ONSHORE OPERATIONS ENVIRONMENTAL MANAGEMENT PLAN AND LIQUID DISCHARGE MANAGEMENT PLAN: ADDENDUM 1 FIREFIGHTING TRAINING

Plan

Document No.: L790-AH-PLN-70000
Security Classification: Public

Rev	Date	Description	Prepared	Checked	Endorsed	Approved
0	11 May 2021	Issued for use	Oakerman	MSteele	JProut	CBlackburn

NOTICE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TABLE OF APPENDICES

Acronyms, abbreviations, and terms

Acronym/abbreviation/term	Definition
DAWE	Department of Agriculture, Water and the Environment
EPL	Environment protection licence (EPL228 as varied)
ERT	emergency response team
Ichthys LNG	The onshore plant site located at Bladin Point
INPEX	INPEX Operations Australia Pty Ltd
kL	kilolitres (equal to a 1000L)
L	litres
LDMP	the Ichthys Onshore LNG Facilities Liquid Discharge Management Plan: Operations (L060-AH-PLN-60050)
lpm	litres per minute
NT EPA	Northern Territory Environment Protection Authority
OEMP	the Onshore Operations Environmental Management Plan (L060-AH-PLN-60005)
QLD Policy	the Queensland *Operational Policy: Environmental Management of Firefighting Foam* (DES 2016)
SDS	Safety Data Sheet
Solberg DOD3155	Solberg DOD3155 Training Foam Concentrate
the activity	the portable/mobile firefighting training activity
the Addendum	Onshore Operations Environmental Management Plan and Liquid Discharge Management Plan: Addendum 1 Firefighting Training (L790-AH-PLN-70000)
training activity	The training activity is anticipated to take place every two years; although, training may occur by exception periodically. The training activity is comprised of five training exercises.

1 INTRODUCTION

INPEX Operations Australia Pty Ltd (INPEX) has an Onshore Operations Environmental Management Plan (OEMP; L060-AH-PLN-60005) and Ichthys Onshore LNG Facilities Liquid Discharge Management Plan: Operations (LDMP; L060-AH-PLN-60050) in place for the operations of the Ichthys LNG facility, located on Bladin Point in the Northern Territory.

INPEX has identified a requirement to undertake portable/mobile firefighting training activities (utilising PFAS-free training foam), at the Ichthys LNG Facility. This activity is not currently described in the OEMP[1] or LDMP. In lieu of a full revision to the OEMP and LDMP, this *Onshore Operations Environmental Management Plan and Liquid Discharge Management Plan: Addendum 1 Firefighting Training* (this Addendum) has been prepared to fulfil the requirements of:

- Condition 32 of the Ichthys LNG facility environment protection licence (EPL228 (as varied)), administrated by the Northern Territory Environment Protection Authority (NT EPA). Specifically:

  32. Each time the OEMP is materially amended, the licensee must provide the amended OEMP to the NT

  EPA, within 10 business days prior to any amendment being implemented, with:

  32.1 a tabulated summary of the amendment(s) with document references;

  32.2 reasons for the amendment(s);

  32.3 an assessment of environmental risk associated with the amendment(s); and

  32.4 where there are more than typographical amendments, with a Qualified Professional's written endorsement and review and endorsement of the amended OEMP that the environmental risks have been properly identified and the risk mitigated.

- Condition 8 of the Ichthys Project Commonwealth Approval (EPBC 2008/4208), administered by the Department of Agriculture, Water and the Environment (DAWE). Specifically:

  8. Liquid Discharge Management Plan

  The person taking the action must submit for the Minister's approval a Liquid Discharge Management Plan or plans to mitigate the environmental effects of any liquid discharge from the proposal, including sewerage and surface water runoff. The Liquid Discharge Management Plan(s) must be for the protection of the Commonwealth marine area and habitat for listed species in Darwin Harbour and must:

  a) identify all sources of liquid discharge;

  b) describe any impacts associated with the discharge of liquids, including the cumulative impacts associated with the discharge of sewerage;

  c) clearly articulate the objectives of the plan and set measurable targets to demonstrate achievement of these;

  d) outline measures to avoid impacts;

[1] The most current OEMP is made available on INPEX's external website <https://www.inpex.com.au/projects/ichthys-lng/our-commitments/>

e) where impacts are unavoidable describe why they are unavoidable and measures to minimise impacts;

f) demonstrate how any discharges into Darwin Harbour are consistent with the guidelines for discharges, and the water quality objectives for Darwin Harbour, developed under the National Water Quality Management Strategy;

g) identify all regulatory requirements relating to the discharge of liquids and how these will be met;

h) include a monitoring regime to determine achievement of objectives and success of measures used;

i) outline reporting and auditing arrangements; and

j) describe how the plan will apply the principles of adaptive management.

*The plan(s) must be submitted prior to the commencement of the **relevant activity** to which they apply. The **relevant activity** may not commence until the plan is approved. Separate Liquid Discharge Management plans can be submitted for the management of liquid discharges in the Commonwealth Marine Area and Darwin Harbour. The approved plan(s) must be implemented.*

This Addendum should be read in conjunction with the OEMP and LDMP, as the Addendum purpose is only to provide new information not already described in these plans, rather than to duplicate information (i.e. the Addendum is not a stand-alone document).

1.1 Background

Liquid hydrocarbon fires are considered a Major Accident Event as identified in the Ichthys LNG Facility Operations Safety Case.

The use of low expansion firefighting foam for fire suppression, extinguishment and prevention of event escalation, is a key element of the Ichthys LNG facility active fire control systems and emergency response operations.

The practiced and proficient use of portable and mobile firefighting foam equipment is integral to the onsite safety management system and mitigation of environmental impact.

It is essential in achieving emergency response aims, ensuring efficacy of foam deployment capabilities and assuring the safety of responders when deploying firefighting foam in an actual fire event.

Responder effectiveness and competency can only be achieved through training in a real-life simulated training environment, which will inform emergency response teams on the correct and appropriate manner to deploy firefighting foam.

1.2 Purpose and scope

The purpose of this Addendum is to:

- describe the proposed portable/mobile firefighting training activities
- demonstrate that the environmental impacts and risks associated with the activity have been reduced to as low as reasonably practicable, through the implementation of appropriate controls in accordance with Condition 28 of EPL228 (as varied), and Condition 8 of EPBC 2008/4208.
- define appropriate monitoring, recording and reporting arrangements.

The scope of the Addendum is limited to portable/mobile firefighting training activities, utilising PFAS-free training foam, that are required to be undertaken throughout the operations phase at the Ichthys LNG Facility.

In accordance with EPL228 (as varied) Condition 32.4, this Addendum includes a qualified professional's written endorsement and review (Appendix A).

2 ACTIVITY DESCRIPTION

An overview of the proposed activity is provided in Table 2-1. Further details on each of the parameters are provided in subsequent sections of this Addendum.

Table 2-1: Overview of activity

Parameters	Description
Frequency/timing	The activity is planned to be undertaken on a two-yearly basis, throughout operations. However, training may occur by exception periodically. The activity would only be undertaken during the dry season from 1 May – 30 September, in any given year.
Activity	Each training activity will involve the following: • five training exercises (to account for the five rotational shifts at Ichthys LNG) • training with portable/mobile firefighting equipment utilising firewater only • training with portable/mobile firefighting equipment utilising a 3% PFAS-free training foam solution* • clean-up and preparation of equipment for response readiness, following each training exercise.
Location	The activity would be undertaken in either of the condensate bunds associated with the Ichthys LNG facility.
Product	Solberg DoD3155 (PFAS-free) Training Foam Concentrate (low-expansion foam).
Wastewater volumes	The total volume of wastewater generated per training activity is approximately 200 kilolitres (kL).
Wastewater disposal	Wastewater would be retained for collection by a licenced contractor and disposed of at a suitably licenced facility.

* This solution comprises 3% Solberg DoD3155 concentrate and 97% water.

2.1 Firefighting training activity

Ichthys LNG facility has five rotational shift groups, which ensure 24/7 operations, 365 days per year. Each shift is comprised of operations and maintenance personnel and incorporates a site-based emergency response team (ERT).

To ensure competency and capability of ERTs to apply low-expansion foam, utilising mobile equipment, onto a unignited non-cryogenic hydrocarbon pool or a hydrocarbon (or B Class) fire, each rotational shift group is required to undertake training to develop skills and knowledge of the following:

- the theoretical use and application of low expansion foam, foam producing mobile equipment and apparatus and its correct application
- pre-emergency deployment preparedness checks, ensuring mobile equipment and resources are stored and operational in a response readiness state
- practical use of low expansion foam production procedures and fire stream delivery equipment using water only
- practical, actual use of low-expansion foam in a scenario-based deployment drill (live foam test), achieving essential and meaningful practical response experience and foam performance awareness

- mobile equipment after use care and readiness checks (e.g. flushing of mobile equipment after use. Check, service and prepare for use).

Training activities which are relevant and addressed in this Addendum are as follows:

- practical use of low-expansion foam production procedures and fire stream delivery equipment (water only)
- practical, actual use of low-expansion foam in a scenario-based deployment drill (live foam test)
- equipment after use care and readiness checks.

Details of the low-expansion foam product to be used during the training exercise are provided in Section 2.4.

2.2 Frequency and timing

To ensure retention of skills and maintenance of competency, the training activity is anticipated to take place every two years. However, training may occur by exception periodically if there is an imperative to develop competence on a risk-based need (i.e. employee turnover).

Based on the risk assessment presented in Section 4, the activity would only be undertaken during the dry season from 1 May – 30 September in any given year.

Each training activity would require five individual training exercises to be undertaken to ensure competency across all five rotational emergency response teams (ERTs).

2.3 Location of activity

The training activity would be undertaken at the Ichthys LNG site, within either of the two condensate tank bunds.

The condensate tank bunds are considered to be the best location to undertake the training as it ensured the foam solution could be retained and contained (preventing potential contamination of the adjacent areas), as well as allowing for the easy collection of the spent foam solution by a licensed waste contractor.

The bund drains will be closed preventing any outflow beyond the bund. While the height of the bund walls (5.5 m) will prevent any foam being released to the areas adjacent to the bund. Condensate bunds specifications are provided in Table 2-2, with the location of the bunds shown in Figure 2-1. Drainage isolations are discussed further in Section 4.2.2.

Table 2-2: Condensate bund specifications

Bund specifications	Description
Bund height	Bund wall height is 5.5m.
Bund capacity	Bund capacity is to 110% of the condensate tank size (66,000m^3) – 72,600m^3.
Bund material	Impermeable concrete hardstand area.

Figure 2-1: Ichthys LNG condensate bund location

2.4 Product details

Following an initial assessment, INPEX selected to undertake training activities using a training foam product (mimic foam) versus the actual firefighting foam which would be used in the event of an emergency. Specifically, Solberg DoD3155 Training Foam Concentrate (Solberg DoD3155) was selected for the purposes of the training activity.

Solberg DoD3155 is marketed a PFAS-free and environmentally benign product (i.e. it is considered non-persistent and biodegradable), which mimics the same properties of an actual low-expansion firefighting foam.

