EPL228 Annual Environmental Monitoring Report 2021-2022

Report

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Abbreviation and definitions

Abbreviation	Description
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
CO	carbon monoxide
COA	certificate of analysis
COC	continuously oily contaminated
COD	chemical oxygen demand
COVID-19	disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)
DEPWS	Department of Environment, Parks and Water Security (NT)

Abbreviation	Description
DO	dissolved oxygen
EC	electrical conductivity
E. coli	*Escherichia coli*
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
LNG	liquified natural gas
LOR	limit of reporting
LPG	liquified propane gas
m	metre
mm	millimetres
MEG	mono ethylene glycol
MDEA	methyl diethanolamine
mg/kg	milligram per kilogram
ml	millilitres
MLSS	mixed liquid suspended solids

Abbreviation	Description
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
NOx	nitrogen oxide (NO and/or NO_2)
NPI	National Pollutant Inventory
NSW	New South Wales
NT	Northern Territory
NT DITT	Northern Territory Department of Industry, Tourism and Trade
NT EPA	Northern Territory Environment Protection Authority
O_2	oxygen
O_3	ozone
OEMP	Onshore Operations Environmental Management Plan
PAH	polycyclic aromatic hydrocarbons
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

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

EXECUTIVE SUMMARY

Ichthys LNG Pty Ltd (INPEX) was issued Environment Protection Licence 228 (as amended from time to time) on 13 December 2017 (**EPL228**). Activation of EPL228 occurred on 14 September 2018 triggering several EPL228 monitoring conditions and Onshore Operations Environmental Management Plan (OEMP) 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 2021 to 30 June 2022.

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, etc.) found that monitoring results were consistent with those reported during the previous years' 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.

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 2019/2020 Annual Environmental Monitoring Report, the Ichthys LNG facility has been in steady state operations. The key milestones are shown in Section 1.4.1.

1.1 Purpose

The purpose of the 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 2021 to 30 June 2022.

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

EPL288 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
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
87.4	summarise operating conditions of each emission source and the resulting air emission quality;	3

EPL288 Condition #	Condition detail	Section
87.5	provide total emissions to air in tonnes per year for the air quality parameters listed in Table 6 in Appendix 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
87.7	report on outcomes of the Receiving Environment Monitoring Program (REMP) monitoring and assessment;	This AEMR
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 objective

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. Monitoring was undertaken in accordance with the Onshore Operations Environmental Management Plan (OEMP) and EPL228 requirements.

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
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
Groundwater quality	To detect changes in groundwater quality and determine if these changes are attributable to Ichthys LNG operations.	4.1

Program	Objective	Section
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.	5.5
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. 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
Oct 2021	Environmental audit undertaken by a qualified auditor in accordance with EPL228 condition 34.
Oct 2021	Completion of 24 months of Ambient Air and Air Toxics monitoring.
Jan 2022	Addendum to statutory environmental audit submitted to NT EPA, specific to regional air quality.
Apr 2022	OEMP revision 8 endorsed. OEMP revised to remove reference to condition 55 of EPL228-04 and revision of monitoring programs following review of the 2020/2021 AEMR.
June 2022	Major scheduled maintenance shutdown commenced 26 June 2022 on both Trains 1 and 2.

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Figure 1-1: Ichthys LNG 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.

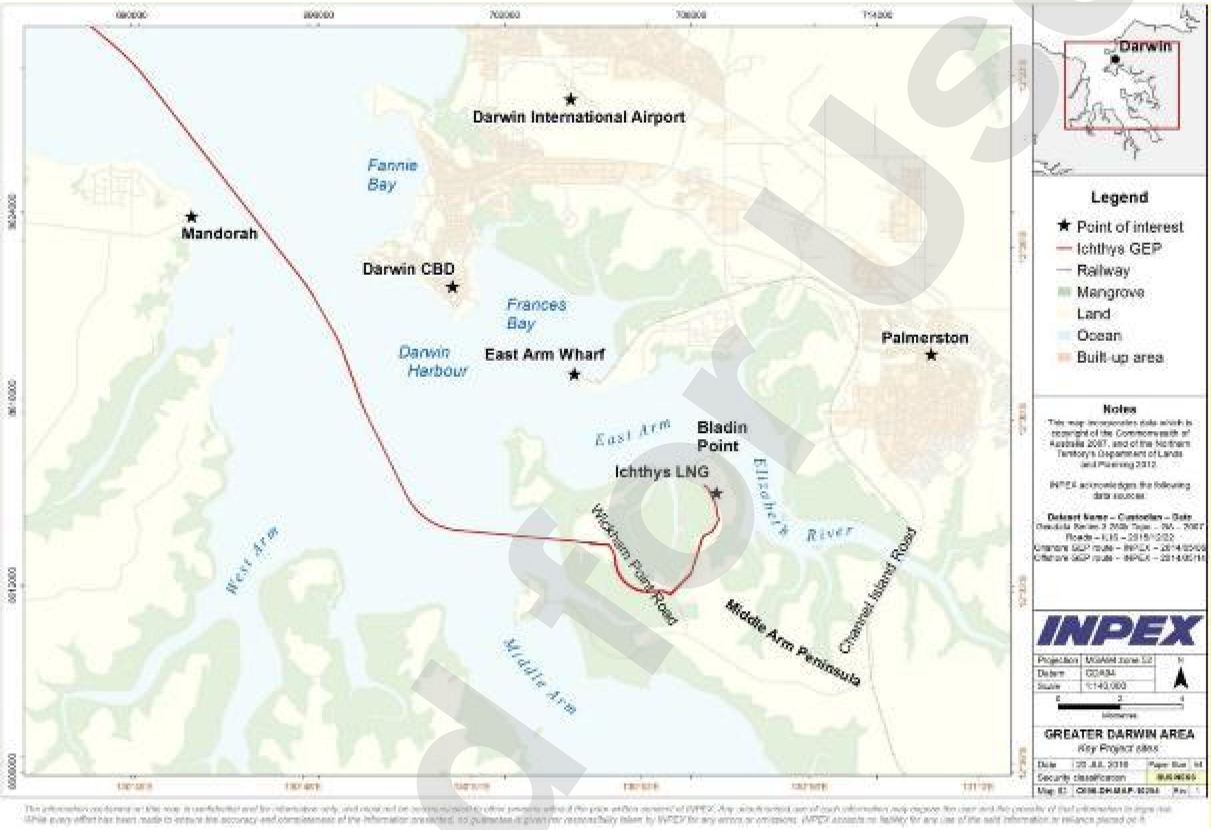

Figure 1-2: Location of Ichthys LNG

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 2020/21 wet season was the wettest since 2017/2018, with 1,271.7 mm of rainfall recorded (Table 1-4 and Figure 1-3).

Table 1-4: Bladin Point wet season and transitional months 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
2020/2021	69.1	87.8	343.5	333.5	194.7	163.4	55.6	1,247.5
2021/2022	67.9	131.9	282.0	357.0	222.2	121.2	89.6	1,271.7

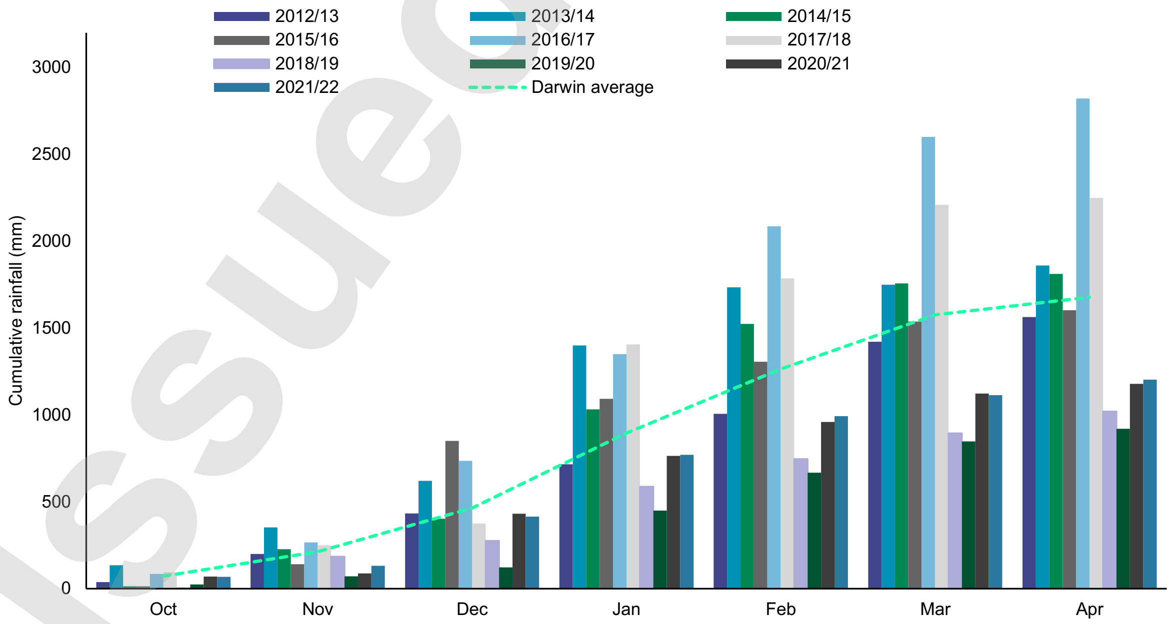

Figure 1-3: Bladin Point cumulative wet seasons

2 DISCHARGES TO WATER

This section describes the outcomes of the comingled treated effluent wastewater monitoring program.

2.1 Commingled treated effluent

The key objective of commingled treated effluent sampling (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 monthly (refer to Table 2-1). Note, biological samples taken on 8 February 2022, were delivered late by the contracted sample courier resulting in the samples being outside of holding times. As such, a re-sample for biological samples was undertaken on 14 February 2022.

Table 2-1: Commingled treated effluent sampling dates

Sample month	Sample collection date
Jul-2021	6*, 20, 23*, 25*
Aug-2021	17, 19*
Sep-2021	14
Oct-2021	12, 18*
Nov-2021	9
Dec-2021	7
Jan-2022	11
Feb-2022	8, 14‡
Mar-2022	8
Apr-2022	13, 26†
May-2022	10
Jun-2022	14

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

† QA/QC sampling.

‡ re-sample of biological parameters due to courier late delivery, resulting in original samples being outside holding times.

2.1.1 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.

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 entered 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
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	INPEX Lab	mg/L	0.02	2

Parameter	Sampling method*	Unit	LOR	Discharge limit
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.

2.1.2 Results and discussion

Routine monitoring results

The results for 750-SC-003 sampling for the reporting period are presented in APPENDIX C:.

During the reporting period, there were three occurrences where wastewater quality was above discharge limits, these are further discussed in Section 2.1.3. Note, following an initial exceedance, further sampling at 750-SC-003 was undertaken to confirm the results as part of an investigation. Any elevated results during the investigation sampling process are considered part of an ongoing original event and the results are included in APPENDIX C:.

Overall, there was 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.

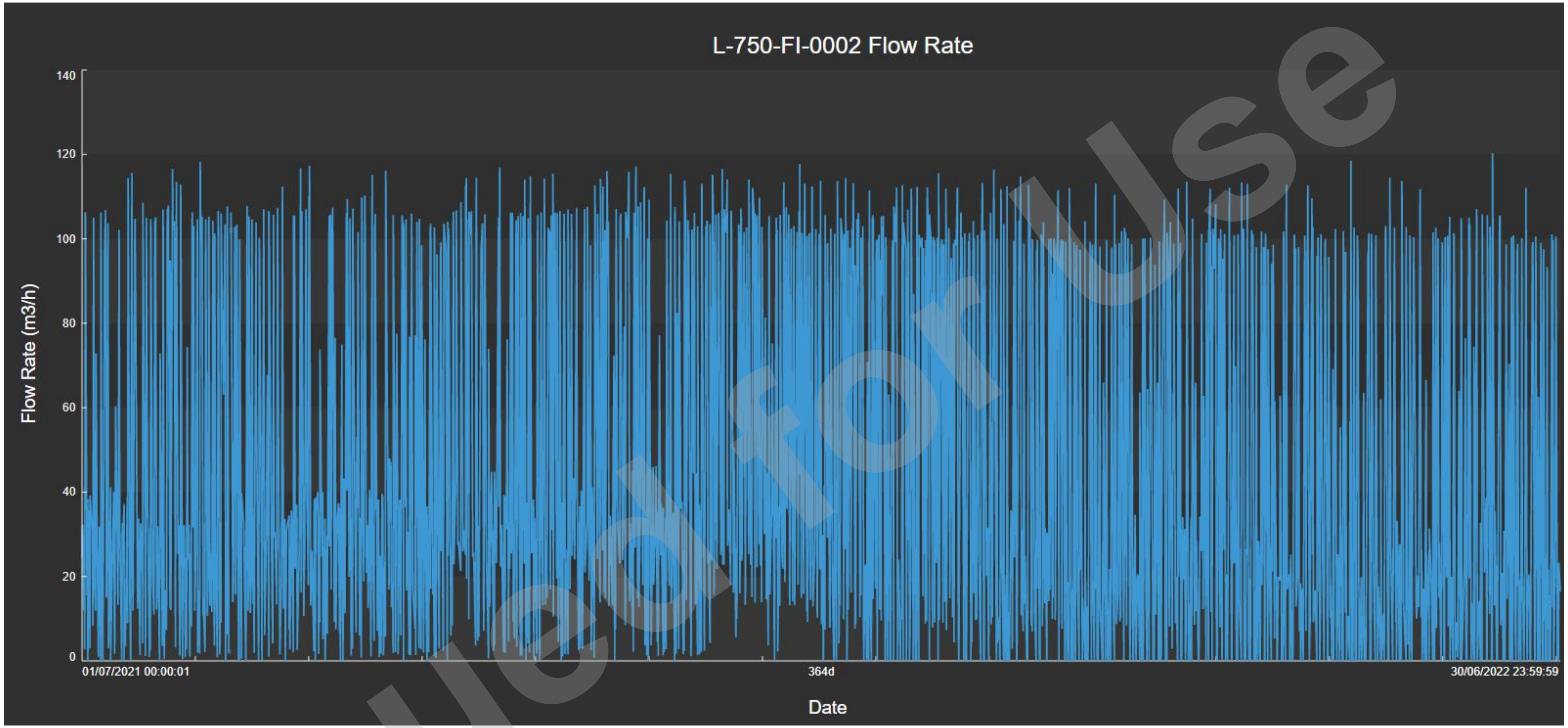

Figure 2-1: Flow rate measured at L-750-FI-0002 flow meter

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
- laboratory designated sample holding times met
- chain of custody forms were completed and accompanied the samples
- INPEX laboratory QA/QC procedures were completed as follows:
  - 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.

Note, biological samples taken on 8 February 2022, were delivered late by the contracted sample courier resulting in the samples being outside of holding times and could not be analysed. As such, a resample for biological samples in was undertaken on 14 February 2022.

2.1.3 Limit exceedances assessment outcomes

Throughout the reporting period, and displayed on the COAs, there were three discharge limit exceedances (refer to APPENDIX C:). A summary table of all discharge limit exceedances, including corrective actions is provided in Table 2-3.

Table 2-3: Summary of commingled treated effluent sample point exceedance events

Date sampled	Exceedance reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
20-July-21	20-July 201	TN	TN 19 mg/L	TN 10 mg/L	During the sampling events on 20 July 2021, only three of the four wastewater streams were flowing into the combined jetty discharge outfall line, being treated steam blowdown, demineralised reject brine and treated sewage. Previous routine sampling undertaken on 19 July 2021 upstream at the treated sewage (sample location 750-SC-009), reported that the sewage treatment plant was working effectively with nitrate results of 1.3 mg/L and it was not the source of the elevated TN. Further sampling on 23 Jul 2021 confirmed the sewage plant was operating in a stable condition. The investigation considered whether the elevated TN was originating from the steam plant within the combine cycle power plant (CCPP), due to the TN comprising mostly of ammonia. A low flow sampling event at location 750-SC-003 (with only the treated steam blowdown and demineralised reject brine) was undertaken, and sampling up-stream in the steam plant of the CCPP confirmed the off-specification waste water was originating from the steam plant. It was subsequently identified in the afternoon of 20 July 2021, that the ammonia dosing pump (which injects ammonia into the steam header) was faulty and overdosing ammonia into the steam system, with the pump still operational with a zero percentage stroke rate (at a zero percent stroke rate no dosing should be occurring). The pump was taken offline for repair, and dosing was switched across to an alternative pump.	The faulty dosing pump was taken offline in the afternoon of 20 July 2021 and dosing undertaken from the secondary ammonia dosing pump. In addition an additional service water flush was added into the jetty outfall discharge pipe to reduce the ammonia levels on the evening of 20 July 2021. Through the incident investigation the following action was identified to prevent reoccurrence: • The faulty ammonia dosing pump is to be repaired and recalibrated. • The reliability of the ammonia dosing pumps will be reviewed.
17-Aug-21	18-Aug-21	TN	TN 12 mg/L	TN 10 mg/L	During the sampling events on 17 August 2021, only three of the four wastewater streams were flowing into the combined jetty discharge outfall line, being treated steam blowdown, demineralised reject brine and treated sewage. Sampling undertaken on 18 August 2021 upstream at the treated sewage (sample location 750-SC-009), reported that the sewage treatment plant was working effectively with a TN results of <2 mg/L and it was not the source of the elevated TN. The investigation considered whether the elevated TN was originating from the steam plant within the combine cycle power plant (CCPP), due to the TN comprising mostly of ammonia. Sampling up-stream in the steam plant of the CCPP confirmed the off-specification waste water was originating from this location.	Through the incident investigation the following actions were identified to prevent reoccurrence: • A trial will be undertaken where the flush wastewater from the ACC LRVP on steam generator 2, will be redirected and captured in a standalone 20 m^3 isotainer with the waste to be taken to either the evaporation basin or offsite for disposal by a licenced waste contractor. • Repairs will continue on the faulty ammonia dosing pumps.

Date sampled	Exceedance reported	Parameter	Result	Limit	Cause and/or contributing factors	Corrective actions
					It was subsequently identified that ammonia is potentially being concentrated in the discharge of the seal flush wastewater stream of the liquid ring vacuum pump (LRVP), in a separator tank, located in the steam air cooled condenser(ACC) system (this waste stream is then treated in a flash tank prior to then flowing to the CCPP blowdown neutralisation plant). In addition, repair works are still ongoing with the ammonia dosing pumps (which injects ammonia into the steam header) so there is potential that overdosing into the steam system is still ongoing. Repair works on the dosing pumps will likely be completed by the end of October 2021.	
12-Oct-21	13-Oct-21	TN	TN 13 mg/L	TN 10 mg/L	During the sampling events on 12 October 2021, all four wastewater streams were flowing into the combined jetty discharge outfall line, being treated steam blowdown, demineralised reject brine, treated sewage and treated accidentally oily contaminated wastewater . Sampling undertaken on 13 October 2021 upstream at the treated sewage (sample location 750-SC-009), reported that the sewage treatment plant was working effectively with a TN results of 8 mg/L and it was not the source of the elevated TN. The investigation considered whether the elevated TN was originating from the steam plant within the combine cycle power plant (CCPP), due to the TN comprising mostly of ammonia. Sampling up-stream in the steam plant of the CCPP confirmed the off-specification waste water was originating from this location. It was subsequently identified that in late September 2021 INPEX increased the operational pressures in the heat recovery steam generation units (HRSGs) due to power limitations (due to a steam turbine being out of service). This then caused a reaction to commence where soluble commissioning contaminants (left over from original commissioning activities, most likely in dead legs of system) such as silica and sodium dissolved and then was identified in much higher concentration levels than in previous operational testing. In an attempt to reduce these contaminant levels, steam blowdown volumes were increased. This had the undesired consequence of adding in higher than normal levels of ammonia to the steam blowdown treatment package. In addition it was also identified that through the improved performance of the recently serviced ammonia dosing pumps (which were previously unreliable) the target pH (9.8) of the boiler feed water was consistently being achieved, this resulted in increased ammonia usage at the site. This, coupled with the increased steam blowdown led to the increased TN levels in the wastewater stream.	To reduce the ammonia levels, additional service water was added into the system, where possible, upstream of the neutralisation plant. Blowdown volumes are now decreasing to normal levels as the contaminates are gradually being removed from the system. Through the incident investigation the following actions were identified to prevent reoccurrence: • Investigate the installation of a condensate water polisher (to remove impurities/contaminates from return condensate) in the steam system. • Transfer of excess blowdown to the evaporation basin and/or offsite for disposal during times of excessive blowdown due to issues with steam chemistry.

