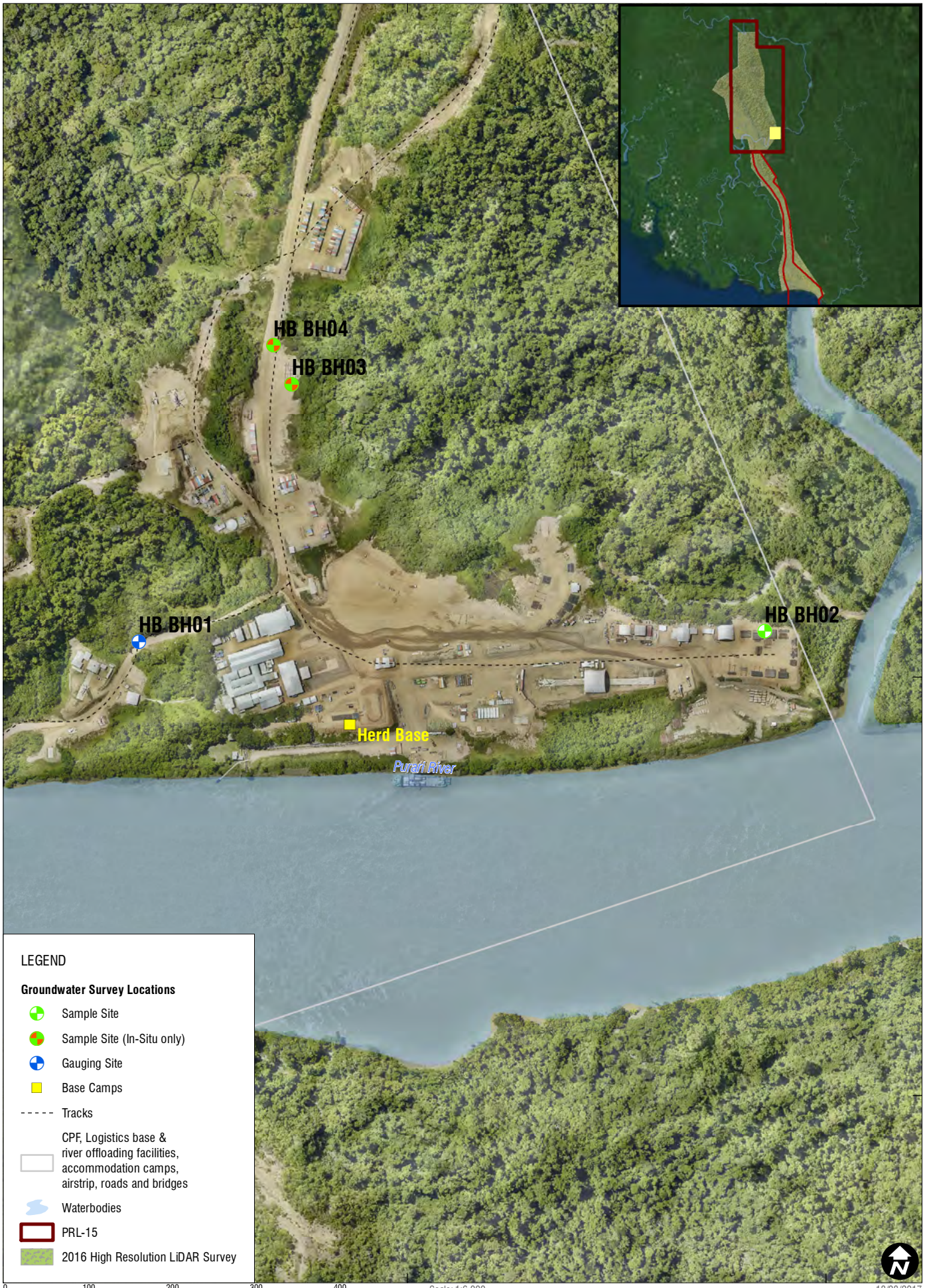
CPF and Herd Base Area Groundwater Observation & Sampling Locations

FIGURE 6



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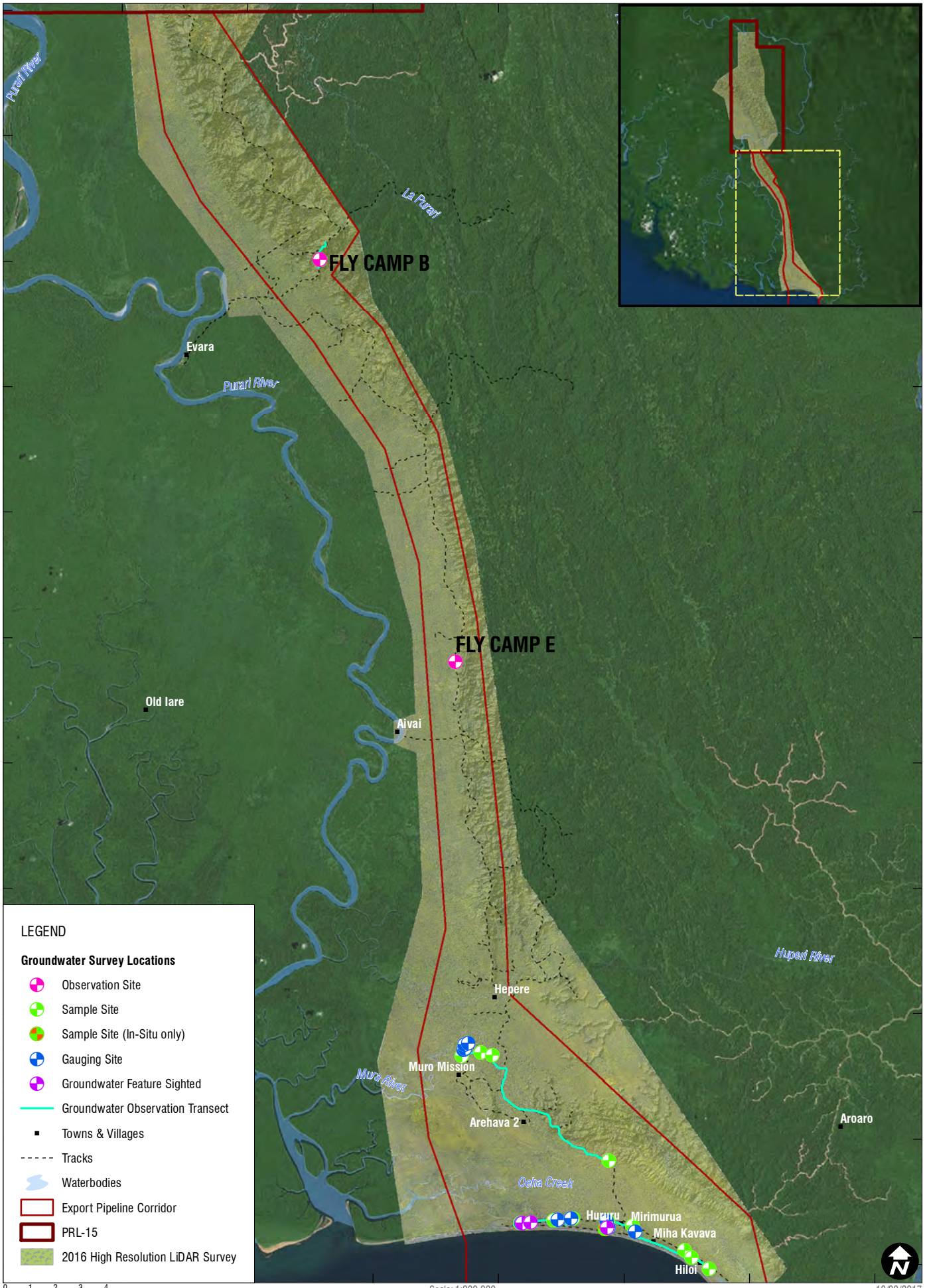
Herd Base Area Groundwater Observation & Sampling Locations

FIGURE 7



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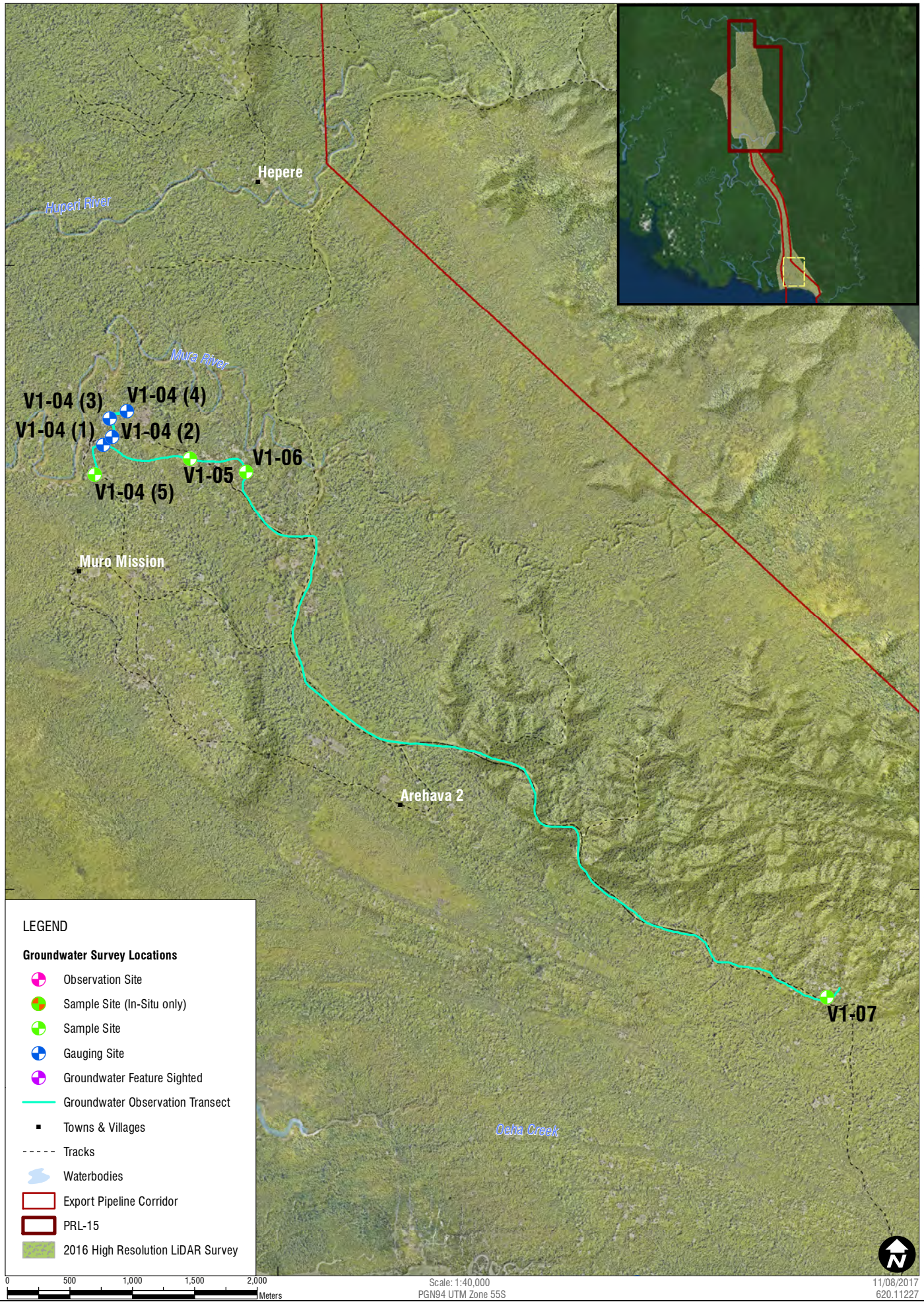
Onshore Export Pipeline Corridor Area Groundwater Observation & Sampling Locations

FIGURE 8



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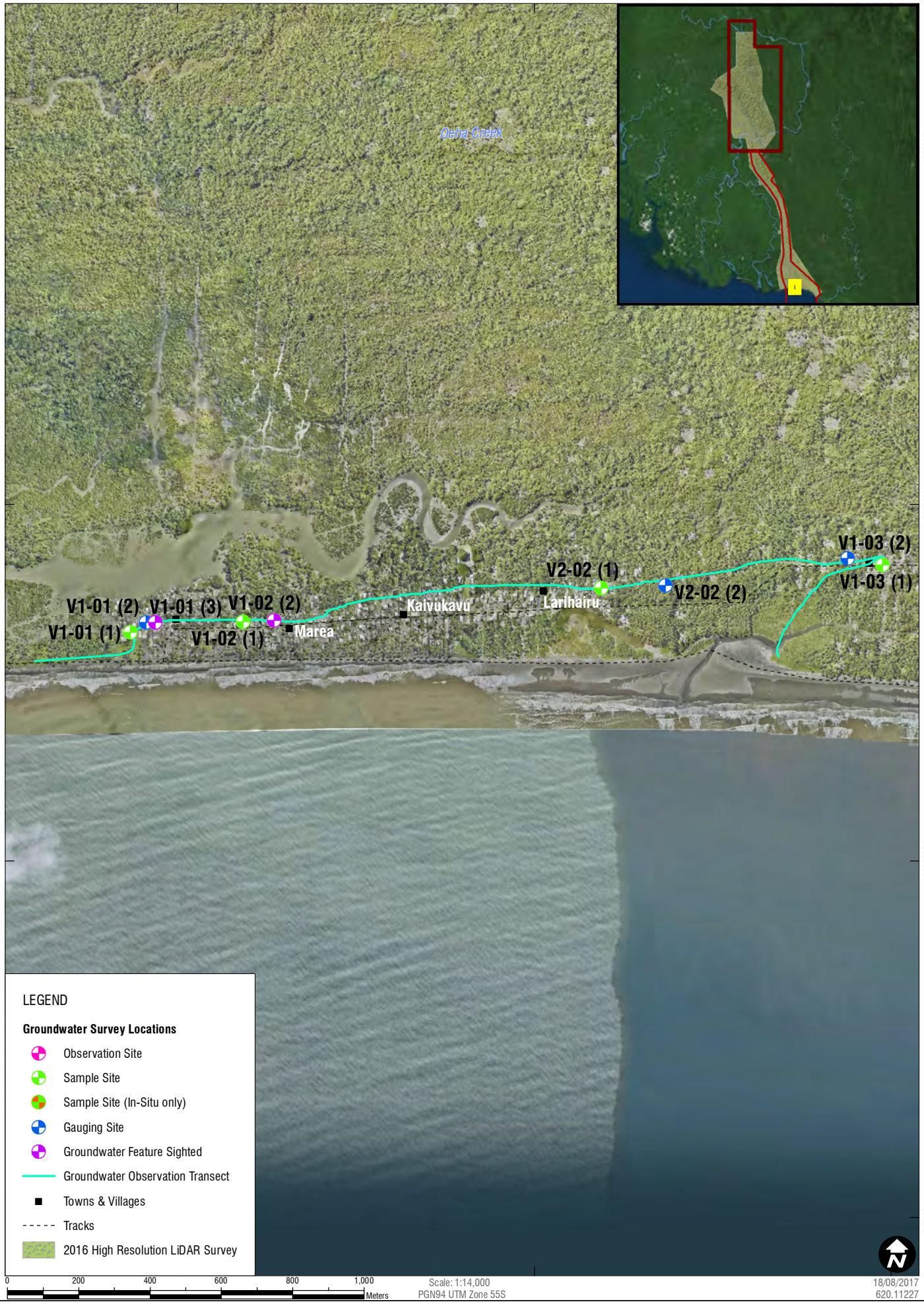
Inland Villages Area Groundwater Observation & Sampling Locations

FIGURE 9



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Western Coastal Villages Groundwater Observation & Sampling Locations

FIGURE 10

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Eastern Coastal Villages Area Groundwater Observation & Sampling Locations

FIGURE 11

6.2 Identified Groundwater Features

6.2.1 Assessment, Gauging and Sampling

A total of 31 groundwater features (wells, springs or bores) were observed and documented. The locations of identified groundwater features are shown in **Figure 4**, **Figure 5**, **Figure 6**, **Figure 7**, **Figure 8**, **Figure 9**, **Figure 10** and **Figure 11**. Details of the assessments are included in **Table 5**. Of the 31 groundwater features documented, water levels were gauged at 28, water quality was measured at 17 and samples were collected from 16. Laboratory analysis was undertaken on samples from 14 of these sites. Photographs of all sampled locations are included in **Appendix A**.

Table 5 Identified Groundwater Features

Bore ID	Date	Latitude	Longitude	Gauged	Field Water quality	Sampled	Analyzed	Description
HB BH01	16-11-2016	-7.35567°	145.22144°	✔	✘	✘	✘	Equipped groundwater supply well at Herd Base – infrequently used – experiences problems with sand ingress.
HB BH02	18-11-2016	-7.35558°	145.22822°	✔	✔	✔	✔	Equipped groundwater supply well at Herd Base workshops, used on a daily basis for vehicle and general wash water.
HB BH03	18-11-2016	-7.35289°	145.22311°	✔	✔	✔	✘	New water supply well drilled late 2015 – no longer considered viable due to sand invasion – sample not scheduled due to bore condition.
HB BH04	18-11-2016	-7.35247°	145.22292°	✔	✔	✔	✘	New water supply well drilled late 2015 – no longer considered viable due to sand invasion – sample not scheduled due to bore condition.
V1-01 (1)	19-11-2016	-7.85231°	145.28457°	✔	✔	✔	✔	Aid agency concrete ring communal well – regular use for wash and stock water occasional use during dry season for drinking water. Advised by community that well never dries.
V1-01 (2)	19-11-2016	-7.85208°	145.28497°	✔	✘	✘	✘	Traditional “palm stump” well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Wooden frame reduces surface water inflow. Communal use. Villagers use containers on string to collect water from the well.
V1-01 (3)	19-11-2016	-7.85207°	145.28521°	✘	✘	✘	✘	Coastal village Harevavo – large open well with wooden stabilization to reduce collapse and to prevent livestock from drinking directly from the well. Described by villagers as contaminated due to inflows of surface water entraining animal waste and other debris. Well had a number of live fish present
V1-02 (1)	19-11-2016	-7.85207°	145.28745°	✔	✔	✔	✔	Coastal village Kaivukavu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970s or 1980s. White PVC pipe shown in photograph is intake for hand pump located ~4m from well (seen in background). Water level is >0.5m below intake and pump is no longer operable (parts stripped).
V1-02 (2)	19-11-2016	-7.85204°	145.28823°	✘	✘	✘	✘	Coastal village Kaivukavu – Traditional “palm stump” well. Seen and photographed but no further assessment undertaken.
V1-03 (1)	19-11-2016	-7.85069°	145.30371°	✔	✔	✔	✔	Coastal village Iuku - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970’s or 1980s. White PVC pipe below water level is intake for hand pump located ~4m from well. Pump is no longer operable (parts stripped).
V1-03 (2)	19-11-2016	-7.85052°	145.30282°	✔	✘	✘	✘	Coastal village Iuku – Traditional “palm stump” well. Seen and photographed but no further assessment undertaken.
V1-04 (1)	21-11-2016	-7.78967°	145.26431°	✔	✘	✘	✘	Inland village Avavu - large open well with corrugated iron sheet cover and fencing. Used by 3 to 4 nearby households.
V1-04 (2)	21-11-2016	-7.78908°	145.26494°	✔	✘	✘	✘	Inland village Avavu - Traditional “palm stump” well. Hand excavated though stump of felled palm tree, less than 1 year old. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well and corrugated sheet cover used. Used by single household.
V1-04 (3)	21-11-2016	-7.78778°	145.26475°	✔	✘	✘	✘	Inland village Avavu – small shallow “spring” excavation. No obvious specific associated households, in “public or common space. Close (<5m) to small creek with iron staining.
V1-04 (4)	21-11-2016	-7.78725°	145.26603°	✔	✘	✘	✘	Inland village Avavu – large open hole with obvious collapses, very poor construction. Dug during 2015.
V1-04 (5)	21-11-2016	-7.79183°	145.26367°	✔	✔	✔	✔	Inland village Avavu - Traditional “palm stump” well. Hand excavated though stump of felled palm tree 2 years old. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well, fitted, hinged steel cover with wooden frame, well roofed and fenced. Used by single nearby household.