At the time of writing, there was no Commonwealth guidance/standard that defined what constitutes a PFAS-free firefighting foam product. The only guidance/standard currently available, which defines limits, is the Queensland *Operational Policy: Environmental Management of Firefighting Foam* (QLD Policy; DES 2016)[2]. In the absence of other guidance/standards, the QLD Policy limits were used and compared with the Solberg DoD3155 concentrated product results of analysis, as part of the initial product screening process.

The results of analysis confirm that Solberg DoD3155 (concentrated product) is well below the QLD Policy limits for PFOS and PFOA compounds (Refer to Table 2-3 and ALS Certificate of Analysis in Appendix B).

In addition to the initial product concentrate laboratory analysis, prior to the delivery and transportation to Ichthys LNG and again prior to the use of the product at Ichthys LNG further analysis will be undertaken on the Solberg DoD3155 product solution (3% product + 97% water) to validate the product is PFAS-free (refer to Section 4.2.1).

The Solberg DoD3155 Safety Data Sheet (SDS), Product Environmental Data Information, Vendor Statement of Commitment and ALS Certificate of Analysis are provided in Appendix B.

Table 2-3: Comparison of QLD Policy limits and Solberg DoD3155 product compounds

Compound	QLD Policy limit (DES 2016)	ALS limit of reporting	Solberg DoD3155 product concentrate
PFOS (Perfluoro-octane sulfonic acid) and PFHxS (perfluorohexane sulfonate).	10 mg/kg (sum)	0.02 mg/kg	<0.02 mg/kg
PFOA (Perfluoro-octanoic acid) and higher homologues, PFOA precursors and higher homologous PFCs as the sum of the total oxidisable precursor assay for C7 to C14 compounds (TOPA C7-C14).	50 mg/kg (as fluorine)	0.02 mg/kg	<0.02 mg/kg

2.5 Wastewater volumes

Approximately 40 kL of wastewater will be generated per training exercise, resulting in total of 200 kL of wastewater generated per - training activity. A breakdown of wastewater volumes are as follows:

[2] The QLD Policy defines limits for "C6 purity-compliant foam" which is intended to assess the presence of higher chain bioaccumulating PFAS compounds such as PFOS, PFOA and other >C6 PFAS.

- Training (firewater only):
  - approximately 10 kL of wastewater generated per training exercise
  - total of approximately 50kL per training activity.
- Training (3% PFAS-free training foam solution[3]):
  - approximately 25 kL[4] of wastewater generated per training exercise
  - total of approximately 125 kL[5] per training activity.
- Clean-up and preparation of firefighting equipment:
  - approximately 5 kL per training exercise
  - total of approximately 25kL per training activity.

Note, natural evaporation may be used between training exercises to reduce the volume of wastewater, prior to its removal and disposal at an appropriate licenced facility.

Wastewater management and disposal is further discussed in Section 4.2.4.

[3] This solution comprises 3% Solberg DoD3155 concentrate and 97% water.

[4] This is based on a maximum flowrate of 2500 lpm and assumes 10 minutes live foam practice.

[5] Total volume – (10 mins x 2500lpm) x 5 training exercises = 125 kL.

3 DESCRIPTION OF ENVIRONMENT

A description of the existing environment surrounding Bladin Point is provided in Section 2 of the OEMP and LDMP.

4 POTENTIAL ENVIRONMENTAL IMPACTS AND MANAGEMENT

4.1 Risk assessment

In order to assess the potential environmental impacts associated with the firefighting training activity an ENVID was undertaken in accordance with the process described in the OEMP (Section 4) and LDMP (Section 4).

The outcomes of the complete risk assessment, inclusive of the potential environmental impacts and proposed mitigation measures are provided in Table 4-1 and Section 4.2.

Table 4-1: Firefighting training risk assessment

Item	Activity	Hazard/Aspect	Potential Impact	Controls	Consequence	Likelihood	Residual Risk

1	Selection and procurement of training foam product	Purchase and subsequent use of training foam product potentially containing PFAS contamination (being discharged into an isolated bunded area)	Contamination of land, groundwater and/or surface waters	• INPEX chemical selection and approval process (refer to Section 3.9 of the OEMP, and Section 3.11 of the LDMP).
				• Selection of a PFAS-free training foam (refer to Section 2.4).
				• Validation of PFAS absence/presence in training foam product prior to use (refer to Section 4.2.1):
				  • Prior to delivery to Ichthys LNG, batch testing of the training foam product will be undertaken by the supplier, to confirm it is PFAS-free prior to transport to Darwin.
				  • Upon arrival in Darwin batch testing of the training foam product will be undertaken by INPEX, to validate the supplier results.
				  • The training foam product will not be delivered/used at Ichthys LNG if PFAS is detected during testing.
					E-minor	5-Highly Unlikely	Low

2	Storage of the training foam product concentrate at Ichthys LNG	Spill/loss of containment of PFAS-free training foam concentrate	Contamination of land, groundwater and/or surface waters	• Storage of training foam product at the Ichthys LNG hazardous chemical storage warehouse or in dedicated dangerous goods shipping containers, or within the bunded area of the fire station. • Existing processes and protocol for the handling and storage of bulk chemicals to the facility, including spill response. • Spill Kits. • Emergency Response Team and hazardous material spill response trailer.	E-minor	5-Highly Unlikely	Low
3	Loading of training foam concentrate into mobile firefighting units	Spill/loss of containment of PFAS-free training foam concentrate	Contamination of land, groundwater and/or surface waters	• If required temporary secondary bunds will be placed beneath mobile equipment during transfer and for the duration of the training exercise (inside the condensate tank bund). Noting that the container the foam is received in, will be connected directly into the fire appliance and there will be no decanting into a separate vessel for the training exercise. The trailer that stores the training foam IBC's will be located in the condensate bund along with the fire appliance, • Attended transfer of training foam product concentrate to mobile equipment. • Spill kits	E-minor	5-Highly Unlikely	Low
4	Undertaking training exercise using PFAS-free training foam solution	Processes not followed during training exercises. Spray drift of training foam solution to external environment. Loss of containment of PFAS-free training foam solution to drainage network.	Contamination of land, groundwater and surface water	• Training would only occur during the dry season between 1 May and 30 September, to reduce the likelihood of rain events. • Weather conditions will be monitored prior and during training exercises. • In the day prior to the training exercise the Bureau of Meteorology Darwin 7 day forecast web page will be checked, and if there is a greater than 10% chance of rainfall the training exercise will be postponed. • In addition, the Bureau of Meteorology Darwin rain radar will be reviewed 1 hour prior to the training exercise and if there is any rain within a 64 km radius heading towards the site the training will be postponed. • No training will occur during windy periods where >19km within the bund) or inclement weather. • Training will only to be undertaken in either of the condensate storage tank bunds, which have a bund wall height of 5.5m (refer to Section 2.3). • The condensate bund drainage network will be isolated prior to commencement and during each training exercise. Drain isolations will remain in place until wastewater, generated by the exercise, has been collected (Section 4.2.2). • The existing foam to be isolated in the fire truck while undertaking the training. • Pre-training readiness checks will be undertaken to confirm relevant controls (i.e. bund isolations, etc.) are in place prior to commencement of the training activity (refer to Section 4.2.3). • A training package will be prepared, which will include a presentation on the training foam product and a guide to undertaking the exercise (including the	E-minor	5-Highly Unlikely	Low

Item	Activity	Hazard/Aspect	Potential Impact	Controls	Consequence	Likelihood	Residual Risk
				necessary controls to mitigate impacts). • After each training exercise a continuous improvement review/lessons learnt process will be undertaken, and where improvements are identified these will be adopted for the subsequent training exercises (refer to Section 5.1).			
5	Disposal of wastewater	Processes not followed for disposal of wastewater following training exercises. Incorrect disposal of wastewater or disposal to an unlicensed facility.	Contamination of land, groundwater and surface waters through incorrect disposal of wastewater. Legal prosecution due to incorrect disposal of wastewater.	• Prior to removal and disposal, wastewater generated during the training exercise will be analysed to confirm the absence/presence of PFAS (refer to Section 4.2.1). • Wastewater will be collected by a suitably licenced contractor using a vacuum truck and disposed of at a suitably licenced facility (refer to Section 4.2.4) • Waste tracking and reporting processes will be implemented (refer to Section 4.2.4) • Implementation of waste management processes and procedures. • Natural evaporation may be used to reduce wastewater volumes, prior to removal and disposal offsite (refer to Section 4.2.4).	E-minor	5-Highly Unlikely	Low

4.1.1 Summary of potential environmental impacts and risks

Based on the risk assessment presented in Table 4-1, spill or loss of containment resulting in potential PFAS contamination of land, groundwater and/or surface is not considered plausible and no further assessment of PFAS potential environmental impacts and risks are considered.

There are no planned discharges to Darwin Harbour of Solberg DoD3155, concentrate or in solution. As such, potential environmental impacts are based on unplanned spill or loss of containment event, which may result in potential contamination of land, groundwater and/or surface water. As described in Section 2.4, Solberg DoD3155 is non-persistent and readily biodegradable. Solberg DoD3155 also has a log P_{ow} of less than three, indicating it has a low bioaccumulation potential. Ecotoxicity data (see Appendix B) provided in the products SDS indicates Solberg DoD3155 has low toxicity. Based on the available ecotoxicity data, if Solberg DoD3155 entered Darwin Harbour it would have a guideline or trigger value of 0.032 mg/L[6].

Given Solberg DoD3155 is non-persistent, biodegradable and has a low bioaccumulation potential and low toxicity, an unplanned spill or loss of containment event would result in temporary local scale contamination of land or waters.

4.2 Management and mitigation measures

The following sections describe the key management and mitigation measures which will be employed prior and during training exercises to minimise potential impacts to the environment.

4.2.1 PFAS characterisation analysis

Prior to the delivery, transportation and use of the product at Ichthys LNG further analysis will be undertaken on the Solberg DoD3155 product solution (3% product + 97% water) to validate the product is PFAS-free. This is to include the following:

- Prior to delivery to Ichthys LNG, batch testing of the training foam product solution will be undertaken by the supplier, to confirm it is PFAS-free prior to transport to Darwin.
- Upon arrival in Darwin, batch testing of the training foam product solution will be undertaken by INPEX, to validate the supplier results.

The training foam product will not be delivered/used at Ichthys LNG if PFAS is detected during testing.

Note, product solution analysis will only be undertaken prior to the first training activity, if analysis confirms the Solberg DoD3155product is PFAS-free, ongoing analysis for future training activities utilising the same product will not be undertaken.

In addition to testing of the product prior to first use at Ichthys LNG, following completion of each training exercise a sample of the generated wastewater will collected and analysed to confirm wastewater is PFAS-free and disposal options.

[6]Assessment factor of 1,000 applied to the lowest (32 mg/L) of three toxicity results (two taxonomic groups) in the Solberg DoD3155 SDS. Acute toxicity data has been assumed for conservatism as tests not specified in SDS. Assessment factor method is based on Warne (2001) as described Warne et al. (2018), which is referred to by ANZG (2018) for deriving water quality guidelines for toxicants.

The testing of the Solberg DoD3155 product and wastewater will be undertaken using the laboratory test method EP231X-ST (28 analytes) or a similar test method to detect the presence of PFAS, fluorine or PFHxS chemicals.