In general, the total nitrogen discharge limit exceedances reported in Table 2-3 above, have been related to ammonia dosing into the steam system of the CCPP. There are four ammonia dosing locations (with each location having one operational pump and a spare pump on standby) into the steam system. In total there are 8 ammonia dosing pumps at the facility (4 operational and four spare).

Following the identification of a faulty ammonia dosing pump, the pump was taken offline, and the spare pump was brought online into service. This allowed for the faulty pump to be removed for repairs either at the INPEX workshop or offsite at a maintenance contractor's workshop.

In addition to improving the reliability of the dosing pumps, INPEX has also changed the location of ammonia dosing, from the feedwater manifold, to direct into steam condensate manifold of the steam system, this occurred in March 2022. This allows for better control of the dosing into the steam system.

With the change in dosing location and improved management of the pumps, there has been a reduction in the consumption rate of ammonia, this has reduced the risk of overdosing in the system. In October 2021, 9,000 L of ammonia was consumed, compare to 7,000 L/per month which is the current consumption rate.

There have been no exceedances of total nitrogen in the discharge wastewater at location 750-SC-003 since 18 October 2021 till September 2022.

It is considered the main change in the improvement of ammonia dosing, and reduction in chemical usage, is due to the new dosing locations in the steam system.

2.1.4 Program rationalisation

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

2.2 Harbour sediment

Harbour sediment monitoring did not occur in the 2021/22 reporting period. As reported in the 2020/2021 AEMR, and following the completion of three years of sampling, the harbour sediment monitoring frequency was reduced to biennial. This is in accordance with the OEMP.

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).

This section also summarises the 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 emissions 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)
NOx as nitrogen dioxide (NO_2)	2096.17
Nitrous oxide (N_2O)	4.9
Mercury (Hg)	0
Particle matter 2.5 ($PM_{2.5}$)	111.62
Particle matter 10 (PM_{10})	111.62
Carbon monoxide (CO)	3567.27
Benzene	5.84
Toluene	5.92
Ethylbenzene	0.94
Xylenes	2.84
Hydrogen sulphide (H_2S)	97.20

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 the LNG trains and the CCPP (in combined cycle) reached steady-state, which occurred 21 October 2019. Following the completion of the first year of monitoring, the air toxics sampling frequency was reduced down from monthly to quarterly.

Table 3-2 provides a summary of the ambient air quality and air toxics monitoring surveys completed during this year's AEMR reporting period. In accordance with EPL228 Condition 55, the ambient air quality and air toxics programs ceased in October 2021, following 24 months of monitoring whilst the facility was operating in a steady-state.

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

Date	Report
July 2021	ATM-Quarterly-Report-July 2021
October 2021	ATM-Quarterly-Report-October 2021

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 Northern Territory (NT) Government's ambient air quality network. This was conducted weekly and reported on a monthly/quarterly basis, with an annual review after the first 12 months and a final review post 24 months steady-state operations.

INPEX reviews data from the NT EPA ambient air quality network 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 ($PM_{2.5}$). Data is then compared against the standards for pollutants specified in the National Environment Protection (Ambient Air Quality) Measure (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, Frances Bay, Stokes Hill site (decommissioned in April 2021), 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 is 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, Stokes Hill (now decommissioned) and Frances Bay 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† (Air NEPM)	Units
NO_2	1 hour	0.0038	0.08 (1 day/yr allowable exceedance)	ppm
	Annual	0.0031	0.015	
SO_2	1 hour	0.0005	0.1 (1 day/yr allowable exceedance)	
	24 hour	0.0005	0.02 (1 day/yr allowable exceedance)	
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.

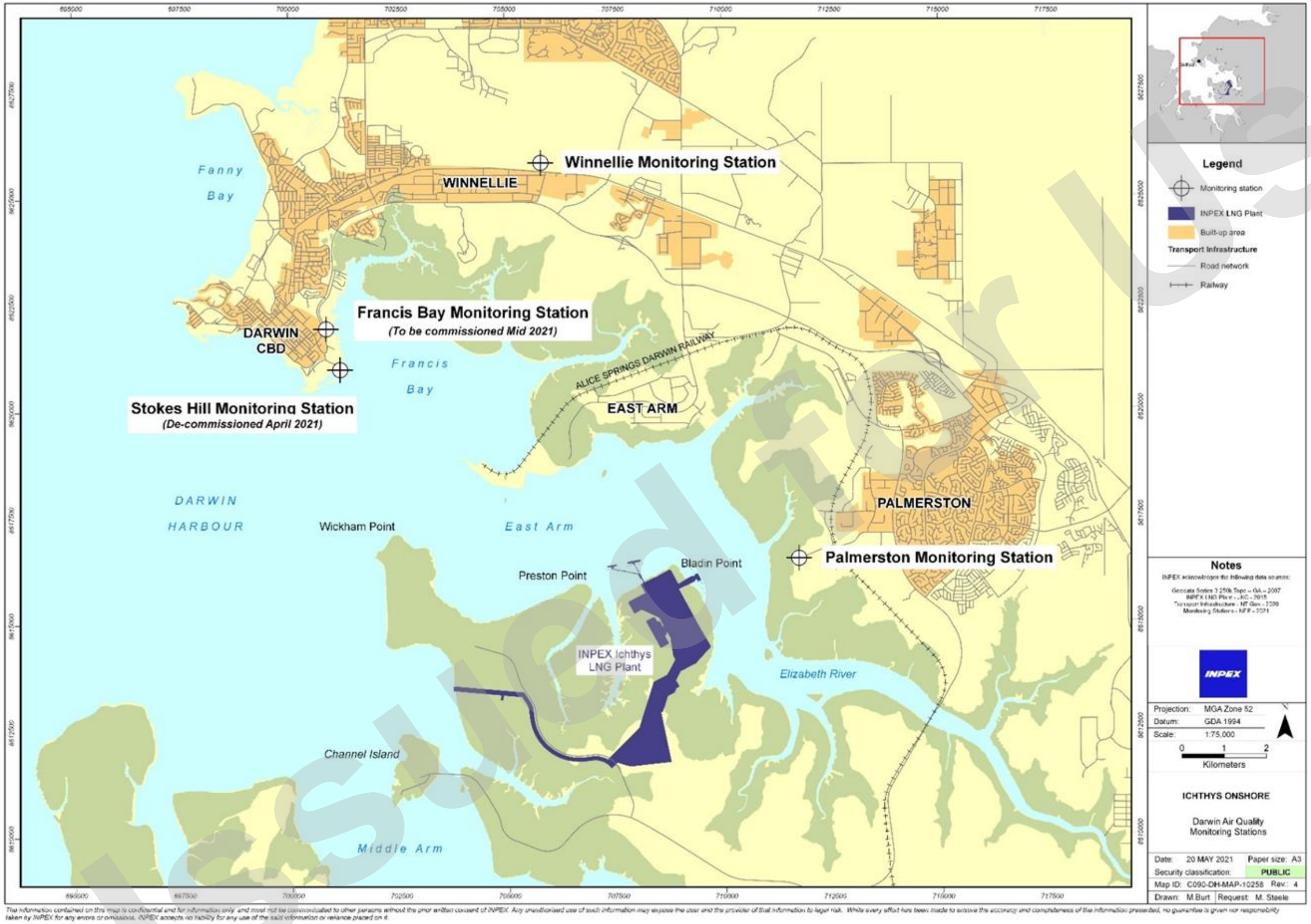

Figure 3-1: NT EPA ambient air quality monitoring station locations

Air Toxics Monitoring

INPEX commenced air toxics ground level monitoring in October 2019. The program was 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 program comprised of monthly monitoring for the first year, after which the frequency reduced to quarterly for the second year.

The receptor locations, when considered in conjunction with prevailing winds and peak dispersion modelling predictions, indicate 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 network monitoring stations were 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 undertook 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 data is then compared against the standards for pollutants specified in the National Environment Protection (Air Toxics) Measure (Air Toxics NEPM), for the Winnellie, Frances Bay and Palmerston AQMS.

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

Consideration was 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 (Air Toxics NEPM)*	Units
Benzene	Annual	0.003	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.

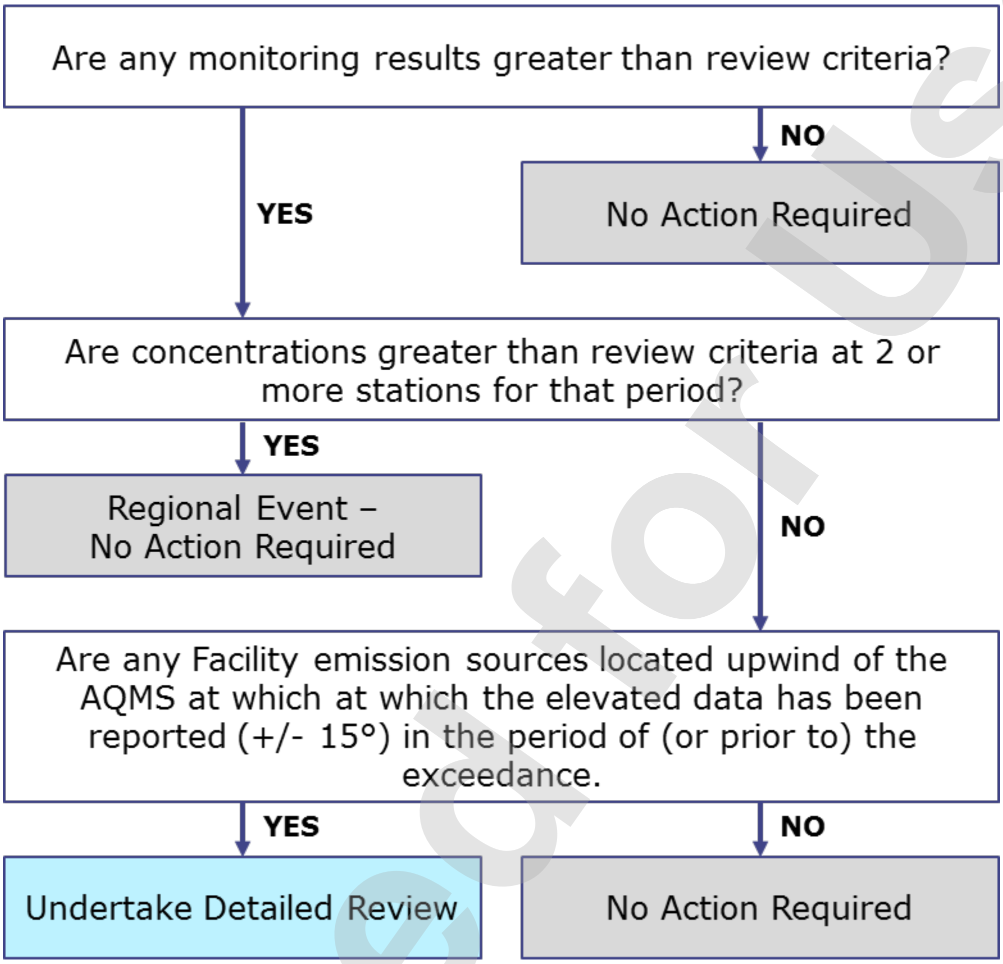

Figure 3-2: Data review process for short-term ambient air quality parameters

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. Results highlighted in bold exceed the review criteria.

During the reporting period, all results of the air toxics monitoring were below the relevant Air Toxics NEPM criteria, (Table 3-4), 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 AQMSs were below the review criteria for each parameter, with the exception of PM_{10} and $PM_{2.5}$.

The NT Department of Environment, Parks and Water Security (DEPWS) 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 outcome of 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 (GHD, Ichthys LNG Air Quality Monitoring Report – August 2019 to October 2021).

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 2021-2022 AEMR reporting period

Period	**Sampling point**	**NO_2**	**SO_2**		**PM_{10}**	**$PM_{2.5}$**	**Benzene**	**Toluene**	**Xylenes**
Quarterly (Nov 20 – Oct 21)	Averaging Period	1 h	1 h	24 h	24 h	24 h	24 h	24 h	24 h
	Unit	ppm	ppm	ppm	μg/m³	μg/m³	-	ppm	ppm
	Review criteria	0.08	0.1	0.02	50	25	N/A	1	0.25
Jul-21	Palmerston	0.0137	0.0774	0.0039	49	**39**	<0.0006	<0.0019	<0.0007
	Frances Bay	0.0263	0.0070	0.0017	**51**	**33**	<0.0006	<0.0019	<0.0007
	Winnellie	0.0201	0.0067	0.0017	**128**	**132**	<0.0006	<0.0019	<0.0007
Oct-21	Palmerston	0.064	0.043	0.0054	**244**	**226**	0.0022	0.0045	0.0035
	Frances Bay	0.024	0.0028	0.0022	**108**	24	<0.0006	<0.0019	<0.0014
	Winnellie	0.019	0.0061	0.0019	**53**	**31**	<0.0009	<0.0019	<0.0014

3.2.3 Review of ambient air and air toxics data

A summary of compliance, for the final review of ambient air and air toxics monitoring data, August 2019 to October 2021 is presented in Table 3-6. It is noted that a number of monthly data reports were assessed in accordance with the now superseded Ichthys LNG Project Environment Protection Licence 228-01 (EPL228-01). In summary, Ichthys LNG operations were not found to contribute significantly to elevated levels or exceedances of any pollutant for any month in the Darwin air shed during 24 month monitoring period.

Table 3-6: Air monitoring compliance summary

<table>
<tr><th>Month</th><th>Compliance with Air Toxics NEPM</th><th>Compliance with Air NEPM</th></tr>
<tr><td>August 2019</td><td rowspan="3">All air toxics monitoring returned results below the limits of reporting.</td><td rowspan="3">Exceedances of the review criteria for particulates were recorded, but were not attributed to INPEX operations.</td></tr>
<tr><td>September 2019</td></tr>
<tr><td>October 2019</td></tr>
<tr><td>November 2019</td><td>Benzene was detected above the limit of reporting; however, was not in exceedance of the Air Toxics NEPM review criteria.</td><td>No exceedances of the review criteria were recorded for the period.</td></tr>
<tr><td>December 2020</td><td rowspan="10">All air toxics monitoring returned results below the limits of reporting.</td><td>Exceedances of review criteria for particulates were recorded, but were not attributed to INPEX LNG operations.</td></tr>
<tr><td>January 2020</td><td rowspan="4">No exceedances of the review criteria were recorded for the period.</td></tr>
<tr><td>February 2020</td></tr>
<tr><td>March 2020</td></tr>
<tr><td>April 2020</td></tr>
<tr><td>May 2020</td><td rowspan="3">Exceedances of the review criteria for particulates were recorded, but were not attributed to INPEX LNG operations.</td></tr>
<tr><td>June 2020</td></tr>
<tr><td>July 2020</td></tr>
<tr><td>August 2020</td><td rowspan="3">No exceedances of the review criteria were recorded for the period.</td></tr>
<tr><td>September 2020</td></tr>
<tr><td>October 2020</td><td>Benzene was detected above the limit of reporting; however, was not in exceedance of the Air Toxics NEPM review criteria.</td></tr>
</table>

Month	Compliance with Air Toxics NEPM	Compliance with Air NEPM
November/December 2020, January 2021	All air toxics monitoring returned results below the limits of reporting.	
February/March/April 2021		
May/June/July 2021		Exceedances of the review criteria for particulates were recorded, but were not attributed to INPEX LNG operations.
August/September/October 2021	Benzene, Toluene and Xylene was detected above the limit of reporting; however, was not in exceedance of the Air Toxics NEPM review criteria.	

Summary of ambient air quality data

Table 3-7 provides a summary of the results from the NT EPA AQMS data in comparison to the NEPM Ambient Air Quality review criteria. Where a cell text is bold, this indicates that the site exceeded the relevant criteria value on at least one occasion during the 24 month monitoring period.

As shown in Table 3-7, there were no exceedances for NO_2 or SO_2 during the 24 month monitoring period. Exceedances were recorded for both averaging periods for $PM_{2.5}$ and PM_{10} during the same period. Investigation into these exceedances is discussed further below, in accordance with the review criteria process outlined in Figure 3-2.

Table 3-7: Averaged ambient air results 2019–2021

Table parameter	Averaging period	Review criteria	Palmerston 2019	Palmerston 2020	Palmerston 2021	Stokes Hill 2019	Stokes Hill 2020	Stokes Hill/Frances Bay 2021	Winnellie 2019	Winnellie 2020	Winnellie 2021	Unit
NO_2	1-Hour	0.08	0.0200	0.0160	0.0640	0.0200	0.0210	0.0230	0.0220	0.0210	0.0200	ppm
	Annual	0.015	0.0030	0.0026	0.0030	0.0022	0.0019	0.0031	0.0016	0.0026	0.0026	
SO_2	1-Hour	0.1	0.0029	0.0028	0.077	0.028	0.0027	0.0095	0.0024	0.0012	0.0067	
	24-Hour	0.02	0.0011	0.0011	0.0054	0.0045	0.0011	0.0022	0.00064	0.00085	0.0020	
	Annual	N/A	0.00055	0.00047	0.00053	0.00053	0.00052	0.0010	0.00005	0.00062	0.00072	
PM_{10}	24-Hour	50	**60**	**52**	**244**	**66**	46	**108**	**70**	**52**	**128**	µg/m^3
	Annual	25	**26**	18	17	**25**	18	19	**27**	17	18	
$PM_{2.5}$	24-Hour	25	**31**	**38**	**226**	**35**	**34**	**33**	**37**	**39**	**132**	
	Annual	8	**11**	7.0	**11**	**10**	6.4	6.9	**10**	6.5	**10**	

Review of exceedance of 24-hour criteria for PM_{10} and $PM_{2.5}$

A summary of 24-hour PM_{10} or $PM_{2.5}$ exceedances for the period are presented in Table 3-8. There were a total of 30 exceedances of the PM_{10} review criteria and 69 exceedances of the $PM_{2.5}$ criteria for the24 month monitoring period.

Table 3-8: Number of exceedances of review criteria during the 24 month monitoring period

Pollutant	Number of exceedance of 24-hour review criteria measured at each station		
	Palmerston	Stokes Hill/Frances Bay	Winnellie
PM_{10}	10	8	12
$PM_{2.5}$	22	9	38

Review of regional contribution to exceedances

The review process as outlined in Figure 3-2 provides a mechanism for consideration of the contribution of regional air quality sources to exceedances measured within the Darwin Airshed. One mechanism for establishing whether an exceedance event is influenced by regional factors is on days where measured concentrations are greater than the review criteria at two or more NTEPA AQMS for that period (day).

Furthermore, some consideration should be made where measured concentrations at multiple stations are elevated in comparison to (however not exceeding) the review criteria and/or where concentrations are elevated for a number of days in a row.

The NT DEPWS conduct regular controlled burns in the rural areas and national parks surrounding Darwin during the dry season (May-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 with PM_{10} and $PM_{2.5}$ above the NEPM standard in the dry season.

Of the 30 exceedances of the PM_{10} criteria, 11 were determined to be associated with regional events. Of the 69 exceedances of the $PM_{2.5}$ criteria, 32 were determined to be associated with regional events. The number of non-regional exceedances at each station is presented in Table 3-9.