Bore ID	Date	Latitude	Longitude	Gauged	Field Water quality	Sampled	Analyzed	Description
V1-05	21-11-2016	-7.79069°	145.27058°	✔	✔	✔	✔	Inland village Ere - Large excavated spring, constructed by women's convention in 1997. Located close to tidal creek. Used by all villagers in Ere, during drought other villages (Kilavi, Avavu) use this water source.
V1-06	21-11-2016	-7.79167°	145.27467°	✔	✔	✔	✔	Inland village Kilavi - Large excavated spring. Located close to tidal creek occasionally floods from creek. Following inundation villages wait for some weeks before cleaning out sediment by hand.
V1-07	21-11-2016	-7.82992°	145.31669°	✔	✔	✔	✔	Inland village Paevera - Large excavated spring. Drain beneath bamboo planks in photograph allows water to flow to creek. Flow estimated to be ~2L/min.
V1-08 (1)	20-11-2016	-7.85456°	145.31519°	✔	✔	✘	✘	Coastal Village – Mareke (Coastal). Concrete ring well installed by householder, appears to be recycled materials from older aid organization well. Well is situated in large depression which appears to be water filled during wet periods. Well is open (sandy) at base. Used by single household. Some tadpoles present.
V1-08 (2)	20-11-2016	-7.85397°	145.31640°	✔	✘	✘	✘	Coastal Village – Mareke (Coastal). Corrugated iron large diameter well. Water appears to be poor quality and a large number of cane toads (dead and alive) present in the well. Located very close to households pit latrine. Private well not in use at present but will be cleaned out and used as dry season progresses.
V1-08 (3)	20-11-2016	-7.85404°	145.31591°	✘	✘	✘	✘	Coastal Village – Mareke (Coastal). Corrugated iron large diameter well. Silted up and with waste present, not in use. In common area, not associated with specific houses.
V1-08 (4)	20-11-2016	-7.85171°	145.31583°	✔	✘	✘	✘	Coastal Village – Mareke (inland). Small shallow open excavation used for washing and irrigation. In common area, not associated with specific houses.
V1-08 (5)	20-11-2016	-7.85166°	145.31617°	✔	✔	✔	✔	Coastal Village – Mareke (inland). Concrete ring well, constructed by householder using materials from road culvert. Daily use by single household.
V1-09	20-11-2016	-7.85546°	145.32600°	✔	✘	✘	✘	Coastal village Kavavu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970s or 1980s. Hand pump located ~4m from well. Pump is no longer operable (parts stripped).
V1-10	20-11-2016	-7.86887°	145.35271°	✔	✔	✔	✔	Coastal village Herakela – Well with steel drum casing, well is open at base. Well is approximately 7 years old. Used by a single household.
V1-11	20-11-2016	-7.86238°	145.34385°	✔	✔	✔	✔	Coastal village Lariau – Traditional "palm stump" well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well has corrugated steel sheet cover. Daily use by single household.
V1-12	20-11-2016	-7.86472°	145.34642°	✔	✔	✔	✔	Coastal village Oru – Traditional "palm stump" well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well. Daily use by single household.
V2-02 (1)	19-11-2016	-7.85124°	145.29655°	✔	✔	✔	✔	Coastal village Larihairu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970s or 1980s. White PVC pipe below water level is intake for hand pump located ~4m from well. Pump is no longer operable (parts stripped).
V2-02 (2)	19-11-2016	-7.85119°	145.29818°	✔	✘	✘	✘	Coastal Village – Larihairu - Small shallow open excavation, usage unknown. In common area, not associated with specific houses.
V2-03	20-11-2016	-7.85331°	145.32514°	✔	✔	✔	✔	Coastal village Mirimurua – Well with steel drum casing beneath house. Well is open at base. Well was in use for laundry at time of sampling. Used by a collection of households.

6.3 Field Results

Measured water levels are presented in **Table 6**. Results of in situ measurements are presented in **Table 7** and included together with laboratory analysis results in **Table 10** where they are compared against relevant screening criteria. A summary of the results is provided below, where the range of measured values and exceedances of the selected screening criteria are identified.

Table 6 Groundwater Level Measurements

ID	Date	Casing Stickup (m)	Diameter (mm)	Depth to Water (m bgl)	Depth to Base (m bgl)
HB BH01	16/11/2016	0.68	150	6.51	16.82
HB BH02	18/11/2016	0.74	150	6.46	18.96
HB BH03	18/11/2016	0.39	150	4.82	22.56
HB BH04	18/11/2016	0.45	150	3.04	17.77
V1-01 (1)	19/11/2016	0.12	910	2.06	2.68
V1-01 (2)	19/11/2016	0.10	~500	0.60	1.00
V1-02 (1)	19/11/2016	0.12	910	1.12	2.54
V1-03 (1)	19/11/2016	0.55	780	0.42	2.25
V1-03 (2)	19/11/2016	0.00	~700	0.40	not measured
V1-04 (1)	21/11/2016	0.00	~700	0.70	1.35
V1-04 (2)	21/11/2016	0.23	~500	1.07	1.77
V1-04 (3)	21/11/2016	0.00	~50 (square)	0.20	1.07
V1-04 (4)	21/11/2016	0.00	~1000 (square)	0.90	1.10
V1-04 (5)	21/11/2016	0.40	500	0.80	1.65
V1-05	21/11/2016	0.00	<2000	0.30	1.40
V1-06	21/11/2016	0.00	<2000	0.20	1.50
V1-07	21/11/2016	0.00	<2000	0.05	1.13
V1-08 (1)	20/11/2016	0.68	910	0.09	1.12
V1-08 (2)	20/11/2016	0.00	1600	0.85	1.20
V1-08 (4)	20/11/2016	0.00	~1000	0.60	1.00
V1-08 (5)	20/11/2016	0.02	780	1.08	2.08
V1-09	20/11/2016	0.24	910	0.59	2.19
V1-10	20/11/2016	-0.57	550	1.62	2.27
V1-11	20/11/2016	0.20	~500	1.30	1.60
V1-12	20/11/2016	0.30	580	0.96	1.50
V2-02 (1)	19/11/2016	0.90	780	0.76	2.43
V2-02 (2)	19/11/2016	0.00	~1000	0.30	not measured
V2-03	20/11/2016	0.50	550	0.82	1.92

Table 7 In-situ Water Quality Measurements

ID	Date	Time	Temp (ºC)	pH	ORP (mV)	EC (µS/cm)	Turbidity (NTU)	DO (mg/L)	DO (%)	TDS (mg/L)
HB BH02	18-11-2016	13:52	27.59	8.99	163	992	1.5	7.53	96.2	635
HB BH03	18-11-2016	11:04	28.10	9.47	161	915	39.9	7.54	97.5	586
HB BH04	18-11-2016	10:00	28.65	9.12	171	765	12.7	8.39	109.3	439
V1-01 (1)	19-11-2016	10:00	28.63	9.20	165	401	0.0	8.54	108.9	261
V1-02 (1)	19-11-2016	12:00	29.19	8.97	168	324	0.0	8.23	108.1	210
V1-03 (1)	19-11-2016	13:45	28.27	9.06	161	390	2.9	8.20	106.3	253
V1-04 (5)	21-11-2016	9:58	27.23	8.60	162	102	21.4	10.15	129	66
V1-05	21-11-2016	11:05	27.28	8.84	147	133	10.7	9.50	121.3	86
V1-06	21-11-2016	11:35	27.46	8.83	140	75	7.5	10.23	130.7	49
V1-07	21-11-2016	15:00	28.32	9.09	125	131	5.6	9.27	120.1	85
V1-08 (1)	20-11-2016	9:52	26.67	9.29	169	222	54.8	8.60	112.4	140
V1-08 (5)	20-11-2016	10:40	27.83	9.05	167	254	0.0	8.85	114.3	62
V1-10	20-11-2016	14:40	27.72	9.28	144	246	12.4	8.75	111.5	160
V1-11	20-11-2016	13:20	27.26	9.27	143	154	1.1	8.84	112.8	100
V1-12	20-11-2016	15:22	28.89	9.40	123	115	0.0	8.28	108.3	75
V2-02 (1)	19-11-2016	12:30	28.74	9.14	159	371	0.3	8.56	111.2	241
V2-03	20-11-2016	11:33	27.48	9.21	157	314	26.4	8.83	113.4	204
		Maximum	29.20	9.50	171	992	54.8	10.20	130.7	640
		Minimum	26.70	8.60	123	75	0.0	7.50	96.2	50
		Average	28.00	9.10	154	347	11.6	8.70	112.4	210

6.3.1.1 Groundwater Levels

The groundwater features assessed during the field survey fall into two categories:

- Drilled groundwater supply bores at Herd Base; or
- Hand dug or natural wells and springs in villages within the onshore export pipeline corridor.

The bores at Herd Base are between 16.80 and 22.56 m in depth, with groundwater levels measured to be from 3.04 to 6.51 meters below ground level (m bgl). The village wells and springs are between 1.0 and 2.68 m in depth, with groundwater levels measured in the range 0.05 to 2.06 m bgl.

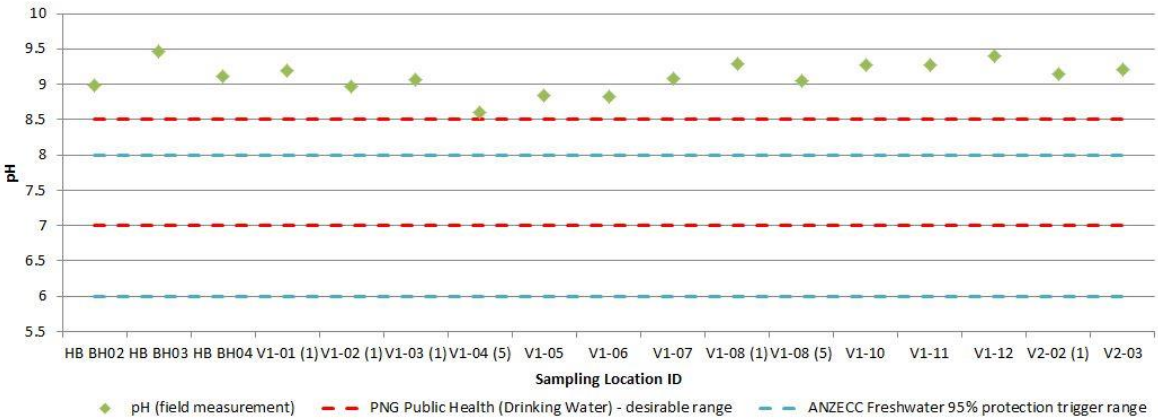
6.3.1.2 Temperature

Groundwater temperatures were in the range 26.7 to 29.2 ºC with an average of 28.0 ºC. Ambient air temperatures during the survey period were approximately 30 ºC.

6.3.1.3 pH

The pH of groundwater was in the range 8.6 to 9.5 with a median value of 9.1 see **Figure 12**. The most alkaline reading was measured at HB BH03, one of the water supply bores at Herd Base. All field pH measurements exceeded the highest desirable level aesthetic standard (pH 8.5) from the Papua New Guinea Public Health (Drinking Water) Regulations (PNG DWR), 1984, the World Health Organization Drinking Water Guidelines (WHO DWG) aesthetic pH maximum (pH 8.0) and the ANZECC freshwater ecosystem protection (ANZECC FEP) guideline pH maximum (pH 8.0). In addition, at six of the 17 locations measured pH exceeded the maximum permissible level aesthetic standard (pH 9.2) from the PNG DWR. Of these six groundwater features, five (V2-03, V1-11, V1-10, V1-08 (1) and V1-12) are currently used by local communities for water supply.

Figure 12 Groundwater pH – Field Measurements



The pH measured is potentially a product of the dominant ions present, i.e., magnesium, calcium and carbonate, as indicated by the water type analysis discussed in **Section 6.5.1.**

6.3.1.4 Dissolved Oxygen

Dissolved oxygen (DO) concentrations were in the range 7.53 to 10.23 mg/L, with percentage saturation ranging from 96 to 131%. These measured values are in line with the oxidation-reduction potential (ORP) readings (discussed below) and indicate that the water is well-oxygenated. The dissolved oxygen concentrations are all greater than the water quality criteria for freshwater (>6 mg/L) provided within the PNG Environment Regulation (ER), 2002. No guideline values are provided within ANZECC FEP or the PNG DWR and WHO DWG. The measured dissolved oxygen concentrations are considered to be high for groundwater. This is likely to be a result of various factors including, the shallow depth to groundwater allowing interaction between water and atmosphere, the rapid rates of rainwater infiltration (particularly in the coastal areas and the low amount of organic matter (and therefore biological oxygen demand)) likely in relatively homogenous sand aquifer material. The construction of the groundwater features assessed, with large area of air-water interface is also likely to promote high dissolved oxygen concentrations. Limitations of the sampling method that may have contributed to the high DO concentrations measured are discussed in **Section 5.3.3**.

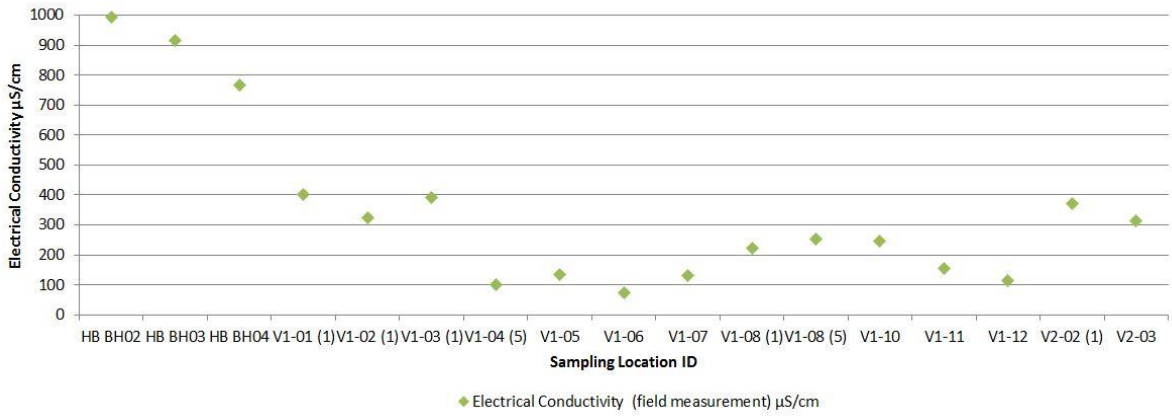
6.3.1.5 Oxidation-Reduction Potential

Oxidation-reduction potential (ORP) measured at the groundwater assessment sites was in the range 123 to 171 mV. No guideline values for ORP are provided within the project groundwater quality criteria. The results of ORP or redox potential measurements in clean water environments have limited value where no known dominant redox active chemical species are present. The high ORP measured at the groundwater locations assessed is likely to be a result of the relatively oxic shallow groundwater environment and large area of air-water interface within the large diameter wells common within this assessment (as discussed in **Section 6.3.1.4**).

6.3.1.6 Electrical Conductivity

The groundwater in bores at Herd Base had electrical conductivity (EC) in the range 765 to 992 µS/cm, which is considered toward the upper range of 'good' drinking water. The conductivity of groundwater in the village springs and wells was lower, being in the range 75 to 401 µS/cm. Results of field electrical conductivity measurement are presented in **Figure 13**. The low conductivities in village wells close to the coast suggest that salt water impact to the shallow groundwater has not occurred either through intrusion or overland flow (e.g. storm surges).

Figure 13 Groundwater Electrical Conductivity – Field Measurements



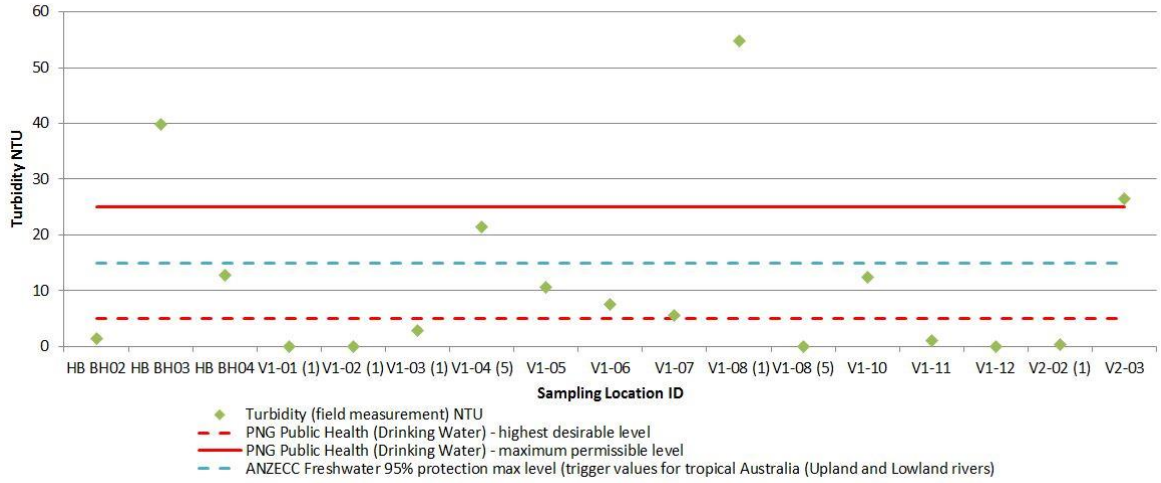
6.3.1.7 Total Dissolved Solids

Total dissolved solids (TDS) were measured in the range 50 to 640 mg/L with an average of 0.21 mg/L. With the exception of measurements from three locations which were greater than the WHO DWG (600 mg/L) these levels are considered acceptable for drinking water, based on aesthetic considerations. The TDS readings are consistent with measured electrical conductivities and therefore the TDS measurements further support the interpretation that seawater has not impacted the groundwater sampled.

6.3.1.8 Turbidity

The turbidity of assessed groundwater was in the range 0.0 to 54.8 NTU (as shown in **Figure 14**), with an average of 11.6 NTU. It is noted that turbidity greater than 5 NTU is considered to be aesthetically unacceptable to most water consumers. Of the 17 locations where turbidity was measured, nine exceeded the PNG DWR highest desirable level (5 NTU) which is equal to the WHO DWG. . In addition, at three of the 17 locations where turbidity was measured, the maximum permissible level (25 NTU) from the same regulation was exceeded. Of these three groundwater features, two (V2-03 and V1-08 (1)) are currently used by local communities for water supply, whilst the third is a supply bore at Herd Base (HB BH03). The field measurements of turbidity were within the ANZECC FEP range of trigger values provided within ANZECC FEP for upland and lowland rivers (in tropical Australia) with the exception of four samples which were above this range.

Figure 14 Groundwater Turbidity – Field Measurements



6.4 Laboratory Results

Water samples collected at 14 sites were submitted to ALS Brisbane for analysis of the following suite:

- Total petroleum hydrocarbons (TPH), Total recoverable hydrocarbons (TRH), benzene, toluene, ethylbenzene and xylene (BTEX) and polycyclic aromatic hydrocarbons (PAH);
- Total suspended solids (TSS);
- Total nitrogen, total phosphorus, nitrate/nitrite, ammonia and orthophosphate;
- Total and dissolved metals (Al, As, Ag, Ba, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Se, V, Zn);
- Total organic carbon (TOC);
- Dissolved organic carbon (DOC);
- Major cations and anions; including alkalinity; and
- Microbiological – total coliforms and fecal streptococci (enterococci).

Note: Laboratory analysis for petroleum hydrocarbons has been reported as both TPH and TRH. Both report the results of the same extraction method that assesses the concentrations of the same compounds. The TRH reporting convention was introduced as a way of improving consistency of reporting hydrocarbon analysis results and specifically relates to Australian assessment guidance. TRH results are therefore not relevant for the purposes of this assessment.

