EPL228 Annual Environmental Monitoring Report 2019-2020

Report

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ABBREVIATION AND DEFINITIONS

Abbreviation	Details
µg/L	microgram per litre
µm	micrometre
µs/cm	microsiemens per centimetre
AEMR	annual environmental monitoring report
AGRU	acid gas removal unit
aMDEA	activated methyl diethanolamine
AOC	accidentally oil contaminated
AQMS	air quality monitoring stations
AS	Australian Standard
ASU	artificial settlement unit
BTEX	benzene, toluene, ethylbenzene, xylenes
BTX	benzene, toluene, xylenes
CCPP	combined cycle power plant
CCR	central control room
CFI	calibrated field instrument
CFU	colony-forming unit
cm	centimetre
CPF	central processing facility
CO	carbon monoxide
CO_2	carbon dioxide
COA	certificate of analysis
COC	continuously oily contaminated
COVID-19	disease caused by the severe acute respiratory symdrome coronavirus 2 (SARS-CoV-2)

Abbreviation	Details
dBA	A-weighted decibel
DENR	Department of Environment and Natural Resources
DO	dissolved oxygen
EC	electrical conductivity
E. coli	*Escherichia coli*
EIMP	Environmental Impact Monitoring Program
EPL228	Environment Protection Licence 228 (as amended)
FRP	filterable reactive phosphorus
GEP	gas export pipeline
H_2S	hydrogen sulphide
Hg	mercury
HM	hinterland margin
HRSG	heat recovery steam generator
Ichthys LNG	collectively, the onshore gas export pipeline and the gas processing plant
INPEX	Ichthys LNG Pty Ltd
km	kilometre
LIMS	laboratory information management system
LA_{90}	A-weighted sound pressure level which is exceeded for 90 per cent of the time interval considered and is one of two measure that determines background noise levels for the day/evening period
LA_{eq}	A-weighted sound pressure level and is the value of the A-weighted sound pressure level of a continuous steady sound that has the same acoustic energy as a given time-varying A-weighted sound pressure level when determined over the same measurement time interval
LNG	liquified natural gas
LOR	limit of reporting
LPG	liquified propane gas

Abbreviation	Details
m	metre
mm	millimetres
MEG	mono ethylene glycol
MDEA	methyl diethanolamine
mg/kg	milligram per kilogram
ml	millilitres
m^3/h	cubic metres per hour
MPN	most probable number
NAGD	National Assessment Guideline for Dredging
NATA	National Association of Testing Authorities, Australia
NCW	non-contaminated water
NEPM	National Environmental Protection Measure(s)
NGERS	National Greenhouse and Energy Reporting Scheme
NO	nitrogen monoxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxide (NO and/or NO_2)
NPI	National Pollutant Inventory
NSW	New South Wales
NT	Northern Territory
NT DPIR	Northern Territory Department of Primary Industry and Resources
NT EPA	Northern Territory Environment Protection Authority
O_2	oxygen
O_3	ozone
OEMP	Onshore Operations Environmental Management Plan
PAH	polycyclic aromatic hydrocarbons

Abbreviation	Details
PCS	process control system
pH	measure of acidity or alkalinity
$PM_{2.5}$	particulate matter with aerodynamic diameter less than 2.5 µm
PM_{10}	particulate matter with aerodynamic diameter less than 10 µm
ppm	parts per million
ppmv	parts per million by volume
PSD	particle size distribution
QA/QC	quality assurance/quality control
RBL	rating background level
REMP	Receiving Environment Monitoring Program
SFLA	sample for laboratory analysis
SLR	SLR Consulting Australia Pty Ltd
SO_2	sulphur dioxide
SQGV	sediment quality guideline value
STG	steam turbine generator
SWL	standing water level
TC	tidal creek
TEG	triethylene glycol
TF	tidal flat
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TPH	total petroleum hydrocarbons
TPP	temporary power plant

Abbreviation	Details
TRH	total recoverable hydrocarbons
TSS	total suspended solid
USEPA	United States Environmental Protection Authority
UV	ultraviolet

EXECUTIVE SUMMARY

Ichthys LNG Pty Ltd was issued Environment Protection Licence 228 (EPL228 as amended) on 13 December 2017. Activation of EPL228 occurred on 14 September 2018 triggering several EPL228 monitoring conditions and Onshore Operations Environmental Management Plan monitoring commitments.

This Annual Environmental Monitoring Report (AEMR) has been developed to meet Condition 86 of EPL228. Condition 86 requires an AEMR to be submitted to the Northern Territory Environment Protection Authority (NT EPA) for each year of the licence, unless otherwise agreed, for scheduled activities conducted during the preceding 12 months (i.e. the reporting period). For the purpose of this AEMR and as agreed with NT EPA, the reporting period is defined as 1 July 2019 to 30 June 2020.

Monitoring undertaken during the reporting period found that liquid effluent discharges were typically within EPL228 discharge limits and these discharges had no discernible impact on Darwin Harbour.

All other terrestrial and marine monitoring programs (e.g. groundwater, mangroves, weeds, marine sediment etc.) found that monitoring results were consistent with those reported during the previous year's AEMR and construction phase.

Based on monitoring results for the reporting period, there were no adverse effects to the declared beneficial uses and objectives of Darwin Harbour or Elizabeth-Howard River Region Groundwater.

The point source emission, ambient air quality and air toxics monitoring programs reported that all permanent plant and equipment were typically within EPL228 air emission limits, and the emissions had no discernible impact on the ambient air quality of the Darwin Region.

The Coronavirus (COVID-19) pandemic had a minor impact on monitoring activities. Impacts occurred from March 2020 till the end of the reporting period. Border travel restrictions and controls were imposed by the NT Government and INPEX's Pandemic Plan was activated, resulting in access restrictions for non-essential personnel working at Ichthys LNG. The two programs impacted, were the quarter 2 2020 stationary source emissions monitoring survey and the 2020 weed mapping survey.

1 INTRODUCTION

Ichthys LNG Pty Ltd (hereafter referred to as INPEX) was issued Environment Protection Licence 228 (as amended and hereafter referred to as the EPL228) on 13 December 2017 with a validity of five years for the purposes of:

> *Operating premises for processing hydrocarbons so as to produce, store and/or despatch liquefied natural gas or methanol, where:*
>
> *a) the premises are designed to produce more than 500,000 tonnes annually of liquefied natural gas and/or methanol; and*
>
> *b) no lease, licence or permit under the Petroleum Act or the Petroleum (Submerged lands) Act relates to the land on which the premises are situated.*
>
> *All the activities in relation to onshore production design capacity of 12.15 million tonnes per annum of hydrocarbons, being up to:*
>
> - *8.9 million tonnes of liquefied natural gas per annum from two LNG processing trains;*
> - *1.65 million tonnes of liquefied petroleum gas per annum; and*
> - *20,000 barrels of condensate per day (1.6 million tonnes of condensate per annum).”*

Since the last 2018/2019 AEMR, the Ichthys LNG facility has achieved steady state operations. The key milestones are shown in Section 1.4.1.

1.1 Purpose

The purpose of this annual environmental monitoring report (AEMR) is to satisfy Condition 86 of the EPL228 for the Licensed Premises (hereafter Ichthys LNG). The reporting period for this AEMR is 1 July 2019 to 30 June 2020.

1.2 Condition 87 requirements

Table 1-1 provides details of Condition 87 of EPL228 as it relates to the AEMR requirements and the relevant section for where it has been addressed within this report.

Table 1-1 Annual environmental monitoring report condition requirements

EPL228 Condition #	Condition detail	Section
87	The Annual Environmental Monitoring Report must:	-
87.1	report on monitoring required under this licence;	This AEMR
87.2	summarise performance of the authorised discharge to water, compared to the discharge limits and trigger values specified in Table 3 in Appendix 2;	2.1 and 2.2
87.3	summarise performance of the authorised emissions to air, compared to the emission limits and targets specified in Table 5 in Appendix 3, when the fuel burning or combustion facilities for the Scheduled Activity have operated under normal and maximum operating conditions for the annual period;	3.3

EPL228 Condition #	Condition detail	Section
87.4	summarise operating conditions of each emission source and the resulting air emission quality;	3.3
87.5	provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;	3.3
87.6	assess the contribution of the authorised emissions on the Darwin region ambient air quality during periods not affected by bushfire smoke for Wet and Dry seasons;	3.2
87.7	report on outcomes of the Receiving Environment Monitoring Program (REMP) monitoring and assessment;	2 to 5
87.8	summarise measures taken to reduce waste;	6
87.9	consider the NT EPA Guideline for Reporting on Environmental Monitoring;	APPENDIX A:
87.10	be reviewed by Qualified Professional(s); and	APPENDIX B:
87.11	be provided to the NT EPA with the Qualified Professional(s) written, certified review(s) of the Annual Environmental Monitoring Report.	APPENDIX B:

1.3 Program objectives

An overview of the environmental monitoring programs, their objectives and cross-references to sections within the AEMR which provide more detail, are listed in Table 1-2.

Table 1-2 Monitoring program objectives

Program	Objective	Section
Commingled treated effluent (750-SC-003)	To ensure commingled treated effluent does not exceed discharge criteria specified in EPL228.	2.1
Jetty outfall	To determine if liquid discharges from the jetty outfall are within acceptable limits.	2.2
Harbour sediment	To detect changes in surficial sediment quality in the vicinity of the jetty outfall and determine if changes are attributable to Ichthys LNG operations.	2.3
Ambient air quality	To assess the potential impact of Ichthys LNG air emissions on the Darwin region.	3.2
Point source emissions to air	To determine if air emissions from stationary point sources are within acceptable limits	3.3
Dark-smoke events	To determine if air emissions from the flare systems are within acceptable limits.	3.5

Program	Objective	Section
Airborne noise	To validate the noise model and confirm model predictions at sensitive locations	3.6
Groundwater quality	To detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations.	4.1
Mangrove health, intertidal sediment and bio-indicator	To informatively monitor mangroves adjacent to the Ichthys LNG Plant. To detect changes in intertidal sediment quality attributable to Ichthys LNG Plant operations. To determine through bio-indicator monitoring if changes in seafood quality is occurring and if so determine if it is attributable to Ichthys LNG Plant operations.	5.1
Nearshore marine pests	To assess the presence/absence of invasive marine pest at the Ichthys LNG product loading jetties, through a coordinated approach with the Northern Territory (NT) Biosecurity Unit.	5.2
Introduced terrestrial fauna	To determine the presence, location and methods used to control nuisance species.	5.3
Weed survey	To identify the abundance and spatial distribution of known and new emergent weed populations, especially in areas susceptible to weed invasion, to inform weed management control activities.	5.4
Weed management	To manage invasive weeds onsite.	5.6
Vegetation rehabilitation monitoring	To determine if vegetation recovery through natural processes has occurred.	5.6
Cultural heritage	To determine if there has been any interference to cultural heritage sites.	5.7

1.4 Site information

1.4.1 Ichthys LNG operational milestones

Table 1-3 provides an overview of the Ichthys LNG key milestones for the reporting period.

The COVID-19 pandemic had a minor impact on monitoring activities. Impacts occurred from March 2020 till the end of the reporting period. Border travel restrictions and controls were imposed by the NT Government and INPEX's Pandemic Plan was activated, resulting in access restrictions for non-essential personnel working at Ichthys LNG.

Programs impacted were primarily the stationary source emission monitoring program, (refer to Section 3.3 for further information) and weed mapping survey (refer to Section 5.4 and Section 5.5 for further information).

A general Ichthys LNG site layout is shown in Figure 1-1

Table 1-3 Ichthys LNG key milestones during the reporting period

Date	Report
Aug 2019	Commencement of ground level ambient air quality and air toxics monitoring.
Aug 2019	Commencement of monitoring of the emissions for each stationary source, following steady state conditions being achieved. As required by EPL228 condition 65
Oct 2019	Environmental audit undertaken by a qualified auditor in accordance with EPL228 condition 34.
11 Oct 2019	First start-up of the Combined Cycle Power Plant (CCPP) in combine cycle.
21 Oct 2019	CCPP achieved steady state operations in combine cycle (note the temporary power plant (TPP) demobilised from the site at this date)
8 Nov 2019	EPL228-03 issued. The licence was revised to remove first start-up activities, which included deletion of the utility boilers and TPP from the licence
14 Apr 2020	OEMP revision 4 endorsed. OEMP revised to remove reference to first start up activities.
8 May 2020	EPL228-04 issued. The licence was revised to include chlorine in the wastewater parameter list for monitoring, and removal of 27% monitoring investigation criteria of the National Environment Protection (Ambient Air Quality) Measure (Air NEPM) and National Environment Protection (Air Toxics) Measure (Air Toxic NEPM) for the ambient air quality and air toxics monitoring programs.

Figure 1-1 Ichthys LNG site layout

1.4.2 Environmental context

Ichthys LNG is located on Bladin Point, on the northern side of Middle Arm Peninsula in Darwin Harbour (Figure 1-2). Bladin Point is a low-lying peninsula in Darwin Harbour, which is separated from the mainland by a mudflat. Ichthys LNG is approximately 4 km from Palmerston (the nearest residential zone) and approximately 10 km south-east of the Darwin central business district, across Darwin Harbour.

Figure 1-2 Location of Ichthys LNG

Ichthys LNG lies in the monsoonal tropics of northern Australia, which has two distinct seasons; a hot wet season from November to April and a warm dry season from May to October. April and October are transitional months between the wet and dry seasons. Darwin experiences an overall mean annual rainfall of ~1,730 mm, the majority of which occurs during the wet season. The 2019/2020 wet season was the driest wet season on record since monitoring commenced at Ichthys LNG, with only 944.3 mm recorded (Table 1-4 and Figure 1-3). It is also worth noting that the previous 2018/2019 reporting period was the second-driest wet season on record since monitoring commenced at Ichthys LNG, with rainfall more than 660 mm below average

Table 1-4 Bladin Point wet season and transitional months monthly rainfall (mm)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total
Darwin average	70.6	141.7	250.8	426.3	374.6	319.0	102.2	1,685.2
2012/2013	36.8	199.8	232.4	282.8	291.2	415.2	141.6	1,599.8
2013/2014	134.8	352	268	780	335	14.4	111	1,995.2
2014/2015	13	226.4	175.4	630	492.2	233.8	54.2	1,825.0
2015/2016	12.6	140.6	709.4	243.2	213.4	231.8	63.8	1,614.8
2016/2017	83.8	265.4	469.8	614.2	736	515.8	220.6	2,905.6
2017/2018	93	249.2	125.4	1,031.6	380.4	423.4	39	2,342.0
2018/2019	2.6	183.8	91.6	311.4	159.6	147.8	125.8	1,022.6
2019/2020	24.0	71.2	51.5	327.2	217.7	179.9	72.9	944.3

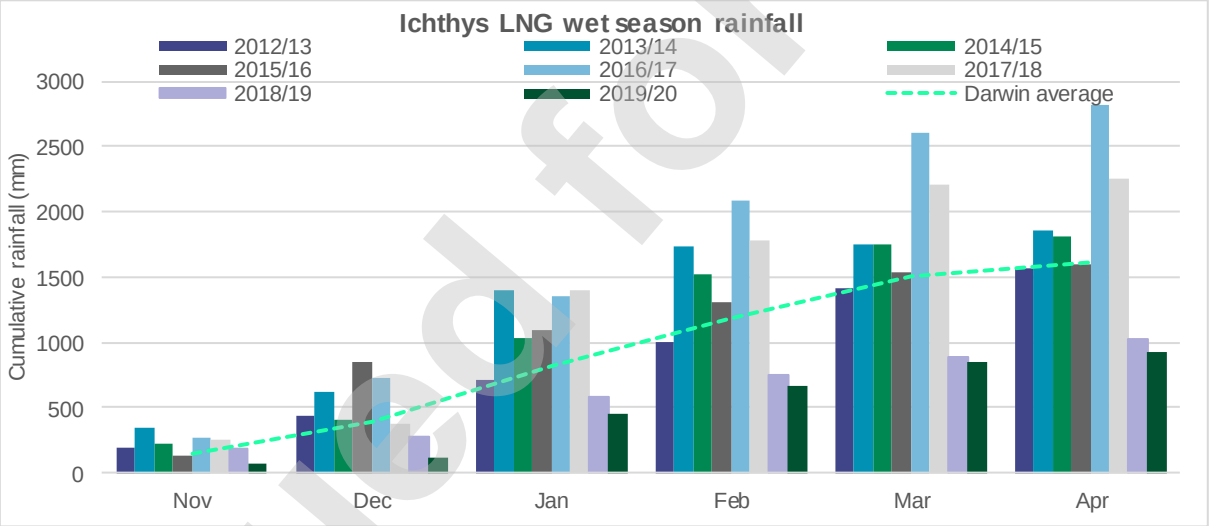


Figure 1-3 Bladin Point cumulative wet season rainfall

2 DISCHARGES TO WATER

This section describes the outcomes of the following wastewater monitoring programs, which include:

- Comingled treated effluent (Section 2.1)
- Jetty outfall (Section 2.2)
- Harbour sediment (Section 2.3).

2.1 Commingled treated effluent

The key objective of commingled treated effluent sampling from sampling point 750-SC-003 is to ensure discharge criteria specified in Table 3, Appendix 2 of EPL228 are not exceeded for wastewater discharged from Ichthys LNG.

The monitoring frequency, as specified in Table 3, Appendix 2 of EPL228 was implemented, with sampling occurring at least monthly (Table 2-1).

In accordance with EPL228 condition 59, weekly sampling was implemented following the treated steam blow down being discharged to the combined jetty outfall, during the construction phase of the project. For this AEMR this program lasted for a 12 week duration, in accordance with the commissioning monitoring plan (L750-AH-PLN-60001) (discussed in Section 2.1.1). Data from the 2018/2019 AEMR was also used for the commissioning monitoring plan reporting.

Table 2-1 Commingled treated effluent sampling dates

Sample month	Sample collection date
Jul-19	11
Aug-19	13
Sep-19	10
Oct-19	1*, 9*, 15*, 22*, 29*
Nov-19	5*, 11*, 19*, 26*
Dec-19	3*, 10*, 17#, 24#
Jan-20	20
Feb-20	12
Mar-20	10
Apr-20	15
May-20	12
Jun-20	9, 23#, 26#, 29#, 30#

*- Sampling conducted as part of the commissioning monitoring plan (L750-AH-PLN-60001) post-steam blowdown.

#- Additional sampling following an exceedance at location 750-SC-003.

2.1.1 Jetty outfall commissioning monitoring plan

As per EPL228 Condition 59, INPEX developed and implemented a Jetty Outfall Commissioning Monitoring Plan (L750-AH-PLN-60001). The objective of the plan was to monitor and assess the degree in variance in three nominated physical water quality parameters (pH, electrical conductivity and temperature) of the treated wastewater being discharged into the harbour, through combined jetty outfall. The intent was to justify why continuous online monitoring at sampling location 750-SC-003 is not required.

To monitor the degree of variance of the parameters, INPEX scheduled a weekly monitoring program, prior and post introduction of the steam blowdown water from the CCPP to gather data from the plant in steady state conditions. Sampling for this program was completed by INPEX onshore laboratory technicians whom are qualified samplers.

2.1.2 Method overview

The commingled treated effluent sampling point (750-SC-003) is located downstream of treated effluent observation basin and upstream of the jetty outfall. Samples collected from 750-SC-003 represent liquid effluent that is discharged to Darwin Harbour via the jetty outfall. The sampling point consists of two valves, an isolation valve and a sample needle valve, with the latter used to regulate flow for sample collection. Sampling from the commingled treated effluent sample point was conducted by trained laboratory analysts using National Association of Testing Authorities, Australia (NATA) accredited analysis methods by both the INPEX onshore laboratory and external third-party laboratories.

The parameters, sampling methods, limit of reporting (LOR) and discharge limits for the commingled treated effluent monitoring program are provided in Table 2-2. Note, free chlorine was added to EPL228 on 8 May 2020 following an amendment to the licence. As such, only sampling results from May and June 2020 are included in this report for free chlorine.

All results are reported through the INPEX onshore laboratory database systems (laboratory information management system; (LIMS)) that produce sample Certificates of Analysis (COA) inclusive of the laboratory NATA accreditation number. To enable the identification of an exceedance, the discharge limits specified in Table 3, Appendix 2 of EPL228 (refer to Table 2-2) have been input into the LIMS. Sample results are compared to their respective discharge limits in the COA. If a result exceeds the discharge limit, it is highlighted in the COA and the onshore laboratory generate an out of specification report.

Table 2-2 Commingled treated effluent discharge monitoring, methods and discharge limits

Parameter	Sampling method#	Unit	LOR	Discharge limit
Volumetric flow rate	CFI	m^3/hr	n/a	180
pH	INPEX Lab	pH Unit	n/a	6.0 - 9.0
Electrical conductivity (EC)	INPEX Lab	µS/cm	10	n/a
Temperature	CFI	°C	-	35°C
Turbidity	INPEX Lab	NTU	0.5	n/a
Dissolved oxygen	CFI	%	-	n/a
TPH as oil and grease	INPEX Lab	mg/L	1.0	6

Parameter	Sampling method[#]	Unit	LOR	Discharge limit
Total recoverable hydrocarbons (TRH; C10-C40)	External lab	µg/L	100	n/a
Total suspended solids (TSS)	INPEX Lab	mg/L	5	10
Biochemical oxygen demand (BOD)	External lab	mg/L	2	20
Chemical oxygen demand (COD)	INPEX Lab	mg O_2/L	10	125
Free Chlorine (from 8/5/20)	INPEX Lab	mg/L	0.02	2
Ammonia	INPEX Lab	mg N/L	2	n/a
Total nitrogen (TN)*	Calculation	mg N/L	2	10
Total phosphorus (TP)	INPEX Lab	mg P/L	0.5	2
Filterable reactive phosphorus (FRP)	INPEX Lab	mg P/L	0.2 and 0.5	n/a
Cadmium (total)	External lab	µg/L	0.1	n/a
Chromium (total)	External lab	µg/L	1	n/a
Copper (total)	External lab	µg/L	1	n/a
Lead (total)	External lab	µg/L	1	n/a
Mercury (total)	External lab	µg/L	0.1	n/a
Nickel (total)	External lab	µg/L	1	n/a
Silver (total)	External lab	µg/L	1	n/a
Zinc (total)	External lab	µg/L	5	n/a
Enterococci	External lab	cfu/100mL	1	n/a
Escherichia coli	External lab	cfu/100mL	1	100
Faecal coliforms	External lab	cfu/100mL	1	400
Anionic surfactants	External lab	mg/L	0.1	n/a
Activated methyl diethanolamine (aMDEA)[##]	External lab/INPEX lab	mg/L	0.001 and 5	n/a
Glycol**	External lab/INPEX lab	mg/L	2 and 5	n/a

[#]CFI = calibrated field instrument

*Total nitrogen is a sum of Nitrite, Nitrate and total Kjeldahl nitrogen (TKN). TKN analysis was completed by both INPEX onshore laboratory and external laboratory interchangeable, depending on INPEX onshore laboratory equipment availability. Nitrate and nitrite were measured by INPEX onshore laboratory.

[##]Methyl diethanolamine (MDEA with a LOR of 1 µg/L) was measured instead of aMDEA until the INPEX laboratory achieved NATA accreditation for aMDEA which occurred in November 2019

**Measured as mono-ethylene glycol (MEG) and Triethylene glycol (TEG) external laboratory used until the INPEX laboratory achieved NATA accreditation in November 2019

2.1.3 Results and discussion

Routine monitoring results

The results for 750-SC-003 sampling for the reporting period are presented in APPENDIX C:. Results that exceeded discharge limits are highlighted and in bold text.

During the reporting period, there were four occurrences where wastewater quality was above discharge limits, which are further discussed in Section 2.1.4. Note following an initial exceedance, further sampling at 750-SC-003 was generally undertaken to confirm the results as part of an investigation. Any results from the investigation sampling process from an exceedance event at sampling location 750-SC-003 are included in APPENDIX C:, where they elevated they are considered part of an ongoing original event.

Overall, there was generally little variability of the wastewater quality, with the majority of results below EPL228 discharge limits. This demonstrates the wastewater treatment systems were operating effectively.

Volumetric flow rate data for the reporting period is shown in Figure 2-1. The data confirms that the volumetric flow rate throughout the period remained well below the 180 m^3/h discharge limit.

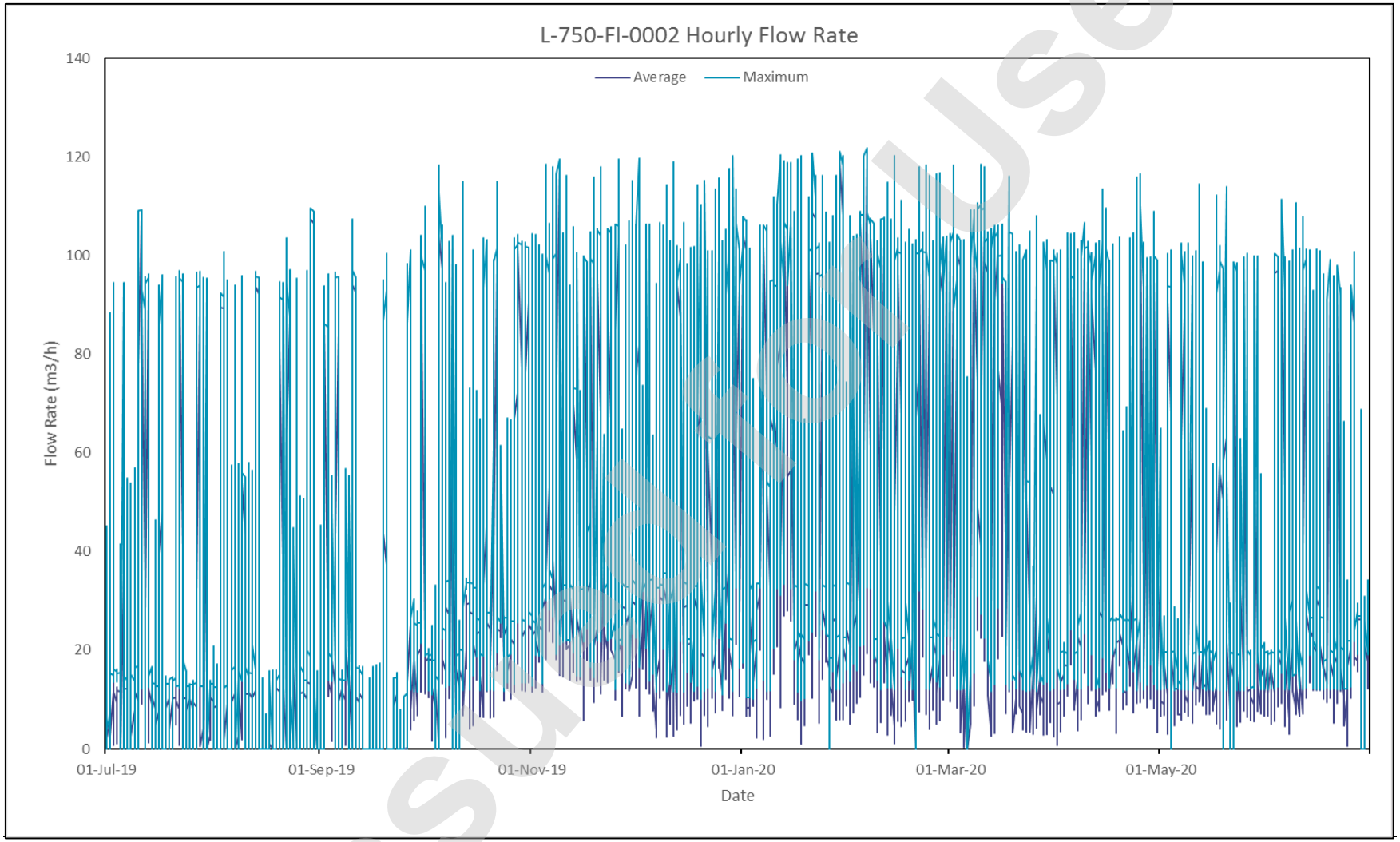


Figure 2-1Hourly maximum and average flow rate measured by 750-FI-0002 flow meter

Jetty outfall commissioning monitoring plan results

The intensive monitoring program reported little variation in the physical water quality parameters, for the combined jetty outfall wastewater stream, (refer to data in APPENDIX C: and from the 2018/2019 AEMR).

Throughout the commissioning monitoring period the pH value results ranged between 7.10 and 8.40, with an average value of 7.80 and standard deviation of 0.27. All results were within the EPL228 discharge limit range for pH (range 6-9).

Throughout the commissioning monitoring period the electrical conductivity value results ranged between 167.0 and 1111.0 µs/cm with an average value of 454.75 µs/cm and standard deviation of 203.4. There is no discharge EPL228 limit for conductivity. It is considered the water quality is of fresh water quality <500 µs/cm.

Throughout the commissioning monitoring period the temperature reading results ranged between 24.00 and 34.60°C with an average value of 30.54°C and standard deviation of 1.97. All results were below the EPL228 discharge limit of 35°C.

The results demonstrated that the various wastewater treatment packages used to treat wastewater streams (treated sewage, accidentally oily contaminated (AOC)/continuously oily contaminated (COC), demineralisation plant reject brine, and neutralised CCPP steam blowdown) are working effectively and producing on-specification treated effluent.

INPEX considers that installing online water quality analysers downstream of sampling location 750-SC-003 is currently not required.

Quality assurance/quality control

The quality assurance/quality control (QA/QC) procedures specific to the collection and analysis of samples from sample location 750-SC-003 included:

- NATA accredited analytical laboratories were used for all analysis or a test method managed under a NATA accredited quality management system was used
- laboratory designated sample holding times met
- chain of custody forms were completed and accompanied the samples
- INPEX laboratory QA/QC procedures as followed were completed:
  - laboratory blanks
  - replicates/duplicate
  - spikes
  - calibration against standard reference materials
  - INPEX laboratory review of external laboratory QA/QC analysis reports
  - annual sampling verification, which involves the collection of two samples and trip blanks
- calibration of all field-testing equipment using the INPEX standard method(s) was undertaken.

There was one QA/QC breach identified during the reporting period (15 April 2020). whereby Anionic Surfactants were not analysed within the prescribed holding time.

The holding time breach was recorded as a laboratory non-conformance event, prompting a cause analysis investigation on laboratory sample handling procedures. Table 2-3 outlines non-conformance event descriptions and corrective actions for the reporting period.

Table 2-3 INPEX onshore laboratory holding time non-conformance events

Non-conformance description	Event overview
Sample ID L00029063 was sampled from L-750-SC-003 on 15/04/2020. All testing completed within holding time of sample being taken with the exception of Anionic Surfactants	Anionic Surfactants were analysed by external laboratory one day outside of holding time due to the original flight the samples were on being cancelled due to COVID-19 related matters. Holding time breach mentioned on COA as a disclaimer.

2.1.4 Limit exceedances assessment outcomes

Throughout the reporting period, and displayed on the COAs, there were four discharge limit exceedances (refer to APPENDIX C:). A summary table of all discharge limit exceedances including corrective actions is provided in Table 2-4.

Table 2-4 Summary of commingled treated effluent sample point exceedance events

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
13-Aug-19	16-Aug-19	Total nitrogen	14.0 mg N/L	10 mg N/L	The investigation identified at the time of sampling the sewage treatment plant was the only source discharging into the combined jetty outfall line. The potential cause of the total nitrogen exceedance was due to the poor performance of the sewage treatment plant. The sewage plant was returning back into service following extensive maintenance activities in the week prior to the exceedance and not in a stable operating condition. Once stable operations for the plant were achieved the total nitrogen levels were below the EPL228 limit.	Following the identification that the source of the elevated total nitrogen was from the sewage treatment plant the following occurred: • the treated sewage effluent was prevented from discharging to the comingled jetty outfall line on the afternoon of 16 August 2019. The treated sewage was diverted into the accidentally oil contaminated (AOC) drainage network where this waste stream could comingle with additional wastewater. • Further sampling of the combined wastewater stream (AOC/treated sewage effluent) from the AOC holding basin on 19 August 2019 reported a total nitrogen concentration of 9.2 mg/L, while sampling of the individual stream from the sewage plant reported a total nitrogen concentration of 8.8 mg/L, while the AOC system reported a total nitrogen level of 2.2 mg/L.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
						• Discharge of the comingled effluent from the AOC system re-commenced on 22 August 2019, following the issue of the interim laboratory report, as all the individual streams entering into the combine jetty outfall were below 10 mg/L. Due to all the individual streams being below 10 mg/L the treated sewage was lined back up to directly discharge into the combined jetty outfall, as it was considered the sewage treatment plant was in a stable operating mode. • Increased field testing for total nitrogen of the treated effluent quality has occurred following the return to service of equipment post maintenance activities at the sewage treatment plant, to ensure the effluent quality is below EPL228 prior to discharge to the jetty outfall. • Treated effluent will be held up if over the EPL228 limit and sent for re-treatment.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
10-Sep-19	17-Sep-19	*E. coli*	130 cfu/ 100mL	100 cfu/ 100mL	On investigation, it was determined that at the time of sampling (10 September 2019) there were two streams discharging into the jetty outfall line; the first stream was from the AOC treatment system (including the demineralisation plant reject brine) and the second was the stream from the sewage treatment system. The investigation found that the most probable cause of the elevated *E. coli* levels was due to a faulty ultraviolet (UV) sensor equipment which affected the sterilisation process in the sewage treatment plant. Following the identification of the *E. Coli* contamination chlorine dosing was carried out in both the AOC and sewage treatment plant systems on 17 September 2019. Note at this time the treated sewage was diverted to the AOC holding basin and not discharging to the jetty outfall.	• Decontamination of the *E. coli* from within the sewage treatment plant, through chlorine dosing was implemented on 17 September 2019. • Replacement UV sensor parts were procured and the repair work of the system occurred. • In addition, a small floating chlorine dosing unit has been installed up-stream of the UV sterilisation system as a backup system to the UV system in the sewage treatment.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
					On 18 September 2019 extensive sampling from various locations within both the sewage and AOC treatment plants occurred to determine the source of the *E. Coli*. The treated sewage post UV sterilisation reported *E. coli* levels at 23 CFU/100 mL (noting this value is below the EPL228-02 limit of 100 CFU/100 mL), this result indicated that system was only partially treating *E. coli,* while the AOC system testing reported *E. coli* levels of 6 and <1 CFU/100 mL. Replacement UV sterilisation parts were procured and the repair work occurred shortly after delivery of the parts. The source of the *E. coli* from the sewage treatment system is not able to be identified unequivocally, as it could have been from either animal waste or dead animals (e.g. cane toads) present in the AOC drainage system. Following the chlorine dosing, all resultant water was held in the observation basin to allow for the chlorine to degrade to non-detectable levels (< 0.02 mg/L; consistent with the trigger value used for the receiving environment during the construction phase (refer CEMP) and the lowest level in situ equipment is able to read). Discharge to the jetty outfall recommenced on 19 September 2019 following the chlorine dosing of the water treatment systems.	

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
					A further wastewater sample was collected from location 750-SC-003 on 1 October 2019, subsequently reported an *E. coli* level of 2 CFU/100 mL, with the same streams discharging into the outfall line at the time of sampling.	
1-Oct-19	7-Oct-19	Total nitrogen	10.5 mg N/L	10 mg N/L	The cause of the total nitrogen exceedance was the poor performance of the sewage treatment plant, due to the supply line of the sugar dosing system being left closed following the swap out of the sugar bulk storage. This resulted in the sugar dosing system being offline for approximately three days, which then caused an imbalance in the sewage treatment plant resulting in high total nitrogen discharge levels. Following the identification that the sugar feed supply was not operational, the sugar supply line was re-opened.	The treated sewage effluent was prevented from discharging to the comingled jetty outfall line on the afternoon of 7 October 2019. • The treated sewage was diverted into the accidentally oil contaminated (AOC) drainage network where this waste stream could comingle with additional wastewater. • Further sampling of the combined wastewater stream (AOC/treated sewage effluent) from the AOC observation basin on 8 October 2019 reported a total nitrogen concentration of <2 mg/L, while sampling of the individual stream from the sewage plant reported a total nitrogen concentration of 4 mg/L on 9 October 2019. • Discharge of the comingled effluent from the AOC system re-commenced on 9 October 2019, as all the individual stream entering into the combine jetty outfall were below 10 mg/L.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
						• Sampling form sample location 750-SC-003 on 9 October 2019 reported total nitrogen concentration of <2 mg/L. • INPEX revised the inspection checklist to ensure that a daily check is undertaken to ensure that the sugar dosing system is operational for the sewage treatment plant.
23-Jun-20	23-Jun-20	Total nitrogen	13.3 mg N/L	10 mg N/L	The investigation identified that main cause of the total nitrogen exceedance was identified as being due to several sources of elevated ammonia in the CCPP steam system entering the steam blowdown treatment package which was unable to be treated, due to the elevated ammonia concentration being above the level the steam blowdown package is designed to treat.	INPEX identified that the main source of the elevated total nitrogen was from the steam system and the following actions have occurred: • A single service water hose was plumbed into the jetty outfall line to dilute the steam blowdown from the CCPP on 27 June 2020, while the engineering team was developing the logic changes required to address the issues identified with the ammonia dosing pumps. • A second service water hose was subsequently added to the jetty outfall line on 28 June 2020, and third on 29 June 2020. • The logic settings on ammonia dosing pumps were changed on 1 July 2020. • An additional service water hose added to the jetty outfall to aid in dilution on 6 July 2020

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
						• The line up to flash tank was corrected and verified as per design requirements on 7 July 2020 • Repair and maintenance of the level transmitters in the steam system flash tanks in July 2020 • Servicing of the sugar dosing pump occurred on 24 June 2020, with the dosing system returned to normal operations on this date. Following the implementation of the above actions, sampling at location 750-SC-003 was conducted on 11 and 14 July 2020, to verify the actions had reduced the total nitrogen concentration to below 10 mg/l in the CCPP steam blowdown. Note a full combined comingled jetty outfall sampling event occurred on 14 July 2020, which reported a total nitrogen concentration of <2 mg/L. Corrective actions that have or will be undertaken to ensure the non-compliance does not reoccur: Through the incident investigation several additional actions were identified to prevent reoccurrence which require a longer lead time. These involve: • Reducing the ammonia concentration of the fluid which is injected into the steams system from 19% to 10%.

Date sampled	Exceedance Reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
						• Calibration of the ammonia dosing pumps. INPEX has placed in a maintenance service request for this works to occur, and it is scheduled to occur by the end of August 2020. • Undertake an engineering review of the ammonia injection dosing pump arrangements, with the intent to change out to an alternative Grundfos pump type, with a lower rate of injection, if viable. • Undertake an engineering review to investigate the redirection of the ammonia dosing injection location from directly into the header, to the induvial heat recovery steam generator (HRSG) drums.

2.1.5 Program rationalisation

Sampling is to remain as per EPL228 requirements, therefore no changes are proposed.

2.2 Jetty outfall

The key objective of the jetty outfall water quality monitoring program is to detect changes in water quality attributable to liquid discharges from the jetty outfall. The purpose of the jetty outfall monitoring program is to monitor for any potential impacts associated with liquid discharges from the jetty outfall, as required in EPL228.

Monitoring frequency as specified in Appendix 2 of EPL228 is quarterly for the first 24 months following completion of first start-up of LNG Train 2. Start-up of LNG Train 2 was completed 19 June 2019 when steady state operations were achieved. Table 2-5 provides a summary of the four quarterly jetty outfall surveys completed during the reporting period (1 July 2019 – 30 June 2020).

Table 2-5 Jetty outfall survey details

Survey	Date	Report	INPEX Doc #
4	11 Jul 2019	Jetty Outfall Monitoring – Trigger Assessment Report No. 4	F280-AB-REP-60034
		Jetty Outfall Monitoring – Interpretative Report No. 4	F280-AB-REP-60024
5	7 Oct 2019	Jetty Outfall Monitoring – Trigger Assessment Report No. 5	F280-AB-REP-60033
		Jetty Outfall Monitoring – Interpretative Report No. 5	F280-AB-REP-60023
6	4 Feb 2020*	Jetty Outfall Monitoring – Trigger Assessment Report No. 6	F280-AB-REP-60032
		Jetty Outfall Monitoring – Interpretative Report No. 6	F280-AB-REP-60022
7	14 Apr 2020	Jetty Outfall Monitoring – Trigger Assessment Report No. 7	F280-AB-REP-60031
		Jetty Outfall Monitoring – Interpretative Report No. 7	F280-AB-REP-60021

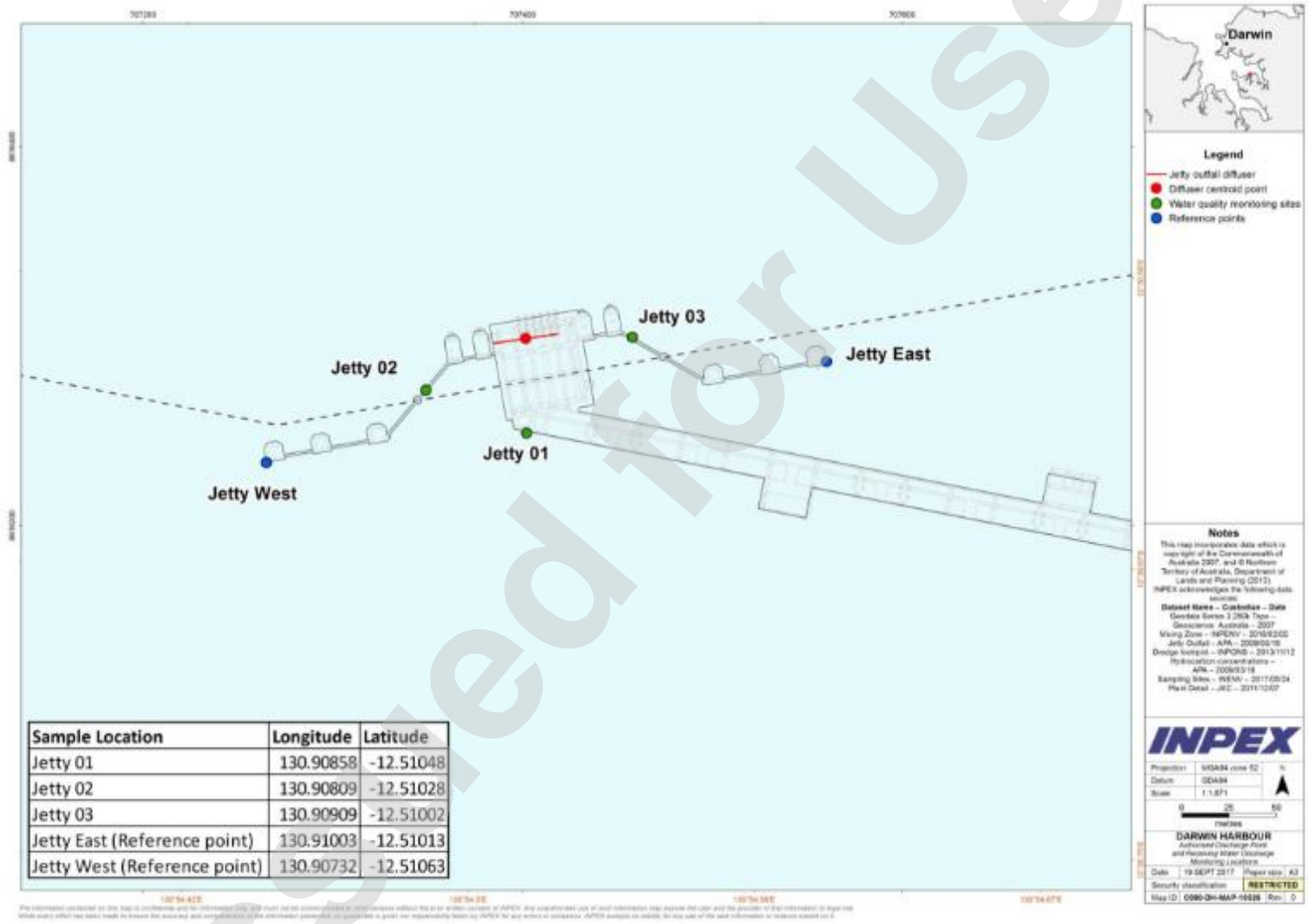
*Sampling was attempted on 20 January 2020; however, due to inclement weather the field sampling was abandoned and undertaken on the next neap tide (i.e. next sampling window).

2.2.1 Method overview

Jetty outfall surveys were performed in accordance with the INPEX-approved Jetty Outfall Monitoring Plan (F280-AB-PLN-60002), which was developed in consideration of the monitoring requirements specified in EPL228. Surficial water samples were collected from the five sampling locations (three potential impact sites and two reference sites) shown in Figure 2-2, during slack water on a neap high tide[1]. Following sample collection, calibrated field instruments were used to measure parameters that could be measured in situ and for those that could not, samples were taken and sent to a NATA accredited laboratory for analysis. Table 2-6 provides a summary of parameters, sampling methods and trigger values. Note, trigger values are provided for information only (see Section 2.2).

Free chlorine was added to EPL228 on 8 May 2020 following an amendment to the licence. As such, free chlorine was not sampled for the Jetty Outfall scope during the reporting period for this AEMR.

[1] Slack water is defined as 1.5 hours either side of low or high tide while neap tide is defined as <3 m of tide range as this aligns with Northern Territory Department of Environment and Natural Resources (DENR) water quality monitoring protocol.



Sample Location	Longitude	Latitude
Jetty 01	130.90858	-12.51048
Jetty 02	130.90809	-12.51028
Jetty 03	130.90909	-12.51002
Jetty East (Reference point)	130.91003	-12.51013
Jetty West (Reference point)	130.90732	-12.51063

Figure 2-2 Jetty outfall sampling locations

Table 2-6 Jetty outfall monitoring parameters, methods and trigger values

Parameter	Unit	Sampling method*	Trigger value#
pH	pH units	SFLA	Outside 6.0 and 8.5
Electrical conductivity (EC)	µS/cm	SFLA	n/a
Temperature	°C	CFI	±3 from ambient
Turbidity	NTU	CFI	>10 from ambient
Dissolved oxygen (DO)	%	CFI	Outside 80 to 100
Visual clarity and colour	n/a	O	No decrease in visual clarity or increase in odour
Surface films	n/a	O	None observed
Total Petroleum Hydrocarbons (TPH) as oil and grease	mg/L	SFLA	No visible sheen or emulsion, no odour
TPH/Total Recoverable Hydrocarbons (TRH)	µg/L	SFLA	Greater than reporting limit
Total suspended solids (TSS)	mg/L	SFLA	10
Free chlorine^	mg/L	SFLA	0.2
Ammonia	µg N/L	SFLA	20
Total nitrogen (TN)	µg N/L	SFLA	300
Total phosphorus (TP)	µg P/L	SFLA	30
Filtered reactive phosphorus (FRP)	µg P/L	SFLA	10
Cadmium	µg/L	SFLA	0.7
Chromium	µg/L	SFLA	4.4
Copper	µg/L	SFLA	1.3
Lead	µg/L	SFLA	4.4
Mercury	µg/L	SFLA	<0.1
Nickel	µg/L	SFLA	7
Silver	µg/L	SFLA	1.4
Zinc	µg/L	SFLA	15
Enterococci	cfu/100mL	SFLA	50

*SFLA = sample for laboratory analysis, CFI = calibrated field instrument, O = observation

Not compliance limits. Exceedance of Trigger Values requires review and assessment of cause at the time results are received as per ANZECC & ARMCANZ recommendations. A trigger for investigation occurs when the median value of the three receiving environment sites from water samples collected in the same day exceeds the trigger value and the exceedance is also not present at the upstream reference site determined form the tidal phase of sampling on the same day.

^ Free chlorine was added to EPL228 on 8 May 2020 following an amendment to the licence. As such, free chlorine was not samples for the Jetty Outfall scope during the reporting period for this AEMR.

2.2.2 Results and discussion

Impact and reference site results for the four surveys undertaken in the reporting period are summarised in Table 2-7 (see APPENDIX D: for all results), where exceedances were detected these are indicated in bold.

Exceedances of trigger values (defined in EPL 228) are flagged in the survey Trigger Assessment Report and investigated by INPEX to determine if the exceedance is a result of Ichthys LNG. Minor exceedances were reported for Enterococci in Survey 6 (Table 2-7), and results of the trigger investigation are discussion in Section 2.2.3.

A slick was observed at impact site Jetty 02 during Survey 4 (reported in F280-AB-REP-60024) which was not reported as a trigger exceedance given the slick was not present at the other impact sites, and there have been no reported hydrocarbon spills that could contribute to the slick. On review of photos provided, the slick does not appear to comprise of hydrocarbons since there is no discernible sheen, colouring or change in surface water tension (Figure 2-3).

Generally, results for all parameters in all four surveys show little variability between impact and reference sites, indicating the discharged commingled treated effluent had no discernible influence on samples collected at these locations. As such, discharges have not adversely affected the declared beneficial uses or water quality objectives for Darwin Harbour.

Table 2-7 Median impact (Imp) and reference (Ref) site sample results for jetty outfall surveys 4, 5, 6 and 7

Parameter	Unit	Survey 4		Survey 5		Survey 6		Survey 7	
		Imp	Ref	Imp	Ref	Imp	Ref	Imp	Ref
pH	pH units	8.0	8.0	7.9	7.9	7.8	7.8	7.8	7.8
EC	µS/cm	53590	53670	54600	54600	48240	47955	56050	55875
Temp	°C	25.8	25.8	29.6	29.5	31.3	31.1	33.2	33.1
Turbidity	NTU	1.9	2.0	1.9	2.0	1.3	1.2	5.4	5.6
DO	%	97.2	97.8	97.1	97.2	101.8	102.3	90.3	89.8
Visual clarity and colour	n/a	No change	No change	No change	No change	No change	No change	No change	No change
Surface films	n/a	None	None	None	None	None	None	None	None
Silver	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	µg/L	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	µg/L	0.3	0.2	0.3	0.2	<0.2	<0.2	<0.2	<0.2
Copper	µg/L	0.4	0.6	0.4	0.5	0.6	0.6	0.4	0.6
Mercury	µg/L	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Nickel	µg/L	0.4	0.4	0.4	<0.3	<0.3	<0.3	0.4	0.3
Lead)	µg/L	0.2	0.2	0.2	0.1	<0.1	<0.1	<0.1	<0.1
Zinc	µg/L	1.0	1.0	2.0	<1	2.0	2.0	1.0	<1
Ammonia	µg N/L	<3	<3	<3	<3	5.0	4.0	5.0	6.0

Parameter	Unit	Survey 4		Survey 5		Survey 6		Survey 7	
		Imp	Ref	Imp	Ref	Imp	Ref	Imp	Ref
FRP	µg P/L	7.0	7.0	6.0	6.0	3.0	2.0	8.0	8.5
Total phosphorus	µg P/L	19.0	17.5	18.0	19.5	13.0	12.0	22.0	21.5
Total nitrogen	µg N/L	110.0	95.0	120.0	135.0	130.0	130.0	150.0	155.0
TSS	mg/L	2.0	2.0	1.0	2.0	4.0	3.0	5.0	4.5
TPH as Oil and grease	n/a	None	None	None	None	None	None	None	None
	mg/L	<5	<5	<5	<5	<5	<5	<5	<5
TPH (C6 – C36)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50
Enterococci	MPN/100mL	<10	<10	<10	<10	**83.0**	82.5	<10	<10

Note: values in bold represent an exceedance of reference site and trigger value.