All samples will be collected by qualified personnel and sent to a NATA accredited laboratory for analysis.

A summary of the sampling, test method and number of samples which will be undertaken is provided in Table 4-2. Limits of reporting for ultra/super trace analysis are provided in Appendix C.

Table 4-2: PFAS characterisation analysis

Timing	Product	Test method	Number of samples
Prior to delivery to Ichthys LNG, batch testing of the training foam product will be undertaken by the supplier, to confirm it is PFAS-free prior to transport to Darwin.	3% Solberg DoD3155 and water solution	Ultra/super trace sampling method using an extended suite of PFAS analytes (n=≥28), (i.e. EP231X-ST or a similar test).	5 per batch
Upon arrival in Darwin, batch testing of the training foam product will be undertaken by INPEX, to validate the supplier results.	3% Solberg DoD3155 and water solution	Ultra/super trace sampling method using an extended suite of PFAS analytes (n=≥28) , (i.e. EP231X-ST or a similar test).	5 per batch
Upon completion of each training exercise INPEX will undertake testing of wastewater to confirm presence/absence of PFAS and disposal options.	Wastewater	Ultra/super trace sampling method using an extended suite of PFAS analytes (n=≥28) , (i.e. EP231X-ST or a similar test).	1 sample per exercise

4.2.2 Bunding and drainage isolation

Bunds are provided around the two condensate tanks to contain potential spills and contaminated surface runoff. As described in Section 2.3, each bund wall is 5.5m in height and the entire bund is constructed of impermeable concrete.

Each condensate tank bund is provided with two closed drain valves to permit drain down of the surface runoff collected within the dike in case of rain or fire event (one routed to accidental oil contaminated and one to non-contaminated water drainage network). During the training activity bunds will be isolated at these locations to prevent ingress of generated wastewater. The location of isolation valves relative to the condensate tanks and images each valve are shown in Figure 4-1 and Figure 4-2.

Figure 4-1: Condensate tanks bund drain isolation valves

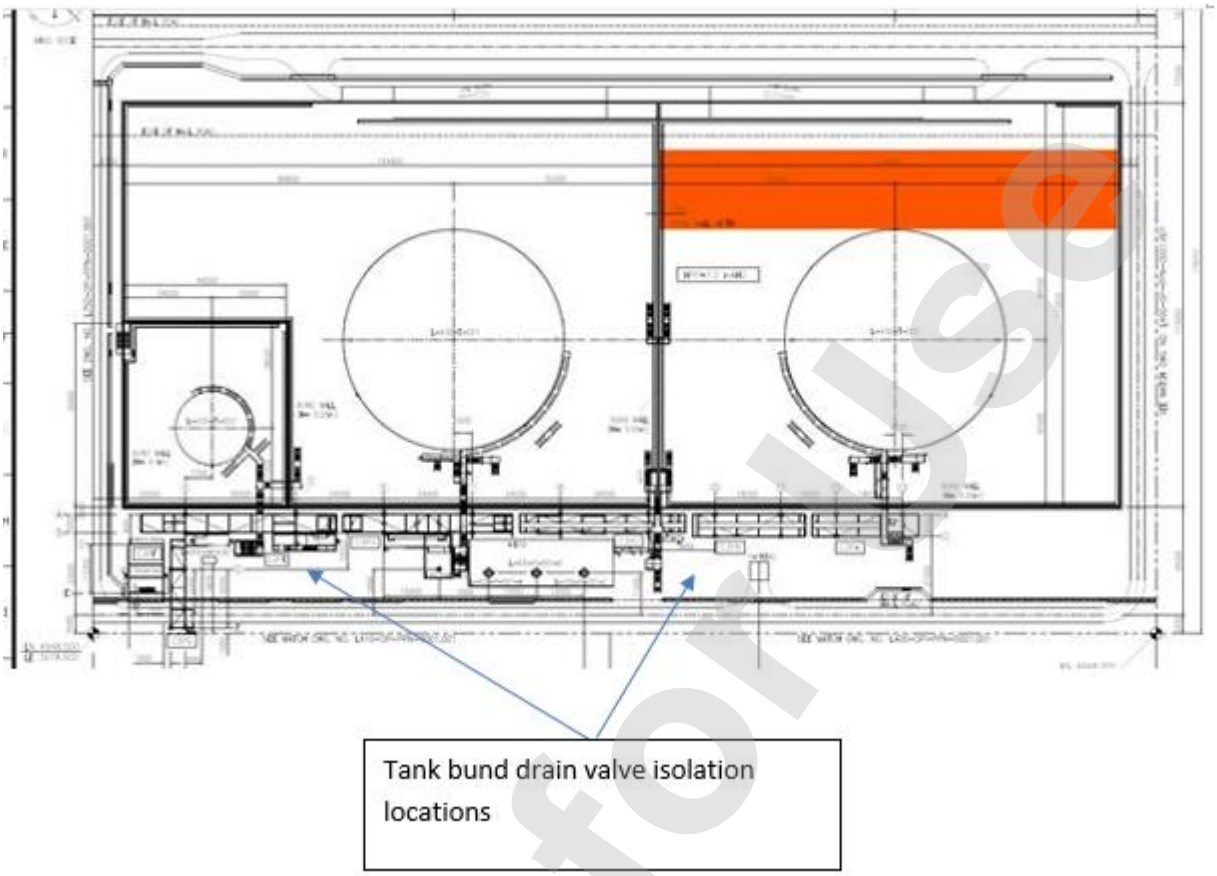


Figure 4-2: Condensate bund isolation valve locations

4.2.3 Pre-training readiness checks

Prior to commencing testing, the Operations Team Lead (ERT Incident Commander) will confirm:

- environment conditions are suitable for testing (i.e. low wind, no rain forecast, etc.)
- all relevant controls are in place (e.g. drain isolations, spill kits, etc.).

To ensure no undue influence from adverse weather conditions, wind speed, rain/storm forecast will be monitored.

In the day prior to the training exercise the Bureau of Meteorology Darwin 7 day forecast web page will be checked, and if there is a greater than 10% chance of rainfall the training exercise will be postponed.

In addition, the Bureau of Meteorology Darwin rain radar will be reviewed 1 hour prior to the training exercise and if there is any rain within a 64 km radius heading towards the site the training will be postponed.

The training exercise would not proceed if wind speed is greater than 19 km/h within the bund, noting that the Bureau of Meteorology describes light wind as <19 km/h or <10 knots (BOM 2021).

Records of pre-training readiness checks will be maintained for audit purposes.

4.2.4 Wastewater management and disposal

Following the completion of the training exercise, PFAS characterisation analysis (refer Section 4.2.1) of the generated wastewater will be undertaken to confirm disposal requirements in accordance with the licenced waste contractor requirements. The INPEX Onshore laboratory will be responsible for the collection of samples following each training exercise and will arrange the testing of the wastewater at an external laboratory.

If laboratory results confirm wastewater is PFAS-free, the wastewater will be removed by vacuum truck by a licenced waste contractor for offsite disposal in the Northern Territory.

In the event that laboratory results indicate the presence of PFAS in wastewater, INPEX will engage a suitable licenced waste contractor to transport the PFAS contaminated wastewater to an authorised interstate waste facility. Note, this is considered a highly unlikely scenario given Solberg DoD3155 is marketed as PFAS-free product and laboratory batch testing of the product (once by the supplier and once by INPEX) will be undertaken to confirm it is PFAS-free, prior to delivery to and use at Ichthys LNG (refer to Section 4.2.1).

The receiving licenced waste facility will be notified of the estimated volume of wastewater and the characteristics of the contaminated wastewater.

Records pertaining to transport, treatment and disposal of wastewater will be maintained.

5 ENVIRONMENTAL PERFORMANCE AND REPORTING

5.1 Continuous improvement

After each training exercise a continuous improvement review/lessons learnt process will be undertaken, with the changes to be made for the proceeding exercises.

5.2 Records

The following records will be maintained for audit purposes:

- Solberg DoD3155 product solution results of laboratory analysis
- Pre-training readiness checks
- records pertaining to transport, treatment and disposal of wastewater.

5.3 Reporting

In addition to the reporting required in Section 6.3.3 of OEMP and Section 6.1.3 of LDMP, copies of all laboratory analysis of the product solution will be provided to both the NT EPA and DAWE, for information, prior to first use on site.

As noted in Section 4.2.1, the training foam product will not be delivered/used at Ichthys LNG if PFAS is detected during testing.

6 REFERENCES

ANZG – see Australian and New Zealand Guidelines

Australian and New Zealand Guidelines 2018. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Governments and Australian state and territory governments, Canberra, Australian Capital Territory.

BOM—*see* Bureau of Meteorology

Bureau of Meteorology. 2021. *Wind*. Bureau of Meteorology, Melbourne, Victoria. Accessed on 11 February 2021 at <Wind - Reference material - Marine Knowledge Centre (bom.gov.au)>

DES—*see* Department of Environment and Science (QLD)

Department of Environment and Science (QLD). 2016. *Operational policy: environmental management of firefighting foam*. Department of Environment and Science, Brisbane, Queensland.

Warne, M.St.J. 2001. Derivation of the ANZECC and ARMCANZ Water Quality Guidelines for Toxicants. *Australasian Journal Ecotoxicology*, **7**, 123–136.

Warne M.St.J., Batley G.E., van Dam R.A., Chapman J.C., Fox D.R., Hickey C.W. and Stauber J.L. 2018. Revised Method for Deriving Australian and New Zealand Water Quality Guideline Values for Toxicants – update of 2015 version. Prepared for the revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra, Australian Capital Territory.

APPENDIX A: QUALIFIED PROFESSIONAL REVIEW AND ENDORSEMENT

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

14 May 2021

Reference: ERM 0565508

Dear Maris

Subject: OEMP/REMP firefighting addendum review and re-endorsement

Environmental Resources Management Australia Pty. Ltd (ERM) was engaged by INPEX Corporation (INPEX) to undertake a Qualified Professional's[1] independent review of the Ichthys LNG Facility's onshore Operational Environmental Management Plan (OEMP) firefighting addendum. This is a requirement of operational condition 31 and 32 of EPL228-04, whereby the OEMP requires a review and endorsement by a 'Qualified Professional' each time there is a material change to the document.

Since the original OEMP/REMP review and endorsement (Golder, 2018), there have been a number of changes to the document, which has triggered the need for re-endorsement by a Qualified Professional as per Environmental Protection Licence 228-04 (EPL 228-04) Condition 32.4. 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) for the re-endorsement of the OEMP/REMP.

Scope

The scope of the review is pursuant to Condition 31 and 32, and taking into consideration conditions 31 and 32 of the EPL 228-04, stated as follows:

Condition 31: *The OEMP must:*

31.1 be prepared with consideration to the NT EPA Guideline for the Preparation of an Environmental Management Plan;

31.2 be endorsed by a Qualified Professional with the experience and qualifications to be able to assess the environmental risks associated with carrying out the Scheduled Activity and to assess the adequacy of the OEMP to facilitate compliance with the conditions of this licence; and 31.3 be provided to the NT EPA with the Qualified Professional's written endorsement and review of the current OEMP, no later than three months after commencement of this licence.'