The results of analysis undertaken are discussed in the following sections with data summarized in **Table 10** and laboratory certificates of analysis included as **Appendix B. Table 10** highlights results exceeding the adopted screening criteria, described in **Section 2.4**.

6.4.1 Quality Assurance and Quality Control

A single field duplicate was collected during the sampling field work. The results of laboratory analysis of this duplicate sample have been compared to the relevant primary sample in order to calculate relative percentage difference (RPD). RPD is a statistical indicator of precision of the laboratory results. RPD values greater than 50% are considered to represent a cause for concern and that investigation into the cause of the discrepancy should be undertaken. Where either primary or duplicate samples had concentrations of an analyte below the laboratory level of reporting, the RPD was not calculated. A summary of RPD exceedances (>50%) is included in **Table 8** below with full RPD results included in **Table 11**.

Table 8 Summary of RPD Exceedances

Primary Sample ID	Duplicate Sample ID	Analyte	Primary Result	Duplicate Result	RPD %
HB BH02	DUP 1	Ionic Balance %	0.04	0.58	**174.2**
HB BH02	DUP 1	Total Coliforms MPN/100mL	40	79	**65.5**

There were only two RPD exceedances, identified for ionic balance and total coliforms. The laboratory report qualifies the discrepancy in ionic balance as being due to the contribution of analytes not quantified in this report. The second RPD exceedance was for total coliforms by MPN. This analytical method uses statistical interpretation of confirmed coliform presence (rather than a coliform count) in a number aliquots from the same sample. The statistical nature of this method means that minor differences in a number of positive detections in individual aliquots are magnified in the final result and this can affect precision.

6.5 Laboratory Quality Assurance and Quality Control

ALS Environmental Ltd (ALS) undertook the laboratory analysis of all samples with the exception of microbiological samples which were analyzed by DTS Food Laboratories. The following internal data validation processes were used by ALS to determine the accuracy and precision of results and to assess the reliability of the data. **Table 9** outlines the analytical data validation criteria, qualifications to the data and the overall quality control (QC) procedures used for the laboratory-testing program. The full results of laboratory QC are included in the ALS Quality Control Report within **Appendix B.**

Table 9 Laboratory Quality Control

Protocol	Description
Holding Times	Holding times are the maximum permissible elapsed time in days from the collection of the sample to its extraction and/or analysis.
Laboratory Duplicates	The quality control term Laboratory Duplicate refers to a randomly selected intra-laboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%
Method / Laboratory Blank	The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.
Matrix Spikes/Matrix Spike Duplicates	The quality control term Matrix Spike (MS) refers to an intra-laboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference

The results of the laboratory quality control program showed that there were outliers associated with the sample holding times for nitrate and reactive phosphorus. All other analytes were extracted and analyzed within the required holding times.

The results of the remaining laboratory QC procedures were acceptable with the exception of laboratory duplicates and matrix spikes for PAH and TRH (semi-volatile components) (see note regarding TRH in **Section 6.4)**, which were considered by the laboratory as QC outliers as they failed to conduct the analysis for these species in the QC samples.

The identified QC outliers are not considered to compromise the usefulness of the laboratory result provided as the potential for impact to groundwater from nitrate and reactive phosphorus is considered low and PAH and TRH concentrations were below the laboratory limit of reporting in all samples analyzed.

The laboratory QA program indicates that the laboratory data was obtained under appropriate sample analysis QC and that the certificate of analysis is reliable for the purposes of this assessment.

6.5.1 Major Ions and Alkalinity

Major cations (magnesium (Mg), calcium (Ca), sodium (Na), and potassium (K)) and anions (chloride (Cl), sulfate (SO_4)) together with carbonate and bicarbonate alkalinity can be used to describe a geochemical "signature" of sampled water. This geochemical signature can be used to interpret the possible origin of and/or relationships between analyzed waters.

The results of major ion and alkalinity analysis have been used to construct a Piper trilinear plot, presented as **Figure 15**. This show the relative proportions of the major ions and allows interpretation regarding the similarity of samples to be made. In addition to the groundwater results, surface water (fresh water) data from sampling undertaken by BMT WBM within PRL-15 for the Project in July 2016 (BMT WBM, 2016) has been plotted.

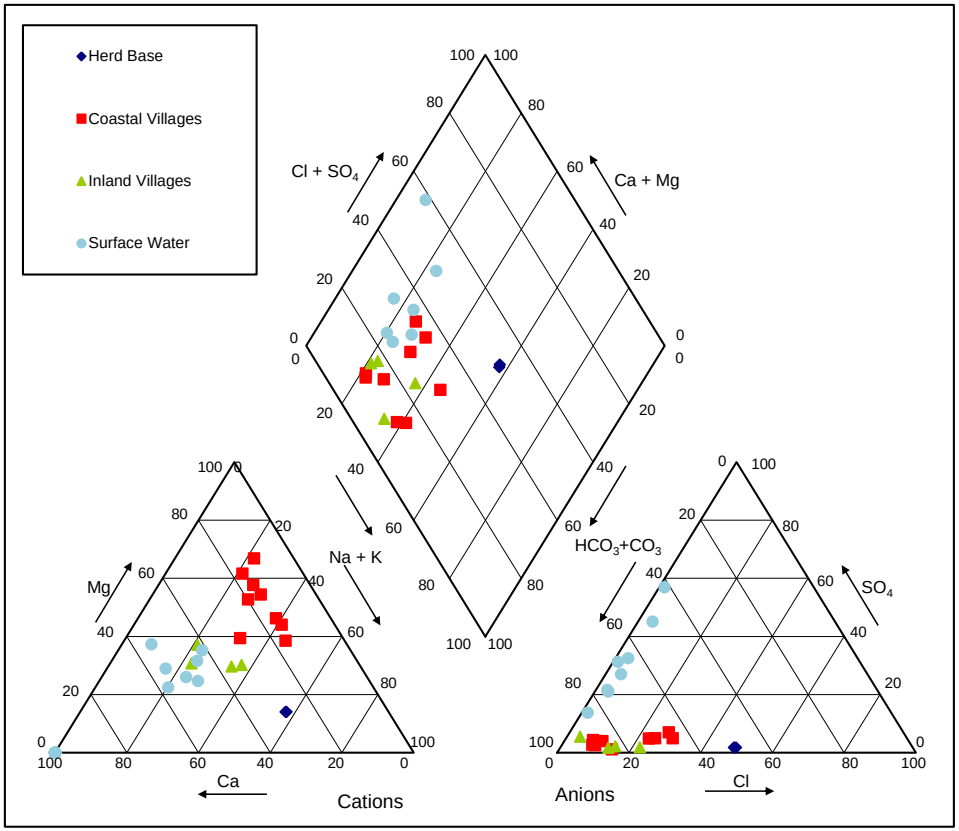
The data has been split into four groups for presentation related to the type of sampling location. The groups are Herd Base (supply bore), Coastal Villages (shallow wells), Inland Villages (shallow wells and springs) (as defined in **Section 3.4**) and Surface Water (rivers and streams). Previous interpretation by BMT WBM of the surface water samples showed them to be broadly similar in composition and classified as calcium-carbonate type waters. In comparison, the coastal village groundwater results show magnesium to be the dominant cation and carbonate to be the dominant anion. These groundwaters are therefore described as magnesium-carbonate type.

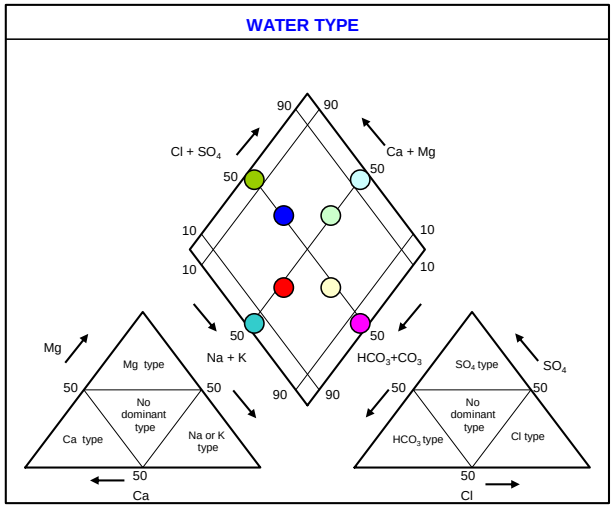
The inland village's groundwater is similar in signature to the surface water results though with slightly higher chloride concentrations and lower calcium dominance. These waters can still be broadly described as calcium-carbonate type.

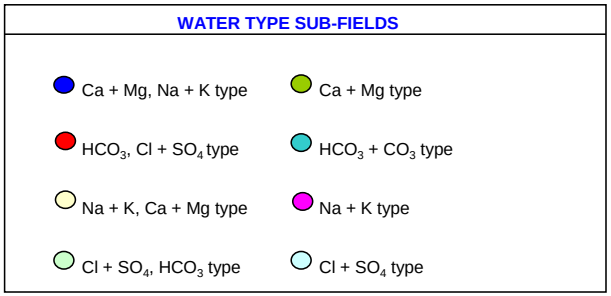
The carbonate dominance within analyzed waters may be the cause of the alkaline pH levels measured at the sampling locations, as described in **Section 6.3.1.3**.

The similarity of ground and surface water types suggests that there is some linkage between the two systems and that both are likely to be recharged quickly by rainfall, with shallow groundwater being very young and readily replenished by rainwater recharge moving through the system.

The results of major ion and alkalinity analysis are also included in **Table 10** together with relevant screening criteria. All major ions measured were at concentrations below the relevant drinking water criteria at all locations sampled. Potassium was measured at concentrations in excess of the PNG ER guideline value for freshwater (5 mg/L) at seven locations to a maximum concentration of 13 mg/L at V1-03(1). ANZECC FEP does not propose any standards for major ion concentrations or alkalinity and where guideline values are provided within PNG DWR for major ions no exceedances were measured.







Piper Diagram

Date: 01-12-2016	Project:	Papua LNG Project	Description: Upstream Groundwater Baseline Report
	Project No:	620.11227.00400	Client: TOTAL E&P PNG Limited

Figure 15 Piper Tri-linear Plot of Major Ions – Groundwater Data (SLR November 2016), Surface Water (BMT WBM June/July 2016)

Table 10 - Groundwater Results Summary

Analyte	Environment (Water Quality Criteria) Regulation 2002 - Schedule 1 Environment Act 2000	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000	Public Health (Drinking Water) Regulation 1984 - Standards for Drinking Water			World Health Organization Guidelines for Drinking-water Quality		Client sample ID (1st):		HB BH02	DUP 01	V1 - 01(1)	V1 - 02(1)	V1 - 03(1)	V1 - 04(5)	V1 - 05	V1 - 06	V1 - 07	V1 - 08(5)	V1 - 10	V1 - 11	V1 - 12	V2 - 02(1)	V2 - 03
								ALS Sample number:		EB1627934009	EB1627934010	EB1627934014	EB1627934008	EB1627934011	EB1627934017	EB1627934015	EB1627934016	EB1627934013	EB1627934002	EB1627934001	EB1627934005	EB1627934003	EB1627934007	EB1627934004
			Toxic Standards	Aesthetic and other qualities standards				Sampling Date		18/11/2016	18/11/2016	19/11/2016	19/11/2016	19/11/2016	21/11/2016	21/11/2016	21/11/2016	19/11/2016	20/11/2016	20/11/2016	20/11/2016	20/11/2016	19/11/2016	20/11/2016
	Fresh-water	Trigger Values for freshwater 95% Protection level	Upper Limit of Concentration	Highest desirable level	Maximum permissible level	Health	Aesthetic	Units	LOR	Herd Base	Herd Base - duplicate of HB BH02	Coastal Village - Harevavo	Coastal Village - Kiavukavu	Coastal Village - Iuku	Inland Village - Avavu	Inland Village - Ere	Inland Village - Kilavi	Inland Village - Paevera	Coastal Village - Mareke	Coastal Village - Herakela	Coastal Village - Lariau	Coastal Village - Oru	Coastal Village - Larihairu	Coastal Village - Mirimurua
General Parameters																								
Temperature	No Change >2°C	*/-20%	-	-	-	-	-	°C		27.59	27.59	28.63	29.19	28.27	27.23	27.28	27.46	28.32	27.83	27.72	27.26	28.89	28.74	27.48
pH	No change	6.0-8.0[+10]	-	7.0-8.5	6.5-9.2	-	6.5-8			8.99	8.99	9.2	8.97	9.06	8.6	8.84	8.83	9.09	9.05	9.28	9.27	9.4	9.14	9.21
Oxidation-Reduction Potential (ORP)	-	-	-	-	-	-	-	mV		163	163	165	168	161	162	147	140	125	167	144	143	123	159	157
Electrical Conductivity	-	20-250[+10]	-	-	-	-	-	µS/cm		992	992	401	324	390	102	133	75	131	254	246	154	115	371	314
Turbidity	No Change >25	2-15[+10]	-	5	25	-	5	NTU		1.5	1.5	0	0	2.9	21.4	10.7	7.5	5.6	0	12.4	1.1	0	0.3	26.4
Dissolved Oxygen	>6	-	-	-	-	-	-	mg/L		7.53	7.53	8.54	8.23	8.2	10.15	9.5	10.23	9.27	8.85	8.75	8.84	8.28	8.56	8.83
Dissolved Oxygen	-	85-120%[+10]	-	-	-	-	-	%		96.2	96.2	108.9	108.1	106.3	129	121.3	130.7	120.1	114.3	111.5	112.8	108.3	111.2	113.4
Total Dissolved Solids (TDS)	-	-	-	500	1500	-	600	mg/L		635	635	261	210	253	66	86	49	850	615	160	100	75	241	204
Suspended Solids (SS)	-	-	-	-	-	-	-	mg/L	5	12	11	<5	8	5	<5	5	<5	<5	<5	8	499	15	44	9
Alkalinity																								
Hydroxide Alkalinity as $CaCO_3$	-	-	-	-	-	-	-	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	-	-	-	-	-	-	-	mg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	-	-	-	-	-	-	-	mg/L	1	288	290	169	124	194	45	63	40	51	128	124	75	53	140	115
Total Alkalinity as $CaCO_3$	-	-	-	200[*3]	600[*3]	-	-	mg/L	1	288	290	169	124	194	45	63	40	51	128	124	75	53	140	115
Major ions																								
Calcium	-	-	-	75	200	-	100	mg/L	1	60	61	14	12	18	10	13	6	9	10	6	6	5	24	10
Magnesium	-	-	-	30[*4]	150	-	-	mg/L	1	18	18	30	17	29	4	7	3	5	22	22	11	9	20	22
Sodium	-	-	-	-	-	-	200	mg/L	1	138	138	25	33	21	5	7	6	11	11	12	15	13	26	15
Potassium	5	-	-	-	-	-	-	mg/L	1	3	3	11	8	13	<1	<1	<1	<1	6	3	4	5	8	7
Sulfate as SO_4	400	-	-	200	400	-	250	mg/L	1	8	8	9	7	2	<1	1	2	<1	3	3	3	2	12	7
Chloride	-	-	-	200	1000	-	250	mg/L	1	164	169	32	26	20	5	6	1	9	8	7	4	4	35	31
Ionic Balance																								
Total Anions	-	-	-	-	-	-	-	meq/L	0.01	10.5	10.7	4.47	3.36	4.48	1.04	1.45	0.87	1.27	2.84	2.74	1.67	1.21	4.03	3.32
Total Cations	-	-	-	-	-	-	-	meq/L	0.01	10.6	10.6	4.54	3.64	4.53	1.04	1.53	0.81	1.34	2.94	2.71	1.96	1.68	4.18	3.14
Ionic Balance	-	-	-	-	-	-	-	%	0.01	0.04	0.58	0.78	4.02	0.54	----	----	----	----	----	----	----	----	1.76	2.74
Dissolved Metals (ecosystem protection)																								
Aluminum	-	0.055[*11]	-	-	-	-	-	mg/L	0.01	<0.01	<0.01	<0.01	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	0.02	<0.01	<0.01
Arsenic	0.05	0.013[*12]	-	-	-	-	-	mg/L	0.001	0.009	0.009	0.01	0.003	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	0.001	0.002	0.001
Barium	1	-	-	-	-	-	-	mg/L	0.001	0.03	0.03	0.001	0.001	0.01	<0.001	0.03	0.003	0.002	0.001	0.001	0.002	<0.001	0.002	0.001
Cadmium	0.01	0.00001[*13]	-	-	-	-	-	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	0.05[*7]	0.0006[*7*13]	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	0.001[*8]	-	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	1	0.0014[*13]	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	0.002	0.003	0.002	0.002	<0.001	0.002	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	0.005	0.0034[*13]	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	1	0.011[*13]	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	0.01	0.011	-	-	-	-	-	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	0.05	0.00005	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001
Vanadium			-	-	-	-	-	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	5	0.008	-	-	-	-	-	mg/L	0.005	<0.005	<0.005	0.007	0.007	0.011	0.006	0.016	<0.005	<0.005	0.012	0.008	<0.005	0.006	<0.005	0.011
Iron	1	-	-	-	-	-	-	mg/L	0.05	2.18	2.26	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	0.06	<0.05	<0.05
Mercury	0.0002	0.0006[*14]	-	-	-	-	-	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Total Metals (drinking water)																								
Aluminum	-	-	-	-	-	-	-	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.03	0.13	<0.01	0.02	0.02	0.30	0.07	0.02	0.01
Arsenic	-	-	0.05	-	-	0.01	-	mg/L	0.001	0.01	0.01	0.01	0.003	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.002	<0.001	0.003	0.002
Barium	-	-	-	-	-	0.7	-	mg/L	0.001	0.04	0.04	0.001	<0.001	0.004	<0.001	0.002	0.01	0.004	0.001	0.003	0.002	<0.001	0.002	0.005
Cadmium	-	-	0.01	-	-	0.003	-	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	-	-	-	-	-	0.05	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	-	-	-	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	-	-	-	0.05	1.5	2	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	-	-	-	0.1	-	0.01	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	-	-	-	-	-	0.07	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	-	-	0.01	-	-	0.04	-	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	-	-	0.05	-	-	-	-	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	-	-	-	-	-	-	-	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	-	-	-	2	15	-	3	mg/L	0.005	<0.005	<0.005	0.01	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	0.012	0.006	0.02	<0.005	<0.005	0.01
Iron	-	-	-	0.1	1	-	0.3	mg/L	0.05	3.05	3.02	0.1	<0.05	0.64	0.89	0.81	0.49	0.08	0.14	1.21	0.89	0.36	0.16	1.11
Mercury	-	-	0.001	-	-	0.006	-	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Fluoride																								
Fluoride	1.5	-	-	1	1.5	1.5	-	mg/L	0.1	0.2	0.2	0.1	0.1	0.2	<0.1	<0.1	<0.1	<0.1	0.1	0.1	0.2	0.1	0.1	<0.1