Table 3-9: Number of exceedances of review criteria not excluded as regional events

Pollutant	Number of exceedance of 24-hour review criteria at each station not excluded as regional events		
	Palmerston	Stokes Hill/Frances Bay	Winnellie
PM_{10}	6	5	8
$PM_{2.5}$	11	0	26

Review of wind conditions during exceedances

The review process as stipulated in Figure 3-2, suggests that where a regional event has not been shown to contribute to the exceedance, then an investigation should be carried out to determine if any facility emission source is upwind during the exceedance. 24-hour vector wind directions are taken from the AQMS where the exceedance is recorded and compared to the direction of the AQMS from the INPEX site. Based on this assessment, of the 19 exceedances of the PM_{10} criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions. Of the 37 exceedances of the $PM_{2.5}$ criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions. A summary of non-regional exceedances where the INPEX site is upwind of the exceedance location is shown in Table 3-10.

Table 3-10: Number of exceedances of 24-hour review criteria measured at each station not excluded as regional events and where INPEX site is downwind of the exceedance location

Pollutant	Number of exceedance of 24-hour review criteria measured at each station not excluded as regional events and where Ichthys LNG is downwind of the exceedance location		
	Palmerston	Stokes Hill/Frances Bay	Winnellie
PM_{10}	1	2	2
$PM_{2.5}$	2	0	3

Discussion of exceedances not excluded by the review process

After the standard review process there were eight days where exceedances of either the $PM_{2.5}$ and/or the PM_{10} criteria occurred. A summary of data during these exceedance days is shown in Table 3-11. Exceedances not removed by the review criteria are shown in purple, with exceedances previously removed by the review criteria shown in green.

Table 3-11 $PM_{2.5}$ and PM_{10} concentrations at all stations on exceedance days

Date	24-hour $PM_{2.5}$ concentration ($\mu g/m^3$)			24-hour PM_{10} concentration ($\mu g/m^3$)		
	Palmerston	Stokes Hill /Frances Bay	Winnellie	Palmerston	Stokes Hill/Frances Bay	Winnellie
13/09/19	23.4	17.0	15.8	50.7	46.4	45.9
14/09/19	30.7	24.5	22.1	59.2	47.7	55.9
13/05/21			28.9			33.9
5/07/21	12.0	10.0	44.2	17.0	27.2	50.1
6/07/21	23.7	14.9	132.2	28.2	28.4	127.9
29/07/21	26.0	22.7	21.5	34.3	38.7	31.9
22/09/21	12.3	5.2	14.0	29.1	67.4	35.9
23/09/21	24.4	23.9	23.4	39.9	94.1	40.4

Discussion of exceedance days

A summary of discussion for each exceedance day is a follows:

- **13 September and 14 September 2019**: A sole PM_{10} exceedance on 13 September and a sole $PM_{2.5}$ exceedance on 14 September were not screened out by the review process. However, PM_{10} exceedances were measured at multiple stations on 14 September and were screened out as a regional event. On 13 September, PM_{10} concentrations were close to exceeding at Stokes Hill and Winnellie, and similarly so for $PM_{2.5}$ on 14 September. Based on the above, it is most likely that the exceedances on 13 and 14 of September 2019 were associated with regional events.
- **13 May 2021**: No data measured at Palmerston or Stokes Hill during this period and as such, classification of this event as a regional event was not possible. Figure 3-3 shows that there were several exceedance days at Winnellie from 13 May 2021 through 29 May 2021, which were excluded due to the facility not being upwind of the station on these days. Given the above, it is likely that in fact the exceedance on 13 May (and others during this month) was associated with a regional event, but was not able to be classified as such without data from Palmerston or Stokes Hill. It is not expected that facility operations contributed to the exceedance on 13 May 2021.
- **05 July 2021 and 06 July 2021**: Exceedances at Winnellie on 05 and 06 July are expected to be associated with instrumentation issues. Figure 3-3 shows that data availability prior to these dates was low, with a negative value recorded on 03 July 2021. The days after the exceedance events saw consecutive negative 24-hour concentrations (-47 and -346 $\mu g/m^3$ for $PM_{2.5}$). After these dates, the instrument was taken offline for six days before being returned to service on 15 July 2021. The above suggests that issues with the instrument produced false/unreliable data and therefore

it is not expected that the facility operations contributed to the exceedances on 05 or 06 July 2021.

- **29 July 2021**: The exceedance at Palmerston was not excluded by the review process as a regional event. However, a review of the data in Figure 3-3 shows that concentrations at all three stations were elevated for a number of days surrounding this period and therefore it is probable that in fact the exceedance on 29 July at Palmerston was a regional event. It is not expected that facility operations contributed to the exceedance on 29 July 2021.
- **22 September 2021 and 23 September 2021**:- Exceedances of the PM_{10} criteria during these days were not screened out by the review process. Figure 3-4 shows a timeseries of 24-hour average PM_{10} concentrations for the months of September and October 2021. The data shows that during later September, data measured at Stokes Hill deviated from measurements at the other stations significantly. Further, negative values were recorded for three periods. It is likely that the PM10 instrument at Stokes Hill was experiencing technical issues, leading to incorrect concentrations being reported. It is therefore not expected that the facility operations contributed to exceedances on 22 September 2021 and 23 September 2021.

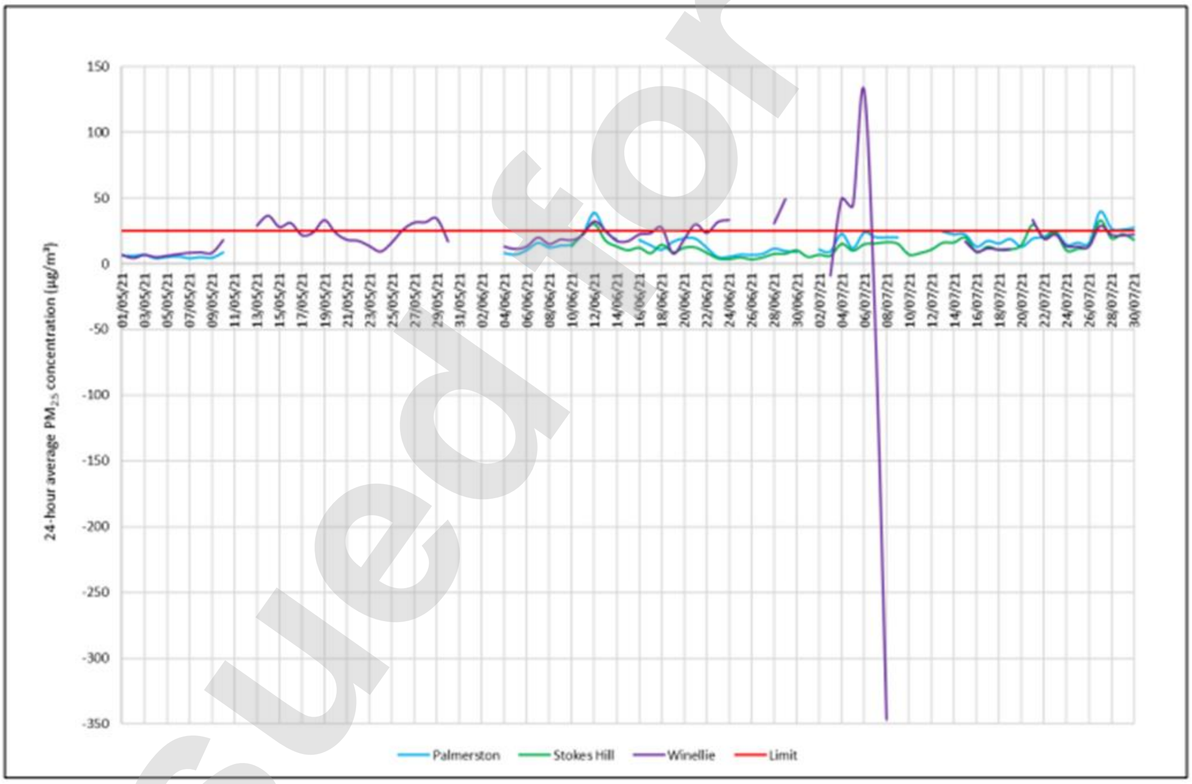

Figure 3-3: Timeseries of 24-hour average $PM_{2.5}$ concentrations 01/05/21 - 30/07/21

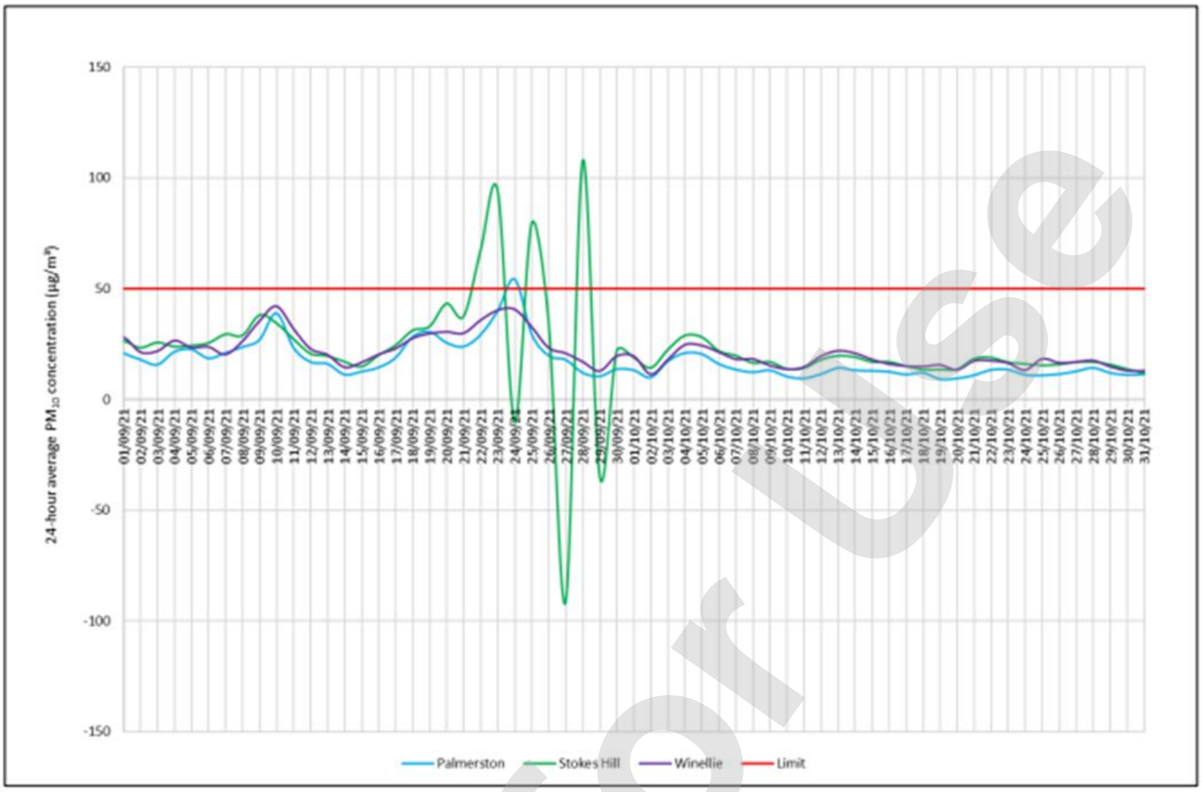

Figure 3-4: Timeseries of 24-hour average PM_{10} concentration 01/09/21 - 31/10/21

Review of exceedance of annual PM_{10} and $PM_{2.5}$ review criteria

The annual review criteria for $PM_{2.5}$ and PM_{10} are exceeded for several stations during the 24 month monitoring period. It is noted that only one full calendar year average period is available (2020). These exceedances are not unexpected due to frequently elevated particulate levels associated with regional vegetation burning during the dry season. Table 3-12 shows the average $PM_{2.5}$ and PM_{10} concentrations for the dry season and wet season for the period. The values in the table demonstrate that average particulate concentrations during the dry season are significantly greater than during the wet season and therefore that seasonal influences on regional air quality are likely to be the driver of exceedance of the annual review criteria the AQMS. Furthermore, as previously discussed, review of exceedances of the short term (24-hour) criteria found that INPEX LNG operations were unlikely to have contributed significantly to exceedances of the criteria. As such it is also unlikely that INPEX LNG operations have contributed significantly to the exceedance of the annual average review criteria.

Table 3-12: Seasonal average $PM_{2.5}$ and PM_{10} concentrations

Period	Average $PM_{2.5}$ concentration for the period (µg/m³)			Average PM_{10} concentration for the period (µg/m³)		
	Palmerston	Stokes Hill/Frances Bay	Winnellie	Palmerston	Stokes Hill/Frances Bay	Winnellie
Dry (01 May-31 Oct)	13	11	12	24	25	24
Wet (01 Nov – 30 Apr)	4.0	3.3	3.7	13	14	14

Summary of air toxics sampling data

Table 3-13 provides a summary of the results from the air toxics monitoring program for the review period. The results show that air toxics concentrations are significantly below the review criteria for the annual period.

Table 3-13: Air toxics results 2019-2021

Parameter	Averaging period	Review criteria (Air Toxic NEPM) (ppm)	Sample pollutant concentration (ppm)*								
			Palmerston			Stokes Hill/Frances Bay			Winnellie		
			2019	2020	2021	2019	2020	2021	2019	2020	2021
Benzene	24-hour	N/A	0.0009	0.0014	0.0022	0.0009	0.0006	0.0009	0.0009	0.0006	0.0009
	Annual	0.003	0.00066	0.00067	0.0011	0.00066	0.00059	0.00075	0.00066	0.00059	0.00075
Toluene	24-hour	1	0.002	0.0019	0.0045	0.002	0.0019	0.0019	0.002	0.0019	0.0019
	Annual	0.1	0.002	0.0019	0.0026	0.002	0.0019	0.0019	0.002	0.0019	0.0019
Xylene	24-hour	0.25	0.002	0.0014	0.0035	0.002	0.0014	0.0018	0.002	0.0014	0.0018
	Annual	0.2	0.0012	0.0014	0.0020	0.0012	0.0014	0.0016	0.0012	0.0014	0.0016

* For the purposes of reporting against the NEPM criteria, the laboratory data is converted from micrograms per cubic meter (µg/m^3) to parts per million (ppm), this calculation assumes a standard temperature and pressure of 25°C and 1 atmosphere.

Summary

Air quality report monitoring and reporting were completed monthly between August 2019 and October 2020, and quarterly between November 2020 and October 2021 in accordance with OEMP and EPL228 conditions.

Each monitoring event and report involved assessment of air quality monitoring data measured at three NT EPA AQMS located at Palmerston, Stokes Hill/Frances Bay and Winnellie. Measurement of ambient air toxics was completed for each report at the NT EPA AQMS locations.

A review of ambient air quality data from the NT EPA AQMS found several exceedances of the review criteria for PM_{10} and $PM_{2.5}$ during the 24 month monitoring period. The data review screening process (as presented in Figure 3-2) was carried out and concluded the following:

- The majority of exceedances were associated with regional events during the dry season.
- Where regional events were not considered to contribute to exceedances, the INPEX site was not found to be upwind of AQMS for any exceedance.
- Some exceedances were associated with instrumentation error.
- Exceedance of the annual average criteria is associated with regional influences during the dry season.

Consequently, INPEX LNG operations are not considered to have significantly contributed to exceedances of the NEPM Ambient Air Quality review criteria during the 24 month monitoring period.

Air toxics sampling collocated with the NT EPA AQMS returned non-detect (below LoR) results for the majority of samples. An assessment of all air quality sampling data for the review period found that there were no exceedances against the 24-hour or annual NEPM Air Toxics review criteria adopted for this programme.

3.2.4 Program rationalisation

In accordance with EPL228 Condition 55, the ambient air quality and air toxics programs ceased in October 2021, following 24 months of monitoring whilst the facility was operating in a steady-state.

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 required quarterly emissions monitoring for the first 18 months after the completion of first start-up (six monitoring events), 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.

Annual monitoring is being undertaken in accordance with the requirements of EPL228.

Table 3-14 provides a summary of the point source emission monitoring conducted for the reporting period.

Table 3-14: Point source emissions survey dates

Survey	Start date	End Date
Survey 7 Q4 2021	October 2021	October 2021

3.3.1 Method overview

Stationary source emissions monitoring is undertaken at 13 point sources (with a total of 18 stacks) on the Baker Hughes Frame 7 compression turbines, CCPP Baker Hughes 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 3-15 and Table 3-16 shows the EPL228 air emission target and limits and the constituents that are required to be monitored at the point source locations. Figure 3-5 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.

All stack sampling, where applicable, is undertaken in accordance with:

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

However, 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 stack emission monitoring Contractor, Ektimo, have 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 3-15: Contaminant release limits to air at authorised stationary emission release points

Release point number	Source	Pollutant	Concentration target		Concentration limit	
			mg/Nm^3	ppmv	mg/Nm^3	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)	NOx 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

Table 3-16: 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)	annually	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	annually	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		
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	annually	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	annually	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	annually and during incinerator by-pass*	BTEX, H_2S, volumetric flow rate
A13-3	541-SC-001	Feed gas to AGRU – LNG Train 1 – prior to release at A3	annually and during incinerator by-pass	Hg
A14-1	L-552-FT-031	AGRU Incinerator – LNG Train 2	annually	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	annually 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	annually and during incinerator by-pass	Hg

Release Point Number	Sampling Location Number	Source	Monitoring Frequency	Parameter
A15	L-640-A-001-A	Heating Medium Furnaces	annually	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	annually	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	all flare events	mass of hydrocarbons flared
A18	L-700-F-001-A/B	Ground flare #2 cold		
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		

* 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.

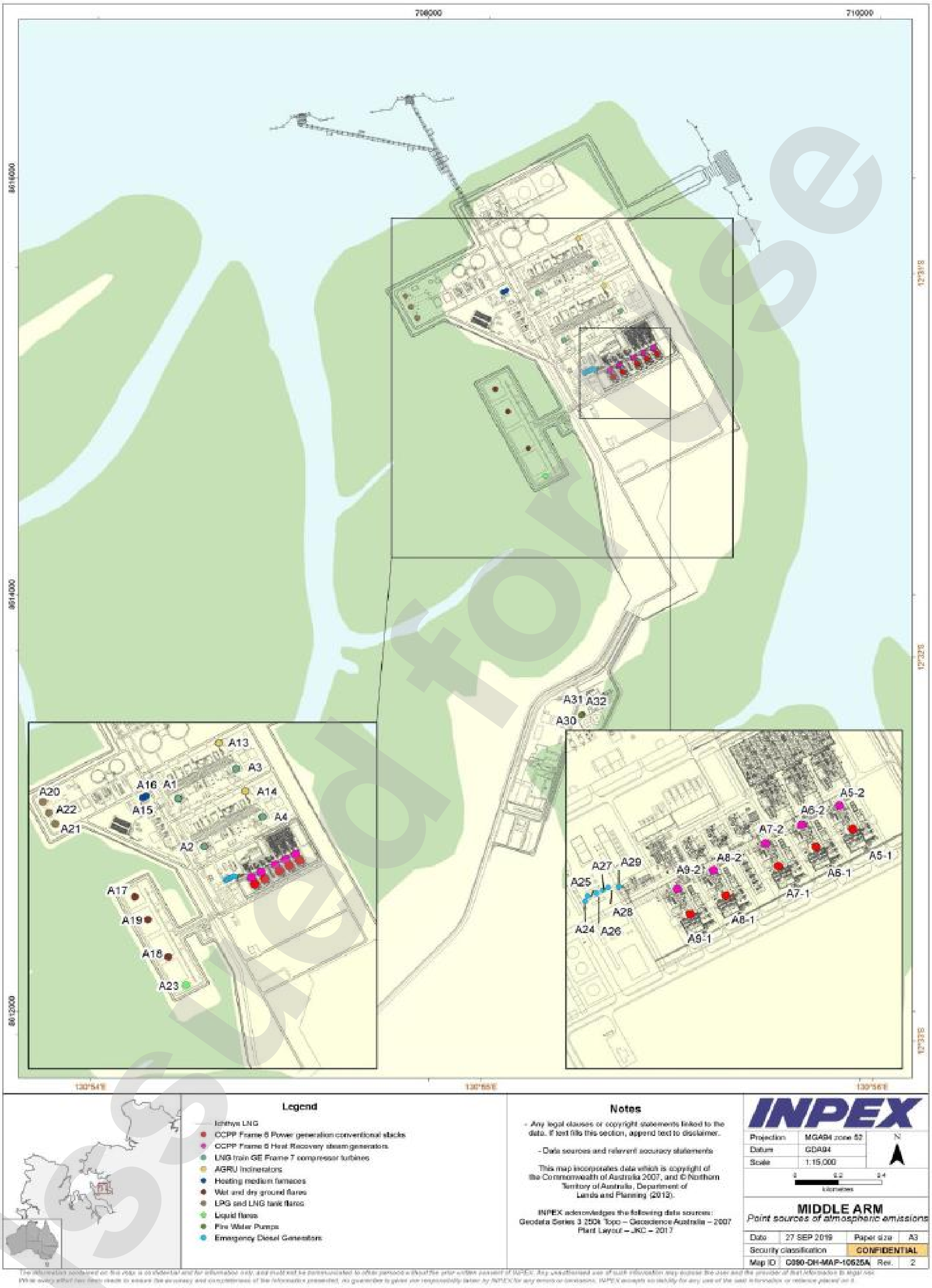

Figure 3-5: Location of authorised stationary emission release points

3.3.2 Results and discussion

All results for the permanent plant were below limit criteria provided in Appendix 3, Table 5 of EPL228.