[1] A '*qualified professional*' as described by the EPL228 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.

Registered office
Environmental Resources Management Australia Pty Ltd
Level 15, 309 Kent Street
Sydney NSW 2000 Australia

ABN: 12 002 773 248
ACN: 002 773 248

Offices worldwide

A member of the
ERM Group

Condition 32:

32 Each time the OEMP is materially amended, the licensee must provide the amended OEMP to the NT EPA, within 10 business days prior to any amendment being implemented, with:

32.1 a tabulated summary of the amendment(s) with document references;

32.2 reasons for the amendment(s);

32.3 an assessment of environmental risk associated with the amendment(s); and

32.4 where there are more than typographical amendments, with a Qualified Professional's written endorsement and review and endorsement of the amended OEMP that the environmental risks have been properly identified and the risk mitigated.

Qualified Professional

The purpose of the Qualified Professional review of the OEMP/REMP is to provide an independent technical assessment verifying that the OEMP/REMP is compliant with the conditions of EPL228-04. The review was undertaken by Qualified Professionals as deemed appropriate for the document's technical content. The Qualified Professionals are listed in Table 1.

Table 1 ERM Qualified Professionals used in this re-endorsement

Area of expertise	Qualified Professional
Water	Ken Kiefer

The following paragraphs provide a brief description of the Qualified Professional's experience. Further details are provided in the CVs, included in **Attachment C** of this report.

Water

Ken 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. 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.

Review process

INPEX presented ERM with a draft version of the firefighting training addendum to the OEMP/REMP. As the previous endorsed version was accepted by NT EPA, the scope of this review, comprised the firefighting training addendum only. The addendum to the OEMP/REMP included the following:

- A description of the purpose and scope;
- A description of the firefighting training activity including frequency and timing, location, product details and waste management;
- An assessment of potential environmental impacts and management; and
- Environmental performance and reporting requirements.

The Qualified Professional reviewed the draft version of the OEMP/REMP with respect to the EPL228-04 conditions 31 and 32 and relevant area of expertise. The comments raised were recorded in a comments register, which is appended to this report in **Attachment A**. The register was provided to INPEX seeking comment on how the identified issues will be closed out. INPEX resubmitted the revised OEMP/REMP addendum to ERM for review. This version incorporated the agreed changes and the comments register. Comments raised were resolved in the updated OEMP/REMP addendum and updates of the comments register returned to ERM (OEMP FFF addendum comments register_REVA_ERM_INPEX) on 04 May 2021.

The following references were used in executing the review process:

- Guideline for the Preparation of an Environmental Management Plan, Version 1.0, May 2015, NT EPA;
- Environmental Protection Licence EPL228-04 issued by NT EPA;
- Onshore Operations Environmental Management Plan, Revision 3, Doc No. 0000-AK-TPL-60061, Nov. 2019; and
- Onshore Operations Environmental Management Plan and Liquid Discharge Management Plan: Addendum 1 Firefighting Training (Doc No. L790-AH-PLN-70000).

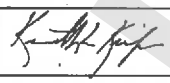
Findings and statement of verification

A total of six items were queried during the review. ERM is satisfied that each of these has been appropriately closed out and the document remains compliant with the requirements of conditions 31 and 32 of EPL228-04. Table 2 describes how the modifications to the OEMP/REMP remain compliant with the identified conditions.

Table 2 Findings and condition compliance

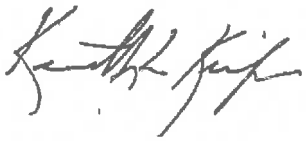
Condition text	Description of how text modification remain compliant with condition
Condition 31: *The OEMP must:*	
31.1 be prepared with consideration to the NT EPA Guideline for the Preparation of an Environmental Management Plan;	The amendments to the OEMP (i.e. the addendum) do not change the framework or structure of the document, the checklist in the NT EPA guidelines remain applicable as endorsed with the original OEMP April 2018.
31.2 be endorsed by a Qualified Professional with the experience and qualifications to be able to assess the environmental risks associated with carrying out the Scheduled Activity and to assess the adequacy of the OEMP to facilitate compliance with the conditions of this licence; and	This document constitutes the re-endorsement by Qualified Professionals.
31.3 be provided to the NT EPA with the Qualified Professional's written endorsement and review of the current OEMP, no later than three months after commencement of this licence.'	This document contains written re-endorsement by Qualified Professionals.
Condition 32*:*	
32 Each time the OEMP is materially amended, the licensee must provide the amended OEMP to the NT EPA, within 10 business days prior to any amendment being implemented, with:	
32.1 a tabulated summary of the amendment(s) with document references;	A summary of amendments is attached as **Attachment A** to this letter.
32.2 reasons for the amendment(s);	Addition of firefighting training tasks.
32.3 an assessment of environmental risk associated with the amendment(s); and	Section 4 of the firefighting training addendum.
32.4 where there are more than typographical amendments, with a Qualified Professional's written endorsement and review and endorsement of the amended OEMP that the environmental risks have been properly identified and the risk mitigated.	This document contains written re-endorsement by Qualified Professionals.

The following verification statement is based on the findings in this letter that result from the Qualified Professionals review of the identified changes in the OEMP/REMP since its endorsement in April 2018.

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 OEMP complies with Conditions 31 and 32 of the EPL228-04 for the 2019-2020 period.		
Area of expertise	**Qualified professional**	**Qualified Professional Signatures**
Water	Ken Kiefer	

Yours sincerely,

For Environmental Resources Management Australia Pty. Ltd.



Ken Kiefer
Technical Director

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

ATTACHMENT A COMMENTS REGISTER

No.	Context	Reviewer Comment/Recommendation (23.04.2021)	INPEX Response	Reviewer Response
1	Licence and Commonwealth approval conditions	Section 1 states that the firefighting training addendum 1 was prepared to "fulfil the requirements of: ■ Condition 32 of the Ichthys LNG facility environment protection licence (EPL228 (as varied)), administrated by the Northern Territory Environment Protection Authority (NT EPA); and ■ Condition 8 of the Ichthys Project Commonwealth Approval (EPBC 2008/4208), administered by the Department of Agriculture, Water and the Environment (DAWE)." For completeness and ease of reference, it is recommended that the wording of the above conditions are included in the report.	The relevant condition text has been inserted under each condition as follows: INPEX has identified a requirement to undertake portable/mobile firefighting training activities (utilising PFAS-free training foam), at the Ichthys LNG Facility. This activity is not currently described in the OEMP or LDMP. In lieu of a full revision to the OEMP and LDMP, this Onshore Operations Environmental Management Plan and Liquid Discharge Management Plan: Addendum 1 Firefighting Training (this Addendum) has been prepared to fulfil the requirements of: ■ Condition 32 of the Ichthys LNG facility environment protection licence (EPL228 (as varied)), administrated by the Northern Territory Environment Protection Authority (NT EPA). Specifically: *32. Each time the OEMP is materially amended, the licensee must provide the amended OEMP to the NT EPA, within 10 business days prior to any amendment being implemented, with:* *32.1 a tabulated summary of the amendment(s) with document references;* *32.2 reasons for the amendment(s);* *32.3 an assessment of environmental risk associated with the amendment(s); and* *32.4 where there are more than typographical amendments, with a Qualified Professional's written*	That update satisfies the comment

No.	Context	Reviewer Comment/Recommendation (23.04.2021)	INPEX Response	Reviewer Response
			endorsement and review and endorsement of the amended OEMP that the environmental risks have been properly identified and the risk mitigated. ■ Condition 8 of the Ichthys Project Commonwealth Approval (EPBC 2008/4208), administered by the Department of Agriculture, Water and the Environment (DAWE). Specifically: *8. Liquid Discharge Management Plan* *The person taking the action must submit for the Minister's approval a Liquid Discharge Management Plan or plans to mitigate the environmental effects of any liquid discharge from the proposal, including sewerage and surface water runoff. The Liquid Discharge Management Plan(s) must be for the protection of the Commonwealth marine area and habitat for listed species in Darwin Harbour and must:* *a) identify all sources of liquid discharge;* *b) describe any impacts associated with the discharge of liquids, including the cumulative impacts associated with the discharge of sewerage;* *c) clearly articulate the objectives of the plan and set measurable targets to demonstrate achievement of these;* *d) outline measures to avoid impacts;* *e) where impacts are unavoidable describe why they are unavoidable and measures to minimise impacts;*	

No.	Context	Reviewer Comment/Recommendation (23.04.2021)	INPEX Response	Reviewer Response
			f) demonstrate how any discharges into Darwin Harbour are consistent with the guidelines for discharges, and the water quality objectives for Darwin Harbour, developed under the National Water Quality Management Strategy; *g) identify all regulatory requirements relating to the discharge of liquids and how these will be met;* *h) include a monitoring regime to determine achievement of objectives and success of measures used;* *i) outline reporting and auditing arrangements; and* *j) describe how the plan will apply the principles of adaptive management.* *The plan(s) must be submitted prior to the commencement of the relevant activity to which they apply. The relevant activity may not commence until the plan is approved. Separate Liquid Discharge Management plans can be submitted for the management of liquid discharges in the Commonwealth Marine Area and Darwin Harbour. The approved plan(s) must be implemented.*	
2	Section 2.2 Frequency and timing	Section 2.2 states that "Based on the risk assessment presented in Section 4, the activity would only be undertaken during the dry season from 1 May – 30 September in any given year." Section 4.2.1 recommends checking rainfall forecast. For planning purposes provide a criteria cut-off for situations where training should be postponed.	The following process will be used during the period of training, and will be included in the addendum: In the day prior to the training exercise the Bureau of Meteorology Darwin 7 day forecast web page will be checked, and if there is a greater than 10% chance of rainfall the training exercise will be postponed. In addition, the Bureau of Meteorology Darwin rain radar will be reviewed 1 hour prior to the training exercise and if there is any rain within a 64 km radius heading towards the site the training will be postponed.	That update satisfies the comment

No.	Context	Reviewer Comment/Recommendation (23.04.2021)	INPEX Response	Reviewer Response
		Also clarify in Section 2.2 that fire training activities would also not occur in a significant rain event during the dry season.		
3	Section 2.4. Queensland Operational Policy: Environmental Management of Firefighting Foam (DES 2016) requirements	Add clarification that the QLD Policy defines limits for "C6 purity-compliant foam" which is intended to assess the presence of higher chain bio-accumulating PFAS compounds such as PFOS, PFOA and other >C6 PFAS.	Have included a footnote acknowledging this. At the time of writing, there was no Commonwealth guidance/standard that defined what constitutes a PFAS-free firefighting foam product. The only guidance/standard currently available, which defines limits, is the Queensland Operational Policy: Environmental Management of Firefighting Foam (QLD Policy; DES 2016). In the absence of other [2] The QLD Policy defines limits for "C6 purity-compliant foam" which is intended to assess the presence of higher chain bio-accumulating PFAS compounds such as PFOS, PFOA and other >C6 PFAS.	That update satisfies the comment
4	Section 4.1 Risk Assessment	Should the risk assessment consider residual PFAS from historical uses that maybe present in infrastructure or bunded surfaces to could reach the environment without controls? Existing controls and PFAS sampling of wastewater would adequately address these. If these surfaces and infrastructure have been tested already or have not had historical uses that would have introduced PFAS, inclusion could be rationally excluded.	There has been no historical PFAS contamination, within the condensate tank bunds. The preference is to use the condensate tank 2 storage bund, which has had no historical uses that would introduce PFAS. The tank 1 bund will only be used if the tank 2 bund is unavailable. Previous commissioning performance testing of the foam system has been performed for condensate Tank 1, this was undertaken during the construction phase. During the testing on the condensate tank 1 foam system, there were no spills or leaks from the removal of waste from the tank and the lines from the foam	No further actions

