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MEMO

To: Jacob Cumpstay, Senex Energy

From: Chrissy Peterson, EHS Support

CC: Gonzalo Fernandez, Senex Energy
Joe Hayes, EHS Support
Dana McCue, EHS Support

Date: 10 April 2025

Re: Chemical Risk Assessment for Atlas Stage 3 Gas Project – SuperScavenger Drilling Product

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This technical memorandum provides a chemical risk assessment of the chemicals in SuperScavenger, a product proposed to be used in coal seam gas (CSG) operations (drilling and completions) within the Senex Energy ("Senex") Atlas Stage 3 Development. This document was prepared in accordance with the Chemical Risk Assessment Framework (CRAF; Klohn Crippen Berger, 2024a) and the *Senex Atlas Stage 3 DCCEEW PD Response Drilling Chemical Risk Assessment* ("March 2024 CRAR"; Klohn Crippen Berger, 2024b) for chemical risk assessments for this area.

The CRAF incorporates best practice risk assessment methodologies for the assessment of the potential impacts of the chemicals proposed to be used in CSG operations on Matters of National Environmental Significance (MNES).

This assessment process is designed to align with national guidance and other regulatory frameworks and assesses the full lifecycle of chemicals that are stored, handled, used and/or disposed during or following drilling and hydraulic fracturing activities. Accidental release scenarios are not included; however, the outcomes of the assessment will be used to inform emergency response actions.

Goals

The aim of the chemical risk assessment is to evaluate the potential risks and effects of chemicals used during CSG operations (defined as drilling and completions) to MNES. No hydraulic fracturing is proposed for the Senex Atlas Stage 3 Development and SuperScavenger is not proposed for use in water treatment.

The goal of the chemical risk assessment is to demonstrate that potential risks to MNES, associated with the chemicals within SuperScavenger, a product proposed for use in CSG operations, have been eliminated or reduced as much as is reasonably practicable. In addition, potential risks to non-MNES receptors (for example residents, agricultural workers and livestock) will be assessed where an activity results in exposure to water resources and there is potential for a complete exposure pathway to the non-MNES receptor (e.g., drilling and completion activities near a water bore used for drinking water). Effects to terrestrial MNES and water resource MNES will be assessed via the identification of potentially complete exposure pathways to soils.

Approach

As noted above, formal assessments must be conducted on each chemical in accordance with the CRAF (Klohn Crippen Berger, 2024a). This technical memo serves as an addendum to the March 2024 CRAR and follows the assessment methodology outlined in the CRAF for the chemicals present within SuperScavenger.

The framework for the chemical risk assessment involves a two-step process:

- Step 1 – classification of chemicals
- Step 2 – assessment of chemicals

The criteria to be used in the chemical category classification within this framework is provided in Appendix 1 of the CRAF (**Attachment 1**). Consistent with the CRAF, chemicals categorised as Tier 1 chemicals are designated as 'low concern' chemicals. Chemicals categorised as Tier 2 or Tier 3 chemicals are designated as 'potential concern' or 'potentially high concern' chemicals, respectively.

Based on the Tier classification of the chemical (and its potential toxicity, persistence and bioaccumulation potential in the environment), different levels of assessment are conducted with the most robust assessment conducted on the highest classification. Consistent with the screening matrix in Appendix 1 of the CRAF (**Table 1**):

- Chemicals previously assessed by national (e.g. NICNAS) or international regulators and considered to be of low hazard, and therefore low risk for human health and the environment to not require further assessment pursuant to the CRAF.
- Tier 1 chemicals, which are effectively low toxicity and therefore low hazard, would be subject to only the screening assessment.
- Tier 2 chemicals, in addition to the screening assessment, will be subjected to a qualitative risk assessment.
- Tier 3 chemicals will be subject to an additional quantitative risk assessment.

A Register of Assessed Chemicals has been developed and is published and maintained on Senex's website and includes chemicals assessed in the March 2024 CRAR[1]. The Register of Assessed Chemicals will, for each published chemical, provide a summary of the outcomes of the screening assessment, including the Tier (and Risk Level) categorisation, the activities the chemical has been assessed for (i.e. drilling and completions and/or production operations) and the assessed end use/fate of the chemical. Toxicological information for all chemicals will be re-evaluated approximately every 5 years.

Chemicals evaluated in this assessment were identified based on a review of the safety data sheet (SDS) for SuperScavenger (**Attachment 2**). A Register of Assessed Chemicals for chemicals evaluated in this risk assessment is included in **Attachment 3** and was developed for inclusion in the online Register of Assessed Chemicals (**Attachment 3**).

In the development of this screening assessment, toxicological profiles have been developed for all chemicals (Tier 1 through 2) and these are provided in **Attachment 4** and **Attachment 5** (as applicable). Consistent with the guidance documents contained within the CRAF, the risk assessment includes the following components for the different Tiers of Chemicals (**Table 2**).

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[1] https://senexenergy.com.au/news/atlas3/

TABLE 1 ASSESSMENT AND REPORTING REQUIREMENTS BY TIER

Tier	Risk Category	Screening Assessment and Categorisation	Toxicological Profile	Qualitative Risk Assessment	Quantitative Risk Assessment	Prohibited from Use on Project
1	Low Concern	X	X			
2	Potential Concern	X	X	X		
3	Potentially High Concern	X	X	X	X	
Prohibited From Use	Very High Concern					X

TABLE 2 QUALITATIVE AND QUANTITATIVE RISK ASSESSMENT COMPONENTS

Tier 2 (Qualitative Risk Assessment)	Tier 3 (Quantitative Risk Assessment)
Problem Formulation and Issue Identification Hazard Assessment Risk Communication and Management	Problem Formulation and Issue Identification Hazard Assessment Exposure Assessment Risk Characterisation Risk Communication and Management

Screening Assessment Findings

Chemical Classification and Risk Assessment

Senex is proposing to use SuperScavenger as a drilling product. Superscavenger will be installed with the surface casing vent (i.e., between the surface casing and production casing) to act as a corrosion inhibitor. In production wells and as part of well abandonment, the production casing will be cemented and surface casing will be filled with SuperScavenger to preserve the surface well casing. For abandoned wells, after a period of approximately six months, the top of the surface casing will be grouted, effectively encapsulating the liquid.

Exposure was assessed for the constituents of potential concern (COPCs) in SuperScavenger during the drilling process. The chemicals identified in SuperScavenger are detailed in **Table 3**. The SDS for the SuperScavenger is included as **Attachment 2**.

TABLE 3 SUPERSCAVENGER CHEMICALS

Chemical Name	CAS No.
Sodium sulfite	7757-83-7
Trizinc bis(orthophosphate)	7779-90-0
Tetrakis(hydroxymethyl)phosphonium sulfate (THPS)	55566-30-8

The chemicals identified for evaluation as part of this chemical risk assessment were reviewed using the approved CRAF provided in **Attachment 1**. Based on the tier classification of the chemical (and its potential toxicity, persistence and bioaccumulation potential in the environment), different levels of assessment are conducted with the most robust assessment conducted on the highest classification.

The findings of the screening assessment based on the CRAF is included in the Register of Assessed Chemicals provided as **Attachment 3**. This table documents the chemicals assessed, the key findings from the hazard assessment, the classification Tier determined, the activities the chemical has been assessed for (i.e. drilling and completions, hydraulic fracturing) and the assessed end use/fate of the chemical.

As presented in the Register of Assessed Chemical in **Attachment 3**, 3 chemicals were assessed as part of this Chemical Risk Assessment:

- 2 chemicals were assessed as Tier 1 chemicals
- One (1) chemical was assessed as a Tier 2 chemical
- No chemicals were assessed as Tier 3.

Consistent with the CRAF, the following actions were conducted based on the assigned Tiers:

- Tier 1 – Screening/Hazard Assessment Only, and
- Tier 2 – Screening/Hazard Assessment and Qualitative Risk Assessment

Each of these assessments (Tier 1 or 2) are provided as an attachment to this memorandum. Tier 1 assessments are provided in **Attachment 4**. The Tier 2 assessment is provided in **Attachment 5**.

As provided in each of the attachments, toxicological profiles (risk assessment dossiers) were developed for all chemicals. These are critical data sources for first responders (including emergency services) in the event of a release during transportation (determined to be the highest probability release event), Senex operators and the regulatory community.

Summary

The aim of this chemical risk assessment was to evaluate the potential risks and effects of chemicals in SuperScavanger used during CSG extraction (drilling, completions and production) to MNES. The goal of the chemical risk assessment was to demonstrate that potential risks to MNES associated with the chemicals used in CSG extraction have been eliminated or reduced as much as is reasonably practicable.

The life cycle of the drilling and completion and production was assessed specifically for the proposed operations and included:

- storage, usage (e.g., blending, injection), and recovery of chemicals throughout operations; beneficial reuse of recovered drilling fluids and cuttings for well lease rehabilitation; and,
- storage of produced water.

In accordance with the CRAF an evaluation of all chemicals proposed for use was conducted, with two(2) chemicals classified as Tier 1 chemicals (refer **Attachment 3**). One (1) chemical was assessed as a Tier 2 assessment. No chemicals were assessed as Tier 3 chemicals.

The chemical risk assessments completed for each chemical indicated negligible risks and effects of chemicals used during CSG operations (drilling and completions and production) to MNES when appropriate management and mitigation controls were in place. Should assessments of additional chemicals indicate additional management control, the EMP and associated management plans will be updated accordingly.

In general, the management practices adopted and implemented by Senex are appropriate and have eliminated or reduced as much as is reasonably practicable the potential risks to MNES associated with the chemicals used in CSG extraction.

References

Klohn Crippen Berger. (2024a). Atlas Stage 3 DCCEEW PD Response Chemical Risk Assessment Framework. Final. Revision 1. March.

Klohn Crippen Berger. (2024b). Atlas Stage 3 DCCEEW PD Response Drilling Chemical Risk Assessment. Final. Revision 2. March.

Attachment 1 CRAF Screening Matrix

Criteria		**INITIAL CHECK**	**TIER 1**	**TIER 2**	**TIER 3**	**PROHIBITED FROM USE**
Concern/Risk Level		**LOW CONCERN**	**LOW CONCERN**	**POTENTIAL CONCERN**	**POTENTIALLY HIGH CONCERN**	**VERY HIGH CONCERN**
Risk assessment level		Screening risk assessment	Screening risk assessment	Detailed risk assessment	Refined Risk assessment	Prohibited from use on project
Listed as chemical of concern (COC) on relevant databases		1. Initial check to identify chemicals previously assessed by national or international regulators and considered to be of low hazard, and therefore low risk, for human health and the environment.	Not listed as a chemical of potential concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Listed as a chemical of concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Listed as a chemical of concern on the following databases: - European Union Substance of Very High Concern (EU SVHC). - US National Toxicology Program (US NTP) Report on Carcinogens or International Agency Research on Cancer (IARC) Monographs. - European Commission Endocrine Disruptors Strategy - list of Category 1 substances with endocrine disrupting capacity. - Chemical Substances Control Law of Japan (CSCL) Class I and II Specified Chemical.	Chemicals noted in the Rotterdam Accord including: - octabromodiphenyl ether - pentabromodiphenyl ether - perfluorooctane sulfonic acid - perfluorooctane sulfonates - perfluorooctane sulfonamides - perfluorooctane sulfonyls - polybromated biphenyls - short chain chlorinated paraffins - tetramethyl lead - tributyl tin compounds Chemicals restricted in the State of Queensland including: - Benzene* - Toluene* - Ethylbenzene* - m-&p- and o-Xylene*
Persistence		N/A	Not persistent as defined by: Air - Half life < 2 days Water - Half life < 60 days Soil and Sediment - Half life < 6 months	Persistent as defined by: Air - Half life ≥ 2 days Water - Half life ≥ 60 days Soil and Sediment - Half life ≥ 6 months	Persistent as defined by: Air - Half life ≥ 2 days Water - Half life ≥ 60 days Soil and Sediment - Half life ≥ 6 months	N/A
Bioaccumulative		N/A	Does not Bioaccumulate as defined by: - Aquatic - BAF < 2000 or BCF < 2000 or log KoW < 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa < 6 and log Kow < 2 - Food Chain Bioaccumulation Potential - BMF < 1	Does not Bioaccumulate as defined by: - Aquatic - BAF < 2000 or BCF < 2000 or log KoW < 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa < 6 and log Kow < 2 - Food Chain Bioaccumulation Potential - BMF < 1	Does Bioaccumulate as defined by: - Aquatic - BAF ≥ 2000 or BCF ≥ 2000 or log KoW ≥ 4.2 (if BAF and BCF are not available) -Terrestrial - log Koa ≥ 6 and log Kow ≥ 2 - Food Chain Bioaccumulation Potential - BMF > 1	N/A
Toxicity	**Acute toxicity**	N/A	Fish -96h LC 50 > 10 mg/L Invertebrates - 48h EC50 > 10 mg/L Algae and other aquatic plants -72 or 96h ErC50 > 10 mg/L	Fish -96h LC 50 >1 to < 10 mg/L Invertebrates - 48h EC50 >1 to < 10 mg/L Algae and other aquatic plants -72 or 96h ErC50 >1 to < 10 mg/L	Fish -96h LC 50 ≤ 1 mg/L Invertebrates - 48h EC50 ≤ 1 mg/L Algae and other aquatic plants -72 or 96h ErC50 ≤ 1 mg/L	N/A
	Chronic toxicity	N/A	Fish NOEC or Ecx >1 mg/L Invertebrates NOEC or Ecx > 1 mg/L Algae and other aquatic plants - NOEC or Ecx > 1 mg/L	Fish NOEC or Ecx >0.1 to < 1 mg/L Invertebrates NOEC or Ecx >0.1 to < 1 mg/L Algae and other aquatic plants - NOEC or Ecx >0.1 to < 1 mg/L	Fish NOEC or Ecx ≤ 0.1 mg/L Invertebrates NOEC or Ecx ≤ 0.1 mg/L Algae and other aquatic plants - NOEC or Ecx ≤ 0.1 mg/L	N/A
Risk assessment action required		N/A	Toxicological profile	Toxicological profile Qualitative risk assessment	Toxicological profile Quantitative risk assessment	N/A

Attachment 2 Safety Data Sheet

COHO RESOURCES

Safety Data Sheet

Product Name **SODIUM SULFITE LIQUID** **Revision: 22/02/2024**

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Hazardous Statement	Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG
Supplier name	**COHO Drilling Fluids**
Address	3/35 Astor Terrace, Spring Hill, QLD, Australia 4000,
Telephone	+61 7 3870 0849
Emergency	+61 447 725 362 Hennie@coho-resources.com
Synonym(s)	Na2-SO3, anhydrous sodium sulphite, sodium salt.
Use(s)	Reducing Agent.
SDS Revision Date	25 March 2019

Australian Poisons Information Centre	24-hour hotline	13 11 26
	Police / Fire	000
New Zealand Poisons Information Centre	Dunedin:	+64 3 479 1200 (Business Hours)
		+64 3 474 0999 (Emergency)

2. HAZARDS IDENTIFICATION

NOT CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

Risk Phrases	None allocated
Safety Phrases	None allocated

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE

UN Number	None Allocated	**Transport Hazard Class**	None Allocated
Packing Group	None Allocated	**Hazchem Code**	None Allocated

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Ingredient	CAS Number	EC Number	Content
Sodium Sulfite	7757-83-7	-	~10%
Water		-	Remainder

4. FIRST AID MEASURES

Eye	If in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, a doctor, or for at least 15 minutes.
Inhalation	If inhaled, remove from contaminated area. Apply artificial respiration if not breathing.
Skin	If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. Continue flushing with water until advised to stop by a Poisons Information Centre or a doctor.
Ingestion	If swallowed, induce vomiting immediately by giving two glasses of water and sticking fingers down throat; never give anything to an unconscious person. Get medical attention.
Advice to doctor	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flammability	Non-flammable. May evolve toxic gases if strongly heated.
Fire and explosion	No fire or explosion hazard exists.
Extinguishing	All standard firefighting media.
Hazchem code	None Allocated

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Wear Personal Protective Equipment (PPE) as detailed in section 8 of the SDS.
Environmental precautions	Prevent product from entering drains and waterways.
Methods of cleaning up	Contain spillage, scoop up collect and place in suitable containers for disposal.
References	See Sections 8 and 13 for exposure controls and disposal.