The stationary source emission monitoring results are provided in APPENDIX D:.

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 A9-1/A9-2, CCPP gas turbine generator 5, was offline during the Q4 2021 survey due to planned maintenance.

Noting that in normal operations for the CCPP only 4 of the 5 turbines will be online, with one generally on standby or offline for planned maintenance.

No monitoring results exceeded concentration limit criteria.

The mass of hydrocarbons flared for the reporting period for each flare source is presented in Table 3-17.

Figure 3-6 and Figure 3-7 show the vented acid gas flow rates in m^3/h for Train 1 and Train 2. During the time the acid gas incinerators were offline, the acid gas was hot vented when the LNG trains were online. Figure 3-8 and Figure 3-9 **Error! Reference source not found.**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, in addition monthly sampling from the locations were also undertaken.

The Train 1 acid gas incinerator was offline for approximately half of the reporting period due to faults, and venting was required. The faults included bellows, gaskets, and ignitors. Due to the COVID-19 pandemic there were delays in the procurement of parts sourced internationally.

The Train 2 acid gas incinerator was offline for approximately a quarter of the reporting period due to faults (including with bellows, ignitors and valves), which required parts and equipment to be manufactured and sent from overseas. Due to the COVID-19 pandemic there were delays in the procurement of parts internationally.

Table 3-17: 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	26,103
A18 / A19	L-700-F-001-A/B / L-700-F-003	Ground flare #2 cold / Ground flare #1 spare	47,629
A20	L-700-F-005-A/B	Tank flare #1 LNG	63
A21	L-700-F-006-A/B	Tank flare #2 LPG	8,792

Release Point number	Location Number	Source	Mass of hydrocarbons flared (tonnes)
A22	L-700-F-007	Tank flare #3 LNG/LPG	9,279
A23	L-700-F-004	Liquid flare	0

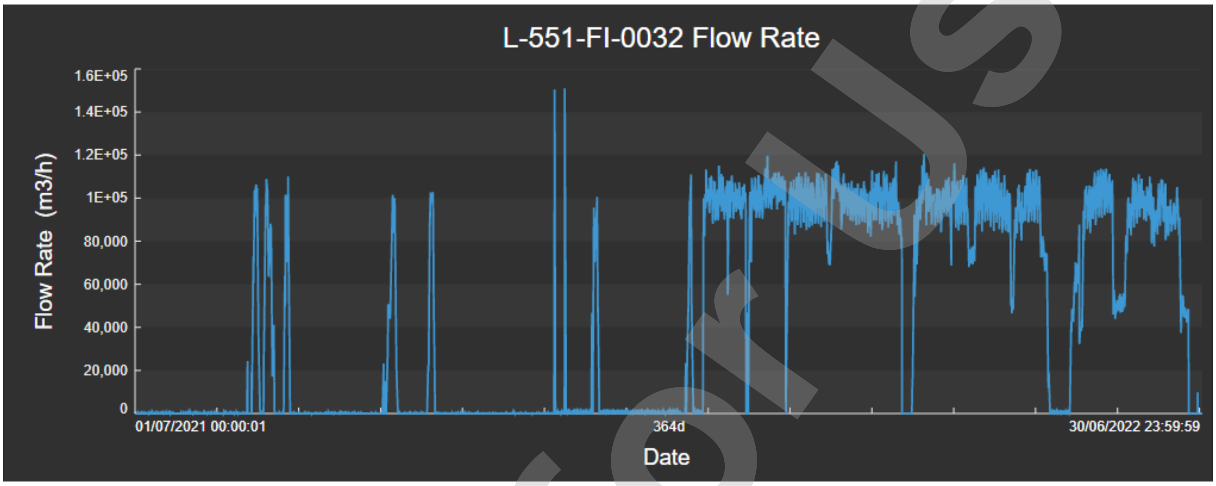

Figure 3-6 Train 1 acid gas venting flow rates

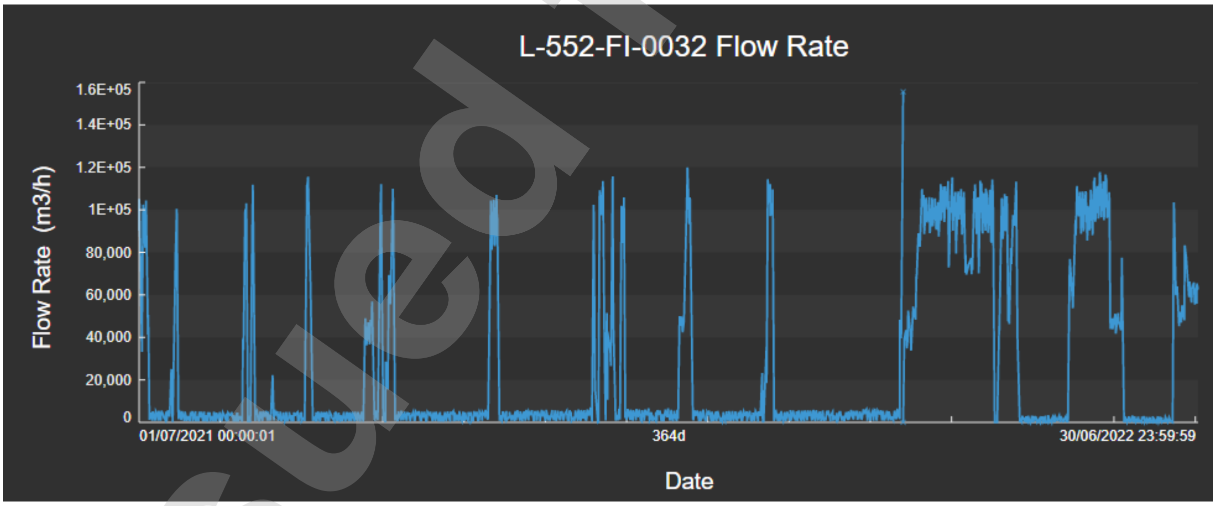

Figure 3-7 Train 2 acid gas venting flow rate

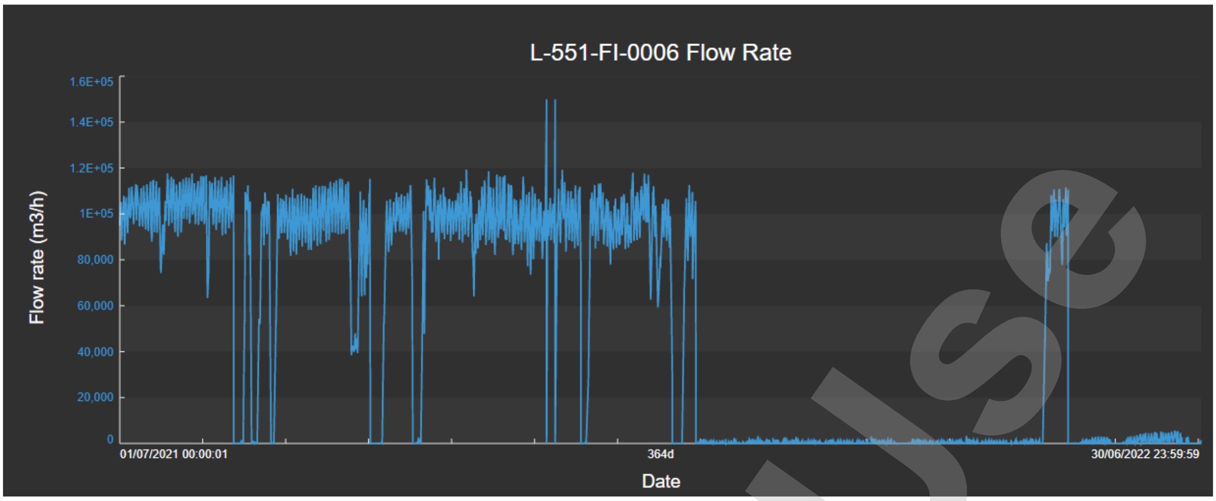

Figure 3-8 Train 1 acid gas incinerator flow rates

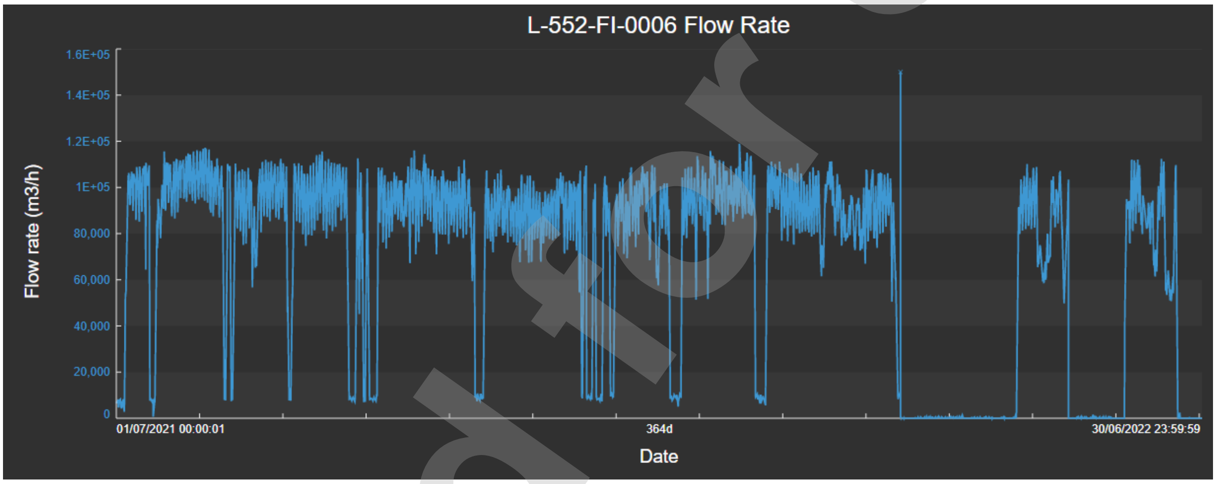

Figure 3-9 Train 2 acid gas incinerator flow rates

3.3.3 Program rationalisation

No rationalisation is currently proposed and monitoring will be conducted as per the EPL228 requirements.

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 3-18 based on information presented in Sections 3.1, 3.2, and 3.3. As stated above the acid gas incinerator for LNG Train 1 was online for the majority of the reporting period, while the incinerator for LNG Train 2 was offline for the majority of 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 3-18: 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
A13-1	AGRU Incinerator – LNG Train 1	Operational	Acceptable
A13-2	AGRU Hot Vent – LNG Train 1, prior to release at A3	Operational	Acceptable

Release point number	Emission source	Status	Air emissions
A14-1	AGRU Incinerator – LNG Train 2	Intermittent Operations	Acceptable
A14-2	AGRU Hot Vent – LNG Train 2, prior to release at A4	Operational	Acceptable
A15	Heating medium furnace 1	Operational	Acceptable
A16	Heating medium furnace 2	Operational	Acceptable

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 3-19.

Table 3-19: 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

There were no dark smoke events during the reporting period.

3.5.3 Program rationalisation

No program rationalisation is proposed.

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 operations.

As per the OEMP, groundwater quality is required to be monitored biannually (e.g. twice yearly at 15 sites). 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 #
8	18—20 October 2021	Groundwater Quality Monitoring – Trigger Assessment: Report No 8	L290-AH-REP-70011
		Groundwater Quality Sampling Report No 8	L290-AH-REP-70035
9	4—6 April 2022	Groundwater Quality Monitoring – Trigger Assessment: Report No 9	L290-AH-REP-70029
		Groundwater Quality Sampling Report No 9	L290-AH-REP-70044

4.1.1 Method overview

The groundwater quality monitoring surveys were undertaken in accordance with the Groundwater Quality Monitoring Plan (L290-AH-PLN-70000). 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 below.

Prior to sampling, groundwater wells were gauged with an interface probe to determine the standing water level (SWL). 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	
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

Parameter	Unit	Sampling method*	Trigger value	Trigger value reference
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 E:. Note presentation of groundwater data trends include data collected during the construction phase. Groundwater surveys undertaken during the reporting period in accordance with the OEMP are specified in Table 4-1. To date, groundwater monitoring during the operations phase of Ichthys LNG shows that 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).

Survey 8: October 2021

Forty-seven exceedances against both the trigger and background concentrations were recorded in the eighth groundwater monitoring event in October 2021. Exceedances include ten for pH, 19 for nutrients and 18 for dissolved metals. This is less than the 53 exceedances recorded during the sixth groundwater monitoring event undertaken during October 2020.

All exceedances have been compared to data recorded during the dry season months of May to October between May 2016 and October 2021 using Mann-Kendall trend analysis.

Exceedances of pH were recorded at ten monitoring bores. No trends were discernible for pH at eight of these monitoring bores during the operational monitoring phase. The exceptions were at bores BPGW07, where pH is identified as decreasing (becoming more acidic), and BPGW41, where pH is identified as probably increasing (becoming less acidic).

A total of 19 nutrient exceedances were recorded. Visual assessment of time plotted data indicate that several analyte exceedances represent short-term spikes, potentially related to seasonal environmental variables, rather than increasing trends. Visual assessment of time plotted data has confirmed the following trends identified by the Mann-Kendall analysis:

- Ammonia: Increasing trends at BPGW20, BPGW40, BPGW41 and VWP341
- FRP: Increasing trends at BPGW07, BPGW19A and VWP341.

A total of 18 metals exceedances were recorded during the eighth groundwater monitoring event. Visual assessment of time plotted data has confirmed the following trends that were also identified by the Mann-Kendall analysis:

- Cobalt: Increasing trend at VWP341
- Zinc: Increasing trend at BPGW07, probably increasing at VWP341.

The following historical maximum values were recorded during the eighth groundwater monitoring event:

- Cadmium at BPGW07 (1.5 µg/L), BPGW08A (0.8 µg/L) and BPGW09 (0.9 µg/L)
- Cobalt at VWP341 (110 µg/L).

Historical minimum values for pH were recorded at the following four bores:

- BPGW09 (5.24), BPGW18 (5.13), BPGW28 (5.71) and BPGW41 (5.68)

Bores identified as having increasing trends for specific analytes, and bores where historical maxima were recorded in October 2021 were placed on a watch list. Results of the investigation into each of the exceedances are described in Section 4.1.3.

Survey 9: April 2022

Twenty exceedances against both the trigger and background concentrations were recorded in the ninth groundwater monitoring event in April 2022. Exceedances include one for pH, nine for nutrients and 10 for dissolved metals.

Exceedances have been plotted on time series graph to compare to pre-construction and construction data and discern trends in the data.

One pH exceedance was recorded at VWP341.

Nine nutrient exceedances were recorded. A visual assessment of time plotted data indicates that some analyte exceedances represent short-term increases in concentration, rather than increasing trends. Visual assessment of time plotted data has identified the following trends:

- Increasing trends for ammonia at VWP341, BPGW40 and BPGW41
- Increasing trend for FRP at BPGW07.

Ten metals exceedances were recorded during the ninth groundwater monitoring event. Visual assessment of time plotted data has identified the following trends:

- Arsenic: Increasing trend at BPGW08
- Cobalt: Increasing at BPGW40 and VWP341
- Zinc: Increasing trend at VWP341.

The following historical maximum value was recorded during the ninth groundwater monitoring event:

- Ammonia at BPGW40 (420 µg/L).

Bores identified as having increasing trends for specific analytes, and bores where historical maxima were recorded in April 2022 were placed on a watch list. Results of the investigation into each of the exceedances are described in Section 4.1.3.

Bore watch list

Several bores were identified as having increasing trends for specific analytes, as well as historical maximum values during the eighth groundwater monitoring event undertaken in October 2021. These bores were placed on a watch list to determine whether increasing concentrations of analytes represent an anomaly or an ongoing trend requiring further investigation. Some bores have been added to the watch list following the April 2022 groundwater monitoring event.

Table 4-2 shows April 2022 results at bores that were placed on a watch list following the October 2021 groundwater monitoring event. Those bores that did not have an exceedance in April 2022 will be removed from the list, and those that had an exceedance retained.

Table 4-3 Groundwater bore watch list as of April 2022

Bore	October 2021 result	April 2022 result	Action
pH			
BPGW09	Historical maxima	No exceedance	Remove from list
BPGW18	Historical maxima	No exceedance	Remove from list

Bore	October 2021 result	April 2022 result	Action
BPGW28	Historical maxima	No exceedance	Remove from list
Ammonia			
BPGW20	Increasing trend	No exceedance. Stable trend	Remove from list
BPGW40	Increasing trend	Exceedance recorded. Increasing trend	Retain on list
BPGW41	Increasing trend	Exceedance recorded. Increasing trend	Retain on list
VWP341	Increasing trend	Exceedance recorded. Increasing trend	Retain on list
FRP			
BPGW07	Increasing trend	Exceedance recorded. Increasing trend	Retain on list
BPGW19A	Increasing trend	No exceedance. Stable trend	Remove from list
VWP341	Increasing trend	No exceedance. Stable trend	Remove from list
Arsenic			
BPGW08	No exceedance	Exceedance recorded. Increasing trend	Retain on list
Cadmium			
BPGW07	Historical maxima	No exceedance. Stable trend	Remove from list
BPGW08A	Historical maxima	No exceedance. Stable trend	Remove from list
BPGW09	Historical maxima	No exceedance. Stable trend	Remove from list
Cobalt			
BPGW40	No exceedance	Exceedance recorded. Increasing trend	Retain on list
VWP341	Increasing trend. Historical maxima	Exceedance recorded. Increasing trend	Retain on list

Bore	October 2021 result	April 2022 result	Action
Zinc			
BPGW07	Increasing trend	No exceedance. Stable trend	Remove from list
VWP341	Probably increasing trend	Exceedance recorded. Increasing trend	Retain on list

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 8 – Trigger Investigation Report (L290-AH-REP-70035)
- Groundwater Survey 9 – Trigger Investigation Report (L290-AH-REP-70044).

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
Survey 8*	Oct	13	19	18
Survey 9†	April	1	9	10

* Includes 1 technical trigger exceedance, which occurred as a result of laboratory LOR not being achieved due to matrix interference.