No.	Context	Reviewer Comment/Recommendation (23.04.2021)	INPEX Response	Reviewer Response
			generation system were flushed with clean fire water, so that no residual foam remained in the lines.	
5	Section 4.1. Risk Assessment	Section 4.1 provides a risk assessment for the use of Solberg DoD3155 concentrate. Based on the hazards and controls documented, it is not clear how the training foam will be transferred to the mobile firefighting units. i.e. Pouring with a funnel? Pumping? What controls are in place to reduce the potential for concentrate to contact ground for the selected methodology of transferring concentrate?	The IBC will be connected directly into the fire appliance and there will be no decanting into a separate vessel for training use. The trailer that stores the training foam IBC's will be located in the condensate bund along with the fire appliance, so there is no need for secondary bunding of the trailer or fire truck. The training foam IBC's will be stored in bunded areas while not in use, either in the fire station or in the warehouse complex.	Updated text consistent with the response will satisfy the comment
6	Continuous improvement	Section 5.1 states that a continuous improvement review/lessons learnt process would be implemented. Is further information available on what the process may look like?	A post training action review will be undertaken following each training session, this will involve an assessment of how the training went, and identification of any improvements that can be implemented for the next training session. This is INPEX's standard practices for any emergency response training exercise and is recorded through internal systems.	No further actions

ATTACHMENT B - STATUTORY DECLARATIONS

THE NORTHERN TERRITORY OF AUSTRALIA

STATUTORY DECLARATION

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

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

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

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

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

Declared at Sydney the 12th day of May 2021

(3) Signature of the person making the declaration

.....

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

Witnessed by:

.....

Chanhthavone List

(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

Environmental Resources Management Australia Pty Ltd located at Level 15, 309 Kent Street, Sydney, New South Wales. Phone: (02) 8586 8765

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.

ATTACHMENT C QUALIFIED PROFESSIONAL PROFILE AND CV

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.

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 ERM's Global Leader of the Human Health and Ecological Risk Assessment Technical Community.

Mr. Kiefer as a Senior Risk Assessor and Technical Focal Point has provided senior technical and quality programmes management as part of the management of large portfolios (>100 sites) of petroleum hydrocarbon sites across Australia and Southeast Asia.

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
- Quantitative health and ecological risk assessment
- Vapour intrusion evaluations
- Environmental fate and transport
- Probabilistic risk assessment
- Toxicological evaluations

Relevant Presentations

- Vida Maulina, Lisa Thomson, **Ken Kiefer**. *Derivation of Water Quality Guideline Value For Marine Discharge Of Monoethylene Glycol.* CleanUp Conference 2019. Adelaide.
- 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

Key Projects

- Ecological risk assessment for Water Treatment Plant effluent as part of remediation of former gas works. Risk assessment successfully led to allowed for increases in EPL discharge limits.
- In support of EPL compliance for an oil and gas facility, developed discharge limits for activated-methyldiethanolamine (aMDEA), piperazine, triethylene glycol (TGA), and monoethylene glycol (MEG), and surfactants
- Human Health and Ecological Risk assessment of a nutrient groundwater plume within the Safety Bay / Becher Sand Aquifer discharging to Cockburn Sound. In addition to quantification of nutrient mass flux into the adjacent Cockburn Sound the work also include a Tier 2 ecological risk assessment that considered off-site groundwater use for irrigation following ANZECC (2000) guidance.
- 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.
- 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 Projects

- **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.
- **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.
- **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.

Additional Risk Assessment Projects

- 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 (including complex major hazard facilities such as refineries and terminals) across Australia, New Zealand and southeast Asia. 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).
- 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.

- 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.
- 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

ALGA Large PFAS Site Investigations Webinar Series. Invited Speaker. June 2019. "The Distribution of PFAS in the Marine Environment and Implications for Decisions Making."
Presenter at the ALGA 1-Day How to Conduct Vapour Intrusion Assessments training course. Brisbane, Perth, Adelaide, and Melbourne (2018).
Presenter at the ALGA 2-Day Risk Assessment 101 training course. Auckland and Christchurch, NZ (2017) and Hobart (2018).

Presentations

- Matthew Colthorpe, Kathryn East, Peter Lavelle, and **Ken Kiefer**. AFFF – Methods for Product Sampling. CleanUp Conference 2019. Adelaide.
- Wijnand Gemson, **Ken Kiefer**, Paulo Vale, Olga Vounaki. 1,4-Dioxane As Co-Contaminant With Chlorinated Solvents, Consideration Of Chemical Properties And Effective Remedial Solutions. CleanUp Conference 2019. Adelaide.
- Nanda Hermes, Jennifer Byrd, Paulo Valle, **Ken Kiefer**, and Lyn Denison5. How Compounds Become Identified As Emerging/New Contaminants, And The Implications For Stakeholders. CleanUp Conference 2019. Adelaide.
- **Ken Kiefer**, Nanda Hermes, Andrea Herch and Jennifer Byrd. The Evolution Of Global Regulation For Per- And Poly-Fluorinated Alkyl Substances (PFAS). CleanUp Conference 2019. Adelaide.
- S. Wood, **K. Kiefer** and K. Dodd. Site-Specific Investigation Levels for PFOS And PFOA In Soil. CleanUp Conference 2019. Adelaide.
- Kathleen Prohasky, Lyn Denison, and **Ken Kiefer**. Using Arsenic Site-Specific Bioaccessibility In Soils – An Approach To Develop Site Specific Target Levels For Arsenic To Refine Remedial Targets. CleanUp Conference 2019. Adelaide.
- Vida Maulina, Lisa Thomson, **Ken Kiefer**. Derivation Of Water Quality Guideline Value For Marine Discharge Of Monoethylene Glycol. CleanUp Conference 2019. Adelaide.
- **Ken Kiefer** and Darren Reedy. Addressing Challenges/Uncertainties in PFAS Risk Assessment. AquaConSoil Conference 2019. Antwerp Belgium.
- **Ken Kiefer** and Darren Reedy. ***PFAS*** *Health Risk Assessment*. EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer** Kylie Dodd and Darren Reedy. *The Distribution of* ***PFAS*** *Compounds in the Marine Environment and Implications for Ecological Risk*. EcoForum 2018 Conference, Sydney, NSW.
- Lisa Thomson, **Ken Kiefer**, Kylie Dodd and Darren Reedy *Bioaccumulation of* ***PFAS*** *Within Aquatic Trophic Levels in an Australian Estuarine Environment*. EcoForum 2018 Conference, Sydney, NSW.
- Gavin Powell, Rob MacIntosh, **Ken Kiefer**, Wijnand Gemson, and Peter Madden. ***PFAS*** *and Urban Stormwater: Use of Mass Discharge Assessment in the Interpretation of the Conceptual Site Model*. EcoForum 2018 Conference, Sydney, NSW.

- **Ken Kiefer**, Kylie Dodd, and Darren Reedy. *Using **TOPA** in Risk Assessment.* EcoForum 2018 Conference, Sydney, NSW.
- **Ken Kiefer**, Wijnand Germs, Nathan Seaver, Kylie Dodd, and Ed Dennis. *Differentiating Groundwater Sources Using Mass Flux*. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Re-Assessing Remedial Targets Based on Changes in Total Recoverable Hydrocarbons Mixtures During Remediation. CleanUp 2017 Conference, Melbourne, NSW.
- **Ken Kiefer**. Reducing Uncertainty in Vapour Intrusion Risks and Conservatism in Chlorinated Hydrocarbon Site Decision Making. CleanUp 2017 Conference, Melbourne, NSW.
- Kathryn East, **Ken Kiefer**. Extended **PFAS** Suite: Future-Proofing, or Creating More *Uncertainty?* EcoForum 2016 Conference, Freemantle, WA.
- W. Germs, **K. Kiefer**, and A. Kohlrusch. You Can't Manage What You Don't Measure: 1,4–Dioxane as Co-Contaminant at Chlorinated Solvent Sites. EcoForum 2016 Conference, Freemantle, WA.
- Sophie Wood, Phillippa Biswell, **Ken Kiefer** and Warren Pump. *The Trouble with Environmental Management Plans….* EcoForum 2016 Conference, Freemantle, WA.
- **Ken Kiefer** and Thavone List. What Are Total Recoverable Hydrocarbons? Implications for Contaminated Site Management. EcoForum 2016 Conference, Freemantle, WA.
- **Ken Kiefer** and Kathleen Prohasky. Evaluation of Primary Industry Beneficial Water Use and Consideration of Non-Health and –Environmental Risk Endpoints. EcoForum 2016 Conference, Freemantle, WA.
- Joseph Ferring and **Ken Kiefer**. *Using D Data Analysis and Visualisation to Reduce Uncertainty.* EcoForum 2016 Conference, Freemantle, WA.
- **Kenneth Kiefer**, Kathleen Prohasky, Wijnand Germs, Neil Gray and Tamie Weaver. September 2015. A Comparison Of Passive Sampling And Low-Flow Or Bailed Sampling Results Across A Range Of Australian Hydrogeological Settings. Cleanup 2015, Melbourne, Vic.
- **Kenneth Kiefer** and Thavone Shaw. September 2015. *Using Mass Balance In Risk Assessment.* Cleanup 2015, Melbourne, Vic.
- Kathleen Prohasky and Kenneth Kiefer. September 2015. *Complications Of Ambient Sources In Assessing Vapour Intrusion Risks.* Cleanup 2015, Melbourne, Vic.
- Kathleen Prohasky and Kenneth Kiefer. September 2015. Developing Groundwater Tier 1 Screening Criteria For Chronic And Acute Vapour Risks For Chlorinated Hydrocarbons. Cleanup 2015, Melbourne, Vic.
- **Ken Kiefer,** Joseph Ferring, & Will Ellis. October 2014. *Differentiating Between Soil and Groundwater Solvent Sources in Soil Vapour Risk Assessment.* EcoForum 2014 Conference, Gold Coast, QLD.
- Christine Lussier, Kathryn East & Ken Kiefer. October 2014. *Screening Levels for Polychlorinated Biphenyls in Water.* EcoForum 2014 Conference, Gold Coast, QLD.
- Jeremy Hogben, Steven Morrison & Kenneth Kiefer. October 2014. *Assessing Polar Compounds as Degradation Metabolites of Hydrocarbon Sources – The Need for Change.* EcoForum 2014 Conference, Gold Coast, QLD.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2014. *Tier 1 Screening of Vapour Risks from Groundwater Data for Chlorinated Hydrocarbons*. ACTRA Conference. Coogee, NSW.
- **Kenneth L. Kiefer,** Alyson N. Macdonald, Kathleen Prohasky & Sophie Wood. October 2013. *Tier 1.5 Soil Vapour Screening For Non-Petroleum Volatile Organic Compounds.* CleanUp Conference, Melbourne, VIC.
- Kathleen V. Prohasky and Kenneth L. Kiefer. October 2013. Assessing Degradation Processes of Subsurface Vapours from a Petroleum Source in Fractured Basalt Using a Carbon Filter. CleanUp Conference, Melbourne, VIC.
- Ron Arcuri, Ken Kiefer, Belinda Goldsworthy. October 2013. Developing Surface Water Screening Levels For Compounds Associated With **Aqueous Film Forming Foams**. CleanUp Conference, Melbourne, VIC.