Figure 2-3 Surface slick observed at Jetty 02 during Survey 4 (July 2019)

2.2.3 Trigger assessment outcomes

Survey 6 median Enterococci values at impact sites (83.0 MPN/100mL) exceeded both the reference site value (<10 MPN/100mL) and the trigger value (50 MPN/100mL), therefore a trigger investigation report was completed (L290-AH-REP-70003).

The resulting investigation determined that the elevated Enterococci results were not a result of the Ichthys LNG jetty outfall discharge, given in-line monitoring results and initial dilution. Elevated results may have been a result of initial flush of Darwin Harbour triggered by recent rainfall events.

2.2.4 Program rationalisation

No program rationalisation is proposed. In accordance with EPL228[2], jetty outfall surveys are only required for the first 24 months following completion of start-up of Train 2 (19 June 2019) post operation (cessation due quarter 2 2021).

However, it was noted during monitoring that the sample frequency may not always be achievable, and delays may occur. This is because there is only a small sampling window (i.e. slack water on a neap high tide) and if this coincides with a liquefied petroleum gas (LPG) or condensate offtake due to a late change in the shipping schedule, sampling cannot occur due to access being prevented during an offtake. Further, to ensure sample integrity and holding times can be met, sampling should only be undertaken Monday to Wednesday, as this allows samples to be transported to respective laboratories in accordance with required holding times and preservation requirements. This further reduces the sampling window as the neap tide must align with these days, noting there would also have to be no LPG or condensate offtake occurring as well.

2.3 Harbour sediment

The purpose of the harbour sediment quality monitoring program is to provide an early warning of potential accumulation of contaminants from wastewater discharges from Ichthys LNG in surficial sediments surrounding the jetty outfall. The key objective is to determine if changes are attributable to Ichthys LNG operations.

As per the OEMP (L060-AH-PLN-60005), harbour sediment quality is required to be monitored annually for the first 36 months of operations (i.e. EPL activation) with longer term requirements assessed based on a review of these results. Table 2-8 provides a summary of the harbour sediment quality survey completed during the reporting period.

Table 2-8 Harbour sediment quality survey details

Survey	Date	Report	INPEX Doc #
1	12 Jun 2020	Harbour Sediment Quality Monitoring – Trigger Assessment Report No. 2	F280-AH-REP-60053
		Harbour Sediment Quality Monitoring – Interpretative Report No. 2	F280-AH-REP-60056

[2] Refer to EPL228, Appendix 2, footnote 7.

2.3.1 Method overview

The harbour sediment quality survey was performed in accordance with the INPEX approved Harbour Sediment Quality Monitoring Plan (F280-AQ-PLN-60002). Surficial sediment samples were collected using a grab sampler from 16 potential impact sites radiating away from the jetty outfall and four control sites in East Arm (Figure 2-4). The sediment grab sampler and QA/QC procedures followed were in accordance with the Harbour Sediment Quality Monitoring Plan, which was developed in consideration of the National Assessment Guidelines for Dredging (NAGD; Commonwealth of Australia 2009). The use of NAGD ensures consistency in sediment characterisation programs and is largely adopted for use in the Northern Territory (NT EPA 2013).

Following collection, surficial sediment samples were sent to NATA accredited laboratory for analysis for parameters listed in Table 2-9. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred.

Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant sediment quality guideline value (SQGV; also referred to guideline value) as per ANZG (2018) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels were calculated based on results presented in Darwin Harbour Baseline Sediment Survey 2012 (Munksgaard et al. 2013). Note, where measured metal or metalloids exceeded SQGVs, results where possible are normalised for aluminium concentrations based on the methods described in Munksgaard (2013) and Munksgaard et al. (2013) [3] and compared to background levels (i.e. baseline or reference levels).

[3] Aluminium normalised metal concentrations can be calculated as the equivalent metal concentration at an aluminium concentration of 10,000 mg/kg (1% by weight).

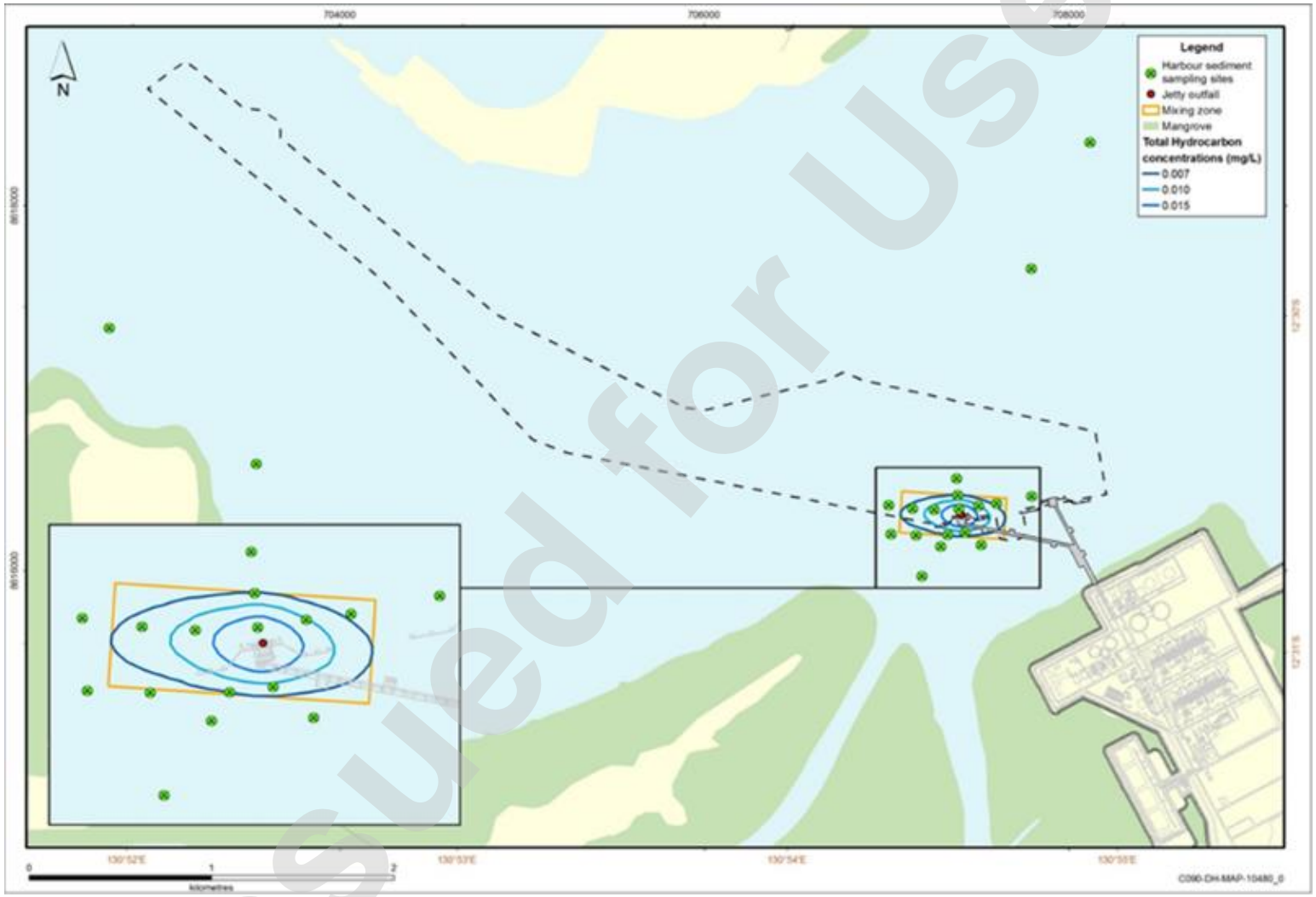


Figure 2-4 Harbour sediment quality sampling locations

Table 2-9 Harbour sediment quality monitoring parameters, trigger and background values

Parameter	Unit	Trigger value*	Background value#
Total organic carbon (TOC)	%	n/a	n/a
TPH	mg/kg	280	n/a
Benzene, toluene, ethylbenzene and xylene (BTEX)	mg/kg	n/a	n/a
Aluminium	mg/kg	n/a	n/a
Antimony	mg/kg	2	n/a
Arsenic	mg/kg	20	16.0
Cadmium	mg/kg	1.5	0.07
Chromium	mg/kg	80	17.5
Copper	mg/kg	65	4.7
Lead	mg/kg	50	8.8
Mercury	mg/kg	0.15	n/a
Nickel	mg/kg	21	8.7
Zinc	mg/kg	200	21.4
Particle size distribution (PSD)	µm	n/a	n/a

* ANZG (2018) sediment quality guideline value.

Background levels are from Munksgaard et al. (2013), using the average of non-normalized sediment samples collected from intertidal (n=247) areas within the Darwin Harbour.

2.3.2 Results and discussion

Metal and metalloid results for harbour sediment quality are presented in Table 2-10. One arsenic trigger exceedance was recorded at control site C3. High levels of arsenic are known to naturally occur in Darwin Harbour and are considered a reflection of local geology rather than anthropogenic activities (Padovan 2003). Further, as the trigger exceedances were reported at control sites, elevated levels of arsenic were not attributed to Ichthys LNG operations.

Table 2-10 Harbour sediment quality survey metal and metalloid results.

Site#	Aluminium	Antimony	Arsenic ^	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Guideline values	n/a	2	20	1.5	80	65	50	21	200	0.15
Background level	n/a	n/a	16.0	0.071	17.5	4.7	8.8	8.7	21.4	n/a
I1	8180	<0.50	11.5	<0.1	23.7	5.8	8.6	7.5	23	<0.01
I2	8250	<0.50	9.47	<0.1	24.1	5.6	8.3	7.6	21.8	<0.01
I3	7850	<0.50	10.5	<0.1	23	5.2	7.9	7.5	20.7	<0.01
I4	7020	<0.50	8.79	<0.1	20.9	4.9	7.1	6.4	19.3	<0.01
I5	8360	<0.50	9.85	<0.1	23.7	5.7	8.5	7.3	21.5	<0.01
I6	8760	<0.50	10.1	<0.1	24.7	5.8	8.6	7.8	23	<0.01
I7	9430	<0.50	10.6	<0.1	26.3	6.8	9.3	8.4	23.8	<0.01
I8-1	7600	<0.50	9.37	<0.1	21.1	4.8	7.8	6.7	19.5	<0.01
I8-2	7810	<0.50	9.83	<0.1	21.8	5	8.1	6.9	20	<0.01
I8-3	8400	<0.50	9.69	<0.1	23.5	5.7	9	7.4	22.7	<0.01
I9	6390	<0.50	9.82	<0.1	19	4.2	7.3	5.8	16.8	<0.01
I10	7810	<0.50	11.8	<0.1	21.7	4.9	7.7	6.9	19.8	<0.01
I11	7570	<0.50	9.63	<0.1	21.5	5.2	8.2	6.9	19.7	<0.01
I12	7060	<0.50	10.2	<0.1	20.3	4.7	7.8	6.4	18.7	<0.01
I13-a	6240	<0.50	9.74	<0.1	18.9	6.5	7.2	6.1	17.8	<0.01
I13-b	6100	<0.50	9.19	<0.1	19.2	6.1	5.6	6.4	17.7	<0.01
I13-c	11000	0.3	12	0.05	28	10	8.9	12	30	0.01
I14	5970	<0.50	16.8	<0.1	39.1	4.2	10.8	5.1	17.6	<0.01
I15	7240	<0.50	10.9	<0.1	20.6	4.9	8.4	6.5	18.8	0.01
I16	1530	<0.50	9	<0.1	5.6	1	1.9	1.5	4	<0.01
C1-1	3400	<0.50	12.2	<0.1	13.2	2.8	4.5	3.2	9.5	<0.01
C1-2	2780	<0.50	11.3	<0.1	11.2	2.2	3.9	2.6	7.9	<0.01
C1-3	3290	<0.50	13.3	<0.1	13.8	2.6	4.4	3.1	8.9	<0.01
C2	6400	<0.50	9.72	<0.1	20.2	5	7.9	5.6	18.4	<0.01

Site#	Aluminium	Antimony	Arsenic ^	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
C3	3310	<0.50	**22.9**	<0.1	22	1.4	5.6	2.8	6.7	<0.01
C4	3700	<0.50	15.7	<0.1	42.2	1.8	9.2	2	4.6	<0.01

[#] C = Control Site, I = Impact site.

[^] Bold values indicate trigger exceedance and results in brackets have been normalised for aluminium concentrations as per Munksgaard (2013)[3].

All impact and control locations were below the laboratory LOR for Benzene, Toluene, Ethylbenzene and Xylene (BTEX) (Table 2-11). All sampling locations had at least one result above the LOR for TPH, within the petroleum hydrocarbon fraction range of C15 – C36. However, none of the results exceeded the guideline value of (280 mg/kg). The presence of TPH in all samples likely indicates the presence of non-petrogenic hydrocarbons of biological origin (e.g. vegetable/animal oils and greases, humic and fatty acids). Non-petrogenic hydrocarbons of biological origin are known to occur in Darwin Harbour with mangrove sediment samples analysed during the construction and operational phases returning positive results for TPH. Samples were reanalysed following silica gel clean-up, with the majority of samples subsequently returning a result below LOR, indicating the presence of non-petrogenic hydrocarbons.

Table 2-11 Harbour sediment quality survey organic results

Site#	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)
Guideline values	n/a	280	n/a
Background level	n/a	n/a	n/a
I1	1.28	53	<1.0
I2	1.13	34	<1.0
I3	0.94	24	<1.0
I4	0.86	24	<1.0
I5	1.17	37	<1.0
I6	0.96	44	<1.0
I7	1.09	38	<1.0
I8-1	1.01	35	<1.0
I8-2	1.01	18	<1.0
I8-3	1.1	19	<1.0
I9	0.91	38	<1.0
I10	1.14	40	<1.0
I11	0.96	27	<1.0
I12	0.97	20	<1.0
I13-a	0.78	26	<1.0
I13-b	0.85	23	<1.0
I13-c	0.9	<275	<1.0

Site#	TOC (%)	TPH (mg/kg)	BTEX (mg/kg)
I14	0.74	25	<1.0
I15	1.06	51	<1.0
I16	0.49	28	<1.0
C1-1	0.54	23	<1.0
C1-2	0.51	14	<1.0
C1-3	0.49	15	<1.0
C2	0.85	18	<1.0
C3	0.39	46	<1.0
C4	0.23	<14	<1.0

C = Control Site, I = Impact site

Table 2-12 and Figure 2-5 provides a summary of the particle size distribution for impact and control sites. Impact sites contain a higher proportion of fines (i.e. silts and clays <63 µm) compared to control sites. It is important to consider this difference when comparing impact and control site data as fine particles such as clay and silt are more likely to absorb organic and heavy metal contaminants (Simpson et al. 2013). To address this difference, metals should be normalised to aluminium (Munksgaard 2013) and organics to TOC (Simpson et al. 2013), as done for potential trigger exceedances in this survey.

Overall, there were no changes to harbour sediment quality associated with Ichthys LNG activities. As such, discharges have not adversely affected the declared beneficial uses or objective for Darwin Harbour.

Table 2-12 Harbour sediment quality survey mean particle size composition (%)

Sites	Clay (<4 µm)	Silt (4-63 µm)	Sand (63-2,000 µm)	Gravel (>2,000 µm)
Impact	9.81	54.88	33.47	1.84
Control	5.33	32.82	50.12	11.73

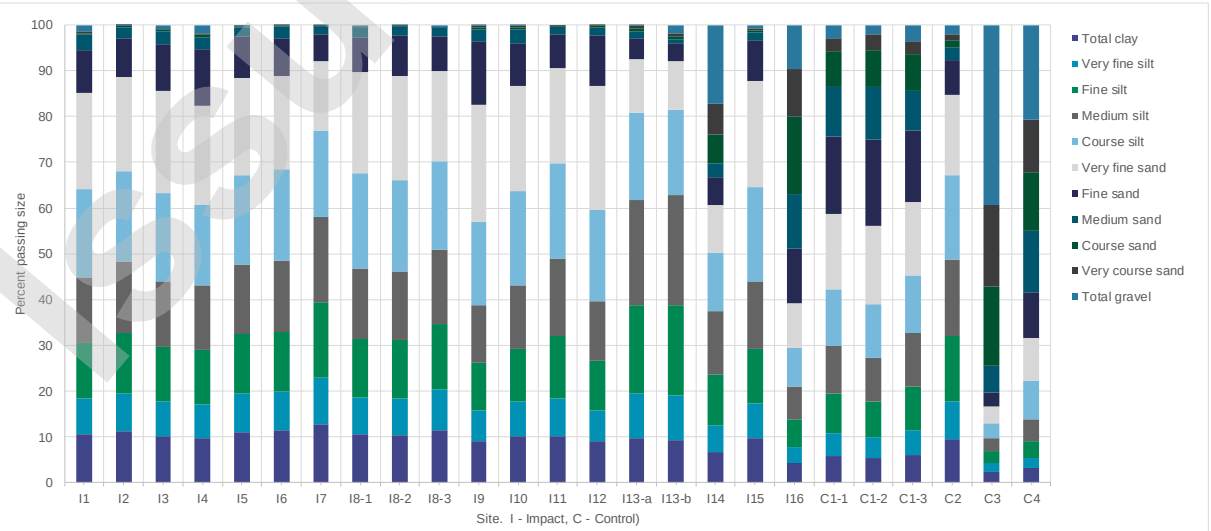


Figure 2-5 Harbour sediment quality survey particle size distribution

2.3.3 Trigger assessment outcomes

No trigger exceedances were reported for this period. The arsenic exceedance was limited to one control site, therefore is not attributable to Project activities. In addition, high levels of arsenic are known to naturally occur in Darwin Harbour and are considered a reflection of local geology rather than anthropogenic activities (Padovan 2003). As such, no further investigation was undertaken.

2.3.4 Program rationalisation

As per the OEMP, once monitoring has been undertaken annually for the first 36 months, the results will be reviewed, and program frequency reassessed. However, a reduction in parameters is proposed for the 2020/2021 AEMR reporting period.

Reduction in parameters

Sediment PSD is an informative parameter as higher portions of fines can increase the available binding sites for contaminants. The fines component of PSD is also sometimes used to normalise metal concentrations. However, research in Darwin Harbour by Munksgaard (2013) states there is a strong correlation between aluminium and fines (<63 µm) in Darwin Harbour and normalisation to the fines content produces similar results to aluminium normalisation. The Munksgaard (2013) recommendation to normalise metals based on aluminium concentrations is implemented for sediment sampling scopes in this AEMR, such as mangroves, where values exceed benchmark levels.

Given analysis of PSD is informative and is not required for normalisation and to reduce exposure risks on field personnel (i.e. PSD is a standalone sample that needs to be collected) PSD analysis will cease following the reporting period of this AEMR.

3 EMISSIONS TO AIR

This section includes the outcomes of the following monitoring programs:

- Ambient air quality and air toxics (Section 3.2)
- Point source emissions (Section 3.3)
- Dark smoke events (Section 3.5)
- Airborne noise (Section 3.6).

This section also summarises operating condition of each emission source and the resulting air emission quality (Section 3.4), and provides a summary of total emissions to air in tonnes per year for the main parameters outlined in EPL228 (Section 3.1)

3.1 Total emission to air

INPEX is required to provide total emissions to air (tonnes/year) for air quality parameters (Condition 87.5 of EPL228 listed in Table 6, Appendix 3 of EPL228). Estimated total emissions to air for the reporting period are provided in Table 3-1, which are based on INPEX's Commonwealth emission reporting requirements for National Pollutant Inventory (NPI) and National Greenhouse and Energy Reporting Scheme (NGERS).

Table 3-1 Estimated total emissions to air for reporting period

Parameter	Emission (t/yr)
NO_x as nitrogen dioxide (NO_2)	2100
Nitrous oxide (N_2O)	19
Mercury (Hg)	0.00001
Particle matter 2.5 ($PM_{2.5}$)	110
Particle matter 10 (PM_{10})	110
Carbon monoxide (CO)	3700
Benzene	9
Toluene	9
Ethylbenzene	1
Xylenes	3
Hydrogen sulphide (H_2S)	140

3.2 Ambient air quality and air toxics

The key objective of the ambient air quality and air toxics monitoring program is to ensure compliance with EPL228 Condition 55 which requires:

The licensee must undertake ground level measurements for pollutants specified in National Environment Protection (Ambient Air Quality) Measure and monitoring investigation levels for air toxicants specified in National Environment Protection (Air

Toxics) Measure, during the first 24 months of commencement of operations, when both LNG trains and the CCPP are operating at steady state.

In accordance with EPL228 Condition 55, Ambient air quality and air toxics monitoring was implemented when LNG trains and the CCPP (in combined cycle) reached steady-state, which occurred 21 October 2019. .

Table 3-2 provides a summary of the ambient air quality and air toxics monitoring surveys completed during the reporting period. Due to the program commencing in October, only nine months of data are available for this report. Subsequent AEMRs will contain annual averages of monitoring data

Table 3-2 Ambient air quality and ambient air toxics survey dates

Survey	Date	Report
Survey 1	October 2019	ATM-Monthly-Report-Oct 2019
Survey 2	November 2019	ATM-Monthly-Report-Nov 2019
Survey 3	December 2019	ATM-Monthly-Report-Dec 2019
Survey 4	January 2020	ATM-Monthly-Report-Jan 2020
Survey 5	February 2020	ATM-Monthly-Report-Feb 2020
Survey 6	March 2020	ATM-Monthly-Report-Mar 2020
Survey 7	April 2020	ATM-Monthly-Report-Apr 2020
Survey 8	May 2020	ATM-Monthly-Report-May 2020
Survey 9	June 2020	ATM-Monthly-Report-June 2020

3.2.1 Method overview

Ambient air quality monitoring

As a means of assessing the potential impact of Ichthys LNG air emissions on the broader environment, INPEX reviewed the ambient air monitoring data collected from the NT Government's ambient air quality network. This was conducted weekly and reported on a monthly basis, with an annual review for the first 24 months during steady-state operations.

INPEX reviews and reports on the following ambient air parameters: nitrogen dioxide (NO_2), sulphur dioxide (SO_2), particulate matter with aerodynamic diameter less than 10 µm (PM_{10}) and particulate matter with aerodynamic diameter less than 2.5 µm ($PM_{2.5}$) from the NT EPA ambient air quality network. Data is then compared against the standards for pollutants specified in the Air NEPM, refer to Table 3-3 for the review criteria.

The NT EPA ambient air quality network consists of three air quality monitoring stations (AQMS) (Winnellie, Stokes Hill and Palmerston) which have instrumentation set up in accordance with the Air NEPM (NTEPA 2015). The location of the NT EPA ambient air quality monitoring stations is presented in Figure 3-1. Each station monitors the following parameters:

- PM_{10} and $PM_{2.5}$
- CO
- Nitrogen monoxide (NO) and NO_2
- Ozone (O_3)
- SO_2.

In addition to the air quality data, meteorological data are also collected, including wind direction and speed, rainfall, temperature, humidity and solar radiation levels. The meteorological data is collected directly from instruments housed in the Palmerston and Stokes Hill stations. The Winnellie station sources meteorological data from the Bureau of Meteorology instruments located at the same site.

Table 3-3 Data review criteria – Ambient air quality parameters

Parameter	Averaging Period	Existing Background*	Review Criteria** (Ambient Air Quality NEPM)	Units
NO_2	1 hour	0.0038	0.12 (1 day/yr allowable exceedance)	ppm
	Annual	0.0031	0.03	
SO_2	1 hour	0.0005	0.2 (1 day / yr allowable exceedance)	
	24 hour	0.0005	0.08 (1 day /yr allowable exceedance)	
	Annual	0.0004	0.02	
PM_{10}	24 hour	24	50	µg/m³
	Annual	20	25	
$PM_{2.5}$	24 hour	10	25	
	Annual	7	8	

*Existing background nominated as 70th percentile of 2017 AQMS monitoring data (maximum station).

**Weekly review to be limited to short-term (1 hour and 24 hour) criteria. Performance against annual average statistics to be reviewed on an annual basis.

Figure 3-1 NT EPA Ambient air quality monitoring station locations

Air Toxics Monitoring

INPEX has commenced an air toxics ground level monitoring during the 2019/2020 monitoring period. The program is required for the first 24 months following the commencement of steady state operations (when both LNG trains and the CCPP are operating at steady state).

The receptor locations, when considered in conjunction with prevailing winds and peak dispersion modelling predictions, indicated that the NT EPA ambient air quality networks monitoring stations are appropriately located within the Darwin Airshed, in order to be used for the assessment of air toxics from Ichthys LNG.

Accordingly, the three NT EPA ambient air quality networks monitoring stations are currently used for the air toxics monitoring program. The locations of the NT EPA ambient air quality monitoring stations are presented in Figure 3-1.

Supplementary to the NT EPA ambient air quality monitoring program, INPEX undertakes periodic air toxics monitoring using evacuated canisters for sample capture (24 hour regulator), with subsequent analysis for Benzene, Toluene and Xylene (BTX) using gas chromatography - mass spectrometry techniques. Consistent with the Air Toxics NEPM monitoring framework, this monitoring is conducted using the United States Environmental Protection Authority (USEPA) TO-15 analytical methodology (USEPA 1995) using a NATA accredited laboratory. The frequency of monitoring is monthly for the first 12 months and reduces to quarterly for the subsequent year, data is then compared against the standards for pollutants specified in the Air Toxics NEPM, for the Winnellie, Stokes Hill and Palmerston AQMS.

The review criteria for the monitoring program, as per Air Toxics NEPM monitoring framework, are provided in Table 3-4 below.

Consideration is also given to potential interference from air toxics sources in the immediate vicinity of each AQMS location. The influence of such emissions may impair the ability to evaluate the potential contribution of Ichthys LNG to ambient air toxics concentrations, and also render monitoring results unrepresentative of air quality within the broader vicinity of the monitoring location. Accordingly, in cases where localised interference sources are present, locations within 1 km of the AQMS location may be used, so that interference is minimised.

Table 3-4 Data review criteria – Air toxics parameters

Parameter	Averaging Period	Review Criteria (NEPM)*	Units
Benzene	Annual	0.03	ppm
Toluene	24 hour	1	
	Annual	0.1	
Xylenes	24 hour	0.25	
	Annual	0.2	

* Air toxics review criteria excludes allowance for background. Upon review, potential project increment (above background) is to be addressed through consideration of spatial variability of sample results.

Review process

An investigation is triggered where results are found to be above the review criteria and cannot be attributed to a regional event. If an investigation is required (i.e. review criteria being met), then the relevant AQMS meteorological data is analysed to determine the most likely source contributing to the exceedance. The process of this review is outlined below in Figure 3-2.

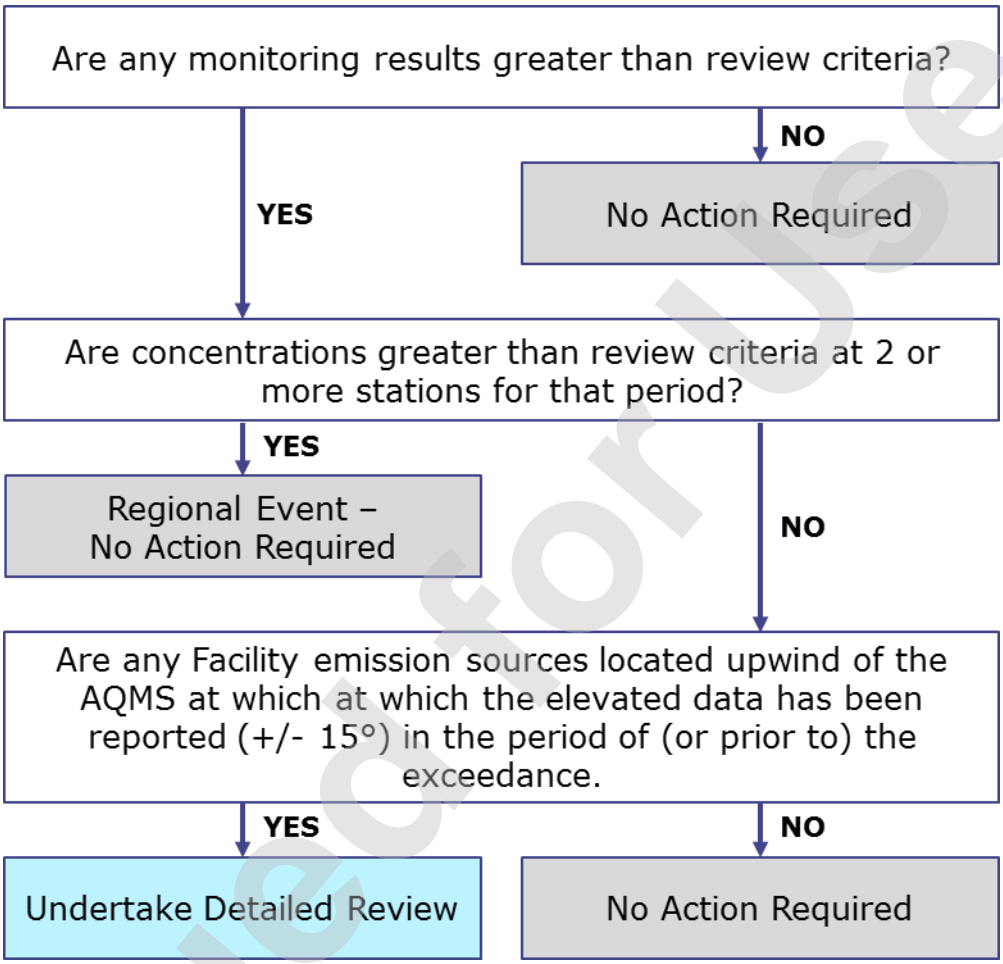


Figure 3-2 Data review process for short-term ambient air quality parameters

3.2.2 Results and discussion

A summary table of results of both the ambient air quality and air toxics monitoring are provided in Table 3-5 below. Results highlight in bold exceed the review criteria.

All results of the air toxics monitoring are below the relevant NEPM criteria, (Table 3-3 and Table 3-4), including less 27% of the NEPM criteria, and generally the limit of reporting. This indicates that during times when the acid gas incinerators are offline for maintenance and venting of the off-gas is occurring there is no reported impact on the Darwin regional air shed, and no further investigation into the presence of BTX has been conducted.

The majority of ambient air quality results collated from the Darwin AQMS are below the review criteria for each parameter, including less than 27% of the NEPM criteria, with the exception of PM_{10} and $PM_{2.5}$.

The NT Department of Environment and Natural Resources (DENR) conduct regular controlled burns in the rural areas and national parks surrounding Darwin during the late wet and early dry season (April-November). Particulates generated from vegetation burning are the primary air pollutants in the Darwin region, and this results in the Darwin area experiencing a high number of days where PM_{10} and $PM_{2.5}$ are above the Air NEPM criteria in the dry season.

A review of the daily (24 hour) exceedances of PM_{10} and $PM_{2.5}$ at each station was conducted using the review process stipulated in Figure 3-2. Based on the review process, exceedances of $PM_{2.5}$ and PM_{10} can be attributed to planned controlled burns or bushfires in the Darwin region and these exceedances did not occur downwind of Ichthys LNG.

Based on the monitoring results for the reporting period, there were no adverse effects to the ambient air quality of the Darwin Region attributable to Ichthys LNG operations.

Table 3-5 Ambient air quality and air toxic results for the reporting period

Period	Sampling Point	NO_2	SO_2		PM_{10}	$PM_{2.5}$	Benzene	Toluene	Xylenes
Monthly	Averaging Period	1 h	1 h	24 h	24 h	24 h	24 h	24 h	24 h
	Unit	ppm	ppm	ppm	µg/m^3	µg/m^3	-	ppm	ppm
	Review criteria	0.12	0.2	0.08	50	25	N/A	1	0.25
Oct-19	Palmerston	0.015	0.001	0.00069	**51**	23	<0.0006	<0.0020	<0.001
	Stokes Hill	0.015	0.005	0.00066	42	16	<0.0006	<0.0020	<0.001
	Winnellie	0.0069	0.001	0.00036	47	20	<0.0006	<0.0020	<0.001
Nov-19	Palmerston	0.011	0.0009	0.00056	35	13	<0.0006	<0.0020	<0.001
	Stokes Hill	0.012	0.0018	0.0004	33	11	<0.0006	<0.0020	<0.001
	Winnellie	0.010	0.0007	0.00024	32	10	<0.0006	<0.0020	<0.001
Dec-19	Palmerston	0.01	0.0007	0.00037	33	19	<0.0006	<0.0020	<0.001
	Stokes Hill	0.018	0.0279	0.0045	35	21	<0.0006	<0.0020	<0.001
	Winnellie	0.009	0.0014	0.00025	33	18	<0.0006	<0.0020	<0.001
Jan-20	Palmerston	0.0049	0.00089	0.00046	26	5	<0.0005	<0.0020	<0.001
	Stokes Hill	0.012	0.00093	0.00048	29	5	<0.0005	<0.0020	<0.001
	Winnellie	0.0067	0.00053	0.00017	28	5	<0.0005	<0.0020	<0.001
Feb-20	Palmerston	0.0045	0.00062	0.00052	30	4	<0.0006	<0.0020	<0.007
	Stokes Hill	0.0065	0.0011	0.00065	29	5	<0.0006	<0.0020	<0.007
	Winnellie	0.006	0.00032	0.0001	30	4	<0.0006	<0.0020	<0.007

Period	Sampling Point	NO_2	SO_2		PM_{10}	$PM_{2.5}$	Benzene	Toluene	Xylenes
Mar-20	Palmerston	0.0058	0.00056	0.00048	23	3	<0.0006	<0.0020	<0.001
	Stokes Hill	0.01	0.0011	0.00076	20	3	<0.0006	<0.0020	<0.001
	Winnellie	0.0068	0.00076	0.00061	18	3	<0.0006	<0.0020	<0.001
Apr-20	Palmerston	0.0078	0.00078	0.00068	29	5	<0.0006	<0.0020	<0.007
	Stokes Hill	0.0071	0.00093	0.00065	28	6	<0.0006	<0.0020	<0.007
	Winnellie	0.008	0.00083	0.00069	34	6	<0.0006	<0.0020	<0.007
May-20	Palmerston	0.012	0.0019	0.0012	**52**	**38**	<0.0006	<0.0020	<0.007
	Stokes Hill	0.0083	0.0021	0.00095	45	**27**	<0.0006	<0.0020	<0.007
	Winnellie	0.015	0.0023	0.001	50	**36**	<0.0006	<0.0020	<0.007
Jun-20	Palmerston	0.0083	0.0013	0.0008	44	**33**	<0.0006	<0.0020	<0.007
	Stokes Hill	0.0094	0.0018	0.0005	46	**34**	<0.0006	<0.0020	<0.007
	Winnellie	0.014	0.0012	0.0005	**53**	**39**	<0.0006	<0.0020	<0.007

3.2.3 Program rationalisation

No changes are proposed to parameters that will be monitored. In accordance with the OEMP, the frequency of monitoring will revert to quarterly in October 2020, following completion of the first 12 months monitoring, if there are no exceedance of the criteria attributed to Ichthys LNG.

To date there have been no exceedances attributed to Ichthys LNG operations..

3.3 Point source emissions to air

The key objective of the point source emission monitoring (commonly referred to as stack sampling) is to ensure air emissions do not exceed the concentration limit criteria as specified in Table 5, Appendix 3 of EPL228. The frequency of monitoring is outlined in Condition 65 of EPL228, which requires quarterly emissions monitoring for the first 18 months after the completion of first start-up, and then annually thereafter.

Point source emission monitoring commenced within two months of steady-state, following completion of first start-up of the first LNG (Condition 65 of EPL228). Steady-state operations for Train 1 and 2, occurred on 19 June 2019, and INPEX commenced monitoring from August 2019. For the first survey the CCPP was operating in open cycle, with additional power being supplied by the TPP. In late October 2019, the CCPP was operating in combined cycle and had achieved steady-state . Subsequently the TPP was decommissioned and demobilised from Ichthys LNG in October 2019 (noting it taken offline 6 September 2019) and has been removed from EPL228.

As such, quarterly monitoring has been undertaken in the reporting period, with the exception of the quarter 2 (Q2) 2020. Due to the COVID-19 pandemic and the travel restriction imposed between States and Territories during this time, no stationary source emission monitoring was conducted for this quarter. No suitably qualified personnel are based in the NT. NT EPA agreed to delay the Q2 2020 survey to no later than 31 August 2020 which (prior to the quarter 3 (Q3) 2020 survey).

Following steady state operations being achieved for the CCPP operating in combined cycle on 21 October 2019, the TPP was decommissioned and demobilised from Ichthys LNG on 25 October 2019. Subsequently, only the Q3 2019 monitoring survey was completed on the four TPP turbines (fuel source: gas) prior to demobilisation and the EPL228 was amended to remove the TPP as an emission source location.

Table 3-6 provides a summary of the point source emission monitoring conducted for the reporting period.

Table 3-6 Point source emissions survey dates

	Start Date	End Date
Survey 1 – Q3 2019	12th August 2019	27th August 2019
Survey 2 – Q4 2019	12th November 2019	22nd November 2019
Survey 3 – Q1 2020	14th February 2020	20th February 2020

3.3.1 Method overview

Stationary source emissions monitoring is undertaken at 13 point sources (with a total of 18 stacks) on the Frame 7 compression turbines, CCPP Frame 6 power generation turbines, CCPP utility boilers, acid gas removal unit (AGRU) Incinerators and heating medium furnaces.

For the CCPP Frame 6 turbines, each turbine has two stacks, one which allows for normal operation of the turbine (with exhaust emissions directed to a conventional stack) and a separate stack with an associated heat recovery steam generator (HRSG), allowing for steam to be generated through the duct burning of fuel. The two stacks cannot be operated together so stack monitoring is dependent on which stack is in use at the time of sampling.

Table 3-7 and Table 3-8 shows the EPL228 air emission target and limits and the constituents that are required to be monitored at the point source locations. Figure 3-3 shows the locations of the stationary source emissions monitoring locations at Ichthys LNG.

The following locations are inline gas sampling points (not ports) and as such are exempt from the standard methods for point source emissions sampling:

- 551-SC-003 (release point number A13-2),
- 552-SC-003 (release point number A14-2),
- 541-SC-001 (release point number A13-3) and
- 542-SC-001 (release point number A14-3)

INPEX conducts inhouse gas sampling and analysis from these locations for BTEX, hydrogen sulphide (H_2S) and mercury (Hg) using conventional industry methods which are not NATA accredited. The analysis of these gases are conducted using test methods that are managed under a NATA accredited Quality Management System.

Stationary source and gas samples are either collected by INPEX laboratory technicians and tested in the on-site NATA-accredited laboratory, or are collected by an external NATA-accredited contractor and analysed in the field or by external laboratories.

All stack sampling ports have been installed in accordance with AS4323.1-1995 Stationary source emissions – Selection of sampling ports.

While all stack sampling, where applicable, is undertaken in accordance with:

- New South Wales (NSW) Department of Environment and Conservation Approved Methods for the Sampling and Analysis of Air Pollutants in NSW; or
- USEPA Method 30B for mercury emissions.

Currently there are no approved NSW Test Methods for the sampling and analysis of nitrous oxide, nor any approved Australian Standard or USEPA methods.

For the sampling and analysis of nitrous oxide, INPEX and the Contractor performing stack emission monitoring, has followed the procedures as listed in NSW Test Method 11, which cross references to USEPA Method 7E *Determination of Nitrogen Oxide Emission from Stationary Sources (Instrumental Analyser Procedure)*. This lists comprehensive quality control and calibration procedures that must be followed to ensure accurate and reliable results. The analysis of nitrous oxide is also managed under a NATA accredited Quality Management System.

Table 3-7 Contaminant release limits to air at authorised stationary emission release points

Release Point Number	Source	Pollutant	Concentration Target		Concentration Limit	
			mg/Nm³	ppmv	mg/Nm³	ppmv
A1, A2, A3, A4	LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)	NO_x as NO_2	50 @ 15% O_2 dry	25 @ 15% O_2 dry	70	35 @ 15% O_2 dry
A5-1, A6-1, A7-1, A8-1, A9-1	CCPP Gas Turbine Generators (GE Frame 6s, 38 MW)	NO_x as NO_2	50 @ 15% O_2 dry	25 @ 15% O_2 dry	70	35 @ 15% O_2 dry
A5-2, A6-2, A7-2, A8-2, A9-2	CCPP Gas Turbine Generators (GE Frame 6s, 38 MW) also burning vaporised iso-pentane in duct burners	NO_x as NO_2	150 @ 15% O_2 dry	75 @ 15% O_2 dry	350	175 @ 15% O_2 dry
A13-1, A14-1	AGRU Incinerators	NO_x	320 @ 3% O_2 dry	160 @ 3% O_2 dry	350	175 @ 15% O_2 dry
A15, A16	Heating Medium Furnaces	NO_x	160 @ 3% O_2 dry	80 @ 3% O_2 dry	350	175 @ 3% O_2 dry
TPP Turbine 1 TPP Turbine 2 TPP Turbine 3 TPP Turbine 4	TPP GE TM2500 dual fuel turbines (fuel source gas)	NO_x as NO_2	50 @ 15% O_2 dry	25 @ 15% O_2 dry	70	35 @ 15% O_2 dry

Table 3-8 Air emission monitoring program

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A1	L-641-A-001	LNG Train 1 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A2	L-642-A-001	LNG Train 2 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A3	L-641-A-002	LNG Train 1 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A4	L-642-A-002	LNG Train 2 Refrigerant Compressor Driver Gas Turbine (GE Frame 7)		
A5-1	L-780-GT-001	CCPP Gas Turbine Generator #1 (GE Frame 6) – conventional stack	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A6-1	L-780-GT-002	CCPP Gas Turbine Generator #2 (GE Frame 6) – conventional stack		
A7-1	L-780-GT-003	CCPP Gas Turbine Generator #3 (GE Frame 6) – conventional stack		
A8-1	L-780-GT-004	CCPP Gas Turbine Generator #4 (GE Frame 6) – conventional stack		
A9-1	L-780-GT-005	CCPP Gas Turbine Generator #5 (GE Frame 6) – conventional stack		

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A5-2	L-630-F-001	CCPP Gas Turbine Generator #1 (GE Frame 6) – HRSG stack		
A6-2	L-630-F-002	CCPP Gas Turbine Generator #2 (GE Frame 6) – HRSG stack		
A7-2	L-630-F-003	CCPP Gas Turbine Generator #3 (GE Frame 6) – HRSG stack		
A8-2	L-630-F-004	CCPP Gas Turbine Generator #4 (GE Frame 6) – HRSG stack		
A9-2	L-630-F-005	CCPP Gas Turbine Generator #5 (GE Frame 6) – HRSG stack	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A13-1	L-551-FT-031	AGRU Incinerator – LNG Train 1	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A13-2	551-SC-003	AGRU Hot Vent – LNG Train 1, prior to release at A3	quarterly and during incinerator by-pass [4]	BTEX, H_2S, volumetric flow rate
A13-3	541-SC-001	Feed gas to AGRU – LNG Train 1 – prior to release at A3	quarterly and during	Hg

[4] If AGRU off gas quality can be demonstrated to be predictable and does not vary greatly when the by-pass of the incinerator occurs, the NT EPA may approve quarterly sampling for first 18 months after commencement of Steady-State, then annual.

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
			incinerator by-pass	
A14-1	L-552-FT-031	AGRU Incinerator – LNG Train 2	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A14-2	552-SC-003	AGRU Hot Vent – LNG Train 2, prior to release at A4	quarterly and during incinerator by-pass [20]	BTEX, H_2S, volumetric flow rate
A14-3	542-SC-001	Feed gas to AGRU – LNG Train 2 – prior to release at A4	quarterly and during incinerator by-pass	Hg
A15	L-640-A-001-A	Heating Medium Furnaces	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A16	L-640-A-001-B	Heating Medium Furnaces	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
A17	L-700-F-002	Ground flare #5 warm		mass of hydrocarbons flared

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A18	L-700-F-001-A/B	Ground flare #2 cold	all flare events	
A19	L-700-F-003	Ground flare #1 spare		
A20	L-700-F-005-A/B	Tank flare #1 LNG		
A21	L-700-F-006-A/B	Tank flare #2 LPG		
A22	L-700-F-007	Tank flare #3 LNG/LPG		
A23	L-700-F-004	Liquid flare		
TPP Turbine 1	TPP Turbine 1	TPP GE TM2500 dual fuel turbines (fuel source gas)	quarterly	NO_x as NO_2, N_2O, Hg, $PM_{2.5}$, $PM_{10,}$ CO, temperature, efflux velocity, volumetric flow rate
TPP Turbine 2	TPP Turbine 2	TPP GE TM2500 dual fuel turbines (fuel source gas)		
TPP Turbine 3	TPP Turbine 3	TPP GE TM2500 dual fuel turbines (fuel source gas)		

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
TPP Turbine 4	TPP Turbine 4	TPP GE TM2500 dual fuel turbines (fuel source gas)		

Figure 3-3 Location of authorised stationary emission release points

3.3.2 Results and discussion

All results for the permanent plant were below the target and limit criteria provided in Appendix 3, Table 5 of EPL228. For TPP Turbine 1 and TPP Turbine 2, NOx concentrations of 81ppm@15%O_2 and 50ppm@15%O_2 were reported during the Q3 2019 survey, which exceed the EPL228 concentration limit of 35ppm@15%O_2. In addition, NO_x concentrations were also above the EPL228 concentration targets for the four TPP turbines during the Q3 2019 survey.

The stationary source emission monitoring results are provided in APPENDIX E:. Results that exceeded discharge limits are highlighted and in bold text.

Due to equipment being offline for planned maintenance and extended unplanned equipment fault outages, the following point sources were unable to be tested during various quarterly events:

- release point number A13-1, Train-1 Acid Gas Incinerator was out of service for an extended period of time due to an equipment fault, during the Q3 2019 and Q4 2019 surveys;
- release point number A16, Heating Medium Furnace B, was offline for maintenance during the Q4 2019 survey;
- release point number A7-1/A7-2, CCPP gas turbine generator 3, was offline during the Q1 2020 survey due to planned maintenance; and
- release point number A9-1/A9-2, CCPP gas turbine generator 5, was offline during the Q1 2020 survey due to planned maintenance.

The NT EPA were informed each time monitoring was unable to be conducted at the above locations. Noting that in normal operations for the CCPP only 4 of the 5 turbines will be online, with one generally on standby or offline. Figure 3-4 and Figure 3-5 show the vented acid gas flow rates in m^3/h for Trains 1 and Train 2. During the time the acid gas incinerators were offline the acid gas was hot vented.

Figure 3-6 and Figure 3-7 provided the flow rate of acid gas to the Train 1 and Train 2 acid gas incinerators, while the incinerator was in service.

While the acid gas incinerators were offline and venting was occurring, gas sampling was undertaken in accordance with EPL228 requirements.

The mass of hydrocarbons flared for the reporting period for each flare source is presented in Table 3-9.