7. STORAGE AND HANDLING

Storage	Store in a cool, dry location. Store away from oxidizers. Keep away from excessive heat.
Handling	Avoid contact with skin, eyes or clothing. Avoid inhaling dust. Wash hands after contact. Launder contaminated clothing.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure standards	No exposure standard(s) allocated.
Biological limits	No biological limit allocated.
Engineering controls	Avoid inhalation. Use in well ventilated areas.
PPE	
Eye / Face	Dust proof goggles.
Hands	Normal work gloves.
Body	Normal work coveralls.
Respiratory	Dust respirator.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Liquid
Odour	Odourless
Flammability	Not applicable
Flash point	Not applicable
Boiling point	Decomposes
Melting point	Decomposes
Evaporation rate	Not applicable
Ph as a solution (1%)	7.0-9.8
Vapour density	Not available
Specific gravity	1.1 (anhydrous)
Solubility (water)	Reacts
Vapour pressure	>1
Upper explosion limit	Not applicable
Lower explosion limit	Not applicable
Partition coefficient	Not applicable
Autoignition temperature	Not applicable
Decomposition temperature	>500°c
Viscosity	Not applicable
Explosive properties	Not applicable
Oxidising properties	Not applicable
Odour threshold	Not applicable
% Volatiles	Not applicable

10. STABILITY AND REACTIVITY

Chemical stability	Stable under recommended conditions of storage.
Conditions to avoid	Avoid heat, sparks, open flames and other ignition sources.
Material to avoid	Incompatible with oxidising agents (e.g. hypochlorites) and acids (e.g. nitric acid).
Hazardous Decomposition Products	May evolve toxic gases if heated to decomposition.
Hazardous Reactions	Polymerization is not expected to occur.

11. TOXICOLOGICAL INFORMATION

Health Hazard Summary	Low toxicity - low irritant. This product may present a hazard with direct eye contact or prolonged skin contact. Chronic effects are not anticipated.
Eye	May cause eye irritation.
Inhalation	Low irritant. May cause respiratory irritation. May cause allergic respiratory reaction.
Skin	May cause skin irritation.
Ingestion	May cause abdominal pain, vomiting, nausea, and diarrhea. May cause central nervous system depression including headache, dizziness, drowsiness, muscular weakness, incoordination, slowed reaction time, fatigue blurred vision, slurred speech, giddiness, tremors and convulsions.
Toxicity data	LD50: 2,825 mg/kg (Rat)

12. ECOLOGICAL INFORMATION

Toxicity	No information provided.
Persistence and degradability	No information provided.
Bioaccumulative potential	No information provided.
Mobility in soil	No information provided.
Other adverse effects	No information provided.

13. DISPOSAL CONSIDERATIONS

Waste disposal	For small amounts, absorb with sand or similar and dispose of to an approved landfill site. Contact the manufacturer/supplier for additional information (if required). Ensure that appropriate personal protective equipment is used during disposal.
Legislation	Dispose of in accordance with relevant local legislation.

14. TRANSPORT INFORMATION

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE, IMDG OR IATA

	LAND TRANSPORT (ADG)	**SEA TRANSPORT (IMDG / IMO)**	**AIR TRANSPORT (IATA / ICAO)**
UN Number	None Allocated	None Allocated	None Allocated
Proper Shipping Name	None Allocated	None Allocated	None Allocated
Transport Hazard Class	None Allocated	None Allocated	None Allocated
Packing Group	None Allocated	None Allocated	None Allocated

Environmental hazards	No information provided
Special precautions for user	None
Hazchem code	None Allocated

15. REGULATORY INFORMATION

Poison schedule	A poison schedule number has not been allocated to this product using the criteria in the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP).
Inventory Listing(s)	**AUSTRALIA: AICS (Australian Inventory of Chemical Substances)** All components are listed on AICS or are exempt.

16. OTHER INFORMATION

Additional information	PERSONAL PROTECTIVE EQUIPMENT GUIDELINES: The recommendation for protective equipment contained within this report is provided as a guide only. Factors such as method of application, working environment, quantity used, product concentration and the availability of engineering controls should be considered before final selection of personal protective equipment is made. HEALTH EFFECTS FROM EXPOSURE: It should be noted that the effects from exposure to this product will depend on several factors including: frequency and duration of use; quantity used; effectiveness of control measures; protective equipment used and method of application. Given that it is impractical to prepare a report which would encompass all possible scenarios, it is anticipated that users will assess the risks and apply control methods where appropriate.

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
CAS #	Chemical Abstract Service number - used to uniquely identify chemical compounds
CNS	Central Nervous System
EC No.	EC No - European Community Number
GHS	Globally Harmonized System
IARC	International Agency for Research on Cancer
LC50	Lethal Concentration, 50% / Median Lethal Concentration
LD50	Lethal Dose, 50% / Median Lethal Dose
mg/m³	Milligrams per Cubic Metre Occupational
OEL pH	Exposure Limit relates to hydrogen ion concentration using a scale of 0 (high acidic) to 14 (highly alkaline).
ppm	Parts Per Million
STEL	Short-Term Exposure Limit
STOT-RE	Specific target organ toxicity (repeated exposure)
STOT-SE	Specific target organ toxicity (single exposure)
SUSMP	Standard for the Uniform Scheduling of Medicines and Poisons
SWA	Safe Work Australia
TLV	Threshold Limit Value
TWA	Time Weighted Average

Revision history

Revision	Description
1.0	Standard SDS Review

Disclaimer

This SDS is prepared in accord with the Safe Work Australia document “Code of Practice for the Preparation of Safety Data Sheets for Hazardous Chemicals - December 2011”

The information contained in this safety data sheet is provided in good faith and is believed to be accurate at the date of issuance. COHO Resources Pty. Ltd makes no representation of the accuracy or comprehensiveness of the information and to the full extent allowed by law excludes all liability for any loss or damage related to the supply or use of the information in this material safety data sheet. The user is cautioned to make their own determinations as to the suitability of the information provided to the circumstances in which the product is used.

COHO RESOURCES

Safety Data Sheet

Product Name **SUPER SCAVENGER** **Revision: 22/02/2024**

1. IDENTIFICATION OF THE MATERIAL AND SUPPLIER

Hazardous Statement	Non-Hazardous according to the criteria of the 3rd Revised Edition of the Globally Harmonised System of Classification and Labelling of Chemicals (GHS), Non-Dangerous Goods according to the criteria of ADG
Supplier name	**COHO Drilling Fluids**
Address	3/35 Astor Terrace, Spring Hill, QLD, Australia 4000,
Telephone	+61 7 3870 0849
Emergency	+61 447 725 362 Hennie@coho-resources.com
Synonym(s)	Na2-SO3, anhydrous sodium sulphite, sodium salt.
Use(s)	Reducing Agent.
SDS Revision Date	25 March 2019

Australian Poisons Information Centre	24-hour hotline Police / Fire	13 11 26 000
New Zealand Poisons Information Centre	Dunedin:	+64 3 479 1200 (Business Hours) +64 3 474 0999 (Emergency)

2. HAZARDS IDENTIFICATION

NOT CLASSIFIED AS HAZARDOUS ACCORDING TO SAFE WORK AUSTRALIA CRITERIA

Risk Phrases	None allocated
Safety Phrases	None allocated

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE

UN Number	None Allocated	**Transport Hazard Class**	None Allocated
Packing Group	None Allocated	**Hazchem Code**	None Allocated

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Ingredient	CAS Number	EC Number	Content
Sodium Sulfite	7757-83-7	-	~10%
Corrosion Inhibitor	7779-90-0		~10%
Biocide	55566-30-8		~10%
Water		-	Remainder

4. FIRST AID MEASURES

Eye	If in eyes, hold eyelids apart and flush continuously with running water. Continue flushing until advised to stop by a Poisons Information Centre, a doctor, or for at least 15 minutes.
Inhalation	If inhaled, remove from contaminated area. Apply artificial respiration if not breathing.
Skin	If skin or hair contact occurs, remove contaminated clothing and flush skin and hair with running water. Continue flushing with water until advised to stop by a Poisons Information Centre or a doctor.
Ingestion	If swallowed, induce vomiting immediately by giving two glasses of water and sticking fingers down throat; never give anything to an unconscious person. Get medical attention.
Advice to doctor	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flammability	Non-flammable. May evolve toxic gases if strongly heated.
Fire and explosion	No fire or explosion hazard exists.
Extinguishing	All standard firefighting media.
Hazchem code	None Allocated

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Wear Personal Protective Equipment (PPE) as detailed in section 8 of the SDS.
Environmental precautions	Prevent product from entering drains and waterways.
Methods of cleaning up	Contain spillage, scoop up collect and place in suitable containers for disposal.
References	See Sections 8 and 13 for exposure controls and disposal.

7. STORAGE AND HANDLING

Storage	Store in a cool, dry location. Store away from oxidizers. Keep away from excessive heat.
Handling	Avoid contact with skin, eyes or clothing. Avoid inhaling dust. Wash hands after contact. Launder contaminated clothing.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Exposure standards	No exposure standard(s) allocated.
Biological limits	No biological limit allocated.
Engineering controls	Avoid inhalation. Use in well ventilated areas.
PPE	
Eye / Face	Dust proof goggles.
Hands	Normal work gloves.
Body	Normal work coveralls.
Respiratory	Dust respirator.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance	Liquid
Odour	Odourless
Flammability	Not applicable
Flash point	Not applicable
Boiling point	Decomposes
Melting point	Decomposes
Evaporation rate	Not applicable
Ph as a solution (1%)	7.0-9.8
Vapour density	Not available
Solubility (water)	Reacts
Vapour pressure	>1
Upper explosion limit	Not applicable
Lower explosion limit	Not applicable
Partition coefficient	Not applicable
Autoignition temperature	Not applicable
Decomposition temperature	>500ºc
Viscosity	Not applicable
Explosive properties	Not applicable
Oxidising properties	Not applicable
Odour threshold	Not applicable
% Volatiles	Not applicable

10. STABILITY AND REACTIVITY

Chemical stability	Stable under recommended conditions of storage.
Conditions to avoid	Avoid heat, sparks, open flames and other ignition sources.
Material to avoid	Incompatible with oxidising agents (e.g. hypochlorites) and acids (e.g. nitric acid).
Hazardous Decomposition Products	May evolve toxic gases if heated to decomposition.
Hazardous Reactions	Polymerization is not expected to occur.

11. TOXICOLOGICAL INFORMATION

Health Hazard Summary	Low toxicity - low irritant. This product may present a hazard with direct eye contact or prolonged skin contact. Chronic effects are not anticipated.
Eye	May cause eye irritation.
Inhalation	Low irritant. May cause respiratory irritation. May cause allergic respiratory reaction.
Skin	May cause skin irritation.
Ingestion	May cause abdominal pain, vomiting, nausea, and diarrhea. May cause central nervous system depression including headache, dizziness, drowsiness, muscular weakness, incoordination, slowed reaction time, fatigue blurred vision, slurred speech, giddiness, tremors and convulsions.
Toxicity data	LD50: 2,825 mg/kg (Rat)

12. ECOLOGICAL INFORMATION

Toxicity	No information provided.
Persistence and degradability	No information provided.
Bioaccumulative potential	No information provided.
Mobility in soil	No information provided.
Other adverse effects	No information provided.

13. DISPOSAL CONSIDERATIONS

Waste disposal	For small amounts, absorb with sand or similar and dispose of to an approved landfill site. Contact the manufacturer/supplier for additional information (if required). Ensure that appropriate personal protective equipment is used during disposal.
Legislation	Dispose of in accordance with relevant local legislation.

14. TRANSPORT INFORMATION

NOT CLASSIFIED AS A DANGEROUS GOOD BY THE CRITERIA OF THE ADG CODE, IMDG OR IATA

	LAND TRANSPORT (ADG)	SEA TRANSPORT (IMDG / IMO)	AIR TRANSPORT (IATA / ICAO)
UN Number	None Allocated	None Allocated	None Allocated
Proper Shipping Name	None Allocated	None Allocated	None Allocated
Transport Hazard Class	None Allocated	None Allocated	None Allocated
Packing Group	None Allocated	None Allocated	None Allocated

Environmental hazards	No information provided
Special precautions for user	None
Hazchem code	None Allocated

15. REGULATORY INFORMATION

Poison schedule	A poison schedule number has not been allocated to this product using the criteria in the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP).

Inventory Listing(s)

AUSTRALIA: AICS (Australian Inventory of Chemical Substances)
All components are listed on AICS or are exempt.

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16. OTHER INFORMATION

Additional information

PERSONAL PROTECTIVE EQUIPMENT GUIDELINES:
The recommendation for protective equipment contained within this report is provided as a guide only. Factors such as method of application, working environment, quantity used, product concentration and the availability of engineering controls should be considered before final selection of personal protective equipment is made.

HEALTH EFFECTS FROM EXPOSURE:
It should be noted that the effects from exposure to this product will depend on several factors including: frequency and duration of use; quantity used; effectiveness of control measures; protective equipment used and method of application. Given that it is impractical to prepare a report which would encompass all possible scenarios, it is anticipated that users will assess the risks and apply control methods where appropriate.

Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
CAS #	Chemical Abstract Service number - used to uniquely identify chemical compounds
CNS	Central Nervous System
EC No.	EC No - European Community Number
GHS	Globally Harmonized System
IARC	International Agency for Research on Cancer
LC50	Lethal Concentration, 50% / Median Lethal Concentration
LD50	Lethal Dose, 50% / Median Lethal Dose
mg/m^3	Milligrams per Cubic Metre Occupational
OEL pH	Exposure Limit relates to hydrogen ion concentration using a scale of 0 (high acidic) to 14 (highly alkaline).
ppm	Parts Per Million
STEL	Short-Term Exposure Limit
STOT-RE	Specific target organ toxicity (repeated exposure)
STOT-SE	Specific target organ toxicity (single exposure)
SUSMP	Standard for the Uniform Scheduling of Medicines and Poisons
SWA	Safe Work Australia
TLV	Threshold Limit Value
TWA	Time Weighted Average

Revision history

Revision	Description
1.0	Standard SDS Review

Disclaimer

This SDS is prepared in accord with the Safe Work Australia document “Code of Practice for the Preparation of Safety Data Sheets for Hazardous Chemicals - December 2011”

The information contained in this safety data sheet is provided in good faith and is believed to be accurate at the date of issuance. COHO Resources Pty. Ltd makes no representation of the accuracy or comprehensiveness of the information and to the full extent allowed by law excludes all liability for any loss or damage related to the supply or use of the information in this material safety data sheet. The user is cautioned to make their own determinations as to the suitability of the information provided to the circumstances in which the product is used.

Attachment 3 Chemical Register

Attachment 3
Chemical Register

Chemical Name	CAS No.	Contained in the following drilling fluids:	Document Control			Stage 1: Initial Check	Stage 2: Screening Assessment							RISK ASSESSMENT			Assessed Drilling Activity(ies)					
			Initial Cheimcal Assessment Date	Independent Peer Review	Chemical Re-evaluation Date	Previously Assessed as low hazard by NICNAS? Y/N	Listed as a COC on a relevant database?	Persistence Tier	Bioaccumulation Tier	Acute Toxicity Tier^1	Chronic Toxicity Tier^1	Overall Tier	Concern/Risk Level	Toxicological Profile?	Qualitative Risk Assessment?	Quantiative Risk Assessment?	Drilling additive - CSG Production Well	Drilling Additive - Completion and Workover	Drilling Additive - Exploration and Core Holes	Drilling Additive - Abandonment	Production Operations	Monitoring Wells
Sodium sulfite	7757-83-7	SuperScavenger	20/03/2025			N	No	1	1	1	1	1	Low	YES	N/A	N/A				X	X	
Trizinc bis(orthophosphate)	7779-90-0	SuperScavenger	20/03/2025			N	No	1	1	3	2 (fish & inv), 3 (algae)	2 [a]	Potential	YES	YES	N/A				X	X	
Tetrakis(hydroxymethyl)phosphonium sulfate (THPS)	55566-30-8	SuperScavenger	20/03/2025			N	No	1	1	1 (fish, inv); 3 (algae)	2 (fish); 3 (inv, algae)	1 [b]	Low	YES	N/A	N/A				X	X	

Footnotes:

1 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 – Tier 1 – Hazard Assessment only based on the preponderance of test data greatly exceeding the toxicity screening criterion

a - Preponderance of data indicates appropriateness of Tier 2. See dossier for more information

b - Preponderance of data indicates appropriateness of Tier 1. See dossier for more information.

Notes:

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

Attachment 4 Tier 1 Risk Assessment Dossiers

SODIUM SULFITE

This dossier on sodium sulfite presents the most critical studies pertinent to the risk assessment of sodium sulfite in its use in coal seam gas extraction activities. This dossier does not represent an exhaustive or critical review of all available data. The information presented in this dossier was obtained primarily from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – Sodium sulfite is classified as a **tier 1** chemical and requires a hazard assessment only.