† Includes multiple technical trigger exceedances, which occurred as a result of samples being analysed to LORs higher than those required for the monitoring program, as well trigger exceedances resulting from the relative percentage difference (RPD) of QA/QC samples above the performance criteria of <30%.

4.1.4 Program rationalisation

No changes to groundwater monitoring at Ichthys LNG are proposed, as the current biannual monitoring is appropriate to capture seasonal impacts from unplanned discharges to ground.

5 FLORA, FAUNA AND HERITAGE

5.1 Mangrove health and intertidal sediment

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

- informatively monitor mangroves adjacent to Ichthys LNG
- detect changes in intertidal sediment quality attributable to Ichthys LNG.

As per the OEMP, mangrove health is required to be monitored biennially. Table 5-1 provides a summary of the mangrove health and intertidal sediments survey completed during the reporting period.

Table 5-1: Mangrove health and intertidal sediment monitoring survey details

Survey	Date	Report	INPEX Doc #
4	20—22 June 2022	Mangrove Health and Intertidal Sediment Trigger Assessment Report - No. 4	L290-AH-REP-70046
		Mangrove Health and Intertidal Sediments Monitoring: Report No 4	L290-AH-REP-70045

5.1.1 Method overview

The mangrove health and intertidal sediment survey was completed in accordance with the Mangrove Health and Intertidal Sediment Monitoring Plan (L290-AH-PLN-70002). This included monitoring at 9 sites; two control and seven potential impact sites. 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, 13 quadrats (i.e. seven potential impact and six control quadrats) are monitored during each annual survey. Each of the 13 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 52 subplots).

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

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Figure 5-1: Mangrove health and intertidal sediment monitoring locations

Table 5-2: Monitoring parameters, methodologies and associated parameters

Parameter	Methodology	Monitoring Parameters
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) • TPH • pH (measured in field) • Redox (measured in field)

Mangrove health monitoring

Mangrove canopy cover was measured at each site using established fixed quadrats and using a spherical densitometer (Stickler 1959) to provide an estimate of foliage cover. Three replicate foliage cover measurements were taken within each 5 m × 5 m (25 m^2) subplot formed by the fixed quadrat four corner posts and a centre post in the assemblage adjacent to Ichthys LNG and a subset of transects in high risk areas. The canopy cover for each quadrat was then calculated by averaging the mean of the foliage cover readings from each subplot. The spherical densitometer was not modified according to the Stickler method due to human error, which represents a deviation from the monitoring plan.

A known limitation of densitometers is that they may be 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, a digitised method for measuring canopy cover (e.g. Percentage Cover application) was trialled for the reporting period. Percentage Cover (%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). This method was trialled at control site CSMC01. Two records were taken within each of the three subplots at this site, and a mean value of canopy cover was calculated.

Mangrove surveillance photo-monitoring was also undertaken in quadrats adjacent to Ichthys LNG to provide a visual record of the communities' appearance and condition (e.g. leaf colour). Repeatable photos were captured facing away from the quadrat centre post towards each of the four corner posts.

Sediment monitoring

To test for potential changes in sediment composition and sediment quality, a single surficial sediment sample was taken (top 2—5 cm) from within each of the 13 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) were 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.

5.1.2 Results and discussion

Mangrove health monitoring

Canopy cover

Canopy cover across all sites has remained relatively stable over time (Figure 5-2). During Survey 4, canopy cover at sites BPMC16 and BPMC26 was lower than baseline values. Canopy cover was reduced by 4.6% and 18.8% respectively. No sites showed decreases in canopy cover near to levels considered to indicate ecologically significant change (a 30% decrease in canopy cover).

Trial of the digital percentage cover method (%Cover application) at site CSMC01 indicated that the results differ significantly when compared with the spherical densitometer method. However, it was noted that the results represented a small sample size. Notably, the inability to bring mobile phones onto the Ichthys LNG site under a hot works permit also prevented trial of this method at impact sites.

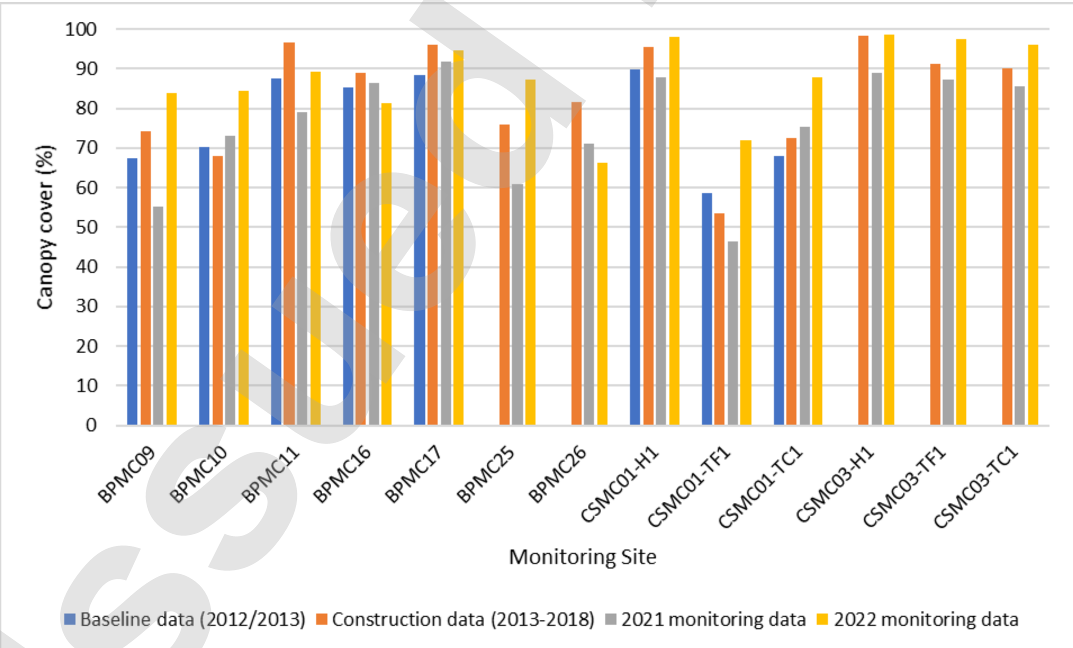

Figure 5-2: Mangrove canopy cover

Community health

All sites were classified as healthy in 2022 with no signs of deterioration or abnormal stress based on indices of leaf colour, regeneration (i.e. seedlings and saplings), visible vertebrate fauna and infaunal bioturbation.

Sediment monitoring

In-situ sediment measurements

In-situ measurements of pH and redox are displayed below in Table 5-3. In-situ measurements for pH at impact sites ranged from 5.91 to 6.95, with a mean value of 6.38. Measurements of pH at control sites ranged from 6.38 to 7.53 at control sites, with a mean value of 7.13. The range of pH values recorded reflects the conditions experienced by the surface sediments which are well oxygenated and regularly flushed by tidal waters. The results indicate that that mangrove sediments at both impact and control sites range from being slightly alkaline to slightly acidic. Subsurface mangrove soils are typically anaerobic and microbial decomposition takes place through a series of oxygen-reduction (redox) processes. Most mangrove soils are well buffered, having a pH in the range of 6-7, but some have a pH as low as 5.

In-situ measurements for redox potential at impact sites ranged from -5.1 mV to 204.6 mV, with a mean of 105.2. Redox potential at control sites ranged from 34.2 mV to 237.2 mV, with a mean of 158.5 mV. The positive ORP values indicate that mangrove sediments at monitoring sites in the top 5 cm are oxidising.

Table 5-3: Mangrove sediment in situ monitoring results

Location	**Date**	**pH**	**ORP (mV) (redox potential)**
Impact sites			
BPMC09	21/06/2022	6.51	-5.1
BPMC10	21/06/2022	6.95	93.2
BPMC11	20/06/2022	6.21	141.1
BPMC16	20/06/2022	5.91	161.5
BPMC17	20/06/2022	6.44	204.6
BPMC25	21/06/2022	6.01	58.9
BPMC26	20/06/2022	6.65	81.9
Mean		**6.38**	**105.15**
Control sites			
CSMC01 - H	22/06/2022	6.38	122.5
CSMC01 -TF	22/06/2022	7.07	34.2
CSMC01 -TC	22/06/2022	7.53	122.5
CSMC03 - H	22/06/2022	7.20	208.5
CSMC03 -TF	22/06/2022	7.24	237.2

Location	Date	pH	ORP (mV) (redox potential)
CSMC03 -TC	22/06/2022	7.37	226.1
Mean		7.13	158.5

Sediment chemistry

A summary of the mangrove sediment chemistry results is provided in Table 5-4 and Table 5-5. Elevated arsenic concentrations are consistent with those recorded from the broader Darwin Harbour region and from previous monitoring undertaken during the baseline and construction phases. Elevated concentrations of arsenic in Darwin Harbour sediments have historically been attributed to local geological influence rather than anthropogenic sources (Padovan, 2003; Fortune, 2006).

Arsenic and chromium exceedances were recorded at both impact and control sites, therefore the exceedances are unlikely to be due to Ichthys LNG operations, and further investigation was not warranted.

Organic results were below the limit of reporting for all sites but CSMC03-TF (Table 5-5). Given this result (170 mg/kg) was still below the trigger level (280mg/kg) and the result was from a control site, further investigation was not warranted.

Table 5-4: Summary of inorganic mangrove sediment chemistry

Analyte	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Moisture Content	Total Organic Carbon
Unit	**mg/kg**										**%**	**mg/kg**
LOR	**10**	**0.5***	**1**	**0.1**	**1**	**1**	**1**	**0.01***	**1**	**1**	**1**	**1000**
Trigger Value	**-**	**2**	**20**	**1.5**	**80**	**65**	**50**	**0.15**	**21**	**200**	**-**	**-**
BPMC09	8,600	<0.5	7.9	<0.1	22	3.1	5.5	<0.01	3.4	9.8	29	15,000
BPMC10	7,200	<10	5.8	<0.1	16	4.4	5.2	<0.1	4.2	45	36	17,000
BPMC11	1,100	<0.5	5.9	<0.1	7.2	<1	1.6	<0.01	<1	2.3	19	4,000
BPMC16	1,500	0.6	5.3	<0.1	15	1.4	1.0	<0.1	<1	4.3	15	3,000
BPMC17	6,600	1.8	**35**	<0.1	**110**	5.5	5.4	<0.1	5	38	23	9,000
BPMC25	19,000	<0.5	**23**	<0.1	40	8.1	13	0.02	12	72	60	65,000
BPMC26	8,300	<10	9.6	<0.1	17	4.2	5.8	<0.1	4.3	32	48	71,000
CSMC01-TC	20,000	<10	15	<0.1	45	6.8	12	0.02	10	27	24	20,000
CSMC01-H	5,000	<10	1.0	<0.1	9.2	1.9	1.6	<0.1	1.9	5.9	60	55,000
CSMC01-TF	2,100	<10	4.6	<0.1	12	<1	1.9	<0.01	1.0	5.9	17	2,000
CSMC03-TC	20,000	<0.5	**34**	<0.1	44	8.2	13	0.02	12	33	28	9,000

Analyte	Aluminium	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Moisture Content	Total Organic Carbon
CSMC03-H	22,000	<10	**29**	<0.1	**110**	11	34	0.02	13	38	61	60,000
CSMC03-TF	19,000	<10	**23**	<0.1	45	7.9	13	0.02	10	30	58	65,000

*Bold value indicates trigger exceedance.

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

Site	TPH C10-C36 (sum of total)
Guideline value	**280**
Background	**n/a**
BPMC09	<50
BPMC10	<50
BPMC11	<50
BPMC16	<50
BPMC17	<50
BPMC25	<50
BPMC26	<50
CSMC01-HM	<50
CSMC01-TF	<50
CSMC01-TC	<50
CSMC03-HM	<50
CSMC03-TF	170
CSMC03-TC	<50

5.1.3 Trigger assessment outcomes

There were no trigger exceedances for the 2022 mangrove health and intertidal sediment survey attributable to Ichthys LNG operations. Arsenic and chromium exceedances were noted at both control and impact sites, and therefore were representative of wider background elevation and not considered to be due to Ichthys LNG operations. No further investigation was undertaken.

5.1.4 Program rationalisation

No further rationalisation is proposed for Mangrove Health and Intertidal Sediments the next round of monitoring will occur in the 2023/24 AEMR period.

5.2 Nearshore marine pests

5.2.1 Method overview

Invasive marine pests monitoring is undertaken to assess the presence/absence of invasive marine pest species at the Ichthys LNG LPG/condensate product loading jetties (Figure 5-3). The two site located on the product loading jetties have been incorporated in the wider Darwin Harbour program, managed by NT Aquatic Biosecurity Unit, within the Fisheries Division of the Northern Territory Department of Industry, Tourism and Trade (NT DITT). NT DITT provide the artificial settlement units (ASUs; Figure 5-4) for INPEX to deploy at the jetties. Each ASU consists of four settlement plates (back to back) and two rope mops.

Photo-monitoring of ASUs is undertaken monthly with ASUs collected and replaced every fourth month (an example of monitoring photographs is shown in Figure 5-5). Collected ASUs and monthly photos of the traps are sent to NT DITT for species identification.

The ASUs were installed in September 2018 with monthly monitoring commencing in October 2018. During the reporting period monthly photo inspections occurred and the traps were collected and provided to Fisheries every four months for identification of species.

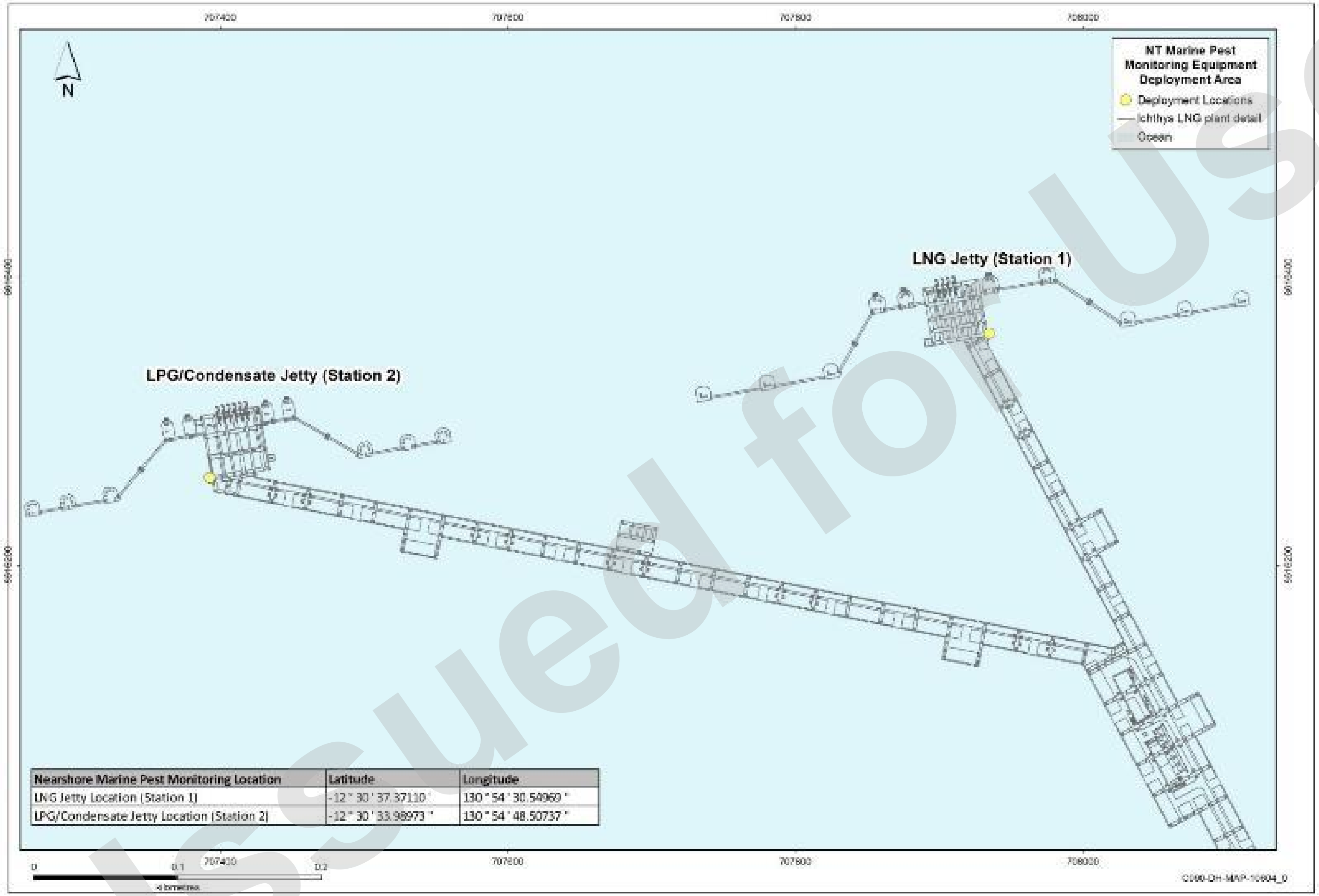

Figure 5-3: Nearshore marine pest monitoring locations

Figure 5-4: Nearshore marine pest ASU

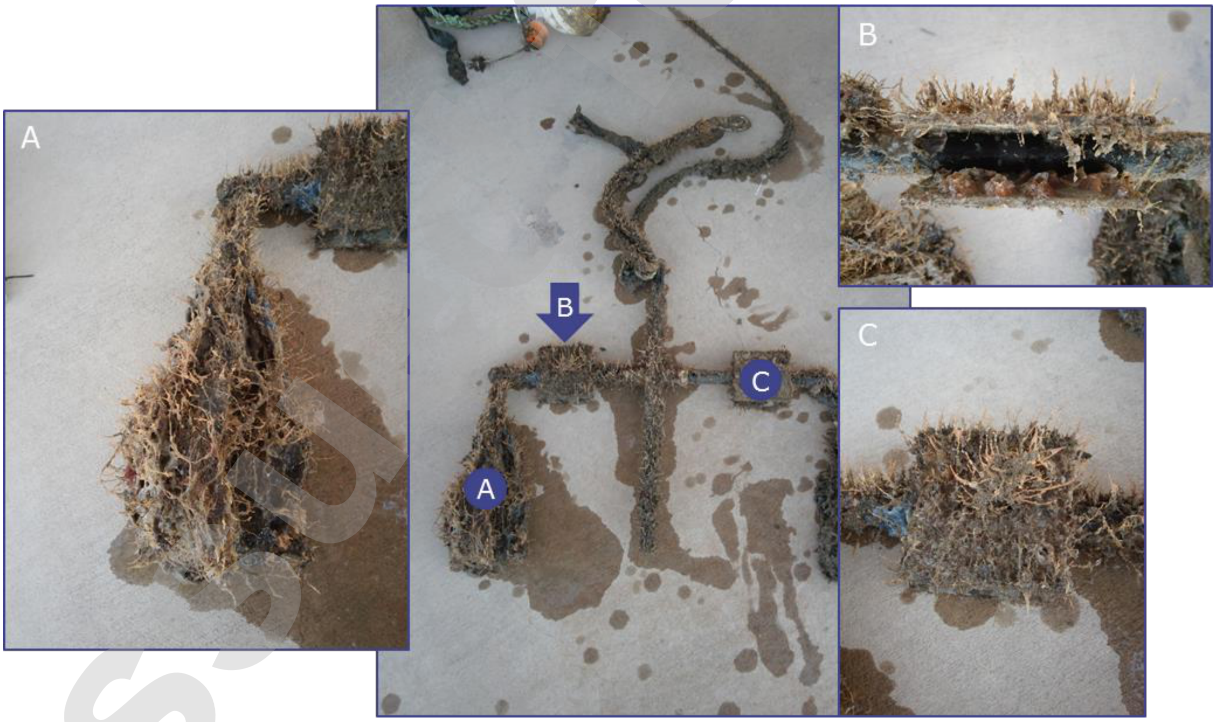

Figure 5-5: Example of monitoring photographs taken during monthly inspection a) rope mop, b) inside the plates and c) plates surface biofouling conditions

5.2.2 Results and discussion

NT DITT did not identify any invasive marine species when ASUs were collected (i.e. every four months) or on review of photos taken during monthly inspections.