Table 10 - Groundwater Results Summary

Analyte	Environment (Water Quality Criteria) Regulation 2002 - Schedule 1 Environment Act 2000	Australian and New Zealand Guidelines for Fresh and Marine Water Quality, 2000	Public Health (Drinking Water) Regulation 1984 - Standards for Drinking Water			World Health Organization Guidelines for Drinking-water Quality		Client sample ID (1st):		HB BH02	DUP 01	V1 - 01(1)	V1 - 02(1)	V1 - 03(1)	V1 - 04(5)	V1 - 05	V1 - 06	V1 - 07	V1 - 08(5)	V1 - 10	V1 - 11	V1 - 12	V2 - 02(1)	V2 - 03
								ALS Sample number:		EB1627934016	EB1627934013	EB1627934005	EB1627934015	EB1627934002	EB1627934004	EB1627934003	EB1627934007	EB1627934001	EB1627934010	EB1627934009	EB1627934011	EB1627934014	EB1627934017	EB1627934008
			Toxic Standards	Aesthetic and other qualities standards				Sampling Date		21/11/2016	19/11/2016	20/11/2016	21/11/2016	20/11/2016	20/11/2016	20/11/2016	19/11/2016	20/11/2016	18/11/2016	18/11/2016	19/11/2016	19/11/2016	21/11/2016	19/11/2016
	Fresh-water	Trigger Values for freshwater 95% Protection level	Upper Limit of Concentration	Highest desirable level	Maximum permissible level	Health	Aesthetic	Units	LOR	Herd Base	Herd Base - duplicate of HB BH02	Coastal Village - Harevavo	Coastal Village - Kiavukavu	Coastal Village - Iuku	Inland Village - Avavu	Inland Village - Ere	Inland Village - Kilavi	Inland Village - Paevera	Coastal Village - Mareke	Coastal Village - Herakela	Coastal Village - Lariau	Coastal Village - Oru	Coastal Village - Larihairu	Coastal Village - Mirimurua
Nutrients																								
Ammonia as N	0.05 [*9]	0.9	-	-	-	-	35	mg/L	0.01	2.39	2.36	0.15	0.06	0.05	0.03	0.02	0.08	0.02	0.01	0.04	0.02	0.11	0.07	0.03
Nitrite as N	-	-	-	-	-	3	-	mg/L	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	45	0.7	45	-	-	50	-	mg/L	0.01	0.03	0.03	0.1	1.03	<0.01	0.02	0.02	0.02	<0.01	0.04	<0.01	0.02	0.09	0.09	0.21
Nitrite + Nitrate as N	-	-	-	-	-	-	-	mg/L	0.01	0.03	0.03	0.1	1.04	<0.01	0.02	0.02	0.02	<0.01	0.04	<0.01	0.02	0.09	0.09	0.21
Total Kjeldahl Nitrogen as N	-	-	-	-	-	-	-	mg/L	0.1	2	2	0.2	0.2	0.2	1.5	0.3	0.1	0.1	<0.1	<0.1	0.1	0.2	0.1	<0.1
Total Nitrogen as N	-	-	-	-	-	-	-	mg/L	0.1	2	2	0.3	1.2	0.2	1.5	0.3	0.1	0.1	<0.1	<0.1	0.1	0.3	0.2	0.2
Total Phosphorus as P	-	-	-	-	-	-	-	mg/L	0.01	0.81	0.86	0.13	0.14	0.10	0.03	0.06	0.01	0.02	0.05	0.11	0.07	0.04	0.14	0.07
Reactive Phosphorus as P	-	-	-	-	-	-	-	mg/L	0.01	0.13	0.13	0.13	0.14	0.04	<0.01	<0.01	<0.01	<0.01	0.05	0.03	<0.01	0.02	0.14	0.01
Dissolved Organic Carbon (DOC)																								
Dissolved Organic Carbon	-	-	-	-	-	-	-	mg/L	1	4	4	<1	<1	1	<1	<1	<1	<1	<1	<1	1	3	<1	<1
Total Organic Carbon	-	-	-	-	-	-	-	mg/L	1	4	4	<1	<1	2	<1	<1	<1	<1	<1	<1	1	3	<1	<1
PAH																								
Naphthalene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	-	-	-	-	-	0.7	-	µg/L	0.5	----	----	<0.5	----	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	-	-	-	-	-	-	-	µg/L	1	----	----	<1.0	----	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Sum of PAH	-	-	-	-	-	0.7 [*5]	-	µg/L	0.5	----	----	<0.5	----	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ (zero)	-	-	-	-	-	-	-	µg/L	0.5	----	----	<0.5	----	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Total Petroleum Hydrocarbons																								
C6 - C9 Fraction	-	-	-	-	-	-	-	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction	-	-	-	-	-	-	-	µg/L	50	----	----	<50	----	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C15 - C28 Fraction	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
C29 - C36 Fraction	-	-	-	-	-	-	-	µg/L	50	----	----	<50	----	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
C10 - C36 Fraction (sum)	-	-	-	-	-	-	-	µg/L	50	----	----	<50	----	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
TRH - NEPM 2013 Fractions																								
C6 - C10 Fraction	-	-	-	-	-	-	-	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C6 - C10 Fraction minus (F1) [*1]	-	-	-	-	-	-	-	µg/L	20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C16 - C34 Fraction	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C34 - C40 Fraction	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C16 Fraction minus (F2) [*2]	-	-	-	-	-	-	-	µg/L	100	----	----	<100	----	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
BTEXN																								
Benzene	-	0.95	-	-	-	10	-	µg/L	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	-	-	-	-	-	700	-	µg/L	2	3	3	3	3	2	3	3	<2	3	2	3	3	3	3	2
Ethylbenzene	-	-	-	-	-	300	-	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	-	0.2 [*15]	-	-	-	500	-	µg/L	2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX								µg/L	1	3	3	3	3	2	3	3	<1	3	2	3	3	3	3	2
Naphthalene	-	-	-	-	-	-	-	µg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Microbiological																								
Total Coliforms	-	-	-	-	0	-	-	MPN/ 100mL		40	79	1600	16000	1600	18000	16000	350	46	140	350	18000	5400	920	540
Fecal Streptococci (enterococci)	200	-	0 [*6]	-	-	0 [*6]	-	cfu/ 100mL		<1	62	>80	34	>80	35	>80	>80	36	10	29	>80	>80	>80	>80

Notes

*1 - C6 - C10 Fraction minus BTEX (F1)
*2 - >C10 - C16 Fraction minus naphthalene(F2) [*2]
*3 - Based on value for total hardness ($CaCO_3$)
*4 - If sulfate >250mg/L
*5 - Based on standard for Benzo(a)Pyrene
*6 - Based on standard for e.coli
*7 - Conservatively screened against standard for Cr(VI)
*8 - Limit of detectability
*9 - Based on pH of 9 and temperature of 30°C
*10 - Based on trigger values for Tropical Australia (Upland and Lowland rivers)
*11 - pH>6.5
*12 - Conservatively screened against standard for As(V)
*13 - Chemicals for which criteria is affected by hardness. The values have been calculated using a hardness of 1 mg/L $CaCO_3$ - based on laboratory results
*14 – Mercury (inorganic)
*15 - Conservatively screened against standard for p-xylene

Cadmium	0.00001
chromium	0.00006
copper	0.00008
lead	0.00005
nickel	0.00061
zinc	0.00044

Highlighting shows exceedance of screening criteria with color matching the most conservative criteria.

Table 11 - QA/QC RPD Analysis

Analyte	Client sample ID (1st):		HB BH02	DUP 01	Relative Percentage Difference (RPD) - Values greater than 50% in bold
	ALS Sample number:		EB1627934009	EB1627934010	
	Sampling Date		18/11/2016	18/11/2016	
	Units	LOR	Herd Base	Herd Base - duplicate of HB BH02	
Suspended Solids (SS)					
Suspended Solids (SS)	mg/L	5	12	11	8.7
Alkalinity					
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	288	290	0.7
Total Alkalinity as $CaCO_3$	mg/L	1	288	290	0.7
Major ions					
Calcium	mg/L	1	60	61	1.7
Magnesium	mg/L	1	18	18	0.0
Sodium	mg/L	1	138	138	0.0
Potassium	mg/L	1	3	3	0.0
Sulfate as SO_4	mg/L	1	8	8	0.0
Chloride	mg/L	1	164	169	3.0
Ionic Balance					
Total Anions	meq/L	0.01	10.5	10.7	1.9
Total Cations	meq/L	0.01	10.6	10.6	0.0
Ionic Balance	%	0.01	0.04	0.58	**174.2**
Dissolved Metals					
Arsenic (total)	mg/L	0.001	0.01	0.01	0.0
Barium	mg/L	0.001	0.03	0.03	3.1
Iron	mg/L	0.05	2.18	2.26	3.6
Total Metals					
Arsenic (total)	mg/L	0.001	0.01	0.01	0.0
Barium	mg/L	0.001	0.04	0.04	5.1
Iron	mg/L	0.05	3.05	3.02	1.0
Fluoride					
Fluoride	mg/L	0.1	0.2	0.2	0.0
Nutrients					
Ammonia as N	mg/L	0.01	2.39	2.36	1.3
Nitrate as N	mg/L	0.01	0.03	0.03	0.0
Nitrite + Nitrate as N	mg/L	0.01	0.03	0.03	0.0
Total Kjeldahl Nitrogen as N	mg/L	0.1	2	2	0.0
Total Nitrogen as N	mg/L	0.1	2	2	0.0
Total Phosphorus as P	mg/L	0.01	0.81	0.86	6.0
Reactive Phosphorus as P	mg/L	0.01	0.13	0.13	0.0
Dissolved Organic Carbon (DOC)					
Dissolved Organic Carbon	mg/L	1	4	4	0.0
Total Organic Carbon	mg/L	1	4	4	0.0
BTEXN					
Toluene	µg/L	2	3	3	0.0
Sum of BTEX	µg/L	1	3	3	0.0
Microbiological					
Total Coliforms	MPN/ 100mL		40	79	**65.5**
Fecal Streptococci (enterococci)	cfu/ 100mL		<1	62	NC

NC - Not calculated - Analyte was not detected in primary sample but was detected in duplicate or vice versa

6.5.2 Total and Dissolved Metals

A suite of 15 metals were analyzed in all groundwater samples collected, with both total and dissolved (field filtered <0.45 µm) concentrations measured and reported. With the exception of zinc, iron and arsenic all metals concentrations (both total and dissolved) were below the relevant water quality screening criteria, with most results being less than limits of reporting (LoR). The LoR for silver (0.001 mg/L) was higher than the ANZECC FEP (0.0005 mg/L), therefore direct comparison with this guideline cannot be undertaken. However given silver concentrations are less than the LoR, results are considered suitable to describe existing conditions.

The metals concentrations exceeding relevant screening criteria are discussed below.

Total arsenic concentration measured in the sample collected from HB BH02 at Herd Base was equal to the WHO DWG (0.01 mg/L). This concentration was also measured in a duplicate sample (DUP 01) collected at this location. The dissolved concentrations of arsenic measured in both the primary and duplicate samples from this location were 0.009 mg/L, which is below the WHO DWG. Arsenic concentrations were below all other guideline criteria.

Dissolved and total iron concentrations measured at HB BH02 exceeded both PNG ER (1 mg/L) and PNG DWR (0.1 mg/L) (an aesthetic-based standard based on staining) with the primary sample from this location having a dissolved concentration of 2.18 mg/L (3.05 mg/L total). In addition, total iron concentrations greater than the PNG DWR highest desirable level (0.1 mg/L) were measured at 11 of the village groundwater wells and springs with two locations (V1-10 and V2-03) results being in excess of the PNG ER standard (1 mg/L). It is noted that both these locations use steel drums as well casings, which may be the source of the elevated iron. There is no ANZECC FEP guideline value for iron.

The dissolved zinc concentrations measured in five of the groundwater samples were in excess of the ANZECC FEP (0.008 mg/L). Concentrations in the range 0.008 to 0.016 mg/L were measured at V1-03(1), V1-05, V1-08(5), v1-10 and V2-03. All zinc concentrations (dissolved and total) were below PNG ER, PNG DWR and WHO DWG.

It is noted that dissolved concentrations should be lower than total concentrations due to the removal of metals associated with solids via field filtering, however a number of the dissolved zinc concentrations were greater than the total zinc concentrations. This was identified by the laboratory at the time of analysis and the anomalous results are described within the laboratory reports as “within the experimental variation of the methods”.

6.5.3 Nutrients

Measured ammonia concentrations were screened against the PNG ER standard (corrected for pH 9 and temperature 30°C) of 0.05 mg/L. Concentrations at or exceeding this level were measured in groundwater at seven locations, with the highest concentration being 2.39 mg/L, measured in sample HB BH02 from Herd Base. The maximum concentration measured in village wells was 0.15 mg/L at V1-01(1).

The ANZECC FEP provides a trigger value of 0.7 mg/L for nitrate. Nitrate was measured at a concentration exceeding this in a single village well (V1-02(1) – 1.02 mg/L). All nitrate concentrations measured were below PNG ER and DWR standards (45 mg/L) and WHO DWS (50 mg/L) limits.

6.5.4 Hydrocarbons

There were no detections of total petroleum hydrocarbons (TPH), total recoverable hydrocarbons (TRH) or polycyclic aromatic hydrocarbons (PAH) in any of the samples collected and analyzed.

With the exception of toluene, all concentrations of BTEX (benzene, toluene, ethylbenzene and xylenes) compounds were below the laboratory LoR. Toluene was detected in samples from 13 locations with a maximum concentration of 3 µg/L measured at 10 locations. This is just above the LoR of 2 µg/L and over two orders of magnitude lower than the WHO DWS for toluene of 700 µg/L. It is noted that the LoR for benzene (1 µg/L) is essentially equivalent to the ANZECC FEP (0.95 µg/L), therefore compliance with this water quality guideline is reasonable to assume.

6.5.5 Microbiological

Collected samples were analyzed for both total coliforms and fecal streptococci (enterococci) by DTS Food Laboratories, subcontracted by ALS.

Primary and duplicate samples were collected from HB BH02 at Herd Base. The total coliform results for these two samples being 40 and 79 MPN/100mL, respectively. These results both exceed the PNG DWR and WHO DWG values which are both 0 MPN/100mL. Both results from HB BH02 for fecal streptococci (enterococci) (<1 cfu/100mL primary, 62 cfu/100 mL) were below the PNG ER standard for fecal coliforms 200 MPN/100 mL, which has been applied to fecal streptococci (enterococci).

Coliforms were present in all of the 13 village wells or springs sampled and therefore exceeded the PNG DWR criteria of 0 MPN/100 mL. The maximum coliform result was 18,000 MPN/100mL in sample V1-04(5). The samples from village wells and springs were either detections for fecal streptococci (enterococci) or the results exceeded the maximum countable result (>80 cfu/100 mL). The PNG ER standard for fecal coliforms (200 MPN/100mL) has been applied to fecal streptococci (enterococci). All counts above the countable limit (80 cfu/100mL) have been taken as exceedances and therefore 8 of the 13 village wells or springs are considered to exceed the environmental criteria.

6.6 Discussion

The results of laboratory analysis undertaken on samples collected indicate that on the whole the groundwater quality in the sampled systems within the study area is relatively good with no evidence of gross chemical contamination. The exceedances of drinking water and environmental standards for chemical analytes noted are considered minor and likely to be either a result of naturally occurring chemical species or from well installation materials. The identified exceedances are unlikely to impact on human health and communities are likely to have become used to the aesthetic /taste effects of the water chemistry.

The assessment of water quality with respect to drinking water and environmental guidelines and standards was conducted as the shallow groundwater are utilized as a water source for a variety of purposes (including drinking water) and because at the majority of sampling locations depth to groundwater was extremely low with some potential (particularly at excavated springs), for groundwater to discharge to surface waters. The quality and quantities of water likely to be discharging to surface waters are not considered sufficient to have a detectable effect on receiving waters.

The microbiological results do indicate contamination of all the sampled water with respect to bacteria. All wells and springs at the village sampling locations were relatively open, allowing exposure to biological contamination. Potential sources of microbiological contamination include the well/spring users, surface runoff entraining waste and debris, direct contact with domestic and wild animals (drinking from features, bird droppings), subsurface migration of sewerage impacted water from pit latrines and informal toileting and/ or windblown detritus. Whilst the village wells are not always the sole source of drinking water, with rainwater tankage present in most locations, there is increased usage of groundwater during extended dry periods and therefore the microbiological quality of water is a health concern.

Microbiological water quality was also below standards in the groundwater sample collected at Herd Base from bore HB BH02. This bore has a basic cap at headworks and downhole contamination is possible from insects, amphibians, etc. which may gain access to the bore. The current usage of water from HB BH02 is limited to vehicle and workshop washdown and the water quality is considered suitable for this purpose.

7 GROUNDWATER CONCEPTUALISATION

Based on the review of existing information relating to the study area (see **Section 4**) a conceptual understanding of known and likely groundwater conditions is provided below. The study area has been divided into four sections for discussion here. The sections have been selected based on a combination of physical characteristics, proposed Project activities and or existing anthropomorphic setting.

7.1 Elk and Antelope Gas Field Area

The Elk and Antelope gas field area in the north of PRL-15 (see **Figure 5**) is characterized by steep slopes and incised valleys and experiences high rainfall. In this area localized bodies of shallow, unconfined, perched groundwater are thought to be present within superficial material including alluvium, colluvium, landslide debris and weathered material. This perched groundwater is considered likely to exist within 10 m of ground surface where present. The superficial material in this area is thought to have high capacity to contain and transmit water, releasing it slowly from springs and seeps, and acts as a buffer that sustains stream base flow for some time after rainfall events. These shallow groundwater systems are thought to be localized (confined to single valleys) with recharge and discharge areas in close proximity. Due to the antecedent rainfall conditions (little to no rainfall) prior to and during the field survey, limited evidence of this was witnessed in the field, though this interpretation is supported by multiple examples of spring type erosion (rill erosion starting mid slope) and minor seeps observed within the area. It was not possible to sample groundwater from this system and therefore definitive comment on groundwater quality cannot be made. It is noted that no visual evidence of gross contamination was observed during the field study.

Detail regarding deeper groundwater in this area is unknown though it is likely that permanent groundwater may be encountered in more extensive alluvial deposits in the major river valleys. This groundwater is likely to be in connectivity with surface water.

With the possible exception of sandstones within the Era beds, the solid geology is not considered to support sufficient groundwater to classify there being aquifers present. The Orubadi beds are dominated by mudstones and siltstones likely to have low hydraulic conductivities. This, in addition to the depth to this formation, supports the interpretation that this material does not support significant groundwater systems.

7.2 CPF and Herd Base Area

The topography in the area of the proposed CPF and Herd Base (see **Figure 6**) has low relief when compared to the gas field area yet it still includes steep slopes and incised valleys. In addition there are a number of major surface streams including the Purari River and Kuku Creek. Local shallow, perched groundwater is considered likely in superficial materials as evidenced by seeps and spring type erosion. Again recharge and discharge areas for these minor systems are likely to be close together.

Permanent shallow groundwater is known to be present within alluvial sediments close to the confluence of Kuku Creek and the Purari River as evidenced by bore logs and data from the Herd Base water supply bores. At Herd Base, there are four groundwater abstraction bores targeting groundwater from the alluvial material associated with the Purari River and its tributary Kuku Creek. These bores were drilled up to 50 m in depth and encountered groundwater sufficient in quantity to meet design needs within fine grained sand lenses in the upper 50 m. These sands are interpreted as alluvial deposits from historical river channels. Two of the Herd Base bores are equipped with electric submersible pumps and have supplied reliable water for several years. However issues with sand ingress are common, with the two more recent bores severely impacted by sand ingress under no pumping. Water quality in the sampled bore (HB BH02) is suitable for its current usage (washdown water at workshop and stores). The groundwater encountered by these bores is thought to have connectivity with the surface waters of Kuku Creek and the Purari River.

7.3 Onshore Export Pipeline Corridor

The onshore export pipeline corridor (see **Figure 8**) from the Purari River near Herd Base runs through an area topographically similar to PRL-15 with steep slopes and strike ridges before grading to the coast in the south. The weathered material overlying competent geology is considered to support perched groundwater following rains acting as a storage buffer. Evidence of spring erosion was seen in this area. No information regarding deeper groundwater is known in this area however the geology of the ridge lines (Orubadi beds) is dominated by mudstones and siltstones that are not thought to represent aquifer materials. The quality of groundwater present is unlikely to have suffered widespread contamination, although this area does include logging camps and associated tracks that may include potential contamination sources.