Table 3-9 Mass of hydrocarbons flared

Release Point number	Location Number	Source	Mass of hydrocarbons flared (tonnes)
A17 / A19	L-700-F-002 / L-700-F-003	Ground flare #5 warm/ Ground flare #1 spare	51,703
A18 / A19	L-700-F-001-A/B / L-700-F-003	Ground flare #2 cold / Ground flare #1 spare	46,998
A20	L-700-F-005-A/B	Tank flare #1 LNG	73
A21	L-700-F-006-A/B	Tank flare #2 LPG	9,674
A22	L-700-F-007	Tank flare #3 LNG/LPG	28,848
A23	L-700-F-004	Liquid flare	0

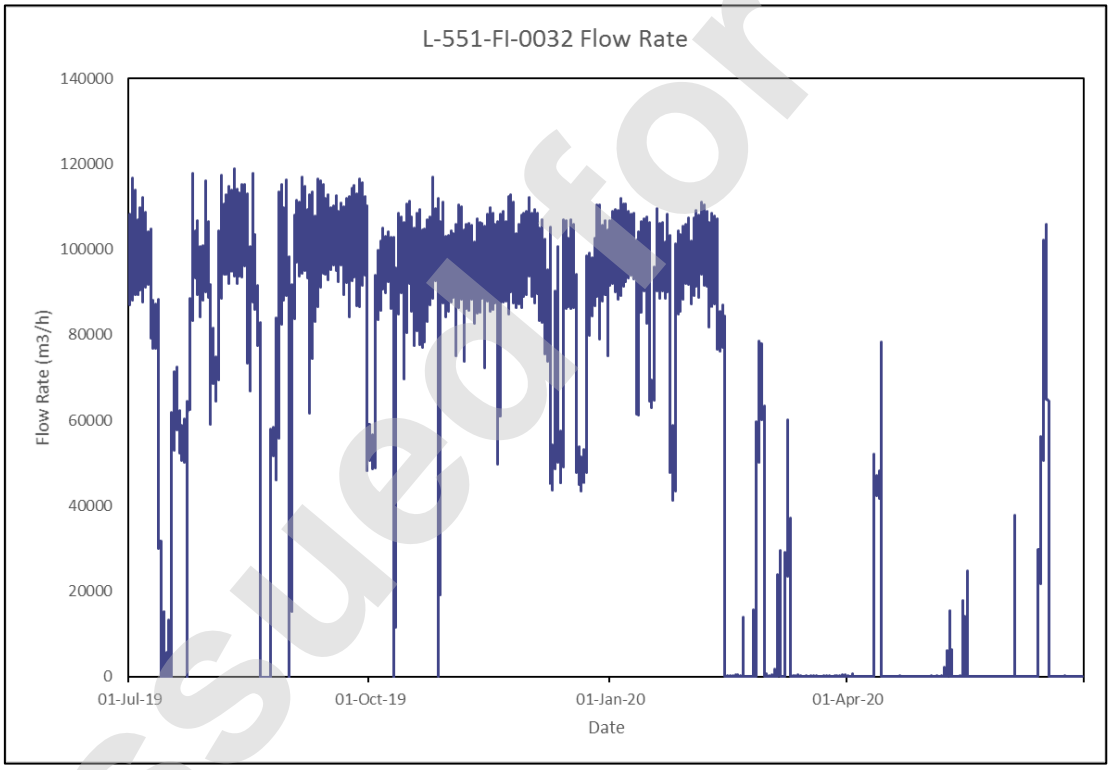


Figure 3-4 Flow meter showing flow rates of venting of acid gas – Train 1

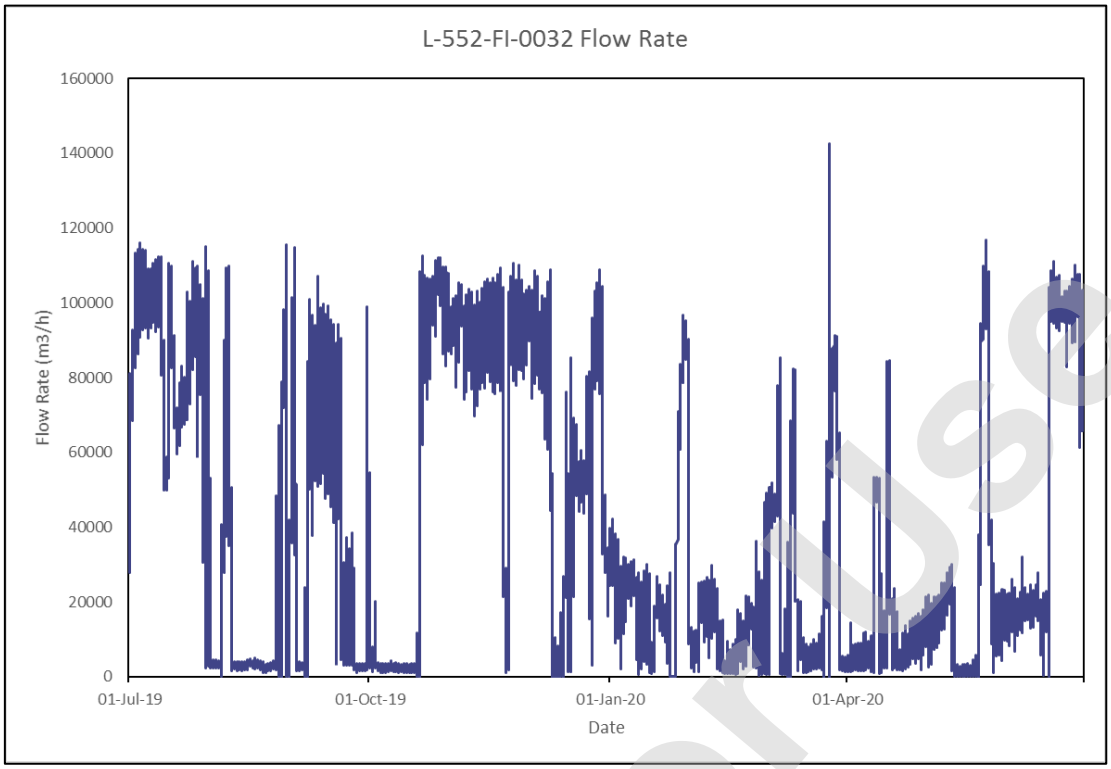


Figure 3-5 Flow meter data showing flow rates of venting acid gas – Train 2

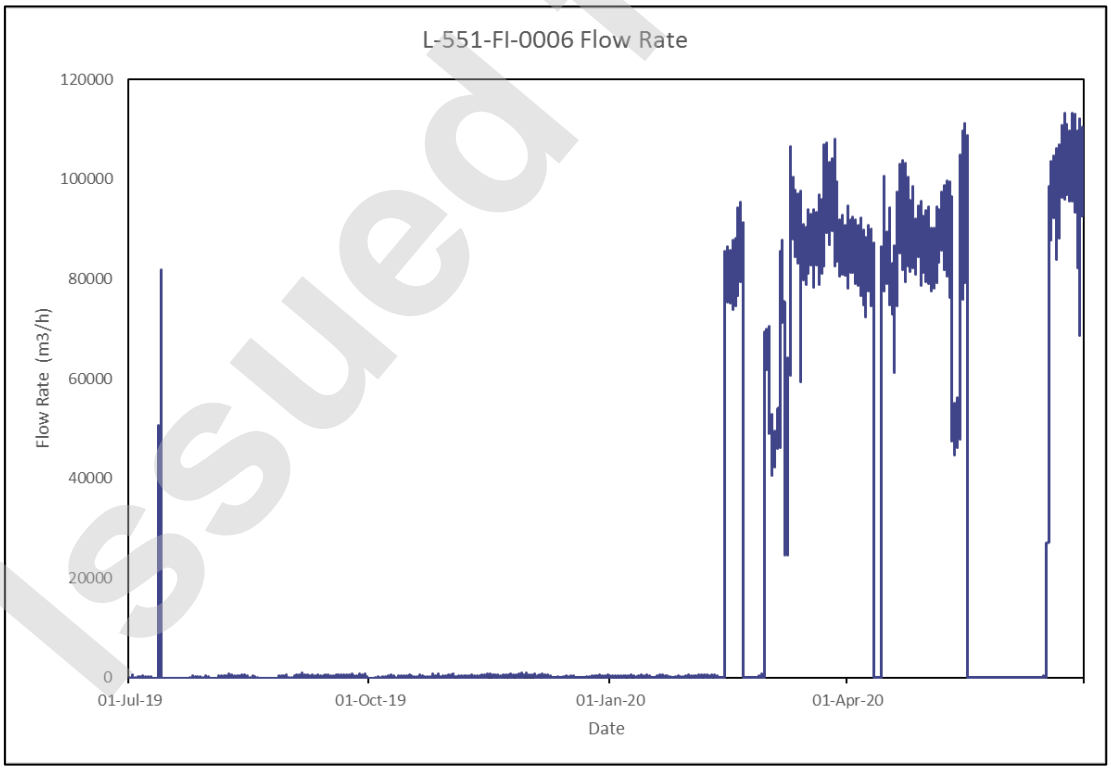


Figure 3-6 Flow meter data for acid gas incinerated in the Train 1 acid gas incinerator

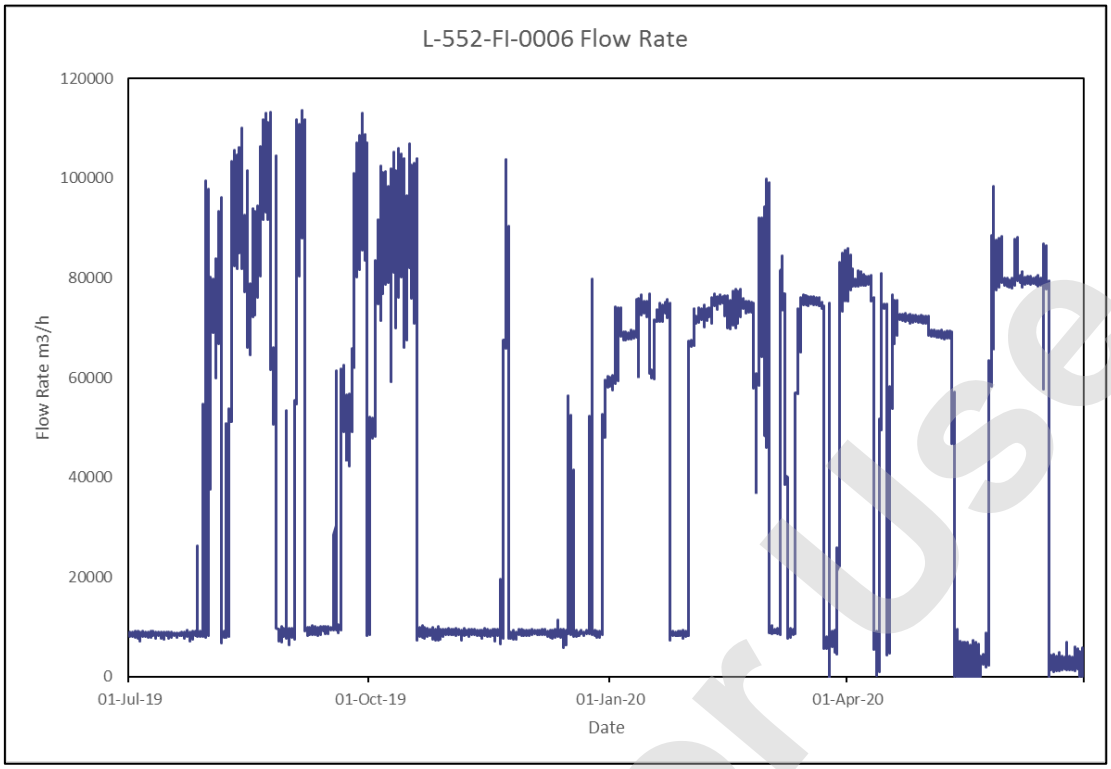


Figure 3-7 Flow meter data for acid gas incinerated in the Train 2 acid gas incinerator

3.3.3 Limit exceedance assessment outcomes

As noted in Section 3.3.2, two of the temporary dual fuel turbines, TPP Turbine 1 and TPP Turbine 2, recorded NO_x concentrations above the EPL228 concentration limits during the Q3 2019 survey.

An investigation identified that potentially the system controlling the low NOx water injection process, was not functioning effectively to reduce NOx levels for both of the turbines. The investigation also identified that during the mobilisation and start-up of the TPP, the mobile turbines were not emission mapped prior to being placed into service. Emission mapping ensures turbine combustion is producing emission as per the data specification of the turbine.

Corrective actions proposed included the recalibration of metering valves and flow meters on the TPP water injection systems; however, prior to corrective actions being implement the TPP was taken offline (6 September 2019) due to commissioning of the CCPP and other handover testing requirements and was subsequently not required to be brought online again after this period. Decommissioning of the TPP commenced in early October 2019 and was fully demobilised in late October 2019.

A review of the data from the NT EPA ambient air quality monitoring network (refer to Section 3.2) for the period 20 August 2019 to 27 August 2019 was undertaken, which reported NO_x concentrations at all three stations were below the Air NEPM maximum concentration standard for a 1 hour averaging period of 0.12 ppm.

3.3.4 Program rationalisation

No rationalisation is currently proposed and monitoring will be conducted as per the EPL228 requirements. Note, as per EPL228, quarterly monitoring is required for the first 18 months, following steady state operations, after which it is reduced to annually, this will occur in 2021.

3.4 Overall summary of performance of stationary emission sources

The status of the stationary point source emissions at Ichthys LNG is provided in Table 3-10 below based on information presented in Sections 3.2, 3.3, and 3.5. As stated above the TPP was decommissioned in late October 2019, while the acid gas incinerators for both LNG trains have operated intermittently during the reporting period due to equipment faults and delays in the delivery of spare parts with impacts on shipping caused by the current COVID-19 pandemic. During the period that the acid gas incinerators were offline, sampling of the vented gas occurred as per EPL228 requirements.

Table 3-10 Stack emission status and air quality

Release Point Number	Emission Source	Status	Air emissions
A1	Compressor turbine WHRU West 1 (Frame 7)	Operational	Acceptable
A2	Compressor turbine WHRU West 2 (Frame 7)	Operational	Acceptable
A3	Compressor turbine WHRU East 1 (Frame 7)	Operational	Acceptable
A4	Compressor turbine WHRU East 2 (Frame 7)	Operational	Acceptable
A5-1	Power generation turbine 1 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A6-1	Power generation turbine 2 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A7-1	Power generation turbine 3 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A8-1	Power generation turbine 4 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A9-1	Power generation turbine 5 (Frame 6)	Intermittent use, when HRSG offline	Acceptable
A5-2	Power generation turbine 1 HRSG (Frame 6)	Operational	Acceptable
A6-2	Power generation turbine 2 HRSG (Frame 6)	Operational	Acceptable
A7-2	Power generation turbine 3 HRSG (Frame 6)	Operational	Acceptable
A8-2	Power generation turbine 4 HRSG (Frame 6)	Operational	Acceptable
A9-2	Power generation turbine 5 HRSG (Frame 6)	Operational	Acceptable
A10	Utility boiler #1	Decommissioned	n/a
A11	Utility boiler #2	Decommissioned	n/a
A12	Utility boiler #3	Decommissioned	n/a

Release Point Number	Emission Source	Status	Air emissions
A13-1	AGRU Incinerator – LNG Train 1	Intermittent Operations	Acceptable
A13-2	AGRU Hot Vent – LNG Train 1, prior to release at A3	Operational	n/a
A14-1	AGRU Incinerator – LNG Train 2	Intermittent Operations	Acceptable
A14-2	AGRU Hot Vent – LNG Train 2, prior to release at A4	Operational	n/a
A15	Heating medium furnace 1	Operational	Acceptable
A16	Heating medium furnace 2	Operational	Acceptable
TPP 1	TPP GE TM2500 dual fuel turbines (fuel source – gas)	Demobilised	n/a
TPP 2	TPP GE TM2500 dual fuel turbines (fuel source – gas)	Demobilised	n/a
TPP 3	TPP GE TM2500 dual fuel turbines (fuel source – gas)	Demobilised	n/a
TPP 4	TPP GE TM2500 dual fuel turbines (fuel source – gas)	Demobilised	n/a

3.5 Dark-smoke events

Ichthys LNG has been designed to minimise dark-smoke events. However, dark-smoke can result during flaring due to incomplete combustion of hydrocarbons. The environmental impacts from smoke emitted from Ichthys LNG are considered negligible, though smoke could become a cause of visual amenity impact and community concern.

3.5.1 Method overview

Visual monitoring and closed-circuit television monitoring of flares is undertaken to detect possible dark smoke events. If dark smoke is produced during operations, the shade (or darkness) of the smoke is estimated using the Australian Miniature Smoke Chart (AS 3543:2014), which uses Ringelmann shades. The shade and duration of the dark-smoke event is recorded. Dark smoke monitoring targets and limits for all the flare systems are provided in Table 3-11.

Table 3-11 Dark smoke monitoring targets and limits

Emission source	Pollutant	Target	Limit
Flares	Smoke	<Ringelmann 1	Visible smoke emissions darker than Ringelmann shade 1

Flaring and other data is stored in the sites Process Control System (PCS). The PCS serves as the primary means to control and monitor Ichthys LNG and automatically maintains operating pressures, temperatures, liquid levels and flow rates within the normal operating envelope with minimal intervention from operator consoles in the central control room (CCR). The system has built-in redundancy in communication, control and human interface. Information from the PCS is displayed on visual display units in the CCR. During process upset conditions, the system has detailed alarm handling and interrogation functions to minimise operator overload. The PCS is also equipped with a database function that permits operations personnel to investigate a historical sequence of events. In addition, volatile organic compound emissions are estimated by use of the NPI and NGERS reporting tools.

3.5.2 Results and discussion

One dark smoke event greater than Ringelmann shade 1 occurred during the reporting period. Dark smoke was emitted from the LNG tankage flare on 16 September 2019, for a period of less than two hours, with a Ringelmann intensity between 1 and 2 as shown as the Figure 3-8,. This was caused by a passing valve, which was allowing propane to pass to the LNG tankage flare at low pressure and velocity, and consequently resulted in incomplete combustion in the LNG tankage flare system. Following the event, the LNG vessel procedure for preparing a vessel for loading was revised to remove use of propane assist gas in the flare systems due to it not being required.

Figure 3-8 Photos of dark smoke event 16 September 2019

3.5.3 Program rationalisation

No program rationalisation is proposed.

3.6 Airborne noise

The OEMP committed to undertake an airborne noise survey to confirm that the sound level of Ichthys LNG could meet the design and operational requirements, and validate predicted noise levels at nearby sensitive locations during early steady-state operations (refer to Section 7.1 of the OEMP).

For this section the term 'sound' and 'noise' are interchangeable, except that 'noise' commonly refers to unwanted sound.

A noise survey was conducted by INPEX's main construction contractor JKC Australia Pty Ltd, using subcontractor, SLR Consulting Australia Pty Ltd (SLR) during the period 7 October to 20 October 2019 to verify design predicted noise levels. This involved both a site boundary survey at nine locations, and an offsite environmental survey at three locations. The survey method and locations are described in further detail in Section 3.6.1.

3.6.1 Method overview

Site boundary noise levels

Noise levels at Ichthys LNG were measured at nine locations that were either on the Ichthys LNG boundary or in proximity of the Ichthys LNG boundary (refer to Table 3-12, Figure 3-9 and Figure 3-10). These locations were determined from a general inspection of noise levels at areas of the Ichthys LNG.

Attended noise measurements were conducted within the Ichthys LNG boundary, generally adjacent to the Ichthys LNG security fence-line. The Ichthys LNG boundary noise limit, A-weighted, equivalent continuous sound level (LA_{eq}) of 70 dBA was selected as the boundary criteria for the survey, as per design criteria (SLR 2020).

Table 3-12 Noise monitoring locations – Site boundary

Monitoring Location	Nearest site boundary	Adjacent area of the Ichthys LNG facility
Boundary 1 (B1)	Eastern Boundary	Train 1 and Train 2
Boundary 2 (B2)	Eastern Boundary	Train 1
Boundary 3 (B3)	Eastern Boundary	Train 1
Boundary 4 (B4)	Eastern Boundary	Train 2 and CCPP
Boundary 5 (B5)	Eastern Boundary	CCPP
Boundary 6 (B6)	Eastern Boundary	CCPP
Boundary 7 (B7)	Eastern Boundary	CCPP
Boundary 8 (B8)	Western Boundary	Inlet Facilities Area
Boundary 9 (B9)	Eastern Boundary	Utilities Annex Area

Figure 3-9 Boundary noise level monitoring locations – Process area (SLR 2020)

Figure 3-10 Boundary noise level measurement locations – Operations complex area (SLR 2020)

Environmental noise levels

In addition to the Ichthys LNG boundary monitoring, three locations were selected for a continuous offsite environmental noise monitoring survey (refer to Table 3-13 and Figure 3-11). Selection of locations gave consideration to the following:

- at least one location was representative of noise levels at the closest residential, institutional and education areas.
- to locations were representative of noise levels at sensitive residential land uses and receptors nearby to the Ichthys LNG
- where field staff could safely and reliably access the sound level measurement equipment at selected locations.

The environmental noise limit of LA_{eq} 55 dBA daytime and LA_{eq} 45 dBA night time were selected as the criteria for the survey, as per design criteria (SLR 2020).

Table 3-13 Noise monitoring location – Receptors around Ichthys LNG

Monitoring location	Nearest site boundary	Logging periods	Time zone*	Coordinates
Location 1	Catalina Road, Palmerston	10th Oct 2019 – 20th Oct 2019	Daytime, evening and night time	E 712442 m, N 8616781 m
Location 2	Ichthys LNG Laydown Area (Lot 1888)	10th Oct 2019 – 17th Oct 2019	Daytime, evening and night time	E 708682 m, N 8611570 m
Location 3	Bladin Village, Channel Island Road	11th Oct 2019 – 18th Oct 2019	Daytime, evening and night time	E 7084134 m, N 8610051 m

*Daytime – 7:00am to 6:00pm, Evening – 6:00pm to 10:00pm and Night time – 10:00pm to 7:00am

Figure 3-11 Noise level monitoring locations – Receptors around Ichthys LNG (SLR 2020)

3.6.2 Results and discussion

Site boundary noise levels

The noise levels results at the Ichthys LNG boundary are presented in Table 3-14 from the SLR survey. The Ichthys LNG boundary noise limit of 70 dBA was achieved at all of the boundary locations, with the exception of one localised area immediately adjacent to the CCPP, at locations Boundary 5 and Boundary 6. The noise level at location Boundary 5 was 77 dBA and Boundary 6 was 74 dBA, which exceeded the limit of 70 dBA; however, these survey locations are adjacent to security fence line and were not representative of the actual noise levels on the actual boundary, which is approximately a further 30 m east.

Table 3-14 Boundary location noise level results

Monitoring Location	Noise Level (LA_{eq})	Noise Limit (LA_{eq})	Assessment against noise limits
Boundary 1	67 dBA	70 dBA	Complies with the boundary noise limit
Boundary 2	65 dBA		Complies with the boundary noise limit
Boundary 3	66 dBA		Complies with the boundary noise limit
Boundary 4	69 dBA		Complies with the boundary noise limit
Boundary 5	77 dBA		STG (CCPP) steam ventilation pipework noise emissions trigger boundary noise limit
Boundary 6	74 dBA		STG (CCPP) steam ventilation pipework noise emissions trigger boundary noise limit
Boundary 7	67 dBA		Complies with the boundary noise limit
Boundary 8	<65 dBA		Complies with the boundary noise limit
Boundary 9	50 dBA		Complies with the boundary noise limit

As the SLR survey was not undertaken on the actual premises boundary for locations Boundary 5 and 6, INPEX conducted a further noise survey on 3 March 2020 to assess the levels at the actual Ichthys LNG boundary.

The INPEX monitoring location was set approximately 20 m east, away from the toe of rock batter in the mangroves, adjacent to the Ichthys LNG boundary. The location of the new monitoring location is shown in Figure 3-12 (see survey point (Boundary)).

A 15 minute attended noise measurement taken at the new monitoring location reported a noise level of 69.8 dBA, which is below the boundary noise limit of 70 dBA. During the monitoring periods, public address and general alarm system noise from the CCPP area was identified as another noise source. In addition to the new monitoring location a measurement was also conducted adjacent to the Ichthys LNG security fence-line, to confirm the SLR levels, (Figure 3-12; survey point (fence line)), which reported a noise level (LA_{eq}) of 73.4 dBA, which is similar to the values reported by SLR (2020) in the initial survey at the same location.

In summary INPEX considers that a boundary noise limit of less than 70 dBA, was achieved for all of the boundary.

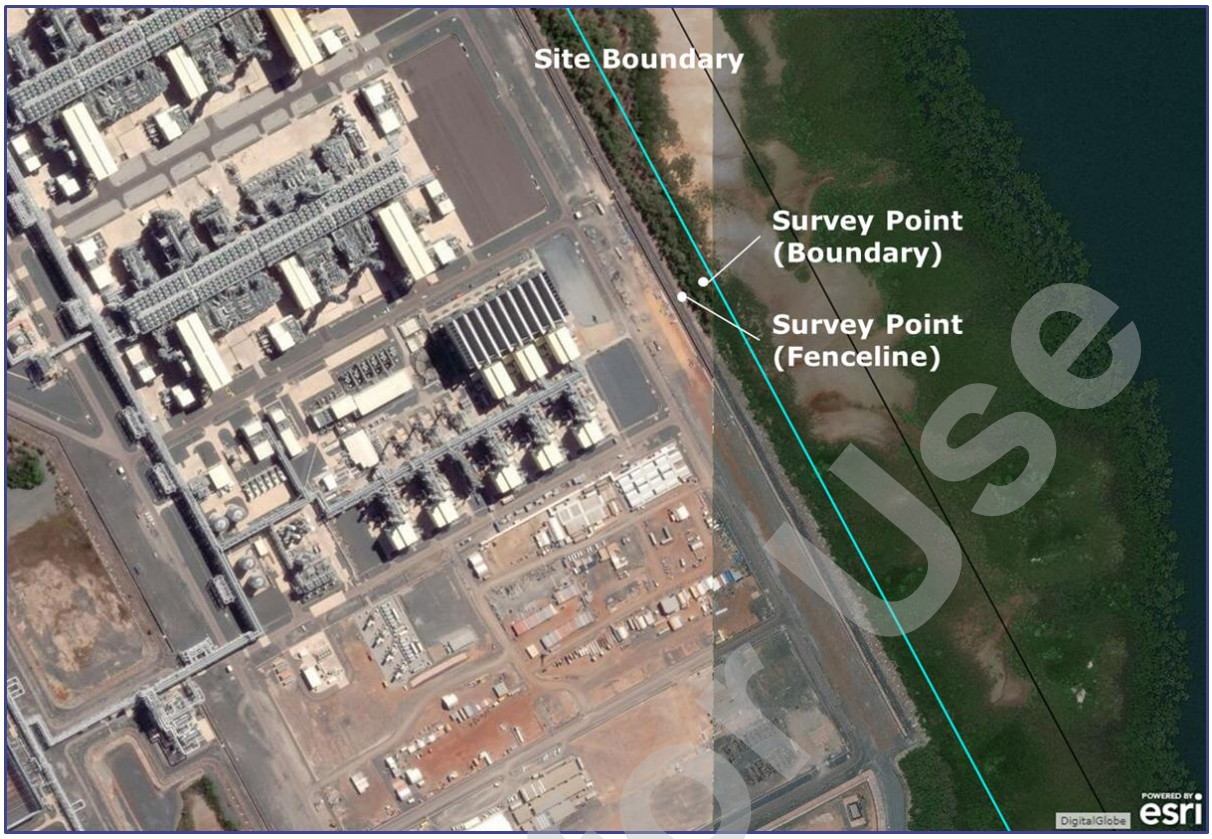


Figure 3-12 INPEX survey boundary sound level monitoring location

Environmental noise levels

The monitored environmental noise levels and in-situ observations identified that noise from the Ichthys LNG was audible above the local ambient noise levels during the daytime and night time, at the three offsite locations (SLR 2020).

The specific noise contribution from Ichthys LNG was measured and observed to be not greater than the following noise levels during the night time period when the noise level contributions from other source locations was minimal (SLR 2020):

- Location 1 (Palmerston) LA_{eq},T 35dBA
- Location 2 (Ichthys LNG Laydown Area Lot 1888) LAeq,T 31 dBA
- Location 3 (Bladin Village) LA_{eq},T 27 dBA.

The noise levels were determined by continuous monitoring of noise levels with the noise loggers, supported with attended monitoring. Results from the long-term environmental noise monitoring program are presented in Table 3-15. The rating background level (RBL) referenced in the Table 3-15 is determined from statistical analysis of the measured LA_{90} noise levels and has been applied as a measure of the steady state environmental noise level at each location.

On the basis of the detailed environmental noise monitoring survey, the environmental noise limit of LA_{eq} 55 dBA and LA_{eq} 45 dBA night time were achieved at the nearest residential, institutional and educational areas, taking into the contribution from Ichthys LNG.

Table 3-15 Environmental noise levels

Time Period	Noise Descriptor	Measured noise levels (dBA)		
		Location1	Location2	Location3
Daytime	LA_{eq}	55	45	57
Night time	LA_{eq}	42	38	45*
Daytime	RBL	30	26	28
Night time	RBL	31	27	25

* Localised intermittent noise events from Bladin Village maintenance traffic in the early morning periods between 5.00 am and 7.00 am resulted in measured night-time noise levels at Location 3 were greater than those in the evening period.

4 UNPLANNED DISCHARGES TO LAND

4.1 Groundwater quality

The key objective of the groundwater monitoring program is to detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations. Note there are no planned discharges directly to groundwater, other than rainfall and non-contaminated water (NCW); however, there is potential for groundwater to become contaminated as a result of an accidental spill, leak or rupture during Ichthys LNG start-up and operations.

As per the OEMP, groundwater quality is required to be monitored quarterly for the first 12 months of operations (following EPL228 activation) with potential to change to biannual (e.g. twice yearly) sampling upon review of the first 12 months of data. As per the recommendation made in the 2018/2019 AEMR (L060-AH-REP-60029) and in accordance with the OEMP, sampling frequency changed to biannual following the fourth quarterly survey (Survey 4) as there had been no change in groundwater quality attributable to Ichthys LNG.

Table 4-1 provides a summary of the groundwater quality surveys completed during the reporting period.

Table 4-1 Groundwater quality monitoring survey details

Survey	Sampling period	Report	INPEX Doc #
4	23-30 Jul 2019	Groundwater Quality Monitoring – Trigger Assessment Report No. 4	F280-AH-REP-60069
		Groundwater Quality Sampling Report No. 4	F280-AH-REP-60077
5	15-30 Jan 2019	Groundwater Quality Monitoring – Trigger Assessment Report No. 5	F280-AH-REP-60070
		Groundwater Quality Sampling Report No. 5	F280-AH-REP-60078

4.1.1 Method overview

The groundwater quality monitoring surveys were undertaken in accordance with the Groundwater Quality Monitoring Plan (F280-AQ-PLN-60003), which includes monitoring at 20 wells (Figure 4-1). The Groundwater Quality Monitoring Plan was developed in consideration of Australian, State and Territory groundwater sampling standards and guidelines. A high-level summary of methods is provided here.

Prior to sampling, groundwater wells were gauged with an interface probe to determine the standing water level (SWL) and to determine the presence of light non-aqueous phase liquid (LNAPL). Following gauging, groundwater wells were purged using a low flow micro purge pump with SWL and in situ parameters being measured every three to five minutes. Once the well had been purged and in-situ parameters were stable, groundwater samples were then collected for analysis.

Following sample collection, groundwater samples were sent to NATA accredited laboratories for analysis of parameters listed in Table 4-2. Results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred.

Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant trigger value (see Table 4-2) and the same analyte also exceeding the background level for each groundwater well. Well specific background level trigger values were calculated using the approach described in ANZG (2018). In short, the 80th and/or 20th percentile value for each parameter was determined using the monthly groundwater data collected during the construction phase of Ichthys LNG between 2013 and 2018.

Table 4-2 Groundwater quality monitoring parameters, methods and trigger values

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
pH	pH units	CFI	Outside 6.0 and 8.5	NRETAS 2010
EC	µS/cm	CFI	n/a	n/a
Dissolved oxygen	%	CFI	n/a	
Oxygen reduction potential	mV	CFI	n/a	
Temperature	°C	CFI	n/a	
Total dissolved solids	mg/L	SFLA	n/a	
Oxides of nitrogen	µg N/L	SFLA	20	NRETAS 2010
Ammonia	µg N/L	SFLA	20	
TN	µg N/L	SFLA	300	
TP	µg P/L	SFLA	30	
FRP	µg/L	SFLA	10	
Phenols	µg/L	SFLA	n/a	n/a
TRH**	µg/L	SFLA	600	Ministry of Infrastructure and the Environment (2009)
Benzene	µg/L	SFLA	500	ANZG 2018
Toluene	µg/L	SFLA	180	
Ethylbenzene	µg/L	SFLA	5	
Xylenes	µg/L	SFLA	75	
Aluminium	µg/L	SFLA	24	Golding et al. 2015
Arsenic	µg/L	SFLA	2.3	ANZG 2018
Cadmium	µg/L	SFLA	0.7	
Chromium III	µg/L	SFLA	10	
Chromium VI	µg/L	SFLA	4.4	
Cobalt	µg/L	SFLA	1	
Copper	µg/L	SFLA	1.3	
Lead	µg/L	SFLA	4.4	

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
Manganese	µg/L	SFLA	390	J. Stauber and R. Van Dam Pers.Com. 23 March 2015 cited in Greencap (2016)
Mercury	µg/L	SFLA	0.1	ANZG 2018
Nickel	µg/L	SFLA	7	
Silver	µg/L	SFLA	1.4	
Vanadium	µg/L	SFLA	100	
Zinc	µg/L	SFLA	15	
Biological oxygen demand (BOD)#	mg/L	SFLA	n/a	n/a
Faecal coliform#	cfu-100mL	SFLA	n/a	
Escherichia coli#	cfu-100mL	SFLA	n/a	

*SFLA = sample for laboratory analysis, CFI = calibrated field instrument

Only at BPGW19A and BPGW27A

**Where TRH is detected over the prescribed limits a silica gel clean-up will be undertaken and reanalysed to remove false positive natural oil results

Figure 4-1 Groundwater quality sampling locations

4.1.2 Results and discussion

A high-level summary of groundwater results and trends is provided in the following sections, with data collected during the reporting period provided in APPENDIX F. Note presentation of groundwater data trends include data collected during the construction phase. Groundwater surveys undertaken in accordance with the OEMP are specified in Table 4-1. To date, groundwater monitoring during the operations phase of Ichthys LNG activities has shown there has been no change in groundwater quality (i.e. Elizabeth-Howard Rivers Region groundwater declared beneficial uses or objectives have not been adversely affected).

Physio-chemical

Physio-chemical monitoring results measured during the reporting period are consistent with those from the construction period and 2018/2019 AEMR. Ichthys LNG is located on low-lying peninsula connected to the mainland by a small isthmus. Most of the groundwater wells are located around the perimeter of Ichthys LNG and are saline with average electrical conductivity of 30,000 to 40,000 µS/cm (Figure 4-2). Groundwater is also acidic to neutral with average pH typically between 5.2 and 5.8 (Figure 4-3). Similar to previous surveys, groundwater elevation was higher (e.g. water table was shallower) following the wet season and decreased during the dry season (Figure 4-4). The SWL of groundwater at Ichthys LNG is influenced by rainfall, although some bores are located slightly below the highest astronomical tide line and are tidally influenced. As such, these wells have less variability in their SWL. Note the reduced SWL in the reporting period is likely to be associated with low rainfall over the 2018/2019 and 2019/2020 wet seasons (see Section 1.4.2). Further, peak SWL typically occurs in September/October, while SWL is lowest in February/March, while groundwater surveys for the reporting period were completed in July 2019 and January 2020. An assessment of groundwater fluctuations during the construction phase of Ichthys LNG (2013 to 2019) concluded that construction of Ichthys LNG had not adversely impacted groundwater levels (Greencap 2019).

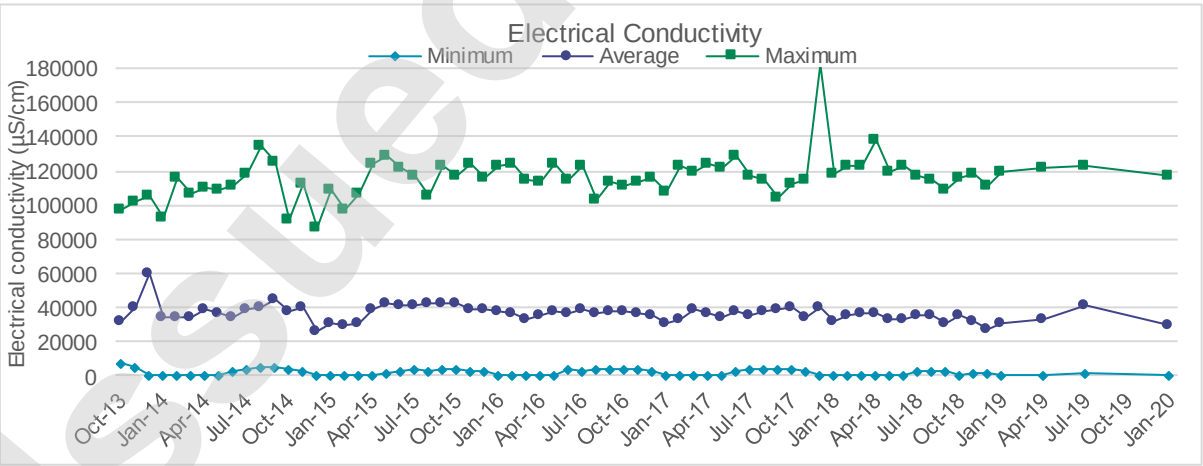


Figure 4-2 Average, minimum and maximum electrical conductivity for Ichthys LNG groundwater wells

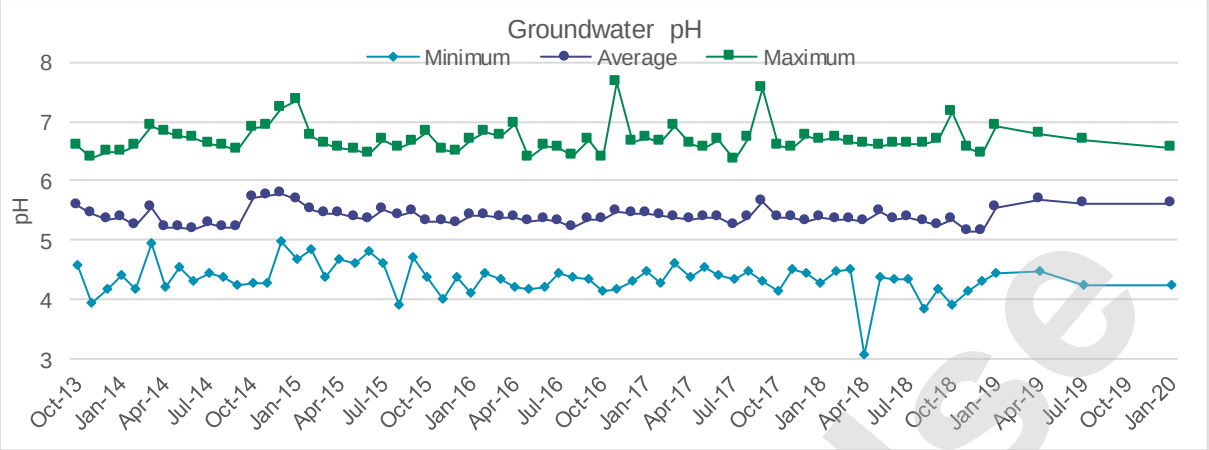


Figure 4-3 Average, minimum and maximum pH for Ichthys LNG groundwater wells

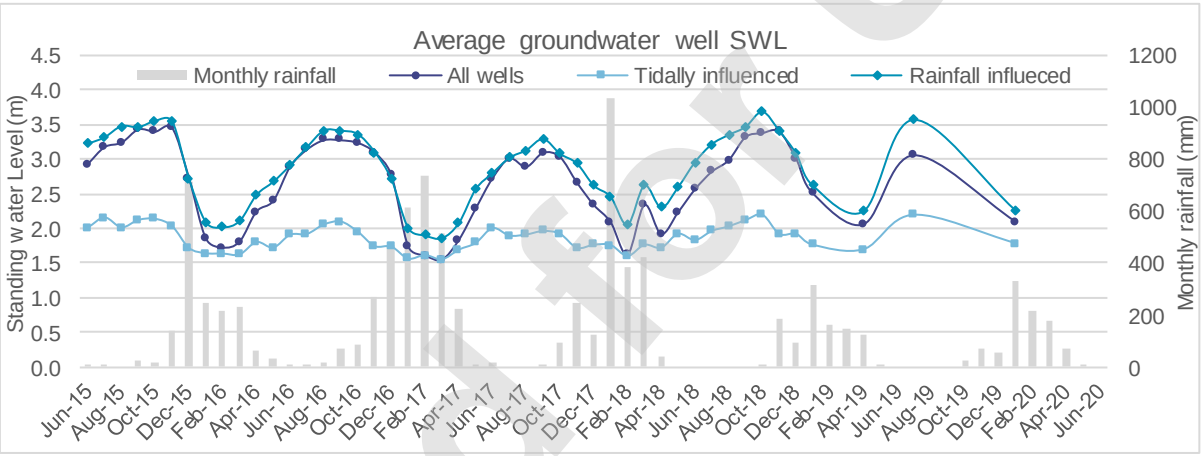


Figure 4-4 Average SWL for Ichthys LNG groundwater wells

Nutrients

Nutrient monitoring results measured during the reporting period were generally consistent with those from the construction period and previous operations 2018/2019 AEMR. Nutrient concentrations are known to vary inter-annually and seasonally (Figure 4-5 and Figure 4-6). Nutrients can also be highly variable between groundwater wells (Figure 4-7).

During the reporting period, and similar to 2018/2019 AEMR, ammonia was the nutrient that had the greatest number of trigger exceedances (10 in Survey 4; July 2019 and five in Survey 5; January 2020). Ammonia also demonstrated a strong seasonal trend, with concentrations increasing during the dry season and decreasing in the wet season (Figure 4-5). Interannual variability is likely to be associated with natural factors such as rainfall; both the total rainfall and timing of rain (e.g. early in the season or late in the season). As mentioned in Section 1.4.2, the 2019/2020 wet season rainfall was well below average and the driest wet season since construction of Ichthys LNG began. This follows on from the previous wet season, which at that point in time was the driest wet season on record and well below average. The dry 2019/2020 wet season has likely contributed the concentrations and subsequently the number of ammonia exceedances recorded during the reporting period.

Overall the variations in nutrient concentrations measured are considered to be the result of natural variations and not attributable to Ichthys LNG activities.

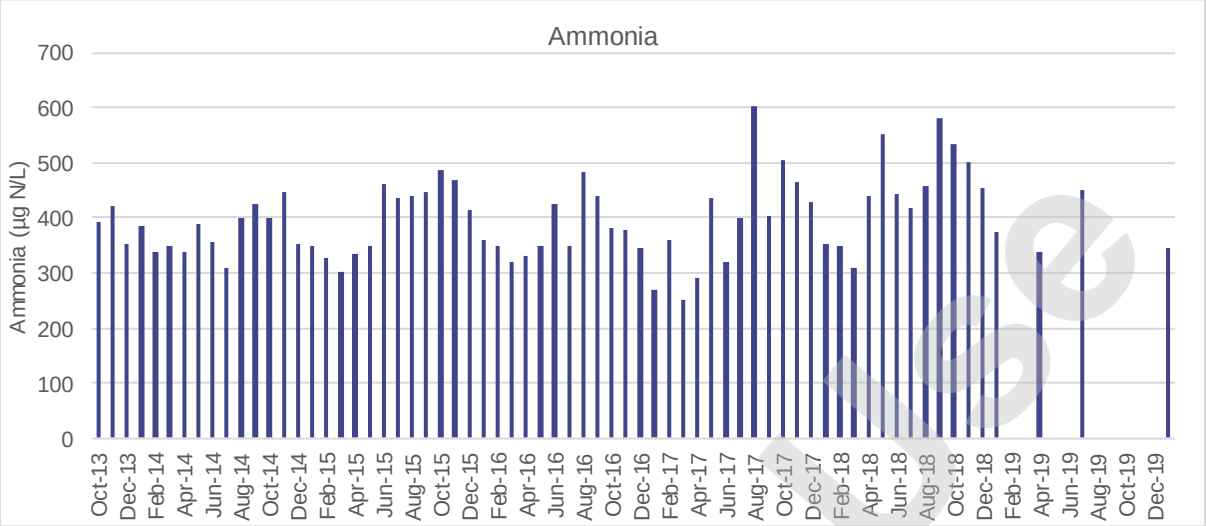


Figure 4-5 Average ammonia concentrations for all groundwater wells

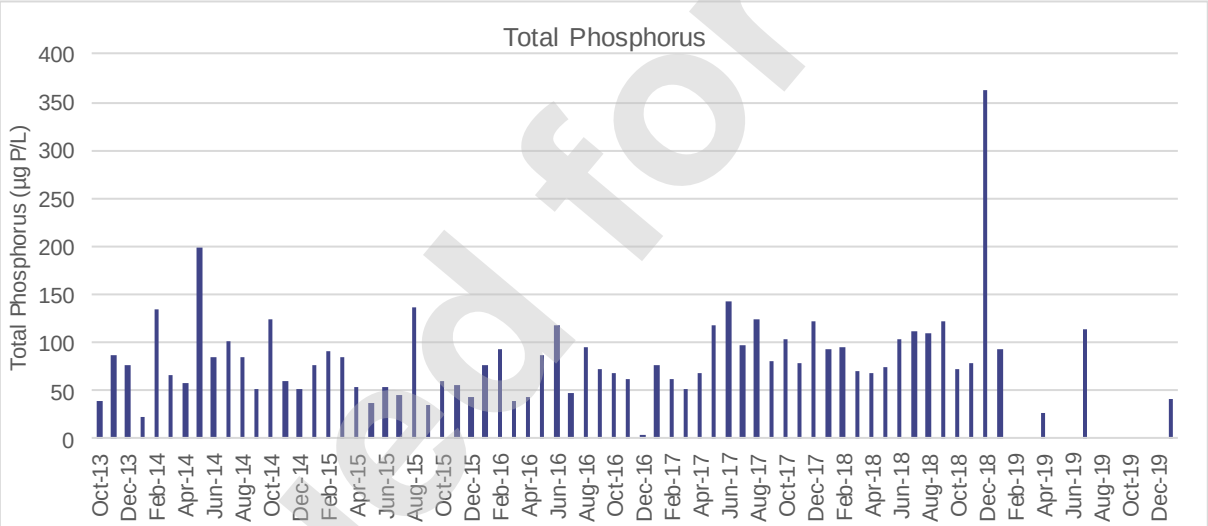


Figure 4-6 Average total phosphorus concentrations for all groundwater wells

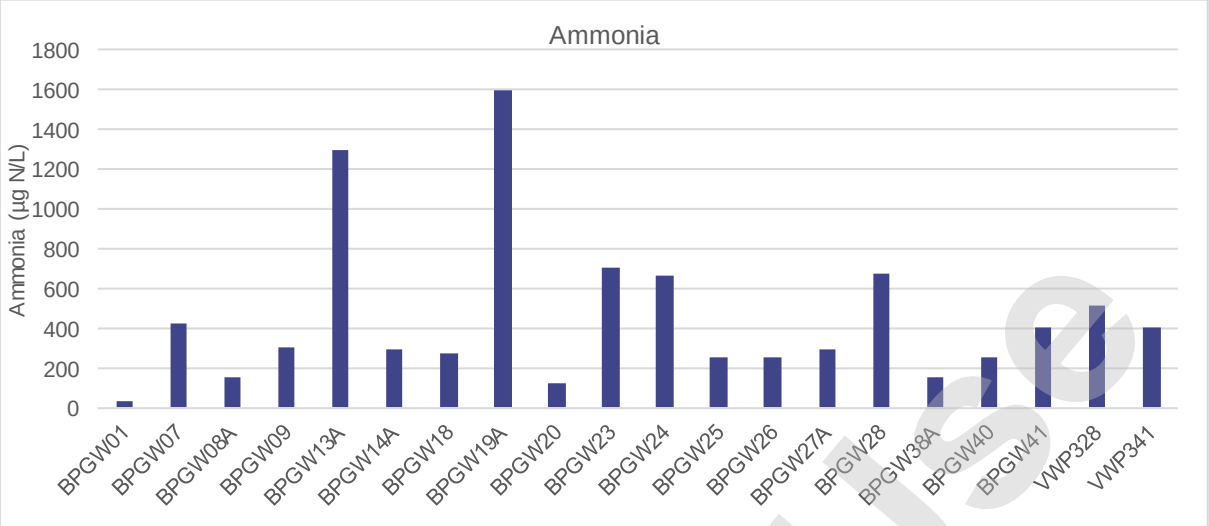


Figure 4-7 Groundwater survey 4 ammonia concentrations

Metals and metalloids

Groundwater metal concentrations measured during the reporting period were generally consistent with those from the construction period and previous operations 2018/2019 AEMR. Similar to nutrients, metal concentrations are known to vary inter-annually and seasonally (see Figure 4-8 for an example). Metals can also be highly variable between groundwater wells (see Figure 4-9 for an example).

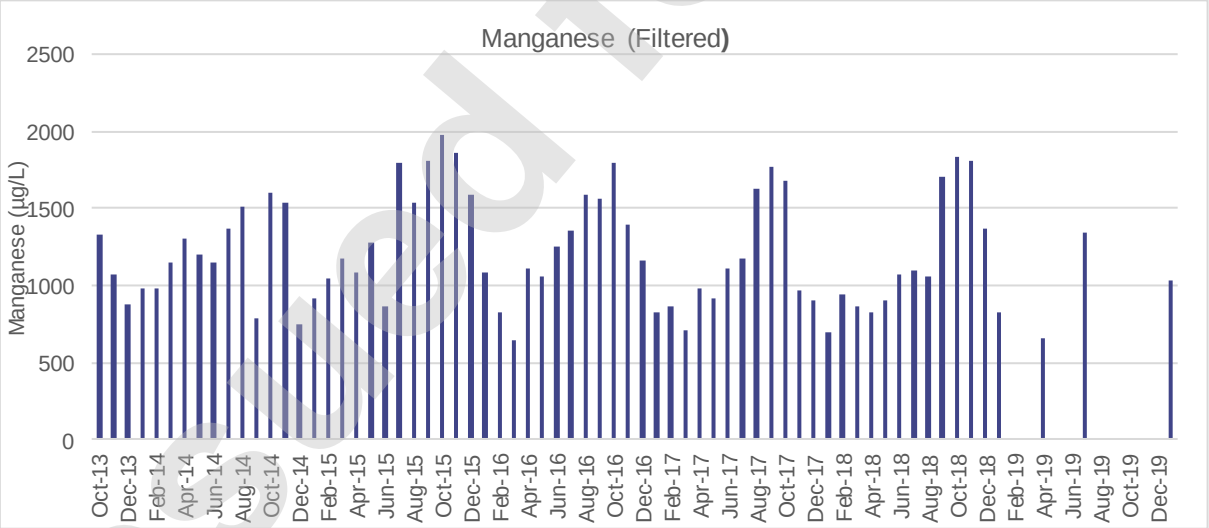


Figure 4-8 Average manganese concentrations for all groundwater wells

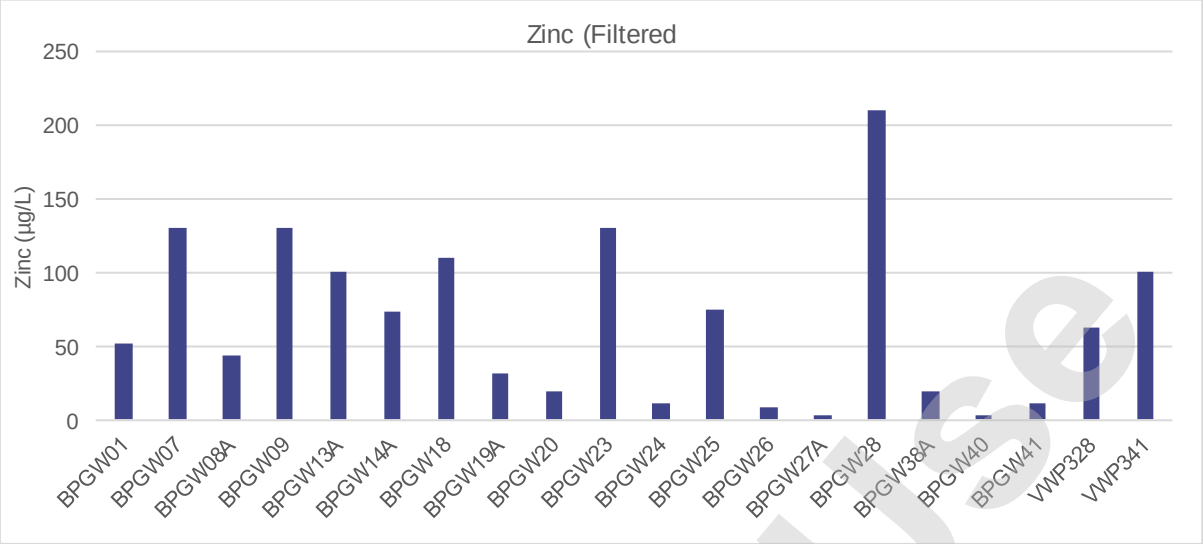


Figure 4-9 Groundwater survey 4 zinc concentrations

During the reporting period and similar to 2018/2019 AEMR, zinc was the metal that had the greatest number of trigger exceedances (12 in July 2019 and four in January 2020) and showed a strong seasonal trend, whereby concentrations typically increase during the dry season and typically decrease in the wet season following the onset of wet season rainfalls (see Figure 4-10 for example of seasonality at a well).

Interannual variability is likely to be associated with natural factors such as rainfall; both the total rainfall and timing of rain (e.g. early in the season or late in the season). As mentioned in Section 1.4.2, the 2019/2020 wet season rainfall was well below average and the driest wet season since construction of Ichthys LNG began. This follows on from the previous wet season, which at that point in time was the driest wet season on record and well below average. The dry 2019/2020 wet season has likely contributed the concentrations and subsequently the number of zinc exceedances recorded during the reporting period.

Overall the variations in metal and metalloid concentrations measured are considered to be the result of natural variations and not attributable to Ichthys LNG activities.