1 BACKGROUND

Sodium sulfite readily dissociates in aqueous media to the sodium (Na+) and sulfite (SO_3^{2-}) ions. At neutral pH, a mixture of 50% sulfite (SO_3^{2-}) and 50% bisulfite (HSO_3^{2-}) is present. In surface waters, sulfite is oxidized to sulfate either catalytically by air oxygen or by microbial action. The presence of cations like iron, copper or manganese in the environment accelerates the oxidation rate significantly.

Biodegradation is not applicable to inorganic compounds. Bioaccumulation is not to be expected because of the resulting strong anionic nature of the substance, as well as its rapid oxidative transformation to sulfates under physiological and environmental circumstances. Sodium sulfite is of low toxicity concern to aquatic life.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): Disodium sulfite

CAS RN: 7757-83-7

Molecular formula: Na_2SO_3

Molecular weight: 126.04 g/mol

Synonyms: Sodium sulfite; sodium sulphite; sodium sulfite anhydrous; sulfurous acid, disodium salt

3 PHYSICO-CHEMICAL PROPERTIES

Key physical and chemical properties for the substance are shown in Table 1.

Table 1 Overview of the Physico-chemical Properties of Sodium Sulfite

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	White, hexagonal, crystalline solid	2	ECHA
Melting Point	911°C @ 101.3 kPa	2	ECHA

Property	Value	Klimisch score	Reference
Boiling Point	No data	-	-
Density	2630 kg/m^3 @ 20^{o}C	2	ECHA
Partition Coefficient (log K_{ow})	Not applicable	-	-
Water Solubility	307 g/L @ 25^{o}C	2	ECHA

4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for sodium sulfite.

NICNAS has assessed sodium sulfite in an Inventory Multi-tiered Assessment and Prioritisation (IMAP) Tier 1 assessment and concluded that it poses no unreasonable risk to the environment[1] .

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5 ENVIRONMENTAL FATE SUMMARY

Sodium sulfite readily dissociates in aqueous media to the sodium (Na^+) and sulfite (SO_3^{2-}) ions. Biodegradation is not applicable to inorganic compounds. Bioaccumulation is not to be expected because of the resulting strong anionic nature of the substance, as well as its rapid oxidative transformation to sulfates under physiological and environmental circumstances. Because of the anionic nature, any quantitatively relevant adsorption onto soil, sediments or suspended matter for sodium sulfite as well as its dissociation products is not to be expected. (ECHA).

6 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

Sodium sulfite is of low toxicity concern to aquatic life.

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[1] https://www.industrialchemicals.gov.au/chemical-information/search-assessments?assessmentcasnumber=7757-83-7%2C+

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies on sodium sulfite.

Table 3 Acute Aquatic Toxicity Studies on Sodium Sulfite and Sodium Disulfite

Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
Golden orfe	96-hr LC_{50}	316	2	ECHA
Daphnia magna	48-hr EC_{50}	89* (59)	2	ECHA
Desmodesmus subspicatus	72-hr EC_{50}	43.8* (29)	2	ECHA

*Test substance: sodium disulfite; adjusted concentration for sodium sulfite in parentheses

Chronic Studies

Table 4 lists the results of chronic aquatic toxicity studies conducted on sodium sulfite and sodium disulfite.

Table 4 Chronic Aquatic Toxicity Studies on Sodium Sulfite and Sodium Disulfite

Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
Zebrafish	34-d NOEC	>316	1	ECHA
Daphnia magna	21-d NOEC	>10* (6.6)	1	ECHA
Desmodesmus subspicatus	72-hr-EC_{10}	33.3* (22)	2	ECHA

*Test substance: sodium disulfite; adjusted concentration for sodium sulfite in parentheses

C. Terrestrial Toxicity

No studies are available.

7 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REACH Criteria methodology (IChEMS, 2022; ECHA, 2023).

Sodium sulfite dissociates completely to sodium and sulfite ions in aqueous solutions. Biodegradation is not applicable to these inorganic ions. For the purposes of this PBT assessment, the persistence criteria is not considered applicable.

Bioaccumulation is not to be expected because of the resulting strong anionic nature of the substance, as well as its rapid oxidative transformation to sulfates under physiological and environmental circumstances. Thus, sodium sulfite does not meet the screening criteria for bioaccumulation.

The NOEC or EC_{10} values from chronic aquatic toxicity studies on sodium sulfite is >0.1 mg/L. Thus, sodium sulfite does not meet the criteria for toxicity.

The overall conclusion is that sodium sulfite is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for sodium sulfite.

8 SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Sodium sulfite	7757-83-7	Not a PBT	No	No	NA	No	No	No	1	1	1

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).
3 – Tier 1 – Hazard Assessment only.

Notes:

NA = not applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

9 REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

European Chemicals Agency [ECHA]. ECHA REACH database: http://echa.euroa.eu/information-on-chemicals/registered-substances.

European Chemicals Agency [ECHA]. (2023). Chapter R.11: vPvB assessment. In *Guidance on information requirements and chemical safety assessment*. Version 4.0. Available: https://echa.europa.eu/guidance-documents/guidance-on-information-requirements-and-chemical-safety-assessment

Industrial Chemicals Environmental Management Standard [IChEMS]. (2022). Australian Environmental Criteria for Persistent, Bioaccumulative and/or Toxic Chemicals. Available: https://www.dcceew.gov.au/sites/default/files/documents/australian-pbt-criteria.pdf

Klimisch, H.J., Andreae, M., and Tillmann, U. (1997). A systematic approach for evaluating the quality of experimental and toxicological and ecotoxicological data. Regul. Toxicol, Pharmacol. 25:1-5.

B. Abbreviations and Acronyms

°C	degrees Celsius
AICS	Australian Inventory of Chemical Substances
CAS RN	Chemical Abstract Services Registry Number
COC	constituent of concern
EC	effective concentration
ECHA	European Chemicals Agency
EU	European Union
g/L	grams per litre
IChEMS	Industrial Chemicals Environmental Management Standard
IMAP	Inventory Multitiered Assessment and Prioritisation
IUPAC	International Union of Pure and Applied Chemistry
kg/m^3	kilograms per cubic metre
kPa	kilopascal
LC	lethal concentration
LOEC	lowest observed effective concentration
mg/L	milligrams per litre
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NOEC	no observed effective concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic

REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SGG	Synthetic Greenhouse Gases
SIDS	Screening Information Data Set

TETRAKIS(HYDROXYMETHYL)PHOSPHONIUM SULFATE

This dossier on tetrakis(hydroxymethyl)phosphonium sulfate (THPS) presents the most critical studies pertinent to the risk assessment of its use in drilling muds, hydraulic fracturing fluids and water treatment. It does not represent an exhaustive or critical review of all available data. The information presented in this dossier was obtained primarily from the IPCS Environmental Health Criteria document on flame retardants, which included THPS (IPCS, 2000) and from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – THPS was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. THPS was assessed as a tier 1 chemical for acute toxicity in fish and invertebrates and a tier 3 chemical for acute toxicity (based on a singular study) in algae. THPS was assessed as a tier 2 chemical for chronic toxicity in fish and a tier 3 chemical for chronic toxicity in invertebrates and algae. Limited chronic toxicity tests were available for fish, invertebrates and algae (based on a singular study). Acute aquatic toxicity tests for fish (6 studies) and invertebrates (8 studies) were greater than 10 mg/L. Based on the preponderance of the acute toxicity data set, the limited chronic toxicity data set, combined with the potential for biodegradation, this substance is classified overall as a **tier 1** chemical and requires a hazard assessment only.

1 BACKGROUND

THPS is readily or inherently biodegradable depending on test conditions. It is not expected to bioaccumulate, and it has a low to moderate potential to adsorb to soil and sediment. THPS has a high acute toxicity concern to aquatic organisms.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): bis[tetrakis(hydroxymethyl)phosphonium] sulfate

CAS RN: 55566-30-8

Molecular formula: $C_8H_{24}O_8P_2O_4S$

Molecular weight: 406.28 g/mol

Synonyms: Tetrakis(hydroxymethyl)phosphonium sulfate; bis[tetrakis(hydroxymethyl)phosphonium] sulfate; Octakis (hydroxymethyl) phosphonium sulfate; Tolcide PS75; THPS

3 PHYSICO-CHEMICAL PROPERTIES

Key physical and chemical properties for the substance are shown in Table 1.

Table 1 Overview of the Physico-chemical Properties of THPS (75% solution)

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Colourless liquid	1	ECHA
Melting Point	54 - 82 °C @ 101.3 kPa (measured in dried solid THPS [100%])	1	ECHA
Boiling Point	108.5°C @ 101.3 kPa	1	ECHA
Density	1390 kg/m^3 @ 20°C	1	ECHA
Vapour Pressure	Negligible @ 25°C	1	ECHA
Partition Coefficient (log K_{ow})	-9.8 (calculated) (temperature not provided)	2	ECHA
Water Solubility	37,700 g/L @ 21 °C	1	ECHA
Dissociation constant (pKa)	Not available	-	-
Viscosity	Not available	-	-

4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for THPS.

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5 ENVIRONMENTAL FATE SUMMARY

A. Summary

THPS is readily or inherently biodegradable depending on test conditions. It is not expected to bioaccumulate, and it has a low to moderate potential to adsorb to soil and sediment.

B. Partitioning

THPS is highly soluble in water. Volatilisation from water surfaces or moist soil surfaces is not expected to be an important fate process based upon this compound's estimated Henry's Law constant of 1.7×10^{-18} Pa m^3/mol. It is also not expected to volatilise from dry soil surfaces based upon its vapor pressure (NCBI, 2025).

Hydrolysis is expected to be an important environmental fate process since this compound contains functional groups that hydrolyse under environmental conditions (pH 5 to 9) (PubChem). The hydrolysis of THPS is pH-dependent: half-lives at 25°C were 131, 72, and 7 days at pH 5, 7, and 9, respectively (IPCS, 2000).

C. Biodegradation

Available tests relevant for ready biodegradability (OECD 306 and BOD/COD) and inherent biodegradability (OECD302B) are invalidated due to toxicity of THPS towards the inoculum at the recommended test concentrations (ECHA). Two simulation tests were therefore performed at environmental relevant concentrations in freshwater/sediment test systems, under aerobic and anaerobic conditions. Both studies showed that THPS is inherently biodegradable (70% ultimate degradation before Day 28) under aerobic conditions (70% mineralisation at Day21) and rapidly biodegradable (DT50 mineralisation< 16 days) under aerobic (DT50 mineralisation= 2 days) and anaerobic (DT50 mineralisation= 14 days) conditions.(ECHA) [Kl. Score = 1]

If a chemical is found to be inherently biodegradable or readily biodegradable, it is categorised as Not Persistent since its half-life is substantially less than 60 days (DoEE, 2017).

D. Environmental Distribution

The estimated K_{oc} values estimated from tested soil and sediment samples using radiolabelled THPS ranged from 72 to 266, with a mean value of 153. The samples included sand, silt loam, sandy loam, pond sediment, and marine sediment (IPCS, 2000). Based on these estimated values, THPS is expected to be mobile to moderately mobile in soil. If released to water, based on the K_{oc} value and its high water solubility, it is also not expected to adsorb to suspended solids and sediment.

E. Bioaccumulation

There are no bioaccumulation studies on THPS. THPS is not expected to bioaccumulate based on a log K_{ow} of -9.8 (IPCS, 2000).

6 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

THPS has a high acute and chronic toxicity concern to aquatic organisms.

B. Aquatic Toxicity

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies conducted on THPS.

Table 3 Acute Aquatic Toxicity Studies on THPS

Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
Oncorhynchus mykiss	96-hr LC_{50}	71	1	ECHA
Lepomis macrochirus	96-hr LC_{50}	74	1	ECHA
Cyprinodon variegatus	96-hr LC_{50}	72	1	ECHA
Daphnia magna	48-hr EC_{50}	11.3	1	ECHA
Daphnia magna	48-hr EC_{50}	14.3	2	ECHA
*Pseudokirchneriella subcapitata**	96-hour EC_{50}	0.492	1	ECHA

*one study available

Chronic Studies

Limited chronic aquatic toxicity studies on THPS are available. Table 4 lists the results of chronic aquatic toxicity studies conducted on THPS.

Table 4 Chronic Aquatic Toxicity Studies on THPS

Test Species	Endpoint	Results (mg/L)	Klimisch Score	Reference
*Pimephales promelas**	32-day NOEC	0.83	1	ECHA
*Daphnia magna**	21-day NOEC	0.0242	1	ECHA
*Pseudokirchneriella subcapitata**	96-hour NOEC	0.048	1	ECHA

*one study available

C. Terrestrial Toxicity

An OECD Guideline 208 study was conducted using three species: Triticum aestivum (Wheat), Sinapis alba (Mustard) and Medicago sativa (Alfalfa). The lowest 14-day $L(E)C_{50}$ was reported to be 102 mg/kg soil dw (ECHA) [Kl. score =1].

A 28-d NOEC of 600 mg/kg soil dw was determined in aerobic soil microorganisms in an OECD Guideline 216 study (ECHA) [Kl. score = 1].

The LD_{50} to mallard duck (*Anas platyryncus*) is 311 mg/kg (IPCS, 2000). The dietary LC_{50} values to mallard ducks and bobwhite quail are 1,313 and 2,414 mg/kg diet, respectively (IPCS, 2000).

7 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REACH Criteria methodology (IChEMS, 2022; ECHA, 2023).

THPS is inherently biodegradable (70% ultimate degradation before Day 28) under aerobic conditions (70% mineralisation at Day21) and rapidly biodegradable (DT50 mineralisation< 16 days) under aerobic (DT50 mineralisation= 2 days) and anaerobic (DT50 mineralisation= 14 days) conditions. Thus, THPS does not meet the screening criteria for persistence.

Based on a measured log K_{ow} of -9.8, THPS does not meet the screening criteria for bioaccumulation.

The NOECs from the chronic aquatic toxicity studies on THPS are < 0.1 mg/L for invertebrates and algae in a singular study. The acute $E(L)C_{50}$ values from the acute aquatic toxicity studies on THPS are < 1 mg/L in a single algae study. The remaining toxicity test data for fish and invertebrates are orders of magnitude greater than the 1 mg/L. However, THPS has been classified as meeting the criteria for toxicity.

The overall conclusion is that THPS is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for THPS.

8 SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	Identified as Polymer of Low Concern	P criteria fulfilled?	Other P Concerns	B criteria fulfilled?	T criteria fulfilled?	Acute Toxicity [2]	Chronic Toxicity[2]	
Tetrakis(hydroxymethyl)phosphonium sulfate	55566-30-8	Not a PBT	No	No	No	No	No	Yes	1 (fish, inv); 3 (algae)	2 (fish); 3 (inv, algae)	1[a]

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 – Tier 1 – Hazard Assessment only based on the preponderance of test data greatly exceeding the toxicity screening criterion

a – Preponderance of data indicates appropriateness of Tier 1. See dossier for more information.

Notes:

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

9 REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

Department of the Environment and Energy [DoEE]. (2017). Chemical Risk Assessment Guidance Manual: for chemicals associated with coal seam gas extraction, Guidance manual prepared by Hydrobiology and ToxConsult Pty Ltd for the Department of the Environment and Energy, Commonwealth of Australia, Canberra. Available: https://www.dcceew.gov.au/water/coal-and-coal-seam-gas/national-assessment-chemicals/consultation-risk-assessment-guidance-manual

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IPCS (2000). Flame Retardants: Tris(2-butoxyethyl)phosphate, Tris (2-ethylhexyl) phosphate and tetrakis (hydroxymethyl)phosphonium Salts, Environmental Health Criteria 218, International Programme on Chemical Safety, United Nations Environment Programme, International Labour Organisation, World Health Organization.

National Center for Biotechnology Information [NCBI]. (2025). PubChem Compound Summary for CID 41478, Tetrakis(hydroxymethyl)phosphonium sulfate. Retrieved January 28, from https://pubchem.ncbi.nlm.nih.gov/compound/41478.