7.4 Inland Villages

Inland villages (as shown in **Figure 9**) at the southern end of the onshore export pipeline corridor use groundwater for domestic purposes (drinking water, washing and stock water). Inhabitants of the inland villages often access groundwater from excavated springs, constructed and maintained over many years. This groundwater is considered to be laterally extensive and given the very shallow depths is likely to support groundwater dependent ecosystems (freshwater swamps). The springs targeted by villagers provide reliable year round water from shallow alluvial sediments, recharged during local rainfall. In addition to springs, villagers also excavate hand dug wells using the root balls of palm trees to stabilize the loose sediments into which they are excavated. Wells and springs are excavated to approximately 2 m in depth. Sampling results show water quality with respect to chemistry generally acceptable with only minor exceedances of drinking water and environmental standards measured. Measured pH levels in the water are high, likely attributable to the dominant ions present potentially as a result of carbonate material in the areas parent geology. Potential for impact to the chemical quality of shallow groundwater by current village activities is thought to be low as very few chemicals are used by or available to the villagers. The exception to this is the use of fuel in boat outboard motors. This is used and traded within the villages though no bulk (>200 L) storage was observed. In addition, potential exists for shallow groundwater to be impacted by the materials selected to construct groundwater wells, such as steel drums (that may have contained hydrocarbons, and are also susceptible to rust) were observed being used as well casing at some locations. However, it is noted that no detections of hydrocarbons were measured in any of the samples collected.

The microbial water quality within the sampled wells and springs is poor with high coliform counts widespread. The nature of the wells and springs with open access to domestic animals (pigs and dogs) and wildlife, as well as the proximity of some locations to latrines, means that the shallow groundwater is susceptible to impact from these sources.

No information regarding deeper groundwater is known in this area however the unconsolidated sediments are thought to be underlain by mudstones and siltstones of the Orubadi beds which are not considered to include aquifer materials.

7.5 Coastal Villages

Villages on the coastal strip (see **Figure 10** and **Figure 11**) within the onshore export pipeline corridor also use shallow groundwater. Wells here include several installed by aid agencies. The aid agency wells comprise concrete rings buried to approximately 2 m bgl with water inflow through the open base. Wells installed by villagers include traditional palm root wells and wells that use steel drums as casing. The wells target shallow (approximately 1 m bgl) freshwater within marine/sandy beach and back beach deposits. The freshwater is considered likely to lie on top of more saline water in the deeper sediments below. The recharge zone for this freshwater is considered likely to be very localized with high levels of infiltration likely due to the sandy material and the absence of dense groundcover vegetation or man-made barriers to inflow.

During major storm events wells may become inundated by surface flows of seawater. These wells show no evidence of gross impact from chemical contaminants, though it is noted that iron levels are highest where steel support casing is used.

The potential for impact to the chemical quality of shallow groundwater by current village activities is thought to be low as very few chemicals are used by or available to the villagers. The exception to this is the use of fuel in boat outboard motors. This is used and traded within the villages though, similar to observations at the inland villages, no bulk (>200 L) storage was observed. In addition, potential exists for shallow groundwater to be impacted by the materials selected to construct groundwater wells, such as steel drums used as well casing at some locations. However, similar to observations at the inland villages, no detections of hydrocarbons were measured in any of the samples collected.

The microbial water quality within the sampled wells and springs is poor with coliform detections widespread. The nature of the wells and springs with open access to domestic animals (pigs and dogs) and wildlife, as well as the proximity of some locations to latrines, means that the shallow groundwater is susceptible to impact from these sources. In addition the method of well construction makes them susceptible to surface water inflow (possibly transporting contaminants) and seawater inundation during tidal surges.

8 CONCLUSIONS

The baseline groundwater study undertaken for the upstream components of the Papua LNG Project has:

- Defined the study area for the groundwater baseline characterization that would support an impact assessment;
- Identified and assessed a number of groundwater features within the study area;
- Characterized the current groundwater quality in shallow aquifers in the coastal and inland villages; and
- Developed the conceptual understanding of the groundwater systems within the study area.

The field survey identified shallow groundwater to be present and used extensively by the communities of the coastal and inland villages within the onshore export pipeline corridor. Groundwater usage within the study area is predominantly for washing but during dry periods there is extensive reliance on groundwater as a drinking water resource. The quality of the water encountered largely met the relevant quality criteria for its intended use (drinking water standards) with respect to chemical properties. However, widespread microbiological contamination is evident. The groundwater resource targeted by villagers is extremely shallow, generally being less than 1 m bgl, and therefore is highly susceptible to impact from potentially contaminating activities and processes. Identified risks include overland runoff (following rainfall) entraining contaminants particularly animal waste, sewerage effluent from latrines, inundation of wells by seawater and potential spills and/or mismanagement of hydrocarbons (boat fuel).

Groundwater at Herd Base is present within the alluvium of the Purari River. The water quality in this aquifer is good and suitable for its usage at the time of survey (wash-down water at vehicle workshop). The age of the bores in use at Herd Base is unknown; anecdotal evidence suggests that the targeted groundwater is sufficient in quantity to meet the current demands. Testing of one of the bores at Herd Base has been interpreted as showing that the intersected water yielding unit is capable of yielding at least 0.8 L/sec. The depth to water bearing material (greater than 15 m) and overlying low permeability fine silts and clay materials provides some degree of protection to this resource from potentially contaminating activities.

Isolated perched, shallow (less than 10 m bgl) groundwater occurs within superficial and weathered material throughout the study area but particularly in the areas of steep slopes and incised valleys within PRL-15. This is likely to support good quality water and to act as an important recharge source for stream and creek base flow.

Little information regarding deeper groundwater within the competent geology of the Era and Orubadi beds is available. However the lithologies that occur in these formations, including mudstones and siltstones are not considered likely to support significant groundwater. In addition, were groundwater to be present in discreet horizons within these formations the occurrence of low permeability mudstones and siltstones will restrict groundwater movement and interaction. This interpretation is the basis for the conclusion that any groundwater occurrence within the Era or Orubadi beds would represent confined systems with little or no connectivity to overlying aquifers or surface water in the study area.

It is also likely that small quantities of groundwater may occur within the geology of the gas resource target, the Kapau Limestone. The depth to this geology is in excess of 1,700 m and the thickness of overlying low permeability material is understood to have contained the hydrocarbon resource and will effectively confine water occurring in this unit.

9 STUDY TEAM

This groundwater baseline report has been prepared by the SLR Hydrology and Hydrogeology Team including the personnel listed in **Table 12** below.

Table 12 Study Team – Groundwater Baseline Report

Name	Role	Qualifications
Derwin Lyons	Principal Hydrogeologist – Technical Review	BSc (Hons) Hydrogeology
John Leyland	Associate Hydrogeologist – Field Hydrogeologist	BSc Geology MSc Environmental Hydrogeology

10 GLOSSARY AND ABBREVIATIONS

10.1 Glossary

Alluvial	Relating to sediments that have been deposited by streams.
Ambient	Pertaining to the surrounding environment or prevailing conditions.
Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs.
Aquitard	A saturated but poorly permeable bed, formation, or group of formations that does not yield water freely to a well or a spring. An aquitard may transmit appreciable water to or from adjacent aquifers.
Background	The existing groundwater quality in the study area.
Base flow	That portion of stream flow derived from groundwater seeping into a stream.
Colluvial	Relating to sediments that have been carried by gravity downhill slopes where they then accumulate.
Confined aquifer	An aquifer that lies below a low permeability material. The piezometric surface in confined aquifers is above the base of the confining material.
Drawdown	The distance between the static water level and the surface of the cone of depression.
Electrical conductivity	The capacity of a material to conduct electricity. In a fluid, electrical conductivity increases with total dissolved solids. A measure of water salinity.
Grab Sample	Sample collected directly from standing water within groundwater feature with no purging to induce inflow of groundwater.
Groundwater	The water contained in interconnected pores, gaps or fractures located below the water table in an unconfined aquifer or located in a confined aquifer.
Groundwater affecting activity	Any activity that has the potential to change groundwater conditions (levels and quality).
Guideline	A general rule, principle, or piece of advice. A statement or other indication of policy or procedure by which to determine a course of action.
Hydraulic conductivity	A coefficient of proportionality describing the rate at which water can move through a permeable medium. Horizontal hydraulic conductivity (Kh) refers to the coefficient of proportionality in the horizontal direction, whereas vertical hydraulic conductivity (Kv) refers to the coefficient of proportionality in the vertical direction.
Hydraulic gradient	The rate of change in total head per unit distance in a given direction. The direction of gradient is that yielding the maximum rate of decrease in head.
Rill Erosion	Rill erosion is the removal of soil by concentrated water running through little streamlets, or headcuts. Detachment in a rill occurs if the sediment in the flow is below the amount the load can transport and if the flow exceeds the soil's resistance to detachment. As detachment continues or flow increases, rills will become wider and deeper.
Screen	Perforated well casing that allows water to enter the well from an aquifer.
Standing water level	The level at which groundwater within a well occurs. A measure of the hydraulic potential of an aquifer over the screened interval of the well.
Topography	Detailed mapping or charting of the features of a relatively small area, district, or locality.
Total dissolved solids	The total amount of dissolved solid matter in water. A measure of salinity.
Unconfined aquifer	A water table aquifer.
Water table	The surface between the unsaturated and saturated zones of the subsurface at which the hydrostatic pressure is equal to that of the atmosphere.
Well	A borehole that has been cased with pipe, usually steel or PVC plastic, in order to keep the borehole open in unconsolidated sediments or unstable rock. Often used interchangeably with the term bore.

10.2 Abbreviations, Symbols and Units

ASL	Above sea level
ANZECC	Australian and New Zealand Environment and Conservation Council
bgl	Below ground level
BTEX	Benzene, toluene, ethylbenzene and xylene
CPF	Central processing facility
m^3	Cubic meter
C^o	Degrees Celsius
DOC	Dissolved organic carbon
DO	Dissolved oxygen
EC	Electrical conductivity
EHS	Environment, health and safety
EIS	Environmental impact statement
HSU	Hydro-stratigraphic unit
IFC	International Finance Corporation
km	Kilometer
LoR	Limit of reporting
L	Liter
µS/cm	Micro Siemens per centimeter
µg	Microgram
µg/L	Microgram per liter
µm	Micron
mg/L	Milligram per liter
mm	Millimeter
mV	Millivolts
NTU	Nephelometric turbidity unit
ORP	Oxidation - reduction potential
PNG	Papua New Guinea
%	Percent
PDL	Petroleum development license
PPFL	Petroleum processing facility Licenses
PL	Pipeline license
PAH	Polycyclic aromatic hydrocarbons
m^2	Square meter
TOC	Total organic carbon
TPH	Total petroleum hydrocarbons
TSS	Total suspended solids
US EPA	United States Environmental Protection Agency
UTM	Universal transverse mercator
WHO	World Health Organization

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Field Observations and Photographs

Bore ID	Date	Time	Color	Bubbles	Sheen	Odor	Algae	Bacterial Aggregates	Precipitates	Comment
HB BH01	16-11-2016	15:17								
HB BH02	18-11-2016	13:52	Clear	x	x	Slight sulfur	x	x	x	Small quantity of black sand settled from purged water
HB BH03	18-11-2016	11:04	Light brown/straw	x	x	x	x	x	x	
HB BH04	18-11-2016	10:00	Light brown/straw	x	x	x	x	x	x	
V1-01 (1)	19-11-2016	10:00	Clear	x	x	x	x	x	x	
V1-01 (2)	19-11-2016	10:30	Clear	x	x	x	x	x	x	
V1-01 (3)	19-11-2016	10:35	Cloudy blueish	x	x	x	x	x	x	Fish (<150mm) present, described as contaminated by villagers due to surface water (including animal waste) inflow.
V1-02 (1)	19-11-2016	12:00	Clear	x	x	x	x	x	x	
V1-02 (2)	19-11-2016	10:40	Slightly Cloudy	x	x	x	x	x	x	
V1-03 (1)	19-11-2016	13:45	Clear	x	x	x	x	x	x	Some floating debris including chewing gum
V1-03 (2)	19-11-2016	13:30	Cloudy Orange	x	x	x	x	x	x	
V1-04 (1)	21-11-2016	9:21	Slightly cloudy brown	x	x	x	x	x	x	
V1-04 (2)	21-11-2016	9:26	Clear	x	x	x	x	x	x	
V1-04 (3)	21-11-2016	9:34	Cloudy blueish	x	x	x	x	x	x	
V1-04 (4)	21-11-2016	9:40	Cloudy brown	x	x	x	x	x	x	Poor condition
V1-04 (5)	21-11-2016	9:58	Clear	x	x	x	x	x	x	
V1-05	21-11-2016	11:05	Slightly cloudy blueish	x	x	x	x	x	x	
V1-06	21-11-2016	11:35	Slightly cloudy blueish	x	x	x	x	x	x	
V1-07	21-11-2016	15:00	Clear	x	x	x	x	x	x	
V1-08 (1)	20-11-2016	9:52	clear	x	x	x	x	x	x	

V1-08 (2)	20-11-2016		orangy brown	x	x	slight odour	x	x	x	Live and dead toads (odour) present
V1-08 (3)	20-11-2016		brown cloudy	x	x	x	x	x	x	
V1-08 (4)	20-11-2016	10:35	slight tanin staining	x	x	x	x	x	x	
V1-08 (5)	20-11-2016	10:40	clear	x	x	x	x	x	x	
V1-09	20-11-2016	12:17	clear	x	x	x	x	x	x	
V1-10	20-11-2016	14:40	clear	x	x	x	x	x	x	
V1-11	20-11-2016	13:20	clear	x	x	x	x	x	x	
V1-12	20-11-2016	15:22	clear	x	x	x	x	x	x	
V2-02 (1)	19-11-2016	12:30	clear	x	x	x	x	x	x	
V2-02 (2)	19-11-2016	13:20	Slightly cloudy blueish	x	x	x	x	x	x	
V2-03	20-11-2016	11:33	clear	x	x	x	x	x	x	

Observation Point	Latitude	Longitude	Comments	Photograph
ANT-3	-7.143156	145.142036	Laydown area down slope from ANT-3. Spring type erosion and algal/water dependent plant growth around springs. Water appears to flow within imported "aggregate" material and out crops mid slope. Visual evidence suggests seeps have been ongoing for at least a few weeks. Water accumulated at top of laydown area.	

ANT-3 to ANT-5	-7.153898	145.132767	ANT 3 – ANT 5 Road – water issue/seep seen in up slope road cutting. Water springs from interface between weathered profile and more solid material.	

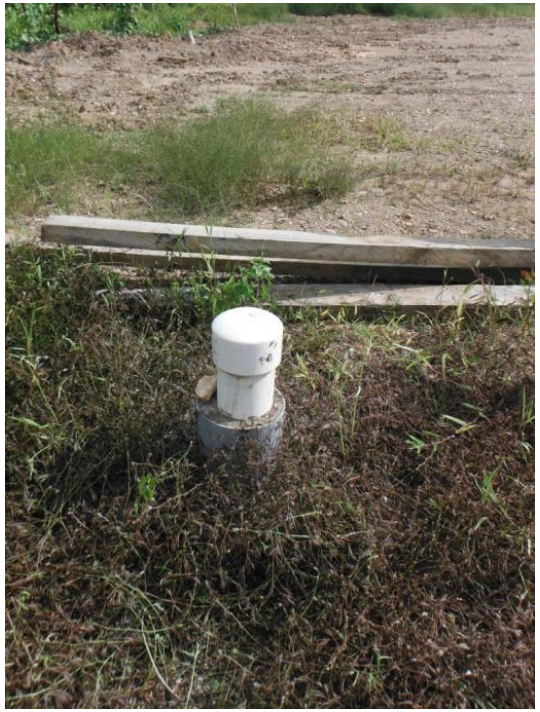
ANT-5	-7157435	145.135411	Water seep within south side road cutting on haul road to ANT 5 well pad. Water issuing from interface between weathered material and landslide debris and underlying more competent grey fissile mudstone.	

ANT-6	-7.151674	145.158232	Drilling platform cut for ANT 6. Back bench wall shows planar bedding of sandstone, shales and mudstones. Vegetation occurrence on out crop coincides with water issues on top of lower permeability material (visible as light coloured beds in the bottom right of the photograph).	
CPF-01	-7.349821	145.191221	Shallow depression seen in mid slope interpreted as spring type erosion. Springs of this type likely to be active following high rainfall periods.	

ETL-1	-7.331674	145.218405	Deeply incised creek channel with bedrock in river bed. Demonstrates the thickness of weathered and superficial materials.	
ETL-1	-7.333474	145.218293	Deeply incised rill within access track. Eroded material appears to be alluvial in origin with well rounded gravels and cobbles. This is thought to be imported material for road improvement. Visual evidence that this material supports shallow subsurface flow.	

ETL2	-7.275084	145.194403	Minor seeps with iron staining in river cliff approximately 1 m below surrounding ground level.	
Fly Camp D	-7.313636	145.138359	Minor seeps in river cliff approximately 1 m below surrounding ground level from above clay layer. Iron staining evident around water issue. Material below water issue level is grey in colour suggesting saturation.	

Herd Base HB01	-7.355667	145.221444	Equipped groundwater abstraction well at Herd Base. Fitted with electric submersible pump but not used due to availability of alternative supply and silting issues.	
Herd Base HB02	-7.355583	145.228222	Equipped groundwater abstraction bore near Herd Base workshops. Used on a daily basis to provide wash-down water. Workshop advises that bore is generally pumped for 45mins to an hour every morning. Pumps at a rate of approximately 0.5L/sec. Sample was collected from bore following purging of 1,650L from the bore.	

Herd Base HB03	-7.352889	145.223111	Unequipped groundwater bore drilled during November 2015. Bore had silting issues immediately after installation and was never pumped or tested. During assessment bore was silted above the level of screens and therefore the sample collected was not scheduled for analysis.	
Herd Base HB04	-7.352472	145.222917	Unequipped groundwater bore drilled during November 2015. Bore was pump tested immediately after installation for 24hrs at a rate of approximately 1L/sec. During assessment bore was silted above the level of screens and therefore the sample collected was not scheduled for analysis.	

V1-01 (1)	-7.852306	145.284574	Coastal village Harevavo - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970s or 1980s. White PVC pipe shown in photograph is intake for hand pump located ~4m from well. Water level is >0.5m below intake and pump is no longer operable (parts stripped). Other pipes seen are understood to be present to prevent the concrete rings from subsiding. Well is open (sandy) at base. Communal use. Villagers use containers on string to collect water from the well. Sampled.	
V1-01 (2)	-7.852077	145.284969	Coastal village Harevavo – Traditional "palm stump" well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Wooden frame reduces surface water inflow. Communal use. Villagers use containers on string to collect water from the well.	

V1-01 (3)	-7.852067	145.285210	Coastal village Harevavo – large open well with wooden stabilization to reduce collapse and to prevent livestock from drinking directly from the well. Described by villagers as contaminated due to inflows of surface water entraining animal waste and other debris. Well had a number of live fish present.	
V1-02 (1)	-7.852067	145.287446	Coastal village Kaivukavu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970's or 1980's. White PVC pipe shown in photograph is intake for hand pump located ~4m from well (seen in background). Water level is >0.5m below intake and pump is no longer operable (parts stripped). Well is open (sandy) at base. Communal use. Villagers use containers on string to collect water from the well. Sampled.	

V1-02 (2)	-7.852038	145.288227	Coastal village Kaivukavu – Traditional “palm stump” well. Seen and photographed but no further assessment undertaken.	
V1-03 (1)	-7.850685	145.303708	Coastal village Iuku - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970’s or 1980’s. White PVC pipe below water level is intake for hand pump located ~4m from well. Pump is no longer operable (parts stripped). Well is open (sandy) at base. Communal use. Villagers use containers on string to collect water from the well. Sampled. Photograph pre-dates baseline survey.	

V1-03 (2)	-7.850523	145.302817	Coastal village Iuku – Traditional “palm stump” well. Seen and photographed but no further assessment undertaken.	
V1-04 (1)	-7.789667	145.264306	Inland village Avavu - large open well with corrugated iron sheet cover and fencing. Used by 3 to 4 nearby households.	

V1-04 (2)	-7.789083	145.264944	Inland village Avavu - Traditional "palm stump" well. Hand excavated though stump of felled palm tree, less than 1 year old. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well and corrugated sheet cover used. Used by single household.	
V1-04 (3)	-7.787778	145.264750	Inland village Avavu – small shallow spring excavation. No obvious specific associated households, in public or common space. Close (<5m) to small creek with iron staining.	