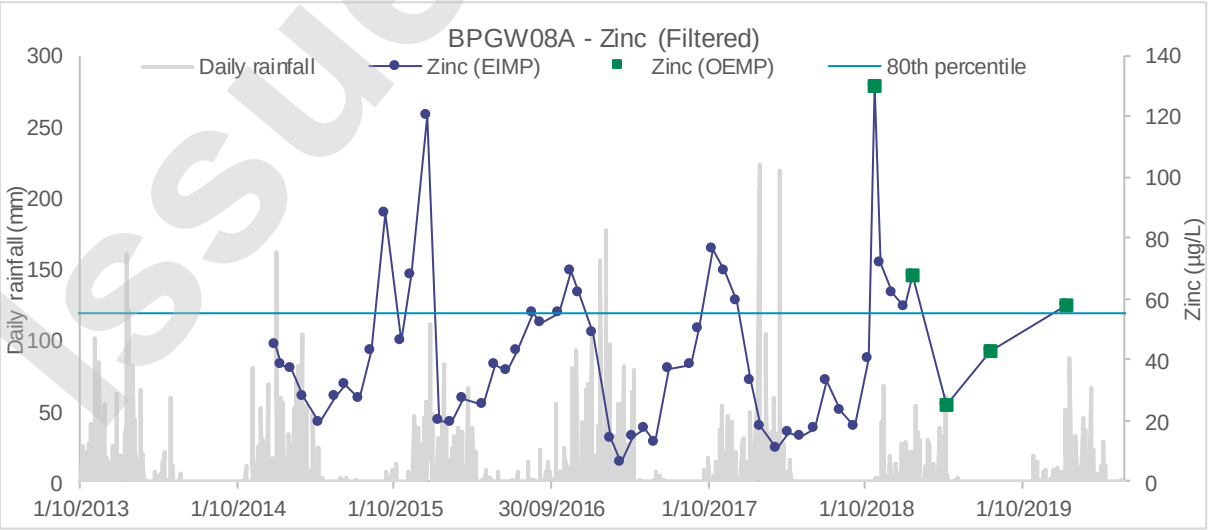


Figure 4-10 Groundwater well BPGW08A zinc (filtered) concentrations with daily rainfall

Organics

No BTEX or phenols were reported in any of the samples from any of the wells during the reporting period, there was also no detection of LNAPL at any well during the reporting period. A positive TRH result (200 µg/L) for well VWP328 was reported in July 2019, the only TRH result for the reporting period. The reported TRH concentration was not a trigger exceedance as it was below the TRH trigger value (600 µg/L). During the construction phase 31 positive TRH groundwater samples were reported. Twenty-three of these were reanalysed following silica gel clean-up for TPH, all of which returned results below laboratory LOR indicating presence of non-petrogenic hydrocarbons (e.g. lipids, plant oils, tannins, animal fats, proteins, humic acids, fatty acids). Although silica gel clean-up wasn't undertaken for the positive result at VWP328 in July 2019, it is likely this was caused by non-petrogenic hydrocarbons similar to previous positive detections. It was also noted that the following January 2020 survey reported TRH below laboratory LOR. Note as per the OEMP, silica gel clean-up is only completed when TRH results exceed the trigger value.

Microbiological

Faecal coliforms (total) and *E. coli* were not detected at BPGW19A during the reporting period, while low concentrations were reported in January 2020 at BPGW27A (Table 4-3).

Table 4-3 Microbiological results for the reporting period

Well	Date	*E. coli* (mpn/100 mL)	Faecal coliform (total) (mpn/100 mL)	BOD (mg/L)
BPGW19A	Survey 4	<1	<1	2
	Survey 5	<1*	<1*	34
BPGW27A	Survey 4	<1	<1	<1
	Survey 5	9*	9*	4.9

*cfu/100 mL, equivalent to mpn/100 mL

4.1.3 Trigger assessment outcomes

In accordance with the receiving environment adaptive management process outlined in Section 7.5 of the OEMP, groundwater trigger exceedances were investigated (i.e. results that exceeded benchmark levels, see Section 4.1.1). A summary of the number of trigger exceedances by survey is provided in Table 4-4 with corresponding investigation reports listed below:

- Groundwater Survey 4 – Trigger Investigation Report (L290-AH-REP-70000)
- Groundwater Survey 5 – Trigger Investigation Report (L290-AH-REP-70001)

Investigation for all trigger exceedances using multiple lines of evidence concluded that the reported trigger exceedances were likely natural (e.g. represent seasonal trends and natural variability) and no further evaluation or management response was required.

Table 4-4 Summary of groundwater trigger exceedances

Date	Month	Physio-chemical	Nutrients	Metals	Total
Survey 4	July	4	23	29	56
Survey 5	January	5	14	36*	55*

*Includes 11 technical trigger exceedances which occurred as a result of laboratory LOR being higher than the trigger value and benchmark level

4.1.4 Program rationalisation

To date, groundwater monitoring during the operations phase of Ichthys LNG activities has shown there has been no change in groundwater quality (i.e. Elizabeth-Howard Rivers Region groundwater declared beneficial uses or objectives have not been adversely affected). In addition, if no changes attributed to Ichthys LNG are detected in groundwater quality following the next two groundwater surveys (planned for October 2020, and April 2021), INPEX will investigate reducing the groundwater survey frequency to annual. In consideration of this, the following program rationalisation is currently proposed, as described in the following sections.

Reduction in monitoring wells

The groundwater monitoring program for operations was designed on the basis that Ichthys LNG had no planned discharges directly to groundwater, other than rainfall and NCW water (flowing to the NCW drainage network). However, it was acknowledged that there was potential for groundwater to become contaminated as a result of an accidental spill, leak or rupture during Ichthys LNG operations. Therefore, a risk-based approach was used to identify groundwater wells downstream of potential contamination sources (e.g. condensate storage) should there be a spill, leak or rupture of infrastructure. The program was also designed to ensure as much continuity as possible with the construction phase groundwater monitoring program. This continuity was integral as:

- most wells had more than six years of monthly data, providing valuable insight into groundwater seasonality and historic trends at individual wells and Ichthys LNG as a whole.
- the construction phase and operations phase overlapped for a period of time for a large proportion of Ichthys LNG site. Construction and operations had different risk sources (e.g. storage locations of chemicals and hydrocarbons, ground disturbance activities). Therefore, some construction source risks were considered in the design of the operations groundwater monitoring program to ensure there were no gaps during the overlap period between construction and operations.

Final construction activities at Ichthys LNG were on the CCPP, which were completed in April 2019. Subsequent commissioning activities for the CCPP were completed in October 2019 (i.e. steady state achieved). During this period construction demobilisation activities were also being undertaken in the construction/commissioning lay down areas. The location of the CCPP as well as construction demobilisation activities are shown in Figure 4-11.

Following the cessation of construction activities, an environmental risk assessment to identify credible source-pathway-receptor linkages was undertaken by the construction environmental monitoring contractor. This included assessing the magnitude of the risk of an adverse effect. The outcome of the risk assessment was that environmental monitoring under the construction Environmental Impact Monitoring Program (EIMP) could cease as of 30 April 2019 (Greencap 2019) due to the cessation of construction activities and reduction in scale of activities (e.g. demobilisation). The assessment found that there was either no linkage between a source and receptor (i.e. no impact pathway) or the residual risk of remaining pathways was low due to reduced likelihood and magnitude of risk sources. Figure 4-11 shows the location of groundwater wells monitored under the EIMP at the cessation of construction activities. Groundwater wells were focussed around areas of remaining final construction, commissioning and demobilisation activities.

The cessation of construction EIMP monitoring activities on 30 April 2019 occurred more than seven months after the activation of EPL228 (i.e. operations) on 14 September 2018. This overlap or transitional period from construction to operations also meant the construction risks up to 30 April 2019 were also being monitoring by the operations phase groundwater program (i.e. wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25), albeit at reduced number of monitoring locations compared to the EIMP. Monitoring at these wells under operations has continued for more than 12 months post-construction activities with no change in groundwater quality as a result of Ichthys LNG activities (construction or operations).

All bulk hydrocarbon stores on Bladin Point (e.g. condensate tanks) are located on the northern side of the groundwater mound. The groundwater model for Bladin Point (location of Ichthys LNG) shows that groundwater flows radially from the central part of Ichthys LNG towards low lying areas typically inundated by tides (Greencap 2015; Figure 4-13). Therefore, there is not an impact pathway for hydrocarbon bulk storage to wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25, south of the groundwater mound.

The area of land adjacent to groundwater wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25 is predominantly flat grade (i.e. gravel; see Figure 4-12). Further, the continuously oil contaminated (COC) and AOC drains and treatment systems are in place around any infrastructure that contain hydrocarbons or chemicals to capture and contain spills or leaks from infrastructure for treatment.

Based on the aforementioned information, there is no credible impact pathway for contamination of groundwater upstream of wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25. As such, these wells will cease to be sampled following the reporting period of this AEMR. Note, these wells will not be decommissioned in the event they are needed in the future.

Figure 4-11 Location of final construction, commission and demobilisation areas and EIMP groundwater and mangrove monitoring locations

Figure 4-12 Aerial image of Ichthys LNG towards end of construction phase and start of operations phase (September 2018) and the current (July 2020) state of Ichthys LNG a) and b) previous construction phase laydown areas and c) location of construction phase temporary waste water treatment facility

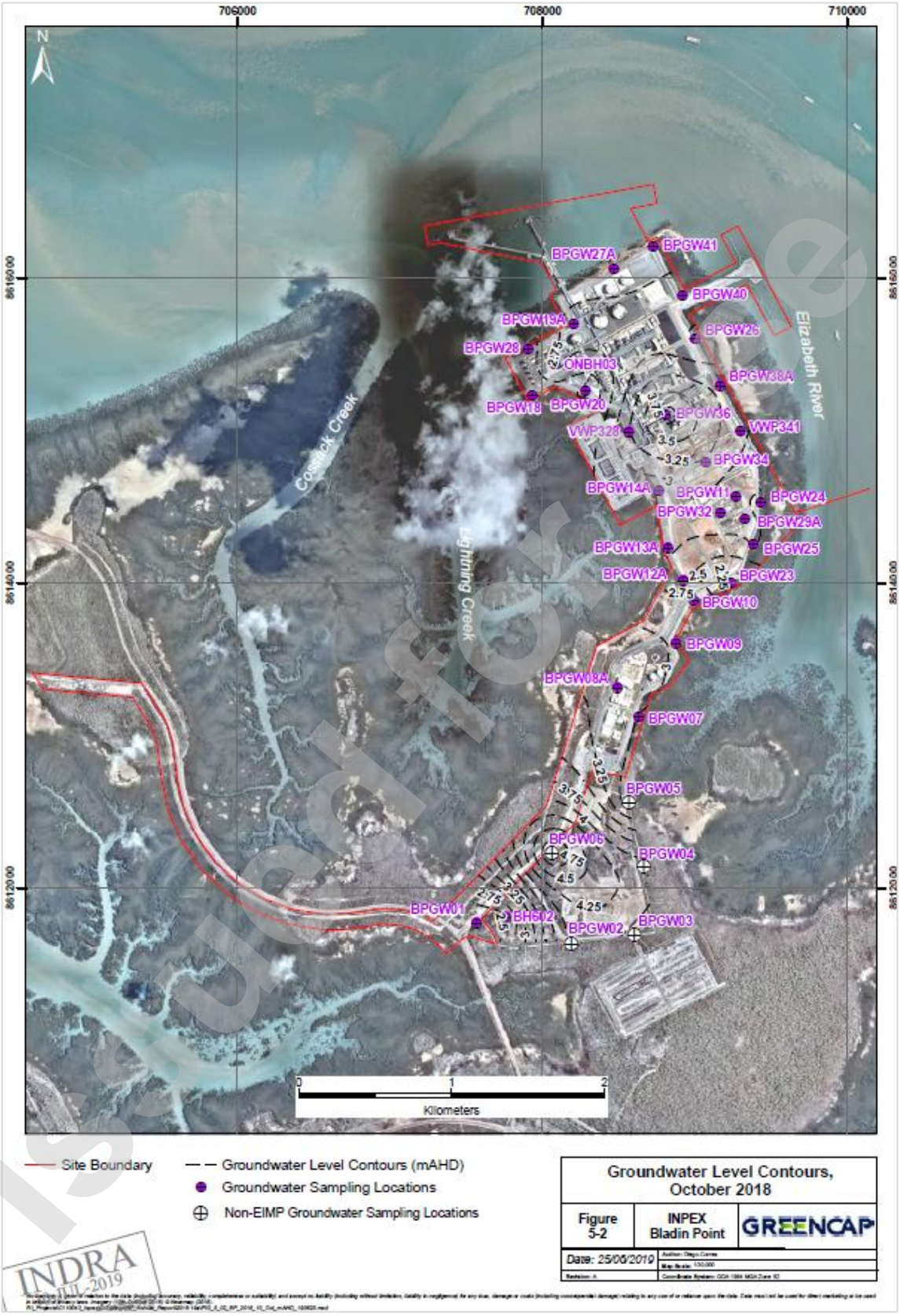


Figure 4-13 October 2018 groundwater contours for Ichthys LNG (source: Greencap (2019))

Reduction in parameters

Metal and metalloids

Table 7-8 of the OEMP currently doesn't specify total or dissolved (also known as filtered) metals for groundwater analysis. To date, all groundwater trigger exceedance assessments and investigations have been based on the dissolved fraction only in accordance with ANZG (2018). ANZG (2018) states that when evaluating metal concentrations against guideline values the first option is to compare total metal concentrations against the guideline values. However, as the dissolved fraction is the bioavailable fraction and thus the toxic component, it is more common to compare the dissolved fraction to guideline values. As groundwater analysis to date has included total and dissolved metals, with the former being an optional step, following this AEMR only dissolved metals will be analysed. Analysis of dissolved metals only also aligns with the jetty outfall monitoring program, which under EPL228 only requires analysis of dissolved metals for the aforementioned reasons.

In addition, it is proposed that mercury speciation (i.e. inorganic mercury) will no longer occur following this AEMR, only total dissolved mercury will be analysed. Analysis of total dissolved mercury contains multiple mercury complexes and is a more conservative analysis to understand total mercury concentrations. Speciation may occur where total dissolved mercury exceeds benchmark levels (i.e. part of the investigation process) to determine if inorganic mercury is driving the exceedance. This risk-based decision process of mercury speciation following total dissolved mercury trigger exceedance aligns with the decision tree for metal speciation guidelines specified in ANZECC/ARMCANZ (2000).

Organics

Phenols occur naturally in petroleum products and generally partition into the water (e.g. produced water) when present. The majority of liquids extracted offshore (e.g. condensate and water) are removed from the gas on the central processing facility (CPF) offshore, prior to the gas being compressed and sent onshore to Ichthys LNG via the gas export pipeline (GEP). The CPF sends extracted liquids to the floating, production, storage and offloading facility where they are separated into condensate, lean MEG and produced water, with the latter discharged offshore following treatment. As such, phenols are not sent to Ichthys LNG from offshore.

There is no storage of phenols at Ichthys LNG. However, it is noted that very low/trace levels of phenols may be present in petroleum products used at Ichthys LNG (i.e. lubricating or fuel oils). Ichthys LNG has been designed so that equipment that uses contaminants of concern, such as oils, are bunded and any leaks or spills are capture by the AOC or COC drains and treatment system.

Based on the aforementioned information there is no credible impact pathway for phenols to enter the groundwater. Further, phenols are analysed for information purposes only as no trigger value is included in the OEMP. Given phenols have not been detected in groundwater to date, there is no credible impact pathway and it is an informative parameter, phenols will cease to be analysed following this AEMR. Removal of phenols aligns the groundwater quality program with commingled treated effluent (Section 2.1) and jetty outfall (Section 2.2) monitoring programs (i.e. phenols are not analysed for these programs as there is no credible impact pathway).

5 FLORA, FAUNA AND HERITAGE

5.1 Mangrove health, intertidal sediment and bio-indicators

Mangrove health, intertidal sediments and bio-indicators were monitored to detect potential adverse changes in mangrove community health as an indirect result of Ichthys LNG operations. The objectives of annual mangrove health, intertidal sediment and bio-indicator surveys are to:

- informatively monitor mangroves adjacent to Ichthys LNG
- detect changes in intertidal sediment quality attributable to Ichthys LNG
- determine through bio-indicator monitoring if changes in seafood quality is occurring and if so determine if it is attributable to Ichthys LNG operations.

As per the OEMP, mangrove health, intertidal sediments and bio-indicators are required to be monitored annually for the first 36 months of operations (following EPL228 activation) with longer term requirements assessed based on a review of these results. Table 5-1 provides a summary of the mangrove health, intertidal sediments and bio-indicators survey completed during the reporting period.

Table 5-1 Mangrove health, intertidal sediment and bio-indicator monitoring survey details

Survey	Date	Report	INPEX Doc #
1	30 Mar – 3 Apr 2020	Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring – Trigger Assessment Report No. 2	F280-AH-REP-60089
		Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring – Interpretative Report No. 2	F280-AH-REP-60092

5.1.1 Method overview

The mangrove health, intertidal sediment and bio-indicator monitoring was undertaken in accordance with the Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring Plan (F280-AH-PLN-60009). This included monitoring at 11 sites; three control and eight potential impact. At each site, a transect from the landward margin of the Hinterland assemblage to the seaward margin of the Tidal Creek assemblage was established during construction phase monitoring. The transects traverse each of the three main Darwin Harbour mangrove assemblages, where present; Hinterland Margin (HM), Tidal Flat (TF) and Tidal Creek (TC). The location of each transect is shown in Figure 5-1.

Monitoring at each site is undertaken at fixed quadrats (10 m × 10 m) established along each transect. At impact sites, monitoring is undertaken at the fixed quadrat within the most landward assemblage present. The location of impact transects were selected based on their proximity to groundwater sampling locations and their location downstream of potential contamination sources, such as condensate storage tanks. For each control site monitoring is undertaken at three fixed quadrats along transects that were also established during construction phase monitoring, with each quadrat representing a different community assemblage. As such, 17 quadrats (i.e. eight potential impact and nine control quadrats) are monitored during each annual survey. Each of the 17 monitoring quadrats is divided into four 5 m × 5 m subplots formed by the fixed quadrat, four corner posts and a centre post (resulting in a total of 68 subplots).

An overview of the monitoring parameters is presented in Table 5-2.

Table 5-2 Monitoring parameters, methodologies and associated metrics

Parameter	Methodology	Monitoring Metrics
Mangrove health	• Mangrove canopy cover assessment • Surveillance photo-monitoring	• Percentage canopy cover • Observations on mangrove health (e.g. leaf colour).
Sediment quality	• Sediment sampling and laboratory analysis • In situ sediment measurements for pH and redox.	• Metal and metalloids (Al, Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Zn) • TRH • PSD (laser diffraction) • pH (measured in field) • Redox (measured in field) • Total Organic Carbon (for normalisation of TRH)
Biota	• Collection of mud whelks and laboratory analysis.	• Metal and metalloids (Al, Sb, As, Cd, Cr, Cu, Pb, Hg, Ni, Zn) • TRH* • Poly Aromatic Hydrocarbons (PAH)*

* Following year one, mud whelk hydrocarbon analysis is not required unless an incident has occurred (e.g. discharge of significant hydrocarbon volume to the mangroves).

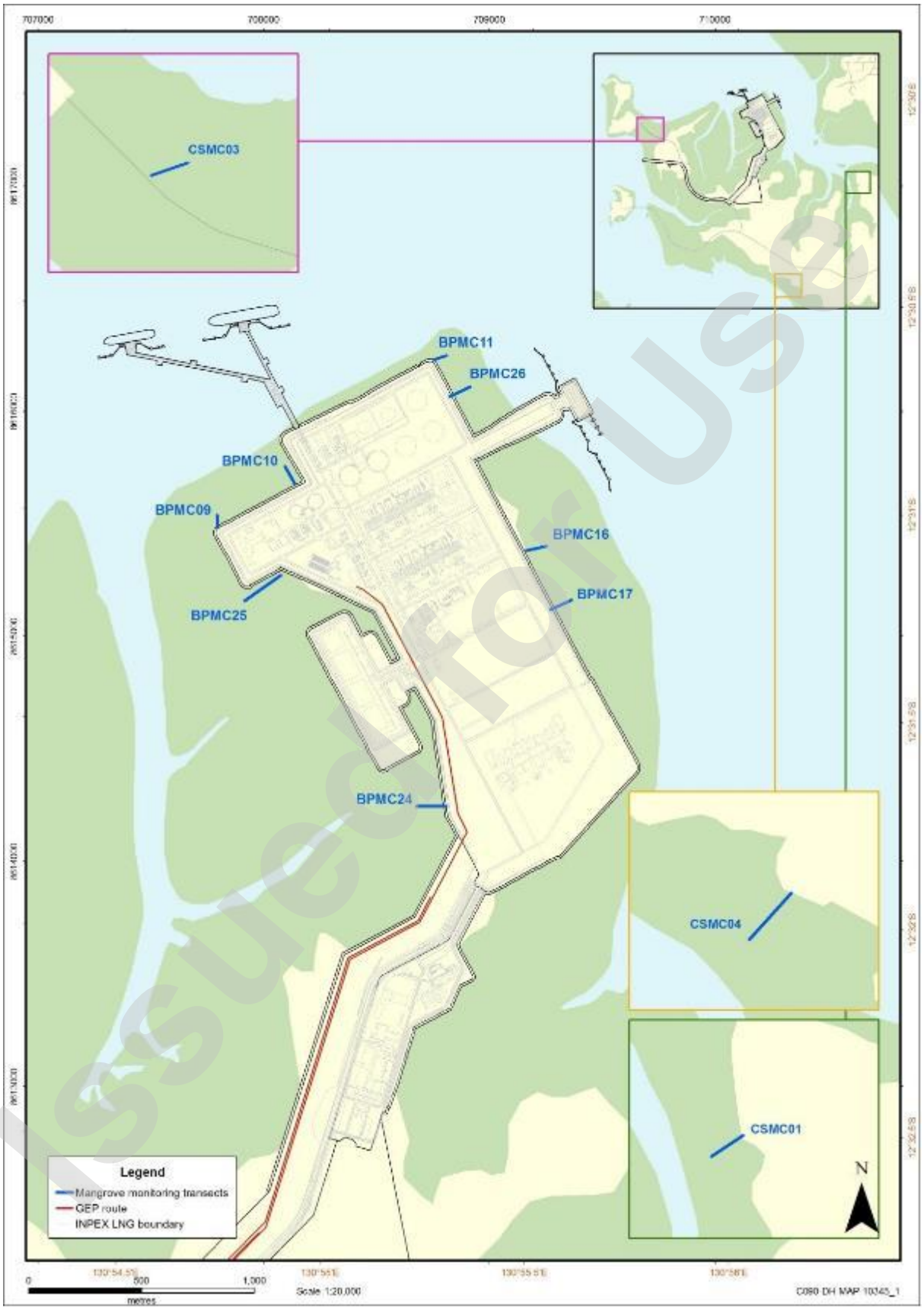


Figure 5-1 Mangrove health, intertidal sediment and bio-indicator monitoring locations

Mangrove health monitoring

At each of the 17 quadrats, mangrove canopy cover was measured within each sub-plot (total 68 subplots) using a Stickler's modified spherical densiometer (Stickler 1959). Three replicated measurements consisting each of four directional cover estimates (i.e. turning 90° to take four measurements from each replicate location) were taken within each sub-plot to provide an estimate of foliage cover.

Repeatable mangrove surveillance photo-monitoring was also undertaken at each site to provide a visual record of the communities' appearance and condition (e.g. leaf colour). General observations with respect to the condition of the mangroves and surrounding areas were also noted (i.e. presence of litter, erosion, general indications of mangrove health, flowering, presence of propagules or seedlings).

Sediment monitoring

To test for potential changes in sediment composition and sediment quality, two replicate surficial sediment samples were taken (top 2-5 cm) from within each of the 17 monitoring quadrats. Collected sediments were sent to NATA accredited laboratories for analysis. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding its relevant Sediment Quality Guideline Value (SQGV; also referred to default guideline value) as per ANZG (2018) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels (i.e. average concentration) were calculated based on intertidal results presented in Darwin Harbour Baseline Sediment Survey 2012 (Munksgaard et al. 2013). Note, where measured metal or metalloids exceeded SQGVs, results where possible will be normalised for aluminium concentrations based on the methods described in Munksgaard (2013) and Munksgaard et al. (2013) and compared to background levels (i.e. baseline or reference levels)

Sediments were also tested in-situ for pH, temperature and redox potential within two subplots of each quadrat.

Bio-indicator monitoring

Mud whelk (*Telescopium telescopium*) samples were collected from 10 locations during the survey from a combination of impact and control sites (six impact and four control sites) for testing of levels of metal contamination. Collected mud whelks were sent to NATA accredited laboratories for analysis. Laboratory results were then compared to benchmark levels to ascertain whether a trigger exceedance had occurred. Exceedance of a benchmark level is defined as a measured analyte exceeding the national food standards contaminant levels for molluscs (FSANZ 2013) and the same analyte also exceeding the background level for Darwin Harbour sediment. Background levels (i.e. average concentration) were calculated based on reference site results presented in French (2013).

5.1.2 Results and discussion

Mangrove health monitoring

Canopy cover

Canopy cover across all assemblages has remained relatively stable over time (Figure 5-2). The one notable change between March 2014 and March 2015 for control site tidal flat is due to the inclusion of two new control sites (CSMC03 and CSMC04) rather than an actual increase in canopy cover.

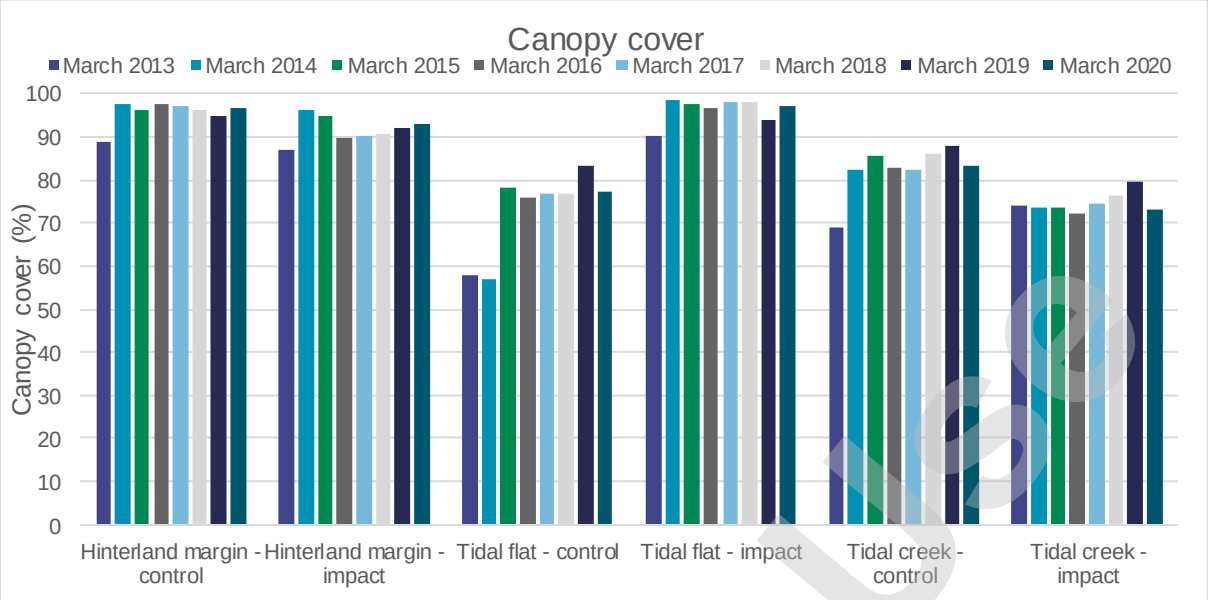


Figure 5-2 Mangrove canopy cover

Community health

All sites were classified as healthy in 2020 based on indices of leaf colour, regeneration (i.e. seedlings and saplings), visible vertebrate fauna and infaunal bioturbation (Figure 5-3). The presence of flowers and immature fruits was low or absent in all sites, reflecting the poor rainfall recorded during the 2019-2020 wet season (see Section 1.4.2). Insect damage was low in most sites, with the greatest rates of herbivory recorded for many *Avicennia marina* trees in the Tidal Flat assemblages.

Sediment monitoring

In-situ sediment measurements

In situ sediment measurements indicated that sediment at all sites is slightly acidic and highly reducing (Table 5-3), which is typical and characteristic of mangrove environments (Bomfim et al. 2018; Huang et al. 2018; Hossain and Nuruddin, 2016; Matthijs et al. 1999). Measurements were relatively consistent across impact and control sites and do not indicate contamination or disturbance.

Table 5-3 Mangrove sediment in situ monitoring results

Assemblage	pH		Temperature (°C)		Redox potential (mV)	
	Impact	Control	Impact	Control	Impact	Control
Hinterland margin	6.3	6.3	29.0	30.0	-110.4	-167.9
Tidal flat	6.1	6.5	34.3	30.5	-78.1	-176.9
Tidal creek	6.4	6.6	32.8	29.3	-203.9	-217.3

A) thick leaf litter surrounding a hooded burrow of the semi-terrestrial crab *Neosarmatium australiense*; B) the common tree-climbing potamidid snail *Certhidea anticipata*; C) a large conspicuous mound of the mangrove mudlobster *Thalassina squamifera*

Figure 5-3 Photo examples of healthy mangrove forest stands observed in 2020

Sediment chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-4 and Table 5-5. Exceedances of the benchmark levels were recorded at both impact and control sites for hydrocarbons. Two exceedances of arsenic and a single exceedance of chromium was also found at control sites, but was not investigated further as no exceedances were found at impacts sites.

For hydrocarbons, a TPH exceedance was limited to two impact sites, with all three control sites (four of nine quadrats) also recording exceedances. In accordance with recommendations made in the 2018/2019 AEMR, silica gel clean-up was performed on samples that exceeded the TPH trigger value to remove non-petrogenic hydrocarbons. Following silica gel clean-up, TPH results were all below laboratory LOR (50 mg/kg). This indicates the presence of naturally occurring hydrocarbons (e.g. lipids, plant oils, tannins, animal fats, proteins, humic acids, fatty acids). As such, TPH trigger exceedances were not investigated further.

Table 5-4 Summary of inorganic mangrove sediment chemistry (mg/kg).

Site	Aluminium	Antimony	Arsenic*	Cadmium	Chromium*	Copper	Lead	Nickel	Zinc	Mercury
Guideline value	n/a	2	20	1.5	80	65	50	21	200	0.15
Background	n/a	n/a	16.0	0.071	17.5	4.7	8.8	8.7	21.4	n/a
BPMC09	4,075	<0.5	7.0	<0.1	13	3.8	4.7	3.7	19.7	<0.01
BPMC10	3,650	<0.5	6.0	<0.1	12	3.3	4.2	3.5	15.8	<0.01
BPMC11	615	<0.5	1.6	<0.1	3	<1.0	<1.0	<1.0	1.4	<0.01
BPMC16	1,290	<0.5	2.7	<0.1	12	1.5	1.2	<1.0	3.3	<0.01
BPMC17	3,705	<0.5	9.3	<0.1	52	3.1	3.7	1.7	12.6	<0.01
BPMC24	5,615	<0.5	18.6	<0.1	72	5.1	7.0	2.6	11.3	<0.01
BPMC25	4,290	<0.5	5.4	<0.1	13	2.7	4.4	3.5	9.4	<0.01
BPMC26	4,665	<0.5	6.9	<0.1	18	4.0	5.3	4.2	13.0	<0.01
CSMC01-HM	1,390	<0.5	<1.0	<0.1	5	1.5	1.0	<1.0	2.1	<0.01
CSMC01-TF	1,550	<0.5	4.4	<0.1	8	1.1	2.7	1.2	6.7	<0.01
CSMC01-TC	10,450	<0.5	15.5	<0.1	32	6.8	11.9	9.1	31.5	0.015
CSMC03-HM	8,340	<0.5	17.1	<0.1	**85**	10.5	29.9	8.9	31.2	0.01
CSMC03-TF	10,500	<0.5	**24.8** (23.6)	<0.1	33	6.4	12.8	8.0	25.2	0.015
CSMC03-TC	6,265	<0.5	**27.0** (64.7)	<0.1	27	5.0	7.9	7.4	18.9	<0.01
CSMC04-HM	2,750	<0.5	12.1	<0.1	15	9.4	9.4	3.6	18.4	0.01
CSMC04-TF	13,100	<0.5	12.8	<0.1	38	6.4	12.7	10.4	26.6	0.02
CSMC04-TC	15,050	<0.5	13.5	<0.1	41	7.8	13.8	11.9	32.0	0.02

*Bold value indicates trigger exceedance and results in brackets have been normalised for aluminium concentrations as per Munksgaard (2013)[3].

Table 5-5 Summary of organic mangrove sediment chemistry (mg/kg).

Site	TOC (%)	TPH C10-C36 (sum of total)	TPH C10-C36 (sum of total after silica gel clean-up)
Guideline value	n/a	280	280
Background	n/a	n/a	n/a
BPMC09	1.43	177	n/a
BPMC10	1.31	137	n/a
BPMC11	0.52	33.5	n/a
BPMC16	0.96	165	n/a
BPMC17	3.67	**415**	<50
BPMC24	0.48	63.5	n/a
BPMC25	3.84	184	n/a
BPMC26	5.28	**322**	<50
CSMC01-HM	1.71	203	<50
CSMC01-TF	0.69	88.5	n/a
CSMC01-TC	8.61	**780**	<50
CSMC03-HM	0.79	108.5	n/a
CSMC03-TF	6.88	**613**	<50
CSMC03-TC	5.21	207	<50
CSMC04-HM	3.78	238	<50
CSMC04-TF	6.65	**544**	<50
CSMC04-TC	6.87	**350.5**	<50

*Bold value indicates trigger exceedance

Bio-indicator monitoring

A summary of the trigger assessment for bio-indicator monitoring is provided in Table 5-6. All parameters were below benchmark levels with the exception of arsenic at three control site sampling locations. Interestingly all mud whelk samples recorded arsenic concentrations greater than FSANZ (2013). High levels of arsenic in mud whelks is likely a reflection of the naturally occurring high levels of arsenic in Darwin Harbour sediments which is a reflection of local geology rather than anthropogenic activities (Padovan 2003). As exceedances of benchmark levels for arsenic were only recorded at control sites they were not investigated further.

Table 5-6 Summary of mangrove bio-indicator chemistry results (mg/kg).

Site	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Mercury
Guideline value	n/a	n/a	1	2	n/a	n/a	2	n/a	n/a	Mean of >0.5
Background	n/a	n/a	3.8	0.31	n/a	n/a	0.54	n/a	n/a	n/a
BPMC09	150	<0.4	3.0	0.15	0.3	18	<0.2	0.7	89	0.14
BPMC10	660	<0.4	3.2	0.13	0.9	23	0.3	1.0	66	0.13
BPMC25	110	<0.4	3.5	0.10	0.2	18	<0.2	0.4	46	0.72
BPMC26	92	<0.4	3.0	0.22	0.2	27	<0.2	1.8	66	0.09
CSMC01-HM	64	<0.4	2.8	0.05	0.1	25	<0.2	0.4	28	0.14
CSMC01-TF	9	<0.4	**4.4**	0.13	0.1	22	<0.2	0.7	65	0.20
CSMC01-TC	16	<0.4	3.1	0.09	0.1	17	<0.2	0.4	36	0.22
CSMC03-HM	30	<0.4	3.2	0.15	0.2	45	<0.2	0.4	20	0.21
CSMC03-TF	17	<0.4	**3.8**	0.18	<0.1	33	<0.2	0.5	37	0.13
CSMC03-TC	11	<0.4	**4.0**	0.11	<0.1	37	<0.2	0.5	29	0.11

*Bold value indicates trigger exceedance

5.1.3 Trigger assessment outcomes

As trigger exceedance for arsenic in sediments and mud whelks were only reported for control sites they were not investigated further. Silica gel clean-up to remove non-petrogenic hydrocarbons returned TPH concentration below laboratory LORs and benchmark levels, as such no further investigation was undertaken.

5.1.4 Program rationalisation

To date, monitoring during the operations phase has shown there has been no demonstratable change in mangrove health, intertidal sediment or bio-indicator quality attributable to Ichthys LNG operations. In consideration of this, the following program rationalisation are proposed.

Reduction in monitoring sites

When designing the mangrove health, intertidal sediment and bio-indicator monitoring for operations, mangrove sites as close to and downstream of groundwater wells. In this program, mangroves are the end receptor and groundwater is the potential impact pathway for a spill, leak or rupture. This is because there are no planned discharges to groundwater or mangroves during operations other than clean rainfall and NCW water (flowing to the NCW drainage network).

As described in Section 4.1.4, there was a transitional period where construction and operations overlapped. This included additional risks/impact pathways associated with construction activities that were included in the operations mangrove monitoring program, albeit at reduced number of monitoring locations compared to the EIMP.

Following the cessation of construction activities, an environmental risk assessment to identify credible source-pathway-receptor linkages was undertaken by the construction environmental monitoring contractor. This included assessing the magnitude of the risk of an adverse effect. The risk assessment determined environmental monitoring under the construction EIMP could cease as of 30 April 2019 (Greencap 2019) due to the cessation of construction activities and reduction in scale of activities (e.g. demobilisation) The assessment found that there was either no linkage between a source and receptor (i.e. no impact pathway) or the residual risk of remaining pathways was low due to reduced likelihood and magnitude of risk sources.

Based on the aforementioned information, it was identified that there is no credible impact pathway for contamination of groundwater upstream of well BPGW13A. As such, this well will cease to be sampled following the reporting period of this AEMR (see Section 4.1.4). As mangrove site BPMC24 is located downstream of groundwater well BPGW13A, which has no credible impact pathway for contamination, mangrove site BPMC24 also has no credible impact pathway for contamination and will cease to be monitored following the reporting period of this AEMR.

One control site (CSMC04) will also be removed from the mangrove health, intertidal sediment and bio-indicator monitoring program following the reporting period of this AEMR. This is because risks associated with mangrove monitoring are high relative to other monitoring programs and a reduction in risk to personnel can be achieved without compromise to the monitoring program. Control sites are located away from Ichthys LNG with increased emergency response times. Further, as quadrats are located in all three assemblages at each control site, field personnel are required to traverse large distances across dense, difficult and muddy terrain in hot humid conditions with heavy equipment and samples, increasing their injury exposure risks (e.g. manual handling, fatigue, heat illnesses). Therefore, reducing the number of control sites to two (e.g. CSMC01 and CSMC03) reduces exposure risk to field personnel with no increased environmental risk.

This reduction will have minimal impact on the monitoring program as two control sites will remain. Although three control sites is desirable for control/impact monitoring program design, mangrove health indices at all sites to date has shown little temporal variability and consistency between sites, so reduction in a control site is unlikely to impact future results. Note a third control site is desirable to account for abnormal trends at other control sites that may impact the ability to detect a change outside natural variability, however the data to date little temporal variability and consistency between sites shows this is not of a concern for this program.

Reduction in sample effort

Sediment samples

Current field QA/QC for intertidal sediment samples as per the Mangrove Health, Intertidal Sediment and Bio-indicator Monitoring Plan (F280-AH-PLN-60009) include:

- transport blank – one per field trip to assess potential contamination introduced during sample transport
- field blank – one per field trip to assess potential contamination introduced during the sampling process
- field triplicate – three separate samples collected from the same site used to assess fine scale spatial variability in physical and chemical characteristics, undertaken at 10% of sites
- field split – a single sample split into three separate containers with two samples sent blindly to the primary laboratory and the third sample sent to a secondary laboratory to assess intra- and inter-laboratory variation in analysis, undertaken at 5% of sites

This QA/QC approach for sediment sampling is based on the National Assessment Guidelines Dredging (NAGD; Commonwealth of Australia 2009) and includes QA/QC above that specified in ANZG (2018). As the current QA/QC meets industry and Australian Standards for sediment sampling, the secondary sample that has been collected adjacent to every quadrat to date will cease following the reporting period of this AEMR (i.e. one sample per quadrat will continue to be collected and analysed as well as the aforementioned QA/QC samples).

Mud whelks

The mud whelk (*T. telescopium*) are known bio-accumulators and are used as a bio-indicator in Darwin Harbour (French 2013). Mud whelks have been collected from mangrove locations around Ichthys LNG since 2013. However, it is proposed that the collection and analysis of mud whelks for metal and metalloids is ceased following the reporting period of this AEMR, as done for hydrocarbons in the 2018/2019 AEMR.

Collection and analysis of mud whelks will be based on incident response, as there is currently no impact pathway for mud whelks. This change is based on data to date showing there has been no impacts to mud whelks or mangrove sediments that that may lead to bio-availability for or bio-accumulation of contaminants in mud whelks.

Further, sufficient data has now been collected for comparison should future analysis be required (e.g. incident or spill to mangroves). Additionally, the continued collection of mud whelks, up to seven years at some sites, is likely placing undue pressure on mud whelk populations, with mud whelks only present at half the potential impact sites in 2020.

Reduction in parameters

Intertidal sediments PSD is an informative parameter as higher portions of fines can increase the available binding sites for contaminants. The fines component of PSD is also sometimes used to normalise metal concentrations. However, research in Darwin Harbour by Munksgaard (2013) states there is a strong correlation between aluminium and fines (<63 µm) in Darwin Harbour and normalisation to the fines content produces similar results to aluminium normalisation. Munksgaard's (2013) recommendation to normalise metals based on aluminium concentrations is implemented for sediment sampling scopes in this AEMR, such as mangroves, where values exceed benchmark levels.

Given analysis of PSD is informative, not required for normalisation and to reduce exposure risks on field personnel (i.e. PSD is a standalone sample that needs to be collected) PSD analysis will cease following the reporting period of this AEMR.

Trial new method

A Stickler's modified 17-point spherical densiometer is currently used to provide an estimate of foliage cover. A known limitation of densiometers is that they are slightly subjective and known to potentially produce observer bias (Cook et al. 1995, Korhonen et al. 2006). However, consistent and reliable results can be achieved if the same scientist is used.

To eliminate potential future bias, INPEX will trial a digitised method for measuring canopy cover (e.g. *Percentage Cover* [%Cover] application) in 2021. *Percentage Cover* combines photography and smart device technology to allow rapid assessment of canopy cover, while also providing a digital archive of canopy cover in a vertical direction, which is a 'true' measurement of canopy cover (Jennings et al. 1999). Outcomes of the trial will be included in the 2020/2021 AEMR.

5.2 Nearshore marine pests

5.2.1 Method overview

Nearshore marine pests were monitored to assess the presence/absence of invasive marine species at the Ichthys LNG and LPG/condensate product loading jetties (Figure 5-4) using artificial settlement units (ASUs; Figure 5-5). Each ASU consists of four settlement plates (back to back) and two rope mops. The ASUs are provided by NT Aquatic Biosecurity Unit, within the Fisheries Division of the Northern Territory Department of Primary Industry and Resources (NT DPIR).

Photo-monitoring of ASUs is undertaken monthly with ASUs collected and replaced every fourth month. Collected ASUs were sent to NT DPIR for identification.

The ASUs were installed in September 2018 with monthly monitoring commencing in October 2018. Table 5-7 provides a summary of nearshore marine pest monitoring dates for the reporting period.

Table 5-7 Nearshore marine pest monitoring dates

Monitoring date	Sample collection/ replacement
17-Jul-19	No
12-Aug-19	Yes – Unplanned sample request from DPIR. No trap replacement.
11-Sep-19	Yes
16-Oct-19	No
13-Nov-19	No
11-Dec-19	No
17-Jan-20	Yes
13-Feb-20	No
12-Mar-20	No
20-Apr-20	No
18-May-20	Yes
19-Jun-20	No

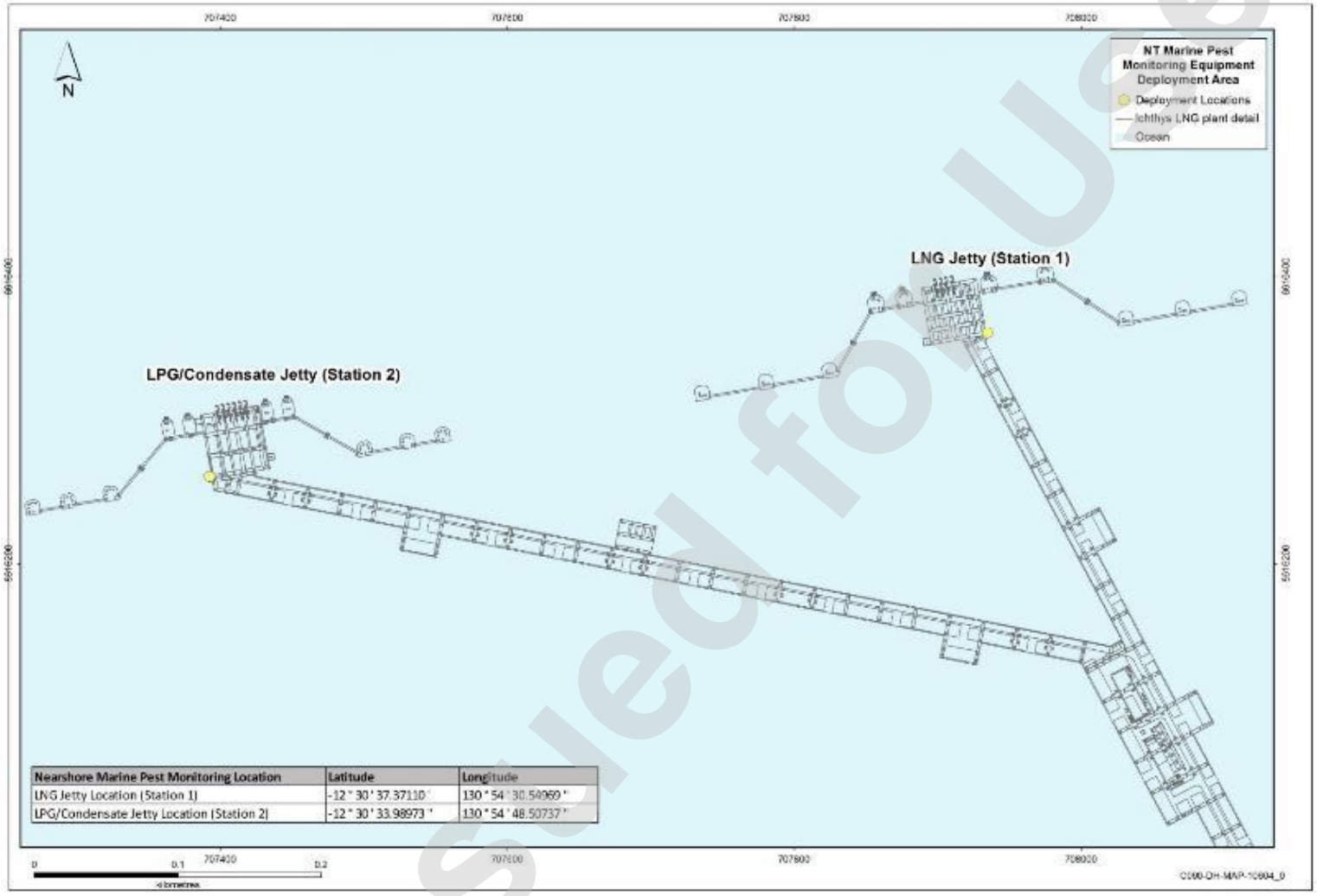


Figure 5-4 Nearshore marine pest monitoring locations

Figure 5-5 Nearshore marine pest ASU

Figure 5-6 Example of monitoring photographs taken during monthly inspection (September 2019), a) rope mop, b) inside the plates and c) plates surface biofouling conditions.

5.2.2 Results and discussion

No invasive marine species have been identified during this reporting period by the NT Aquatic Biosecurity Unit during four monthly inspections, or by INPEX during the monthly visual inspections. Table 5-8 provides a summary of organisms identified on LNG and LPG/condensate jetty ASUs in the monitoring after collection.

Table 5-8 Organisms identified on ASUs during reporting period by NT DPIR

Jetty	ASU	Aug 2019	Sep 2019	Jan 2020	May 2020
LNG	Plates	-	Sabellids, barnacles, polychaetes, hydroids, silt, encrusting bryozoans, branching bryozoans, colonial ascidians, oysters, serpullids	Barnacles, colonial ascidian, solitary ascidian, hydroids, oysters, sabellids, mussels, encrusting bryozoans, serpullids	Colonial ascidian, solitary ascidian, barnacles, oysters, encrusting bryozoans, serpulids
	Rope mops	-	Solitary ascidians, branching bryozoan, hydroids, encrusting bryozoan, serpullids, colonial ascidian, silt	Sabellids, serpullids, solitary ascidians, colonial ascidians, hydroids, scallops, mussels, branching bryozoans	Colonial ascidian, solitary ascidian, silt, sabellids, serpulids, hydroids, encrusting bryozoans, branching bryozoans, *Didemnum*, sponge, mussel, oysters
LPG/ condensate	Plates	*Planostrea pestigris*	Hydroids, branching bryozoan, silt, oysters, barnacles, solitary ascidian, encrusting bryozoan, sabellids, serpullids, *Didemnum*, colonial ascidian	Sabellids, serpullids, barnacles, colonial ascidian, solitary ascidian, oysters, encrusting bryozoans, silt	Barnacles, oysters, hydroids, colonial ascidians, serpulids, sabellids, encrusting bryozoans, solitary ascidian
	Rope mops	-	Silt, colonial ascidian, solitary ascidian, sabellids, branching bryozoan, hydroids, serpullids	Sabellids, serpullids, solitary ascidians, colonial ascidians, hydroids, scallops, mussels, branching bryozoans	Sponge, silt, oysters, mussels, barnacles, colonial ascidians, solitary ascidians, hydroids, *Didemnum*, serpulids, sabellids, branching bryozoans

An ASU detached from the anchor at LPG jetty on 19 June 2020 and was unable to be located. An investigation determined that a faulty, un-moused shackle parted resulting in loss of the ASU. A spare trap was deployed to the same monitoring location and an additional securing loop was installed to ensure the incident could not be repeated.

5.2.3 Program rationalisation

No change proposed to the marine pest monitoring. Monitoring on each of jetties will be completed for the first three years of operations. Following this, the program will be reviewed to assess adequacy and determine whether or not future monitoring is warranted.

5.3 Introduced terrestrial fauna

Introduced terrestrial fauna may be monitored to determine the presence, location and methods used to control nuisance species.

5.3.1 Method overview

In the event introduced terrestrial fauna are deemed to be a nuisance at Ichthys LNG, INPEX will undertake an annual survey using a third-party licenced pest management contractor.

5.3.2 Results and discussion

During the reporting period there were no reports of introduced terrestrial fauna being deemed a nuisance, as such, no annual survey was undertaken. The routine and ad-hoc pest management programs including baiting and trapping adequately managed introduced terrestrial fauna at Ichthys LNG.

5.3.3 Program rationalisation

No change to the current program is proposed

5.4 Weed mapping

The key objectives of the weed mapping program are to:

- identify the abundance and spatial distribution of known and new emergent weed populations; and
- inform weed management and control activities.

Weed surveys were undertaken biannually (twice yearly) during distinct 'wet' and 'dry' seasons. Table 5-9 provide a summary of surveys completed during the reporting period.

Table 5-9 Weed survey details

Survey	Date	Report	INPEX Doc #
Survey 3	October 2019	Weed Management Report No. 3	F280-AH-REP-60102
Survey 4	April 2020	Weed Management Report No. 4	F280-AH-REP-60103

5.4.1 Method overview

Weed surveys were performed in accordance with the INPEX approved Weed Mapping Plan (F280-AH-PLN-60010). Site access restrictions related to the COVID-19 pandemic (refer Section 1.4) prevented mapping occurring within the production and operations area of site (i.e. within the Ichthys LNG security fence); however, weed management records from activities detailed in Section 5.5 were used to verify no reportable weeds present. The area surveyed is shown in Figure 5-7.

Note: COVID-19 site access restrictions prevented weed mapping within the Operations and Production Area
Source: F280-AH-REP-60103

Figure 5-7 Weed survey area

Parameters monitored during the weed surveys are listed in Table 5-10. Where identification of a species was not possible in the field, a voucher sample, together with photographs were taken to facilitate post survey identification.