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 are undertaken annually at the end of the wet season (nominally in April). Table 5-6 provides a summary of surveys completed during the reporting period.

Table 5-6: Weed survey details

Survey	Date	Report	INPEX Doc #
Survey 7	April 2022	Weed Management Report No. 7	L290-AH-REP-70033

5.4.1 Method overview

Weed surveys were performed in accordance with the INPEX LNG Weed Mapping and Vegetation Surveillance Monitoring Plan (L290-AH-PLN-70001). The area surveyed is shown in Figure 5-6.

Parameters monitored during the weed surveys are listed in Table 5-7. Where identification of a species was not possible in the field, a voucher sample, together with photographs were taken to facilitate post survey identification.

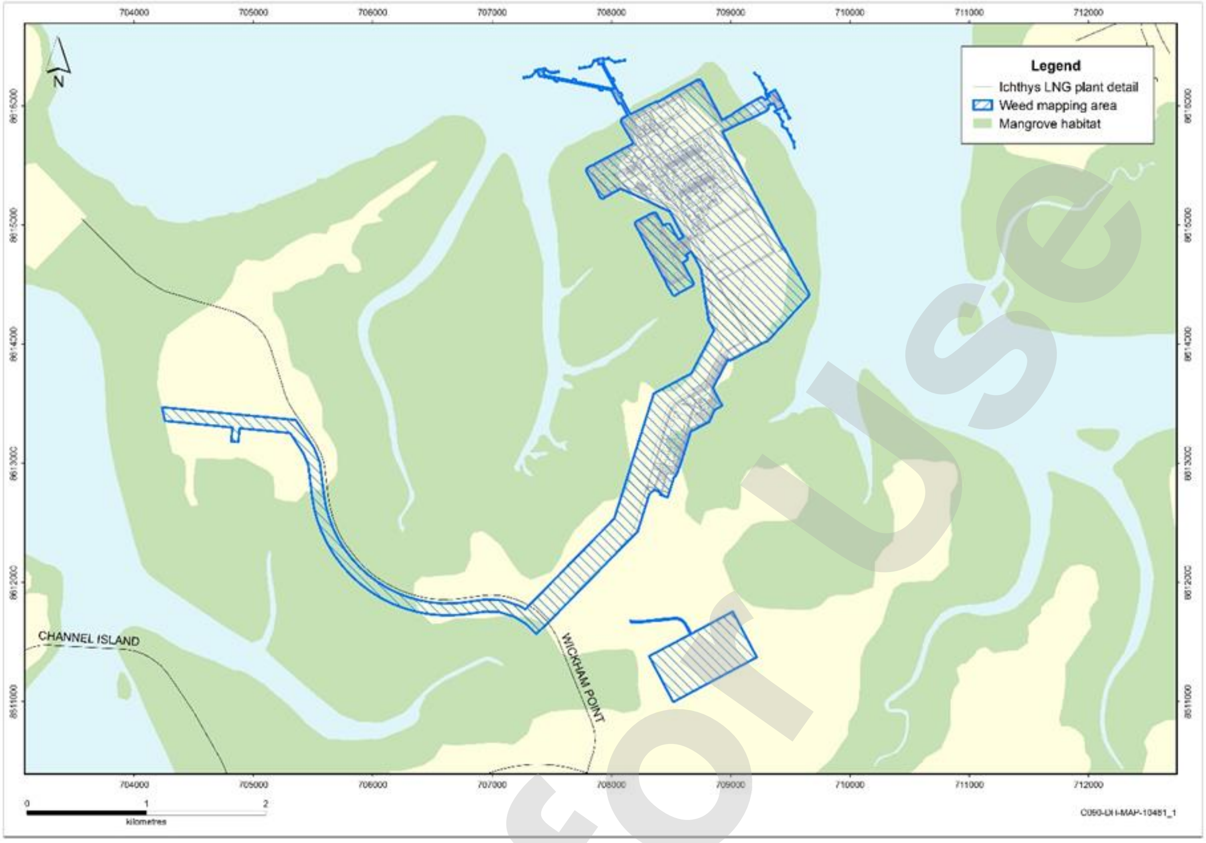

Figure 5-6: Weed survey area

Table 5-7: 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

2021/2022 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 5-6). Declared weed species previously identified were:

- perennial mission grass
- neem tree
- flannel weed

- annual mission grass
- gamba grass
- hyptis/horehound.

The results of the 2022 weed survey show an increase in the density and distribution of gamba grass across the site since the 2021 survey. Of particular note is the extent of recorded medium-density gamba within Section 1888, which has exponentially expanded from 25m^2 in the 2021 survey to over 3000m^2 in 2022 .

These findings are generally consistent with operations phase weed monitoring surveys in 2020/21, 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 weed species present on the site.

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

Declared weed infestation trend analysis

A trend analysis for weed results from all surveys was completed (Figure 5-7). Gamba grass infestations substantially increased during the 2021-2022 wet season. While individual gamba grass plants have remained relatively consistent; there has been a significant increasing multi-plant infestations (Survey 7 compared to Survey 6).

The favourable growth conditions over the 2021/22 wet season has resulted in significant patches of hyptis establishing with the GEP Corridor and Bladin Point Road Corridor. Previous surveys have detected hyptis in both of these weed management zones and also within Section 1888. The overall extent of hyptis infestation recorded has decreased compared to Survey 6 results.

A single patch of perennial mission grass was observed in the GEP corridor and within the operations area adjacent to the perimeter fence. These patches are a very high priority for control. Perennial mission grass appears to be increasing in area between AEMR reporting periods (Figure 5-7).

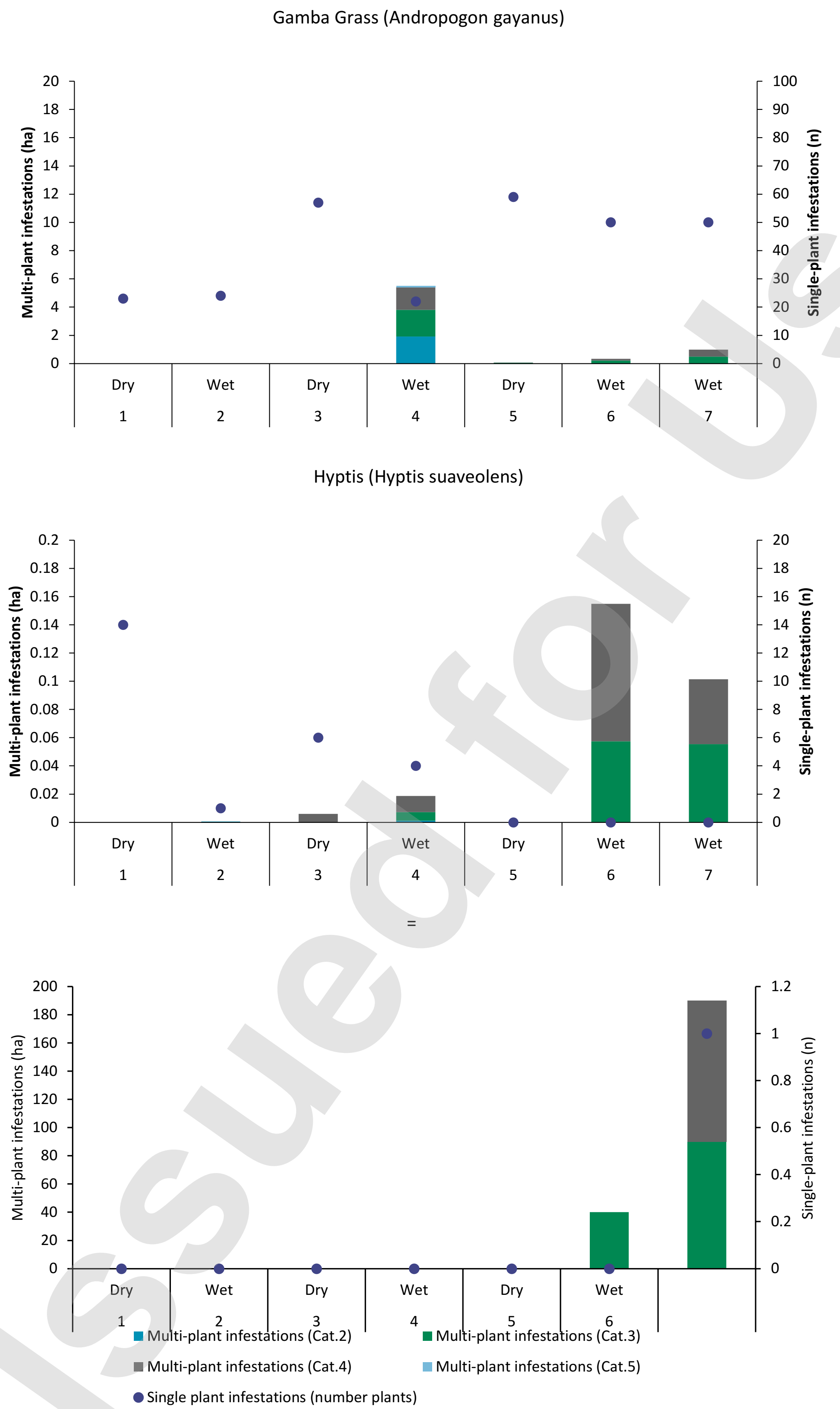

Figure 5-7: Comparison of declared weed infestations between AEMR reporting periods

5.4.3 Program rationalisation

No changes to weed surveys is proposed. The current annual weed surveys will still allow INPEX to fulfil its commitments under the OEMP and *Weeds Management Act* (NT).

5.5 Weed management

5.5.1 Method overview

Weed control at the site was undertaken and managed by a weed management contractor 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 in the wet season through spray application of herbicides, boom spray, quick-spray handguns and backpacks.

Total vegetation and woody weed control was undertaken through hand pulling and slashing along the GEP corridor.

5.5.2 Results and discussion

Overall weed management measures undertaken during the reporting period were adequate.

5.5.3 Program rationalisation

No changes are proposed to weed management at Ichthys LNG.

5.6 Vegetation rehabilitation monitoring

Vegetation rehabilitation did not occur in the 2021/22 reporting period. In accordance with the OEMP, vegetation rehabilitation is now biennial.

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 were required 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 sites 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).

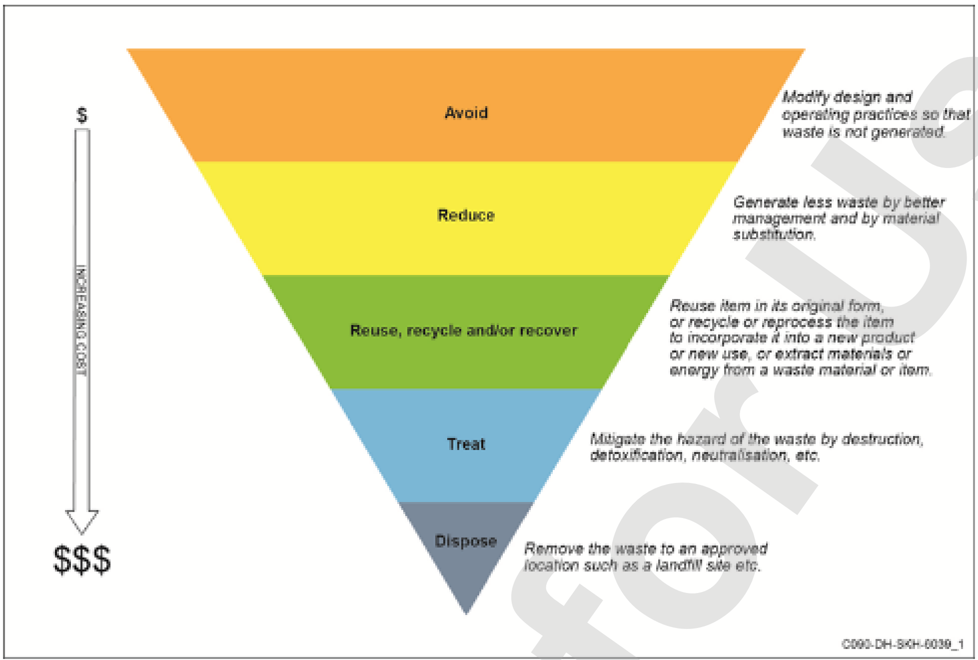

Figure 6-1: INPEX waste control hierarchy

Waste streams at the site are categorised into four broad classes (which include both liquid and solid waste, as outlined in section 3.8.3 of the OEMP):

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

Note, the onsite treatment of wastewater and disposal via the onsite evaporation basin are exclude from reportable waste data (refer to Table 6-1), and only records from licenced waste contractors are used for this waste section.

Solid 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 following classification by waste contractors.

Table 6-1 presents a comparison of the waste streams from the 2019-2020 and 2020-2021 reporting periods against the current reporting period (2021-2022). The increase of recyclable non-hazardous waste was a result of a campaign to remove scrap metal from the Ichthys LNG facility. While the reduction of non-recyclable hazardous waste was due to the planned maintenance shutdown falling outside of the 2021/2022 reporting period.

Note, firefighting foam wastewater is included in Table 6-1 as a non-recyclable hazardous waste stream. In the reporting period, a moderate amount of firefighting foam was disposed following a contained spill of foam. Approximately 120 m^3 of foam contaminated wastewater was disposed of from the site during the reporting period, with the waste being classified as non-recyclable hazardous liquid waste, which underwent plasma arc destruction.

Table 6-1: Waste stream data comparison 2019-2020 and 2021-2022

Waste Stream	2019-2020 (tonnes)	2020-2021 (tonnes)	2021-2022 (tonnes)
Recyclable / non-hazardous	251.113	304.348	1126.347
Recyclable / hazardous	16.218	6.378	10.366
Non-recyclable / non-hazardous	1241.768	2413.149	2090.523
Non-recyclable / hazardous	569.319	1122.224	625.965

The main waste reduction measure implemented during the reporting period (i.e. reduce waste being disposed or treated offsite) was through the use of the onsite evaporation basin and transfer to the Ichthys LNG site's waste water treatment plants (mainly daily sewage transfers due to the transfer pumps being taken offline for maintenance and cleaning). The evaporation basin is designed to handle low level chemical and hydrocarbon contaminated water generated at Ichthys LNG, while inter-site transfers to the wastewater treatment plants took place. Approximately 3,858 tonnes of liquid waste was transferred to the evaporation basin and 774 tonnes of wastewater transferred to the various water 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).
- During the June/July 2022 shutdown, a small water recycling plant was brought onsite for use in high pressure cleaning activities. Waste wash-water was collected, filtered and then reused. This reduced the amount of waste water produced from this activity.

Although not directly related to solid and liquid waste, there was a significant amount energy recovery that occurred at the site through the use of the waste heat recovery systems. Heat recovery units are located on the GE Frame 7 gas turbine stacks, which capture the heat of the turbine exhaust and then transfer the energy to the site heating medium system. A similar heat transfer method is also used in the CCPP, where the exhaust heat form the GE Frame 6 turbine stacks used to generate steam, which is then transferred into energy in the steam turbines. Use of the waste heat recovery systems reduce the overall fuel consumption and air emissions.

7 PROGRAM RATIONALISATION SUMMARY

There were no proposed recommendations for changes to monitoring programs and future monitoring will be undertaken in accordance with the current OEMP and EPL228.

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 • 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	Each section includes a subsection with monitoring methods for each monitoring program.

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
	• 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:
	  ◦ units
	  ◦ assessment criteria (e.g. limits/trigger values specified in licences/approvals, or in relevant standards or guidelines2)
	  ◦ analysis type (e.g. for filtered/unfiltered with filter pore size, five-day or
	  ◦ three-day biological oxygen demand, wet or dry weights)
	  ◦ analytical methods
	  ◦ limit of reporting (LOR), or level of precision for results obtained from
	  ◦ field instruments
	  ◦ 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? • 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)?	Monitoring plans (referenced in the method overview section) include QA/QC processes.

NT Guideline for Environmental Reporting	NT Guideline Information	AEMR Reference
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	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.* Note: significant penalties may apply where it is demonstrated that false or misleading information has been supplied to the NT EPA.	APPENDIX B:
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).	Appendices

APPENDIX B: EPL228 AEMR 2020-2021 CERTIFICATION

B.1 INPEX

INPEX	I, Tetsuhiro Murayama (Director, Ichthys LNG Pty Ltd) confirm that to the best of my knowledge and ability all the information provided in the *EPL228 Annual Environmental Monitoring Report 2021-2022* (L060-AH-REP-70027) is true and accurate.
Name	Tetsuhiro Murayama
Position	Director, Ichthys LNG Pty Ltd
Signature	村山徹博
Date	27 September 2022

B.2 Qualified Professional

ERM

Level 3, 1 Havelock St
West Perth WA 6005

Telephone: +61 8 6467 1600

www.erm.com

INPEX Corporation
Maris Steele
Senior Environmental Advisor
Onshore Operations
144 Wickham Road
Wickham NT 0822

21 September 2022

Reference: ERM 0565508

Dear Maris

Subject: 2021-2021 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.

[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.

ERM

21 September 2022
Reference: ERM 0565508
Page 2 of 2

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 review was undertaken by two 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
Air Quality	Christopher Thomson

Each of the qualified professionals individually reviewed the Draft AEMR (Revision C) dated 30 August 2022 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 (Revision D) dated 14 September 2022 to ERM for review, which incorporated the agreed changes and the comments register cross-referenced with the revised sections of the AEMR.

ERM was satisfied that each of the responses had been appropriately incorporated into the updated revision and the comments were closed out. Therefore the following statement of verification was 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 2020-2021 period.

Area of expertise	Qualified professional	Qualified profession Signatures
Discharges to Water	Ken Kiefer	
Air Quality	Christopher Thomson	

Yours sincerely,

For Environmental Resources Management Australia Pty. Ltd.