V1-04 (4)	-7.787250	145.266028	Inland village Avavu – large open hole with obvious collapses, very poor construction. Dug during 2015.	
V1-04 (5)	-7.791833	145.263667	Inland village Avavu - Traditional “palm stump” well. Hand excavated though stump of felled palm tree 2 years old. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well, fitted, hinged steel cover with wooden frame, well roofed and fenced. Used by single nearby household. Sampled.	

V1-05	-7.790694	145.270583	Inland village Ere - Large excavated spring, constructed by women's convention in 1997. Located close to tidal creek. Used by all villagers in Ere, during drought other villages (Kilavi, Avavu) use this water source. Sampled. Photograph from (Finlayson, 2016).	

V1-06	-7.791667	145.274667	Inland village Kilavi - Large excavated spring. Located close to tidal creek occasionally floods from creek. Following inundation villages wait for some weeks before cleaning out sediment by hand. Sampled. Second Photograph from (Finlayson,2016).	

V1-07	-7.829917	145.316694	Inland village Paevera - Large excavated spring. Drain beneath bamboo planks in photograph allows water to flow to creek. Flow estimated to be ~2L/min. Sampled.	
V1-08 (1)	-7.854561	145.315189	Coastal Village – Mareke (Coastal). Concrete ring well installed by householder, appears to be recycled materials from older aid organization well. Well is situated in large depression which appears to be water filled during wet periods. Well is open (sandy) at base. Used by single household. Some tadpoles present.	

V1-08 (2)	-7.851709	145.315829	Coastal Village – Mareke (Coastal). Corrugated iron large diameter well. Water appears to be poor quality and a large number of cane toads (dead and alive) present in the well. Located very close to households pit latrine. Private well not in use at present but will be cleaned out and used as dry season progresses.	
V1-08 (3)	-7.851660	145.316167	Coastal Village – Mareke (Coastal). Corrugated iron large diameter well. Silted up and with waste present, not in use. In common area, not associated with specific houses.	

V1-08 (4)	-7.851709	145.315829	Coastal Village – Mareke (inland). Small shallow open excavation used for washing and irrigation. In common area, not associated with specific houses.	
V1-08 (5)	-7.851660	145.316167	Coastal Village – Mareke (inland). Concrete ring well, constructed by householder using materials from road culvert. Daily use by single household. Sampled.	

V1-09	-7.855464	145.326002	Coastal village Kavavu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970's or 1980's. Hand pump located ~4m from well. Pump is no longer operable (parts stripped). Well is open (sandy) at base. Communal use. Villagers use containers on string to collect water from the well.	
V1-10	-7.868868	145.352708	Coastal village Herakela – Well with steel drum casing, well is open at base. Well is approximately 7 years old. Used by a single household. Sampled	

V1-11	-7.862384	145.343854	Coastal village Lariau – Traditional “palm stump” well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well has corrugated steel sheet cover. Daily use by single household. Sampled	
V1-12	-7.864718	145.346420	Coastal village Oru – Traditional “palm stump” well. Hand excavated though stump of felled palm tree. Root ball stabilizes well walls reducing the potential for collapse. Stump retained at surface to protect well. Daily use by single household. Sampled	

V2-02 (1)	-7.851240	145.296552	Coastal village Larihairu - Concrete ring well installed by aid organization. Villages advise that well was installed in 1970's or 1980's. White PVC pipe below water level is intake for hand pump located ~4m from well. Pump is no longer operable (parts stripped). Well is open (sandy) at base. Communal use. Villagers use containers on string to collect water from the well. Sampled.	
V2-02 (2)	-7.851190	145.298184	Coastal Village – Larihairu - Small shallow open excavation, usage unknown. In common area, not associated with specific houses.	

V2-03	-7.853308	145.325144	Coastal village Mirimurua – Well with steel drum casing beneath house. Well is open at base. Well was in use for laundry at time of sampling. Used by a collection of households. Sampled	

Laboratory Certificates of Analysis

CERTIFICATE OF ANALYSIS

Work Order	: **EB1627934**	Page	: 1 of 15
Client	: **SLR Consulting Australia Pty Ltd**	Laboratory	: Environmental Division Brisbane
Contact	: MR JOHN LEYLAND	Contact	: Customer Services EB
Address	: Level 2 15 ASTOR TERRACE SPRING HILL 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: TOTAL PNG ELK-ANTELOPE	Date Samples Received	: 24-Nov-2016 11:52
Order number	: 620.11227.00400	Date Analysis Commenced	: 24-Nov-2016
C-O-C number	: ----	Issue Date	: 05-Dec-2016 12:52
Sampler	: JOHN LEYLAND		
Site	: ----		
Quote number	: ----		
No. of samples received	: 17		
No. of samples analysed	: 15		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane External Subcontracting, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- It is recognised that EG020T (Total Metals) is less than EG020F (Dissolved Metals) for some samples. However, the difference is within experimental variation of the methods.
- EG020-F (Dissolved Metals by ICP-MS) were found to be higher than EG020-T (Total Metals by ICP-MS) for sample EB1627934 - 015 (V1 - 05). This was confirmed by re-digestion and re-analysis.
- It has been noted that EK055G (Ammonia as N) is greater than EK061G (Total Kjeldahl Nitrogen as N) for some samples, however this difference is within the limits of experimental variation.
- Ionic Balances out of acceptable limits for some samples due to analytes not quantified in this report.
- Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 10	V1 - 08	V1 - 12	V2 - 03	V1 - 11
			Client sampling date / time	20-Nov-2016 14:40	20-Nov-2016 10:50	20-Nov-2016 15:30	20-Nov-2016 11:50	20-Nov-2016 13:35
Compound	CAS Number	LOR	Unit	EB1627934-001	EB1627934-002	EB1627934-003	EB1627934-004	EB1627934-005
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	8	<5	15	9	499
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	124	128	53	115	75
Total Alkalinity as CaCO3	----	1	mg/L	124	128	53	115	75
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	3	2	7	3
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	7	8	4	31	4
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	6	10	5	10	6
Magnesium	7439-95-4	1	mg/L	22	22	9	22	11
Sodium	7440-23-5	1	mg/L	12	11	13	15	15
Potassium	7440-09-7	1	mg/L	3	6	5	7	4
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.01	<0.01	0.02	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	0.002	<0.001	0.001	0.001	0.001
Barium	7440-39-3	0.001	mg/L	0.001	0.001	<0.001	0.001	0.002
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.002	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.002	0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	0.008	0.012	0.006	0.011	<0.005
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.06	<0.05	0.08
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	0.07	0.01	0.30
Arsenic	7440-38-2	0.001	mg/L	0.003	0.001	<0.001	0.002	0.002
Barium	7440-39-3	0.001	mg/L	0.003	0.001	<0.001	0.005	0.002

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 10	V1 - 08	V1 - 12	V2 - 03	V1 - 11
			Client sampling date / time	20-Nov-2016 14:40	20-Nov-2016 10:50	20-Nov-2016 15:30	20-Nov-2016 11:50	20-Nov-2016 13:35
Compound	CAS Number	LOR	Unit	EB1627934-001	EB1627934-002	EB1627934-003	EB1627934-004	EB1627934-005
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	**0.006**	**0.012**	<0.005	**0.011**	**0.015**
Iron	7439-89-6	0.05	mg/L	**1.21**	**0.14**	**0.36**	**1.11**	**0.89**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	**0.1**	**0.1**	<0.1	**0.2**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.04**	**0.01**	**0.11**	**0.03**	**0.02**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	**0.04**	**0.09**	**0.21**	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	**0.04**	**0.09**	**0.21**	**0.02**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	<0.1	**0.2**	<0.1	**0.1**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	<0.1	<0.1	**0.3**	**0.2**	**0.1**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.11**	**0.05**	**0.04**	**0.07**	**0.07**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.03**	**0.05**	**0.02**	**0.01**	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 10	V1 - 08	V1 - 12	V2 - 03	V1 - 11
			Client sampling date / time	20-Nov-2016 14:40	20-Nov-2016 10:50	20-Nov-2016 15:30	20-Nov-2016 11:50	20-Nov-2016 13:35
Compound	CAS Number	LOR	Unit	EB1627934-001	EB1627934-002	EB1627934-003	EB1627934-004	EB1627934-005
				Result	Result	Result	Result	Result
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	2.74	2.84	1.21	3.32	1.67
Total Cations	----	0.01	meq/L	2.71	2.94	1.68	3.14	1.96
Ionic Balance	----	0.01	%	----	----	----	2.74	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	<1	<1	3	<1	1
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	<1	3	<1	1
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 10	V1 - 08	V1 - 12	V2 - 03	V1 - 11
			Client sampling date / time	20-Nov-2016 14:40	20-Nov-2016 10:50	20-Nov-2016 15:30	20-Nov-2016 11:50	20-Nov-2016 13:35
Compound	CAS Number	LOR	Unit	EB1627934-001	EB1627934-002	EB1627934-003	EB1627934-004	EB1627934-005
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	3	2	3	2	3
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	1330-20-7	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	3	2	3	2	3
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1	%	34.4	27.3	28.0	27.5	23.9
2-Chlorophenol-D4	93951-73-6	1	%	81.2	79.7	72.6	73.7	78.7
2.4.6-Tribromophenol	118-79-6	1	%	90.4	91.3	87.2	84.8	103
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1	%	82.6	80.4	73.6	76.1	94.0
Anthracene-d10	1719-06-8	1	%	79.4	81.8	74.8	73.6	86.2
4-Terphenyl-d14	1718-51-0	1	%	87.8	92.7	83.7	81.3	100
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	103	112	96.9	117	110
Toluene-D8	2037-26-5	2	%	95.5	95.5	97.4	97.5	108
4-Bromofluorobenzene	460-00-4	2	%	94.3	88.9	91.3	89.9	86.8

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V2 - 02	V1 - 02	HB BH02	DUP 01	V1 - 03
			Client sampling date / time	19-Nov-2016 12:45	19-Nov-2016 12:00	18-Nov-2016 14:25	[18-Nov-2016]	19-Nov-2016 14:00
Compound	CAS Number	LOR	Unit	EB1627934-007	EB1627934-008	EB1627934-009	EB1627934-010	EB1627934-011
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	44	8	12	11	5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	140	124	288	290	194
Total Alkalinity as CaCO3	----	1	mg/L	140	124	288	290	194
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	12	7	8	8	2
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	35	26	164	169	20
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	24	12	60	61	18
Magnesium	7439-95-4	1	mg/L	20	17	18	18	29
Sodium	7440-23-5	1	mg/L	26	33	138	138	21
Potassium	7440-09-7	1	mg/L	8	8	3	3	13
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	0.03	<0.01	<0.01	0.02
Arsenic	7440-38-2	0.001	mg/L	0.002	0.003	0.009	0.009	0.002
Barium	7440-39-3	0.001	mg/L	0.002	0.001	0.032	0.033	0.005
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	0.003	<0.001	<0.001	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	0.007	<0.005	<0.005	0.011
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	2.18	2.26	0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	0.02	0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	0.003	0.003	0.010	0.010	0.002
Barium	7440-39-3	0.001	mg/L	0.002	<0.001	0.040	0.038	0.004

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V2 - 02	V1 - 02	HB BH02	DUP 01	V1 - 03
			Client sampling date / time	19-Nov-2016 12:45	19-Nov-2016 12:00	18-Nov-2016 14:25	[18-Nov-2016]	19-Nov-2016 14:00
Compound	CAS Number	LOR	Unit	EB1627934-007	EB1627934-008	EB1627934-009	EB1627934-010	EB1627934-011
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	**0.010**
Iron	7439-89-6	0.05	mg/L	**0.16**	<0.05	**3.05**	**3.02**	**0.64**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.1**	**0.1**	**0.2**	**0.2**	**0.2**
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.07**	**0.06**	**2.39**	**2.36**	**0.05**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.09**	**1.03**	**0.03**	**0.03**	<0.01
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.09**	**1.04**	**0.03**	**0.03**	<0.01
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.1**	**0.2**	**2.0**	**2.0**	**0.2**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.2**	**1.2**	**2.0**	**2.0**	**0.2**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.14**	**0.14**	**0.81**	**0.86**	**0.10**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.14**	**0.14**	**0.13**	**0.13**	**0.04**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V2 - 02	V1 - 02	HB BH02	DUP 01	V1 - 03
			Client sampling date / time	19-Nov-2016 12:45	19-Nov-2016 12:00	18-Nov-2016 14:25	[18-Nov-2016]	19-Nov-2016 14:00
Compound	CAS Number	LOR	Unit	EB1627934-007	EB1627934-008	EB1627934-009	EB1627934-010	EB1627934-011
				Result	Result	Result	Result	Result
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	4.03	3.36	10.5	10.7	4.48
Total Cations	----	0.01	meq/L	4.18	3.64	10.6	10.6	4.53
Ionic Balance	----	0.01	%	1.76	4.02	0.04	0.58	0.54
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	<1	<1	4	4	1
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	<1	4	4	2
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1	µg/L	<1.0	----	----	----	<1.0
Acenaphthylene	208-96-8	1	µg/L	<1.0	----	----	----	<1.0
Acenaphthene	83-32-9	1	µg/L	<1.0	----	----	----	<1.0
Fluorene	86-73-7	1	µg/L	<1.0	----	----	----	<1.0
Phenanthrene	85-01-8	1	µg/L	<1.0	----	----	----	<1.0
Anthracene	120-12-7	1	µg/L	<1.0	----	----	----	<1.0
Fluoranthene	206-44-0	1	µg/L	<1.0	----	----	----	<1.0
Pyrene	129-00-0	1	µg/L	<1.0	----	----	----	<1.0
Benz(a)anthracene	56-55-3	1	µg/L	<1.0	----	----	----	<1.0
Chrysene	218-01-9	1	µg/L	<1.0	----	----	----	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	----	----	----	<1.0
Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	----	----	----	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	----	----	----	<1.0
Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	----	----	----	<1.0
Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	----	----	----	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	----	----	----	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	----	----	----	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	<50
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	<100
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	----	----	----	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V2 - 02	V1 - 02	HB BH02	DUP 01	V1 - 03
			Client sampling date / time	19-Nov-2016 12:45	19-Nov-2016 12:00	18-Nov-2016 14:25	[18-Nov-2016]	19-Nov-2016 14:00
Compound	CAS Number	LOR	Unit	EB1627934-007	EB1627934-008	EB1627934-009	EB1627934-010	EB1627934-011
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	<100
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	<100
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	----	----	----	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	----	----	----	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	3	3	3	3	2
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	1330-20-7	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	3	3	3	3	2
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1	%	30.6	----	----	----	30.9
2-Chlorophenol-D4	93951-73-6	1	%	76.4	----	----	----	74.4
2.4.6-Tribromophenol	118-79-6	1	%	85.9	----	----	----	90.3
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1	%	84.1	----	----	----	80.0
Anthracene-d10	1719-06-8	1	%	77.2	----	----	----	73.4
4-Terphenyl-d14	1718-51-0	1	%	87.2	----	----	----	82.5
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	113	106	118	114	103
Toluene-D8	2037-26-5	2	%	112	104	94.8	97.6	96.2
4-Bromofluorobenzene	460-00-4	2	%	91.5	91.3	93.8	93.4	95.0

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 07	V1 - 01	V1 - 05	V1 - 06	V1 - 04
			Client sampling date / time	19-Nov-2016 15:20	19-Nov-2016 10:45	21-Nov-2016 11:05	21-Nov-2016 11:55	21-Nov-2016 09:30
Compound	CAS Number	LOR	Unit	EB1627934-013	EB1627934-014	EB1627934-015	EB1627934-016	EB1627934-017
				Result	Result	Result	Result	Result
EA025: Total Suspended Solids dried at 104 ± 2°C								
Suspended Solids (SS)	----	5	mg/L	<5	<5	5	<5	<5
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	51	169	63	40	45
Total Alkalinity as CaCO3	----	1	mg/L	51	169	63	40	45
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	9	1	2	<1
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	9	32	6	1	5
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	9	14	13	6	10
Magnesium	7439-95-4	1	mg/L	5	30	7	3	4
Sodium	7440-23-5	1	mg/L	11	25	7	6	5
Potassium	7440-09-7	1	mg/L	<1	11	<1	<1	<1
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.006	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.002	0.001	0.033	0.003	<0.001
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	0.002	0.002	<0.001	0.002	0.002
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	0.003
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	0.007	0.016	<0.005	0.006
Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.03	0.13	<0.01
Arsenic	7440-38-2	0.001	mg/L	<0.001	0.006	<0.001	<0.001	<0.001
Barium	7440-39-3	0.001	mg/L	0.004	0.001	0.002	0.008	<0.001

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 07	V1 - 01	V1 - 05	V1 - 06	V1 - 04
			Client sampling date / time	19-Nov-2016 15:20	19-Nov-2016 10:45	21-Nov-2016 11:05	21-Nov-2016 11:55	21-Nov-2016 09:30
Compound	CAS Number	LOR	Unit	EB1627934-013	EB1627934-014	EB1627934-015	EB1627934-016	EB1627934-017
				Result	Result	Result	Result	Result
EG020T: Total Metals by ICP-MS - Continued								
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.006**	<0.005	<0.005	<0.005
Iron	7439-89-6	0.05	mg/L	**0.08**	**0.10**	**0.81**	**0.49**	**0.89**
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	<0.1	**0.1**	<0.1	<0.1	<0.1
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.02**	**0.15**	**0.02**	**0.08**	**0.03**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	**0.10**	**0.02**	**0.02**	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	**0.10**	**0.02**	**0.02**	**0.02**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.1**	**0.2**	**0.3**	**0.1**	**1.5**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.1**	**0.3**	**0.3**	**0.1**	**1.5**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.02**	**0.13**	**0.06**	**0.01**	**0.03**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	**0.13**	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 07	V1 - 01	V1 - 05	V1 - 06	V1 - 04
			Client sampling date / time	19-Nov-2016 15:20	19-Nov-2016 10:45	21-Nov-2016 11:05	21-Nov-2016 11:55	21-Nov-2016 09:30
Compound	CAS Number	LOR	Unit	EB1627934-013	EB1627934-014	EB1627934-015	EB1627934-016	EB1627934-017
				Result	Result	Result	Result	Result
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	1.27	4.47	1.45	0.87	1.04
Total Cations	----	0.01	meq/L	1.34	4.54	1.53	0.81	1.04
Ionic Balance	----	0.01	%	----	0.78	----	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	<1	<1	<1	<1	<1
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	<1	<1	<1	<1	<1
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthylene	208-96-8	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Acenaphthene	83-32-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluorene	86-73-7	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Phenanthrene	85-01-8	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Anthracene	120-12-7	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Fluoranthene	206-44-0	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Pyrene	129-00-0	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	56-55-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Chrysene	218-01-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	<1.0	<1.0	<1.0	<1.0
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L	<0.5	<0.5	<0.5	<0.5	<0.5
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	<20	<20	<20	<20
C10 - C14 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
C15 - C28 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
C29 - C36 Fraction	----	50	µg/L	<50	<50	<50	<50	<50
^ C10 - C36 Fraction (sum)	----	50	µg/L	<50	<50	<50	<50	<50
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	<20	<20	<20