B. Abbreviations and Acronyms

°C	degrees Celsius
µg/g	microgram per gram
AICS	Australian Inventory of Chemical Substances
BMPA	bishydroxymethyl phosphonic acid
COC	constituent of concern
EC	effective concentration
ECHA	European Chemicals Agency

EU	European Union
g/L	grams per litre
IChEMS	Industrial Chemicals Environmental Management Standard
IUPAC	International Union of Pure and Applied Chemistry
kg/m^3	kilograms per cubic metre
Kl	Klimisch scoring system
kPa	kilopascal
LC	lethal concentration
mg/L	milligrams per litre
mm	millimetre
NOEC	no observed effects concentration
OECD	Organisation for Economic Co-operation and Development
PBT	Persistent, Bioaccumulative and Toxic
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SGG	Synthetic Greenhouse Gases
THPO	trihydroxymethyl phosphine oxide
THPS	tetrakis(hydroxymethyl)phosphonium sulfate
USEPA	United States Environmental Protection Agency

Attachment 5 Tier 2 Risk Assessment

Qualitative Tier 2 Assessment

Trizinc bis(orthophosphate)

In accordance with the Senex Energy ("Senex") Atlas Stage 3 Chemical Risk Assessment Framework (CRAF; Klohn Crippen Berger, 2024), chemicals assigned a Tier 2 designation require a hazard assessment and qualitative assessment of risk.

Consistent with National Industrial Chemicals Notification and Assessment Scheme (NICNAS), the human health hazards for each chemical are characterised by analysing the toxicokinetics (the absorption, distribution, metabolism and excretion of the chemical in humans or laboratory animals), acute toxicity, irritation and corrosivity, repeat dose toxicity, genotoxicity, carcinogenicity, reproductive toxicity, and other health effects. The environmental hazards for each chemical are characterised by analysing the environmental fate properties (such as mobility, persistence, bioavailability and bioaccumulation), acute toxicity and chronic toxicity. In support of the hazard assessment, a risk assessment dossier is prepared for each of the chemicals included in the assessment.

Potentially complete exposure pathways (in that a source, a migration pathway, a mechanism for exposure, and a potential receptor are present) are assessed herein to determine the potential for risk. An incomplete pathway precludes an exposure occurring and an associated potential risk. In this context, site setting and management protocols associated with the action are evaluated. Key controls limiting the potential for exposure include:

- Engineering controls (including fencing and secondary containment);
- Storage (drums, totes and storage tanks) constructed in accordance with Australian standards and managed and monitored in accordance with regulatory requirements;
- Maintenance of access control restrictions during site activities that will preclude access by the public, livestock and large native fauna; and,
- Safe Work Australia and Senex Health, Safety and Environmental Management System (HSEMS) used to minimise human health exposure.

This qualitative assessment provides information to be used as a complement to the risk assessment dossier to provide a summary of human and ecological hazards that may occur from exposure to the chemical. Where a potential hazard exists, additional information is provided in the risk assessment dossiers and safety data sheets (SDSs) and are available to emergency responders, health and safety managers, and environmental hazard clean-up teams.

As a result, the assessment for this Tier 2 chemical includes the following components: completing the screening; developing a risk assessment dossier and Predicted No Effect Concentrations (PNECs) for water and soil; and, providing a qualitative discussion of risk. Each of these components is detailed within this memorandum.

Background

Trizinc bis(orthophosphate) is a component in a product proposed for use in drilling and completion activities and well abandonment. During drilling, the product will be installed with the surface casing vent (i.e., between the surface casing and production casing) to act as a corrosion inhibitor. In production wells and as part of well abandonment, the production casing will be cemented and surface casing will be filled with chemicals to preserve the surface well casing. For abandoned wells, after a period of approximately six months, the top of the surface casing will be grouted, effectively encapsulating the liquid.

The purpose and maximum quantity for this chemical was calculated from the product quantity utilised per well and the maximum concentration presented on the SDS provided by Senex and is summarised in **Table 1**.

Table 1 Drilling Chemicals

Chemical Name	CAS No.	Use	Concentration
Trizinc bis(orthophosphate)	7779-90-0	Corrosion Inhibitor	1.43 kg/m^3

CAS No = Chemical Abstracts Service Number
kg/m^3 = kilograms per cubic meter

The assessment of toxicity of this chemical was used to evaluate human health exposure scenarios and is presented in the risk assessment dossier provided in **Attachment 1**. There was no sufficient evidence of carcinogenicity in rat and mouse chronic studies conducted on trizinc bis(orthophosphate). Thus, a cancer reference value was not derived. Trizinc bis(orthophosphate) is a zinc compound. Since an Australian Drinking Water Value is available for zinc (see Table 2), toxicological reference values (TRVs) were not derived. A detailed discussion of the drinking water guideline value is presented in **Attachment 1**.

Table 2 Australian Drinking Water Values

Constituent (CAS No.)	Drinking Water Screening Guideline	Drinking Water Guideline (mg/L)
Trizinc bis(orthophosphate) (CAS No. 7779-90-0)	Zinc	3

CAS = Chemical Abstracts Service
mg/L = milligram per litre

For ecological receptors, the assessment utilises the information presented in the dossiers on the relative toxicity of the aquatic and terrestrial flora and fauna to the chemical. This assessment focuses on the aquatic invertebrate and fish species within the surface water resources and the soil flora and fauna associated with releases to the soil.

The determination of TRVs was conducted according to the PNEC guidance in the *Environmental Risk Assessment Guidance Manual for Industrial Chemicals* prepared by the Australian Environmental Agency (AEA, 2009). PNECs for freshwater and sediment were developed to assess aquatic receptors, and PNECs for soil were developed for terrestrial receptors.

Table 3 presents the chemical, the endpoint, no observable effects concentration (NOEC) (milligrams per litre [mg/L]), assessment factor, and the aquatic PNEC (mg/L). PNECs for sediment and soil are detailed in **Tables 4** and **5,** respectively. Refer to **Attachment 1** for the development of PNECs, or the rationale for PNECs that do not have a calculated PNEC.

Table 3 PNECs Water – Tier 2 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/L)	Assessment Factor	$PNEC_{water}$ (mg/L)
Trizinc bis(orthophosphate) (CAS No. 7779-90-0)	[a]	-	-	0.008

[a] ANZG DGV for 95% species protection level for zinc in freshwater for slightly-to-moderately disturbed ecosystems.
EC_{50} = effects concentration – 50%
mg/L = milligram per litre
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

Table 4 PNECs Sediment – Tier 2 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/kg wet wt)	Assessment Factor	$PNEC_{sed}$ (mg/kg wet wt)
Trizinc bis(orthophosphate) (CAS No. 7779-90-0)	[a]	-	-	289.1

[a] Calculated using sensitivity distribution method and an assessment factor of 1.
EC_{50} = effects concentration – 50%
mg/kg wet wt = milligram per kilogram wet weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

Table 5 PNECs Soil – Tier 2 Chemicals

Constituents	Endpoint	EC_{50} or NOEC (mg/kg dry wt)	Assessment Factor	$PNEC_{soil}$ (mg/kg dry wt)
Trizinc bis(orthophosphate) (CAS No. 7779-90-0)	[a]	-	-	163.6

[a] Calculated using sensitivity distribution method and an assessment factor of 1.
EC_{50} = effects concentration – 50%
mg/kg dry wt = milligram per kilogram dry weight
NOEC = no observable effects concentration
PNEC = predicted no effect concentration
Refer to **Attachment 1** for information on the development of PNECs listed above.

A detailed assessment of the potential risks posed by this Tier 2 chemical is provided in the following sections.

General Overview

Zinc is a natural element, which is essential for all living organisms. It occurs in the metallic state, or as zinc compound, such as trizinc ortho(bisphosphate). The molecular structure for trizinc bis(orthophosphate) is presented in **Figure 1**.

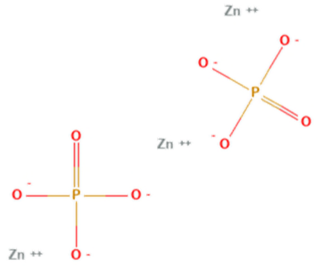

Figure 1 Molecular Structure of Trizinc bis(orthophosphate)[1]

Trizinc bis(orthophosphate) is an inorganic compound not subject to biodegradation. It is sparingly soluble to insoluble in water. It is expected to partition to soil and sediment. Bioconcentration/bioaccumulation is not considered relevant for all inorganic zinc substances.

The Persistent, Bioaccumulative and Toxic (PBT) assessment for trizinc ortho(bisphosphate) is included in the dossier provided in **Attachment 1**. Based on physico-chemical properties and screening data detailed below, the overall conclusion was that the substance is not a PBT substance.

Human Health Hazards

Zinc is a natural element, which is essential for all living organisms. Zinc, as an essential element, plays an important role in many processes in the body. It occurs in the metallic state, or as zinc compound, such as trizinc ortho(bisphosphate). Trizinc bis(orthophosphate) has low acute toxicity by the oral and inhalation routes. It is not irritating to the eyes and skin. No skin sensitisation is expected. In repeat dose toxicity studies, mild effects were observed. Trizinc bis(orthophosphate) has low repeated dose toxicity and low reproductive and developmental toxicity. It is not genotoxic nor is it carcinogenic. NICNAS has assessed trizinc bis(orthophosphate) in an IMAP Tier 1 assessment and concluded that it poses no unreasonable risk to human health[2].

The assessment of toxicity of this chemical was used to evaluate human health exposure scenarios and is presented in **Attachment 1**. Trizinc bis(orthophosphate) is not a carcinogen and TRVs were not derived. The Australian drinking water guideline (ADWG) values for zinc is 3 mg/L based on aesthetics (see **Table 2**). ADWG has concluded that higher zinc concentrations can impart undesirable taste and a cloudy appearance (ADWG, 2011). A detailed discussion of the drinking water guideline values is presented in **Attachment 1**.

The lifecycle of chemicals, including trizinc bis(orthophosphate), used in the drilling and completion of wells and in well abandonment, includes the following general categories: transportation of chemicals; drilling and completion operations; and, treatment, recycling, disposal and beneficial reuse. Without management controls in place, there is the potential for human receptors to be

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[1] Source https://chem.nlm.nih.gov/chemidplus/rn/7779-90-0

[2] https://services.industrialchemicals.gov.au/assessment-detail/?id=c4b6433e-f36b-1410-8de4-00e8f2afc108

exposed to drilling fluid chemicals that contain trizinc bis(orthophosphate) during drilling, completion and well abandonment operations and management of wastes. Wastes associated with drilling operations and abandonment of wells will be either removed from well sites for disposal at a licensed facility, or disposed of using mix-bury-cover or other method of disposing to land that is certified as not causing environmental harm (Senex, 2023; EHS Support, 2024). Based on an assessment of land use and an understanding of the project description (Senex, 2023; EHS Support, 2024), potential human receptors include:

1. Workers at the well lease involved with blending, storage, transfer, reuse, recovery and recycling of drilling fluids and cuttings; well abandonment activities; recycling, reuse or disposal of recovered materials including beneficial reuse activities such as land applications of drilling materials and dust suppression; and, mitigating releases at the well lease or along the transport or conveyance routes.
2. Agricultural workers or residents in irrigation areas.
3. Landholders that have access to the water supply from a bore hydraulically downgradient of well lease.

In terms of risks associated with transport of chemicals and wastes, this risk is considered to be managed to a level as low as reasonably practicable. This is because the potential for a release is controlled through implementation of traffic management principles including use of designated trucking routes, vehicle signage, vehicle management systems (to manage speed and driving behaviour/habits) and, in the unlikely event of a vehicular accident, implementation of incident and spill response procedures. Given the highly regulated nature of transportation of chemicals (at both a Commonwealth and State level), transport-related scenarios are not evaluated further in this assessment. However, the outcome of the assessment should be used to inform emergency response actions.

Exposure of workers to drilling fluid chemicals is possible via inadvertent spills and leaks, during the recycling and beneficial reuse of recovered materials (e.g., drilling fluids and cuttings), and during application of the recovered material to land. However, chemical exposures to workers are controlled through engineering, management controls and personal protective equipment, which are focused on elimination and mitigation of the potential for dermal contact and potential for incidental ingestion. In addition, Safe Work Australia and Senex Health, Safety and Environmental Management System (HSEMS) are used to minimise human health exposure. As a result, petroleum workers, are also excluded from assessment. No potentially complete exposure pathways were identified.

The management of chemicals and wastes will be conducted at the well lease using drums, totes and engineered tanks designed to contain the fluids. In the unlikely event of a release to ground, the potential for exposures (other than workers) is limited. Releases on the well pad would be of limited volumes and well pad sites are fenced and access is controlled, which limits access to the public. If drilling fluid chemicals are spilled to ground then investigation, remediation and rehabilitation activities would be implemented to address soil impacts.

On-lease storage may utilise tanks, pits or turkey nests and there is the possibility that a containment failure could result in the release of the materials to the well lease and the surrounding environment. Releases on the well pad would be of limited volumes and as such these products would not be anticipated to migrate a significant distance off lease to the surrounding environment, including proximal water bodies.

The potential for a significant drilling fluid loss during drilling is rare, particularly given the volumes used and the management controls in place during drilling. Where lost circulation is identified during drilling, a lost circulation fluid (i.e., cellulose) is used to plug the interval and prevent further loss of fluids. Likelihood of losses during production operations and well abandonment is considered low because the fluid will be encapsulated within established casing. Despite the limited potential for large scale losses during drilling, EHS Support (2015) completed modelling of how a conservative tracer or highly soluble organic constituents could migrate in the subsurface to assess the potential effects of potential loss of drilling muds on groundwater systems. The BIOSCREEN model was utilized to facilitate assessment of organic constituent mobility with and without biodecay. The modelling indicated that the potential for impact on ground water quality is limited even under a worst-case scenario utilising conservative assumptions.

Exposure of potential receptors (other than workers) is also possible to residual chemicals in areas that have been used for the application of materials for beneficial reuse. However, Environmental Authority (EA) or Beneficial Use Approval conditions regulate project reuse. A plan for the beneficial reuse of materials is being developed by a Suitably Qualified Person (SQP) in accordance with the EA conditions and will require materials of a certain quality and controls the maximum volumes that can be applied to land. In addition, the application techniques and location of application are controlled with specific monitoring required. Additional details regarding mitigation and management controls are discussed in the CRAF.

As a result, potential exposures during drilling and completion activities and well abandonment are low due to the employment of mechanical equipment/processes, engineering controls (including secondary containment) and other mitigation and management strategies. Similarly, there is a low potential for human receptors exposed to surface water bodies that may receive runoff from beneficial reuse applications. Finally, the probability of any surface related discharge infiltrating subsurface soils and migrating to groundwater is very low.

Environmental Hazards

The ecotoxicity of zinc and zinc compounds is due to the zinc (2^+) ion (ECHA). Zinc and zinc compounds may present a hazard for the environment depending on the release/bioavailability of zinc ions and on the conditions of the receiving environment (pH, hardness, dissolved organic carbon [DOC]). Zinc in acute aquatic toxicity studies is very toxic and in chronic aquatic toxicity studies is very toxic with long lasting effects. Zinc exhibits low toxicity in terrestrial organisms. Trizinc bis(orthophosphate) would release less zinc ions than other metal salts thus lowering its potential bioavailability and toxicity. Therefore, it can be expected that the ecotoxicity of trizinc bis(orthophosphate) would be less than what has been reported for the zinc (2^+) ion.

No information is available for trizinc bis(orthophosphate); information is available for adsorption/desorption of zinc chloride. If released to soil, trizinc bis(orthophosphate) has a low potential to leach to underlying groundwater. Likewise, combined with its insolubility, if released to water it is expected to strongly sorb to suspended solids and sediment in the water column.

Trizinc bis(orthophosphate) is an inorganic compound not subject to biodegradation. Bioconcentration/bioaccumulation is not considered relevant for all inorganic zinc substances.

ANZG derived a freshwater high reliability trigger value for zinc of 8 µg/L using the statistical distribution method at 95% protection (ANZG, 2018). The 95% species protection level for zinc in freshwater (8 µg/L) is recommended for adoption in the assessment of slightly-to-moderately disturbed ecosystems. Considering the land uses in the vicinity of the well leases, which includes light to moderate grazing, adoption of this level of protection is considered appropriate (**Table 3**).

A PNEC for sediment and soil were calculated for trizinc bis(orthophosphate) using the species sensitivity distribution method (see **Table 4** and **Table 5**). PNEC calculations and assumptions are detailed in the dossier provided in **Attachment 1**. In addition, ANZG[3] has developed a sediment quality guideline value of 200 mg/kg for zinc and a range of ecological investigation levels (EILs) for soil are available in ASC NEPM (NEPC, 2013), which are dependent on site-specific characteristics. Sediment and soil quality guideline values are also detailed in the dossier.