Christopher Thomson
Consulting Director

Paul Fridell
Partner

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

ANNEX A: - COMMENTS REGISTER

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2021/2022

Contract Number	INPEX PO 4500072962 (ERM proposal 0550625)
Reviewer	ERM
Document Name	EPL228 Annual Environmental Monitoring Report 2021-2022
Company Document No#	L060-AH-REP-70027
Document Revision No# / Date	Revision C / 30 Aug 2022 and Revision D / 14 September 2022

No.	Context	Reviewer Comment/Recommendation	INPEX Response	ERM response
Air Quality (Qualified Professional - Chris Thomson)				
1	Page 27, Table 3-1	Review reported total emissions in Table 3-1 and report to 1 or 2 significant figures. See previous years' reports.	Noted, comment accepted. Will amend to two significant figures in Table 3-1.	Checked final report. Closed
2	Page 29, Table 3-3	In header amend 'Air NEMP' to 'Air NEPM'.	Noted, comment accepted, will correct to 'Air NEPM'	Checked final report. Closed
3	Page 29, Table 3-3	NEPM criteria has been updated as follows: • NO_2 1-hour = 0.08 ppm • NO_2 annual = 0.015 ppm • SO_2 1-hour = 0.1 ppm • SO_2 24-hour = 0.02 ppm • SO_2 annual = removed Amend in document.	Noted, comment accepted. Will amend the new NEPM criteria in the document.	Checked final report. Closed
4	Page 34, Table 3-5	Amend table to include revised NEPM criteria mentioned above.	Noted, comment accepted. Will amend the new NEPM criteria in the document.	Checked final report. Closed
5	Page 35, Table 3-6	Multiple mentions in the table of 'INPEX LNG operations'. Previous reports exclude 'LNG'. Review and amend for consistency.	'LNG' was included in this year's AEMR to remain consistent with the term throughout the entire document in other sections.	Checked final report. Closed
6	Page 35, Table 3-6	October 2020, wording 'NEPM air toxics standard' should be amended to 'Air Toxics NEPM review criteria' for consistency.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
7	Page 35, Table 3-6	October 2020, wording 'INPEX was not located upwind of the facility during this period' should be reviewed. This wording was removed from previous years reporting.	Noted, comment accepted. To remain consistent with previous reporting the wording will be removed, as the reported values did not exceed the adopted criteria.	Checked final report. Closed
8	Page 35, Table 3-6	August/September/October 2021, wording 'NEPM air toxics standard' should be amended to 'Air Toxics NEPM review criteria'.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
9	Page 36, Paragraph 2	Use subscripts on pollutants.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
10	Page 37, Table 3-7	Note previous comment regarding updated NEPM criteria and update the table.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2021/2022

11	Page 37, Table 3-7	SO_2 annual Winnellie 2019, GHD has this value as '-0.00005'. Consider and amend accordingly.	INPEX contacted GHD whom confirmed it was a typo and should have been '0.00005' In addition, based on data from the GHD report 'Ichthys LNG Air Quality Monitoring Report - August 2019 to September 2020', and the monthly and quarterly reports for 2020, the value is 0.00005.	Checked final report. Closed
12	Page 37, Table 3-7	PM_{10} 24-hour Winnellie 2020 and 2021, remove italics and make bold.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
13	Page 37, Table 3-7	PM_{10} annual Stokes Hill 2019, the GHD report considers this as an exceedance. Make bold.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
14	Page 37, Table 3-7	$PM_{2.5}$ annual Palmerston 2020, amend to 7.0.	Noted, comment accepted. Will amend from 7 to 7.0.	Checked final report. Closed
15	Page 39, Paragraph 1 and Page 45 Summary, Bullet Point 2	On Page 39, the text states that '...an investigation should be carried out to determine if any facility emission source is downwind during the exceedance'. The text goes on to say that 'Based on this assessment, of the 19 exceedances of the PM_{10} criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions. Of the 37 exceedances of the $PM_{2.5}$ criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions.' There may be typos in the text that 'upwind' should be 'downwind'. In addition, Page 45 states that 'Where regional events were not considered to contribute to exceedances, the INPEX site was not found to be upwind of AQMS for any exceedance'. This statement contradicts the statements on Page 39. Recommend review of the words 'upwind' and 'downwind' and amend accordingly. The main aim is to understand if the exceedances occur downwind of Ichthys LNG.	INPEX contacted GHD whom confirm it should be upwind and the following changes will be made to the text to clarify: 'The review process as stipulated in Figure 3-2, suggests that where a regional event has not been shown to contribute to the exceedance, then an investigation should be carried out to determine if any facility emission source is 'upwind' during the exceedance. 24-hour vector wind directions are taken from the AQMS where the exceedance is recorded and compared to the direction of the AQMS from the INPEX site. Based on this assessment, of the 19 exceedances of the PM_{10} criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions. Of the 37 exceedances of the $PM_{2.5}$ criteria not associated with regional events, the INPEX site was upwind of the exceedance location on five occasions. A summary of non-regional exceedances where the INPEX site is 'upwind' of the exceedance location is shown in **Error! Reference source not found.**.'	Checked final report. Closed
16	Page 40, Table 3-11	24-hour $PM_{2.5}$ concentration Palmerston 29/07/21, amend to 26.0.	Noted, comment accepted. Will amend from 26 to 26.0.	Checked final report. Closed
17	Page 40, bullet point 1	Text states that 'However, PM_{10} exceedances were measured at multiple stations on 13 September and were screened out as a regional event'. This text appears to be a typo and should be 14 September. Review and amend accordingly.	Noted, comment accepted. Typo error will amend to 14 September	Checked final report. Closed
18	Page 40, bullet point 2	Text states that '...there were several exceedance days at Winnellie from 13 May 2021 through 29 May 2021, which were excluded due to the facility not being downwind of the station on these days.	INPEX contacted GHD whom confirmed it should be upwind and was a typo. The text will be amend to: 'there were several exceedance days at Winnellie from 13 May 2021 through 29 May 2021, which were excluded due to the facility not being 'upwind' of the station on these days.'	Checked final report. Closed

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		The above states that the facility is upwind (not downwind) of the station. As per Figure 3-2 in the report, if the facility emission sources are located upwind of the AQMS then this requires a detailed review. Please clarify if the facility is located upwind of the AQMS on the days mentioned.	As stated in the bullet point, only 1 of the 3 NT EPA air quality monitoring stations were operational during this period and the assessment to determine a regional event was not possible and the flow chart process could not be applied. In addition, the onshore facility commenced a major maintenance shutdown on 14 May 2021, where both trains were taken offline for maintenance works until the middle of June 2021, with the powerplant running at minimum load. Due to the facility being down for a major maintenance shutdown there were minimal emissions from the facility during this period, there were also no dark smoke events reported during this time. Due to this, it is considered with the facility being offline for maintenance, it did not contribute to the exceedance during the period 13 May to 29 May 2021.	
19	Page 42, header	Header 'Review of exceedance of annual....' use subscript on PM_{10} and $PM_{2.5}$ and review throughout.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
20	Page 44, Table 3-13	Third column, amend 'NEMP' to 'NEPM'.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
21	Page 44, Table 3-13	Footnote – amend 'NEPM standard' to 'NEPM criteria'.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
22	Page 46, Table 3-14	Add space in 'October2021'.	Noted, comment accepted. Will amend in the document.	Checked final report. Closed
23	Page 46, Section 3.3.1	Amend 'New South Wales (NSW) Department of Environment and Conservation' to 'New South Wales (NSW) Environment Protection Authority'	This text is consistent with condition 64.2 of the Environment Protection Licence 228-04. INPEX propose to leave in to match the EPL228-04 condition. It is noted the new guidelines were issued by the NSW EPA in January 2022. EPL228 is currently being revised as part of a 5-year renewal process and INPEX will inform the NT EPA of the changes to the reference document.	Noted that this has been changed in the text to be New South Wales (NSW) Environment Protection Authority (formerly the Department of Environment and Conservation) Approved Methods for the Sampling and Analysis of Air Pollutants in NSW. Closed
24	Page 52, Table 3-17	Review reported mass of hydrocarbons flared in Table 3-17 and report to 1 or 2 significant figures. See previous years' reports.	Noted, comment accepted. Will amend to 1 or 2 significant figures in Table 3-17	Checked final report. Closed
25	Page 85	Add 2021 NEPM reference.	Noted, comment accepted. Will update to include NEPM reference.	Checked final report. Closed
Discharges to Water (Qualified Professional – Ken Kiefer)				
1	Table 2-3 Re: TN exceedance, investigation and corrective actions regarding the ammonia dosing	The narratives provided under the 'Cause' and 'Corrective Actions' columns in relation to the investigation of potential ammonia dosing issues currently suggest different timelines of events. It appears that the ammonia dosing pump was identified to be faulty in the early evening on 20 July (i.e. suggesting 4-5 pm) and subsequently taken offline and	The investigation was reviewed, and the ammonia dosing pump was identified as being faulty in the afternoon of 20 July 21. The text will be amended to 'afternoon'.	Checked final report. Closed

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2021/2022

<table>
<tr><td></td><td>pump from 20-Jul-21.</td><td>switched to an alternative pump (i.e. suggesting later than 5 pm or following day). However, under 'Corrective Actions', the dosing pump was taken offline in the afternoon of 20 July (i.e. suggesting earlier than 4-5 pm).
Suggest clarifying the timeline of investigative events in this table row for consistency.</td><td></td><td></td></tr>
<tr><td>2</td><td>Table 2-3
Re: TN exceedance, investigation and corrective actions regarding the ammonia dosing pump from 17-Aug-21.</td><td>Currently, table text indicates that 'repairs will continue' by the end of October 2021 and that while repairs are undertaken, overdosing is likely to be an ongoing issue. This relates to the findings provided in this same table under a reported TN exceedance on 12-Oct-21.
Suggest elaborating on the number and timing of repairs undertaken during this reporting period to fix identified faulty ammonia dosing pumps.</td><td>For the powerplant steam system there are four ammonia dosing locations (with each location having one operational pump and a spare pump on standby). In total there are 8 ammonia dosing pumps at the facility (4 operational and four spare). When the main operational pump is identified as faulty or is required to be serviced it is taken offline and the spare brought online. Generally, the faulty pump is removed for repairs, either at the INPEX workshop or offsite at maintenance contractor's workshop.
Having faults with ammonia dosing pumps on a steam system is not uncommon, therefore redundancy is built into the system, as the dosing pumps operate at high pressure to inject the chemical into the steam system.
In addition to improving the reliability of the dosing pumps, INPEX has also changed the location of dosing from the feedwater manifold to direct into steam condensate manifold in March 2022. This allows better control of the dosing into the steam system.

With the change in dosing location and improved management of the pumps, there has been a reduction in the consumption rate of ammonia, this has reduced the risk of overdosing in the system. in October 2021, 9,000 L of ammonia was consumed, compare to 7,000 L/per month which is the current consumption rate.

There have been no exceedances of total nitrogen in the discharge wastewater at location 750-SC-003 since 18 October 2021 till September 2022.

It is considered the main change in the improvement of dosing, and reduction in chemical usage, is due to the new dosing locations in the steam system.

Below is a tabulated summary of the maintenance works complete in 2021 and early 2022 for the ammonia dosing pumps at the site. During this period INPEX experienced delays in the supply and transport of parts required for repair work due to COVID, which had an impact on maintenance activities.

<table>
<tr><th>Date maintenance request raised</th><th>Pump identification</th><th>Maintenance description</th><th>Date maintenance request closed</th></tr>
<tr><td>03/01/2021</td><td>L-630-P-903-B</td><td>Replace pump with rotable</td><td>02/03/2022</td></tr>
<tr><td>11/02/2021</td><td>L-630-P-904-A</td><td>Change Out Pump Control Parts</td><td>17/01/2022</td></tr>
<tr><td>11/07/2021</td><td>L-630-P-904-B</td><td>BFW Ammonia Pump Failure</td><td>09/08/2021</td></tr>
<tr><td>11/08/2021</td><td>L-630-P-904-B</td><td>Inspect and repair pump</td><td>11/08/2021</td></tr>
</table></td><td>The tabulated summary of the maintenance works completed in 2021 and early 2022 (yellow text) was not included in revision D of the report. ERM was satisfied that the preceding text, summarised in response to comment #4 adequately addressed the comment.
Closed.</td></tr>
</table>

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			26/08/2021 – L-630-P-904-B – Replace dosing pump. – 31/10/2021 24/10/2021 – L-630-P-901-A – INVESTIGATE: Pump not pumping. – 03/03/2022 31/10/2021 – L-630-P-904-A – REPLACE: Pulsation Dampener – 17/01/2022 28/01/2022 – L-630-P-904-A – Investigate output press on dosing pmp A – 30/01/2022 14/02/2022 – L-630-P-904-A – Check Valve and PTP Valve Changeout – 17/02/2022 18/02/2022 – L-630-P-904-B – Repair Dosing Pump – 31/03/2022	
3	Table 2-3 Re: TN exceedance, investigation and corrective actions regarding the ammonia dosing pump from 12-Oct-21.	Previous text under the August 2021 TN exceedance indicates that the overdosing of ammonia is an ongoing issue beyond October 2021. The text provided under the October TN exceedance only indicates that the ammonia-dosing pump was 'recently serviced' and had 'improved performance'. However, there is no clear mention of whether overdosing issues have been resolved or will be resolved with future corrective actions. Suggest elaborating on whether the continuous repair on faulty ammonia dosing pumps between August and October 2021 were ultimately successful or still ongoing. If repairs are still ongoing, ERM suggests to also provide a high-level reference to relevant corrective actions to this table row (noting that details are generally contained in the site actions register) for closure.	Please refer to the comment above, regarding repair of ammonia dosing pumps and the change of ammonia dosing location which has resulted in reduction in ammonia chemical usage and improved management of dosing pumps.	As above. The tabulated summary of the maintenance works completed in 2021 and early 2022 (yellow text) was not included in revision D of the report. ERM was satisfied that the preceding text adequately addressed the comment. Closed.
4	Section 2 general Re: Discussion on ongoing ammonia dosing pump issues.	To facilitate clearer tracking of continuous improvement per OEMP objectives, a high-level summary section discussing the ongoing issues with the ammonia dosing pump is recommended to be added to the end of Section 2. Items that may be worth including are: - Current issues (as of end of reporting period) - High-level mention of future corrective actions (referencing the site actions register) Reference to the additional interim sampling of ammonia and TN required to monitor the efficacy of corrective actions (23 and 25 July; 19 Aug, 18 Oct). Note it is understood these were not intended to be amendments to EPL228, but rather provide context and closure on efforts to address ammonia discharge issues.	Please refer to the previous comments above. The following text will be included at the end of Section 2.1.3 'In general, the total nitrogen discharge limit exceedances reported in Table 2-3 above, have been related to ammonia dosing into the steam system of the CCPP. There are four ammonia dosing locations (with each location having one operational pump and a spare pump on standby) into the steam system. In total there are 8 ammonia dosing pumps at the facility (4 operational and four spare). Following the identification of a faulty ammonia dosing pump, the pump was taken offline, and the spare pump was brought online into service. This allowed for the faulty pump to be removed for repairs either at the INPEX workshop or offsite at maintenance contractor's workshop.	As above. The tabulated summary of the maintenance works completed in 2021 and early 2022 (yellow text) was not included in revision D of the report. ERM was satisfied that the preceding text adequately addressed the comment. Closed.

COMMENTS REGISTER - QUALIFIED PROFESSIONALS REVIEW: AEMR 2021/2022

			In addition to improving the reliability of the dosing pumps, INPEX has also changed the location of ammonia dosing, from the feedwater manifold, to direct into steam condensate manifold of the steam system, this occurred in March 2022. This allows for better control of the dosing into the steam system. With the change in dosing location and improved management of the pumps, there has been a reduction in the consumption rate of ammonia, this has reduced the risk of overdosing in the system. In October 2021, 9,000 L of ammonia was consumed, compare to 7,000 L/per month which is the current consumption rate. There have been no exceedances of total nitrogen in the discharge wastewater at location 750-SC-003 since 18 October 2021 till September 2022. It is considered the main change in the improvement of ammonia dosing, and reduction in chemical usage, is due to the new dosing locations in the steam system.'	

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 3, 1 Havelock St, West Perth, Western Australia 6005.

(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 21nd day of September 2021.

(3) Signature of the person making the declaration

....

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

Witnessed by: ......Saleha......

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

......Saleha Quadsia......

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

46A Kennedy Road, Morley 6062.

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

(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

I, Kenneth Leo Kiefer of Environmental Resources Management Australia Pty Ltd located at Level 15, 309 Kent Street, Sydney, NSW 2000 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 Sydney, the 21th day of September 2022

(3) Signature of the person making the declaration

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

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

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

Witnessed by:

Grace Kiefer, U30 1 Harbourview Cr. Abbotsford, New South Wales.

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.

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 20+ 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 and the AEMR review and endorsement for the 2019/2020-2020/2021 periods 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

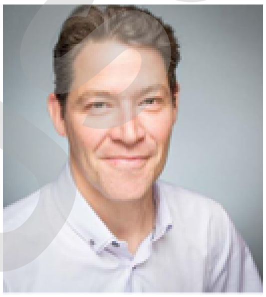
Ken Kiefer (Water Quality - Qualified Professional)

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.

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

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.

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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.

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

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

Shaded cells with bold text indicate a trigger exceedance. These are further described in Table 2-3.

Date	TIME	LIMS Sample ID	pH	Electrical conductivity	Temperature	Turbidity	Dissolved oxygen	TPH as oil & grease	TRH (C6-C10)	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	µg/L	mg/L	mg/L	mg/L	mg/L	µg N/L	mg N/L	mg P/L	mg 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	n/a	10	20	125	2	n/a	10	2	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
6/07/21	9:05	L2102932001														4																	
20/07/21	7:45	L2103198001	9.0	670	27.2	1.0	91	< 1	<20	<100	< 5	<2	12	< 0.02	19	**19**	< 0.5	< 0.5	<0.1	<1	6	<1	<0.1	<1	<1	40	<1	<1	<1	<0.1	< 5	< 5	< 5
20/07/21	14:47	L2103219001													43																		
23/07/21	9:50	L2103273001	8.1												< 2	2																	
25/07/21	9:40	L2103306001	8.1												< 2	< 2																	
17/08/21	7:50	L2103538001	8.8	610	27.9	0.5	87	< 1	<20	<100	< 5	<2	19	< 0.02	10	**12**	< 0.5	< 0.5	<0.1	<1	9	<1	<0.1	<1	<1	37	33	<1	<1	<0.1	< 5	< 5	< 5
19/08/21	12:00	L2103708001													4	4																	
14/09/21	9:00	L2104092001	8.6	379	30.2	1.5	97	< 1	<20	<100	< 5	<2	15	< 0.02	< 2	< 2	< 0.5	< 0.5	<0.1	<1	7	<1	<0.1	2	<1	260	10	7	8	<0.1	< 5	< 5	< 5
12/10/21	7:50	L2104550001	8.8	365	31.2	4.5	97				6		15	< 0.02	10	**13**	< 0.5	< 0.5													< 5	< 5	< 5
18/10/21	8:40	L2104699001	8.4	404	31.3	1.5	94	< 1	<20	<100	< 5	2	12	0.02	4	4	< 0.5	< 0.5	<0.1	<1	5	<1	<0.1	5	<1	766	<1	<1	<1	<0.1	< 5	< 5	< 5
9/11/21	8:44	L2105020001	8.2	513	32.1	1.0	94	< 1	<20	<100	< 5	5	8	< 0.02	5	10	< 0.5	< 0.5	<0.1	<1	4	<1	<0.1	<1	<1	30	<1	<1	<1	<0.1	< 5	< 5	< 5
7/12/21	8:30	L2105392001	8.1	294	30.0	2.0	95	< 1	<20	<100	< 5	<2	11	< 0.02	7	8	0.6	< 0.5	<0.1	<1	<1	<1	<0.1	2	<1	739	<1	<1	<1	<0.1	< 5	< 5	< 5
11/01/22	9:15	L2200144001	8.3	234	33.2	2.5	90	< 1	<20	<100	< 5	2	11	< 0.02	5	6	< 0.5	< 0.5	<0.1	<1	<1	<1	<0.1	1	<1	275	2	<1	<1	<0.1	< 5	< 5	< 5
8/02/22	7:45	L2200531001	8.7	235	29.0	1.5	94	< 1	<20	<100	< 5	<2	11	< 0.02	6	6	< 0.5	< 0.5	<0.1	<1	1	<1	<0.1	<1	<1	278				<0.1	< 5	< 5	< 5
14/02/22	9:14	L2200583001																									2	4	4				
8/03/22	7:25	L2200957001	8.2	310	29.1	1.0	90	< 1	<20	<100	< 5	3	11	0.02	5	6	< 0.5	< 0.5	<0.1	<1	3	<1	<0.1	3	<1	411	4	1	1	<0.1	< 5	< 5	< 5
13/04/22	8:10	L2201552001	8.1	269	29.9	1.5	92	2	<20	<100	< 5	3	8	< 0.02	< 2	3	< 0.5	< 0.5	<0.1	<1	2	<1	<0.1	1	<1	540	44	60	80	<0.1	< 5	< 5	< 5
26/04/22	8:10	L2201923001																									10	15	15				
10/05/22	08:25	L2202127001	8.1	257	28.4	2.5	91	1	<20	<100	<5	2	18	0.02	<2	<2	<0.5	<0.5	<0.1	<1	1	<1	<0.1	1	<1	588	42	<1	<1	<0.1	< 5	< 5	< 5
14/06/22	07:40	L2202662001	8.6	396	24.6	0.5	88	<1	<20	<100	<5	<2	10	0.03	6	8	<0.5	<0.5	<0.1	<1	1	<1	<0.1	<1	<1	92	4	5	12	<0.1	< 5	< 5	< 5