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	V1 - 07	V1 - 01	V1 - 05	V1 - 06	V1 - 04
			Client sampling date / time	19-Nov-2016 15:20	19-Nov-2016 10:45	21-Nov-2016 11:05	21-Nov-2016 11:55	21-Nov-2016 09:30
Compound	CAS Number	LOR	Unit	EB1627934-013	EB1627934-014	EB1627934-015	EB1627934-016	EB1627934-017
				Result	Result	Result	Result	Result
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions - Continued								
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	<20	<20	<20	<20
>C10 - C16 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C16 - C34 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
>C34 - C40 Fraction	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C40 Fraction (sum)	----	100	µg/L	<100	<100	<100	<100	<100
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L	<100	<100	<100	<100	<100
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	<1	<1	<1	<1
Toluene	108-88-3	2	µg/L	3	3	3	<2	3
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	<2	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	<2	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	<2	<2
^ Total Xylenes	1330-20-7	2	µg/L	<2	<2	<2	<2	<2
^ Sum of BTEX	----	1	µg/L	3	3	3	<1	3
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	<5	<5
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1	%	25.6	22.8	29.1	30.1	25.1
2-Chlorophenol-D4	93951-73-6	1	%	77.1	71.4	72.3	63.4	74.8
2.4.6-Tribromophenol	118-79-6	1	%	100	82.6	79.4	72.3	95.2
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1	%	95.5	78.2	73.4	63.4	88.6
Anthracene-d10	1719-06-8	1	%	85.9	71.5	72.8	64.2	80.5
4-Terphenyl-d14	1718-51-0	1	%	98.2	82.8	79.8	74.2	95.8
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	125	115	114	121	116
Toluene-D8	2037-26-5	2	%	97.6	102	91.4	88.5	114
4-Bromofluorobenzene	460-00-4	2	%	92.9	97.8	88.3	94.1	92.3

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2.4.6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

QUALITY CONTROL REPORT

Work Order	: **EB1627934**	Page	: 1 of 13
Client	: **SLR Consulting Australia Pty Ltd**	Laboratory	: Environmental Division Brisbane
Contact	: MR JOHN LEYLAND	Contact	: Customer Services EB
Address	: Level 2 15 ASTOR TERRACE SPRING HILL 4000	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: TOTAL PNG ELK-ANTELOPE	Date Samples Received	: 24-Nov-2016
Order number	: 620.11227.00400	Date Analysis Commenced	: 24-Nov-2016
C-O-C number	: ----	Issue Date	: 05-Dec-2016
Sampler	: JOHN LEYLAND		
Site	: ----		
Quote number	: ----		
No. of samples received	: 17		
No. of samples analysed	: 15		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Diana Mesa	2IC Organic Chemist	Brisbane Organics, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane External Subcontracting, Stafford, QLD
Greg Vogel	Laboratory Manager	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EA025: Total Suspended Solids dried at 104 ± 2°C (QC Lot: 667728)									
EB1627934-001	V1 - 10	EA025H: Suspended Solids (SS)	----	5	mg/L	8	7	19.4	No Limit
EB1627934-013	V1 - 07	EA025H: Suspended Solids (SS)	----	5	mg/L	<5	<5	0.00	No Limit
ED037P: Alkalinity by PC Titrator (QC Lot: 667815)									
EB1627733-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	436	436	0.00	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	436	436	0.00	0% - 20%
EB1627791-003	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	702	698	0.517	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	702	698	0.517	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 667817)									
EB1627934-009	HB BH02	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	288	286	0.686	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	288	286	0.686	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 667447)									
EB1627934-001	V1 - 10	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	3	3	0.00	No Limit
EB1627934-013	V1 - 07	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	0.00	No Limit
ED045G: Chloride by Discrete Analyser (QC Lot: 667448)									
EB1627934-001	V1 - 10	ED045G: Chloride	16887-00-6	1	mg/L	7	7	0.00	No Limit
EB1627934-013	V1 - 07	ED045G: Chloride	16887-00-6	1	mg/L	9	9	0.00	No Limit
ED093F: Dissolved Major Cations (QC Lot: 671100)									
EB1627934-011	V1 - 03	ED093F: Calcium	7440-70-2	1	mg/L	18	18	0.00	0% - 50%

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
ED093F: Dissolved Major Cations (QC Lot: 671100) - continued									
EB1627934-011	V1 - 03	ED093F: Magnesium	7439-95-4	1	mg/L	29	29	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	21	22	0.00	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	13	14	0.00	0% - 50%
EB1627934-001	V1 - 10	ED093F: Calcium	7440-70-2	1	mg/L	6	6	0.00	No Limit
		ED093F: Magnesium	7439-95-4	1	mg/L	22	22	0.00	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	12	12	0.00	0% - 50%
		ED093F: Potassium	7440-09-7	1	mg/L	3	3	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 671102)									
EB1627934-011	V1 - 03	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.005	0.005	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.011	0.013	10.6	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.02	0.02	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	0.05	0.05	0.00	No Limit
EB1627934-001	V1 - 10	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-F: Barium	7440-39-3	0.001	mg/L	0.001	0.001	0.00	No Limit
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.008	0.008	0.00	No Limit
		EG020A-F: Aluminium	7429-90-5	0.01	mg/L	0.01	0.01	0.00	No Limit
		EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	<0.05	0.00	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 671103)									
EB1627934-011	V1 - 03	EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EB1627934-001	V1 - 10	EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 667636)									
EB1627623-001	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	0.0001	0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.001	<0.001	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 667636) - continued									
EB1627623-001	Anonymous	EG020A-T: Barium	7440-39-3	0.001	mg/L	0.057	0.056	2.88	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	0.006	0.006	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	0.054	0.052	3.43	0% - 20%
		EG020A-T: Lead	7439-92-1	0.001	mg/L	0.003	0.003	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.002	0.002	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	0.031	0.031	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	15.8	14.6	8.06	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	0.03	0.02	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	10.4	9.68	6.84	0% - 20%
EB1627623-010	Anonymous	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.015	0.014	0.00	0% - 50%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	1.22	1.24	1.06	0% - 20%
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	1.10	1.12	1.81	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 667637)									
EB1627623-001	Anonymous	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EB1627623-010	Anonymous	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 667638)									
EB1627934-010	DUP 01	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	0.010	0.010	0.00	No Limit
		EG020A-T: Barium	7440-39-3	0.001	mg/L	0.038	0.038	0.00	0% - 20%
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.00	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.00	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.02	0.00	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report LOR	Unit	Original Result	Duplicate Result	RPD (%)	Recovery Limits (%)
EG020T: Total Metals by ICP-MS (QC Lot: 667638) - continued									
EB1627934-010	DUP 01	EG020A-T: Iron	7439-89-6	0.05	mg/L	3.02	3.02	0.00	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 667639)									
EB1627934-010	DUP 01	EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	<0.001	0.00	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 671101)									
EB1627934-013	V1 - 07	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1627934-001	V1 - 10	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 667640)									
EB1627623-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB1627623-011	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 667641)									
EB1627934-010	DUP 01	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 667814)									
EB1627733-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.2	0.2	0.00	No Limit
EB1627791-003	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 667816)									
EB1627934-009	HB BH02	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.2	0.2	0.00	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 667849)									
EB1627934-001	V1 - 10	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.04	<0.01	122	No Limit
EB1627934-013	V1 - 07	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.02	<0.01	79.6	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 667449)									
EB1627934-001	V1 - 10	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1627934-013	V1 - 07	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 667850)									
EB1627934-001	V1 - 10	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB1627934-013	V1 - 07	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 670884)									
EB1627934-002	V1 - 08	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EB1627875-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	10.3	10.8	4.50	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 670885)									
EB1627934-014	V1 - 01	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.2	<0.1	0.00	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 670883)									
EB1627934-002	V1 - 08	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.05	0.04	0.00	No Limit
EB1627875-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	4.93	5.03	2.00	0% - 20%
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 670886)									
EB1628105-004	Anonymous	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.02	0.01	0.00	No Limit
EB1627934-014	V1 - 01	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.13	0.11	17.5	0% - 50%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 667450)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Client sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 667450) - continued									
EB1627934-001	V1 - 10	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.03	0.03	0.00	No Limit
EB1627934-013	V1 - 07	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EP002: Dissolved Organic Carbon (DOC) (QC Lot: 669850)									
EB1627934-001	V1 - 10	EP002: Dissolved Organic Carbon	----	1	mg/L	<1	1	0.00	No Limit
EB1627934-011	V1 - 03	EP002: Dissolved Organic Carbon	----	1	mg/L	1	1	0.00	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 669780)									
EB1627934-001	V1 - 10	EP005: Total Organic Carbon	----	1	mg/L	<1	<1	0.00	No Limit
EB1627934-011	V1 - 03	EP005: Total Organic Carbon	----	1	mg/L	2	<1	82.4	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 671316)									
EB1627934-001	V1 - 10	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EB1627934-013	V1 - 07	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.00	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 671316)									
EB1627934-001	V1 - 10	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EB1627934-013	V1 - 07	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.00	No Limit
EP080: BTEXN (QC Lot: 671316)									
EB1627934-001	V1 - 10	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	3	3	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit
EB1627934-013	V1 - 07	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.00	No Limit
		EP080: Toluene	108-88-3	2	µg/L	3	3	0.00	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.00	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.00	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.00	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Recovery Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA025: Total Suspended Solids dried at 104 ± 2°C (QCLot: 667728)								
EA025H: Suspended Solids (SS)	----	5	mg/L	<5	150 mg/L	103	88	112
				<5	1000 mg/L	97.7	88	112
ED037P: Alkalinity by PC Titrator (QCLot: 667815)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	95.7	80	120
ED037P: Alkalinity by PC Titrator (QCLot: 667817)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	103	80	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 667447)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	109	85	118
				<1	100 mg/L	101	85	118
ED045G: Chloride by Discrete Analyser (QCLot: 667448)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	92.4	90	115
				<1	1000 mg/L	93.9	90	115
ED093F: Dissolved Major Cations (QCLot: 671100)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
ED093F: Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
ED093F: Sodium	7440-23-5	1	mg/L	<1	----	----	----	----
ED093F: Potassium	7440-09-7	1	mg/L	<1	----	----	----	----
EG020F: Dissolved Metals by ICP-MS (QCLot: 671102)								
EG020A-F: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	94.5	79	118
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	94.2	88	116
EG020A-F: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	89.2	70	130
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	92.1	88	108
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	94.9	87	113
EG020A-F: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	94.0	86	112
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	97.2	88	114
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	97.3	89	110
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	92.1	89	113
EG020A-F: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.9	83	112
EG020A-F: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	99.8	88	114
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	93.4	87	113
EG020A-F: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	92.7	82	114
EG020F: Dissolved Metals by ICP-MS (QCLot: 671103)								
EG020B-F: Silver	7440-22-4	0.001	mg/L	<0.001	0.1 mg/L	85.7	85	114

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EG020T: Total Metals by ICP-MS (QCLot: 667636)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	114	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	112	88	112
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	109	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	109	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	111	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	111	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	114	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	108	89	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	105	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	107	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	113	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	110	84	114
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	110	82	118
EG020T: Total Metals by ICP-MS (QCLot: 667637)								
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.1 mg/L	106	84	117
EG020T: Total Metals by ICP-MS (QCLot: 667638)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	108	80	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	107	88	112
EG020A-T: Barium	7440-39-3	0.001	mg/L	<0.001	0.5 mg/L	104	70	130
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	104	88	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	109	89	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	105	89	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.2 mg/L	111	88	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	106	89	112
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	110	88	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	104	79	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	113	87	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.2 mg/L	105	84	114
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	107	82	118
EG020T: Total Metals by ICP-MS (QCLot: 667639)								
EG020B-T: Silver	7440-22-4	0.001	mg/L	<0.001	0.1 mg/L	101	84	117
EG035F: Dissolved Mercury by FIMS (QCLot: 671101)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	101	84	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 667640)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	98.0	80	100
EG035T: Total Recoverable Mercury by FIMS (QCLot: 667641)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	90.4	80	100
EK040P: Fluoride by PC Titrator (QCLot: 667814)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%) LCS	Recovery Limits (%) Low	Recovery Limits (%) High
EK040P: Fluoride by PC Titrator (QCLot: 667814) - continued								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	104	80	117
EK040P: Fluoride by PC Titrator (QCLot: 667816)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	10 mg/L	112	80	117
EK055G: Ammonia as N by Discrete Analyser (QCLot: 667849)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	95.9	86	112
EK057G: Nitrite as N by Discrete Analyser (QCLot: 667449)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	96.5	90	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 667850)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	99.9	89	115
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 670884)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	72.2	70	111
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 670885)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	10 mg/L	71.4	70	111
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 670883)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	97.6	77	109
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 670886)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	4.42 mg/L	96.6	77	109
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 667450)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	110	88	115
EP002: Dissolved Organic Carbon (DOC) (QCLot: 669850)								
EP002: Dissolved Organic Carbon	----	1	mg/L	<1	10 mg/L	85.1	80	112
				<1	100 mg/L	92.6	80	112
EP005: Total Organic Carbon (TOC) (QCLot: 669780)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	85.1	79	113
				<1	100 mg/L	93.8	79	113
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 667716)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	10 µg/L	78.4	47	101
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	10 µg/L	84.8	46	109
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	10 µg/L	86.4	50	104
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	10 µg/L	86.9	50	114
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	10 µg/L	89.6	49	114
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	10 µg/L	86.0	48	113
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	10 µg/L	79.9	48	120
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	10 µg/L	83.3	48	119
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	10 µg/L	86.7	48	125
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	10 µg/L	79.0	45	119

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report: Result	Laboratory Control Spike (LCS) Report: Spike Concentration	Spike Recovery (%): LCS	Recovery Limits (%): Low	Recovery Limits (%): High
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 667716) - continued								
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	10 µg/L	89.4	43	130
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	10 µg/L	99.2	46	130
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	10 µg/L	94.2	49	125
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	10 µg/L	96.0	40	132
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	10 µg/L	96.9	42	140
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	10 µg/L	98.3	39	136
EP080/071: Total Petroleum Hydrocarbons (QCLot: 667717)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	1211 µg/L	83.3	38	114
EP071: C15 - C28 Fraction	----	100	µg/L	<100	2103 µg/L	99.2	50	132
EP071: C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 671316)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	160 µg/L	83.7	76	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 667717)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	1696 µg/L	89.5	43	119
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	1496 µg/L	99.8	49	134
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 671316)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	185 µg/L	80.9	75	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
EP080: BTEXN (QCLot: 671316)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	90.5	77	119
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	89.6	78	122
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	89.0	78	119
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	20 µg/L	88.1	77	121
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	80.0	76	121
EP080: Total Xylenes	1330-20-7	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	108	75	120

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Matrix Spike (MS) Report: Spike	SpikeRecovery(%)	Recovery Limits (%)

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 667447)							
EB1627934-002	V1 - 08	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	109	70	130
ED045G: Chloride by Discrete Analyser (QCLot: 667448)							
EB1627934-002	V1 - 08	ED045G: Chloride	16887-00-6	400 mg/L	108	70	130
EG020F: Dissolved Metals by ICP-MS (QCLot: 671102)							
EB1627934-002	V1 - 08	EG020A-F: Aluminium	7429-90-5	0.5 mg/L	99.7	70	130
		EG020A-F: Arsenic	7440-38-2	0.1 mg/L	99.5	70	130
		EG020A-F: Barium	7440-39-3	0.5 mg/L	98.4	70	130
		EG020A-F: Cadmium	7440-43-9	0.1 mg/L	101	70	130
		EG020A-F: Chromium	7440-47-3	0.1 mg/L	100	70	130
		EG020A-F: Cobalt	7440-48-4	0.1 mg/L	100	70	130
		EG020A-F: Copper	7440-50-8	0.2 mg/L	102	70	130
		EG020A-F: Lead	7439-92-1	0.1 mg/L	101	70	130
		EG020A-F: Nickel	7440-02-0	0.1 mg/L	99.0	70	130
		EG020A-F: Selenium	7782-49-2	0.1 mg/L	103	70	130
		EG020A-F: Vanadium	7440-62-2	0.1 mg/L	103	70	130
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	101	70	130
EG020T: Total Metals by ICP-MS (QCLot: 667636)							
EB1627623-002	Anonymous	EG020A-T: Arsenic	7440-38-2	1 mg/L	103	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	101	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	99.4	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	104	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	104	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	106	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	102	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	105	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	105	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	102	70	130
EG020T: Total Metals by ICP-MS (QCLot: 667638)							
EB1627934-011	V1 - 03	EG020A-T: Arsenic	7440-38-2	1 mg/L	104	70	130
		EG020A-T: Barium	7440-39-3	1 mg/L	103	70	130
		EG020A-T: Cadmium	7440-43-9	0.5 mg/L	102	70	130
		EG020A-T: Chromium	7440-47-3	1 mg/L	103	70	130
		EG020A-T: Cobalt	7440-48-4	1 mg/L	104	70	130
		EG020A-T: Copper	7440-50-8	1 mg/L	104	70	130
		EG020A-T: Lead	7439-92-1	1 mg/L	103	70	130
		EG020A-T: Nickel	7440-02-0	1 mg/L	104	70	130
		EG020A-T: Vanadium	7440-62-2	1 mg/L	105	70	130
		EG020A-T: Zinc	7440-66-6	1 mg/L	102	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EG035F: Dissolved Mercury by FIMS (QCLot: 671101)							
EB1627934-002	V1 - 08	EG035F: Mercury	7439-97-6	0.01 mg/L	94.3	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 667640)							
EB1627623-002	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	87.5	70	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 667641)							
EB1627934-011	V1 - 03	EG035T: Mercury	7439-97-6	0.01 mg/L	87.3	70	130
EK040P: Fluoride by PC Titrator (QCLot: 667814)							
EB1627733-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	113	70	130
EK040P: Fluoride by PC Titrator (QCLot: 667816)							
EB1627934-010	DUP 01	EK040P: Fluoride	16984-48-8	5 mg/L	113	70	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 667849)							
EB1627934-002	V1 - 08	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	96.5	70	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 667449)							
EB1627934-002	V1 - 08	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	98.3	70	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 667850)							
EB1627934-002	V1 - 08	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	102	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 670884)							
EB1627875-002	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	# Not Determined	70	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 670885)							
EB1627934-015	V1 - 05	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	84.4	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 670883)							
EB1627875-002	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	# Not Determined	70	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 670886)							
EB1627934-015	V1 - 05	EK067G: Total Phosphorus as P	----	1 mg/L	117	70	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 667450)							
EB1627934-002	V1 - 08	EK071G: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	116	70	130
EP002: Dissolved Organic Carbon (DOC) (QCLot: 669850)							
EB1627934-002	V1 - 08	EP002: Dissolved Organic Carbon	----	100 mg/L	90.5	70	130
EP005: Total Organic Carbon (TOC) (QCLot: 669780)							
EB1627934-002	V1 - 08	EP005: Total Organic Carbon	----	100 mg/L	90.8	70	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 671316)							
EB1627934-002	V1 - 08	EP080: C6 - C9 Fraction	----	40 µg/L	80.8	70	130

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Recovery Limits (%)	
Laboratory sample ID	Client sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 671316)							
EB1627934-002	V1 - 08	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	80.1	70	130
EP080: BTEXN (QCLot: 671316)							
EB1627934-002	V1 - 08	EP080: Benzene	71-43-2	10 µg/L	83.7	70	130
		EP080: Toluene	108-88-3	10 µg/L	83.6	70	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB1627934**	Page	: 1 of 17
Client	: **SLR Consulting Australia Pty Ltd**	Laboratory	: Environmental Division Brisbane
Contact	: MR JOHN LEYLAND	Telephone	: +61-7-3243 7222
Project	: TOTAL PNG ELK-ANTELOPE	Date Samples Received	: 24-Nov-2016
Site	: ----	Issue Date	: 05-Dec-2016
Sampler	: JOHN LEYLAND	No. of samples received	: 17
Order number	: 620.11227.00400	No. of samples analysed	: 15