During the drilling process, there is the potential for environmental receptors to be exposed to drilling fluid chemicals that contain trizinc bis (orthophosphate). Pipelines (where treated water is conveyed) can transect sensitive ecological areas (including Matters of National Environmental Significance [MNES]). There is the concern of wildlife (terrestrial and aquatic receptors) and livestock in the vicinity of the well leases to have adverse effects from potential exposures. Potential environmental receptors include:

1. Wildlife and livestock accessing the well lease and areas adjacent to the well lease, including surface water features, that have received runoff from an accidental release during drilling and completion operations or loss of containment.
2. Wildlife and livestock accessing areas of the well lease where materials have been applied, as well as accessing stored materials in pits and turkey nests.
3. Aquatic flora and fauna within a proximal surface water body that has received runoff from an accidental release during drilling and completion operations or loss of containment, or from beneficial use applications.
4. Wildlife, including livestock, that have access to the water supply from a bore hydraulically downgradient of the well lease.

The potential for exposure of sensitive receptors (including MNES) is considered low. The drilling and completion activities and well abandonment occur over a short duration and are conducted in controlled/operational areas within a perimeter fence. Further, the activity level, noise, etc. will be a disincentive for wildlife and livestock to access the lease through gaps in the fencing or unsecured gates.

Based on the engineering and management controls described in the previous section (Human Health Hazards), there is a low potential for ecological receptors exposed to surface water bodies that may receive runoff from an accidental release. There is also concern that recovered material applied to the land surface could migrate to groundwater or surface water, and therefore result in adverse effects to the environment (e.g., uptake by aquatic receptors). Due to EA conditions regulating land application techniques, the remote nature of the well leases, vertical separation of groundwater and distances to watercourses, the ephemeral nature of the watercourses and the physical and chemical properties of trizinc bis(orthophosphate) post treatment or beneficial reuse, these potential exposures are low.

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[3] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants

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Attachment 1 Risk Assessment Dossier

TRIZINC BIS(ORTHOPHOSPHATE)

This dossier on trizinc bis(orthophosphate) presents the most critical studies pertinent to the risk assessment of trizinc bis(orthophosphate) in its use in coal seam gas extraction activities. This dossier does not represent an exhaustive or critical review of all available data. The majority of information presented in this dossier was obtained from the ECHA database that provides information on chemicals that have been registered under the EU REACH (ECHA). Where possible, study quality was evaluated using the Klimisch scoring system (Klimisch et al., 1997).

Screening Assessment Conclusion – trizinc bis(orthophosphate) was not identified in chemical databases used by NICNAS as an indicator that the chemical is of concern and is not a PBT substance. Trizinc bis(orthophosphate) was assessed as a tier 2 chemical for acute toxicity in fish and invertebrates, a tier 3 chemical for acute toxicity in algae and a tier 3 chemical for chronic toxicity. Aquatic toxicity data is reported for the soluble zinc (2^+) ion rather than the insoluble and less bioavailable/less toxic trizinc bis(orthophosphate). Therefore, this substance is classified overall as a **tier 2** chemical and requires a hazard assessment and qualitative assessment of risk.

1 BACKGROUND

Zinc is a natural element, which is essential for all living organisms. It occurs in the metallic state, or as zinc compound, such as trizinc ortho(bisphosphate).

Trizinc bis(orthophosphate) as an inorganic compound is not subject to biodegradation. It is sparingly soluble to insoluble in water. It is expected to partition to soil and sediment. Bioconcentration/bioaccumulation is not considered relevant for all inorganic zinc substances.

Zinc, as an essential element, plays an important role in many processes in the body. Trizinc bis(orthophosphate) has low acute toxicity by the oral and inhalation routes. It is not irritating to the eyes and skin. No skin sensitization is expected. In repeat dose toxicity studies, mild effects were observed. Trizinc bis(orthophosphate) has low repeated dose toxicity and low reproductive and developmental toxicity. It is not genotoxic nor is it carcinogenic.

The ecotoxicity of zinc and zinc compounds is due to the zinc (2^+) ion (ECHA). Zinc and zinc compounds may present a hazard for the environment depending on the release/bioavailability of zinc ions and on the conditions of the receiving environment (pH, hardness, dissolved organic carbon [DOC]). Zinc in acute aquatic toxicity studies is very toxic and in chronic aquatic toxicity studies is very toxic with long lasting effects. Zinc terrestrial toxicity is low. Trizinc bis(orthophosphate) would release less zinc ions than other metal salts thus lowering its potential bioavailability and toxicity. Therefore, it can be expected that the ecotoxicity of trizinc bis(orthophosphate) would be less than what has been reported for the zinc (2^+) ion.

2 CHEMICAL NAME AND IDENTIFICATION

Chemical Name (IUPAC): trizinc(2+) diphosphate

CAS RN: 7779-90-0

Molecular formula: $Zn_3(PO_4)_2$

Molecular weight: 386.1 g/mol

Synonyms: trizinc bis(orthophosphate); phosphoric acid, zinc salt (2:3); zinc phosphate; zinc orthophosphate

3 PHYSICO-CHEMICAL PROPERTIES

Key physical and chemical properties for the substance are shown in Table 1.

Table 1: Overview of the Physico-chemical Properties of trizinc bis(orthophosphate)

Property	Value	Klimisch score	Reference
Physical state at 20°C and 101.3 kPa	Solid	1	ECHA
Melting Point	846 °C @ 101.3 kPa	1	ECHA
Boiling Point	Substance is a solid which decomposes before boiling	-	ECHA
Density	3260 kg/m^3@ 20 °C	1	ECHA
Vapor Pressure	Negligible, substance is a solid	-	ECHA
Partition Coefficient (log K_{ow})	Not applicable, substance is inorganic	-	ECHA
Water Solubility	0.0027 g/L @ 20 °C	1	ECHA
Dissociation constant (pKa)	Not relevant for a metal salt	-	ECHA
Viscosity	Not applicable, substance is a solid	-	ECHA

Zinc is a natural element, which is essential for all living organisms. It occurs in the metallic state, or as zinc compound, such as trizinc ortho(bisphosphate), with one valency state (Zn^{++}) (ECHA). Chemical and biological processes will affect the speciation of zinc in the environment (OECD SIDS, 2005). Trizinc ortho(bisphosphate) is sparingly soluble to insoluble thus it does not significantly dissociate into zinc (2^+) and phosphate (PO_4^{3-}) ions.

4 DOMESTIC AND INTERNATIONAL REGULATORY INFORMATION

A review of international and national environmental regulatory information was undertaken (Table 2). This chemical is listed on the Australian Inventory of Chemical Substances – AICS (Inventory). No conditions for its use were identified. No specific environmental regulatory controls or concerns were identified within Australia and internationally for trizinc bis(orthophosphate).

NICNAS has assessed trizinc bis(orthophosphate) in an IMAP Tier 1 assessment and concluded that it poses no unreasonable risk to human health[1].

Table 2 Existing International Controls

Convention, Protocol or other international control	Listed Yes or No?
Montreal Protocol	No
Synthetic Greenhouse Gases (SGG)	No
Rotterdam Convention	No
Stockholm Convention	No
REACH (Substances of Very High Concern)	No
United States Endocrine Disrupter Screening Program	No
European Commission Endocrine Disruptors Strategy	No

5 ENVIRONMENTAL FATE SUMMARY

A. Summary

Trizinc bis(orthophosphate) as an inorganic compound is not subject to biodegradation. It is sparingly soluble to insoluble in water. It is expected to partition to soil and sediment. Bioconcentration/bioaccumulation is not considered relevant for all inorganic zinc substances.

B. Partitioning

Trizinc bis(orthophosphate) is sparingly soluble to insoluble in water. Based upon its negligible vapour pressure as an inorganic solid, it is not expected to volatilise from water or soil surfaces. Hydrolysis is not expected to be an important environmental fate process (ECHA).

C. Biodegradation

Biodegradation is not applicable to inorganic compounds.

D. Environmental Distribution

In an OECD Guideline 106 (Adsorption-Desorption Using a Batch Equilibrium Method) Study conducted on the radioactive isotope of zinc chloride, a soil-water partition coefficient (K_p) value of 1,737 L/kg (log K_p of 3.2) was determined based on the median value of 498 soil samples. Soil samples in the study consisted of arable land and grassland (ECHA) [Kl score = 1]. Based on this K_p value, if released to soil, trizinc bis(orthophosphate) has a low potential to leach to underlying groundwater. Likewise, combined with its insolubility, if released to water it is expected to strongly sorb to suspended solids and sediment in the water column.

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[1] https://services.industrialchemicals.gov.au/assessment-detail/?id=c4b6433e-f36b-1410-8de4-00e8f2afc108

E. Bioaccumulation

Zinc is an essential element which is actively regulated by organisms. Bioaccumulation is not considered relevant. As a rule, the ranges of bioconcentration factor values observed have no relation to toxicity. They are the result of these active regulation mechanisms that keep the internal zinc concentration of the organisms within an optimal range (ECHA).

6 HUMAN HEALTH HAZARD ASSESSMENT

A. Summary

Zinc, as an essential element, plays an important role in many processes in the body. Trizinc bis(orthophosphate) has low acute toxicity by the oral and inhalation routes. It is not irritating to the eyes and skin. No skin sensitisation is expected. In repeat dose toxicity studies, mild effects were observed. Trizinc bis(orthophosphate) has low repeated dose toxicity and low reproductive and developmental toxicity. It is not genotoxic nor is it carcinogenic.

B. Toxicokinetics

No data are available on the toxicokinetics of trizinc bis(orthophosphate). As a result, data on other zinc compounds have been used since it has been assumed by others that after intake the substance is changed (at least in part) to the ionic species and that it is this zinc cation that is the determining factor for the biological activities of the zinc compounds (OECD SIDS, 2005).

In humans, a wide range of absorption (8-80%) has been observed. This is likely due to differences in eating habits. Zinc absorption in the gastrointestinal tract occurs throughout the entire small intestine with the highest rate in the jejunum and the rate of total absorption appears to be concentration-dependent. The Zn^{2+} absorption process in the intestines includes both passive diffusion and a carrier-mediated process. The absorption can be influenced by several factors such as ligands in the diet and the zinc status. Some pulmonary absorption via inhalation has been suggested but quantitative data is lacking (ECHA).

Zinc is distributed to all tissues and tissue fluids and it is a cofactor in over 200 enzyme systems. Zinc is primarily excreted via feces, but can also be excreted via urine, saliva, hair loss, sweat and mothermilk (OECD SIDS, 2005).

C. Acute Toxicity

Oral

Trizinc bis(orthophosphate) was tested in an acute oral toxicity study in accordance with OECD Guideline 401. Wistar rats were orally administered 5000 mg/kg trizinc bis(orthophosphate). No mortality occurred and no signs of toxicity was observed. The LD_{50} is >5000 mg zinc phosphate/kg bw (ECHA) [KI score = 1].

Dermal

Acute dermal toxicity studies were not conducted because trizinc bis(orthophosphate) does not meet the criteria for classification as acute toxicity or STOT SE by the oral route. Also, no systemic effects were observed in *in vivo* studies with dermal exposure (e.g., skin irritation, skin sensitisation) (ECHA).

Inhalation

In an OECD Guideline 403 (acute inhalation toxicity) study, 10 male and 10 female animals per group were exposed to zinc oxide aerosol (head and nose only) for 4 h. Aerosol concentration was 5,700 mg/m^3 and the particle size distribution had a mass median aerodynamic diameter of 4mm ± 2.9 (GSD). Only one concentration and a control group were tested. All animals survived up to day 14 post exposure. Apart from a dusty fur on the head the day after the exposure, no effects were seen. Body weights developed normally. At pathological examination all organs were normal. The LC_{50} was >5,700 mg/m^3 (ECHA) [KI score = 2].

D. Irritation

Skin

An in vitro skin irritation test was conducted on trizinc bis(orthophosphate) in a reconstructed human epidermis model (OECD 439). The EpiDerm^{TM} Model is designed to predict and classify the irritation potential of chemicals by measuring its cytotoxic effect as reflected in the MTT assay. Disks of EpiDerm™ Model (three units) were treated with trizinc bis(orthophosphate) (neat) and incubated for 35 minutes 37°C, 5 % CO_2 >95 RH% humidified atmosphere and 25 minutes at room temperature. Exposure of the test item was terminated by rinsing with Dulbecco's Phosphate Buffered Saline (DPBS). Following exposure with trizinc bis(orthophosphate), the mean cell viability was 93.5% compared to the negative control. This is above the threshold of 50%, therefore the test item was considered as being non-irritant to skin (ECHA) [KI score = 1].

Eyes

In an acute eye irritation / corrosion test (OECD 405), 100 mg of trizinc bis(orthophosphate) was administered into the conjuctival sac of the left eye of three male New Zealand White rabbits. The right eye remained untreated and served as control. The eyes (unrinsed) were examined at 1, 24, 48 and 72 hours after administration. Very slight irritation of the conjuctivae (grade 1) was seen as redness (mean scores over 24-72 hours 0, 0.7 and 0.3) and chemosis (mean scores 0, 0.3 and 0.3), which persisted up to 48 hours at the latest. No conjunctival discharge and no iris and corneal lesions were observed. Zinc phosphate is not irritating to the eye. (ECHA) [KI score = 1].

E. Sensitisation

The potential for trizinc bis (orthophosphate) to cause skin sensitisation was assessed using the Local Lymph Node Assay (OECD 429). In this study the contact allergenic potential of trizinc bis (orthophosphate) (0.3, 3, or 30%) was evaluated after topical application to female BALB/c mice. Five mice per group were exposed on the dorsum of both ears once a day by test and control substances during 3 consecutive days. Primary proliferation of lymphocytes in the lymph node draining the site of application was evaluated on the base on using radioactive labelling. The ratio of the proliferation in treated groups to that in vehicular controls, termed the Stimulation index, was determined. Statistical evaluation of ear weight was performed for elimination of false positive findings with certain skin irritants. The animals exposed to the test substance at all concentrations showed no pathological skin reactions and no other negative clinical symptoms of intoxication throughout the experiment. There was no significant difference in body weight increment of all groups in comparison to the vehicle control. The test substance showed a tendency to increased ear weight in the highest of concentrations tested. The result of skin irritation effect was considered as positive- it means the test substance caused irritation of skin. This effect was dose dependent, with a significant ratio of 3.13 at 30%. Positive results in cell proliferation and no clinical symptoms of systemic toxicity revealed that the test substance trizinc bis (orthophosphate) could be a contact allergen in mice but potential irritation effect does not rule out the possibility that it could be false positive result (ECHA) [KI score = 1]. Further, no skin sensitisation was indicated in a more reliable OECD Guideline 406 guinea pig maximisation test conducted on zinc bis(dihydrogen phosphate) (ECHA) [KI score = 1]. Therefore, ECHA concluded that no skin sensitisation is expected (ECHA).

F. Repeated Dose Toxicity

Oral

Based on the results of the following three reliable studies conducted on zinc oxide nanoparticles (ZnO NPs), the no observed adverse effect level (NOAEL) for ZnO NPs of different particle sizes (100 and 20 nm) can be considered approximately 30 mg/kg bw/day which is equivalent to 25 mg Zn/kg bw/day. Although the NOAEL was determined only in one study with 100 nm particle size, all three studies show a very similar dose response relationship with similar target organs and the same lowest observed effects level (LOAEL) of 125 mg/kg bw/day. A description of each of these studies is provided below. No reliable studies conducted on non-nano ZnO or soluble zinc substances were available.

In a 90-day repeated dose toxicity study (OECD 408), ZnO NPs at doses of 31.25, 125 and 500 mg/kg bw/d were administered into the stomach by oral gavage in SD rats 7 days/week once daily for 90 days. No deaths were observed in the animals treated with ZnO NPs with either surface charge. The effects induced by ZnO NPs included treatment-related haematological changes indicative of anaemia. Changes in haematological and blood biochemical analysis were commonly observed in the 500 mg/kg groups of both sexes of negatively and positively charged ZnO NPs compared with in their respective control groups. Mean cell volume (MCV), mean cell haemoglobin (MCH), and mean cell haemoglobin concentration (MCHC) significantly decreased after administration of both test articles, including the 2-week recovery period. Total protein and Albumin levels also decreased. These significant decreases in haematological and blood biochemical parameters were considered to be related to the administration of negatively and positively charged ZnO NPs.