Table 5-10 Weed survey parameters

Key Parameter	Descriptor
Weed names	Scientific and common names
Physical locations	Coordinates of localised outbreaks, polygons for larger occurrences
Abundance	Individual numbers and/or percentage cover, enabling comparison with previous and historic monitoring events
Date	Date of data collection for future and historic comparison

5.4.2 Results and discussion

2020 reporting period results

No new declared or non-declared weed species were recorded at Ichthys LNG during the reporting period, with all species previously recorded during the construction and operations phase. Weed maps covering surveyed areas can be found in Weed Survey reports (Table 5-9). Declared weed species previously identified were:

- perennial mission grass
- neem tree
- flannel weed
- annual mission grass
- gamba grass
- horehound

Annual mission grass infestations and single plants were the most widespread and abundant with the species recorded across the site. Larger infestations were recorded in the GEP corridor and adjacent to Bladin Point Road while single plants and thin strips were observed in the production and operations areas.

These findings are generally consistent with operations phase weed monitoring surveys in 2018/19, which recorded gamba grass, annual mission grass, perennial mission grass and horehound as the weeds with the highest abundance. These weeds were also recorded in the highest abundance during the construction phase weeds monitoring, indicating no significant change in weeds species present on the site.

Weeds identified during the weed mapping surveys were communicated to the Weed Contractor and managed accordingly (see Section 5.5).

Declared weed infestation trend analysis

End of wet season (Weed Surveys 2 and 4) and end of dry season (Weed Surveys 2 and 4) infestation results for declared weeds have been compared to provide an indication of broad trends across Ichthys LNG for post dry and season weed distribution.

Comparison of annual mission grass results between surveys indicates that the distribution between dry season surveys is consistent, with the only increase in category 2 infestations (Table 5-11). Single plan infestations reduced between surveys, indicating a potential moved from single plant to multi plant (category 2) infestations. Similar decreases were also seen in single plant infestations between wet season surveys, with a marked increase in category 3, 4 and 5 infestations between surveys (Table 5-11).

Gamba grass experienced no change in infestations between end of dry surveys (Survey 1 and 3), but a marked increase between end of wet (Surveys 2 and 4), primarily at Section 1888 (Table 5-11). This is reflective of the infestation rate of gamba grass. Gamba grass infestations have subsequently been managed accordingly (see Section 5.5).

Horehound infestations were similar across both end of dry and end of wet surveys (Table 5-11).

Table 5-11 Comparison of declared weed infestations between AEMR reporting periods

Timing	Survey	Single plant infestations (number plants)	Multi-plant infestation (ha) category#			
			2	3	4	5
Annual Mission Grass						
End of dry	1	100	0.21	2.83	3.55	0
	3^	57	2.26	1.8	0.76	0
	Difference	**-43**	**+2.05**	**-1.03**	**-2.79**	**0**
End of wet	2	51	3.04	2.42	0	0
	4	3	3.76	6.21	5.15	1.0
	Difference	**-48**	**+0.72**	**+3.79**	**+5.15**	**+1.0**
Gamba Grass						
End of dry	1	23	0	0	0	0
	3^	57	0	0	0	0
	Difference	**+34**	**0**	**0**	**0**	**0**
End of wet	2	24	0	0	0	0
	4	22	1.91	1.89	1.62	0.09
	Difference	**-2**	**+1.91**	**+1.89**	**+1.62**	**+0.09**
Horehound						
End of dry	1	14	0	0	0	0
	3^	6	0	0	0.0060	0
	Difference	**-8**	**0**	**0**	**+0.0060**	**0**
End of wet	2	1	0.0006	0	0	0
	4	4	0.0012	0.0060	0.0115	0
	Difference	**+3**	**+0.0012**	**+0.0060**	**+0.0115**	**0**

refer report F280-AH-REP-60103 for category definition

^ results exclude Section 1888 to allow for a direct comparison

Source: F280-AH-REP-60103

5.4.3 Program rationalisation

Results of weed mapping have been generally consistent between construction and operations surveys. Survey effort was reduced from construction (quarterly) to operations (bi-annual) with no adverse impact to the effectiveness of weed control, and no significant increase in weed distribution throughout the survey area.

Therefore, the frequency of weed mapping surveys will change to annual, in April at the end of the wet season, following the majority of primary control months for the weeds present at Bladin Point (NTG 2015). This will still allow for a weed mapping survey to occur when weeds are theoretically at their most abundant. The survey timing also allows for weed mapping to inform following years' weed management activities, typically completed throughout the wet season (prior to weeds going to seed) and on and ad-hoc basis over the rest of the year.

Annual weed surveys still allow INPEX to fulfil its commitments under the OEMP and *Weeds Management Act* (NT).

5.5 Weed management

5.5.1 Method overview

Vegetation control at the site was undertaken and managed by Territory Weed Management Pty Ltd during the reporting period. Vegetation control at the site occurred along the fence lines, drains, inside the facility and along the GEP corridor, including the Section 1888 laydown yard. Weed control was conducted predominately in the wet season through spray application of herbicides, boom spray, quikspray handguns and backpacks.

Total vegetation control was undertaken by the application of Sulfomac™ (750g/kg sulfometuron methyl) as residual herbicide. Woody weeds were controlled through the use of Grazon Extra (300 g/L triclopyr, 100 g/L picloram, 8 g/L aminopyralid).

5.5.2 Results and discussion

Territory Weed Management Pty Ltd undertook vegetation control at the site during the period 6 December 2019 to 26 February 2020, with 18 days of field work during this time.

5.5.3 Program rationalisation

No changes are proposed to weed management at Ichthys LNG.

5.6 Vegetation rehabilitation monitoring

The key objectives of the vegetation rehabilitation monitoring were to:

- map the distribution of vegetation communities immediately adjacent to the GEP corridor
- map the pre-clearing vegetation community within the GEP corridor
- classify areas within the GEP corridor according to their rehabilitation progress.

A summary of the vegetation rehabilitation monitoring (also known as vegetation surveillance) for the reporting period is detailed in Table 5-12.

Table 5-12 Vegetation surveillance survey completed

Survey	Date	Report	INPEX Doc #
Survey 2	April 2020	Vegetation Surveillance Report No. 2	F280-AH-REP-60113

5.6.1 Method overview

An annual vegetation surveillance survey was performed in accordance with the INPEX approved Vegetation Surveillance Plan (F280-AH-PLN-60011). The areas surveyed are shown in Figure 5-8. Key parameters assessed the surveillance survey are shown in Table 5-13.

Table 5-13 Vegetation surveillance parameters

Key Parameter	Descriptor
Flora species identifier	Scientific and common names
Vegetation community description	Description of vegetative communities' composition, including species present and life-stages
Vegetation community condition	Description of condition of vegetation communities present, including percentages of vegetative cover, evidence of erosion, bare earth or scalds, weed presence, litter cover, evidence of recruitment, organic crust
Physical locations	GPS coordinates and polygons of communities
Reference photographs	Photograph point locations were established within the first survey for future reference. Point photographs were taken within each key vegetation community identified for future comparison
Date	Date of data collection for future and historic comparison

Figure 5-8 Vegetation surveillance survey area

5.6.2 Results and discussion

The results of the survey indicate that the rate and nature of natural regeneration of vegetation within the GEP corridor differs for each of the vegetation communities:

- *Mixed eucalypt woodland* – as with Survey 1, recruitment of primarily pioneering Acacia species was evident throughout most areas of this community. However only a small number of Eucalypt seedlings were recorded. It is anticipated that with suitable seasonal conditions recruitment events of these and other overstorey species will occur given the prevailing stable soil surfaces and seed source provided by adjacent remnant vegetation. Soil surfaces were observed to be stable in most eucalypt woodland areas however isolated patches of low to moderate gully erosion were recorded at two locations associated with slightly sloping ground where elevated woodland areas transition into tidal communities.
- *Mangrove low closed forest* - Natural regeneration of mangroves was evident in all areas of this community surveyed with scattered seedlings and juveniles of both dominant mangrove species recorded. However large bare areas were evident through the western portion of the survey area. Throughout the eastern area natural mangrove regeneration has occurred, with evidence of several recruitment events and mixed age-class mangroves noted. Surface soils were observed to be stable through the community. These observations indicate that the rehabilitating mangrove communities are trending towards a self-sustaining state.
- *Melaleuca open woodland/sedge land* - Natural regeneration was recorded throughout all areas of this community within the GEP corridor with extensive recruitment of a range of sedge species forming moderately dense stands. Scattered melaleuca juveniles and seedlings were also recorded on elevated areas. Surface soils were observed to be stable through the community. These observations indicate that this community is trending towards a self-sustaining state.
- *Monsoon vine forest* **–** Natural regeneration was recorded throughout the survey area. Eastern communities exhibited low levels of perennial regeneration, large un-vegetated areas and low litter levels. The western communities exhibited higher levels of regeneration, with substantial recruitment of perennial species, including *Acacia auriculiformis* and *Dodonaea platyptera*.

The results of the survey indicate that the current minimal intervention approach is achieving good progress in the rehabilitation of vegetation within the GEP corridor. Natural regeneration has taken place in approximately two thirds of the rehabilitation area, indicating significant progress towards achieving a self-sustaining state whereby perennial vegetation dominates and soil surfaces are stable. Over time it is anticipated that the rehabilitating vegetation communities will approach the structure and species richness of the adjacent remnant vegetation and transition towards the ultimate rehabilitation outcome of self-sustaining vegetation communities resembling the species composition and structure of surrounding remnant vegetation.

Earthen embankments have been constructed primarily along the access track (particularly in areas of sloping ground) and these appear to have largely been successful in arresting surface water flows and preventing accelerated erosion and promoting vegetation regrowth. In addition, branches have also been placed on the rehabilitation strips either side of the access track on some sections and these have also contributed to stabilising soil surfaces and capturing plant litter and seed, thereby enhancing regeneration of native vegetation.

5.6.3 Program rationalisation

No changes are proposed to the vegetation surveillance monitoring surveys. Given good progress in rehabilitation is being reported, vegetation surveillance survey frequency will be reviewed and revised following the 2021 survey to a more appropriate frequency (biennial or quinquennial etc.).

5.7 Cultural heritage

The objective of cultural heritage surveys is to determine if there has been any interference to cultural heritage sites as a result of Ichthys LNG operations.

5.7.1 Method overview

Visually inspections of cultural heritage sites will be undertaken when required at a frequency determined by the Larrakia Advisory Committee.

5.7.2 Results and discussion

No inspections of heritage site occurred during the reporting period. No heritage breaches occurred within the reporting period.

INPEX has engaged the Larrakia Development Corporation to undertake weed management within the heritage site and to install a new protection fence around the Heritage Hill site.

6 WASTE REDUCTION MEASURES

Following the activation of EPL228 in September 2018, the OEMP and supporting waste management documentation were implemented. This involved management of waste in accordance with the INPEX waste management processes and the waste control hierarchy (Figure 6-1).

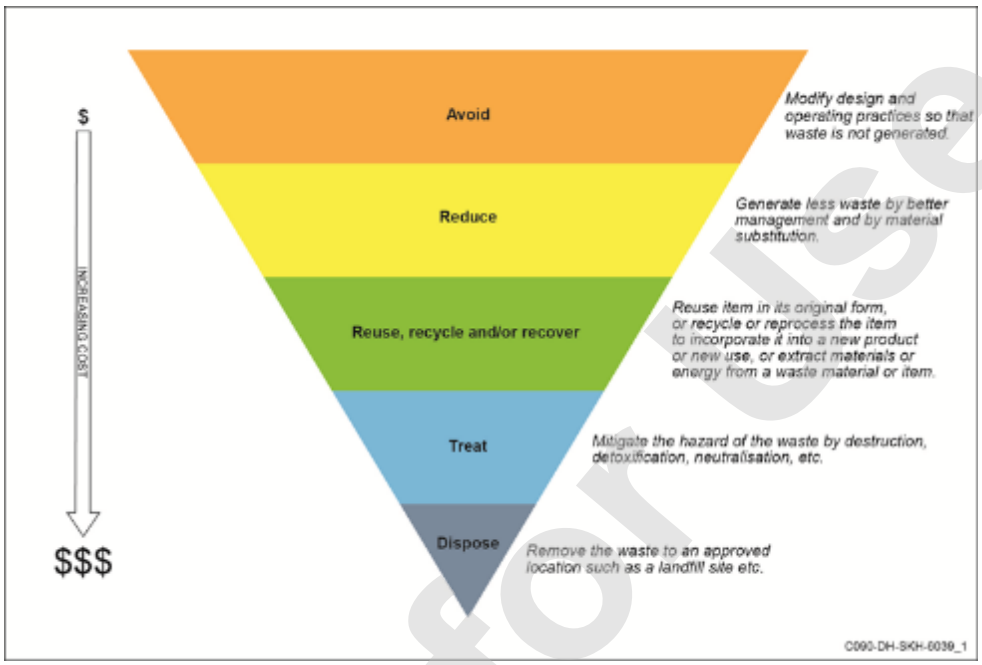


Figure 6-1 INPEX waste control hierarchy

Waste streams at the site are categorised into four broad classes:

- Recyclable (non-hazardous) waste
- Non-recyclable (non-hazardous) waste
- Recyclable (hazardous) waste
- Non-recyclable (hazardous) waste.

Waste segregation measures involved the placement of various recyclable and non-recyclable waste receptacles around Ichthys LNG, while liquid wastes were segregated into recyclable and non-recyclable streams and then disposed of offsite to suitable treatment and disposal facilities.

The main waste reduction measure implemented during the reporting period (i.e. reduce waste being disposed offsite) was through the use of the onsite evaporation basin. The evaporation basin is designed to handle low level chemical and hydrocarbon contaminated water generated at Ichthys LNG, and inter-site transfers to the wastewater treatment plants. Approximately 4,415 tonnes of liquid waste was transferred to the evaporation basin and wastewater treatment plants during the reporting period, which resulted in this liquid waste not being taken offsite for treatment and disposal.

In addition, measures were put in place to minimise the amount of liquid waste being generated at Ichthys LNG. This included the capture and storage of chemical waste streams to avoid the mixture of waste streams and rainwater runoff from Ichthys LNG. This prevents the generation of large volumes of waste water predominately in the AGRU of each LNG train, where amine is used as a solvent to extract acid gases (including carbon dioxide).

A program was also put in place to replace the bandlock seals with oversize seals at various locations within the AGRUs. This was completed to reduce the number of leaks and spills, which then flow into the chemical sewer system. These measures have resulted in an overall reduction of liquid waste generated at Ichthys LNG.

There has been an overall reduction of approximately 1,000 tonnes of liquid waste transferred to the evaporation basin and wastewater treatment plant from this reporting period to the last reporting period.

In addition, a further 143 tonnes of material from Ichthys LNG was recycled. The majority of waste recycled was scrap metal, with other waste streams including paper and cardboard, oil, mixed plastics, aluminium cans and various types of filters.

INPEX will continue to work with its main waste contractor to identify waste reduction measures for Ichthys LNG.

Due to the licence activation being in September 2018, annual waste volumes are estimated annually from September. In Subsequent AEMRs, yearly comparisons of waste stream will be able to be undertaken.

7 PROGRAM RATIONALISATION SUMMARY

Based on the results presented in Sections 2 to 6 a number of recommendations to rationalise monitoring programs have been presented. These changes will only be implemented once the relevant approvals or management plans have been amended and endorsed. A summary of the proposed rationalisation to the monitoring programs is provided in Table 7-1.

Table 7-1 Summary of monitoring program rationalisation

Program	Changes Proposed to Monitoring Program	Section
Commingled treated effluent (750-SC-003)	No changes are proposed.	N/A
Jetty outfall	No changes are proposed.	N/A
Harbour sediment	Cease PSD analysis.	2.3.4
Ambient air quality	No changes are proposed.	3.2
Point source emissions to air	No changes are proposed.	N/A
Dark-smoke events	No changes are proposed.	N/A
Airborne noise	No changes are proposed.	3.6
Groundwater quality	• Cease monitoring at wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25. • Analysis of dissolved metals only at all wells. • Cease analysis of phenols at all wells.	4.1.4
Mangrove health, intertidal sediment and bio-indicator	• Trial digitised canopy cover methodology. • Cease monitoring at mangrove site BPMC24 & CSMC04. • Collection of single sediment samples adjacent to each mangrove quadrat. • Cease the collection of mud whelks for analysis. • Cease PSD analysis of mangrove sediments.	5.1.4
Nearshore marine pests	No changes are proposed.	N/A
Introduced terrestrial fauna	No changes are proposed.	N/A
Weed survey	Proposed to reduce the frequency of weed surveys to annual, at the end of the wet season (April).	5.4.3
Weed management	No changes are proposed.	N/A
Vegetation rehabilitation monitoring	No changes are proposed.	N/A
Cultural heritage	No changes are proposed.	N/A

7.1 Discharges to water

Given analysis of PSD for harbour sediments is informative, and not required for normalisation and to reduce exposure risks on field personnel, PSD analysis will cease following the reporting period of this AEMR.

There are no changes proposed to the jetty outfall or commingled treated effluent monitoring programs. Section 2.2.4 details a number of operational limitations that may impact the ability to execute the jetty outfall monitoring program as described in EPL228.

7.2 Emissions to air

No program rationalisation is proposed, and monitoring will continue in line with EPL228 conditions and OEMP commitments.

7.3 Unplanned discharges to land

No changes in groundwater quality attributable to Ichthys LNG activities have been detected to date (see Section 4.1). Based on data collected to date and rational presented in Section 4.1.4, the following changes to the groundwater quality monitoring program are proposed:

- cessation of monitoring at wells BPGW13A, BPGW14a, BPGW23, BPGW24 and BPGW25 as there is no credible impact pathway for contamination of groundwater upstream of wells during operations
- total metals will no longer be analysed, only dissolved metals as the dissolved fraction is the bioavailable fraction and thus the toxic component and what is used for comparison to trigger levels
- analysis of phenols in groundwater samples will cease as there is no credible impact pathway for contamination of groundwater upstream of wells during operations

7.4 Flora, fauna and heritage

To date, mangrove health, intertidal sediment and bio-indicator monitoring during the operations phase of Ichthys LNG has shown there has been no change or impacts as a result of Ichthys LNG operations (see Section 5.1). Based on data collected to date and rational presented in Section 5.1.4, the following changes to the mangrove health, intertidal sediment and bio-indicator monitoring program are proposed:

- trial of an addition digitised canopy cover methodology to remove potential observer bias while also providing a digital archive of canopy cover
- cessation of monitoring at mangrove site BPMC24 as there is no credible impact pathway for mangroves during operations at this site
- cessation of monitoring at mangrove site CSMC04 to reduce health and safety exposure risks
- collection of single sediment samples adjacent to each mangrove quadrat as QA/QC samples in accordance with industry best practice and Australian Standards are also collected so secondary/replicate sediment samples at each quadrat are not required
- ceasing the collection of mud whelks for analysis to reduce population stress unless there is an incident that could lead to a potential contamination risk as a result of Ichthys LNG activities

- cessation of PSD analysis of mangrove sediments as it is an informative indicator that provides little to no environmental benefit for the mangrove health, intertidal sediment and bio-indicator monitoring program

Results of weed mapping have been generally consistent between construction and operations surveys. Survey effort was reduced from construction (quarterly) to operations (bi-annual) with no adverse impact to the effectiveness of weed control, and no increase in weed distribution throughout the survey area. Therefore, it is proposed to reduce the frequency of weed surveys to annual, at the end of the wet season (April).

There are no changes proposed to any of the other flora, fauna and heritage programs.

8 REFERENCES

ANZECC/ARMCANZ—see Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

ANZG—*see* Australian and New Zealand Governments and Australian State and Territory Governments

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APPENDIX A: NT GUIDELINE FOR ENVIRONMENTAL REPORTING

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
Title page	The title page should include: • report name • reporting period (e.g. October 2014–October 2015) • date of submission • version number • where relevant, licence/approval number, or reference to other document the report is being submitted in relation to (e.g. environmental impact statement, pollution abatement notice) • details of report author, including company details.	Title page and Section 1
Executive summary	The executive summary should succinctly summarise each section of the report, and in particular, the findings of the report.	Executive summary
Monitoring objective	The monitoring objective(s) should be clearly stated in order to enable the results of monitoring to be assessed in the context of the objectives. Note, where monitoring is linked to a licence or approval, the objectives of monitoring: • may already be specified in an approved monitoring plan, or • may simply be the specific conditions on monitoring included in the • licence/approval that state monitoring point locations, analytes, analysis type, frequency and limits/trigger values.	Each section includes a subsection with monitoring objectives for each monitoring program
Monitoring method	*Where there is an approved monitoring plan* Provide details of the approved plan (title, version number, date of submission). *Where there is not an approved monitoring plan* Provide details including: • current map showing sampling locations (including control/reference sites), discharge/emission points, major infrastructure, sensitive environmental receptors, key, scale bar and north arrow • a description of the receiving environment, including environmentally sensitive receptors and significant features	Each section includes a subsection with monitoring methods for each monitoring program

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	• a description of sampling and analysis methods, including detail on reasons for selection of sampling locations (e.g. random stratified), assumptions and deviations from standard sampling/analysis methods1 • factors that may affect variability in monitoring results (e.g. tidal movement, climate, fauna migration, peak production months).	
Monitoring results–presentation	The clear and concise presentation of monitoring results is a critical component of a monitoring report. When presenting results it is important to ensure that: • current results are presented in a table and graph • results are presented along with: o units o assessment criteria (e.g. limits/trigger values specified in o licences/approvals, or in relevant standards or guidelines2) o analysis type (e.g. for filtered/unfiltered with filter pore size, five-day or o three-day biological oxygen demand, wet or dry weights) o analytical methods o limit of reporting (LOR), or level of precision for results obtained from o field instruments o measures of uncertainty • necessary calculations have been made, to compare data with assessment • criteria (e.g. calculation of medians, means, running averages and loads) • modification calculations (such as for hardness) have been made using the modifying parameter recorded at the time of sampling • all results that exceed the assessment criteria are clearly highlighted • summary of previous results (sufficient to highlight trends – usually a minimum of 2–5 years data) is included.	Each section includes a subsection with monitoring results and discussion for each monitoring program
Monitoring results–quality assurance/ quality control (QA/QC) evaluation	Results presented in the monitoring report should be reviewed for data completeness, accuracy and precision. Some typical QA/QC questions include: • for completeness – were all samples taken at the correct location and frequency? • for quality control – _ were all samples collected, preserved in accordance with the specified sampling method or standard sampling methods?	Monitoring plans (referenced in the method overview section) include QA/QC processes.

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	• were calibration checks made and were results within an acceptable range? • was analysis undertaken in accordance with relevant national standards (such as accredited under the National Association of Testing Authorities)?	
Discussion and interpretation of results	This section should include: • discussion of results in context with the monitoring objective(s) • discussion of results where assessment criteria were exceeded, including likely cause of exceedances and likelihood of further exceedances • discussion of trends (consideration of spatial and temporal trends in comparison to previous monitoring data) • discussion of anomalous results, including likely cause • statistical analysis where appropriate • a table of non-conformances with monitoring method.	Each section includes a subsection with monitoring results and discussion for each monitoring program
Conclusion and proposed actions	This section should include conclusions on: • whether the monitoring objective(s) was achieved • compliance with assessment criteria • if, and to what extent, environmental harm may have been caused (such as by emissions/discharges and/or exceedances of assessment criteria –when considering both acute and chronic affects) • major assumptions or uncertainties • conclusions about effectiveness of the monitoring method/plan and overview of any proposed changes (if any) • proposed actions to address exceedances or non-conformances.	Each section includes a subsection for program rationalisation
Certification	In this section the submitter of an environmental monitoring report must confirm that the report is true and accurate. Where the report relates to a licence/approval, confirmation must be provided by a person(s) authorised to legally represent the holder of the licence/approval. The wording for this section should be: *I [NAME AND POSITION], have reviewed this report and I confirm that to the best of my knowledge and ability all the information provided in the report is true and accurate.*	APPENDIX B:

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	Note: significant penalties may apply where it is demonstrated that false or misleading information has been supplied to the NT EPA.	
Abbreviations	Use of abbreviation should be minimised. However, if they are used to improve readability, this section should specify all abbreviations used in the report.	Throughout AEMR
References	If information (facts, findings etc.) from external documents is to be included in the report, the information must be referenced. If references are from documents that are not freely available (e.g. internal reports, mine management plans) then such documents will need to be provided to the NT EPA on request.	Throughout AEMR
Appendices	Appendices should be used for information that is too detailed or distracting to be included in the main body of the report (such as raw data tables, laboratory reports, QA/QC data). Note: raw data should be submitted electronically in a spreadsheet format (such as Microsoft Excel).	Appendices included

APPENDIX B: EPL228 AEMR 2019-2020 CERTIFICATION

B.1 INPEX

INPEX	I **Hitoshi Okawa** confirm that to the best of my knowledge and ability all the information provided in the *EPL228 Annual Environmental Monitoring Report 2019-2020* [L060-AH-REP-70011] is true and accurate.
Name	**Hitoshi Okawa**
Position	**Statutory Director** | INPEX
Signature	
Date	24/09/2020

B.2 Qualified Professional

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INPEX Corporation
Jamie Carle
Team Lead – Environmental Services
Level 22, 100 St Georges Terrace
Perth, WA, 6000

21 September 2020

Reference: ERM 0565508

Dear Jamie

Subject: AEMR Review and certification report

Environmental Resources Management Australia Pty. Ltd (ERM) was engaged by INPEX Corporation (INPEX) to undertake an independent review of the Ichthys LNG Plant's Annual Environmental Monitoring Report (AEMR) by Qualified Professionals[1]. This report documents the review process, identifies the issues raised and their resolution, resulting in a statement of verification and Statutory Declaration as required by the Northern Territory EPA (NT EPA).

The scope of the review is pursuant to Condition 87 of the Environmental Protection Licence (EPL) 228-04, stated as follows:

87 The Annual Environmental Monitoring Report must:

87.1 report on monitoring required under this licence;

87.2 summarise performance of the authorised discharge to water, compared to the discharge limits and trigger values specified in Table 3 in Appendix 2;

87.3 summarise performance of the authorised emissions to air, compared to the emission limits and targets specified in Table 5 in Appendix 3, when the fuel burning or combustion facilities for the Scheduled Activity have operated under normal and maximum operating conditions for the annual period;

87.4 summarise operating conditions of each emission source and the resulting air emission quality;

87.5 provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 3;

87.6 assess the contribution of the authorised emissions on the Darwin region ambient air quality during periods not affected by bushfire smoke for Wet and Dry seasons;

87.7 report on outcomes of the REMP monitoring and assessment;

87.8 summarise measures taken to reduce waste;

87.9 consider the NT EPA Guideline for Reporting on Environmental Monitoring

87.10 be reviewed by Qualified Professional(s); and

87.11 be provided to the NT EPA with the Qualified Professional(s) written, certified review(s) of the Annual Environmental Monitoring Report.

The purpose of the qualified professional review of the AEMR is to provide an independent assessment verifying that the AEMR is compliant with the conditions of EPL228-04. The

[1] A *'qualified professional'* as described by the EPL228-01 is a person who has professional qualifications, training or skills or experience relevant to the nominated subject matters and can give authoritative assessment, advice and analysis about performance relevant to the subject matters using relevant protocols, standards, methods or literature.

Page 1 of 2

review was undertaken by three qualified professionals as deemed appropriate for the content of the AEMR. The qualified professionals are listed in Table 1.

Table 1. Qualified professionals

Area of expertise	Qualified professional
Discharges to Water	Ken Kiefer
Waste	Nicole Bradley
Air Quality	Christopher Thomson

Each of the qualified professionals individually reviewed the AEMR with respect to the EPL228-04 condition 87 and the relevant corresponding area of expertise. The comments raised were recorded in a comments register which is appended to this report in **Annex** A. The register was provided to INPEX seeking comment on how the identified issues will be closed out. INPEX resubmitted the revised AEMR to ERM for review, which incorporated the agreed changes and the comments register cross-referenced with the revised sections of the AEMR.

ERM is satisfied that each of these have been appropriately closed out, enabling the following statement of verification to be made and signed by each of the qualified professionals who undertook the review.

Statement of verification: Based on the review as outlined in this report, ERM confirms that INPEX responded to all comments raised. ERM has reviewed INPEX responses to the comments provided and is satisfied that the content of the AEMR comply with Condition 87 of the EPL228-04 for the 2019-2020 period.		
Area of expertise	**Qualified professional**	**Qualified profession Signatures**
Discharges to Water	Ken Kiefer	
Waste	Nicole Bradley	
Air Quality	Christopher Thomson	

Yours sincerely,

For Environmental Resources Management Australia Pty. Ltd.

Christopher Thomson
Principal Environmental Scientist

Paul Fridell
Partner

Annex A: Comments Register
Annex B: Statutory Declarations
Annex C: Qualified Professionals – profile and CVs

ERM	21 September 2020 Reference: ERM 0565508

ANNEX A: - COMMENTS REGISTER

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

Contract Number	INPEX PO 4500072962 (ERM proposal 0550625)
Reviewer	ERM
Document Name	EPL228 Annual Environmental Monitoring Report 2019-2020
Company Document No#	L060-AH-REP-70011_A_EPL228_AEMR_2019-2020_rev_c
Document Revision No# / Date	Revision A / 9 September 2020

The Comment Ranking reflects relative comment significance: 1 = Critical element related to compliance; 2 =Clarity required; 3= typo/grammar or minor comment.

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
Air Quality (Qualified Professional - Chris Thomson)					
1	Second paragraph page 51	2	Reword for clarity "*In accordance with EPL228 condition 55, ambient air quality and air toxics monitoring commenced in August 2019. This was prior to the LNG trains and CCPP (in combined cycle) reading steady-state operations, which occurred on 21 October 2019*"	Text to be revised to 'In accordance with EPL228 Condition 55, Ambient air quality and air toxics monitoring was implemented when LNG trains and the CCPP (in combined cycle) reached steady-state, which occurred 21 October 2019..' Note due to the program commencing two months prior to the EPL requirement, the first two surveys will be removed to avoid confusion.	Closed
2	third paragraph page 51	2	Elaborate on 3rd paragraph for clarity. Second sentence simply requires *"Only 11 monthly surveys have occurred during the reporting period. The annual report will be prepared on the anniversary of steady state operations for the LNG trains and CCPP; October 2020.*	Text to be revised to 'Due to the program commencing in October, only nine months of data are available for this report. Subsequent AEMRs will contain annual averages of monitoring data.'	Closed
3	First paragraph page 60	2	Reword for clarity the relevant text from the OEMP/AQMP why there will be a reduction in frequency of this component.	Amend text to 'No changes are proposed to parameters that will be monitored. In accordance with the OEMP, the frequency of monitoring will revert to quarterly in October 2020, following completion of the first 12 months monitoring, if there are no exceedance of the criteria attributed to Ichthys LNG. To date there have been no exceedances attributed to Ichthys LNG operations'	Closed
4	Second paragraph, second sentence page 72	2	Sentence seems incomplete, should be clarified - "the mobile turbines were not wet low NOx mapped/tuned prior to being placed into service"	This statement is correct the turbines were not mapped prior to being placed into service. Mapping ensure sthe turbine combustion is producing emission as per the turbines data specifications. If not mapped or incorrectly mapped this generally leads to higher fuel consumption and increased emission (NOx, CO and CO2) . Amended text to include: 'Emission mapping ensures turbine combustion is	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
				producing emission as per the data specification of the turbine.'	
5	last paragraph, page 72	2	120 ppb? - need to match units used in table 3-5	Noted, will amend to '0.12 ppm'	Closed
6	Appendix E	1	PM_{10} and $PM_{2.5}$ are not presented for the stack testing results	This was an oversite from the transfer into the word document from the excel database, will amend and include in the revised report all recorded values are generally below the limit of reporting.	Closed
7	General	3	AQ text requires some proof reading prior to release to EPA. Where considered appropriate for clarity, suggestions are provided.	Noted.	Closed
8	page xi	3	Definition of PM10 and PM2.5 should be changed to "Particulate matter with aerodynamic diameter less than 10µm and Particulate matter with aerodynamic diameter less than 2.5µm"	Noted will amend the section and later in the report.	Closed
9	Second paragraph page 50	3	Correct to "*This section also summarises the operating conditions of each emission source…*"	Noted will amend	Closed
10	Second paragraph page 50	3	correct second part of sentence to "*provides a summary of total emissions to air*"	Noted will amend	Closed
11	Section 3.2 first sentence	3	refer to "air toxics" not "air toxic"	Noted will amend throughout the report	Closed
12	Section 3.2.1 page 52	3	Check on tense throughout document for consistency? i.e. reviewed the ambient air monitoring data, this was conducted weekly.	Noted will correct tense	Closed
13	paragraph 2 page 52	3	Definition of PM_{10} and $PM_{2.5}$ should be changed to "Particulate matter with aerodynamic diameter less than 10µm and Particulate matter with aerodynamic diameter less than 2.5µm"	Noted will amend the text as per above.	Closed
14	Table 3-3 page 53	3	NEPM should be referred to as NEPM (Ambient air quality standards)	Noted will amend.	Closed
15	4th paragraph page 55	3	Air Toxic NEPM (consider changing this to Air Toxics NEPM in table 1-3 page 17) and then apply globally as necessary	Noted will amend	Closed
16	Title for Figure 3-2 page 56	3	Should be short-term not short-time	Noted will amend.	Closed
17	Table 3-5 page 58	3	Suggest inclusion of average period, unit and criteria in recurring header across pages for ease of comprehending the data.	Noted will amend	Closed
18	First paragraph page 60	3	first sentence seems incomplete, elaborate for clarity.	Noted will amend	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
19	First to third paragraphs page 60	3	Clarify text. Some long and wordy sentences/paragraphs can be simplified.	For this section, much of the wording matches the text from the EPL228. Noted and will amend.	Closed
20	fourth paragraph section 3.3	3	second line commences with a '0'	?	Closed
21	fourth paragraph under section 3.3.1 page 61	3	break this paragraph up for clarity.	Noted will amend.	Closed
22	fifth paragraph under section 3.3.1 page 61	3	"~~and~~ or by external laboratories"	Noted will amend	Closed
23	fifth paragraph page 69	3	Isolated sentence paragraph, this can reference figure 3-4 and figure 3-5 after the sentence about monitoring while acid gas incinerators were offline and venting. Or move this sentence to below the table 3-9. Not convinced Figure 3-6 and Figure 3-7 are required as this is during normal operation.	Text will be moved as suggested. The EPL requires the flow of acid gas be reported at locations A13-2 & A14-2. Downstream of the gas sampling locations there are two flow meters, one operates during bypass and the other when the incinerator is online, due to the pipe configuration.	Closed
24	First paragraph page 70.	3	swap sentences around for ease of reading	Noted will amend	Closed
25	Second paragraph page 70.	3	delete 'provided' replace with present, or show.	Noted will amend	Closed
26	Method overview page 74	3	Should explain that the AMSC uses Reference Ringelmann shades in this paragraph, to provide context to target in table 3-11.	Noted will amend	Closed
27	Appendix E	3	The headers in table E.1 are cut off.	Noted will amend	Closed
28	Appendix E	3	The bolding is difficult to see, perhaps provide exceedances in red bold text as an alternative	Noted will amend	Closed
29	Appendix E	3	It is suggested the criteria and name as a greyed out row as it will break up the table to see things easier	Noted will amend	Closed
30	Results and discussion page 69	3	An overview summary of the compliance against the limit in a table format could help with the clarify any exceedances rather than writing this in the text	Due to only the two exceedances INPEX considers the text to be adequate.	Closed
Discharges to Water (Qualified Professional – Ken Kiefer)					
1	Table 2-2 (Section 2.1.2) and Appendix C.1 Table	2	The LORs listed for Total Phosphorous, Filterable reactive Phosphorous, amDEA, and Gycol indicated in Table 2-2 and used in Appendix C.1 do not match (see below). Please ensure the LORs are consistent within these tables.	Noted will amend. The LOR for the external laboratory is 1 µg/L, this will be amended in the text in Appendix C to reflect this, to 0.001 mg/L. Due to the LIMS output a manual revision to this data was required, as the excel table contained both ug/L and mg/L data. Due to the use of	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
			<table><tr><td>Parameter</td><td>LOR stated in Table 2-2</td><td>LOR stated in App C.1</td></tr><tr><td>Total phosphorus (TP)</td><td>0.2 mg P/L</td><td>0.5 mg N/L</td></tr><tr><td>Filterable reactive phosphorus (FRP)</td><td>0.2 mg P/L</td><td>0.2 mg N/L and 0.5 mg/L</td></tr><tr><td>Activated methyl diethanolamine (aMDEA)</td><td>5 mg/L</td><td><0.0001 mg/L and 5 mg/L</td></tr><tr><td>Glycol (as MEG/TEG)</td><td>4 mg/L</td><td>2 mg/L and 5 mg/L</td></tr></table>	external laboratories and the INPEX laboratory the LORs varied.	
2	Section 2.1.3 Results and discussions	1	Please provide copies of the Certificates of Analyses (COA) in an Appendix.	The intent of the AEMR is to not provide the COA in the report. No other COAs are provided for other monitoring scopes. They can be provided separately for ERMs review as required. Note this approach was also adopted for 2018/19 AEMR. Agreed during 18/19 review process with ERM. Consider to rewording to 'Please ensure that all Certificates of Analyses (COA) are available for each sampling event'	Closed
3	Table 2-4 (Section 2.1.4)	1	Results of further sampling conducted following an exceedance in discharge limit/s were not included in this report, specifically the results for the indicated further sampling events dated: - 19 August 2019 (where the total nitrogen concentration of 9.2 mg/L was reported) - 18 September 2019 (where the treated sewage post UV sterilisation reported *E. coli* levels at 23 CFU/100 mL, and AOC system testing reported *E. coli* levels of 6 and <1 CFU/100 mL) Please provide all results as part of the corrective actions, even samples not collected from the discharge point as part of Appendix C consistent with Section 2.1.3 that *states "Any results from the investigation sampling process from an exceedance event are included in APPENDIX C:"*	The text was specific to sample location 750-SC-003 only. Inpex doesn't consider that all internal sampling is provided in the report, with only results from the authorised discharge locations being provided. Text will be amend to reflect this. It is considered that the results of additional sampling from various upstream locations is sufficient in the text of the report. Test revised to 'Any results from the investigation sampling process from an exceedance event at sampling location 750-SC-003 are included'	Closed
4	Appendix C, Appendix D	1	Please ensure that following info are available for each sampling event, other than the info currently reflected in the Appendix C and D: time of samples collection, name of person who collected the samples, chain of custody forms, field measurements, and laboratory QS/QC documentations, as per EPL228-04 condition 62.	Condition 62 of EPL 228-04 requirement is that this information is *'recorded and retained'* (not reported). Information is recorded in Contractor reports (report no's included in AEMR survey timing tables) and retained in INPEX Laboratory Information Management System. Following reports were provided: F280-AB-REP-60034	Closed

INPEX

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
				F280-AB-REP-60024 F280-AB-REP-60033 F280-AB-REP-60023 F280-AB-REP-60032 F280-AB-REP-60022 F280-AB-REP-60031 F280-AB-REP-60021 F280-AH-REP-60053 F280-AH-REP-60056 F280-AH-REP-60069 F280-AH-REP-60077 F280-AH-REP-60070 F280-AH-REP-60078 F280-AH-REP-60088 F280-AH-REP-60092 Note this approach was also adopted for 2018/19 AEMR, and raised during 18/19 review process with ERM (refer comment 2 in document no L060-AH-REP-60029)	
5	Section 2.2.3	2	Please add info regarding the minor exceedance in DO from Survey 6 results.	DO did not represent a trigger exceedance as reference site data was also outside of the allowable range, therefore a trigger assessment was not completed. Footnote added to Table 2-6: Not compliance limits. Exceedance of Trigger Values requires review and assessment of cause at the time results are received as per ANZECC & ARMCANZ recommendations. A trigger for investigation occurs when the median value of the three receiving environment sites from water samples collected in the same day exceeds the trigger value and the exceedance is also not present at the upstream reference site determined form the tidal phase of sampling on the same day.	Closed
6	Section 2.3.4	2	Incomplete sentence noted in the last paragraph. Please consider revising the statement similar to *"Given that the analysis of PSD is informative and is not required for normalisation or to reduce exposure risks on field personnel (i.e. PSD is a standalone sample that needs to be collected), PSD analysis will cease following the reporting period of this AEMR."*	Wording amended	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
7	Appendix D	2	Trigger value for DO as noted in Column 7 of Table 3 of EPL228-04 Licence was "outside the range of 80 to 100". Please correct the DO Trigger value noted as "<80,>100" in Appendix D.	Wording amended	Closed
8	Appendix D	2	Please make the exceedances (>50 MPN/100 mL) in Enterococci in **bold** in Appendix D as stated in Section 2.2.2.	Wording amended	Closed
9	Section 4.1.2	2	Please correct the reference to groundwater data to Appendix F (not Appendix E).	Wording amended	Closed
10	Section 4.1.2 (Nutrients)	2	Based on Appendix F, the number of trigger exceedances for ammonia is 20 in Survey 4 (July 2019) and 14 in Survey 5 (January 2020). Please correct the numbers indicated in the 2nd paragraph of this section which indicated that there were 10 and 5 ammonia trigger exceedances for Surveys 4 and 5, respectively.	As detailed in section 4.1.1 a trigger exceedance only occurs when a measured analyte exceeds benchmark levels which is defined as: • relevant trigger value (stated in Table 4-2) and • the same analyte also exceeding the background level for each groundwater well. Well specific trigger values were calculated using the approach described in ANZG (2018); 80th and/or 20th percentile value for each parameter was determined using the monthly groundwater data collected during the construction phase of Ichthys LNG between 2013 and 2018 (stated in Section 4.1.1). The number of reported exceedances in Table 4-4 are based on the aforementioned trigger assessment process and are correct. Note background levels are not presented for individual wells in the AEMR as there are hundreds and there is no concise way to present. To make this clearer in the AEMR, additional text (in red below) has been added to Section 4.1.3 – "*In accordance with the receiving environment adaptive management process outlined in Section 7.5 of the OEMP, groundwater trigger exceedances were investigated (i.e. results that exceeded benchmark levels, see Section 4.1.1).*"	Closed
11	Section 4.1.2 (Metals and metalloids)	2	Based on Appendix F, the number of trigger exceedances for zinc is 15 in Survey 4 (July 2019) and 7 in Survey 5 (January 2020). Please correct the numbers indicated in the 2nd paragraph of this section which indicated that there were 12 and 4 zinc trigger exceedances for Surveys 4 and 5, respectively	See response to *Discharges to Water (Qualified Professional – Ken Kiefer)* comment 10	Closed
12	Appendix F and Table 4-4 (Section 4.1.3)	2	Please consider highlighting the exceedance values in Appendix E and re-checking the number of Trigger exceedances indicated in Table 4-4. For metals alone, there were around 79 exceedances for Survey 4 and 74	See response to *Discharges to Water (Qualified Professional – Ken Kiefer)* comment 10.	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
			exceedances for Survey 5 (which includes exceedances for Al, Ni, As, Cd, Co, Cu, Pb, Zn, Ni, Mn and Ag).	Further, exceedances have been highlighted in Appendix F for consistency.	
13	Table 2-2 (Section 2.1.2)	3	Please correct the note under Table 2-2 stating "(MDEA with a LOR of 1 µg/L)". The LOR used in Appendix C.1 for MDEA prior to November was <0.0001 mg/L (or 0.1 µg/L).	The LOR for the external laboratory is 1 µg/L (or 0.001 mg/L), the text in Appendix C has been amended to reflect this.	Closed
14	Section 2.1.3 (Routine monitoring results)	3	There was a *typo* in the last sentence of the 2nd paragraph (under *Routine monitoring results* section). Please reword "including" to "*included*"	Noted will amend text to 'Any results from the investigation sampling process from an exceedance event at sampling location 750-SC-003 are included'.	Closed
15	Section 2.1.3 (Jetty outfall commissioning plan results)	3	Based on the results in Appendix C.1 Table, the pH values ranged from 7.7 to 8.9, and temperature reading results ranged from 26.3 and 32.9°C. Please correct the range of values stated in the 2nd and 3rd paragraph of this section, where it was indicated that "the pH value results ranged between 7.10 and 8.40" and "temperature reading results ranged between 24.00 and 34.60°C".	Noted the data range also include the data from the 2018/2019 AEMR. Will amend this in the text.	Closed
16	Table 2-5 (Section 2.2)	3	Date of Survey 5 for the Jetty outfall was dated 8 October 2019 in Table 2-5 but date 7 October 2019 in Appendix D. Please check and amend accordingly.	Amended to 7 October	Closed
17	Table 2-6 (Section 2.2)	3	Revise the Trigger value for Visual Clarity and Odour as "No decrease in visual clarity or increase in colour".	Wording amended	Closed
18	Section 2.2.2	3	Please add a statement to note the minor exceedances in dissolved oxygen for survey 6 which had results >100%. Please also mark the exceedances in DO in Table 2-7 in bold.	See response to comment no 5	Closed
19	Section 2.2.4	*3*	*Typo* noted – Please ament "liquified" to "liquefied"	Wording amended	Closed
20	Annex D	*2*	We note some inconsistency in the AEMR October 2019 Jetty Outfall mercury results reported compared to the REMPs reporting values. The REMPS list Mercury results of 0.05 ug/L for Outfalls 1, 2, 3 and the AEMR lists results of o.1 ug/L. It appears it could be related to changes in the way the data is reported relative to the EPL, which has also changed from 0.05 ug/L to to match the laboratory limit of reporting.(LOR) of <0.1 ug/L.. Results that are <LOR should be reported in a manner so it's clear the results are <LOR (i.e <0.1 ug/l). Please confirm the appropriate results and updated the AEMR as needed.	To address this issue overall the trigger value was increased from 0.05 µg/L to 0.1 µg/L though an amendment of EPL228 (refer to EPL228-04), this has been subsequently updated in the OEMP/REMP. Both are technically correct, the Jacobs report notes that *'The ANZECC/ARMCANZ (2000a) guidelines for water quality monitoring and reporting, suggest that below detection limit data be replaced with half the detection limit'*. In this case the laboratory LOR is <0.1 , µg/L therefore half the detection limit equals the trigger value, this was prior to the amendment to EPL228. Following the amendment to EPL228 the laboratory LOR is being reported.	Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2019/2020

No.	Context	Ranking	Reviewer Comment/Recommendation (09.09.2020)	INPEX Response (11.09.2020)	Reviewer Response (18.09.2020)
				To resolve the issue, INPEX have updated the AEMR Appendix D with a result of 0.05, and the above footnote to match Jacobs report. The footnote to Survey 4 mercury results (which had the same issue) has also been added. This way the information between Jacobs reports and our AEMR is consistent.	
Waste (Nicole Bradley –Qualified Professional)					
1	Section 6, 3rd paragraph pg 125 (EPL Clause 87.8)	2	Please provide detail of any additional measure(s) introduced to increase the recycling rates. Note: As there was no reporting of this last year, unable to verify the reduction in volume.	For this years AEMR the total weight of material recycled was included in the text. This was not previously included in last AEMR. There was no additional measure put in place to increase recycling from those listed in the OEMP and the sites waste management processes. There has been improved waste reporting measures put in place at the site, to now report total recycling weights.	Closed
2	Section 6, last paragraph pg 125	2	It is not clear what this paragraph is saying "annual waste volumes are estimated annually from September." The last AEMR reporting period was detailed from 14 September 2018 (EPL228 activation) to 30 June 2019 while this AEMR reporting period is detailed as July 2019 to 30 June 2020 in Section 1.1. Please clarify the reporting period applicable to waste volumes and if comparable to last years.	Annual waste volumes will be reported from September to September to align with EPL228. This will be second year of waste reporting. For this AEMR waste reduction volumes have been against the AEMR reporting timeframe. For subsequent year of reporting comparison against the last year volumes will be undertaken, due to two years of data soon to be available. The text has been revised to include: 'In Subsequent AEMRs, yearly comparisons of waste stream will be able to be undertaken.'	Closed

ERM

21 September 2020
Reference: ERM 0565508

ANNEX B: - STATUTORY DECLARATIONS

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Christopher James Thomson of Environmental Resources Management Australia Pty Ltd located at Level 18, 140 St Georges Terrace, Perth, Western Australia 6000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Perth on the 18th day of September 2020.

(3) Signature of the person making the declaration

(4) Signature of the person before whom the declaration is made

Witnessed by:

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

Gabriela Thomson

(6) Here insert contact address or telephone number of person before whom the declaration is made

08 9434 3749

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Nicole Jane Bradley of Environmental Resources Management Australia Pty Ltd located at Level 6, 99 King Street, Melbourne, Victoria 3000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Melbourne the 17th day of September 2020

(3) Signature of the person making the declaration

.....

(4) Signature of the person before whom the declaration is made

Witnessed by:

.....

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

Adam Paul Bradley

(6) Here insert contact address or telephone number of person before whom the declaration is made

7 Lorne Street Moonee Ponds Victoria. Phone: 0407 331 063

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

(1) Insert full name and address of person making declaration

I, Kenneth Leo Kiefer of Environmental Resources Management Australia Pty Ltd located at Level 15, 309 Kent Street, Sydney, New South Wales, 2000.

(2) Here insert the matter declared to, either directly following the word "declare" or, if the matter is lengthy, insert the words "as follows" and thereafter set out the matter in numbered paragraphs

solemnly and sincerely declare that the results are accurate to the best of my knowledge or belief and that I have not included in the results information that I know or suspect to be false or misleading or failed to include in the report information that I know to be relevant.

This declaration is true and I know it is an offence to make a statutory declaration knowing it is false in a material particular.

Declared at Abbotsford, NSW 2046 the 18th day of September 2020

(3) Signature of the person making the declaration

(4) Signature of the person before whom the declaration is made

Witnessed by:

Tanya Kiefer

(5) Here insert full name of person before whom the declaration is made, legibly written, typed or stamped

Tanya Noel Kiefer

(6) Here insert contact address or telephone number of person before whom the declaration is made

30/1 Harbourview Cr., Abbotsford, New South Wales, 2046. Phone: 0421 213 439

NOTE: This declaration may be witnessed by any person who is at least 18 (eighteen) years of age.

NOTE: This written statutory declaration must comply with Part 4 of the *Oaths Affidavits and Declarations Act.*

NOTE: Making a declaration knowing it is false in a material particular is an offence for which you may be fined or imprisoned.

ERM

21 September 2020
Reference: ERM 0565508

ANNEX C: - QUALIFIED PROFESSIONAL PROFILE AND CV

Air Quality

Christopher Thomson (Air Quality Qualified Professional)

Chris is a Principal Environmental Scientist and has gained his 19 years' experience in Australia and internationally. His oil and gas experience is highlighted by being seconded as the environment advisor to the Chevron's Central Environment team for Wheatstone, with a focus on streamlining the air quality monitoring scope for the project, whilst maintaining compliance. He was also the air quality lead for the baseline component of the INPEX Masela Project in rural Indonesia. A role that included the planning, development and execution of the air quality monitoring programme, including reporting in accordance with IFC requirements and coordinating the efforts of an international team.

Chris led the preparation of the Ichthys LNG Plant's air quality monitoring plan, and participated in the annual statutory audit for the Ichthys LNG facility in October 2019, providing a focus on the air quality components of the site's operating licence. He also undertook the review of the Ichthys AEMR and OEMP for the 2018/2019 period of operations. These opportunities have provided Chris with a deeper understanding of the operations of the plant and an appreciation of the project's performance.