- **Kenneth Kiefer,** Alyson Macdonald, and Sophie Wood. October 2012. *Why do we need two different methods for screening vapour intrusion risks?* ACTRA. Adelaide SA.
- Dr. Sophie Wood, Ken Kiefer and Olivia Patterson. October 2012. *Health and Ecological Risk Assessment of Hydraulic Fracturing Fluids.* ACTRA. Adelaide SA.
- **Kenneth L. Kiefer**, Jonathan Lekawski, Valerie Phipps, Harrison Swift, and Sophie Wood. March 2012. *Case Studies of Implementing HSLs in Petroleum Hydrocarbon Sites.* EcoForum. Sydney. NSW.
- **Kenneth L. Kiefer**, Chuck E. Schmidt, Mark K. Jones, Ranajit (Ron) Sahu. September 2011. Comparison of Technologies for Assessing Vapour Intrusion In Future Structures from Subsurface Sources - Case Study with Side-by-Side Measured Flux and J&E Modelling. CleanUp Conference, Adelaide, SA.
- Kiefer, K.L., Jones, M., Shibata, M., Olsen, H., Steinmacher, S., and Case, J. April, 2005. *Dealing with Confounding Background Indoor Air Concentrations.* Air & Waste Management Association. Symposium on Air Quality Measurement Methods and Technology, San Francisco, CA
- Shull, L. and Kiefer, K. March 2005. *Those Pesky Emerging Contaminants: Will We Ever Be Done With Them?* Association for Environmental Health and Sciences: The 15th Annual AEHS Meeting & West Coast Conference on Soils, Sediments and Water, San Diego, CA.
- Kiefer, K.L., Shull, L., Bowland, M., and Jones, M. October 2003. Risk Based Decision Making Tools: Property Redevelopment and Arsenic Case Study, Brownfields 2003, Portland, Oregon.

APPENDIX B: SOLBERG DOD3155 PRODUCT INFORMATION

B.1 Safety Data Sheet

1. Identification of the substance/preparation and of the company/undertaking

1.1 Identification of the substance or preparation:

Product name : DoD3155
Synonyms : Solberg DoD 3155 Training Foam Concentrate (Fire Fighting Foam)

1.2 Use of the substance/preparation:

Fire extinguishing medium: concentrate

1.3 Company/undertaking identification:

Australian Supplier

Perimeter Solutions
Solberg Asia Pacific Pty Ltd
3 Charles Street
St. Marys NSW 2760, Australia
Tel: +61 2 9673 5300 (Mon-Fri, 9am to 5pm)

Overseas Supplier:

Perimeter Solutions
AUXQUIMA
Poligono de Baina, Parcela 23
33682 Mieres (Asturias)
Spain
Tel: +34 985 24 29 45

Perimeter Solutions
The Solberg Company
1520 Brookfield Avenue
US-WI 54313 Green Bay - USA
Tel: +1 920 593 9445

1.4 Emergency telephone:

24HR EMERGENCY: 1800 802 902 or (02)9430 6396

2. Hazards identification

2.1 Classification of the substance or mixture

Classification according to the *Globally Harmonised System for the Classification and Labelling of Chemicals* (GHS), as adopted for industrial chemicals in Australia.

Serious Eye Damage/Eye Irritation Category 2A

Aquatic Acute Category 3.

Australian Dangerous Goods Code:

Not classified as Dangerous Goods and would not require any special transport, storage, packaging, or placarding.

2.2 Label elements

Hazard pictograms

GHS07

Signal Word: Warning

Hazard statements:

H319	Causes serious eye irritation.
H402	Harmful to aquatic life.

Precautionary statements:

P202	Do not handle until all safety precautions have been read and understood.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P281	Use personal protective equipment as required.
P305+P351+P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P302+350	IF ON SKIN: Gently wash with plenty of soap and water.
P333+P313	If skin irritation or rash occurs: Get medical advice/attention.
P308+P313	IF exposed or concerned: Get medical advice/attention.
P273	Avoid release to the environment.

2.3 Other hazards

This substance is not considered to be persistent, bioaccumulating nor toxic (PBT)

This substance is not considered to be very persistent nor very bioaccumulating (vPvB).

3. Composition/information on ingredients

Hazardous ingredients	CAS No.	Conc. (%)	Hazards	Hazard Statement
2-(2-butoxyethoxy)ethanol	112-34-5	<10	Eye Irrit. 2	H319
Alcohol sulfate C12-14, triethanolamine salt	90583-18-9	<5	Acute Tox. 4 Skin Irrit. 2 Eye Damage 1 Aquatic Chronic 3	H302 H315 H318 H412
1-propanaminium, 3-amino-N-(carboxymethyl)-N,N-dimethyl-, N-coco acyl derivs., hydroxides, inner salts	61789-40-0	<2	Skin Irrit.2 Eye Irrit. 2 Aquatic Acute 1	H315 H319 H410
Anionic surfactants	Proprietary	<5	Skin Irrit.2 Eye Irrit. 2	H315 H319

4. First aid measures

4.1 After inhalation:
- Remove the victim into fresh air
- Respiratory problems: consult a doctor/medical service

4.2 Skin contact:
- Rinse with water
- Soap may be used
- Take victim to a doctor if irritation persists

4.3 Eye contact:
- Rinse immediately with plenty of water
- Take victim to an ophthalmologist if irritation persists

4.4 After ingestion:
- Rinse mouth with water
- Immediately give lots of water to drink
- Consult a doctor/medical service if you feel unwell

5. Fire-fighting measures

5.1 Suitable extinguishing media:
- Non flammable, non combustible
- For surrounding fires: all extinguishing media allowed

5.2 Unsuitable extinguishing media:
- No data available

5.3 Special exposure hazards:
- On burning: release of toxic and corrosive gases/vapours (nitrous vapours, sulphur oxides, carbon monoxide - carbon dioxide)

5.4 Instructions:
- Dilute toxic gases with water spray

5.5 Special protective equipment for firefighters:
- Heat/fire exposure: compressed air/oxygen apparatus when concentrated product is on fire.
- Protective clothing for exposure to chemicals

6. Accidental release measures

6.1 Personal precautions:
See heading 8.2/13

6.2 Environmental precautions:
- Contain released substance, pump into suitable containers
- Plug the leak, cut off the supply

6.3 Methods for cleaning up:
- Take up liquid spill into inert absorbent material, e.g.: sand/earth
- Scoop absorbed substance into closing containers
- Clean contaminated surfaces with an excess of water
- Wash clothing and equipment after handling

7. Handling and storage

7.1 Handling:
- Observe normal hygiene standards

7.2 Storage:
- Keep container in a well-ventilated place
- Meet the legal requirements
- Keep away from: heat sources

Storage temperature	: 0/50	˚C
Quantity limits	: N.D.	kg
Storage life	: N.D.	days
Materials for packaging	:	
- suitable	: HDPE	
- to avoid	: no data available	

7.3 Specific use(s):
- See information supplied by the manufacturer for the identified use(s)

8. Exposure controls/Personal protection

8.1 Exposure limit values (OEL):

8.1.1 Occupational exposure:

2-(2-butoxyethoxy)ethanol

Australia				
8h TWA	: none	mg/m^3	none	ppm
AU-STEL	: none	mg/m^3	none	ppm
New Zealand				
NZ WES 8h	: none	mg/m^3	none	ppm
NZ-STEL	: none	mg/m^3	none	ppm

Note: While no OELs have been set for this chemical in Australia and New Zealand, it should be noted that The European Committee on Occupational Exposure Limits have recommended an 8hr TWA of 10 ppm (67.5 mg/m3) and STEL of 15 ppm (101.2 mg/m3).

8.1.2 Sampling methods:
- Sulfites, & Sulfates NIOSH 6004

8.2 Exposure controls:

8.2.1 Occupational exposure controls:
- Measure the concentration in the air regularly if likely to exceed OEL
- Work under local exhaust/ventilation

Personal protective equipment:

a) Respiratory protection:
- Wear gas mask with filter type A if conc. in air is likely to exceed OEL

b) Hand protection:
- Gloves
  Suitable materials: Butyl rubber

- Breakthrough time: Not determined

c) Eye protection:
- Safety glasses

d) Skin protection:
- Protective clothing
  Suitable materials: Butyl rubber

8.2.2 Environmental exposure controls: see headings 6.2, 6.3 and 13

9. Physicochemical properties

9.1 General information:

Appearance (at	:	Liquid
Odour	:	Mild
Colour	:	Light yellow

9.2 Important safety and environmental information:
health,

pH value (at 100%)	:	7/8.5	
Boiling point/boiling range	:	100	°C
Flash point/flammability	:	N.A.	°C
Explosion limits (explosive	:	N.D.	vol%
properties) Oxidising properties	:	N.D.	
Vapour pressure (at 20°C)	:	24	hPa
Vapour pressure (at 50°C)	:	N.D.	hPa
Relative density (at 20°C)	:	1.01	
Water solubility	:	COMPLETELY	
Soluble in	:	No data available	
Relative vapour density	:	1	
Viscosity (at °C)	:	<0.003	Pa.s (25°C)
Partition coefficient n-octanol/water	:	N.D.	
Evaporation rate			
ratio to butyl acetate	:	N.D.	
ratio to ether	:	N.D.	