Histopathological findings included squamous cell hyperplasia and vacuolation in non-glandular stomach, intracytoplasmic hyaline droplet, submucosal oedema, inflammatory cell infiltration and mucous cell hyperplasia in the glandular stomach, chronic inflammation and acinar cell apoptosis in the pancreas, suppurative inflammation in the prostate gland, and retinal atrophy in the eye. Thus, the target organs for the test articles are considered to be the stomach, pancreas, eye, and prostate gland. Significant toxic effects were observed in both sexes at doses at and greater than 125 mg/kg bw/d. Therefore, the NOAEL of both ZnO NPs was considered to be 31.5 mg/kg bw/d for both sexes and 125 mg/kg bw/d represents the the LOAEL. (ECHA) [Kl. Score = 2]

In another 90-day repeated dose toxicity study (OECD 408), positively charged ZnO NPs at doses of 125, 250 and 500 mg/kg bw/d were repeatedly administered by gavage in SD rats for 90 days. There was no death related to administration of the test article during the experimental period of either sex. There were no significant toxicological changes in the study animals compared with control animals, of either sex, in terms of functional assessment tests, changes in body weight, food and water consumption, urinalysis, ophthalmological tests, necropsy findings, or organ weights. In terms of clinical signs, salivation was observed immediately after administration in both sexes. Haematological analysis revealed that the total erythrocyte and total leukocyte counts were significantly increased in males, and HGB, Hct, MCV, MCH, and MCHC levels were decreased significantly in both sexes in the 500 mg/kg bw/day group compared with controls. Retinal atrophy in the eyes was observed in males and females in the high-dose group of the main study and in recovery group animals. In all treatment groups, various kinds of gastric inflammatory and degenerative lesions with regeneration were observed. Acinar cell apoptosis and chronic inflammation of the pancreas were observed in all groups. The absorption and accumulation of Zn increased with dose increment in liver, kidney, intestine, plasma, and lung, while there was little or no increase in these in the brain, testis, ovary, spleen, and stomach. The ZnO NPs were also dose-dependently excreted into the faeces. According to the authors, the significant toxic changes were observed to be below 125 mg/kg bw/day, so the NOAEL was not determined, but the LOAEL was considered to be 125 mg/kg bw/day in both sexes. (ECHA) [Kl. Score = 2]

In a third 90-day repeated dose toxicity study (OECD 408), negatively charged ZnO NPs at doses of 125, 250 and 500 mg/kg bw/d were repeatedly administered by gavage in SD rats for 90 days. None of the animals died, but number of adverse symptoms were associated with the NPs, including salivation in all of the test animals. Haematological and blood biochemical analyses revealed small but significant decreases in the amount of HGB, MCV, MCH and MCHC in the male 250 and/or 500 mg/kg groups and in the female 500 mg/kg bw/day group. In addition, total erythrocytes in females in the 500 mg/kg bw/day group were significantly increased. Moreover, total serum protein and albumin levels were significantly decreased in the 250 and/or 500 mg/kg bw/day groups for both sexes. Apoptosis of pancreatic acinar cells, infiltration of periductular lymphoid cells, ductular epithelial hyperplasia and increased numbers of regenerated acinar cells were observed in high dose males and females. Retinal atrophy of the eye was observed in the 250 and 500 mg/kg male groups and the 500 mg/kg female group, and various histopathological lesions were also observed in the stomach of the ZnO NP-treated rats. In the recovery group, the pancreas and stomach lesions resolved, but the retinal atrophy did not. According to the authors, these results indicate that the target organs of the ZnO NPs are the pancreas, stomach, and eye. Toxicokinetic data showed similar dose- and time-dependent increases in the accumulation and absorption of Zn in the liver, kidney, large intestine, and small intestine of both male and female rats. According to the authors, a NOAEL of the ZnO NPs was not determined based on the results of this study, and the lowest dose level of 125 mg/kg in both sexes was considered to be a LOAEL. (ECHA) [Kl. Score = 2]

<u>Dermal</u>

In a dermal repeated dose toxicity study (OECD 411), ZnO NPs with a negative surface charge at doses of 250, 500 mg/kg, and 1000 mg/kg were repeatedly administered by dermal administration for 90 days in SD rats. The toxicity of these NPs in target organs was evaluated, but there was no study-related internal organ toxicity. No effects were observed in mortality, ophthalmology and urinalysis, and no test item-related effects were observed in body weights, food and water consumption, haematology, clinical biochemistry, gross pathology and histopathology. A temporary, dose-dependent inflammation of the skin was observed at the application site. Therefore, no adverse effects were observed with ZnO NPs (20 nm, negatively charged) up to 1000 mg/kg body weight in both sexes of rats and this dose level represents the NOAEL (ECHA) [KI score = 2].

Inhalation

A 90-Day Study (OECD test guideline (TG) 413) combined with the Reproduction/ Developmental Toxicity Screening Test (OECD TG 421) was conducted to compare the toxicity of for two nano zinc oxide materials, zinc sulfate monohydrate and non-nano zinc oxide. Groups of male and female Wistar rats were whole-body exposed to the aerosols of ZnO nano materials, zinc oxide T0420 and zinc oxide T0421, for 6 hours daily, at least 90 days. Zinc oxide T0420 was uncoated, Zinc oxide T0421 was coated. The target concentrations for zinc oxide T0420 and T0421 were 0.5, 2 and 10 mg/m^3 referring to the non-volatile fraction. Microscale zinc oxide T0242, 10 mg/m^3 was tested. Zinc sulfate monohydrate a target concentration of 22 mg/m^3 was tested because this is equimolar to zinc ion of the ZnO materials.

With regards to systemic toxicity, none of the test or reference substances caused any systemic toxicity that were not triggered by the local toxicity. Comparing the local effects of the two nano zinc oxide materials, the overall finding in the lungs, mediastinal lymph nodes, in the nasal cavity were comparable at the tested concentrations, as well as the changes of lavage parameters. The small differences are considered biological variations. There were no considerable differences between the effects caused by zinc oxide nanoparticles and those caused by micron-size zinc oxide particle. For zinc sulfate monohydrate, lower incidence and severity was found in the lungs than in the other zinc oxide treated groups, but higher incidence and severity in nasal cavity and larynx. This difference is considered being related to the different deposition pattern, caused by the different aerodynamic diameter. The aerodynamic diameter of zinc sulfate monohydrate was larger than the different types of zinc oxide. The mean MMAD of zinc sulfate monohydrate was with 2.3 µm considerably higher than those measured at the high concentrations of the test items 1 (1.19 µm) and 2 (0.97 µm). The deposited dose at the upper respiratory tract was higher, while those deposited in the lung was lower. After the recovery period, all parameters in lavage fluid returned to the control level in all animals, irrespective of the exposed test and reference substance. With regards of histological findings in the respiratory tract, all changes reduced greatly in incidence and severity. Only single animals showed still some mild effects. Based on a detailed analysis of local and systemic toxicity of the four substances evaluated, no difference in toxicity was concluded between the nano forms, non-nano forms and soluble zinc salt. As a result, the no observed adverse effect concentration (NOAEC) established for systemic toxicity for zinc oxide TO420, zinc oxide TO421 and microscale zinc oxide TO424 were each 10 mg/m^3, the highest dose tested. For zinc sulfate monohydrate, the NOAEC for systemic toxicity was 22 mg/m^3, the highest dose tested, which as noted above is equimolar to the zinc ion of the ZnO materials (ECHA) [Kl. Score = 1].

In a 90-day subchronic inhalation toxicity study conducted according to OECD Guideline 413, eight-week-old male Wistar (Crl:WI(WU)) rats (65/group) were acclimatised for one day followed by three weeks of training in nose-only tubes without exposure. The test animals were exposed to aerosol target concentration levels of 0.3, 1.5, and 4.5 mg/m^3 (analytical concentrations: 0.31, 1.48, and 4.45 mg/m^3) for 6 hours per day and 5 days per week over a period of 90 days (65 exposure days). A clean air control group was concurrently. The test animals were checked once or twice per day for clinical signs. The body weights and food consumption were measured weekly. One day after euthanasia, haematology and clinical biochemistry as well as urinalysis were performed. Gross pathology and comprehensive histopathological examinations were included. Additionally, bronchoalveolar lavage fluid (BALF) analyses were performed 1, 8, 29 days after the end of the exposure period. Moreover, the study included zinc level measurements in several organs, lung cell proliferation analysis, toxicokinetics, and TEM analysis in nasal cavities, lung, trachea, larynx, bronchioles, kidney, liver, spleen, and erythrocytes. Test substance related findings or losses of animals did not occur. Effects indicating systemic toxicity were not observed. Body weight development did not show any relevant statistically significant changes. Food consumption data show some statistically significant changes, however, these are considered as incidental. Haematology, clinical chemistry and urinalysis data did not show any relevant statistically significant changes as compared to concurrent controls. The organ weight changes observed for the left epididymides and left testes were considered to be not test substance related. Gross pathology revealed no relevant changes. The BALF analyses revealed a statistically significantly increased lactic dehydrogenase activity, when compared to the control group. Overall, no relevant amounts of increased test substance were detected in any body compartment demonstrating the rapid elimination. The TEM analysis did not detect distinct particles at any time point. Under the study condition, the NOAEC for the nano-scaled ZnO was assessed, and science-justified to be 1.5 mg/m³ (analytical concentration: 1.48 mg/m³) (ECHA) [Kl. Score = 1].

G. Genotoxicity

In Vitro

The *in vitro* genotoxicity studies on trizinc bis(orthophosphate) read-across substances are presented in Table 3.

Table 3: *In vitro* Genotoxicity Studies on trizinc bis(orthophosphate) read-across

Test System	Results*		Klimisch Score	Reference
	-S9	+S9		
Salmonella typhimurium TA100, 98, 1535, 1537 (OECD 471: Bacterial Reverse Mutation Assay)	-	-	1	ECHA
Salmonella typhimurium TA100, 98, 1535, 1537 (OECD 471: Bacterial Reverse Mutation Assay)	-	-	1	ECHA
Salmonella typhimurium TA100, 98, 1535, 1537 (non-GLP Bacterial Reverse Mutation Assay)	-	-	2	ECHA

*+, positive; -, negative

In Vivo

In an OECD Guideline 474 (Mammalian Erythrocye Micronucleus Test), read-across substance oxozinc (CAS RN 1314-13-2) was non-mutagenic in immature bone marrow erythrocytes (PCE) of Wistar rats under the conditions tested. There was no evidence of a significantly enhanced mean frequency of micronucleated erythrocytes due to microscaled zinc oxide exposure in males or females, as compared to the vehicle control groups (clean air) at any dose level (ECHA). [Kl. Score = 1]

In a second weight of evidence study two nanosized test substances Zinc oxide T0420 and Zinc oxide T0421 were assessed for their genotoxic potential using the alkaline comet assay after a 14-day exposure period via inhalation. This was a multisite study, where the in-life phase, necropsy, as well as the examination of the lung lavage fluid was performed. The target tissues addressed in this study were the nasal epithelium, the lung, the liver as well as the bone marrow. The three concentrations, selected based on the dose range finding study, were 0.5, 2.0 and 8.0 mg/m³. Wistar rats were exposed whole-body to the indicated concentrations of each test substance for a 6 h period per day for 14 days. In addition, for comparison, a micro-scaled Zinc oxide as well as well as a soluble Zinc salt (Zinc sulfate monohydrate) were tested in parallel under the same conditions at a single (equimolar). During the exposure period, the animals were observed for signs of toxicity before, during and after the exposure. Body weight was determined once weekly. The following mean concentrations and particle size distribution were determined. The assessment of the target tissues in the comet assay did not show any biologically relevant increases in the % tail intensity of the analyzed tissues under the indicated conditions. The positive control group showed a distinct and statistically significant increase in all analyzed tissues. Thus, under the indicated circumstances, the two test substances as well as the reference substances (micro-scaled Zinc oxide and Zinc sulfate monohydrate) are considered as non-genotoxic in this assay (ECHA) [KI score = 2].

H. Carcinogenicity

A study of one-year duration was conducted to evaluate the carcinogenic potential of zinc sulfate in mice. Chester Beatty stock mice (newly-born litters) were administered 22 g/L (5,000 ppm zinc) or 4.4 g/L (1,000 ppm zinc) zinc sulphate in drinking water along with a control group fed a basal diet and normal drinking water. The animals were examined thoroughly once a week throughout the experiment and daily when fed. Weighing was done once every 2 weeks. Deaths of animals occurred during the first 8 weeks of experiment due to an epizootic of ectromelia. The survivors were vaccinated with sheep lymph and animals showing a negative or accelerated response were sacrificed. New group of weanling mice (4 -5 wk old) were added to supplement the control group. All the surviving animals were sacrificed after 1 year of treatment and examined for gross pathology. Histopathological examination was done for suspected neoplastic lesions. Stomachs were examined for tumours and other changes in the forestomach and glandular epithelium. No differences in carcinogenic effects were observed between treatment and control groups under the test conditions. Under the test conditions, the test material was found to be non-carcinogenic in mice. The NOAEL was >22,000 mg/L drinking water (ECHA) [KI score =2].

I. Reproductive and Developmental Toxicity

An OECD Guideline 416 (Two-Generation Reproduction Toxicity Study) was conducted on male and female rats administered doses of 7.5, 15 and 30 mg/kg/d of zinc(2+) ion dichloride (CAS RN 7646-85-7). Exposure of F0 and F1 parental rats to test material showed significant reduction in fertility, viability (days 0 and 4), and the body weight of F1 and F2 pups from the high-dose group but caused no effects on litter size, weaning index, and sex ratio. Significant reduction in body weights of F0 and F1 parental males and postpartum dam weights female rats. Exposure of test material to F0 and F1 generation parental animals resulted in non-significant changes in clinical pathology parameters (except the ALK level). Reduction of brain, liver, kidney, spleen and seminal vesicles weights of males and in the spleen and uterus of females was observed in F0 and F1 rats. Gross lesions were observed in gastro-intestinal (GI) tract, lymphoreticular/ hematopoietic and reproductive tract in parental rats in both generations. Reduced body fat was also recorded in F1 parental rats. Under the test conditions, administration of test material to adult male and female rats throughout maturation, mating, gestation and early lactation resulted in significant effects on adults and offspring at 30 and 15 mg/kg/d. Although effects were seen at 7.5 mg/kg/d, these were considered by the study authors to be toxicologically not significant . Therefore, a NOAEL of 15 mg $ZnCl_2$/kg bw/day (equivalent to 7.2 mg Zn/kg bw/day) was established for fertility and developmental toxicity (ECHA). [KI. Score = 1]

A 90-Day reproduction and developmental toxicity study (OECD 421) was conducted in male and female Wistar rats with neurotoxicity and developmental neurotoxicity evaluation (OECD 426). This includes detailed clinical observations addressing potential neurobehavioral effects, histological and morphological evaluations of the brains of the pups on post-natal day 22. To compare the toxicity of uncoated and coated nano Zinc oxide, these two materials (Zinc oxide T0420 was uncoated, Zinc oxide T0421 was coated) were tested at 0.52, 2.0 or 9.97 mg/m^3. In addition, micronized Zinc oxide T0242 and a soluble salt zinc sulfate monohydrate was tested as reference items. Groups of male and female Wistar rats were whole-body exposed to the aerosols of ZnO nano materials, Zinc oxide T0420 and Zinc oxide T0421, for 6 hours daily, at least 90 days. Zinc oxide T0420 was uncoated, Zinc oxide T0421 was coated. With regards to systemic toxicity, none of the materials caused any systemic toxicity that were not triggered by the local toxicity. Comparing the local effects of the two nano Zinc oxide materials, the overall finding in the lungs, mediastinal lymph nodes, in the nasal cavity were comparable at the tested concentrations, as well as the changes of lavage parameters. The small differences are considered biological variations. There were no considerable differences between the effects caused by zinc oxide nanoparticles and those caused by micron-size zinc oxide particle. None of the substances cause any systemic toxicity, nor were there any developmental neurotoxicity in exposed pups. It was concluded that the NOAEC for local, systemic and developmental toxicity was 2.0, 9.97 and 9.97 mg/m^3, respectively (ECHA) [KI score = 1].

J. Derivation of Toxicological Reference and Drinking Water Guidance Values

Toxicological reference values were not derived for trizinc bis(orthophosphate).

The Australian drinking water guideline values for zinc of 3 mg/L, which is based on aesthetics, is considered applicable. ADWG has concluded that higher zinc concentrations can impart undesirable taste and a cloudy appearance (ADWG, 2011).

K. Human Health Hazard Assessment of Physico-Chemical Properties

Trizinc bis(orthophosphate) does not exhibit the following physico-chemical properties:

- Explosivity
- Flammability
- Oxidizing potential

7 ENVIRONMENTAL EFFECTS SUMMARY

A. Summary

Zinc is a natural element, which is essential for all living organisms. The ecotoxicity of zinc and zinc compounds is due to the zinc (2^+) ion (ECHA). Zinc and zinc compounds may present a hazard for the environment depending on the release/bioavailability of zinc ions and on the conditions of the receiving environment (pH, hardness, DOC). Zinc in acute aquatic toxicity studies is very toxic and in chronic aquatic toxicity studies is very toxic with long lasting effects. Zinc exhibits low toxicity in terrestrial organisms. Trizinc bis(orthophosphate) would release less zinc ions than other metal salts thus lowering its potential bioavailability and toxicity. Therefore, it can be expected that the ecotoxicity of trizinc bis(orthophosphate) would be less than what has been reported for the zinc (2^+).