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser	EB1627875--002	Anonymous	**Total Kjeldahl Nitrogen as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**
EK067G: Total Phosphorus as P by Discrete Analyser	EB1627875--002	Anonymous	**Total Phosphorus as P**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method / **Container** / Client Sample ID(s)	*Extraction / Preparation*			*Analysis*		
	Date extracted	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EK057G: Nitrite as N by Discrete Analyser						
Clear Plastic Bottle - Natural HB BH02, DUP 01	----	----	----	24-Nov-2016	20-Nov-2016	**4**
Clear Plastic Bottle - Natural V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	----	----	----	24-Nov-2016	23-Nov-2016	**1**
Clear Plastic Bottle - Natural V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	----	----	----	24-Nov-2016	22-Nov-2016	**2**
Clear Plastic Bottle - Natural V1 - 05, V1 - 06, V1 - 04	----	----	----	24-Nov-2016	23-Nov-2016	**1**
EK071G: Reactive Phosphorus as P by discrete analyser						
Clear Plastic Bottle - Natural HB BH02, DUP 01	----	----	----	24-Nov-2016	20-Nov-2016	**4**
Clear Plastic Bottle - Natural V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	----	----	----	24-Nov-2016	23-Nov-2016	**1**
Clear Plastic Bottle - Natural V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	----	----	----	24-Nov-2016	22-Nov-2016	**2**
Clear Plastic Bottle - Natural V1 - 05, V1 - 06, V1 - 04	----	----	----	24-Nov-2016	23-Nov-2016	**1**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type / Method	Count QC	Count Regular	Rate (%) Actual	Rate (%) Expected	Quality Control Specification
Laboratory Duplicates (DUP)					
PAH/Phenols (GC/MS - SIM)	0	20	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	20	0.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
PAH/Phenols (GC/MS - SIM)	0	20	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	20	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EA025: Total Suspended Solids dried at 104 ± 2°C							
Clear Plastic Bottle - Natural (EA025H) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**25-Nov-2016**	25-Nov-2016	✓
Clear Plastic Bottle - Natural (EA025H) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**25-Nov-2016**	28-Nov-2016	✓
Clear Plastic Bottle - Natural (EA025H) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**25-Nov-2016**	27-Nov-2016	✓
Clear Plastic Bottle - Natural (EA025H) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**25-Nov-2016**	28-Nov-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**26-Nov-2016**	02-Dec-2016	✓
Clear Plastic Bottle - Natural (ED037-P)								
V2 - 02, V1 - 03, V1 - 01	V1 - 02, V1 - 07,	**19-Nov-2016**	**----**	----	----	**26-Nov-2016**	03-Dec-2016	✓
Clear Plastic Bottle - Natural (ED037-P)								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**----**	----	----	**26-Nov-2016**	04-Dec-2016	✓
Clear Plastic Bottle - Natural (ED037-P)								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**----**	----	----	**26-Nov-2016**	05-Dec-2016	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**24-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Natural (ED041G)								
V2 - 02, V1 - 03, V1 - 01	V1 - 02, V1 - 07,	**19-Nov-2016**	**----**	----	----	**24-Nov-2016**	19-Dec-2016	✓
Clear Plastic Bottle - Natural (ED041G)								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**----**	----	----	**24-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Natural (ED041G)								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**----**	----	----	**24-Nov-2016**	19-Dec-2016	✓
ED045G: Chloride by Discrete Analyser								
Clear Plastic Bottle - Natural (ED045G)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**24-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Natural (ED045G)								
V2 - 02, V1 - 03, V1 - 01	V1 - 02, V1 - 07,	**19-Nov-2016**	**----**	----	----	**24-Nov-2016**	19-Dec-2016	✓
Clear Plastic Bottle - Natural (ED045G)								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**----**	----	----	**24-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Natural (ED045G)								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**----**	----	----	**24-Nov-2016**	19-Dec-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**02-Dec-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**02-Dec-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**02-Dec-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (ED093F) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**02-Dec-2016**	19-Dec-2016	✓
EG020F: Dissolved Metals by ICP-MS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**02-Dec-2016**	17-May-2017	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**02-Dec-2016**	18-May-2017	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**02-Dec-2016**	19-May-2017	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG020B-F) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**02-Dec-2016**	20-May-2017	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) HB BH02, DUP 01	**18-Nov-2016**	**26-Nov-2016**	17-May-2017	✓	**26-Nov-2016**	17-May-2017	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**26-Nov-2016**	18-May-2017	✓	**26-Nov-2016**	18-May-2017	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**26-Nov-2016**	19-May-2017	✓	**26-Nov-2016**	19-May-2017	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG020B-T) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**26-Nov-2016**	20-May-2017	✓	**26-Nov-2016**	20-May-2017	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**02-Dec-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**02-Dec-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**02-Dec-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Filtered; Lab-acidified (EG035F) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**02-Dec-2016**	19-Dec-2016	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**26-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**26-Nov-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**26-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Unfiltered; Lab-acidified (EG035T) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**26-Nov-2016**	19-Dec-2016	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**26-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Natural (EK040P) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**26-Nov-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Natural (EK040P) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**26-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Natural (EK040P) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**26-Nov-2016**	19-Dec-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK055G: Ammonia as N by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**25-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
V2 - 02,	V1 - 02,	**19-Nov-2016**	**----**	----	----	**25-Nov-2016**	19-Dec-2016	✓
V1 - 03,	V1 - 07,							
V1 - 01								
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
V1 - 10,	V1 - 08,	**20-Nov-2016**	**----**	----	----	**25-Nov-2016**	18-Dec-2016	✓
V1 - 12,	V2 - 03,							
V1 - 11								
Clear Plastic Bottle - Sulfuric Acid (EK055G)								
V1 - 05,	V1 - 06,	**21-Nov-2016**	**----**	----	----	**25-Nov-2016**	19-Dec-2016	✓
V1 - 04								
EK057G: Nitrite as N by Discrete Analyser								
Clear Plastic Bottle - Natural (EK057G)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**24-Nov-2016**	20-Nov-2016	✗
Clear Plastic Bottle - Natural (EK057G)								
V2 - 02,	V1 - 02,	**19-Nov-2016**	**----**	----	----	**24-Nov-2016**	23-Nov-2016	✗
V1 - 03,	V1 - 07,							
V1 - 01								
Clear Plastic Bottle - Natural (EK057G)								
V1 - 10,	V1 - 08,	**20-Nov-2016**	**----**	----	----	**24-Nov-2016**	22-Nov-2016	✗
V1 - 12,	V2 - 03,							
V1 - 11								
Clear Plastic Bottle - Natural (EK057G)								
V1 - 05,	V1 - 06,	**21-Nov-2016**	**----**	----	----	**24-Nov-2016**	23-Nov-2016	✗
V1 - 04								
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**25-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
V2 - 02,	V1 - 02,	**19-Nov-2016**	**----**	----	----	**25-Nov-2016**	19-Dec-2016	✓
V1 - 03,	V1 - 07,							
V1 - 01								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
V1 - 10,	V1 - 08,	**20-Nov-2016**	**----**	----	----	**25-Nov-2016**	18-Dec-2016	✓
V1 - 12,	V2 - 03,							
V1 - 11								
Clear Plastic Bottle - Sulfuric Acid (EK059G)								
V1 - 05,	V1 - 06,	**21-Nov-2016**	**----**	----	----	**25-Nov-2016**	19-Dec-2016	✓
V1 - 04								

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK061G) HB BH02, DUP 01	**18-Nov-2016**	**29-Nov-2016**	16-Dec-2016	✓	**29-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**29-Nov-2016**	17-Dec-2016	✓	**29-Nov-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**29-Nov-2016**	18-Dec-2016	✓	**29-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**29-Nov-2016**	19-Dec-2016	✓	**29-Nov-2016**	19-Dec-2016	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK067G) HB BH02, DUP 01	**18-Nov-2016**	**29-Nov-2016**	16-Dec-2016	✓	**29-Nov-2016**	16-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**29-Nov-2016**	17-Dec-2016	✓	**29-Nov-2016**	17-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**29-Nov-2016**	18-Dec-2016	✓	**29-Nov-2016**	18-Dec-2016	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**29-Nov-2016**	19-Dec-2016	✓	**29-Nov-2016**	19-Dec-2016	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural (EK071G) HB BH02, DUP 01	**18-Nov-2016**	**----**	----	----	**24-Nov-2016**	20-Nov-2016	×
Clear Plastic Bottle - Natural (EK071G) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**----**	----	----	**24-Nov-2016**	23-Nov-2016	×
Clear Plastic Bottle - Natural (EK071G) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**----**	----	----	**24-Nov-2016**	22-Nov-2016	×
Clear Plastic Bottle - Natural (EK071G) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**----**	----	----	**24-Nov-2016**	23-Nov-2016	×

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP002: Dissolved Organic Carbon (DOC)								
Amber TOC Vial - Sulfuric Acid (EP002)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**28-Nov-2016**	16-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP002)								
V2 - 02, V1 - 03, V1 - 01	V1 - 02, V1 - 07,	**19-Nov-2016**	**----**	----	----	**28-Nov-2016**	17-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP002)								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**----**	----	----	**28-Nov-2016**	18-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP002)								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**----**	----	----	**28-Nov-2016**	19-Dec-2016	✓
EP005: Total Organic Carbon (TOC)								
Amber TOC Vial - Sulfuric Acid (EP005)								
HB BH02,	DUP 01	**18-Nov-2016**	**----**	----	----	**28-Nov-2016**	16-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP005)								
V2 - 02, V1 - 03, V1 - 01	V1 - 02, V1 - 07,	**19-Nov-2016**	**----**	----	----	**28-Nov-2016**	17-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP005)								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**----**	----	----	**28-Nov-2016**	18-Dec-2016	✓
Amber TOC Vial - Sulfuric Acid (EP005)								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**----**	----	----	**28-Nov-2016**	19-Dec-2016	✓
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM))								
V2 - 02, V1 - 07,	V1 - 03, V1 - 01	**19-Nov-2016**	**25-Nov-2016**	26-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP075(SIM))								
V1 - 10, V1 - 12, V1 - 11	V1 - 08, V2 - 03,	**20-Nov-2016**	**25-Nov-2016**	27-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP075(SIM))								
V1 - 05, V1 - 04	V1 - 06,	**21-Nov-2016**	**25-Nov-2016**	28-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Petroleum Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP071) V2 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**25-Nov-2016**	26-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP071) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**25-Nov-2016**	27-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP071) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**25-Nov-2016**	28-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber VOC Vial - Sulfuric Acid (EP080) HB BH02, DUP 01	**18-Nov-2016**	**29-Nov-2016**	02-Dec-2016	✓	**29-Nov-2016**	02-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**29-Nov-2016**	03-Dec-2016	✓	**29-Nov-2016**	03-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**29-Nov-2016**	04-Dec-2016	✓	**29-Nov-2016**	04-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**29-Nov-2016**	05-Dec-2016	✓	**29-Nov-2016**	05-Dec-2016	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)	Sample Date	Extraction / Preparation			Analysis		
		Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions							
Amber Glass Bottle - Unpreserved (EP071) V2 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**25-Nov-2016**	26-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP071) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**25-Nov-2016**	27-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber Glass Bottle - Unpreserved (EP071) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**25-Nov-2016**	28-Nov-2016	✓	**29-Nov-2016**	04-Jan-2017	✓
Amber VOC Vial - Sulfuric Acid (EP080) HB BH02, DUP 01	**18-Nov-2016**	**29-Nov-2016**	02-Dec-2016	✓	**29-Nov-2016**	02-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**29-Nov-2016**	03-Dec-2016	✓	**29-Nov-2016**	03-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**29-Nov-2016**	04-Dec-2016	✓	**29-Nov-2016**	04-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**29-Nov-2016**	05-Dec-2016	✓	**29-Nov-2016**	05-Dec-2016	✓
EP080: BTEXN							
Amber VOC Vial - Sulfuric Acid (EP080) HB BH02, DUP 01	**18-Nov-2016**	**29-Nov-2016**	02-Dec-2016	✓	**29-Nov-2016**	02-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V2 - 02, V1 - 02, V1 - 03, V1 - 07, V1 - 01	**19-Nov-2016**	**29-Nov-2016**	03-Dec-2016	✓	**29-Nov-2016**	03-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 10, V1 - 08, V1 - 12, V2 - 03, V1 - 11	**20-Nov-2016**	**29-Nov-2016**	04-Dec-2016	✓	**29-Nov-2016**	04-Dec-2016	✓
Amber VOC Vial - Sulfuric Acid (EP080) V1 - 05, V1 - 06, V1 - 04	**21-Nov-2016**	**29-Nov-2016**	05-Dec-2016	✓	**29-Nov-2016**	05-Dec-2016	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	Evaluation	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	3	28	10.71	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	3	28	10.71	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	2	20	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	20	0.00	10.00	×	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	30	10.00	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	3	27	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	3	27	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	3	27	11.11	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	4	35	11.43	10.00	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	20	0.00	10.00	×	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	16	12.50	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	2	28	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	2	15	13.33	10.00	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	28	7.14	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	20	5.00	5.00	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	15	6.67	5.00	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite B	EG020B-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	28	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Suspended Solids (High Level)	EA025H	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Organic Carbon	EP002	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	28	**7.14**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	0	20	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	30	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	27	**7.41**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	35	**5.71**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	20	**0.00**	**5.00**	×	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	16	**6.25**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Suspended Solids (High Level)	EA025H	WATER	In house: Referenced to APHA 2540D. A gravimetric procedure employed to determine the amount of `non-filterable` residue in a aqueous sample. The prescribed GFC (1.2um) filter is rinsed with deionised water, oven dried and weighed prior to analysis. A well-mixed sample is filtered through a glass fibre filter (1.2um). The residue on the filter paper is dried at 104+/-2C . This method is compliant with NEPM (2013) Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM (2013) Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM (2013) Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA 21st edition seal method 2 017-1-L april 2003
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM (2013) Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM (2013) Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Metals by ICP-MS - Suite B	EG020B-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	Method	Matrix	Method Descriptions
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM (2013) Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM (2013) Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM (2013) Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al (1976), Zhang et al (2006). This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM (2013) Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM (2013) Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM (2013) Schedule B(3)
Dissolved Organic Carbon	EP002	WATER	In house: Referenced to APHA 5310 B. This method is compliant with NEPM (2013) Schedule B(3) . Samples are combusted at high termperature in the presence of an oxidative catalyst. The evolved carbon dioxide is quantified using an IR detector.
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM (2013) Schedule B(3)
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015A The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270D Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM (2013) Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260B Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM (2013) Schedule B(3)
Total Coliforms (Water)	TCF-WAT	WATER	Total Coliforms analysis of water matrices conducted by Subcontracting Laboratory

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM (2013) Schedule B(3)
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM (2013) Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510B 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using 60mL DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM (2013) Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for sparging.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ Sydney: 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
☐ Newcastle: 5 Rosegum Rd, Warabrook NSW 2304 Ph:02 4968 9433 E:samples.newcastle@alsenviro.com
☐ Brisbane: 32 Shand St, Stafford QLD 4053 Ph:07 3243 7222 E:samples.brisbane@alsenviro.com
☐ Townsville: 14-15 Desma Ct, Bohle QLD 4818 Ph:07 4796 0600 E: townsville.environmental@alsenviro.com
☐ Melbourne: 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ Adelaide: 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ Perth: 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ Launceston: 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	SLR	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☑ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	BRISBANE		
PROJECT:	TOTAL PNG ELK-ANTELOPE	ALS QUOTE NO.:	BN/330/16
ORDER NUMBER:	620.11227.00400	COC SEQUENCE NUMBER (Circle)	COC 1 2 3 4 5 6 7 OF: 1 2 3 4 5 6 7
PROJECT MANAGER:	J LEYLAND / M CASLIN	CONTACT: +61 7 3858 4800	
SAMPLER:	JOHN LEYLAND	SAMPLER MOBILE: 0421918788	
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	
Email Reports to (will default to PM if no other addresses are listed): jleyland@slrconsulting.com			
Email Invoice to (will default to PM if no other addresses are listed): jleyland@slrconsulting.com			

RELINQUISHED BY: JLEYLAND
courier TO FNT (FOM)
DATE/TIME: 23/11/16 11:15

RECEIVED BY: D.McLan
DATE/TIME: 24-11-16 11 52

RELINQUISH
DATE/TIME:

FOR LABORATORY USE ONLY (Circle)
Custody seal intact? N/A
Free ice cubes present on receipt? N/A
Random Sample
Other comments

Environmental Division Brisbane
Work Order Reference
EB1627934

Telephone : + 61-7-3243 7222

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed t Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filter								
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	TPH, BTEX, PAH	TSS	METALS Al, As, Ag, Ba, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Se, V, Zn dissolved and total	Total nitrogen, total phosphorous, nitrate/nitrite, ammonia and ortho-phosphate	Bacteriological (coliforms and fecal streptococcus	TOC and DOC	Alkalinity	Cations - Na, K, Ca, Mg, Fe Anions - CO_3, HCO_3, SO_4, Cl	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	V1-10	20/11/16 14:40	W	11 BOTTLES	11	✓	✓	✓	✓	✓	✓	✓	✓	
2	V1-08	20/11/16 10:50	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
3	V1-12	20/11/16 15:30	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
4	V2-03	20/11/16 11:50	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
5	V1-11	20/11/16 13:35	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
6	HB BH04	18/11/16 10:35	W	"	11									HOLD
7	V2-02	19/11/16 12:45	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
8	V1-02	19/11/16 12:00	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
9	HB BH02	18/11/16 14:25	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
10	DUP 01	18/11/16	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
11	V1-03	19/11/16 14:00	W	"	11	✓	✓	✓	✓	✓	✓	✓	✓	
12	HB BH03	18/11/16 11:40	W	"	11									HOLD
				TOTAL	132									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ **Sydney:** 277 Woodpark Rd, Smithfield NSW 2176 Ph: 02 8784 8555 E:samples.sydney@alsenviro.com
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☐ **Melbourne:** 2-4 Westall Rd, Springvale VIC 3171 Ph:03 8549 9600 E: samples.melbourne@alsenviro.com
☐ **Adelaide:** 2-1 Burma Rd, Pooraka SA 5095 Ph: 08 8359 0890 E:adelaide@alsenviro.com
☐ **Perth:** 10 Hod Way, Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsenviro.com
☐ **Launceston:** 27 Wellington St, Launceston TAS 7250 Ph: 03 6331 2158 E: launceston@alsenviro.com

CLIENT:	SLR	TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)	☐ Standard TAT (List due date): ☐ Non Standard or urgent TAT (List due date):
OFFICE:	BRISBANE		
PROJECT:	TOTAL PNG ELK-ANTELOPE	ALS QUOTE NO.:	BN/330/16
ORDER NUMBER:	620.11227.00400		
PROJECT MANAGER:	J LEYLAND / M CASLIN	CONTACT: +61 7 3858 4800	
SAMPLER:	JOHN LEYLAND	SAMPLER MOBILE: 0421918788	
COC emailed to ALS? (YES / NO)		EDD FORMAT (or default):	
Email Reports to (will default to PM if no other addresses are listed): jleyland@slrconsulting.com			
Email Invoice to (will default to PM if no other addresses are listed): jleyland@slrconsulting.com			

COC SEQUENCE NUMBER (Circle)

COC	1	2	3	4	5	6	7
OF:	1	2	3	4	5	6	7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:	°C		
Other comments:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
J LEYLAND ~~courier~~ To TNT POM	D. McLaw		
DATE/TIME: 22/11/16 - POM	DATE/TIME: 24.11.16 11:52	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	TPH, BTEX, PAH	TSS	METALS Al, As, Ag, Ba, Cd, Co, Cr, Cu, Fe, Hg, Ni, Pb, Se, V, Zn dissolved and total	Total nitrogen, total phosphorous, nitrate/nitrite, ammonia and ortho-phosphate	Bacteriological (coliforms and fecal streptococcus	TOC and DOC	Alkalinity	Cations - Na, K, Ca, Mg, Fe Anions - CO_3, HCO_3, SO_4, Cl	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
13	V1-07	19/11/16 15:20	W	11 BOTTLES	11	✓	✓	✓	✓	✓	✓	✓	✓	
14	V1-01	21/11/16 10:45	W	11 BOTTLES	11	✓	✓	✓	✓	✓	✓	✓	✓	
15	V1-05	21/11/16 11:05	W	" "	11	✓	✓	✓	✓	✓	✓	✓	✓	
16	V1-06	21/11/16 11:55	W	" "	11	✓	✓	✓	✓	✓	✓	✓	✓	INCORRECT DATE ON BOTTLES
17	V1-04	21/11/16 09:30	W	" "	11	✓	✓	✓	✓	✓	✓	✓	✓	
				TOTAL	55									

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.