Water

Ken Kiefer (Water Quality Qualified Professional)

Ken has over 20 years of experience in the risk assessment and environmental toxicology. He is currently the ERM global risk assessment technical community leader. Ken has experience quantitative health risk assessments for the management of water discharges to the environment to meet a range of client and regulatory objectives in line with environmental policy frameworks within all Australian states, U.S., New Zealand, India, and other international jurisdictions.

Ken has provided human health and ecological risk assessment support for Oil and Gas clients of operational use chemicals in drilling or enhanced production of gas and oil. Ken has also recently provided the aquatic toxicology advice to INPEX supporting the INPEX submission to NT EPA seeking regulatory approval of modified licensed discharge limits of key chemicals likely to be found in discharge water from Ichthys project into Darwin Harbour.

Waste

Nicole Bradley (Waste Qualified Professional)

Nicole is a principal environmental consultant based in Melbourne with approximately 18 years of experience in the environmental industry, fourteen of which have been in consulting and four years with a metropolitan water authority.

As an Environmental Consultant, Nicole has worked on and project managed a variety of broad environmental projects, including development of waste management and minimisation plans and strategies; assisting in the auditing of waste management systems, landfills and other contaminated sites; co-ordination and delivery of regulatory approvals and associated environmental management plans.

Nicole Bradley has also been an auditor support person for Paul Fridell (Qualified Person) on a number of the Ichthys dredging (EPA8) and onshore construction (EPA7) compliance audits, including the most recent May 2019 audit which included an audit of INPEX operations waste records and waste reduction measures.

Christopher Thomson

Principal Environmental Scientist

Chris has 19 years' international experience coordinating Environmental Impact Statements, drafting impact assessments and executing air quality monitoring programs for a range of mining, infrastructure and oil and gas projects.

During his 11 years working in WA, Chris' oil and gas experience is highlighted by be a number of key projects which exemplify his broad capabilities. These include being seconded as the environment advisor to the Chevron's Central Environment team for Wheatstone; successfully managing the execution of 3D Oil's Sauropod EP; undertaking compliance audits for INPEX's Ichthys project in Darwin as well as coordinating a fugitive emissions assessment for Buru Energy in Australia's Kimberly region for its onshore gas operations. This experience allows him to enjoy the advisory aspect to his project management and client-facing role and delivering projects, which meet stakeholder expectation.

Experience: 19 years in air quality and EIA

LinkedIn: https://www.linkedin.com/in/christopher-thomson-6977988a/
Email: Christopher.thomson@erm.com

Fields of Competence

- Air quality impact assessment
- Air quality monitoring and environmental management
- Certified Project Manager
- Environmental impact assessment and approvals preparation / coordination

Education

- Master of Science (Environmental Impact Assessment, Environmental Management Systems and Environmental Auditing), University of East Anglia (UK), 2003
- Bachelor of Science (Chemistry and Environmental Science – double major), Murdoch University W.A, 1997

Languages

- English, native speaker
- Spanish, fluent

The business of sustainability

ERM

Christopher Thomson

Environmental Impact Assessment

HazerGroup: Environmental Approvals strategy and Scoping Study 2019

This study provided an approvals strategy, schedule and risk assessment for a proposed industrial facility within the Perth Metropolitan area. This piece of work identified all relevant approvals for the proponent and allowed the proponent to visualise the development progress allowing decisions to be made at board level.

Teck Australia: Teena Resource, Environmental Approvals strategy and Scoping Study 2019

This study outlined the NT and federal environmental approvals strategy for the development of the Teena Resource. This comprehensive approach included identification of risks and environmental sensitivities related to the development and provision of costings and schedules for execution of the preferred development option. Chris co-authored and reviewed the project for submission.

3D Oil: Sauropod Seismic Environment Plan 2019

Chris was the PM for executing the scopes to produce the offshore seismic environment plan. This involved, coordinating sub-consultant and internal ERM technical expertise to deliver a timely and robust document for public and regulatory review.

Strandline Resources: Coburn Zircon Project 2018

Project manager, and lead approvals advisor for this current project, which is based on his and his team's previous experience at the site. The scope of this project involves the execution of EMP's regulator liaison, site team coordinator, preparation of approvals / obligations register to facilitate execution of the project.

Telstra Singapore Perth fibre optic cable approvals 2018

Engaged to deliver approvals for the beach-landing directional drilling component of this project. This involved preparation of a Development Application to the City of Cambridge, liaison with the DoEE related to potential EPBC referrals and coordination of the delivery of approvals and consultation with the public, though the planning process.

Holcim Australia: Baldivis Quarry Stage 2 expansion 2018

Project manager and approvals lead. Project included preparation of Mining proposal, Mine closure plan, clearing permit, licence amendment for two project options. Project was delivered adhering to budget and time constraints.

Cassini Resources: West Musgraves Environmental Approvals Scoping Study 2017

Project manager and author providing an update to the 2015 study encompassing not only changes to the project but the 2016 changes to the impact assessment process, EPA guidance and preparation of mining proposals under the *Mining Act 1978*. This scoping document outlined an approvals strategy roadmap for successful delivery of the project, covering environmental risks, budget and schedule.

BC Iron: Iron Valley Above / Below Water Table 2011-2012/2015-2017

Project manager, EIA coordinator and lead environmental approvals author for the BCI Iron Valley Below Water Table mining project, this included Part IV and Part V environmental approvals (API level of assessment) and requirements under the Mining Act. The PM role also involved providing ongoing approvals advice to the client throughout the project.

Water Corporation: Neerabup Sewer District Upgrade Project 2016

Preparation of construction environmental management plan, preliminary environmental impact assessment for the placement of sewer pipelines and infrastructure through urban areas north of Perth WA. Involved provision of advice and assessment against clearing principals constrained by environmental sensitive areas and black cockatoo habitat.

Australian Department of Defence: J0091 Replacement Aviation Fire Truck Facilities Project, 2015
This project applied to bases nation-wide, it required effective and coordinated approach. This work involved the technical review of environmental assessments and the preparation of a comprehensive Construction Environmental Management Plan.

Cassini Resources: West Musgraves Environmental Approvals Scoping Study 2015
This study outlined the WA and federal environmental approvals strategy for the development of the Nebo Babel deposit. This provided a comprehensive approach, costings and schedules for execution of the preferred development option. Chris co-authored and reviewed the project for submission.

Chevron Wheatstone LNG Project 2009-2012
Project team lead for the pollution studies which included, air quality, greenhouse gases and noise impact assessments. Authored impact assessments chapters for inclusion to the ERMP approval document. The role also included coordinating sub-consultants for execution of the various technical monitoring studies. Time and schedules were kept on delivering this aspect of the broader project.

BHP Billiton/ Nickel West NDS1 Project 2010-2011
EIA co-ordinator, project manager and lead environmental approvals author for a Nickel expansion mining project (NDS1) in the Northern Goldfields, WA. This involved preparation of all approvals documentation, but also development of the EIA strategy with the client team that was most suitable for its particular circumstances.

BHP Billiton Yeelirrie Project 2010-2011
Project manager for the development of the project's formal environmental approvals. This role involved providing approvals advice to the client as well as being a contributing author to the approvals documentation. (ERMP).

Aviva – Coolimba Power Station project 2008-2009
EIA co-ordinator and project manager and lead approvals author for the Public Environmental Review. This involved power plant and linear infrastructure approvals for the project near Eneabba in Mid-West Region of WA.

Air Quality Monitoring and Environmental Management

Amazon: Environmental Site Assessment, Obligations Register and Environmental Management Plan, 2019- ongoing
Chris was the lead assessor on this project covering a scope that included a site visit / due diligence audit, preparation of the site's operational EMP including comprehensive risk assessment, preparation of a site audit schedule, monitoring plan.

INPEX Australia: Ichthys LNG Plant compliance audit EPL 228 2019
Chris was part of the ERM site team to execute the annual Compliance Audit of INPEX operating licence 228. Chris' focus included the air quality, greenhouse gas and facility emissions from the plant.

GEMCO: Groote Eylandt Air quality management plan, best practice gap analysis 2019
Chris provided technical input to GEMCO's air quality management plan in identifying international best practice management measures ahead of the proposed mine expansion.

Hastings Technology Metals: Yangibana Rare Earths project, AQMP and plume dispersion review assessment 2019
Chris provided project management and technical review of the outgoing deliverables. Purpose of the reporting was to meet approval conditions and present options for process stack heights to feed back into the design and ultimately the works approval for the project.

Woodside LCA comparative assessment – 2019/20
Project manager for the development of a gas reserve specific LCA and energy intensity study. Chris

sustained momentum on the project and coordinated the information flow between the client and ERM project team, to ensure timely delivery of the project within budget.

INPEX air toxics and ambient air quality monitoring plan – 2019
Project manager and air quality lead for the development of the Ichthys LNG Plant air quality monitoring plan.

Roy Hill dust deposition study on mangroves, Port Hedland 2015-2018
Project manager and air quality lead for the execution and management of the study. Data management and report preparation, trouble shooting and programme refinement. Study executed to determine extent of dust deposition and the subsequent effects on mangrove communities near RHI operations.

Buru Energy Fugitive Emissions Assessment 2015-2016
Project manager and local air quality lead. This project involved monitoring fugitive emissions during well completion for onshore gas wells in the Kimberly region of WA. Chris' role included, designing the monitoring program, coordinating field work and drafting final report. The project was supported by technical skills in Brisbane and Texas (USA). The design was an innovative approach which matched technical requirements and project economic constraints.

INPEX Masela LNG Project 2013-2015
Air quality lead for an LNG project in Indonesia. This role included the planning and execution of the air quality component of the impact assessment and monitoring programme, including development of the programme and reporting in accordance with IFC and World Bank best practice requirements.
This also involved management of logistical challenges with monitoring in such environments.

Chevron Wheatstone LNG Project 2014
Environmental Advisor on air quality to the Central Environment Team. This involved deploying air quality monitoring station to Onslow, reviewing technical sub-consultant reports and troubleshooting air quality queries raised by the Central Environment Team. My return to the Wheatstone project was because of my previous experience allowing for historical knowledge gained during the original ERMP 2009 assessment, allowing for delivery of a more streamlined monitoring program entailing cost efficiencies to be incorporated.

JKC – Ichthys LNG Project 2012-2013
Team lead of the air quality (dust) monitoring programme for the construction phase of the project in Darwin. This role included coordinating technical personnel and troubleshooting challenges that result in a smooth delivery of the client's data and reporting requirements. Innovative inclusion of real time data was linked to sms alerts for the site team to implement site dust management activities. This approach proved useful to limit extent of dust emissions from the construction site.

Rio Tinto Nammuldi Below Water Table Project 2012
Project manager for the execution of the project's construction phase dust and noise monitoring programme. This programme focussed on dust and noise emissions from construction on the accommodation village. This involved directional analysis of dust and management of noise sub consultant.

UK Experience

Environmental Impact Assessment
EIA coordinator for the West Wight Wind Farm for Your Energy ltd. 2007
EIA coordinator and author for Bournemouth airport redevelopment, Manchester Airport Group 2007 EIA coordinator and author for the Crowthorne mixed use / business park scheme, Legal & General, 2007
EIA coordinator and author for the West Wight Wind Farm for Your Energy ltd. 2007
EIA coordinator and author for Crewkerne mixed use development, Wimpey homes, 2003
EIA coordinator and author for Newbury Racecourse redevelopment, Newbury Racecourse 2006. Chris

also undertook the air quality impact assessment and baseline monitoring for this project.

Air quality monitoring and Environmental management

Carbon balance and dust impact assessment for inclusion into environmental statement for Six Penny Wood Wind Farm, Your Energy Ltd, 2006.
Carbon balance and dust impact assessment for inclusion into environmental statement for North Rhins Wind farm, Wind Energy Ltd. 2006.
Carbon balance and dust impact assessment for inclusion into environmental statement for A'Chruach Wind Farm, Novera Energy. 2007.
Carbon balance and dust impact assessment for inclusion into environmental statement for Lissett Wind Farm, Wind Energy. 2006.
Drafting of environmental statement air quality chapter of environmental statement from technical report. Newhaven Energy Recovery Facility, Onyx 2004.
Drafting of environmental statement air quality chapter of environmental statement from technical report Hollingdean Materials Recovery Facility, Onyx, 2004.
Traffic emissions monitoring and dust impact assessment for Warren Way Materials Recovery Facility, Onyx, 2004.
Traffic emissions monitoring and dust impact assessment for Leavesden Studio development, MEPC group, 2007.
Traffic emissions monitoring and dust impact assessment South Kilburn Redevelopment, London, 2007.
Traffic emissions monitoring and dust impact assessment, Hollands Wood, campsite extension, New Forest, Forest Enterprises, 2004.

Environmental Management

Drafted environmental management plans for Lissett Wind Farm, Wind Energy, 2006. Drafted dust management plans for Kingston housing project Isle of Wight, 2005.
Drafted dust management plans for Hollands Wood, campsite extension, New Forest, Forest Enterprises, 2004.

Key member of EMS team responsible for implementing and co-ordinating the company EMS (to the ISO14001 standard), which was accredited June 2006. This role included internal audits, communicating initiatives and environmental awareness and monitoring of all key indicators for the firm to achieve carbon neutrality.

BAA Terminal 5, Heathrow Airport, Environmental Management

Using the Terminal 5 project as a case study, Chris carried out a series of internal environmental audits across several of the sub-projects within the wider project. This was done in accordance with the ISO14001 EMS standard, and the information gathered fed into his Masters dissertation, titled *The influence of EIA in developing EMS's and potential for their further integration.*

Casella – Stanger Group West Midlands, UK 1998 to 2002

Chris led small teams to carry out isokinetic industrial emissions air quality compliance monitoring surveys at a variety of processes around the UK. Specific projects included atmospheric emission surveys from automotive and aviation paint spray booths incinerator emission optimisations for commissioning new plant equipment as well as noise and ambient and indoor air quality surveys (environmental and occupational exposure) and COSHH assessments were also included in this work. The client base comprised predominantly multinational automotive manufacturing companies and their suppliers, some clients include Toyota UK - Bernaston Plant, Honda Motors - Swindon, Jaguar Cars - Castle Bromwich, Ford - Southampton, Peugeot - Coventry, Vauxhall Motors – Luton, British Airways – Heathrow Airport.

Other environment professional experience

Universidad de Chile, Santiago, Chile (short term placement) Jan – March 1998

Employed to commission a BAS100B Voltametry and Polarography apparatus for the University's metallurgy faculty. This included research on the suitability of the apparatus for trace analysis of industrial wastewaters

and development of operating procedures designed for the laboratory's routine analysis.

Mining and Environmental Department of SERGEOMIN Oruro, Bolivia, Environmental Chemist (short term) Nov 1997/Jan 1998
Conducted the environmental department's water quality monitoring and treatment programme for the Santa Rita Tin, Lead, Copper and Zinc mine, operated by COMIBOL. Specific duties included onsite monitoring, sampling and lab analysis of surface and subsurface acidic waters.

Yorke Environmental Consultants – Perth, WA. Environmental Assistant, May 1997/Sept 1997
Carried out air emissions monitoring and inline sampling for particulates, sulphurous and nitrous oxides from mining operations and industrial sites around WA. The work required the use of an Andersen GS 80 Stack sampler, ambient sampling and laboratory preparation.

Tiwest Joint Venture Chandala Site, Muchea, Western Australia, Under Graduate Environmental Officer Student Placement, Dec 1995 to Feb 1996
Required to design and implement an ambient dust monitoring programme for the mineral sands separation plant at Muchea in order to determine the quantity, composition and radioactivity of dust in the immediate environment of Chandala. Further duties included groundwater monitoring from onsite bores. Vegetation Health Assessment of dieback contaminated areas and its management.

Ken Kiefer

Technical Director –
Global Human Health and Ecological Risk Assessment Technical Community Director

Mr. Kiefer has over 20 years of experience in the risk assessment and environmental toxicology. He is currently the ERM global risk assessment technical community leader. Mr. Kiefer has experience quantitative health risk assessments for the management of contaminated sites to meet a range of client objectives in line with environmental policy frameworks within all Australian states, U.S., New Zealand, India, and other international jurisdictions.

Mr. Kiefer has provided human health and ecological risk assessment support for Oil and Gas clients of operational use chemicals in drilling or enhanced production of gas and oil. Mr. Kiefer has also provided aquatic toxicology support for regulatory approval of discharge of chemicals.

Experience: 20 years' experience in environmental consultancy, project management and research

LinkedIn: https://www.linkedin.com/in/ken-kiefer-79b07940/

Email: ken.kiefer@erm.com

Education

- M.S., Agricultural and Environmental Chemistry, University of California, Davis (1998)
- B.S., Environmental Toxicology, University of California, Davis (1993)

Professional Affiliations & Registrations

- Australasian College of Toxicology and Risk Assessment
- Australian Contaminated Land Consultants Association
- Australian Land and Groundwater Association (ALGA)

Key Industry Sectors

- Government
- Mining
- Oil and Gas
- Chemical
- Manufacturing
- Power

Languages

- English, native speaker

Fields of Competence

- PFAS
  - Design of investigations of PFAS impact in soil, groundwater, surface water, sediment and biota
  - Environmental fate and transport
  - Quantitative health and ecological risk assessment
  - Toxicological evaluations
- Quantitative health and ecological risk assessment
- Vapour intrusion evaluations
- Environmental fate and transport
- Probabilistic risk assessment
- Toxicological evaluations

Key Recent PFAS Conference Presentations

- Vida Maulina, Lisa Thomson, and **Ken Kiefer**. *(Abstract Accepted)* September 2019. *Derivation Of Water Quality Guideline Value For Marine Discharge Of Monoethylene Glycol*. CleanUp Conference, Adelaide, SA.
- Ron Arcuri, **Ken Kiefer**, Belinda Goldsworthy. October 2013. *Developing Surface Water Screening Levels For Compounds Associated With Aqueous Film Forming Foams*. CleanUp Conference, Melbourne, VIC.

The business of sustainability

ERM

Ken Kiefer

Key Projects

- Aquatic toxicity assessment and derivation EPL discharge limits. The assessment provided a review of specific products that maybe discharged. The derivation of EPL limits also provided a review of the on-site laboratory analytical methodologies to meet the derived EPL criteria.
- Ecological risk assessment for Water Treatment Plant effluent as part of remediation of former gas works. Risk assessment successfully led to increases in discharge limits.
- Human health and ecological risk assessment for residual coal tar impacts to remain post-remediation due to the practical limits of the remediation. Successfully demonstrated isolated residual coal tar impacts do not pose a risk.
- Provided senior technical review and oversight over the delivery of over 30 quantitative human health and ecological risk assessments as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites. The completion of risk assessments include wide ranging complex sites including: site with impact groundwater seeping into car parks of multi-story residential buildings; shallow groundwater plumes affecting multiple residential properties; and emerging contaminants (e.g. PFAS and MTBE).
- PFAS human health and ecological risk assessment for Refinery Senior Technical Lead. Development of surface water Site-Specific Screening Levels (SSSL) for PFOS and PFOA for human health and ecological receptors. The methodology used to derive the ecological screening criteria was based on the NEPM (1999) and the ANZECC (2000) methods used to derive trigger values. The result was a set of surface water SSSLs for PFOS and PFOA protective of aquatic species present in the site area. Human health SSSLs were also developed to be protective of humans consuming fish caught within the site area. The outcomes of the risk assessment process were used to eliminate the need for remediation to mitigate potential risks and highlight areas of the site where management of LNAPL was warranted to meet regulatory requirements. The risk assessment was accepted by the EPA-appointed site Auditor
- PFAS human health and ecological risk assessment. Airport JUHI Facility. Senior Technical Lead. An off-site sediment and surface water sampling program was also undertaken to determine the extent of PFOS and PFOA impacts. Human health and ecological screening criteria were selected for PFOA and PFOS. PFOS and PFOA were not measured above Tier 1 criteria in media relevant to potential fish or ecologically sensitive benthic assemblages. No risks posed by PFOS and PFOA were identified on-site and off-site human or ecological receptors. ERM employed a proactive communication and consultation strategy throughout the life of the project, to assist in the acceptance of the risk assessment outcomes by the Federal Assessor.

PFAS Projects

- **Legacy AFFF and Non-AFFF Product Sampling for PFAS – Multiple Sites, Australia (Department of Defence).** ERM was commissioned to conduct product sampling of both Aqueous Film Forming Foam (AFFF) and non-AFFF (such as aviation hydraulic oils) in order to build an understanding of the type and variability of PFAS compounds in products used across the Defence estate. One of the key objectives was to provide inputs to ongoing investigations, and support management and remediation actions. Ken is providing technical expert support for this work developing sampling strategies and data interpretation.
- **Auditor Technical Expert Support – RAAF Edinburgh and RAAF Wagga, Australia (Department of Defence)** Ken is providing technical expert support to State accredited auditors of the site investigations and risk assessment of legacy PFAS impacts.
- **AFFF Loss of Containment– Brisbane International Airport, Australia (Qantas).** PFAS human health and ecological risk assessment Senior Technical Lead for an AFFF loss of containment to adjacent river and estuary. A multi-media sampling program of sediment, soil, groundwater, surface water, and biota was developed to support the site-specific

risk assessment. The risk assessment used multiple lines of evidence to separate the risks related to the loss of containment with residual baseline pre-existing PFAS impacts; included mass balance assessment; and detailed laboratory analysis as a method to differentiate the PFAS fingerprint of the loss of containment from other PFAS sources. The Federal Assessor accepted the risk assessment. Successfully working with Commonwealth and state (QLD) regulators to demonstrate residual impact post initial water containment treatment efforts did not pose further risk to human health and the environment including indirect exposures associated with bioaccumulation of PFAS in biota. The outcomes of the risk assessment process were used to eliminate the need for further remediation to mitigate potential risks.

- **PFAS human health and ecological risk assessment for a Refinery (Confidential Client).** PFAS human health and ecological risk assessment for a Refinery. Senior Technical Lead. Development of surface water Site-Specific Screening Levels (SSSL) for PFOS and PFOA for human health and ecological receptors. The methodology used to derive the ecological screening criteria was based on the NEPM (1999) and the ANZECC (2000) methods used to derive trigger values. The result was a set of surface water SSSLs for PFOS and PFOA protective of aquatic species present in the site area. Human health SSSLs were also developed to be protective of humans consuming fish caught within the site area. The outcomes of the risk assessment process were used to eliminate the need for remediation to mitigate potential risks and highlight areas of the site where management of LNAPL was warranted to meet regulatory requirements. The risk assessment was accepted by the EPA-appointed site Auditor
- **PFAS human health and ecological risk assessment for a Refinery (Confidential Client).** PFAS human health and ecological risk assessment. Airport JUHI Facility. Senior Technical Lead. An off-site sediment and surface water sampling program was also undertaken to determine the extent of PFOS and PFOA impacts. Human health and ecological screening criteria were selected for PFOA and PFOS. PFOS and PFOA were not measured above Tier 1 criteria in media relevant to potential fish or ecologically sensitive benthic assemblages. No risks posed by PFOS and PFOA were identified on-site and off-site human or ecological receptors. ERM employed a proactive communication and consultation strategy throughout the life of the project, to assist in the acceptance of the risk assessment outcomes by the Federal Assessor.
- **PFAS human health assessment. RAAF Amberley (Department of Defence).** PFAS human health assessment. RAAF Amberley. Senior Technical Lead. Reviewed the consolidation of over six years of soil and groundwater data (for both hydrocarbons and Perfluorinated Compounds (PFCs) to refine the site Conceptual Site Model and understand the risks of undertaking the redevelopment works. Developed Site Specific Target Levels (SSTLs) to inform the remedial requirements and ensure construction works and future use of the site do not have an adverse impact upon human health or the environment.

Risk Assessment Projects

- Mr. Kiefer has provided health and ecological risk assessments as well as senior technical and quality programmes management as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites (including complex major hazard facilities such as refineries and terminals) across Australia, New Zealand and southeast Asia.
- Indoor Air Risk Assessment. Carson, California. Completed a human health risk assessment for exposure to VOCs including TCE and PCE to current on-site commercial workers and off-site residents due vapor intrusion from groundwater plume. Developed site-specific soil vapor attenuation factors and soil vapor target levels. Delineated indoor air concentrations of VOCs related to ambient air from the sub-surface sources.

Ken Kiefer

- Prepared a risk assessment for off-site receptors to supplement an existing on-site risk assessment for a Superfund site. Off-site exposures included indoor air impacts to homes above the chlorinated VOC ground water plume. A number of different approaches were used to evaluate indoor air risks including vapour intrusion modelling from ground water, measured indoor and crawlspace air concentrations. Incorporated the use of GIS to present and communicate the complex environmental and risk information to regulators and the public.
- Human Health Risk Assessment of Rocket Testing Facility - Ventura, CA. Development of site-specific vapour migration model and vapour migration model validation field study focused on vapour transport through fractured bedrock.
- Determination of Ambient Chloroform Indoor Air Concentrations. Hill Air Force Base, UT. Established chloroform indoor air screening concentrations due to chlorinated drinking water.
- Vapour Intrusion Modelling, Mather Air Force Base, CA. Conducted vapour intrusion modelling in support of closure at Castle Air Force Base. Human health risk assessments for potential future receptors at multiple sites. COPCs include TCE and PCE.
- Prospective, Deterministic Baseline Human Health Risk Assessment (Vapour Intrusion) at a Sacramento Brownfield Site. Chico, CA. Industrial Site Redeveloped to Multi-family Land-use. Vapour intrusion assessment for BTEX and 1,2-DCA.
- Area–Specific Risk Assessment. Industrial Complex, South Bend, Indiana. Performed an area-specific risk assessment and developed of risk-based cleanup levels (RBCLs) for COPCs including PCE. The assessment included modelling to evaluate the potential of site constituents in soil to migrate to on-site indoor air and off-site groundwater.
- Soil Vapor Characterization and Risk Assessment, Los Angeles, CA. Developed strategy to address concerns regarding potential risks due to exposure in on-site and off-site indoor air to site related VOCs, including TCE and PCE. Performed risk assessment for current and future indoor receptors.
- Human Health Risk Assessment, Superfund, Olathe, KS. Multi-media human health risk assessment at a former industrial chemical storage and recycling centre. Qualitative and quantitative risk assessment conducted on measured and modelled VOCs in indoor air.
- Focused Human Health Risk Assessment at a former chemical facility, West Sacramento, CA. Conducted exposure and human health risk assessment to volatized CVOCs in indoor and outdoor air under the future land use conditions of a professional sports stadium.
- Performed Human health risk assessment evaluated risks to receptors due to dermal contact or ingestion exposures related to the beneficial use of red and brown mud and phosphogypsum as levee construction materials. This evaluation used the results material specific physiochemistry and aquatic toxicology studies. The evaluation included metals and radionuclides. Radionuclides were evaluated using USEPA RESRAD risk assessment model.
- Development of surface water discharge target levels for groundwater remediation system for a former coal fired power plant. Evaluation considered short-term and long term ecological effects.
- Post-release assessments of material harm to harbour water of high ecological and tourist value. Included innovated multiple-lines of evidence including understanding the nature of the release, the short-lived nature of the contaminants and understand of the complex mixing processes between the release and harbour.
- Human Health Risk Assessment for Complex Industrial Site. Human Health Risk Assessment for the redevelopment of waste-water ponds of former industrial complex of over 2,000 acres. Conducted human health risk assessments for multiple sites. Evaluation includes radionuclide, asbestos, dioxins/furans, PCBs, TPH, metals, SVOCs, and VOCs.
- Conducted human health risk assessment on two proposed >30-acre rural residential development

that was a former orchard. Soils contained arsenic, lead, and organochlorine pesticides. Assessment included probabilistic exposure assessment methodologies; site-specific in-vitro bioaccessability assessment; and background assessment. California regulatory agency approved the risk assessment.

- Provided senior technical review and oversight over the delivery of over 30 quantitative human health and ecological risk assessments as part of the management of a large portfolio (>100 sites) of petroleum hydrocarbon sites.
- Development of surface water Site-Specific Screening Levels (SSSL) for aqueous film forming foam (AFFFs) chemicals perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA) for human health and ecological receptors.
- Developed risk-based cleanup levels for arsenic, copper, and hexavalent chromium at wood treating facility. Cleanup levels were developed for protection of current and future workers as well as ground water quality.
- Completed a prospective human health risk assessment for future hypothetical beneficial uses for impacted ground water beneath a former Naval facility slated for commercial redevelopment. Chemicals of concern included chlorinated hydrocarbons, and BTEX. The assessment included a qualitative screening of many future potential ground water uses to focus the quantitative portion of the risk assessment to the two or three scenarios of greatest concern. Measured ground water concentrations were kriged to estimate areal average concentrations of each constituent, and subsequently three scenarios were quantitatively assessed: two worker scenarios and a school scenario. All scenarios were shown to be below acceptable hazard indices and EPA's risk range.
- Developed site-specific site-specific vapour migration modelling to evaluate potential migration from soil, shallow ground water, and deep ground water, which accounted for potential transport through fractured bedrock.
- Developed site-wide risk assessment methodologies risk from soil, shallow ground water, and deep ground water at a complex rocket testing facility.
- Baseline human health and ecological risk assessment for nitroammonia plant in Mexico to aid in divestment for on-going use. Primarily focused on assessment of off-site risks to current water users and ecological receptors potentially impacted by site groundwater. Included fate and transport modelling for migration of nitrate and ammonia in groundwater.
- Human health and ecological risk assessment related to the sub-surface fraccing and development of coal seam gas wells. Included evaluation of chemical and radiological tracer composition of frac fluids and return; pathway assessment of the potential release scenarios of frac fluids to the environment; and modelling of potential exposures frac fluid due potential surface and sub-surface release scenarios.
- Human health risk assessment related to the sub-surface fraccing and development of shale gas wells. Included evaluation of chemical and naturally occurring radioactive material (NORM) composition of frac fluids and return; pathway assessment of the potential release scenarios of frac fluids to the environment; and modelling of frac fluid into ground water aquifers.
- Human Health and Ecological Risk Assessment of Superfund Site - Former Radionuclide Research Facility and University Landfills. Risk assessment for a former radionuclide research facility and university landfills. Evaluation included tiered ecological and human health evaluation. Evaluation includes metals, VOCs, and radionuclides.
- Ecological Screening Risk Assessment. Performed screening ecological risk assessment for abandoned petroleum storage facility. Evaluated risks terrestrial and aquatic receptors. Developed site-specific surface water and sediment benchmarks.
- Performed screening ecological risk assessment for chemical manufacturing facility including

development of surface water and sediment benchmarks for site-specific constituents.

- Performed screening ecological risk assessment for abandoned petroleum storage facility. Evaluated risks terrestrial and aquatic receptors. Developed site-specific surface water and sediment benchmarks.
- Performed supplemental cumulative ecological risk assessment for U.S. Air Force. Evaluated risks of far-ranging species due to cumulative exposure to multiple individual sites that is not accounted for in individual site assessments.
- Performed baseline human health and ecological risk assessment and development of risk-based corrective action levels at a solvent recycling centre as part of RCRA facility investigations. Implemented a fractionation risk assessment approach for TPH. Performed environmental fate assessment of chemical constituents from soil into ground water using the SESOIL and Summers environmental fate and transport models. Performed environmental fate assessment of chemical constituents from soil into indoor air using the Johnson and Ettinger environmental fate and transport models. Provided statistical characterization and distribution analysis of soil and ground water concentrations.
- Performed screening ecological risk assessment for chemical manufacturing facility including development of surface water and sediment benchmarks for site-specific constituents.
- Developed strategy address concerns regarding potential risks due to exposure in on-site and off-site indoor air to site related VOCs. Assisted in developing site characterization work plan to support future risk assessment.
- Performed an area-specific risk assessment and developed of risk-based cleanup levels (RBCLs). The assessment included modelling to evaluate the potential of site constituents in soil to migrate to on-site indoor air and off-site ground water. The evaluation included VOCs and PCBs.
- Prepared risk assessment in support of RCRA facility investigations. Developed site-wide risk assessment methodologies including site-specific vapour migration modelling to evaluate potential migration from soil, shallow ground water, and deep ground water, which accounted for potential transport through fractured bedrock.
- Conducted risk assessment for a former radionuclide research facility and university landfill. A tiered ecological and human health evaluation included metals, VOCs, and radionuclides.
- Conducted health risk assessment on estimated emissions from a proposed waste to energy facility in Hong Kong. Evaluation included metals, VOCs, and dioxins.
- Performed a preliminary endangerment assessment human health risk assessment for a proposed new school on former agricultural property.
- Performed human health risk assessment and geostatistical evaluation using GIS (ArcView) as part of an analysis of historically released DDT at a manufacturing facility.
- Assisted with exposure and human health risk assessment of volatile organic chemicals in ground water. Performed modelling to assess exposure and risk to volatized chemicals under the future land use conditions of a sports stadium.
- Assisted with exposure and human health risk assessment of inorganic and organic chemicals in soil and sediments. Developed sediment target concentrations for chemicals based on recreational fish ingestion. Modelled transfer from sediments to fish for bioconcentrating chemicals including PCBs, Dioxins, Furans, PARs, and chlorinated pesticides.
- Assisted with exposure and toxicity assessment of over 20 chemicals in soil and ground water. Performed environmental fate assessment in soil and ground water using the SESOIL and VHS environmental fate and transport models. Provided statistical characterization and distribution analysis of soil and ground water concentrations.
- Performed environmental fate assessment of chemical constituents from soil and ground water into indoor and outdoor air using the Johnson and Ettinger and Hannah environmental fate and transport models in support of multiple site-specific risk assessments and development of risk based clean-up levels.

- Performed environmental fate assessment of chemical constituents from domestic water use into indoor air using published air stripping methodologies in support of multiple site-specific risk assessments as well as litigation support.
- Performed air dispersion modelling based on the accidental release scenario using EPA's ALOHA model. Used model outputs to estimate probable exposure levels for comparison with toxicity information.
- Provided litigation support for testifying toxicology and risk assessment expert for plaintiff on a case involving alleged illegal disposal of hazardous waste by a furniture stripping company. Evaluated available data for ability to determine amounts material illegally disposed.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving environmental damages resulting from an accidental release of Cl-containing gases. Researched information and performed air dispersion modelling for expert report in support of a lawsuit regarding phytotoxic effects from an accidental release of chlorine gas. Reviewed phytoxicity studies of chlorine gas to develop toxicity threshold for pine trees and determine the long term effects from an acute exposure event. Performed air dispersion modelling based on the accidental release scenario using EPA's ALOHA model. Used model outputs to estimate probable exposure levels for comparison with toxicity information.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving migration of VOCs and methane from an adjacent landfill into a commercial building.
- Provided litigation support for testifying toxicology and risk assessment expert for the defense on a case involving alleged health effects in inmates in California's Tehachapi Prison associated with hazardous substances in ground water at the prison. Lawsuit regarding potential health effects from exposure to PCE, TCE and nitrate impacted ground water. Reviewed database of ground water analytical results for completeness and reliability. Evaluated exposure levels for toxicological significance, comparing water levels, length of exposure to known toxicology of substances.
- Prepared GIS for a property development at a former orchard site. The GIS was used to geographically integrate risk assessment results with sample locations, and future property planning. Risk-based cleanup decisions were based on the results of GIS geostatistical analyses. Subsequent remediation alternative decisions were also based on the GIS developed for the site.
- Assisted in development of a GIS to support air modelling conducted for several commercial facilities for Proposition 65 warning requirements. The GIS was used to develop a mailing list database for properties within the air emissions plume using GIS geocoding.
- Developed database of surface water and soil concentrations for cadmium, copper, lead, and zinc from available data. Database was designed for use in a GIS for the purpose of evaluating spatial relationships in metal background concentrations. Access and Arc View were used in the development of the GIS.
- Developed GIS database of soils characteristics for use in the exposure and risk assessment model CalTOX. Data from the USDA STATSGO database was used for the development of GIS database of CalTOX soil inputs. ArcINFO was used in the development of the GIS.

Publications

- Kenneth L. Kiefer, Chuck E. Schmidt, Mark K. Jones, Ranajit (Ron) Sahu. 2013. *Assessing Vapour Intrusion - How do assessment technologies compare?* Remediation Australasia. Issue 12. 2013
- Norbeck et al. 1998. *Evaluating Factors That Affect Diesel Exhaust Toxicity*. Center for Environmental Research and Technology, College of Engineering, University of California, Riverside. Final Report Contract No. 94-312.
- Hsieh D.P.H., McKone, T.E., Geng, S., Schwalen, E.T. and Kiefer, K.L., 1995. *The Distribution of Landscape Variables for CalTOX within California*,

Department of Toxic Substances Control, California Environmental Protection Agency, Sacramento, California.

- T.E. McKone, Kiefer, K.L., Currie, R.C., Geng, S. and Hsieh, D.P.H., 1995. *Representing Uncertainty in Risk Assessments; Task I a: Constructing Distributions*, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, California.
- T.E. McKone, Currie, R.C., Chiao, F.F., Kiefer, K.L. and Hsieh, D.P.H., 1995. *Representing Uncertainty in Risk Assessments; Task I b: Representing Uncertainty in Intermedia Transfer Factors: Case Studies*, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency, Berkeley, California.

Invited Speaker

Presenter at the ALGA 2-Day Risk Assessment 101 training course. Auckland and Christchurch, NZ (2017) and Hobart (2018).

Presentations

- **Ken Kiefer** and Darren Reedy. *PFAS Health Risk Assessment*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer** Kylie Dodd and Darren Reedy. *The Distribution of PFAS Compounds in the Marine Environment and Implications for Ecological Risk*. EcoForum 2018 Conference, Sydney, NSW.
- Lisa Thomson, **Ken Kiefer**, Kylie Dodd and Darren Reedy *Bioaccumulation of PFAS Within Aquatic Trophic Levels in an Australian Estuarine Environment*. EcoForum 2018 Conference, Sydney, NSW.
- Gavin Powell, Rob MacIntosh, **Ken Kiefer**, Wijnand Gemson, and Peter Madden. *PFAS and Urban Stormwater: Use of Mass Discharge Assessment in the Interpretation of the Conceptual Site Model*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken** Kiefer, Kylie Dodd, and Darren Reedy. *Using TOPA in Risk Assessment*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer**, Wijnand Germs, Nathan Seaver, Kylie Dodd, and Ed Dennis. *Differentiating Groundwater Sources Using Mass Flux*. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Re-Assessing Remedial Targets Based on Changes in Total Recoverable Hydrocarbons Mixtures During Remediation. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Reducing Uncertainty in Vapour Intrusion Risks and Conservatism in Chlorinated Hydrocarbon Site Decision Making. CleanUp 2017 Conference, Melbourne, NSW.
- Kathryn East, Ken **Kiefer**. Extended **PFAS** Suite: Future-Proofing, or Creating More *Uncertainty?* EcoForum 2016 Conference, Freemantle, WA.
- W. Germs, **K. Kiefer**, and A. Kohlrusch. You Can't Manage What You Don't Measure: 1,4–Dioxane as Co-Contaminant at Chlorinated Solvent Sites. EcoForum 2016 Conference, Freemantle, WA.
- Sophie Wood, Phillippa Biswell, **Ken Kiefer** and Warren Pump. *The Trouble with Environmental Management Plans….* EcoForum 2016 Conference, Freemantle, WA.
- Ken **Kiefer** and Thavone List. What Are Total Recoverable Hydrocarbons? Implications for Contaminated Site Management. EcoForum 2016 Conference, Freemantle, WA.
- **Ken Kiefer** and Kathleen Prohasky. Evaluation of Primary Industry Beneficial Water Use and Consideration of Non-Health and –Environmental Risk Endpoints. EcoForum 2016 Conference, Freemantle, WA.
- Joseph Ferring and **Ken Kiefer**. *Using D Data Analysis and Visualisation to Reduce Uncertainty.* EcoForum 2016 Conference, Freemantle, WA.
- **Kenneth Kiefer**, Kathleen Prohasky, Wijnand Germs, Neil Gray and Tamie Weaver. September 2015. A Comparison Of Passive Sampling And Low-Flow Or Bailed Sampling Results Across A Range Of Australian Hydrogeological Settings. Cleanup 2015, Melbourne, Vic.
- **Kenneth Kiefer** and Thavone Shaw. September 2015. *Using Mass Balance In Risk Assessment.* Cleanup 2015, Melbourne, Vic.
- Kathleen Prohasky and Kenneth Kiefer. September 2015. *Complications Of Ambient*

Sources In Assessing Vapour Intrusion Risks. Cleanup 2015, Melbourne, Vic.

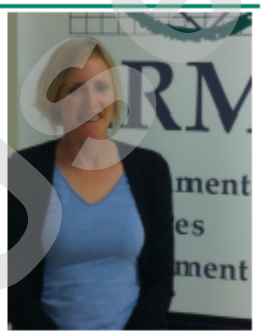
- Kathleen Prohasky and Kenneth Kiefer. September 2015. Developing Groundwater Tier 1 Screening Criteria For Chronic And Acute Vapour Risks For Chlorinated Hydrocarbons. Cleanup 2015, Melbourne, Vic.
- **Ken Kiefer,** Joseph Ferring, & Will Ellis. October 2014. *Differentiating Between Soil and Groundwater Solvent Sources in Soil Vapour Risk Assessment.* EcoForum 2014 Conference, Gold Coast, QLD.
- Christine Lussier, Kathryn East & Ken Kiefer. October 2014. *Screening Levels for Polychlorinated Biphenyls in Water.* EcoForum 2014 Conference, Gold Coast, QLD.
- Jeremy Hogben, Steven Morrison & Kenneth Kiefer. October 2014. *Assessing Polar Compounds as Degradation Metabolites of Hydrocarbon Sources – The Need for Change.* EcoForum 2014 Conference, Gold Coast, QLD.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2014. *Tier 1 Screening of Vapour Risks from Groundwater Data for Chlorinated Hydrocarbons.* ACTRA Conference. Coogee, NSW.
- **Kenneth L. Kiefer,** Alyson N. Macdonald, Kathleen Prohasky & Sophie Wood. October 2013. *Tier 1.5 Soil Vapour Screening For Non-Petroleum Volatile Organic Compounds.* CleanUp Conference, Melbourne, VIC.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2013. Assessing Degradation Processes of Subsurface Vapours from a Petroleum Source in Fractured Basalt Using a Carbon Filter. CleanUp Conference, Melbourne, VIC.
- Ron Arcuri, Ken Kiefer, Belinda Goldsworthy. October 2013. Developing Surface Water Screening Levels For Compounds Associated With **Aqueous Film Forming Foams**. CleanUp Conference, Melbourne, VIC.
- **Kenneth Kiefer,** Alyson Macdonald, and Sophie Wood. October 2012. *Why do we need two different methods for screening vapour intrusion risks?* ACTRA. Adelaide SA.
- Dr. Sophie Wood, Ken Kiefer and Olivia Patterson. October 2012. *Health and Ecological Risk Assessment of Hydraulic Fracturing Fluids.* ACTRA. Adelaide SA.
- **Kenneth L. Kiefer**, Jonathan Lekawski, Valerie Phipps, Harrison Swift, and Sophie Wood. March 2012. *Case Studies of Implementing HSLs in Petroleum Hydrocarbon Sites.* EcoForum. Sydney. NSW.
- **Kenneth L. Kiefer**, Chuck E. Schmidt, Mark K. Jones, Ranajit (Ron) Sahu. September 2011. Comparison of Technologies for Assessing Vapour Intrusion In Future Structures from Subsurface Sources - Case Study with Side-by-Side Measured Flux and J&E Modelling. CleanUp Conference, Adelaide, SA.
- Kiefer, K.L., Jones, M., Shibata, M., Olsen, H., Steinmacher, S., and Case, J. April, 2005. *Dealing with Confounding Background Indoor Air Concentrations.* Air & Waste Management Association. Symposium on Air Quality Measurement Methods and Technology, San Francisco, CA
- Shull, L. and Kiefer, K. March 2005. *Those Pesky Emerging Contaminants: Will We Ever Be Done With Them?* Association for Environmental Health and Sciences: The 15th Annual AEHS Meeting & West Coast Conference on Soils, Sediments and Water, San Diego, CA.
- Kiefer, K.L., Shull, L., Bowland, M., and Jones, M. October 2003. Risk Based Decision Making Tools: Property Redevelopment and Arsenic Case Study, Brownfields 2003, Portland, Oregon.

Nicole Bradley

Principal Consultant / Project Manager
Auditor Assistant

Nicole is a principal environmental consultant based in Melbourne with approximately 18 years of experience in the environmental industry, fourteen of which have been in consulting and four years with a metropolitan water authority.

As an Environmental Consultant, Nicole has worked on and project managed a variety of broad environmental projects, including development of waste management and minimisation plans and strategies; assisting in the auditing of waste management systems, landfills and other contaminated sites; co-ordination and delivery of Victorian EPA Works Approvals and associated environmental management plans.



Experience: 18 years' experience in the environmental sector.

Email: Nicole.bradley@erm.com

Education

- Bachelor of Applied Science (Natural Resource Management), Australia
- Bachelor of Business (Accounting), Australia

Languages

- English, native speaker

Fields of Competence

- Waste Management
- Contaminated Site Assessment
- Works Approvals
- Environmental Management Plans

Key Industry Sectors

- Government
- Oil and Gas
- Mining
- Power
- Development

The business of sustainability

ERM

Key Projects

Waste Management Projects

Environmental Impact Assessment – Waste Management Strategy, Surat Basin, Australia - Queensland Gas Company (QGC) (2012). As a component of an overall EIA prepared by ERM, ERM Waste team in Melbourne Australia prepared the waste management and resource minimisation sections of EIA documentation in collaboration addressing potential wastes generated from drilling operations, construction and demolition wastes and putrescible wastes generated by on-site workers.

Thevenard Island Facility, WA – Waste Management Plans for Cessation and Retirement, Chevron Australia (2013). Technical specialist responsible for waste minimisation inputs of the waste management plans for cessation (systematic shut down) and retirement (decontaminate, decommission and demolition) of Chevron's Thevenard Island Facility. Waste Management Plans were prepared in accordance with Chevron standards and with state and federal legislation.

Confidential O&G Client, Strategic Waste Advice for Decommissioning of LNG Off-shore Platforms (2015). Nicole was the project manager of an initial, high-level desk top assessment of established waste/ decommissioning facilities in Australia and the Asia Pacific Region. The objective of the study was to assess the current or potential waste management capacity of facilities to receive, decommission, recycle, reuse and dispose of materials and associated wastes (both hazardous and non-hazardous) relating to retirement of the client's offshore platforms. ERM prioritised preferred facilities for further consideration/ investigation considered adequate to support the client's requirements.

Mercury and Naturally Occurring Radioactive Material (NORM) Waste Management Review, Ichthys LNG Project, INPEX Australia (2016). ERM was engaged to undertake a legislative and national/international market review of the management and disposal of mercury and NORMs waste streams that will be generated during the operational phase of the INPEX Ichthys LNG project at various locations. Nicole was a technical support to the project manager and partner in charge of reviewing the legislative related to NORM waste.

Waste Management Strategy, Bass Coast Shire Council, (2015). ERM prepared a waste management strategy to provide a sustainable framework for managing the waste of the Bass Coast municipality over the ensuing 10 years, i.e. 2015 – 2025. The strategy was developed collaboratively with council and in line with local, regional, state and federal policies and strategies. It included comprehensive public consultation, including public consultation sessions and directed surveys to identified key stakeholders.

Undertaken at another consultancy):

- **Waste Management Strategy, Mildura Rural City Council (2011)**
- **Council Waste Management Strategy template, Metropolitan Waste Management Group (2011)**

Construction and Operational Environmental Management Plan Audits

Onshore Construction Environmental Management Plan, Ichthys Gas Field Development Project Australia, INPEX Operations Australia Pty Ltd (2012-2019). ERM has provided INPEX Operations Australia Pty Ltd with regular environmental audits of the Onshore Construction Environmental Management Plan as part of the Ichthys Gas Field Development Project (the Ichthys Project). The scope of these audits was an assessment of compliance with the project NT EPA Environmental Approval and the Construction Environmental Management Plans Nicole has supported Paul Fridell (Lead Auditor) on a number of these audits.

NT EPA Qualified Person Review of the Onshore Construction Environmental Management Plan (Revisions 7 and 11), Ichthys Gas Field Development Project Australia, JKC Australia Pty Ltd (2013 - 2018). ERM provided JKC Australia Pty Ltd with Environmental Auditor (Qualified Person) review of the Onshore Construction Environmental Management Plan as part of the Ichthys Gas Field Development Project. Nicole provided audit support to the auditor. The scope of the review undertaken was an assessment the environmental management measures proposed in the Construction Environmental Management Plan for a variety of work packages including underwater piling, sewage outfall impacts, concrete batching plant, quarantine, hazardous materials, waste, dredging, pre-commissioning works, hydrotesting, surface water discharges and general civil earthworks.

NT EPA Qualified Person Review of the Annual Environmental Monitoring Report, Ichthys Gas Field Development Project Australia, JKC Australia (2015 – 2016). ERM provided JKC Australia LNG Pty Ltd with environmental Auditor (Qualified Person) review of the Annual Environmental Monitoring Report 2014 – 2015 and 2015-2016. The scope of the review was an assessment of monitoring data as presented in the report and any observations/explanation of trends, conclusions and recommendations made are technically sound based on the various ERM subject matter expert/s knowledge. Nicole project managed the review to support the auditor.

S53V Landfill Operations Audits

S53V Audit of Mildura Landfill Operations, Mildura City Council (2018). Assist auditor with the audit of an operational landfill in Victoria to identify and where possible quantify the risk of any possible harm or detriment to a segment of the environment caused by operation of a landfill.

Other Projects

Works Approval application for the extension of landfilling space, Australia, Wyndham City Council (2013-2014). Nicole project managed the preparation of a works approval application in support of the extension of the landfilling operations at the facility, including development of Master Plan, Needs Analysis, co-ordination of technical inputs including, odour and air emissions, visual impact assessments, environmental monitoring and management plans, concept designs, and liaison with Victorian Environment Protection Authority (regulator).