B. Aquatic Toxicity

There are no toxicity data available for trizinc bis(orthophosphate). Data presented is primarily related to zinc chloride or zinc sulfate.

Acute Studies

Table 3 lists the results of acute aquatic toxicity studies conducted on members of the zinc family. Values shown were normalized using a pH of 6 to 8, DOC value of 2 mg/L and a hardness value of 40 mg/L (ECHA).

Table 3: Acute Aquatic Toxicity Studies on Zinc Salts

Test Species	Endpoint	Results (mg/L)	Klimisch score	Reference
Oncorhynchus mykiss	96-hr LC_{50}	0.957 (pH 6) 0.525 (pH 8)[1]	2	ECHA
Daphnia magna	48-hr EC_{50}	1.349 (pH 6) 0.706 (pH 8)[2]	1,2	ECHA
Pseudokirchneriella subcapitata	72-hr EC_{50}	0.308 (pH 6) 0.041 (pH 8)[3]	1,2	ECHA

1 - lowest geometric mean values as reported in ECHA. Values ranged from 0.102 mg/L – 24.3 mg/L in freshwater studies.
2 – lowest geometric mean values as reported in ECHA. Values ranged from 0.068 mg/L – 3.29 mg/L.
3 – lowest geometric mean values as reported in ECHA. Values ranged from 0.08 mg/L – 2.05 mg/L.

Trizinc bis (orthophosphate) has a lower solubility as the test substances summarized in Table 3. It is sparingly soluble to insoluble. As a result, trizinc bis(orthophosphate) would release less zinc ions than other metal salts thus lowering its potential bioavailability and toxicity. Therefore, it can be expected that the ecotoxicity of trizinc bis(orthophosphate) would be less than what has been reported for the test substances.

Chronic Studies

Chronic toxicity studies for zinc salts are available for fish, invertebrates and algae. The lowest geometric mean EC10 values determined for fish species *Oncorhynchus mykiss* were 0.765 mg Zn/L (pH 6) and 0. 157 mg Zn/L (pH 8) [Kl. Score = 2]. The lowest geometric mean EC10 values determined for invertebrate *Dapnia magna* were 0.252 mg Zn/L (pH 6) and 0.101 mg Zn/L (pH 8). [Kl. Score = 1]. Key geometric mean EC10 values for algae (*Pseudokircherniella subcapitata*) were 0.118 mg Zn/L (pH 6) and 0.011 mg Zn/L (pH 8) [Kl. Score = 1 or 2]. Similar to the acute studies, values were normalized in ECHA using a pH of 6 to 8, DOC value of 2 mg/L and a hardness value of 40 mg/L.

The ANZECC 2000/ANZG 2018[2] water quality guideline derived a very high reliability default guideline value (DGVs) for (dissolved) zinc in freshwater from 21 chronic (long-term) toxicity data, comprising 11 fish, one amphibian, four crustaceans, one insect, three molluscs and one annelid. A value of 8 µg/L was calculated for zinc using the statistical distribution method with 95% protection. In developing a freshwater guideline for zinc, ANZG considered only the chronic data that were

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[2] The ANZECC 2000 guidelines were revised in 2018. DGVs for zinc developed in ANZECC 2000 were adopted in the 2018 ANZG.

linked to pH and hardness measurements and then further screened for quality and other factors. The dataset was reduced to about 85 data points, which were adjusted for uniform lower hardness (30 mg/L as $CaCO_3$) and other end-points adjusted to NOECs using the method adapted from van de Plassche et al. (1993). The NOEC values reported in ANZG from 6 taxonomic groups were as follows (pH range 6.75 to 8.39):

Fish: 11 species, 24 μg/L (*O. tshawytscha*; from LC_{50}) to 1,316 μg/L (*Ptylocheilus oregonensis*; from LC_{50}); 7 species had geometric means <250 μg/L and a measured NOEC of 38 μg/L was reported for *P. promelas*.

Amphibians: 1 species, *Ambystoma opacum*, 180 μg/L (from LOEC)

Crustaceans: 3 species, 5.5 μg/L (*C. dubia*; from LC_{50}) to 25.3 μg/L (*C. dubia*, plus a figure of 18,480 for the crayfish *Orconectes virillis*)

Insect: 1 species, *Tanytarsus dissimilis*, 5 μg/L (NOEC)

Molluscs: 3 species, 54 μg/L (*Dreissena polymorpha*) to 11,200 μg/L (*Velesunio ambigua*), a NOEC of 487 μg/L was measured for *Physa gyrina*.

Annelid: 1 species, *Limnodrilus hoffmeisteri*, 560 μg/L (from LC_{50})

C. Sediment Toxicity

The available chronic freshwater sediment toxicity database reported in ECHA for zinc salts consists of eight different species (single-species exposures) and two long-term field colonization studies. Sediment-dwelling organisms representing different feeding habits and life strategies including the amphipods *Hyalella azteca* and *Gammarus pulex*, the oligochaetes *Tubifex tubifex* and *Lumbriculus variegatus*, and the insect *Chironomus dilutus, Epheron virgo* and *Hexagenia*. Chronic NOEC/EC10 values ranged between 218 mg/kg ww in crustaceans to 1,101 mg/kg ww in oligochaetes (ECHA). [Kl. Score = 1 or 2]

ANZG DGVs have also been developed for zinc in sediment. The DGV of 200 mg/kg was adapted from the effects range low (ERL) and effects range median (ERM) values of Long et al. (1995). The ERL is represented as the lower 10 percentile data of the effects range whereas the ERM is represented as the median value. The DGV represents the ERL while the upper guideline value (GV-high) represents the ERM. The GV-high value of 410 mg/kg provides an indication of potential toxicity-related adverse effects. Both of these guideline values are applicable to the <2 mm sediment fraction and are used in a weight of evidence approach.

D. Terrestrial Toxicity

Reliable chronic toxicity data are available for the long-term effect of soluble zinc salts on 35 terrestrial species or microbial endpoints covering the 3 trophic levels (12 terrestrial plants, 10 invertebrates and 13 microbial endpoints). Chronic EC10 and NOEC values ranged between 31.2 mg/kg dw and 8003.5 mg/kg dw (ECHA). [Kl. Score = 2]

ASC NEPM has derived ecological investigation level (EILs) for zinc[3]. The EIL is the sum of the added contaminant limit (ACL) and the ambient background concentration (ABC). Zinc ACLs range between 7 mg/kg and 2,000 mg/kg depending on the age of the release, land use (level of protection), soil pH and cation exchange capacity. The ACL values, which are considered high reliability soil quality guidelines (SQGs), were developed using the species sensitivity method and normalization relationships to account for soil characteristics.

E. Calculation of PNEC

PNEC water

The ANZG water quality guideline derived a very high reliability DGV for (dissolved) zinc in freshwater. The DGVs for 99, 95, 90 and 80% species protection are 2.4 µg/L, 8 µg/L, 15 µg/L and 31 µg/L, respectively. The 95% species protection level for zinc in freshwater (8 µg/L) is recommended for adoption in the assessment of slightly-to-moderately disturbed ecosystems (ANZG, 2018).

PNEC sediment

In ECHA, a $\text{PNEC}_{\text{sediment}}$ was derived for trizinc bis(orthophosphate) in freshwater using the species sensitivity distribution method and an assessment factor of 1. The $\text{PNEC}_{\text{sediment}}$ was determined to be 289.1 mg/kg sediment dry weight (dw). This PNEC is within the range of the DGV and GV-high established by ANZG.

PNEC soil

In ECHA, a $\text{PNEC}_{\text{soil}}$ was derived for trizinc bis(orthophosphate) using the species sensitivity distribution method and an assessment factor of 1. The $\text{PNEC}_{\text{soil}}$ was determined to be 163.6 mg/kg soil dw. This PNEC is within the range of NEPM SQGs.

8 CATEGORISATION AND OTHER CHARACTERISTICS OF CONCERN

A. PBT Categorisation

The methodology for the Persistent, Bioaccumulative and Toxic (PBT) substances assessment is based on the Australian and EU REAC Criteria methodology (IChEMS, 2022; ECHA, 2023). Note that PBT assessments are not relevant for metals (ECHA). Despite this, efforts were made to consider PBT for trizinc bis(orthophosphate).

Trizinc bis(orthophosphate) is an inorganic substance. Biodegradation is not applicable. For the purposes of this PBT assessment, the persistent criteria are not considered applicable.

Zinc is an essential element which is actively regulated by organisms. Bioaccumulation is not considered relevant. As a result, bioaccumulation criteria are not considered applicable.

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[3] Schedule B5c: Guideline on Ecological Investigation Levels for Arsenic, Chromium (III), Copper, DDT, Lead, Naphthalene, Nickel & Zinc (https://www.legislation.gov.au/F2008B00713/latest/text/21)

The lowest chronic toxicity data on zinc has NOECs <0.1 mg/L in algae. The lowest acute $E(L)C_{50}$ values are also <1 mg/L. Thus, trizinc bis(orthophosphate) does meet the screening criteria for toxicity.

The overall conclusion is that trizinc bis(orthophosphate) is not a PBT substance.

B. Other Characteristics of Concern

No other characteristics of concern were identified for trizinc bis(orthophosphate).

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9 SCREENING ASSESSMENT

Chemical Name	CAS No.	Overall PBT Assessment [1]	Chemical Databases of Concern Assessment Step		Persistence Assessment Step		Bioaccumulative Assessment Step	Toxicity Assessment Step			Risk Assessment Actions Required[3]
			Listed as a COC on relevant databases?	**Identified as Polymer of Low Concern**	**P criteria fulfilled?**	**Other P Concerns**	**B criteria fulfilled?**	**T criteria fulfilled?**	**Acute Toxicity [2]**	**Chronic Toxicity[2]**	
Trizinc bis(orthophosphate)	7779-90-0	Not a PBT	No	No	NA	No	NA	Yes	3	2 (fish & inv), 3 (algae)	2[a]

Footnotes:

1 - PBT Assessment based on PBT Framework.

2 - Acute and chronic aquatic toxicity evaluated consistent with assessment criteria (see Framework).

3 - Tier 2 - Hazard Assessment and Qualitative Assessment Only. Develop toxicological profile and PNECs for water and soil and provide qualitative discussion of risk.

a - Preponderance of data indicates appropriateness of Tier 2. See dossier for more information.

Notes:

NA = not applicable

PBT = Persistent, Bioaccumulative and Toxic

B = bioaccumulative

P = persistent

T = toxic

10 REFERENCES, ABBREVIATIONS AND ACRONYMS

A. References

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B. Abbreviations and Acronyms

°C	degrees Celsius
ABC	ambient background concentration
ACL	added contaminant limit
ADWG	Australian Drinking Water Guidelines
AICS	Australian Inventory of Chemical Substances
ANZECC	Australian and New Zealand Environment Conservation Council
ANZG	Australian and New Zealand Guidelines
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
COC	constituent of concern
DEWHA	Department of the Environment, Water, Heritage and the Arts
EC	effective concentration
ECHA	European Chemicals Agency
EIL	ecological investigation level
ERL	effects range low
ERM	effects range median
EU	European Union
g/L	grams per litre
IChEMS	Industrial Chemicals Environmental Management Standard
IUPAC	International Union of Pure and Applied Chemistry
kg	kilograms
Kl	Klimisch scoring system
kPa	kilopascal
L	litre
L/kg	litres per kilogram
LC	lethal concentration
LD	lethal dose
LOAEL	lowest observed adverse effect level
m^3	cubic metre
MCI	molecular connectivity index
mg/kg	milligrams per kilogram
mg/L	milligrammes per litre
mg/m^3	milligrams per cubic metre
mL	millilitre
mm	millimetre

mPa s	millipascal second
NICNAS	The National Industrial Chemicals Notification and Assessment Scheme
NOAEC	no observed adverse effect concentration
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
Pa	pascal
PBT	Persistent, Bioaccumulative and Toxic
ppm	parts per million
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SGG	Synthetic Greenhouse Gases
SQG	soil quality guideline

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EHS Support

Attn: Joe Hayes

Independent Peer Review of Chemical Risk Assessments – Tier 1 and Tier 2 Chemicals for Atlas Stage 3

Dr Jackie Wright, Director of Environmental Risk Sciences Pty Ltd (enRiskS) has been commissioned by EHS Support (EHS) to undertake an independent peer review of Tier 1 and Tier 2 Chemical Risk Assessments that have been completed by EHS Support.

Dr Jackie Wright has over 30 years' experience in human health and environmental risk assessment in Australia. Jackie holds a PhD in public health and is a Fellow of the Australasian College of Toxicology and Risk Assessment. A CV for Dr Jackie Wright is included in **Attachment A**.

A Chemical Risk Assessment Framework (CRAF) for the Atlas Stage 3 has been prepared for Senex Energy (Senex). The CRAF provides the framework for the chemical risk assessment process, specifically the classification of chemicals as Tier 1, Tier 2, Tier 3 and Tier 4, and the requirements that need to be addressed in the chemical risk assessments completed for each classification level. The CRAF includes checklists for use in the peer review of the chemical risk assessments.

This review relates to chemicals proposed for the Atlas Stage 3 works.

Two Tier 1 Chemical Risk Assessments were provided for review. Comments were provided as a result of the peer-review process, and the assessments updated. This review has been undertaken by Dr Jackie Wright.

Tier 1 assessments include chemicals that are not persistent or bioaccumulative and are of low toxicity where a hazard assessment and screening level assessment is required. A Tier 1 assessment requires the development of a toxicological profile, which is presented in a chemical dossier. The chemical dossier has been reviewed.

One Tier 2 Chemical Risk Assessment was provided for review. Comments were provided as a result of the peer-review process, and the assessments updated. This review has been undertaken by Dr Jackie Wright.

A Tier 2 assessment includes chemicals that are not persistent or bioaccumulative where a hazard assessment and qualitative assessment as well as a screening level assessment is required. A Tier 2 assessment also requires the development of a toxicological profile (chemical dossier which also includes human health aspects), drinking water guidelines and PNECs for soil, sediment and water.

The review process undertaken includes consideration of whether the correct level of assessment has been completed for the chemicals.

The chemicals assessed in this review are listed in **Table 1**.

Table 1: List of chemicals reviewed

Chemical name	CAS No.
Tier 1 chemicals	
Sodium sulfite	7757-83-7
Tetrakis(hydroxymethyl)phosphonium sulfate (THPS)	55566-30-8
Tier 2 chemical	
Trizinc bis(orthophosphate)	7779-90-0

The peer review process has been undertaken as follows:

- Undertake a detailed review of the Tier 1 and Tier 2 chemical dossiers, in line with the classification criteria and checklists provided in the CRAF. Review comments, along with any relevant notes, have been documented in the peer-review checklists. The review process has included checking that the classification of the Tier 1 and Tier 2 chemicals is appropriate, and if there is the basis for the classification to be revised. No chemicals required reclassification from Tier 1 to Tier 2 or from Tier 2 to a higher level.
- The Tier 1 and Tier 2 chemical risk assessments were revised by EHS Support to address the review comments provided.
- Revisions to the Tier 1 and Tier 2 chemical risk assessments were further reviewed to ensure that the revisions adequately addressed the comments provided.

Peer review checklists have been provided to EHS that detail the review process undertaken for each of these chemicals.

Based on the peer review completed for the Tier 1 and 2 chemical risk assessments reviewed (as listed in **Table 1**), the following is concluded:

- The chemicals assessed are correctly categorised as Tier 1 or Tier 2 chemicals.
- All chemical risk assessments have been prepared appropriately, in accordance with the requirements of the CRAF, and provide an evaluation of each chemical consistent with current scientific knowledge.
- Risks relevant to the use of Tier 1 and Tier 2 chemicals have been appropriately assessed.

Yours sincerely,

Dr Jackie Wright (Fellow ACTRA)
Principal/Director
Environmental Risk Sciences Pty Ltd

Attachment A: CV for Dr Jackie Wright

Dr Jackie Wright

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Director/Principal
Environmental Risk Sciences Pty Ltd
(+61 2) 9614 0297

Professional Profile

Jackie Wright has more than 30 years' experience in human health and ecological risk assessment in Australia. Experience includes leading and developing a national risk practice group for a major consultancy, training of staff, providing technical (and toxicological) direction, developing technical standards and guidance, developing appropriate risk models, providing peer-review and expert evidence.