9.3 Other information:

Melting point/melting range	:	0	°C
Auto-ignition temperature	:	N.D.	°C
Saturation concentration	:	N.D.	g/m^3
Specific conductivity	:	N.D.	pS/m

10. Stability and reactivity

10.1 Conditions to avoid:
- Stable under normal conditions

10.2 Materials to avoid:
- Keep away from: heat sources

10.3 Hazardous decomposition products:
- On burning: release of toxic and corrosive gases/vapours (nitrous vapours, sulphur oxides, carbon monoxide - carbon dioxide)

11. Toxicological information

11.1 Acute toxicity:

Whole Mixture:
Acute oral toxicity (rat): LD50 >5000 mg/kg
Acute dermal toxicity (Rabbit): LD50 > 2000 mg/kg
Acute primary dermal irritation (Rabbit): Non-irritating.
Eye irritation (Rabbit): Moderately irritating

Ingredients:
2-(2-butoxyethoxy)ethanol

LD50 oral rat	: 2410	mg/kg
LD50 dermal rabbit	: 2764	mg/kg

11.2 Chronic toxicity:
No data available.

11.3 Routes of exposure: ingestion, inhalation, eyes and skin

11.4 Acute effects/symptoms:

AFTER EYE CONTACT
- Redness of the eye tissue
- Irritation of the eye tissue

11.5 Chronic effects:

- No data available

12. Ecological information

12.1 Ecotoxicity:

- LC50 (96 h) : 45 mg/l (PIMEPHALES PROMELAS - FATHEAD MINNOW)
- LC50 (96 h) : 32 mg/l (SALMO GAIRDNERI - STEELHEAD FRY)
- EC50 (48 h) : 69 mg/l (DAPHNIA MAGNA)

- Effect on waste water purification : harmless to activated sludge at sufficient dilution

12.2 Mobility:

- Volatile organic compounds (VOC): 0%
- Soluble in water

For other physicochemical properties see heading 9

12.3 Persistence and degradability:

- biodegradation BOD_5 : - Not available
- water : - Readily biodegradable in water
  - test: 91%DOC removal, 14d
  - soil : $T_{1/2}$: Not determined

12.4 Bioaccumulative potential:
- log P_{ow} : <3 (components)
- BCF : N.D.
- not bioaccumulative (components)

12.5 Results of PBT assessment:
- Does not meet PBT criteria

12.6 Other adverse effects:

- Effect on the ozone layer : Not dangerous for the ozone layer

- Greenhouse effect : No data available

13. Disposal considerations

13.1 Provisions relating to waste:
- Dispose according to the requirements of local waste disposal authority.

13.2 Disposal methods:
- Dilute
- May be discharged to wastewater treatment installation or reed bed
- Contains no organic halogen which may add to the AOX value
- Discharge or disposal must be handled according to national or local legislation regulations.

13.3 Packaging/Container:
- Dispose according to the requirements of local waste disposal authority.

14. Transport Information

14.1 IMDG (maritime transport)

CLASS	:Not classified as Dangerous Goods
SUB RISKS	:
PACKING GROUP	:
MFAG	:
EMS	:
MARINE POLLUTANT	:

14.2 ICAO (air transport)

CLASS	: Not classified as Dangerous Goods
SUB RISKS	:
PACKING GROUP	:
PACKING INSTRUCTIONS PASSENGER AIRCRAFT	:
PACKING INSTRUCTIONS CARGO AIRCRAFT	:

14.3 Australia ADG Code

CLASS	: Not classified as Dangerous Goods
SUB RISKS	:
PACKING GROUP	:

14.4 New Zealand NZS 5433:2007

CLASS	: Not classified as Dangerous Goods
SUB RISKS	:
PACKING GROUP	:

15. Regulatory information

15.1 Australia

All components are listed on the Australian Inventory of Chemical Substances (AICS).

15.2 New Zealand

Approval: Fire Fighting Chemicals Group Standard 2006 (HSR002573).
NZIoC: All components are listed on the New Zealand Inventory of Chemical Substances
HSNO Classification: 6.4A Eye irritancy, 9.1D Ecotoxic.

16. Other information

The information provided on this SDS is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text. As we cannot anticipate all use conditions, the user should conduct their own risk assessment.

B.2 Product Environmental Data Information

Solberg Asia Pacific
Product Environmental Data Information

SOLBERG DoD 3155

TRAINING FOAM CONCENTRATE

DESCRIPTION: Water-miscible flammable liquid fire extinguishing agent.

APPEARANCE : Clear, light, yellow liquid

USAGE: A 0.33 - 1.0% concentration of product in water is applied to flammable liquid training fires using standard hand-line fire fighting equipment. Can also be used on LPG simulator fires.

BIODEGRADATION:

Modified OECD Screening Test with DOC Analysis

Average % DOC Removal

Incubation Time (days)	Solberg DoD 3155	Na Lauryl Sulfate (SLS)	Sterile Solberg DoD 3155	Sterile SLS
2	14	36	3.5	-2
7	88	96	12	23
13	92	94	9	13
14	91	94	13	10

(This test showed the product to be readily biodegradable.)

Effect on Microbial Respiration

OECD Activated Sludge Respiration Inhibition Test (OECD Method 209)

Test Duration	Concentration (mg/L)	Respiration % Stimulation	Rate % Inhibition	EC_{50} (mg/L)
30 min	100	29	-	> 1,000
"	135	33	-	at 30 min
"	240	34	-	
"	420	-	-	
"	750	-	27	
"	1000	-	41	
3 hours	100	16	-	> 1,000
"	135	16	-	at 3 hours
"	240	18	-	
"	420	27	-	
"	750	-	30	
	1000	-	48	

SOLBERG DoD 3155 TRAINING FOAM
(continued)

OECD Activated Sludge Inhibition Test (continued)

Stimulation in the microbial respiration rate at lower concentrations indicates an absence of acute toxicity at those concentrations and suggests that at least portions of the product are biodegradable by non-acclimated microbial populations.

AQUATIC TOXICITY:

Test Organisms	96-hr LC_{50} (95% C.I.) (mg/L)
Fathead minnow (Pimephales promelas)	45 (40-60)
Steelhead fry (Salmo gairdneri)	32 (18-56)
	48-hr EC_{50} (95% C.I.) (mg/L)
Water Flea (Daphnia magna)	69 (62-74)

MICROBIAL TOXICITY :

	5min EC_{50} (95% C.L.) (mg/L)
Beckman Microtox® System (Photobacterium phosphoreum)	8.2 (7. 9-8.5)

DISPOSAL :

Feed spent solutions and small product quantities <23 litres of concentrate, to a wastewater treatment system. Reduce discharge rate if foaming occurs. Incinerate bulk product in an industrial or commercial facility. Since regulations vary, consult applicable regulations or authorities before disposal.

Solberg Asia Pacific
Product Environmental Data Information

These data are intended for the use of a person qualified to evaluate environmental data.

All statements, technical information and recommendations contained herein are of general nature and are based on laboratory tests or literature information we believe to be reliable, but the accuracy or applicability to particular circumstances is not guaranteed. Solberg Asia Pacific Pty Ltd makes no representation that the customer's use and disposal of the product will comply with all applicable environmental laws, regulations, and rules.

Relates to Solberg DoD 3155 Training Foam concentrate MSDS

Solberg Asia Pacific Pty Limited
[ABN 27 124 181 791]
3 Charles Street
St. Marys NSW 2760
Australia
Phone: (02) 9673-5300

THE FOAM EXPERTS

Date Issued: October 2007 Supercedes: None

B.3 Vendor Statement of Commitment

October 9, 2013

Press Release - Global Release
FOR IMMEDIATE RELEASE

Solberg Introduces RE-HEALING™ Foam Environmental Warranty

Green Bay, Wisconsin - The Solberg Company, the world's foremost innovator of firefighting foam concentrates and systems hardware, has introduced an environmental warranty for RE-HEALING™ foam concentrates, the company's innovative high performance fluorine-free firefighting foam.

Solberg will warrant to purchasers of RE-HEALING foam concentrate, that for twenty (20) years after the purchase, whether as part of a foam/water fire protection system or as foam concentrate only, the use of RE-HEALING foam will not be restricted in any way due to the presence of any organohalogens, whether in surfactants, polymers, or any other form. The environmental warranty also includes the provision that SOLBERG RE-HEALING foam concentrate will not be banned by any governmental entity or regulatory body for any of the following environmental issues:

- No Governmental restrictions related to the presence of fluorine
- No persistence in the environment
- No bioaccumulation
- No PFOS or PFOA
- No biodegradation into PFOS or PFOA

Should environmental regulations enacted after the purchase of SOLBERG RE-HEALING foam require removal of the RE-HEALING foam concentrate from the market for one of these environmental issues, Solberg will replace the RE-HEALING foam concentrate with a new foam concentrate that meets such newly enacted environmental regulations.

RE-HEALING foam concentrates are intended for use on Class B hydrocarbon and polar solvent fuel fires. Concentrates available include RF1 (1%), RF3 (3%), RF6 (6%) and RF3x6% ATC™ formulations. RE-HEALING foam concentrates can be used to prevent re-ignition of a liquid spill and control hazardous vapors. On Class A fuels, RE-HEALING foam will improvement extinguishment in deep-seated fires.

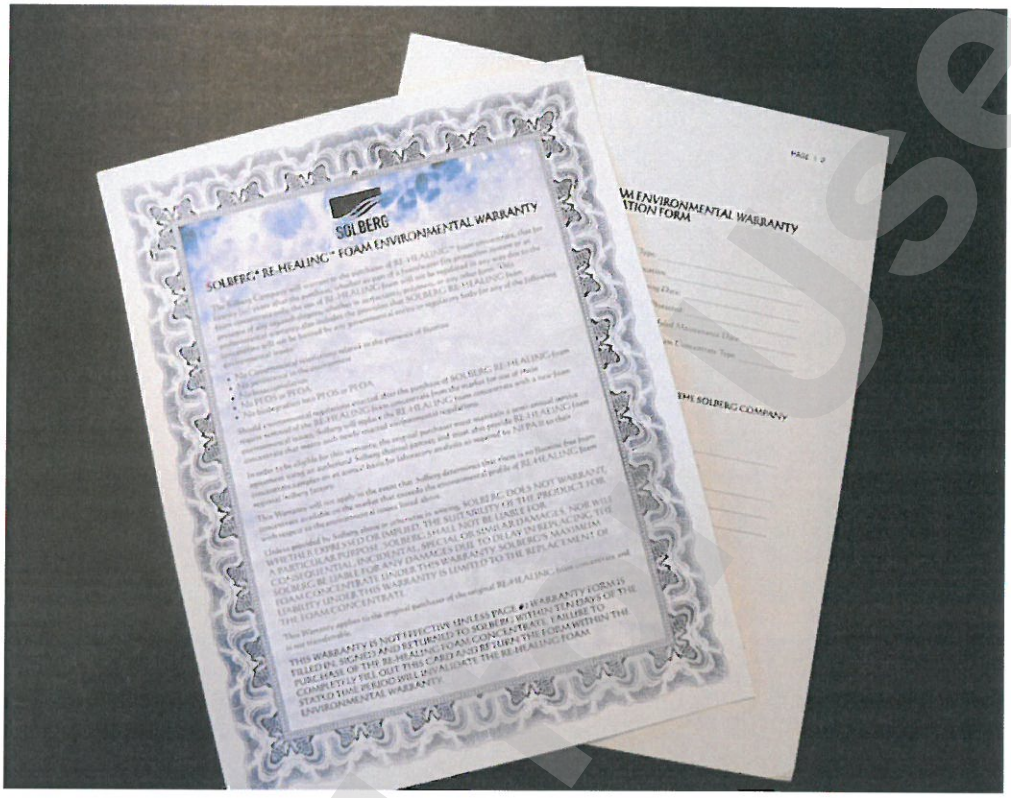
- EN1568 Approved
- UL 162 Standard Listed
- ICAO Certified
- Superior Fire Performance
- Exceptional Burn-back Resistance
- No Special Discharge Devices Required
- Replaces AFFF, FFFP, Protein and Fluoroprotein Foams

Based in Green Bay, Wisconsin, with operations in Bergen, Norway and Sydney, Australia, Solberg (an Amerex Corporation company) has been involved with the manufacture of firefighting foams since the mid-1970s. Solberg's unique technology and foam systems hardware is preferred by customers in the aerospace, aviation, chemical, defense, energy, fire services, marine, mining, oil and gas, petrochemical, pharmaceutical, pipeline, solvent & coatings and utilities industries.