APPENDIX C: COMMINGLED TREATED EFFLUENT (750-SC-003) LABORATORY RESULTS

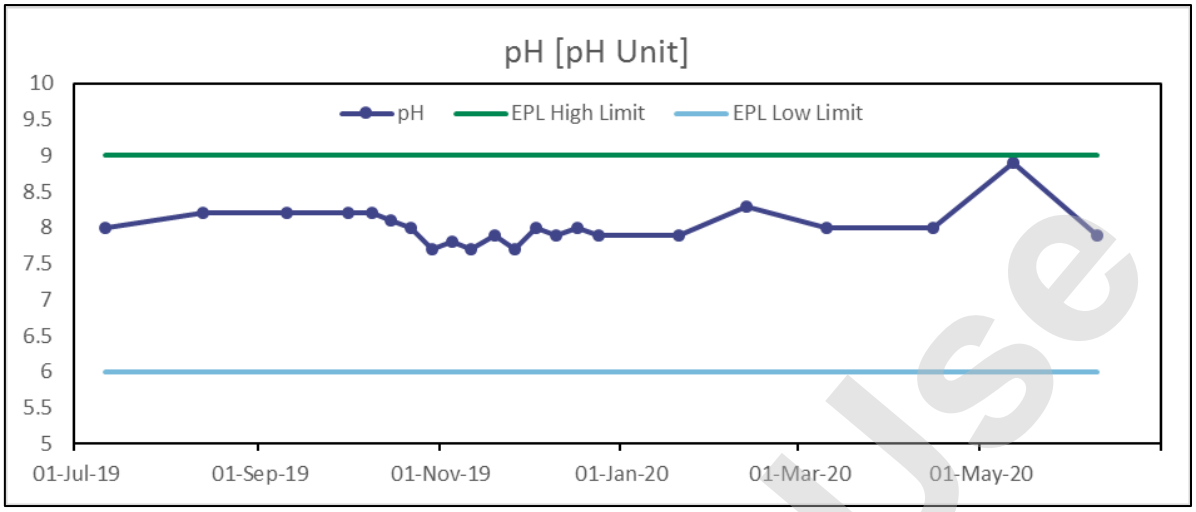
C.1 Weekly/Monthly sampling results for 750-SC-003

Shaded cells indicate trigger exceedances described in Table 2-4

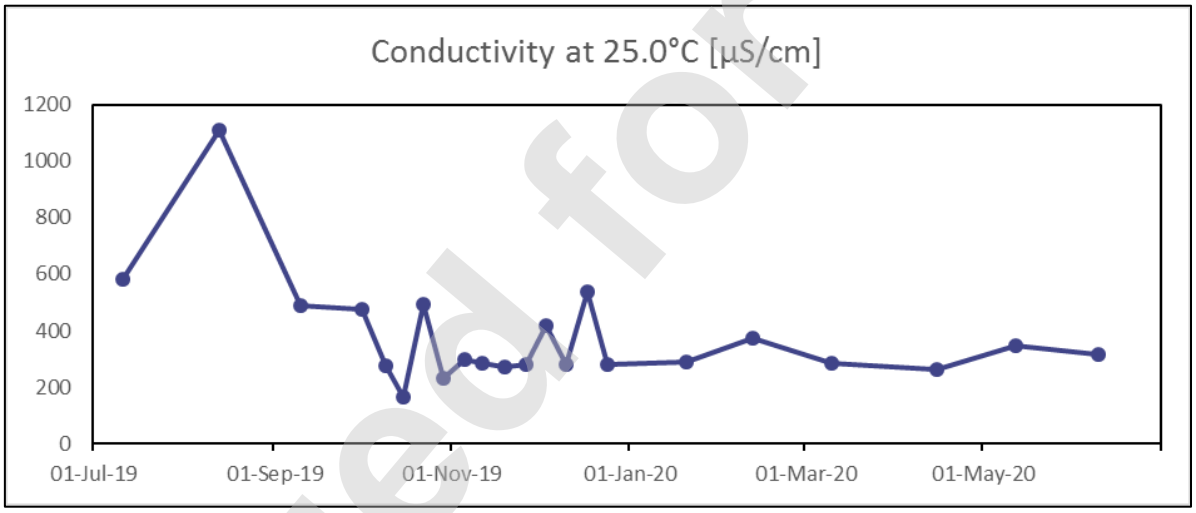
Date	TIME	LIMS Sample ID	pH	Electrical conuctivity	Temperature	Turbiddity	Dissolved oxygen	TPH as oil & grease	TRH (C10-C40)	TSS	BOD	COD	Free Chlorine	Ammonia	Total nitrogen	Total phosphorus	Filterable Reactive Phosphorus	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Enterococci	E coli	Faecal coliforms	Anionic surfactants	aMDEA	Glycol (MEG)	Glycol (TEG)
Unit			pH units	µS/cm	°C	NTU	%	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg N/L	µg N/L	µg P/L	µg P/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	cfu/ 100mL	cfu/ 100mL	cfu/ 100mL	mg/L	mg/L	mg/L	mg/L
Discharge limit			6 to 9	n/a	35	n/a	n/a	6	n/a	10	20	125	2	n/a	10000	2000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100	400	n/a	n/a	n/a	n/a
11-Jul-19	9:15 AM	L1904130001	8.0	582	31	1	92	<1	<100	<5	<2	19	-	60	5000	600	300	<0.1	<1	6	<1	<0.1	4	<1	157	7	<10	10	<0.1	<0.001	<2	<2
13-Aug-19	7:57 AM	L1904898001	8.2	1111	26.3	<0.5	106	<1	<100	<5	<2	20	-	10	**14000**	1200	700	<0.1	<1	5	<1	<0.1	5	<1	13	4	<1	1	<0.1	<0.001	<2	<2
10-Sep-19	8:20 AM	L1905388001	8.2	490	27.4	1.5	89	<1	<100	<5	3	16	-	180	2000	1200	700	<0.1	<1	5	5	<0.1	1	<1	90	64	**130**	130	<0.1	<0.001	<2	<2
01-Oct-19	8:50 AM	L1905753001	8.2	475	29.8	-	-	-	-	-	-	-	-	-	**10500**	450	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
09-Oct-19	7:53 AM	L1905901001	8.2	277	30.5	1.5	93	<1	<100	<5	<2	11	-	60	<2000	500	300	0.1	<1	107	<1	<0.1	24	<1	78	18	1	<1	<0.1	<0.001	<2	<2
15-Oct-19	7:30 AM	L1906058001	8.1	167	30.1	-	-	-	-	-	-	-	-	-	1200	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22-Oct-19	9:22 AM	L1906185001	8.0	493	32.4	-	-	-	-	-	-	-	-	-	3500	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-Oct-19	8:39 AM	L1906339001	7.7	230	29	-	-	-	-	-	-	-	-	-	2600	670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-Nov-19	8:20 AM	L1906501001	7.8	299	30.4	-	-	-	-	-	-	-	-	-	2400	370	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11-Nov-19	9:35 AM	L1906654001	7.7	284	32	1	86	<1	<100	<5	<2	14	-	650	2000	400	<200	<0.1	<1	<1	<1	<0.1	3	<1	741	10	1	2	<0.1	< 5	< 5	< 5
19-Nov-19	8:10 AM	L1906799001	7.9	270	30.5	-	-	-	-	-	-	-	-	-	2600	430	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Nov-19	8:40 AM	L1906964001	7.7	279	30.6	-	-	-	-	-	-	-	-	-	4700	420	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
03-Dec-19	7:48 AM	L1907089001	8.0	417	31.5	-	-	-	-	-	-	-	-	-	5900	750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-Dec-19	9:05 AM	L1907233001	7.9	278	32.9	0.5	75	<1	<100	<5	6	14	-	810	3000	500	300	<0.1	<1	4	<1	<0.1	3	<1	374	17	<1	<1	0.1	< 5	< 5	< 5
17-Dec-19	9:01 AM	L1907336001	8.0	539	32.3	-	-	-	-	-	-	-	-	-	6400	590	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
24-Dec-19	8:25 AM	L1907441001	7.9	281	32.3	-	-	-	-	-	-	-	-	-	4000	<500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-Jan-20	9:48 AM	L2000225001	7.9	290	28.1	<0.5	96	<1	<100	<5	<2	11	-	<2000	6000	<500	<500	<0.1	<1	2	<1	<0.1	<1	<1	40	4	3	3	<0.1	< 5	< 5	< 5
12-Feb-20	10:30 AM	L2000760001	8.3	375	31.7	<0.5	86	<1	<100	<5	<2	8	-	7000	9000	<500	<500	<0.1	<1	6	<1	<0.1	<1	<1	9	21	<1	<1	<0.1	< 5	< 5	< 5
10-Mar-20	8:40 AM	L2001260001	8.0	286	27.8	1	84	<1	<100	<5	2	11	-	<2000	6000	<500	<500	<0.1	<1	5	<1	<0.1	<1	<1	102	58	12	12	<0.1	< 5	< 5	< 5
15-Apr-20	8:00 AM	L2001846001	8	263	30.9	1	87	< 1	<100	< 5	3	9	-	5000	5000	<500	<500	<0.1	<1	4	<1	<0.1	1	<1	236	17	10	10	<0.1	< 5	< 5	< 5
12-May-20	7:30 AM	L2002289001	8.9	346	28.3	0.5	84	< 1	<100	< 5	<2	14	< 0.02	10000	10000	<500	<500	<0.1	<1	14	<1	<0.1	3	<1	166	55	12	12	<0.1	< 5	< 5	< 5
09-Jun-20	7:30 AM	L2002719001	7.9	314	28.2	1	80	< 1	<100	< 5	9	11	< 0.02	2000	4000	<500	<500	<0.1	<1	3	<1	<0.1	1	<1	68	60	18	18	<0.1	< 5	< 5	< 5
23-Jun-20	9:45 AM	L2003006001	-	-	-	-	-	-	-	-	-	-	-	6000	**13000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Jun-20	3:44 PM	L2003007001	-	-	-	-	-	-	-	-	-	-	-	9000	10000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23-Jun-20	4:02 PM	L2003008001	-	-	-	-	-	-	-	-	-	-	-	9000	**14000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
25-Jun-20	10:43 AM	L2003022001	-	-	-	-	-	-	-	-	-	-	-	36000	**35000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26-Jun-20	8:29 AM	L2003052001	-	-	-	-	-	-	-	-	-	-	-	2000	3000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Date	TIME	LIMS Sample ID	pH	Electrical conuctivity	Temperature	Turbiddity	Dissolved oxygen	TPH as oil & grease	TRH (C10-C40)	TSS	BOD	COD	Free Chlorine	Ammonia	Total nitrogen	Total phosphorus	Filterable Reactive Phosphorus	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	Enterococci	E coli	Faecal coliforms	Anionic surfactants	aMDEA	Glycol (MEG)	Glycol (TEG)
		Unit	pH units	µS/cm	°C	NTU	%	mg/L	µg/L	mg/L	mg/L	mg/L	mg/L	µg N/L	µg N/L	µg P/L	µg P/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	cfu/ 100mL	cfu/ 100mL	cfu/ 100mL	mg/L	mg/L	mg/L	mg/L
		Discharge limit	6 to 9	n/a	35	n/a	n/a	6	n/a	10	20	125	2	n/a	10000	2000	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100	400	n/a	n/a	n/a	n/a
27-Jun-20	6:45 AM	L2003061001	-	-	-	-	-	-	-	-	-	-	-	14000	**15000**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29-Jun-20	7:30 AM	L2003115001	-	-	-	-	-	-	-	-	-	-	-	6000	7000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30-Jun-20	9:06 AM	L2003139001	-	-	-	-	-	-	-	-	-	-	-	7000	7000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

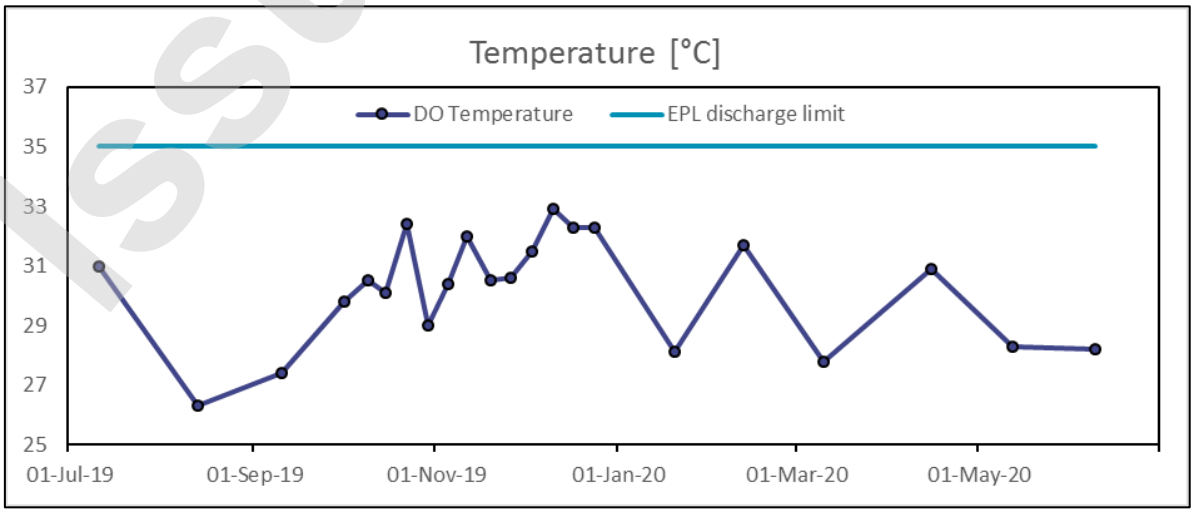
C.2 pH



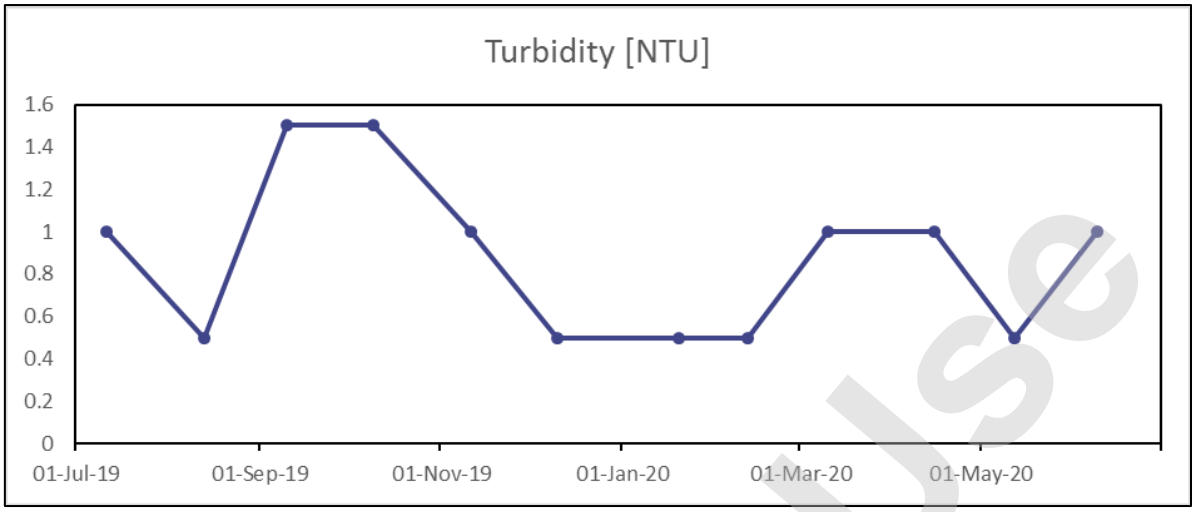
C.3 Conductivity



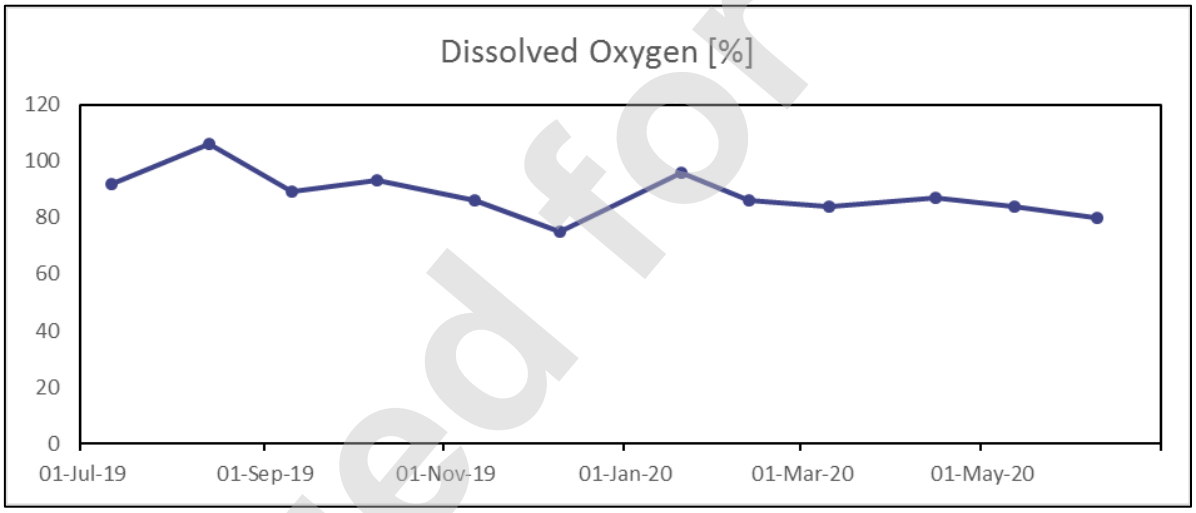
C.4 Temperature



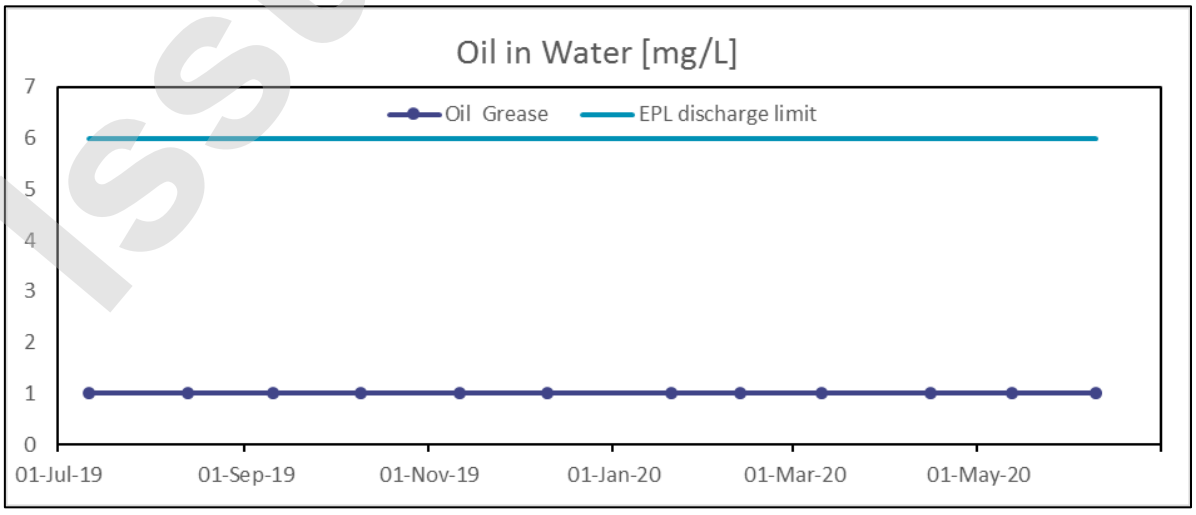
C.5 Turbidity



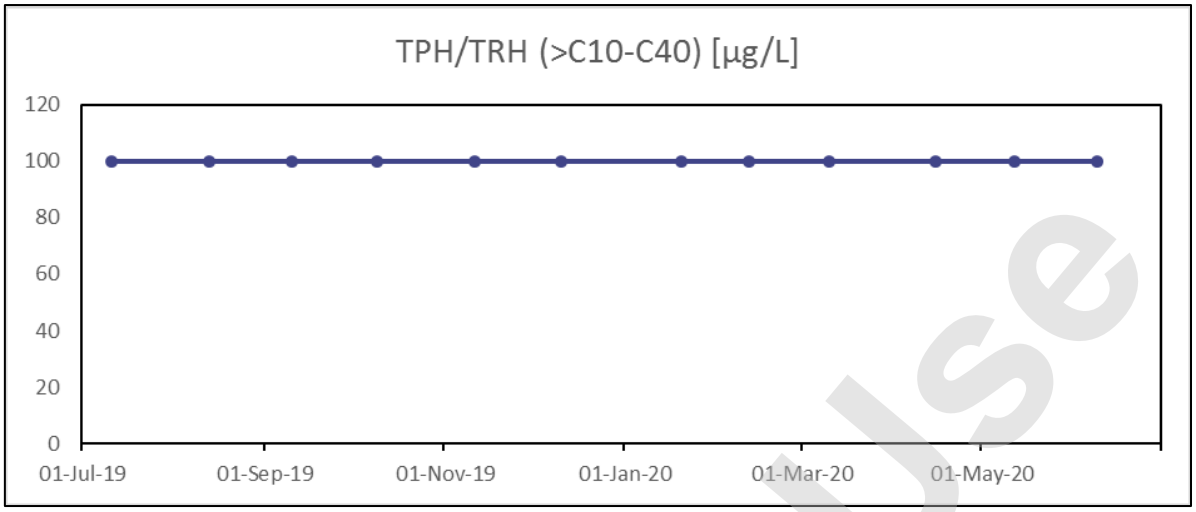
C.6 Dissolved Oxygen (%)



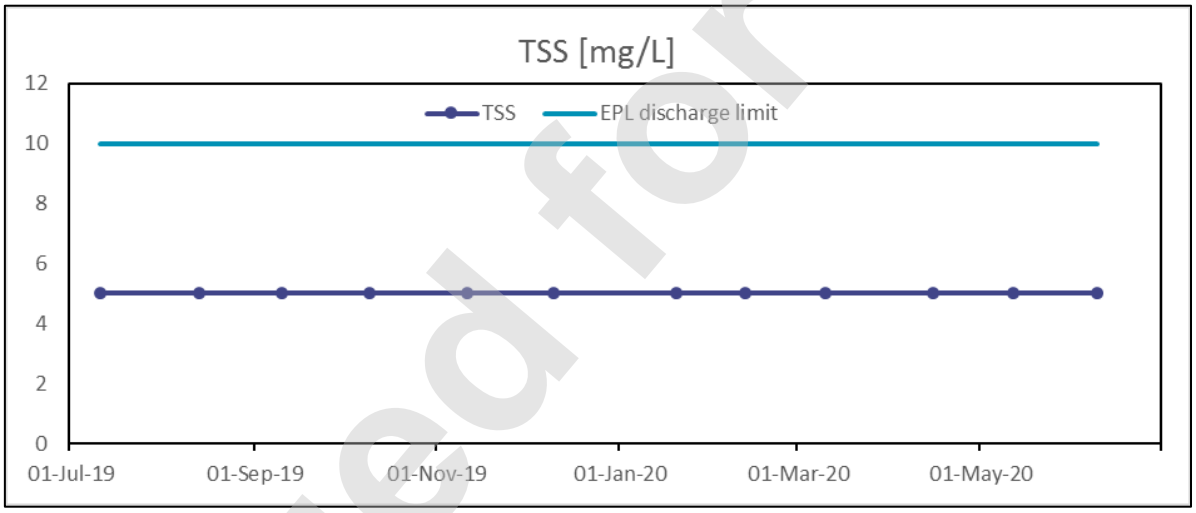
C.7 Oil in Water



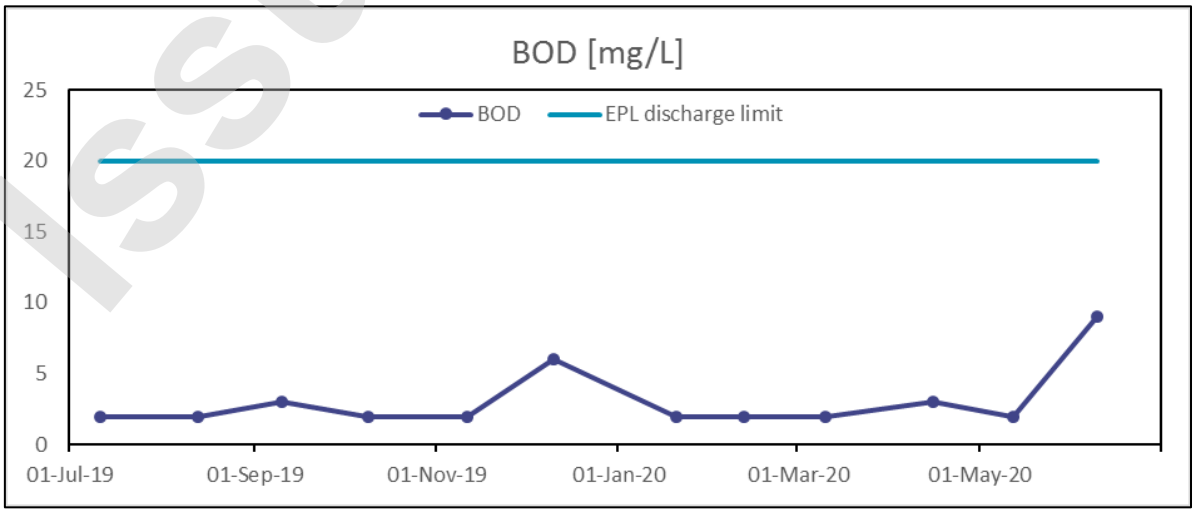
C.8 Total Recoverable Hydrocarbons (C10-C40)