APPENDIX D: AUTHORISED STATIONARY SOURCE EMISSION RELEASE RESULTS

D.1 Stationary source emission test results by Ektimo

Sampling Point Number	Sampling Location Number	Date	LIMS Number	NO_x as NO_2 - Concentration Target		NO_x as NO_2 - Concentration Limit		N_2O		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/m³	mg/m³	mg/m³	ppm	°C	m/s	m³/min
LNG Refrigerant Compressor Driver Gas Turbines (GE Frame 7s)				**50 @ 15%O2**	**25 @ 15%O2**	**70 @ 15%O2**	**35 @ 15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**23**	**-**
A1	L-641-A-001	23/10/2021	L2104664001	12	5.8	12	5.8	3.1	1.6	<0.0003	<0.4	<0.4	<1	<1	182	24	14000
A2	L-642-A-001	23/10/2021	L2104799001	14	6.9	14	6.9	1.3	0.68	<0.0003	<0.4	<0.4	20	16	178	23	14000
A3	L-641-A-002	22/10/2021	L2104661001	15	7.1	15	7.1	1.2	0.63	<0.0003	<0.4	<0.4	1.4	1.1	166	24	15000
A4	L-642-A-002	22/10/2021	L2104660001	9.6	4.7	9.6	4.7	1.6	0.8	<0.0003	<0.4	<0.4	14	11	164	23	14000
CCPP Gas Turbine Generators (GE Frame 6s, 38MW) - HRSG stack				**150 @ 15%O2**	**75 @ 15%O2**	**350 @ 15%O2**	**175 @ 15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**19**	**-**
A5-2	L-630-F-001	18/10/2021	L2104656001	8	4.1	8	4.1	1.2	0.61	<0.00029	<0.4	<0.4	83	66	192	21	6600
A6-2	L-630-F-002	19/10/2021	L2104657001	6.1	3	6.1	3	1.2	0.61	<0.0003	<0.7	<0.7	140	110	194	21	6700
A7-2	L-630-F-003	19/10/2021	L2104658001	6.3	3.1	6.3	3.1	1.1	0.57	<0.0003	<0.7	<0.7	75	60	192	19	6100
A8-2	L-630-F-004	20/10/2021	L2104659001	7.3	3.6	7.3	3.6	2.0	0.99	<0.0003	<0.6	<0.6	44	35	173	21	7200
A9-2	L-630-F-005	N/A Unit offline at the time of sampling for planned maintenance, no results available.															
AGRU Incinerators				**320 @3%O2**	**160 @3%O2**	**350@3%O2**	**175 @15%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**19**	**-**
A13-1	L-551-FT-031	21/10/2021	L2104663001	26	13	26	13	58	30	<0.00037	<0.6	<0.6	230	190	489	20	2800
A14-1	L-552-FT-031	21/10/2021	L2104662001	52	25	52	25	48	25	<0.0003	<0.6	<0.6	170	140	466	22	3100
Heating medium furnaces				**160 @3%O2**	**80 @3%O2**	**350@3%O2**	**175 @3%O2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
A15	L-640-A-001-A	24/10/2021	L2104666001	130	64	130	64	1.1	0.55	<0.0003	<0.8	<0.8	270	220	195	3.1	480
A16	L-640-A-001-B	24/10/2021	L2104667001	130	63	130	63	1.0	0.53	<0.0003	<0.5	<0.5	330	260	191	5.0	770

D.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								
16/07/2021	L2103022001	120	130	< 30	< 30	< 30	< 30	-
07/08/2021	L2103497001	140	<30	< 30	< 30	< 30	< 30	-
11/08/2021	L2103558001	140	30	<30	<30	<30	<30	-
16/08/2021	L2103622001	140	170	<30	<30	<30	<30	-
22/08/2021	L2103750001	130	<30	<30	<30	<30	<30	-
15/09/2021	L2104075001	160	190	30	<30	<30	<30	-
26/09/2021	L2104290001	130	40	<30	<30	<30	<30	-
11/10/2021	L2104529001	120	<30	<30	<30	<30	<30	-
07/11/2021	L2104987001	140	<30	<30	<30	<30	<30	-
06/12/2021	L2105378001	140	<30	<30	<30	<30	<30	-
07/01/2022	L2200076001	140	<30	<30	<30	<30	<30	-
13/01/2022	L2200173001	160	<30	<30	<30	<30	<30	-
27/02/2022	L2200622001	140	<30	<30	<30	<30	<30	-
08/03/2022	L2200938001	160	30	<30	<30	<30	<30	-
09/04/2022	L2201493001	140	<30	<30	<30	<30	<30	-
11/05/2022	L2202115001	140	70	<30	<30	<30	<30	-
21/05/2022	L2202249001	120	120	<30	<30	<30	<30	-
16/06/2022	L2202636001	160	140	<30	<30	<30	<30	-
A13-3 (L-541-SC-001) Feed gas to AGRU – LNG Train 1 – prior to release at A3								
18/07/2021	L2103173001	-	-	-	-	-	-	<0.005
10/08/2021	L2103540001	-	-	-	-	-	-	<0.005
15/08/2021	L2103621001	-	-	-	-	-	-	<0.005
22/08/2021	L2103751001	-	-	-	-	-	-	<0.005
20/09/2021	L2104215001	-	-	-	-	-	-	<0.005
26/09/2021	L2104289001	-	-	-	-	-	-	<0.005
11/10/2021	L2104501001	-	-	-	-	-	-	<0.005

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
25/11/2021	L2105116001	-	-	-	-	-	-	<0.005
05/12/2021	L2105379001	-	-	-	-	-	-	<0.005
26/12/2021	L2105685001	-	-	-	-	-	-	<0.005
07/01/2022	L2200075001	-	-	-	-	-	-	<0.005
13/01/2022	L2200172001	-	-	-	-	-	-	<0.005
18/02/2022	L2200763001	-	-	-	-	-	-	<0.005
28/03/2022	L2201245001	-	-	-	-	-	-	<0.005
21/04/2022	L2201688001	-	-	-	-	-	-	<0.005
14/05/2022	L2202225001	-	-	-	-	-	-	<0.005
17/6/2022	L2202774001	-	-	-	-	-	-	<0.005
A14-2 (L-552-SC-003) AGRU hot Vent Train2, prior to release at A4								
01/07/2021	L2102532001	140	< 30	< 30	< 30	< 30	< 30	-
16/07/2021	L2103021001	140	60	< 30	< 30	< 30	< 30	-
07/08/2021	L2103480001	160	< 30	< 30	< 30	< 30	< 30	-
11/08/2021	L2103559001	160	< 30	< 30	< 30	< 30	< 30	-
29/08/2021	L2103879001	145	< 30	< 30	< 30	< 30	< 30	-
15/09/2021	L2104074001	160	170	< 30	< 30	< 30	< 30	-
21/09/2021	L2104231001	140	< 30	< 30	< 30	<30	<30	-
23/09/2021	L2104258001	150	<30	<30	< 30	< 30	< 30	-
26/09/2021	L2104288001	160	< 30	< 30	< 30	< 30	< 30	-
11/10/2021	L2104528001	140	< 30	< 30	< 30	< 30	< 30	-
30/10/2021	L2104859001	140	< 30	< 30	< 30	< 30	< 30	-
07/11/2021	L2104988001	140	< 30	< 30	< 30	< 30	< 30	-
08/12/2021	L2105458001	140	< 30	< 30	< 30	< 30	< 30	-
10/12/2021	L2105519001	140	< 30	< 30	< 30	< 30	< 30	-
15/12/2021	L2105595001	120	< 30	< 30	< 30	< 30	< 30	-
07/01/2022	L2200078001	140	< 30	< 30	< 30	< 30	< 30	-
03/02/2022	L2200477001	130	< 30	< 30	< 30	< 30	< 30	-
08/03/2022	L2200939001	140	< 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
27/03/2022	L2201302001	120	< 30	< 30	< 30	< 30	< 30	-
16/04/2022	L2201494001	150	170	60	< 30	< 30	< 30	-
11/05/2022	L2202116001	140	120	<30	<30	<30	<30	-
20/05/2022	L2202250001	150	90	<30	<30	<30	<30	-
13/06/2022	L2202637001	140	120	<30	<30	<30	<30	-
A14-3 (L-542-SC-001) Feed gas to AGRU – LNG Train 2 – prior to release at A4								
14/07/2021	L2103071001	-	-	-	-	-	-	< 0.005
26/07/2021	L2103325001	-	-	-	-	-	-	< 0.005
09/08/2021	L2103481001	-	-	-	-	-	-	< 0.005
04/09/2021	L2103878001	-	-	-	-	-	-	< 0.005
21/09/2021	L2104232001	-	-	-	-	-	-	< 0.005
26/09/2021	L2104287001	-	-	-	-	-	-	< 0.005
25/11/2021	L2104858001	-	-	-	-	-	-	< 0.005
07/12/2021	L2105459001	-	-	-	-	-	-	< 0.005
15/12/2021	L2105596001	-	-	-	-	-	-	< 0.005
27/12/2021	L2105804001	-	-	-	-	-	-	< 0.005
07/01/2022	L2200077001	-	-	-	-	-	-	< 0.005
17/02/2022	L2200698001	-	-	-	-	-	-	< 0.005
15/02/2022	L2200787001	-	-	-	-	-	-	< 0.005
04/03/2022	L2200836001	-	-	-	-	-	-	< 0.005
27/03/2022	L2201301001	-	-	-	-	-	-	< 0.005
30/04/2022	L2201796001	-	-	-	-	-	-	< 0.005
20/05/2022	L2202251001	-	-	-	-	-	-	< 0.005
17/06/2022	L2202809001	-	-	-	-	-	-	< 0.005

APPENDIX E: GROUNDWATER QUALITY DATA

Monitoring_Round	LocCode	Sampled_Date-Time	Ammonia as N	Nitrogen (Total)	Oxides of Nitrogen	Phosphate total (P)	Reactive Phosphorus as P	TSS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (hexavalent) (Filtered)	Chromium (Trivalent) (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	Biological oxygen demand (BOD)	E. coli	Entercocci	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Salinity	Temp
Units	n/a	n/a	µg/L																										MPN/100mL	cfu/100mL	% sat	uS/cm	pH_Units	mV	PSU	°C
Operations Survey 8	BPGW01	18/10/2021	260	<500	10	17	9	1600	5	31	0.4	0.25	0.25	27	<1.0	<0.20	1300	0.05	14	0.05	0.25	63	<1	<1	<1	<3	<100	-	-	-	1.6	3948	5.18	61.8		31.9
Operations Survey 8	BPGW07	18/10/2021	380	130	130	22	33	65000	5	12	1.5	0.25	0.25	29	<1.0	2.1	1400	0.05	31	0.2	0.25	55	<1	<1	<1	<3	<100	-	-	-	3.78	131025	4.99	82.4		31.6
Operations Survey 8	BPGW08A	18/10/2021	91	289	3	15	22	12000	5	4.8	0.8	0.25	0.6	61	<1.0	5	5600	0.05	35	0.4	0.25	63	<1	<1	<1	<3	<100	-	-	-	1.7	29852	5.27	164.8		31.3
Operations Survey 8	BPGW09	18/10/2021	590	470	<2	24	0.5	84000	5	47	0.9	0.25	1.7	2.8	<1.0	0.5	300	0.05	1.7	0.4	0.25	5	<1	<1	<1	<3	<100	-	-	-	1.8	52999	5.24	-52.8		31.6
Operations Survey 8	BPGW18	20/10/2021	350	750	<2	50	0.5	60000	5	18	<0.20	0.25	0.25	<0.20	2	0.3	79	0.05	0.5	0.05	1.5	15	<1	<1	<1	<3	<100	-	-	-	2.3	91920	5.13	-47.8		30.2
Operations Survey 8	BPGW19A	20/10/2021	1400	2300	<2	44	11	46000	5	1.6	<0.20	1	0.25	0.3	<1.0	0.7	61	0.05	2.3	0.05	3.7	13	<1	<1	<1	<3	<100	<2	<1	<1	1.5	81889	5.93	-50.5		32.4
Operations Survey 8	BPGW20	20/10/2021	140	260	<2	5	8	870	5	5.1	<0.20	0.25	0.25	2.7	<1.0	<0.20	53	0.05	1.4	0.05	0.9	6	<1	<1	<1	<3	<100	-	-	-	1	2197	5.38	20.2		33.3
Operations Survey 8	BPGW26	19/10/2021	310	460	130	6	1	6200	5	4.7	<0.20	0.25	0.25	11	<1.0	<0.20	3100	0.05	1.4	0.05	1.1	<5.0	<1	<1	<1	<3	<100	-	-	-	1.1	16550	5.27	80.7		32
Operations Survey 8	BPGW27A	20/10/2021	260	270	6	12	5	1500	5	2	<0.20	0.25	0.25	1.9	<1.0	<0.20	41	0.05	0.9	0.05	0.7	6	<1	<1	<1	<3	<100	<2	<1	<1	1.4	2981	5.44	65		33.8
Operations Survey 8	BPGW28	20/10/2021	1000	1500	<2	38	3	83000	5	3.5	<0.20	0.6	0.25	<0.20	<1.0	0.3	170	0.05	0.25	0.05	1.5	<5.0	<1	<1	<1	<3	<100	-	-	-	1.5	19886	5.71	-60.4		31.2
Operations Survey 8	BPGW38A	19/10/2021	93	300	36	5	12	1800	5	0.4	4.4	0.25	0.25	1.3	<1.0	<0.20	38	0.05	1.3	0.05	0.7	<5.0	<1	<1	<1	<3	<100	-	-	-	2.9	4831	5.44	75.3		32.4
Operations Survey 8	BPGW40	19/10/2021	400	660	13	6	4	3500	10	6.2	<0.20	0.25	0.25	0.9	<1.0	<0.20	150	0.05	0.25	0.05	0.7	<5.0	<1	<1	<1	<3	<100	-	-	-	1.6	8931	5.81	-64.1		31.2
Operations Survey 8	BPGW41	19/10/2021	610	900	13	13	8	8200	5	3.9	<0.20	0.25	0.25	<0.20	<1.0	<0.20	12	0.05	0.25	0.05	0.9	<5.0	<1	<1	<1	<3	<100	-	-	-	14.9	33475	5.68	-68		30.1
Operations Survey 8	VWP328	20/10/2021	290	760	<2	47	0.5	75000	5	510	<0.20	0.25	0.25	13	1	0.7	490	0.05	3.9	0.05	1.2	10	<1	<1	<1	<3	<100	-	-	-	3.4	11267	5.19	-42		31.2
Operations Survey 8	VWP341	19/10/2021	580	720	<2	<5.0	0.5	2000	5	5.2	<0.20	0.25	0.25	110	<1.0	<0.20	1300	0.05	13	0.05	0.7	130	<1	<1	<1	<3	<100	-	-	-	1.8	5235	4.96	45		32.5
Operations Survey 9	BPGW01	5/04/2022	57	300	<2	14	9	160	5	7.1	<0.20	0.25	0.25	7.1	<1.0	<0.20	510	0.05	1.8	0.05	0.25	14	<1	<1	<1	<3	<100	-	-	-	9	376.1	5.04	14.9		30.6
Operations Survey 9	BPGW07	5/04/2022	380	1000	<2	26	28	69000	5	23	0.4	0.25	0.5	15	<1.0	1.7	840	0.05	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	37.5	107641	5.61	82.3		31.0
Operations Survey 9	BPGW08A	4/04/2022	220	220	<2	18	1	4300	70	49	0.6	1	0.25	35	<1.0	0.3	2200	0.05	0.25	0.05	1	<5.0	<1	<1	<1	<3	<100	-	-	-	75.9	7421	5.54	-49.8		32.0
Operations Survey 9	BPGW09	5/04/2022	220	300	14	26	0.5	100000	5	85	<0.20	0.25	0.5	4	<1.0	1.6	540	0.05	1.8	0.05	0.25	15	<1	<1	<1	<3	<100	-	-	-	149.6	48207	6	-22.9		30.8
Operations Survey 9	BPGW18	6/04/2022	320	250	30	80	0.5	8300	5	15	<0.20	0.25	0.25	<0.20	<1.0	0.5	79	0.05	0.25	0.05	0.6	<5.0	<1	<1	<1	<3	<100	-	-	-	205.3	77346	6.14	-38.8		30.2
Operations Survey 9	BPGW19A	6/04/2022	1200	240	27	<5.0	1	60000	5	8.3	<0.20	0.25	0.6	<0.20	<1.0	0.2	64	0.05	0.25	0.05	3.2	<5.0	<1	<1	<1	<3	<100	<1	<5	<1	163.5	74965	6.14	-31.9		31.3
Operations Survey 9	BPGW20	6/04/2022	42	120	37	<5.0	1	950	5	2	<0.20	0.25	0.25	1.4	<1.0	<0.20	31	0.05	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	56	1427	5.41	26.3		33.1
Operations Survey 9	BPGW26	4/04/2022	210	220	<2	5	1	5100	5	3.3	<0.20	1	0.25	6.8	<1.0	<0.20	<1.0	0.05	0.9	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	25	8249	5.41	52.7		32.2

Monitoring_Round	LocCode	Sampled_Date-Time	Ammonia as N	Nitrogen (Total)	Oxides of Nitrogen	Phosphate total (P)	Reactive Phosphorus as P	TSS	Aluminium (Filtered)	Arsenic (Filtered)	Cadmium (Filtered)	Chromium (hexavalent) (Filtered)	Chromium (Trivalent) (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	Biological oxygen demand (BOD)	E. coli	Entercocci	Dissolved Oxygen (%)	EC (field)	pH (Field)	Redox	Salinity	Temp
	BPGW27A	6/04/2022	230	230	54	<5.0	0.5	1700	5	1.3	<0.20	0.25	0.25	1.3	<1.0	<0.20	23	0.05	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	<1	<5	>100	38.5	2997	5.18	52.4		33.4
	BPGW28	6/04/2022	920	1300	30	20	0.5	2600	5	6.3	<0.20	0.25	0.25	<0.20	<1.0	0.5	190	0.05	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	123.1	102413	6.44	-58.7		31.1
	BPGW38A	4/04/2022	2.5	580	513	<5.0	2	310	20	0.3	<0.20	2	24	0.3	<1.0	<0.20	3	0.05	18	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	92.9	561	6.32	49.2		33.2
	BPGW40	5/04/2022	420	400	22	8	3	2200	5	6	<0.20	2	0.25	1.4	<1.0	<0.20	150	0.05	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	84.5	5878	6.07	-57.8		30.9
	BPGW41	5/04/2022	570	600	<2	14	0.5	11000	5	4.7	<0.20	0.25	0.6	<0.20	<1.0	0.3	19	0.1	0.25	0.05	0.25	<5.0	<1	<1	<1	<3	<100	-	-	-	1378.2	27804	6.56	-65.8		30.3
	VWP328	6/04/2022	320	450	765	14	0.5	2700	5	720	<0.20	0.25	0.25	<0.20	<1.0	0.6	<1.0	0.05	2.4	0.05	0.25	8	<1	<1	<1	<3	<100	-	-	-	203.7	96496	5.86	-14.5		31.0
	VWP341	4/04/2022	570	550	<2	5	2	2200	10	5	<0.20	2	0.25	100	<1.0	<0.20	<1.0	0.05	0.25	0.05	0.6	130	<1	<1	<1	<3	<100	-	-	-	80.3	3538	5.26	44.5		33.2

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Name	Title	Date and Time	Action
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Andrew Dent	Production Superintende	29/09/22 06:01	Approver