AMERICAS
THE SOLBERG COMPANY
2701 Larsen Road, Suite #BA140
Green Bay, WI 54303
USA
Tel: +1 920 593 9445

EMEA
SOLBERG SCANDINAVIAN AS
Radøyvegen 721 - Olsvollstranda
N-5938 Sæbøvågen
Norway
Tel: +47 56 34 97 00

ASIA-PACIFIC
SOLBERG ASIA PACIFIC PTY LTD
PO Box 182
Kingswood NSW 2747
Australia
Tel: +61 2 9673 5300



SOLBERG® RE-HEALING™ Foam Environmental Warranty

###

About Solberg
Solberg is an Amerex Corporation company with a European heritage. The company is a global one-stop resource for firefighting foam concentrates and custom-designed foam suppression systems hardware and accessories. Solberg offers environmentally sustainable fluorosurfactant and fluoropolymer-free foam concentrate products, an innovation in Class B firefighting foam and traditional firefighting foam concentrates. Solberg's people and processes are committed to quality, service and safety along with environmental responsibility. This philosophy enables the company to flourish while delivering innovations and value. More information can be found at: www.solbergfoam.com

For more information, contact:

Dave Pelton
Vice President, Global Marketing
The Solberg Company
Tel: +1 920 593 9447
E-mail: dave.pelton@solbergfoam.com

B.4 ALS TOPA Certificate of Analysis

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES1806196**	Page	: 1 of 4
Amendment	: **1**		
Client	: **SOLBERG ASIA PACIFIC PTY LTD**	Laboratory	: Environmental Division Sydney
Contact	: TODD HARRIS	Contact	: Customer Services ES
Address	: 3 CHARLES STREET St Marys NSW 2760	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: ----	Telephone	: +61-2-8784 8555
Project	: CLASS A CERTIFICATES	Date Samples Received	: 27-Feb-2018 16:10
Order number	: ----	Date Analysis Commenced	: 02-Mar-2018
C-O-C number	: ----	Issue Date	: 08-Mar-2018 13:17
Sampler	: LLOYD KEEN		
Site	: ----		
Quote number	: SY/532/17		
No. of samples received	: 3		
No. of samples analysed	: 3		

ilac-MRA NATA

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

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

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

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

Signatories

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

Signatories	*Position*	*Accreditation Category*
Franco Lentini		Sydney Organics, Smithfield, NSW

General Comments

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

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

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

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

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

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

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

- Amendment (08/03/2018): This report has been amended as a result of a request to change sample identification numbers (IDs) received by ALS from T. Harris.. All analysis results are as per the previous report.

Analytical Results

Sub-Matrix: PRODUCT (Matrix: PRODUCT)				Client sample ID	Solberg Hi-Expansion Foam	Solberg Fire-Brake 3150A	Solberg DOD3155	----	----
				Client sampling date / time	27-Feb-2018 08:00	27-Feb-2018 08:15	27-Feb-2018 08:10	----	----
Compound	CAS Number	LOR	Unit		ES1806196-001	ES1806196-002	ES1806196-003	--------	--------
					Result	Result	Result	----	----
EP231_TOP_A: Perfluoroalkyl Sulfonic Acids									
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluoropentane sulfonic acid (PFPeS)	2706-91-4	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluoroheptane sulfonic acid (PFHpS)	375-92-8	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorodecane sulfonic acid (PFDS)	335-77-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
EP231_TOP_B: Perfluoroalkyl Carboxylic Acids									
Perfluorobutanoic acid (PFBA)	375-22-4	0.1	mg/kg		<0.1	<0.1	<0.1	----	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorooctanoic acid (PFOA)	335-67-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorononanoic acid (PFNA)	375-95-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorodecanoic acid (PFDA)	335-76-2	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluoroundecanoic acid (PFUnDA)	2058-94-8	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorododecanoic acid (PFDoDA)	307-55-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
Perfluorooctane sulfonamide (FOSA)	754-91-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
EP231_TOP_C: Perfluoroalkyl Sulfonamides									
N-Methyl perfluorooctane sulfonamide (MeFOSA)	31506-32-8	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	4151-50-2	0.05	mg/kg		<0.05	<0.05	<0.05	----	----

Analytical Results

Sub-Matrix: PRODUCT (Matrix: PRODUCT)				Client sample ID	Solberg Hi-Expansion Foam	Solberg Fire-Brake 3150A	Solberg DOD3155	----	----
				Client sampling date / time	27-Feb-2018 08:00	27-Feb-2018 08:15	27-Feb-2018 08:10	----	----
Compound	CAS Number	LOR	Unit		ES1806196-001	ES1806196-002	ES1806196-003	--------	--------
					Result	Result	Result	----	----
EP231_TOP_C: Perfluoroalkyl Sulfonamides - Continued									
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	24448-09-7	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	1691-99-2	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	2355-31-9	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	2991-50-6	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
EP231_TOP_D: (n:2) Fluorotelomer Sulfonic Acids									
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	mg/kg		<0.05	<0.05	<0.05	----	----
EP231_TOP_P: PFAS Sums									
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.02	mg/kg		<0.02	<0.02	<0.02	----	----
^ Sum of TOP C7 - C14 as fluorine	----	0.02	mg/kg		<0.02	<0.02	<0.02	----	----

APPENDIX C: LABORATORY LIMITS OF REPORTING ULTRA/SUPER-TRACE ANALYSIS

Group/Analytes	Water Super Trace (µg/L) Method Code EP231X-ST[5]
Perfluoroalkane Sulfonic Acids	
Perfluorobutane sulfonic acid (PFBS) included in Short Suite	0.0005
Perfluoropentane sulfonic acid (PFPeS)	0.0005
Perfluorohexane sulfonic acid (PFHxS) included in Short Suite	0.0005
Perfluoroheptane sulfonic acid (PFHpS)	0.0005
Perfluorooctane sulfonic acid (PFOS) included in Short Suite	0.0003
Perfluorodecane sulfonic acid (PFDS)	0.0005
Perfluoroalkane Carboxylic Acids	
Perfluorobutanoic acid (PFBA) included in Short Suite	0.002
Perfluoropentanoic acid (PFPeA) included in Short Suite	0.0005
Perfluorohexanoic acid (PFHxA) included in Short Suite	0.0005
Perfluoroheptanoic acid (PFHpA) included in Short Suite	0.0005
Perfluorooctanoic acid (PFOA) included in Short Suite	0.0005
Perfluorononanoic acid (PFNA)	0.0005
Perfluorodecanoic acid (PFDA)	0.0005
Perfluoroundecanoic acid (PFUnDA)	0.0005
Perfluorododecanoic acid (PFDoDA)	0.0005
Perfluorotridecanoic acid (PFTrDA)	0.0005
Perfluorotetradecanoic acid (PFTeDA)	0.0005
Perfluoroalkyl Sulfonamides	
Perfluorooctane sulfonamide (FOSA)	0.0005
N-Methyl perfluorooctane sulfonamide (MeFOSA)	0.001
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	0.001
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	0.001
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	0.001
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	0.0005
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	0.0005
(n:2) Fluorotelomer Sulfonic Acids	
4:2 Fluorotelomer sulfonic acid (4:2 FTS) included in Short Suite	0.001
6:2 Fluorotelomer sulfonic acid (6:2 FTS) included in Short Suite	0.001
8:2 Fluorotelomer sulfonic acid (8:2 FTS) included in Short Suite	0.001
10:2 Fluorotelomer sulfonic acid (10:2 FTS) included in Short Suite	0.001
Sums	

APPENDIX C: LABORATORY LIMITS OF REPORTING ULTRA/SUPER-TRACE ANALYSIS

Group/Analytes	Water Super Trace (µg/L) Method Code EP231X-ST[5]
Perfluoroalkane Sulfonic Acids	
Perfluorobutane sulfonic acid (PFBS) included in Short Suite	0.0005
Perfluoropentane sulfonic acid (PFPeS)	0.0005
Perfluorohexane sulfonic acid (PFHxS) included in Short Suite	0.0005
Perfluoroheptane sulfonic acid (PFHpS)	0.0005
Perfluorooctane sulfonic acid (PFOS) included in Short Suite	0.0003
Perfluorodecane sulfonic acid (PFDS)	0.0005
Perfluoroalkane Carboxylic Acids	
Perfluorobutanoic acid (PFBA) included in Short Suite	0.002
Perfluoropentanoic acid (PFPeA) included in Short Suite	0.0005
Perfluorohexanoic acid (PFHxA) included in Short Suite	0.0005
Perfluoroheptanoic acid (PFHpA) included in Short Suite	0.0005
Perfluorooctanoic acid (PFOA) included in Short Suite	0.0005
Perfluorononanoic acid (PFNA)	0.0005
Perfluorodecanoic acid (PFDA)	0.0005
Perfluoroundecanoic acid (PFUnDA)	0.0005
Perfluorododecanoic acid (PFDoDA)	0.0005
Perfluorotridecanoic acid (PFTrDA)	0.0005
Perfluorotetradecanoic acid (PFTeDA)	0.0005
Perfluoroalkyl Sulfonamides	
Perfluorooctane sulfonamide (FOSA)	0.0005
N-Methyl perfluorooctane sulfonamide (MeFOSA)	0.001
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	0.001
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	0.001
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	0.001
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	0.0005
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	0.0005
(n:2) Fluorotelomer Sulfonic Acids	
4:2 Fluorotelomer sulfonic acid (4:2 FTS) included in Short Suite	0.001
6:2 Fluorotelomer sulfonic acid (6:2 FTS) included in Short Suite	0.001
8:2 Fluorotelomer sulfonic acid (8:2 FTS) included in Short Suite	0.001
10:2 Fluorotelomer sulfonic acid (10:2 FTS) included in Short Suite	0.001
Sums	

Sum of PFAS	0.0003
Sum of PFHxS and PFOS [1]	0.0003
Sum of PFAS (WA DER List) [2]	0.0003
Sum of the total oxidisable precursors for C7 to C14 compounds (TOPA C7-C14) as fluorine [3]	-
Sum of TOPA C4-C14 plus C4-C8 sulfonates [4]	-

1 Sum required for enHealth drinking water guideline and QLD Foam Policy for short-chain fluorous AFFF.

2 PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS,PFHxS, PFOS, 6:2-FTS and 8:2-FTS.

3 Queensland Operational Policy on Environmental Management of Firefighting Foam (6.2.1 and 6.2.2). Foams not meeting criteria must be withdrawn from service.

4 Queensland Operational Policy on Environmental Management of Firefighting Foam (6.4.2).guidance set for disposal of foam concentrates and wastewaters. General analytical requirement for all matrices – see Fluorinated organic compound analyses in the definitions section.

5 ALS. 2016. PFOS trace analysis to meet trace guideline requirements. EnviroMail™, Issue 109, August 2016. Accessed on 11 February 2021 at <EnviroMail 109 PFOS Trace Analysis to Meet Trace Guideline Requirements (1).pdf>