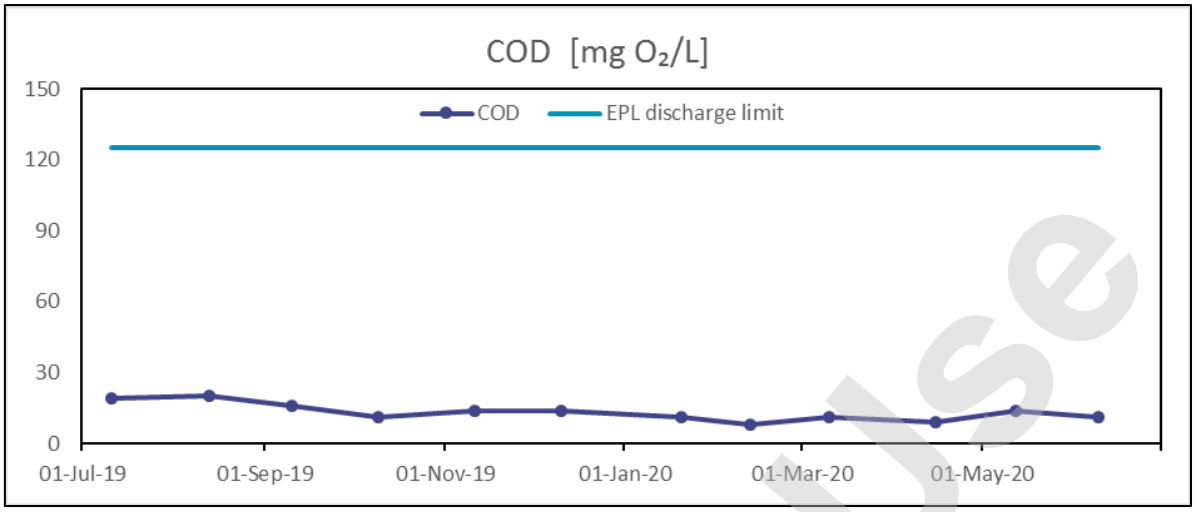
C.9 Total Suspended Solids



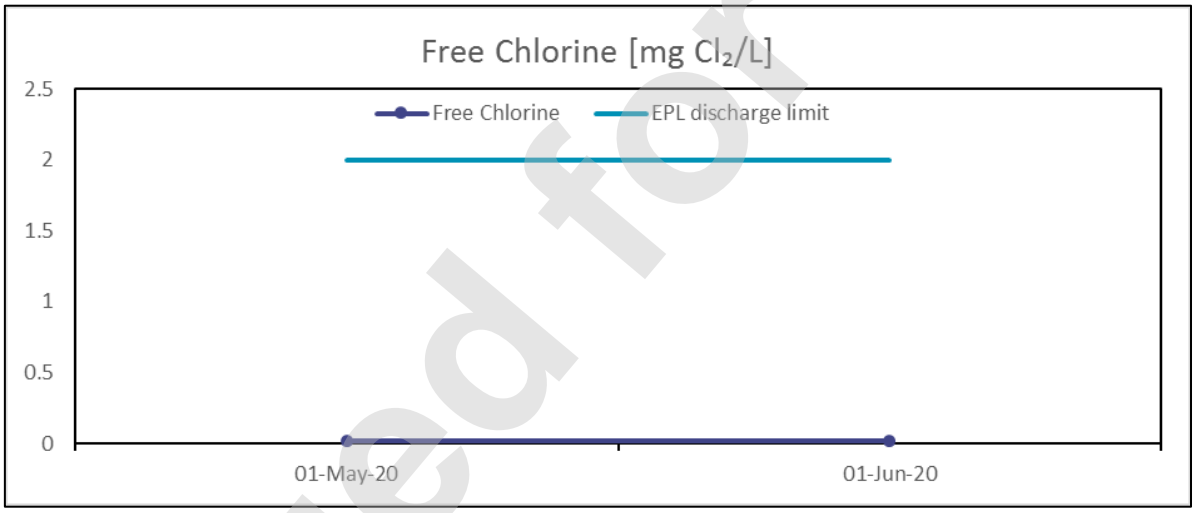
C.10 Biochemical Oxygen Demand



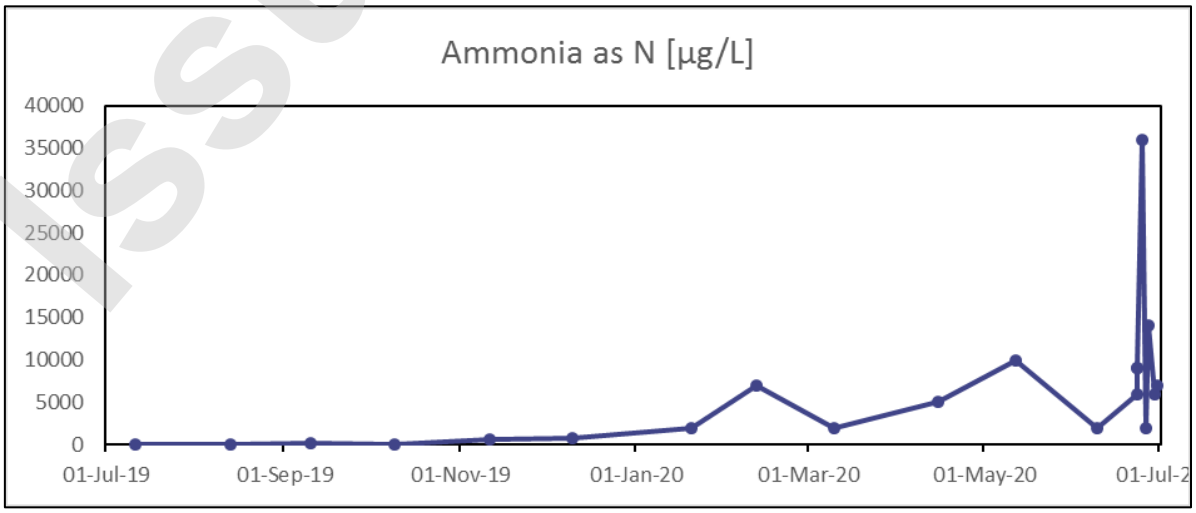
C.11 Chemical Oxygen Demand



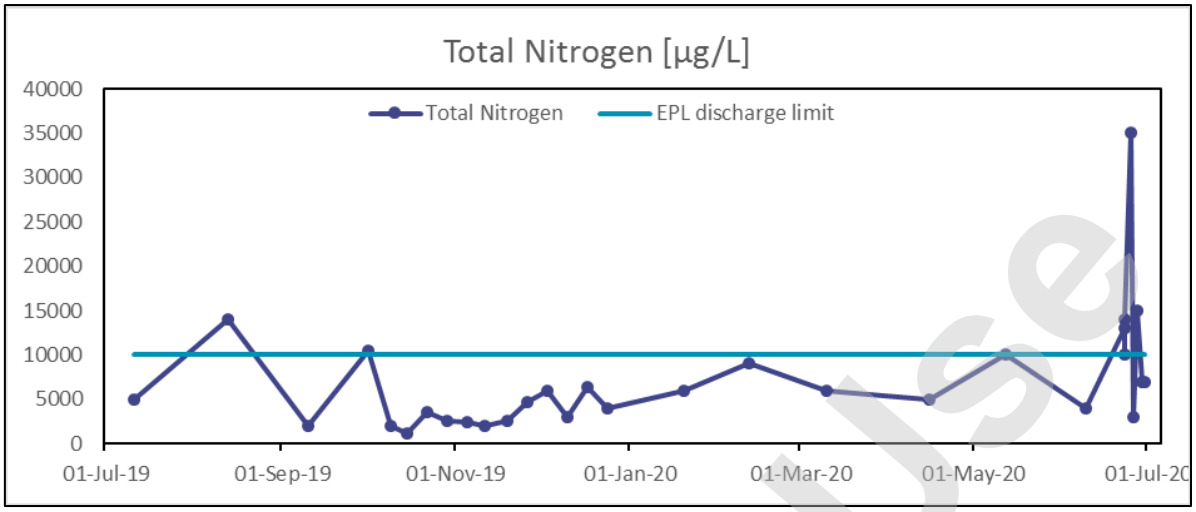
C.12 Free Chlorine



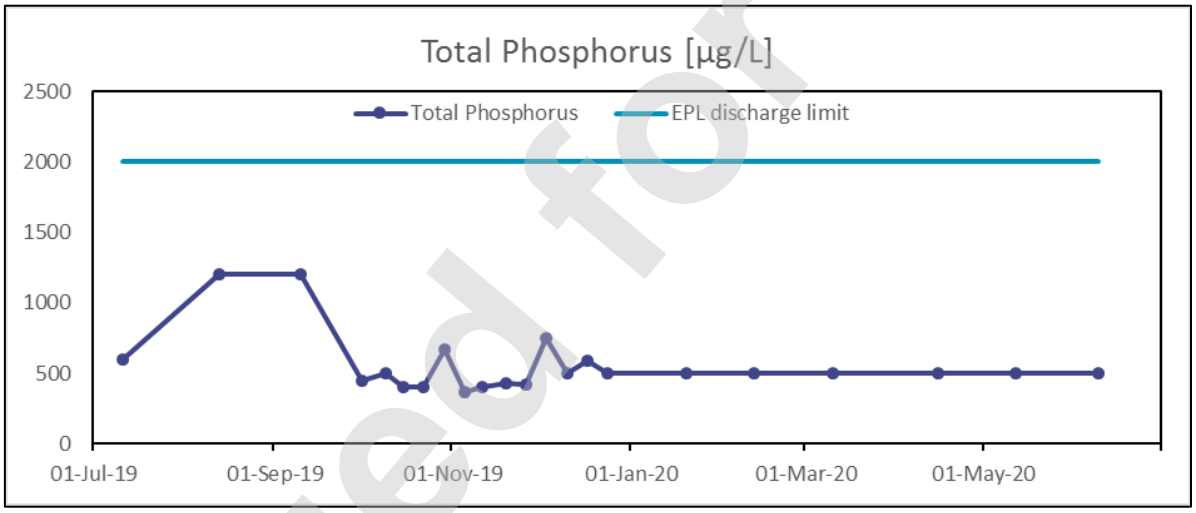
C.13 Ammonia



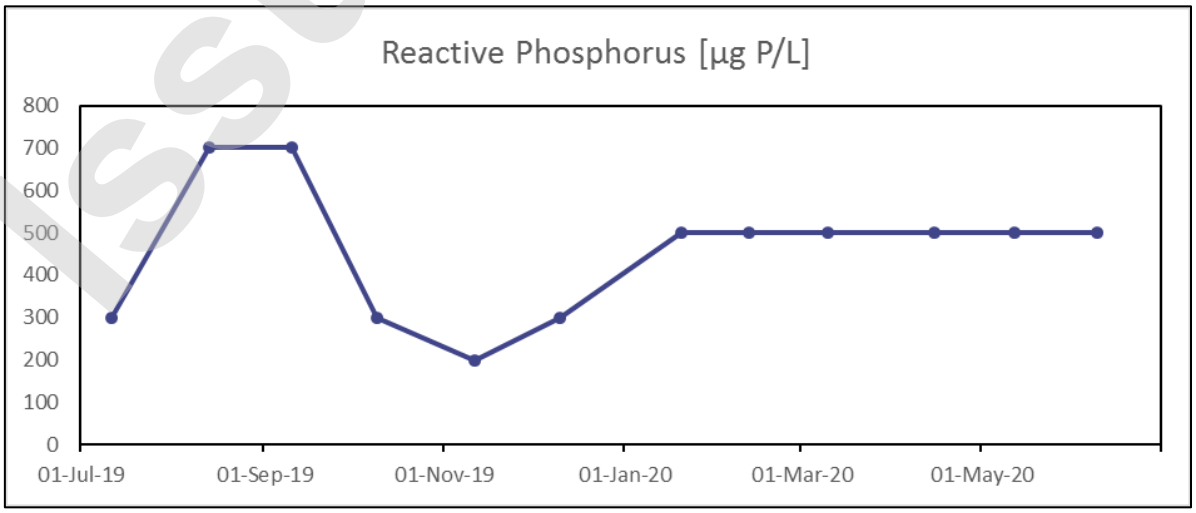
C.14 Total Nitrogen



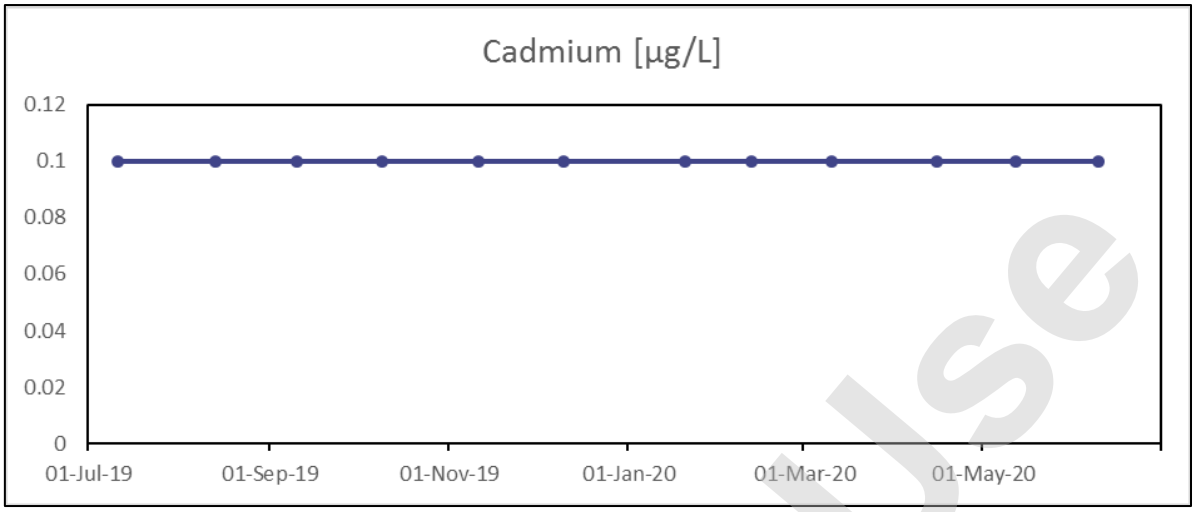
C.15 Total Phosphorus



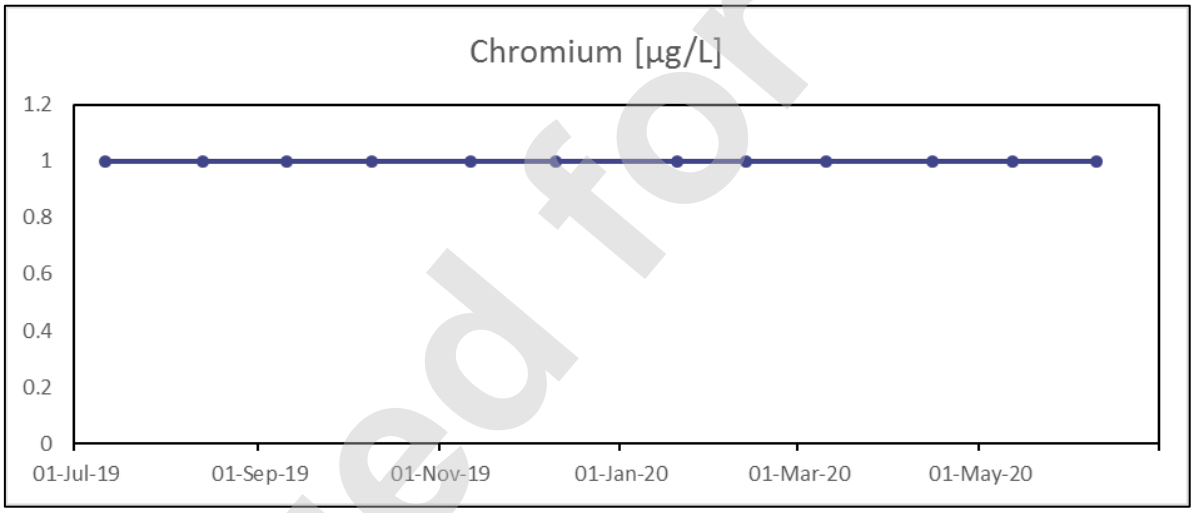
C.16 Filterable Reactive Phosphorus



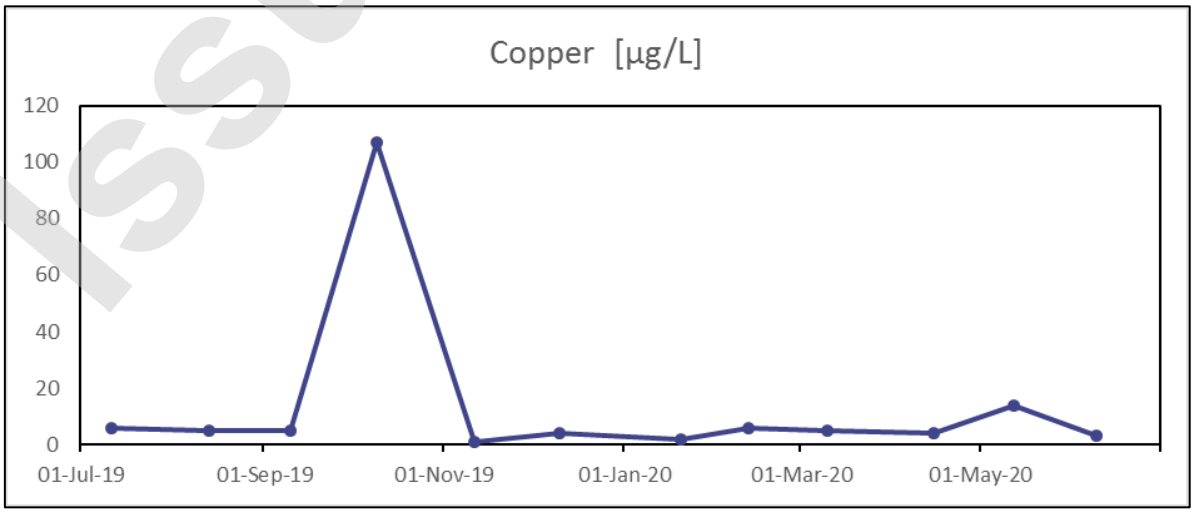
C.17 Cadmium



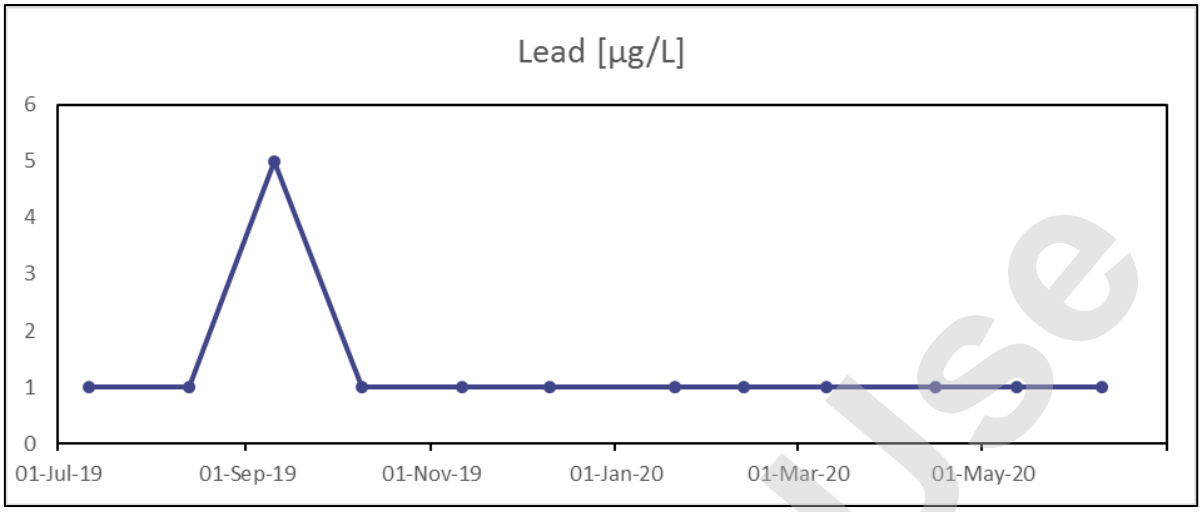
C.18 Chromium



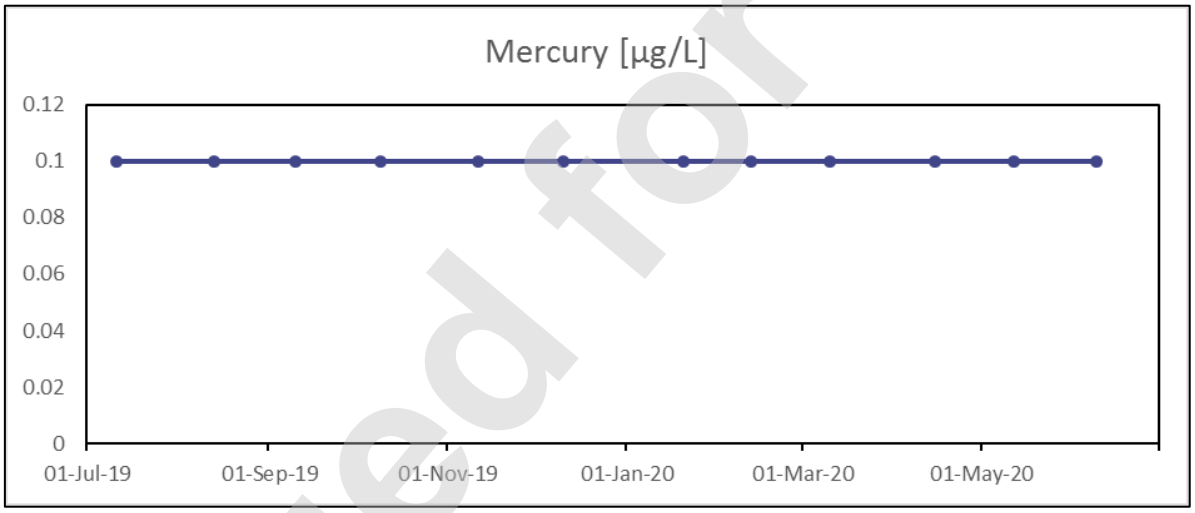
C.19 Copper



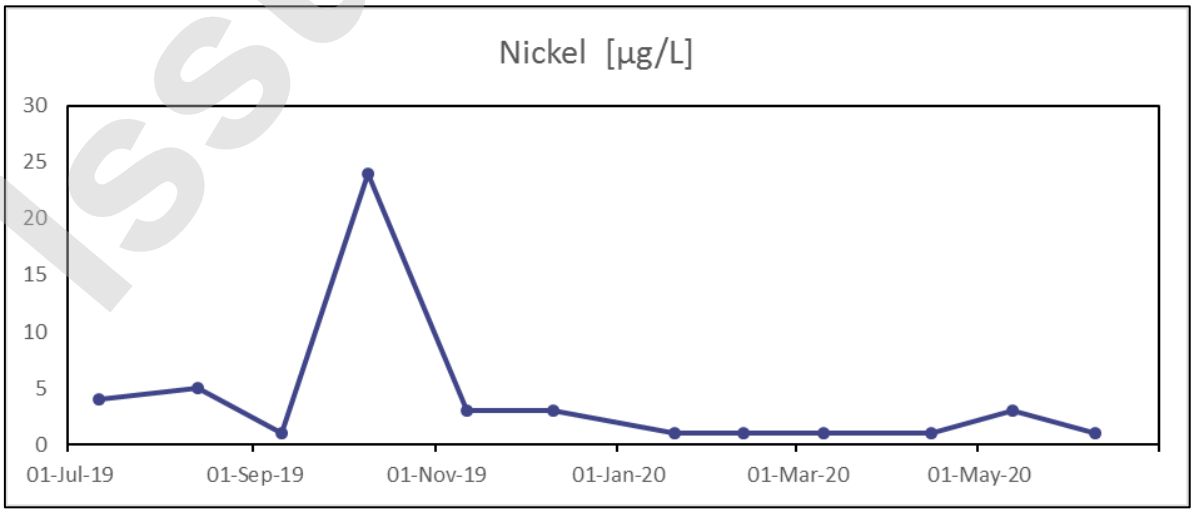
C.20 Lead



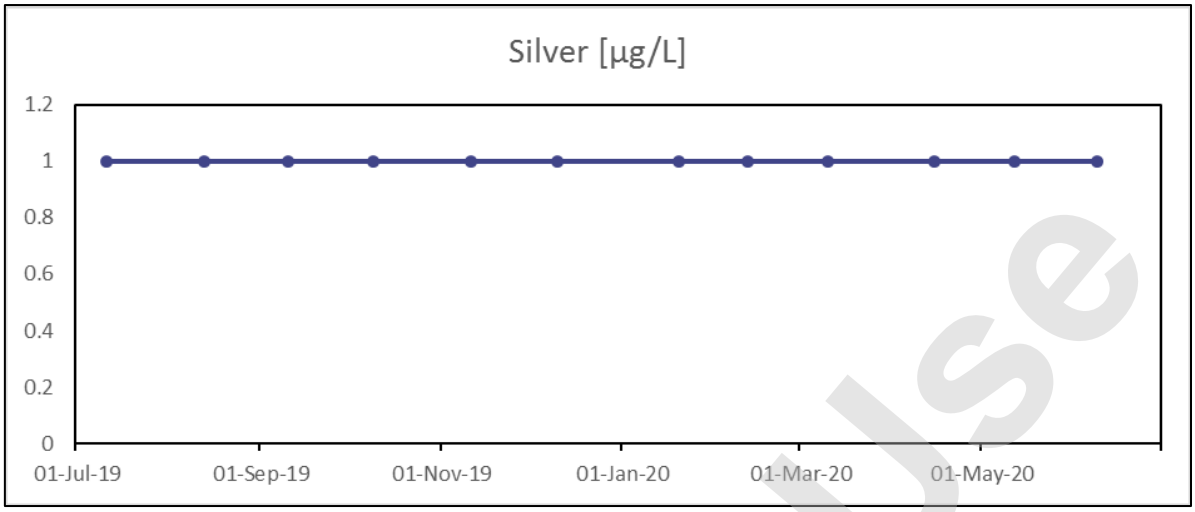
C.21 Mercury



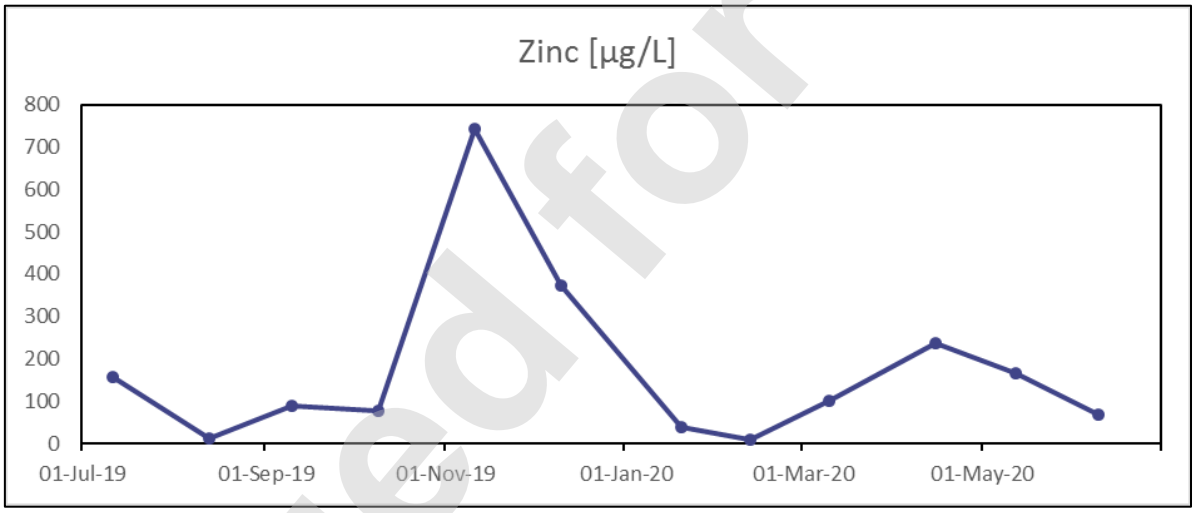
C.22 Nickel



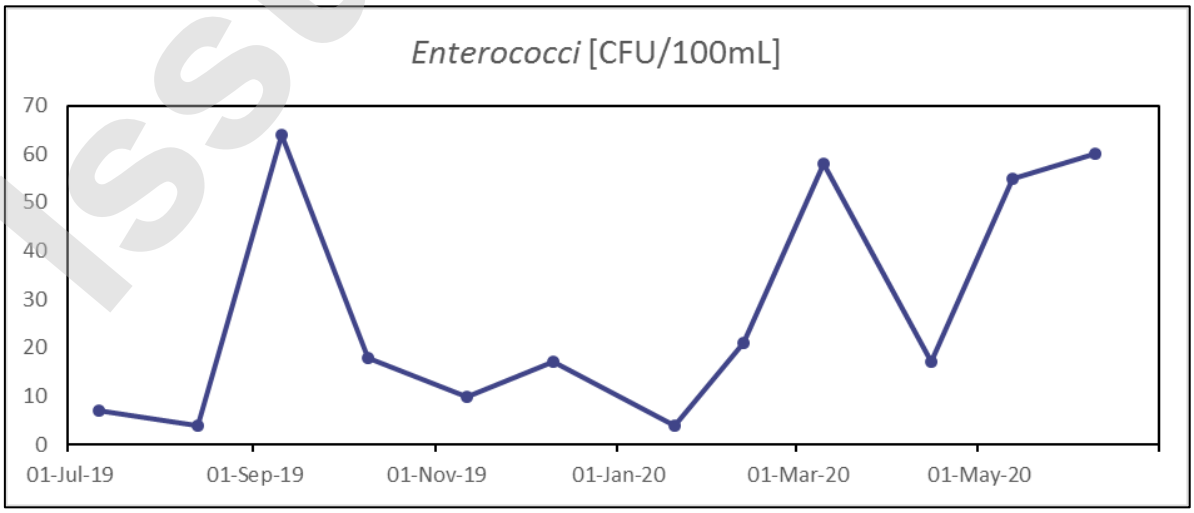
C.23 Silver



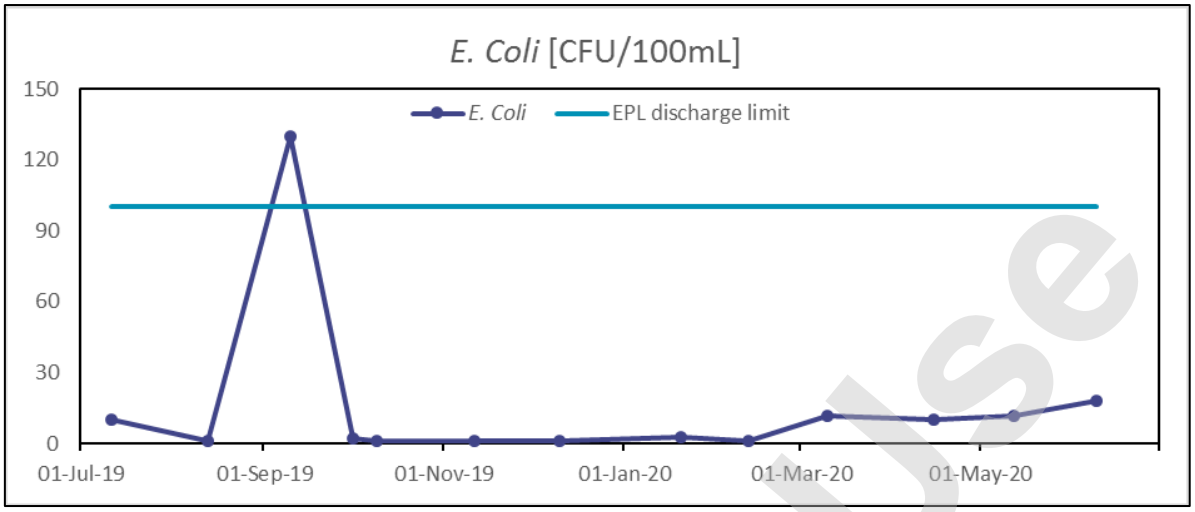
C.24 Zinc



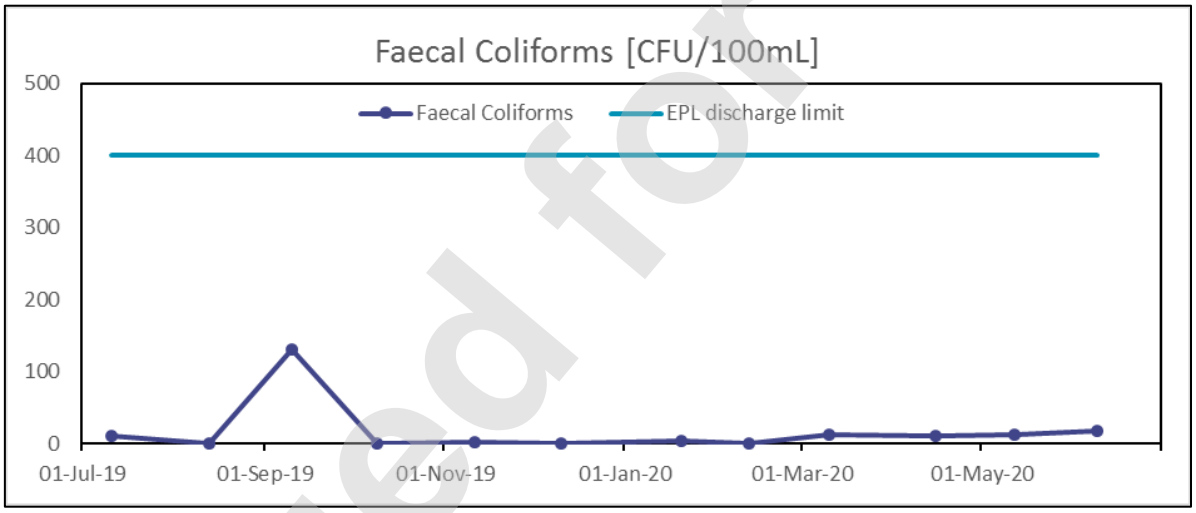
C.25 Enterococci



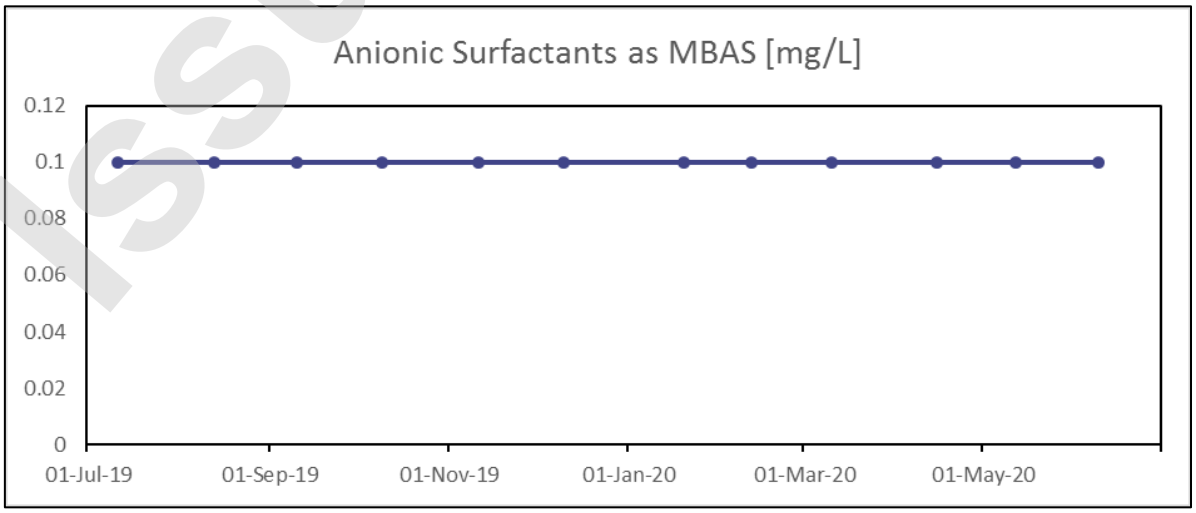
C.26 Escherichia coli



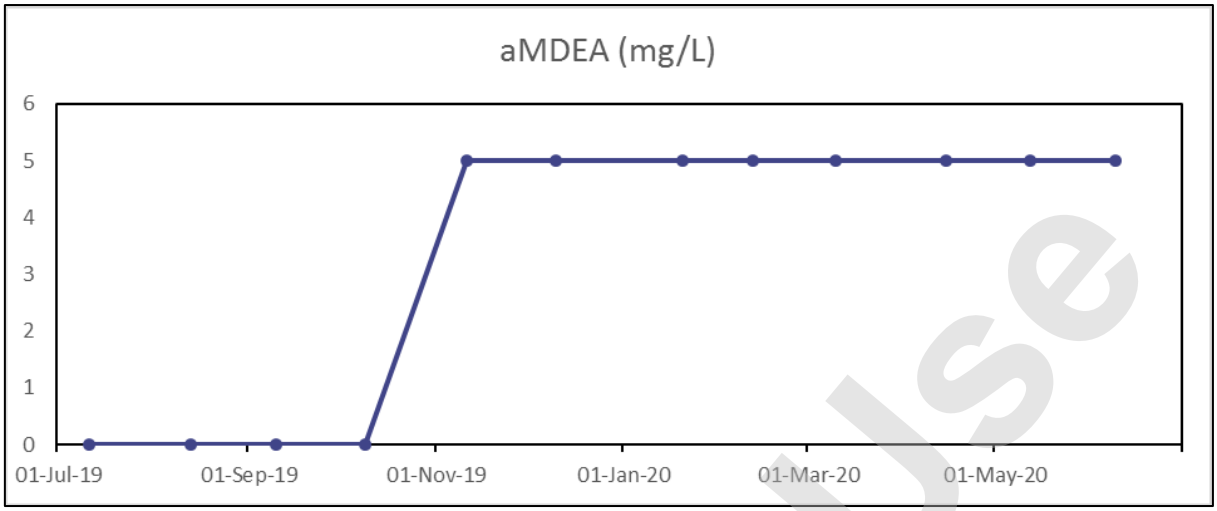
C.27 Faecal Coliforms



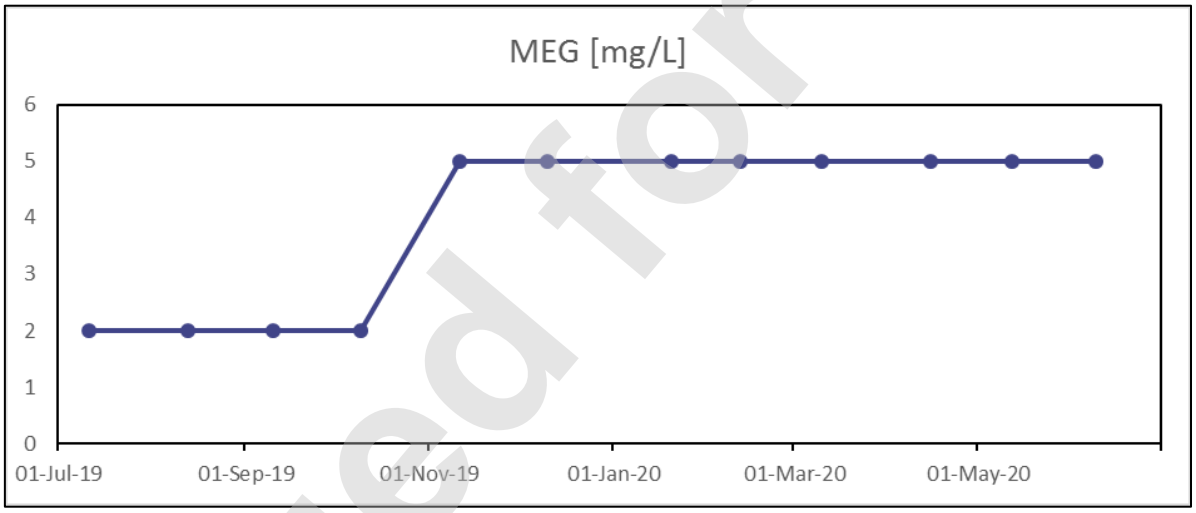
C.28 Anionic Surfactants



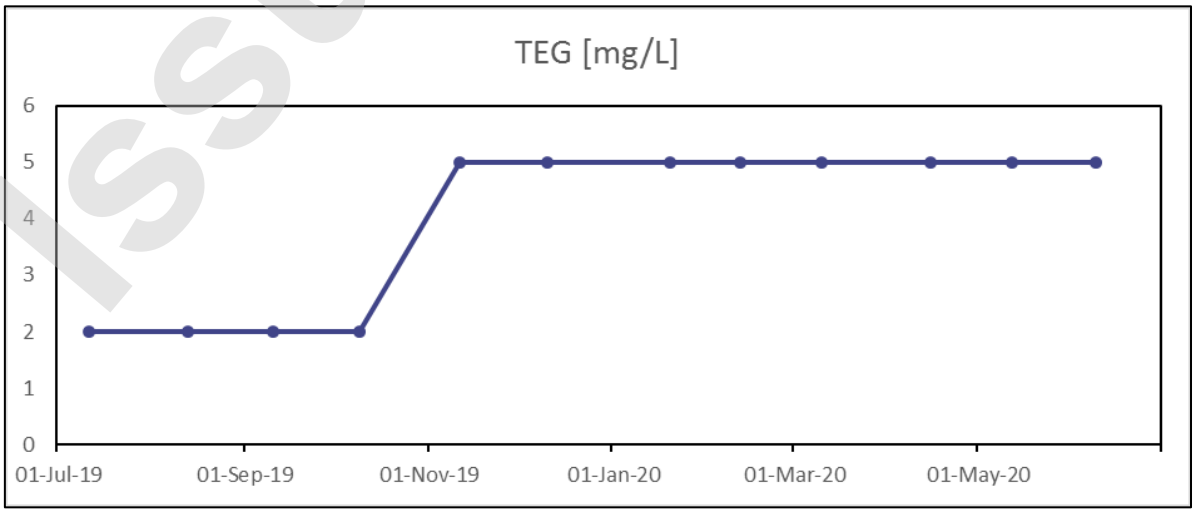
C.29 Activated Methyl Diethanolamine (aMDEA)



C.30 Glycol – MEG



C.31 Glycol – TEG



APPENDIX D: JETTY OUTFALL DATA

Parameter				pH	EC	Temp	Turbidity	DO	Visual clarity and colour	Surface films	Silver (Ag)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Mercury (Hg)	Nickel (Ni)	Lead (Pb)	Zinc (Zn)	Ammonia	FRP	Total phosphorus	Total nitrogen	TSS	TPH as Oil and grease		TPH (C6 – C36)	Enterococci
Trigger value				Outside 6 to 8.5	-	±3 ambient	±10 ambient	Outside the range of 80 to 100	No change from background	None observed	1.4	0.7	4.4	1.3	0.1	7	4.4	15	20	10	30	300	10	No visible sheen or emulsion, no odour	-	<LOR	50
Location	**Date**	**Survey**	**Function**	**pH units**	**µS/cm**	**°C**	**NTU**	**%**	**-**	**-**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**-**	**mg/L**	**µg/L**	**MPN/100mL**
Jetty 01	11/07/2019	4	Impact	8.0	53580	25.69	2	96.9	No change	None	<0.1	<0.1	0.2	0.4	0.05#	0.4	<0.1	1	<3	7	18	120	2	None	<5	<50	<10
Jetty 02	11/07/2019	4	Impact	8.0	53590	25.79	1.7	97.2	No change	Slick present	<0.1	<0.1	<0.2	0.4	0.05#	0.3	0.2	1	<3	10	20	110	1	None	<5	<50	<10
Jetty 03	11/07/2019	4	Impact	8.0	53640	25.87	1.9	97.7	No change	None	<0.1	<0.1	0.3	0.6	0.05#	0.7	0.2	1	<3	7	19	100	2	None	<5	<50	<10
Jetty west	11/07/2019	4	Reference	8.0	53690	25.83	2.1	97.5	No change	None	<0.1	<0.1	0.2	0.8	0.05#	0.5	<0.1	1	<3	7	18	100	1	None	<5	<50	<10
Jetty east	11/07/2019	4	Reference	8.0	53650	25.75	1.8	98.1	No change	None	<0.1	<0.1	0.2	0.4	0.05#	0.3	0.2	<1	<3	7	17	90	3	None	<5	<50	<10
Jetty 01	11/07/2019	4	Duplicate								<0.1	<0.1	<0.2	0.4	0.05#	0.3	<0.1	<1	<3	7	19	120	2	None	<5	<50	<10
Jetty 01	7/10/2019	5	Impact	7.9	54600.0	29.9	2.8	97.8	No change	None	<0.1	<0.1	0.3	0.4	0.05#	0.3	<0.1	2.0	<3	5.0	17.0	120.0	1.0	None	<5	<50	<10
Jetty 02	7/10/2019	5	Impact	7.9	54600.0	29.6	1.6	96.2	No change	None	<0.1	<0.1	0.2	0.4	0.05#	0.4	<0.1	<1	<3	7.0	21.0	120.0	1.0	None	<5	<50	<10
Jetty 03	7/10/2019	5	Impact	7.9	54500.0	29.6	1.9	97.1	No change	None	<0.1	<0.1	0.3	0.5	0.05#	0.4	0.2	<1	<3	6.0	18.0	120.0	2.0	None	<5	<50	<10
Jetty west	7/10/2019	5	Reference	7.9	54600.0	29.5	1.8	97.0	No change	None	<0.1	<0.1	0.2	0.5	0.05#	<0.3	0.1	<1	<3	6.0	19.0	130.0	2.0	None	<5	<50	<10
Jetty east	7/10/2019	5	Reference	7.9	54600.0	29.6	2.1	97.4	No change	None	<0.1	<0.1	0.2	0.4	0.05#	<0.3	0.1	<1	<3	6.0	20.0	140.0	2.0	None	<5	<50	<10
Jetty 01	7/10/2019	5	Duplicate								<0.1	<0.1	0.3	0.5	0.05#	<0.3	<0.1	2	<3	5	16	110	1	None	<5	<50	<10
Jetty 01	4/02/2020	6	Impact	7.8	48290.0	31.3	1.3	101.4	No change	None	<0.1	<0.1	<0.2	0.5	<0.1	<0.3	<0.1	1.0	3.0	3.0	13.0	120.0	4.0	None	<5	<50	**83**
Jetty 02	4/02/2020	6	Impact	7.8	48110.0	31.2	1.1	101.8	No change	None	<0.1	<0.1	<0.2	0.8	<0.1	<0.3	<0.1	7.0	7.0	2.0	11.0	170.0	4.0	None	<5	<50	**98**
Jetty 03	4/02/2020	6	Impact	7.8	48240.0	31.3	1.3	102.1	No change	None	<0.1	<0.1	<0.2	0.6	<0.1	<0.3	<0.1	2.0	5.0	3.0	14.0	130.0	4.0	None	<5	<50	10
Jetty west	4/02/2020	6	Reference	7.8	48340.0	31.4	0.9	101.6	No change	None	<0.1	<0.1	<0.2	0.6	<0.1	<0.3	<0.1	2.0	4.0	2.0	11.0	130.0	3.0	None	<5	<50	10
Jetty east	4/02/2020	6	Reference	7.8	47570.0	30.8	1.4	102.9	No change	None	<0.1	<0.1	<0.2	0.6	<0.1	<0.3	<0.1	2.0	<3	2.0	13.0	130.0	3.0	None	<5	<50	155
Jetty 01	4/02/2020	6	Duplicate								<0.1	<0.1	<0.2	0.5	<0.1	<0.3	<0.1	1	4	<2	12	110	4	None	<5	<50	10
Jetty 01	14/04/2020	7	Impact	7.8	56140.0	33.2	5.1	90.7	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	0.4	<0.1	1.0	5.0	8.0	20.0	130.0	4.0	None	<5	<50	<10
Jetty 02	14/04/2020	7	Impact	7.9	56000.0	33.2	5.4	90.3	No change	None	<0.1	<0.1	<0.2	0.7	<0.1	0.4	<0.1	<1	5.0	8.0	22.0	170.0	5.0	None	<5	<50	<10
Jetty 03	14/04/2020	7	Impact	7.8	56050.0	33.1	6.7	90.3	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	0.5	<0.1	1.0	7.0	8.0	22.0	150.0	6.0	None	<5	<50	<10
Jetty west	14/04/2020	7	Reference	7.9	55810.0	33.1	6.0	88.9	No change	None	<0.1	<0.1	<0.2	0.8	<0.1	0.3	<0.1	<1	7.0	9.0	20.0	140.0	5.0	None	<5	<50	<10
Jetty east	14/04/2020	7	Reference	7.8	55940.0	33.0	5.1	90.6	No change	None	<0.1	<0.1	<0.2	0.4	<0.1	0.3	<0.1	<1	5.0	8.0	23.0	170.0	4.0	None	<5	<50	<10
Jetty 01	14/04/2020	7	Duplicate								<0.1	<0.1	<0.2	0.4	<0.1	0.3	<0.1	1	6	9	21	150	4	None	<5	<50	<10

- The ANZECC/ARMCANZ (2000a) guidelines for water quality monitoring and reporting, suggest that below detection limit data be replaced with half the detection limit. In this case the laboratory LOR is <0.1, therefore half the detection limit equals the trigger value.

APPENDIX E: AUTHORISED STATIONARY SOURCE EMISSION RELEASE RESULTS

E.1 Stationary Source Emission Test results by Ektimo

Sampling Point Number	Sampling Location Number	Date	LIMS Number	NOx as NO2 - Concentration Target		NOx as NO2 - Concentration Limit		N2O		Hg – spiked method USEPA 30B	Hg - un spiked method USEPA 30B	$PM_{2.5}$	PM_{10}	CO		temperature	efflux velocity	volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	mg/Nm³	mg/m³	mg/m³	mg/m³	ppm	^{0}C	m/s	m³/min
LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)				**50 @ 15%O_2**	**25 @ 15%O_2**	**70 @ 15%O_2**	**35 @ 15%O_2**	-	-	-	-	-	-	-	-	-	**23**	-
A1	L-641-A-001	12/08/2019	L2001023001	9.4	4.6	9.3	4.6	<1	<0.5	0.00031	<0.00003	<0.3	<0.3	<1	<1	182	26	16000
		14/11/2019	L2001526001	17	8.1	17	8.1	2.8	1.4	<0.0003	<0.00007	<0.4	<0.4	2.5	2	179	25	15000
		17/02/2020	L2002564001	16	7.9	17	7.9	<1	<0.5	<0.0006	<0.0001	<0.5	<0.5	2.5	2	183	24	14000
A2	L-642-A-001	23/08/2019	L2001025001	19	9.4	19	9.4	1	0.53	0.0016	<0.0001	<0.3	<0.3	<1	<1	178	26	16000
		12/11/2019	L2001529001	15	7.3	16	7.3	3.6	1.8	<0.0006	<0.0001	<0.4	<0.4	2.3	1.9	180	25	16000
		15/02/2020	L2002586001	15	7.2	15	7.2	2.3	1.2	<0.0006	<0.0001	<0.3	<0.3	2.5	2	175	26	16000
A3	L-641-A-002	13/08/2019	L2001024001	24	12	25	12	1.1	0.56	0.0017	<0.00003	<0.3	<0.3	1.9	1.5	176	26	16000
		21/11/2019	L2001527001	19	9	19	9	4.6	2.3	≤0.00061	<0.0001	<0.4	<0.4	1.9	1.5	175	25	15000
		16/02/2020	L2002565001	21	10	22	10	<1	<0.5	<0.0006	<0.0001	<0.3	<0.3	<2	<2	167	24	15000
A4	L-642-A-002	22/08/2019	L2001026001	25	12	25	12	1.1	0.55	0.00098	<0.0001	<0.3	<0.3	<1	<1	176	25	16000
		13/11/2019	L2001530001	22	11	22	11	3.4	1.8	≤0.00021	≤0.0051	<0.4	<0.4	6.6	5.3	170	24	15000
		14/02/2020	L2002587001	16	7.9	15	7.9	2.5	1.3	<0.0006	<0.0001	<0.3	<0.3	2.9	2.3	175	25	16000
CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - conventional stack				**50 @ 15%O_2**	**25 @ 15%O_2**	**70 @ 15%O_2**	**35 @ 15%O_2**	-	-	-	-	-	-	-	-	-	**19**	-
A5-1	L-780-GT-001	21/08/2019	L2001018001	11	5.3	11	5.3	< 1	< 0.5	0.001	<0.0002	<0.6	<0.6	3.1	2.5	597	36	6500
A6-1	L-780-GT-002	16/08/2019	L2001019001	7.4	3.6	7.5	3.6	1	0.53	<0.0006	<0.0002	<0.6	<0.6	7.5	6	585	36	6400
A7-1	L-780-GT-003	24/08/2019	L2001020001	10	5.0	11	5.0	<1	<0.5	0.0015	<0.0002	<0.6	<0.6	1.8	1.5	590	39	6900
A8-1	L-780-GT-004	20/08/2019	L2001021001	17	8.3	17	8.3	<1	<0.5	<0.0007	<0.0001	<0.6	<0.6	3.8	3.1	588	37	6700
A9-1	L-780-GT-005	21/08/2019	L2001022001	12	5.9	12	5.9	<1	<0.5	<0.0005	<0.0001	<0.7	<0.7	8.7	6.9	597	36	6400
CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - HRSG stack				**150 @ 15%O_2**	**75 @ 15%O_2**	**350 @ 15%O_2**	**175 @ 15%O_2**	-	-	-	-	-	-	-	-	-	**19**	-
A5-2	L-630-F-001	20/11/2019	L2001873001	8.3	4.1	11	4.1	2.9	1.5	<0.0006	≤0.00074	<0.7	<0.7	42	34	95	21	6600
		18/02/2020	L2002567001	13	6.3	18	6.3	2.9	1.5	<0.0006	≤0.00074	<0.5	<0.5	22	18	193	22	6900
A6-2	L-630-F-002	20/11/2019	L2001874001	8.7	4.2	11	4.2	2.8	1.4	<0.0006	<0.0006	1	1	74	59	195	22	7200
		18/02/2020	L2002568001	16	7.7	23	7.7	2.7	1.4	≤0.00069	≤0.00016	<0.5	<0.5	43	34	193	22	6800

Sampling Point Number	Sampling Location Number	Date	LIMS Number	NOx as NO2 - Concentration Target		NOx as NO2 - Concentration Limit		N2O		Hg – spiked method USEPA 30B	Hg - un spiked method USEPA 30B	$PM_{2.5}$	PM_{10}	CO		temperature	efflux velocity	volumetric flow rate
				mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	ppm	mg/Nm³	mg/Nm³	mg/m³	mg/m³	mg/m³	ppm	^{0}C	m/s	m³/min
A7-2	L-630-F-003	17/11/2019	L2001875001	10	5	14	5	4.2	2.1	<0.0006	≤0.00016	0.95	0.95	23	18	232	28	8100
		Q1 2020 survey – unit offline at the time of sampling, no results available																
A8-2	L-630-F-004	19/11/2019	L2001876001	16	7.7	21	7.7	3.7	1.9	<0.0006	<0.0001	<0.7	<0.7	11	8.6	230	23	6700
		20/02/2020	L2002569001	15	7.5	23	7.5	4	2.1	<0.0006	<0.0001	<0.5	<0.5	29	23	196	21	6600
A9-2	L-630-F-005	19/11/2019	L2001877001	14	6.8	19	6.8	3.9	2	<0.0006	<0.0001	<0.7	<0.7	4.9	3.9	222	23	6800
		Q1 2020 survey – unit offline at the time of sampling, no results available																
AGRU Incinerators				**320 @3%O_2**	**160 @3%O_2**	**350@3%O_2**	**175 @15%O_2**	-	-	-	-	-	-	-	-	-	**19**	-
A13-1	L-551-FT-031	Q3 2019 survey – unit offline at the time of sampling, no results available. Refer to sampling data for A13-2 and A13-3 for BTEX, H2S and Hg results, as per EPL228 requirement to test while venting																
		Q4 2019 survey – unit offline at the time of sampling, no results available. Refer to sampling data for A13-2 and A13-3 for BTEX, H2S and Hg results, as per EPL228 requirement to test while venting.																
		16/02/2020	L2002570001	52	26	43	8.4	73	37	<0.0006	≤0.00016	<0.4	<0.4	6.1	4.9	525	20	2700
A14-1	L-552-FT-031	15/08/2019	L2001015001	63	31	59	10	12	5.9	<0.0006	<0.0002	3.3	3.3	220	170	543	21	2700
		22/11/2019	L2001525001	57	28	57	9.2	86	44	<0.0009	<0.0002	<0.6	<0.6	6.4	5.1	527	21	2700
		14/02/2020	L2002571001	150	75	130	25	73	37	<0.0006	≤0.00016	<0.4	<0.4	3.4	2.7	525	19	2400
Heating Medium Furnaces				**160 @3%O_2**	**80 @3%O_2**	**350@3%O_2**	**175 @3%O_2**	-	-	-	-	-	-	-	-	-	-	-
A15	L-640-A-001-A	15/08/2019	L2001016001	150	74	110	74	1.1	0.54	0.0018	<0.0002	<0.7	<0.7	140	110	204	3.5	520
		16/11/2019	L2001531001	150	73	110	73	2.9	1.5	<0.0006	<0.0002	<0.7	<0.7	190	150	211	3.8	550
		19/02/2020	L2002584001	120	57	77	57	<1	<0.5	<0.0006	<0.0001	<0.8	<0.8	140	120	211	3.3	470
A16	L-640-A-001-B	15/08/2019	L2001017001	150	72	110	72	<1	<0.5	0.00062	<0.0002	<0.7	<0.7	120	94	207	3.5	520
		Q4 2019 survey – unit offline at the time of sampling, no results available.																
		19/02/2020	L2002585001	110	54	78	54	<1	<0.5	<0.0005	<0.0001	<0.8	<0.8	150	120	211	3.2	460
TPP GE TM2500 Dual Fuel Turbines (Fuel Source - Gas)				**50 @15%O_2**	**25 @15%O_2**	**70@15%O_2**	**35 @15%O_2**	-	-	-	-	-	-	-	-	-	-	-
TPP1	TPP1	26/08/2019	L2001027001	**170**	**81**	**120**	**81**	<1	<0.5	0.00054	<0.0001	<0.6	<0.6	26	21	339	27	6200
TPP2	TPP2	26/08/2019	L2001028001	**100**	**50**	**79**	**50**	<1	<0.5	0.0017	<0.0001	<0.6	<0.6	42	34	339	27	6200
TPP3	TPP3	27/08/2019	L2001030001	**65**	**31**	54	31	<1	<0.5	0.0014	<0.0001	<0.6	<0.6	130	110	339	25	5700
TPP4	TPP4	25/08/2019	L2001031001	**70**	**34**	56	34	<1	<0.5	<0.0006	0.00021	<0.6	<0.6	79	63	339	27	6100

E.2 Gas Sampling Test Results Reported by the INPEX Laboratory

Date	LIMS number	Hydrogen Sulfide (H_2S)	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene	Mercury
	Unit	ppmV	ppmV	ppmV	ppmV	ppmV	ppmV	µg/Nm³
A13-2 (L-551-SC-003) AGRU Hot Vent - LNG Train1, prior to release at A3								
28/06/2019	L1903899001	20	< 30	< 30	< 30	< 30	< 30	-
26/07/2019	L1904541001	150	< 30	< 30	< 30	< 30	< 30	-
25/08/2019	L1905115001	140	50	< 30	< 30	< 30	< 30	-
27/09/2019	L1905719001	160	< 30	< 30	< 30	< 30	< 30	-
15/10/2019	L1906026001	150	< 30	< 30	< 30	< 30	< 30	-
13/11/2019	L1906635001	120	< 30	< 30	< 30	< 30	< 30	-
30/12/2019	L1907205001	37	< 30	< 30	< 30	< 30	< 30	-
05/02/2020	L2000199001	140	< 30	< 30	< 30	< 30	< 30	-
11/02/2020	L2000752001	120	< 30	< 30	< 30	< 30	< 30	-
07/03/2020	L2001217001	130	< 30	< 30	< 30	< 30	< 30	-
18/04/2020	L2001832001	140	50	< 30	< 30	< 30	< 30	-
09/05/2020	L2002239001	160	70	< 30	< 30	< 30	< 30	-
16/06/2020	L2002688001	140	130	40	< 30	< 30	< 30	-
A13-3 (L-541-SC-001) Feed gas to AGRU – LNG Train 1 – prior to release at A3								
04/09/2019	L1905260001	-	-	-	-	-	-	<0.005
10/09/2019	L1905357001	-	-	-	-	-	-	<0.005
16/09/2019	L1905512001	-	-	-	-	-	-	<0.005
19/09/2019	L1905618001	-	-	-	-	-	-	<0.005
22/09/2019	L1905620001	-	-	-	-	-	-	<0.005
05/10/2019	L1905866001	-	-	-	-	-	-	<0.005
14/10/2019	L1906029001	-	-	-	-	-	-	<0.005
27/10/2019	L1906308001	-	-	-	-	-	-	<0.005
04/11/2019	L1906483001	-	-	-	-	-	-	< 0.005
07/11/2019	L1906641001	-	-	-	-	-	-	< 0.005
30/11/2019	L1906944001	-	-	-	-	-	-	< 0.005
03/12/2019	L1907072001	-	-	-	-	-	-	< 0.005
06/12/2019	L1907211001	-	-	-	-	-	-	< 0.005
26/12/2019	L1907316001	-	-	-	-	-	-	< 0.005
18/01/2020	L2000313001	-	-	-	-	-	-	< 0.005
16/02/2020	L2000892001	-	-	-	-	-	-	< 0.005
05/04/2020	L2001407001	-	-	-	-	-	-	< 0.005
17/04/2020	L2001915001	-	-	-	-	-	-	< 0.005
16/06/2020	L2002809001	-	-	-	-	-	-	< 0.005
A14-2 (L-552-SC-003) AGRU hot Vent Train2, prior to release at A4								
28/06/2019	L1903900001	50	< 30	< 30	< 30	< 30	< 30	-
23/07/2019	L1904493001	170	< 30	< 30	< 30	< 30	< 30	-
10/08/2019	L1904845001	150	30	< 30	< 30	< 30	< 30	-
29/09/2019	L1905720001	140	< 30	< 30	< 30	< 30	< 30	-
04/10/2019	L1905748001	130	< 30	< 30	< 30	< 30	< 30	-
30/10/2019	L1906327001	140	< 30	< 30	< 30	< 30	< 30	-
13/11/2019	L1906636001	130	< 30	< 30	< 30	< 30	< 30	-

Date	LIMS number	Hydrogen Sulfide (H_2S)	Benzene	Toluene	Ethylbenzene	m/p-Xylene	o-Xylene	Mercury
	Unit	ppmV	ppmV	ppmV	ppmV	ppmV	ppmV	µg/Nm³
27/11/2019	L1906986001	47	< 30	< 30	< 30	< 30	< 30	-
30/12/2019	L1907206001	30	< 30	< 30	< 30	< 30	< 30	-
05/02/2020	L2000200001	100	< 30	< 30	< 30	< 30	< 30	-
11/02/2020	L2000751001	140	< 30	< 30	< 30	< 30	< 30	-
07/03/2020	L2001173001	105	< 30	< 30	< 30	< 30	< 30	-
13/03/2020	L2001339001	120	< 30	< 30	< 30	< 30	< 30	-
29/03/2020	L2001619001	120	< 30	< 30	< 30	< 30	< 30	-
18/04/2020	L2001831001	120	90	30	< 30	< 30	< 30	-
09/05/2020	L2002240001	160	110	50	< 30	< 30	< 30	-
24/05/2020	L2002482001	100	< 30	< 30	< 30	< 30	< 30	-
10/06/2020	L2002687001	140	80	30	< 30	< 30	< 30	-
19/06/2020	L2002871001	100	50	< 30	< 30	< 30	< 30	-
A14-3 (L-542-SC-001) Feed gas to AGRU – LNG Train 2 – prior to release at A4								
26/06/2019	L1904045001	-	-	-	-	-	-	<0.005
14/07/2019	L1904273001	-	-	-	-	-	-	<0.005
22/07/2019	L1904436001	-	-	-	-	-	-	<0.005
05/08/2019	L1904601001	-	-	-	-	-	-	<0.005
12/08/2019	L1904750001	-	-	-	-	-	-	<0.005
20/08/2019	L1905049001	-	-	-	-	-	-	<0.005
02/09/2019	L1905259001	-	-	-	-	-	-	<0.005
10/09/2019	L1905356001	-	-	-	-	-	-	<0.005
28/09/2019	L1905738001	-	-	-	-	-	-	<0.005
05/10/2019	L1905865001	-	-	-	-	-	-	<0.005
14/10/2019	L1906028001	-	-	-	-	-	-	<0.005
27/10/2019	L1906307001	-	-	-	-	-	-	<0.005
04/11/2019	L1906482001	-	-	-	-	-	-	<0.005
13/11/2019	L1906640001	-	-	-	-	-	-	< 0.005
30/11/2019	L1906943001	-	-	-	-	-	-	< 0.005
03/12/2019	L1907071001	-	-	-	-	-	-	< 0.005
06/12/2019	L1907210001	-	-	-	-	-	-	< 0.005
26/12/2019	L1907422001	-	-	-	-	-	-	< 0.005
28/01/2020	L2000472001	-	-	-	-	-	-	< 0.005
24/02/2020	L2001006001	-	-	-	-	-	-	< 0.005
06/03/2020	L2001174001	-	-	-	-	-	-	< 0.005
13/03/2020	L2001340001	-	-	-	-	-	-	< 0.005
29/03/2020	L2001554001	-	-	-	-	-	-	< 0.005
17/04/2020	L2001916001	-	-	-	-	-	-	< 0.005
28/04/2020	L2002078001	-	-	-	-	-	-	< 0.005
23/05/2020	L2002483001	-	-	-	-	-	-	< 0.005
19/06/2020	L2002872001	-	-	-	-	-	-	< 0.005

APPENDIX F: GROUNDWATER QUALITY DATA

Shaded cells indicate trigger exceedances described in Table 4-4.

Survey	Site	Date	Ammonia	Total Nitrogen	Oxides of Nitrogen	Total Phosphorus	FRP	TDS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium VI (Filtered)	Chromium III (Filtered)	Cobalt (Filtered)	Copper (Filtered)	Lead (Filtered)	Manganese (Filtered)	Mercury (Filtered)	Nickel (Filtered)	Silver (Filtered)	Vanadium (Filtered)	Zinc (Filtered)	Benzene	Ethylbenzene	Toluene	Xylene Total	TRH C6-C40	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Temp	SWL - Top of Casing
		Unit	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	%	µS/cm	pH units	mV	˚C	m
		Trigger value	20	300	20	30	10	n/a	24	2.3	0.7	4.4	10	1	1.3	4.4	390	0.1	7	1.4	100	15	500	5	180	75	600	n/a	n/a	6-8.5	n/a	n/a	n/a
4	BPGW01	25/07/2019	30	260	260	10	<10	3.9	90	3	1.4	<0.5	<0.5	13	1.1	2	520	<0.1	9	<0.1	<5	52	<1	<1	<1	<3	<100	-*	1817	4.66	263.8	31.7	4.34
	BPGW07	30/07/2019	420	500	<50	40	<10	230	<10	14	0.3	<0.5	1.2	23	0.7	1	1100	<0.1	25	<0.1	5	130	<1	<1	<1	<3	<100	-*	89992	5.71	69.7	29.5	1.23
	BPGW08A	23/07/2019	150	400	<50	40	<10	7.7	360	3	0.4	<0.5	<0.5	32	2.9	5	2300	<0.1	21	0.4	<5	43	<1	<1	<1	<3	<100	-*	9668	4.43	253.8	31	3.92
	BPGW09	30/07/2019	300	300	<50	60	30	230	<10	85	<0.2	<0.5	1.1	3.9	0.5	<0.2	390	<0.1	2	<0.1	7	130	<1	<1	<1	<3	<100	-*	123266	6.19	-10.4	26.6	1.12
	BPGW13A	24/07/2019	1300	1400	<50	640	<10	27	<10	4	0.4	<0.5	<0.5	10	0.6	2	950	<0.1	5	<0.1	<5	100	<1	<1	<1	<3	<100	0.26	42748	5.64	26.7	28.7	3.13
	BPGW14A	24/07/2019	290	400	<50	320	<10	31	<10	3	1.2	<0.5	<0.5	5	4.9	<0.2	5200	<0.1	4	0.2	<5	73	<1	<1	<1	<3	<100	1.62	36670	5.96	-42.9	21.8	3.55
	BPGW18	24/07/2019	270	700	<50	420	100	270	40	14	<0.2	<0.5	<0.5	0.5	0.6	2.4	79	<0.1	<1	<0.1	<5	110	<1	<1	<1	<3	<100	0.01	87366	6.13	-64.6	29.9	2.62
	BPGW19A	29/07/2019	1600	1600	<50	70	<10	560	<10	8	<0.2	2.6	2.6	<0.2	1	1.5	70	<0.1	<1	<0.1	5	32	<1	<1	<1	<3	<100	0.02	72142	6.27	-158	28.8	1.76
	BPGW20	24/07/2019	120	<200	<50	<10	<10	2.5	<10	2	<0.2	<0.5	<0.5	2.4	0.3	<0.2	47	<0.1	1	<0.1	<5	19	<1	<1	<1	<3	<100	0.20	1903	5.38	-118	29.9	3.45
	BPGW23	24/07/2019	700	700	<50	290	<10	34	630	4	1.6	<0.5	<0.5	110	11	13	9,100	<0.1	43	4.8	<5	130	<1	<1	<1	<3	<100	0.77	50404	4.24	115	26.4	3.38
	BPGW24	23/07/2019	660	900	<50	10	<10	10	<10	5	<0.2	<0.5	<0.5	22	<0.2	<0.2	180	<0.1	5	<0.1	<5	11	<1	<1	<1	<3	<100	0.32	10313	5.67	-156	27.1	2.6
	BPGW25	23/07/2019	250	3400	<50	20	<10	16	<10	11	0.2	<0.5	<0.5	53	0.4	<0.2	2400	<0.1	30	<0.1	<5	75	<1	<1	<1	<3	<100	0.77	50404	5.68	-242	27.7	2.45
	BPGW26	25/07/2019	250	500	<50	10	<10	7.1	<10	5	<0.2	<0.5	<0.5	8.5	<0.2	<0.2	2700	<0.1	1	<0.1	<5	8	<1	<1	<1	<3	<100	-*	11545	4.24	-39.1	29.1	4.12
	BPGW27A	29/07/2019	290	300	<50	10	<10	<1	<10	2	<0.2	<0.5	<0.5	1.2	<0.2	<0.2	24	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-*	2606	5.36	-2384	30.3	3.99
	BPGW28	29/07/2019	670	670	<50	50	<10	490	<10	7	<0.2	<0.5	<0.5	<0.2	0.6	0.6	160	<0.1	<1	<0.1	6	210	<1	<1	<1	<3	<100	3.70	102866	6.5	-65.4	30.3	3.26
	BPGW38A	25/07/2019	150	300	<50	20	<10	7.3	30	4	22	<0.5	<0.5	2.4	0.8	<0.2	89	<0.1	3	<0.1	<5	19	<1	<1	<1	<3	<100	0.01	6068	5.72	21.5	28.7	3.43
	BPGW40	30/07/2019	250	300	<50	20	<10	37	<10	7	<0.2	<0.5	1.7	0.2	0.3	<0.2	65	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-*	4470	6.33	-77.2	29.6	2,41
	BPGW41	29/07/2019	400	500	<50	40	<10	19	<10	5	<0.2	<0.5	<0.5	<0.2	0.5	<0.2	10	<0.1	<1	<0.1	<5	11	<1	<1	<1	<3	<100	1.57	20016	6.67	-76.2	29.7	2.65
	VWP328	25/07/2019	510	1000	<50	190	20	69	<10	550	<0.2	<0.5	<0.5	13	1.1	0.3	510	<0.1	4	<0.1	<5	62	<1	<1	<1	<3	200	0.03	94072	5.96	-30.8	28.4	2.69
	VWP341	23/07/2019	400	500	<50	10	<10	4.8	10	5	<0.2	<0.5	<0.5	69	<0.2	<0.2	920	<0.1	9	<0.1	<5	100	<1	<1	<1	<3	<100	-*	3461	5.4	-15.7	29.3	4.42
5	BPGW01	21/01/2020	<10	<200	<50	30	<10	<1	60	<1	<0.2	<0.5	1.1	2.3	0.9	0.9	120	<0.1	2	<0.1	<5	8	<1	<1	<1	<3	<100	0.21	144.5	4.86	250.6	29.7	1.62
	BPGW07	29/01/2020	500	<201	<50	70	<10	2	<50	41	0.2	<0.5	<0.5	20	<1	<1	1100	<0.1	21	<5	<5	42	<1	<1	<1	<3	<100	0.00	87486	5.67	-15.3	31.6	0.75
	BPGW08A	15/01/2020	110	<200	<50	40	10	25	540	2	0.6	<0.5	<5	44	4	12	3000	<0.1	29	<5	<5	58	<1	<1	<1	<3	<100	-*	14318	4.25	160.4	31.6	3.21
	BPGW09	29/01/2020	470	<200	<50	20	<10	230	<50	80	0.3	<0.5	<0.5	3	3	<1	490	<0.1	2	<5	<5	<5	<1	<1	<1	<3	<100	-*	110839	6.08	-56.5	30.6	0.7
	BPGW13A	16/01/2020	600	790	190	<10	<10	4.1	230	2	0.6	<0.5	<5	11	24	2	400	<0.1	8	<5	<5	220	<1	<1	<1	<3	<100	3.56	8139	5.11	185.8	33.7	2.38
	BPGW14A	16/01/2020	<10	260	260	<10	<10	<1	<50	<1	<0.2	<0.5	<5	<1	<1	<1	50	<0.1	1	<5	<5	23	<1	<1	<1	<3	<100	1.47	2010	5.89	144.4	34.3	2.47
	BPGW18	30/01/2020	280	280	<50	10	<10	65	<10	8	<0.2	<0.5	<0.5	0.3	1.6	<0.2	110	<1	<1	<50	<5	<5	<1	<1	<1	<3	<100	0.03	82311	6.11	-65.9	30.5	2.14
	BPGW19A	21/01/2020	1600	1900	<50	60	20	89	30	9	<0.2	0.5	1.7	<0.2	<0.2	<0.2	110	<0.1	<1	<0.1	6	<5	<1	<1	<1	<3	<100	-*	64005	6.16	-85.7	31.5	1.31
	BPGW20	28/01/2020	500	500	<50	50	<10	3.6	<10	1	<0.2	<0.5	<0.5	2	<0.2	<0.2	36	<0.1	1	<0.1	<5	<5	<1	<1	<1	<3	<100	-*	1570	5.33	-31.1	33.5	2.45
	BPGW23	22/01/2020	<10	<200	70	<10	<10	<1	140	1	0.7	<0.5	<5	27	2	2	3,700	<0.1	15	<5	<5	27	<1	<1	<1	<3	<100	6.02	135.74	4.78	311	29.2	0.96
	BPGW24	22/01/2020	30	1230	430	<10	<10	<1	280	1	<0.2	<0.5	<5	8	4	<1	100	<0.1	3	<5	<5	14	<1	<1	<1	<3	<100	1.66	1008	5.34	154.7	28.6	0.96
	BPGW25	22/01/2020	380	400	<50	<10	<10	24	120	12	0.4	<0.5	<5	110	<1	<1	4700	<0.1	45	<5	<5	130	<1	<1	<1	<3	<100	-*	29599	5.41	40.3	29.6	1.19
	BPGW26	23/01/2020	<200	<200	<50	<10	<10	2.7	<10	7	<0.2	<0.5	<0.5	7.6	<0.2	<0.2	3300	<0.1	2	<0.1	<5	7	<1	<1	<1	<3	<100	-*	12830	5.47	72.3	31.9	2.86
	BPGW27A	21/01/2020	20	<200	<50	60	<10	<1	<10	2	<0.2	<0.5	<0.5	1.8	<0.2	<0.2	27	<0.1	<1	<0.1	<5	6	<1	<1	<1	<3	<100	0.00	3626	4.95	133.8	32.5	3.44
	BPGW28	28/01/2020	600	600	<50	50	<10	45	<10	3	<0.2	<0.5	<0.5	<0.2	0.5	0.3	220	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	0.15	116540	6.47	-71.4	31.8	2.82
	BPGW38A	23/01/2020	<10	360	360	<10	<10	<1	<10	<1	<0.2	<0.5	<0.5	<0.2	0.4	<0.2	<5	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	2.77	362.3	6.54	135.3	32.6	2.16
	BPGW40	23/01/2020	390	390	<50	<10	<10	26	<10	9	<0.2	<0.5	<0.5	0.5	<0.2	<0.2	180	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-*	7300	6.2	-95.7	30.6	1.96
	BPGW41	23/01/2020	300	300	<50	390	<10	17	<10	7	<0.2	<0.5	<0.5	<0.2	<0.2	<0.2	20	<0.1	<1	<0.1	<5	<5	<1	<1	<1	<3	<100	-*	22552	6.53	-99.8	30.4	2.17
	VWP328	16/01/2020	320	400	<50	<10	<10	56	<50	440	<0.2	<0.5	<5	13	3	1	690	<0.1	5	<5	<5	12	<1	<1	<1	<3	<100	0.12	904382	5.91	-38	31.9	2.58
	VWP341	30/01/2020	470	470	<50	10	<10	1.2	10	5	<0.2	<0.5	<0.5	88	<0.2	0.2	1300	<0.1	12	<0.1	<5	140	<1	<1	<1	<3	<100	0.10	3739	5.33	67.7	32.6	3.76

*CFI reading was negative, as such data is considered erroneous and has not been included.

Document Endorsement and Approvals

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Name	Title

Electronic Endorsement and Approval

Electronic approval of this document complies with the issued INPEX Electronic Approval Standard (0000-A9-STD-60011) and records evidence that the applicable person has either endorsed and/or approved the content contained within this document. The reviewers of this document are recorded in the CDS.

Name	Title	Date and Time	Action
Chris Blackburn	Production Manager	22/09/20 10:20	Approver
Jake Prout	Environmental Operation	22/09/20 09:18	Endorser