Areas of expertise include human and eco-toxicological review and evaluation of chemicals in line with Australian regulatory requirements, human health and ecological risk assessment, health impact assessment, impact of exposure to air and noise pollution, exposure modelling, indoor air quality assessment, fate and transport assessment, air dispersion modelling, environmental chemistry, environmental monitoring, and the assessment of air emissions and air toxics. Human health assessments have included a large number and wide range of sites that involve the evaluation of emissions to air, waste sites, residential and recreation areas, operating industrial plants as well as other industrial plants that have been closed and are in the process of property sales or redevelopment and remediation. Ecological assessments have included screening level and detailed assessments of contamination, potential for contamination and remediation of contamination in soil and the aquatic environment. Risk assessments, ecological and human health, have been conducted for review by regulatory agencies (including Contaminated Land Auditors), with Jackie also providing expert support on both human health and ecological risk assessments (including detailed aquatic eco-toxicological assessments) for a number of Auditors in NSW, Victoria, South Australia, Western Australia and Queensland.

Jackie has been heavily involved in the development of national guidance and investigation levels as presented in the National Environment Protection Measure (NEPM) for Site Contamination (1999 amended 2013), CRC CARE Technical Guidance on Petroleum Vapour Intrusion and Silica-Gel Cleanup, Australian Crime Commission Assessment and Remediation of Clandestine Drug Laboratories (2011) and Australian Voluntary Code of Practice, Assessment, remediation and validation: Former clandestine drug laboratories and other methamphetamine contaminated properties.

In addition, she has extensive experience in the assessment of vapour migration and intrusion, detailed evaluation of exposure by occupational, residential and recreational groups including the application of probability distributions to human health risk assessments. Jackie has also been involved in a number of key projects that require regular risk communication with interest groups, including resident action groups.

- Toxicological (human and ecological) Review and Assessment
- Human Health Risk Assessment
- Environmental Risk Assessment
- Exposure Assessment and Modelling
- Occupational Exposure Assessment
- Clandestine Drug Laboratories and Public Health Issued from Drug Exposures
- Vapour Intrusion
- Indoor Air
- Health Impact Assessment
- Health impacts of air and noise pollution
- Environmental Chemistry, Fate and Transport
- Risk Communication
- Air Dispersion Modelling

Professional Accomplishments

Toxicology and Risk Assessment

- 2005 to 2025 (ongoing process of development and revision) - Prepared over 50 toxicity summaries for a range of chemicals relevant to the inclusion and assessment of these chemicals within human health and ecological risk assessments in accordance with Australian guidance. Toxicity summaries prepared provide detail on the chemical use, sources, exposures, chemical properties, ecotoxicity (terrestrial and aquatic), environmental fate and transport, health effects, review and identification of appropriate data relevant to acute and chronic exposures by the inhalation, oral and dermal routes, including assessment of carcinogenicity and genotoxicity. Range of compounds assessed includes particulate matter, petroleum compounds, chlorinated compounds, asbestos, metals and more obscure industry-specific compounds. More specific, detailed review of arsenic dose-response has been undertaken based on current studies.
- 2014/2015 – conducting detailed toxicological review of TCE, particularly in relation to the quantification of inhalation dose-response.
- 2009 to 2013 – provided detailed toxicological review, determination of appropriate dose-response values, and derivation of proposed 2013 NEPM Soil Health Investigation Levels (HILs), including the interim soil gas HILs, and input into the petroleum Health Screening Levels (HSLs). The review included significant update and revision to Schedules B4 and B7 and involved incorporation of all comments from regulators, industry and the public.
- 2009 and ongoing – Detailed review of the toxicity of a range of illicit drugs relevant to the assessment of environmental exposures or public health impacts of exposure to second or third-hand exposures
- 2010 – provided detailed review of toxicological interactions, biomonitoring data and human exposure to metals (and metal mixtures) for a site in Tasmania.
- 2006 to 2025 (and ongoing) - Presentation and collaboration with regulatory bodies in Australia (New South Wales Environmental Protection Authority [EPA], New South Wales Department of Health and Victorian EPA) with regards to the approach adopted and information presented with toxicity summaries (addressing human health and aquatic toxicity where required) for key, high profile assessments.

Exposure and Risk Assessment (Human Health and General Environmental)

- 1992 to 2025 (ongoing) - Project management and evaluation of human health and environmental risks associated with over 350 contaminated sites in all states of Australia utilising national guidance that include NEPM, enHealth, ANZECC and NH&MRC guidance. Sites include operational sites as well as other industrial areas proposed for redevelopment for industrial, recreational or residential use. Most of the sites assessed are associated with petroleum contamination, chlorinated hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) and metals. Other sites include those impacted with dioxins, phthalates, PCBs and PFOS/PFOA.
- 2011 to 2025 (ongoing) – Conduct of asbestos risk assessments, relevant to contaminated land and materials/recovered materials for reuse. These include assessments of risks to human health using a screening level assessment and detailed site-specific assessments (where required). Assessments have also included consideration of risk management measures relevant to preventing or minimising exposure to asbestos fibres.
- 1995 to 2025 (ongoing) - Detailed assessment and ongoing evaluation of risks to human health associated with contamination issues derived from the Orica Botany

site in Sydney. A number of assessments have been undertaken over a period of 17 years and has involved detailed review of risks to residents (including groundwater extraction and use), workers and recreational users of a large area affected by the discharge of contamination in shallow and deep groundwater to surface water within a drain and an estuary, historically deposited sediments and volatile chlorinated compounds in air. The assessment of risk has been tied closely with ongoing monitoring with detailed exposure reviews, including the collection of additional data and ongoing review of methods, being undertaken for many key aspects of the project. The process required evaluation within context of the NEPM (1999) and enHealth (2002) guidance with regular liaison with the NSW OEH, NSW Department of Health and independent reviewers.

- 2009 to 2015 - Derivation of national guidelines for the investigation and remediation of clandestine drug laboratories in Australia. The work involved the derivation of investigation levels, protective human health and the environment (terrestrial and aquatic), associated with former clandestine drug laboratories in Australia. Project required identification of key indicator compounds from over 200 base, intermediate and waste products that may be associated with over 20 different drug manufacturing methods. This required consideration of human health and environmental toxicity, behaviour/fate and transport in the environment and manufacturing methods. Guidelines were derived for indoor surface residues, indoor air, outdoor soil and the environment (local waterways and soil) for residential, commercial and recreational areas. The guidelines developed have been published by the Australian Government in April 2011. Further development of state guidelines, such as those from NSW Health have been undertaken to 2015.
- 2019 – Development of Australian Voluntary Code of Practice, Assessment, remediation and validation: Former clandestine drug laboratories and other methamphetamine contaminated properties, as published by Environmental Health Australia. The publication of these guidelines ahs included a range of workshops to share information and better understand issues and data gaps in the management of drug affected properties.
- 2017 to 2025 – Review of a range of issues relating to exposures to illicit drugs by the public and provision of expert advice to understand exposure, toxicity and potential for adverse effects.
- 2010 to 2024 – Detailed evaluation of community exposures and risks to PM_{10} and $PM_{2.5}$ derived from urban (combustion) sources as well as crustal (mining) sources. A number of urban projects have been completed, including major road infrastructure projects such as NorthConnex, WestConnex M4 East, WestConnex New M5, WestConnex M4-M5 Link, F6 Stage 1, Western Harbour Tunnel, Beaches Link and Great Western Highway in NSW and West Gate Tunnel and North East Link in Victoria and rail infrastructure projects including the Moorebank Intermodal Terminal and Botany Rail Duplication in NSW and the Suburban Rail Loop East in Victoria. These infrastructure projects have involved the development and researching of appropriate methodologies for the assessment of particulate exposures, with particular focus on community exposures and risks. The work has also considered detailed assessments related to other criteria pollutants that include ozone, nitrogen oxides, sulphur dioxide, particulate matter and other combustion products (such as polycyclic aromatic hydrocarbons and volatile organic compounds). Projects have involved detailed review of current literature in relation to the health effects and the identification and use of appropriate dose-response relationships relevant to the quantification of relevant health endpoints, with consultation conducted with stakeholders, including state health departments and the community. Works undertaken for the West Gate Tunnel, North East Link and Suburban Rail Loop East included the panel inquiry (presentation and

attendance at the inquiry).

- 2018-2019 – Detailed assessment of particulate risks associated with power station emissions, including detailed critical peer review of public commentary papers as well as published papers and the available research underlying current understanding of health impacts from changes to particulate matter in urban and rural air environments.
- 2010 to 2024 – Detailed assessment of health impacts associated noise, as generated from major road or rail infrastructure or from aircraft noise. These assessments require an understanding of various noise guidelines, as well as current literature on the health effects of noise on the community. Assessments have included qualitative, semi-quantitative as well as quantitative assessments of risk and population incidence utilising published exposure-response relationships.
- 2016 to 2018 – Detailed assessment of roadway and tunnel design features to ensure public health is protected. This has included assessment of exposures to nitrogen dioxide and the build-up of carbon dioxide (in-cabin) in long tunnels, design of long tunnels to ensure public safety from fatigue and monotony and design of roadways to ensure flicker effects do not adversely affect road users.
- 2015 to 2025 – conduct of detailed human health and ecological risk assessments for a range of sites (in particular airport and defence sites) where PFAS issues are of potential concern both on the site and in relation to offsite migration, discharge and exposure. Work has involved detailed evaluations and the development of site-specific guidelines and management measures within the context of a moving regulatory environment.
- 2020 to 2024 – Detailed assessment of risks to human health and the environment in relation to the proposed reuse of materials in road infrastructure (considered a wide range of materials proposed for reuse, in a variety of use scenarios).
- 2008 to 2014 - Detailed evaluation of human health and environmental issues associated with a former chlor-alkali plant. The assessment involved detailed evaluation of mercury fate and transport with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered environmental issues associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment, as well as issues associated with mercury (elemental and inorganic) in soil and groundwater with respect to fate and transport, human health and environmental issues.
- 2010 to 2015 (with ongoing advice to 2023) – Conduct of a detailed Health Impact Assessment in relation to major rail infrastructure development proposal at Moorebank. The HIA involved consultation with stakeholders, in particular local councils, NSW Health and the community, with all aspects of the proposal being address in relation to health impacts, both positive and negative. The HIA was peer reviewed by the University of NSW and an international expert. Ongoing advice relates to construction and operational management of PFAS.
- 2016 to 2018 – Literature review and assessment of community health impacts associated with landfill gas emissions, and emissions from water to energy facilities.
- 2018 to 2025 – Conduct of a number of detailed human health risk assessment or health impact assessments in relation to the proposed development of waste-to-energy facilities in NSW, Victoria and Queensland. A number of the projects have been approved.
- 2011 – Quantitative assessment of risks to human health associated with the placement of remediated soil that contains residual levels of radiological contamination, beneath a proposed commercial/industrial development in South Australia.
- 2011 to 2016 – Detailed evaluation and development of chemical risk assessments

for a range of products/compounds utilised during coal seam gas operations in NSW and Queensland.

- 2017 to 2018 – Panel member on the WA Government Technical Enquiry on hydraulic fracturing.
- 2010 – Detailed assessment of risks (including detailed assessment of toxicity of individual compounds and mixtures) to human health associated with the presence of nitrate, nitrite and perchlorate contamination in drinking water (international project).
- 2009 to 2025 (and ongoing) – Expert support for contaminated land Auditors located in New South Wales, Victoria, Queensland, South Australia and Western Australia. Expert support has included review of human health and ecological risk assessments for a range of projects and issues.
- 2000 to 2024 - Detailed evaluation of risks to human health and the environment associated with redevelopment of large a number of gasworks sites in New South Wales and Victoria. Projects have involved the evaluation of the vapour migration pathway, including the collection of relevant soil gas and vapour emissions data to quantify exposure consistent with the proposed developments. The process required liaison with relevant site auditors, Vic EPA, SA EPA, NSW EPA and NSW Department of Health as required.
- 1995 to 2024 - Detailed evaluation, modelling and risk assessment of a number of landfill and waste depots in Australia (in New South Wales, Australian Capital Territory, Queensland and Victoria). This includes proposed waste destruction technologies, proposed waste depots and landfills, operational landfills, composting operations and closed landfills with assessments considering workers, residents and recreational users of the site and surrounding areas. Assessments undertaken have considered issues associated with the presence of a wide range of chemicals, landfill gas emissions, leachate generation and leaks, stormwater management, bioaerosols and other pathogens and bacteria.
- 1995 to 2025 (ongoing process as vapour issues are relevant for many projects) - Evaluation of vapour migration (and vapour intrusion) from numerous sources including contaminated soils and groundwater (dissolved phase and free phase) for many different chemicals, and subsequent assessment of human health risks associated with the estimated vapour concentrations. In addition, Jackie has developed and managed various techniques for the direct measurement of vapour migration in residential, recreational and industrial settings as part of the risk assessment process.
- 2009 to 2024 - Detailed evaluation of public health issues associated with recreational exposures to arsenic, lead and/or PAHs in surface soil in primary/secondary schools, sporting areas and children’s playgrounds. Provision of technical advice along with appropriate general advice relevant for presentation to the public and responses to questions from the general public.
- 1995 to 2021 - Evaluation of human health risks associated with potential exposure to emissions from coal mining activities, including the assessment of potential risks and health effects associated with exposure to fine particulates.
- 1998 to 2009 - Evaluation of human health risks associated with the existence of, and potential remediation of encapsulated scheduled waste materials located near residential and recreational areas. The assessment has involved ongoing monitoring, review of toxicity and exposures on an ongoing basis, review of remediation options and risks derived from the application of preferred remediation options. The encapsulation has now been remediated.
- 2007 to 2013 – Assessment of risks to human health and the environment associated with the re-use of water (including irrigation uses) from a groundwater treatment plant located in Sydney.
- 2000 to 2005 - Evaluation of human health risks associated with a number of

contaminated sites located in Abu Dhabi, Spain and Azerbaijan. These risk assessments involved assessment of human health risks using USEPA guidance as well as WHO guidance.

- 2005 to 2024 - Project management of large human health risk assessment associated with the redevelopment of explosives and munitions factories and firing ranges within various areas of NSW and Victoria.
- 1995 to 1998 - Evaluation of human health risks associated with off-site accumulation of lead from historical deposition associated with a former operating lead paint site located within a residential area in Sydney. Project involved the review of lead exposure and toxicity, identification and agreement to lead action levels relevant for residential properties located close to and further away from the former source.
- 1995 - Evaluation and coordination of a multi-pathway health risk analysis for a large contaminated site in Sydney involving the use of probabilistic risk assessment methodology.
- 2000 to 2005 - Conducting a feasibility assessment for a waste destruction facility in Sydney, using a probabilistic risk assessment methodology. Conduct of a detailed health risk assessment associated with the operation of the selected technology, including presentation to the Commission of Enquiry. Subsequent review of the process and exposures in relation to placing the facility within a rural area (as opposed to an urban area) and consideration of other multi-pathway exposures.
- 1993 - Assessment of risks to human health and the environment associated with sewage sludge incinerators at North Head and Malabar Sewage Treatment Plants.
- 1992 to 2025 (and ongoing) - Determination of preliminary remediation goals for numerous contaminated sites based on risk criteria.
- 1995 to 2025 (and ongoing) - Development of air sampling procedures and techniques to collect air data relevant to the further assessment of vapour migration pathways in a range of areas. This includes the collection of ambient air, soil gas data (active and passive and sub slab) and flux emissions.

Ecological Risk Assessment

- 1998 to 2025 (ongoing) - Derivation of risk-based criteria for a range of projects that are based on the protection of the aquatic environment. Evaluations have considered the potential for physical parameters (turbidity, pH, dissolved oxygen) and contaminants (principally metals, polycyclic aromatic hydrocarbons [PAHs], PFAS, petroleum compounds and chlorinated compounds). The evaluations include the potential for contaminants to leach from soil, migrate to groundwater and potentially discharge to a receiving environment (considered both marine and freshwater [including ephemeral] systems). Some of the assessments have required review and consideration of fate and transport modelling.
- 2009 to 2025 (ongoing) – Identification and derivation of investigation levels protective the terrestrial and aquatic environments associated with former clandestine drug laboratories in Australia. Ecological Tier 1 levels (based on available ecotoxicological data primarily from overseas studies) were identified and proposed for use in remediation guidelines with additional guidance provided in relation to sites where more detailed assessments of environmental risk issues needs to be conducted.
- 2010, 2011 and 2012 – Conduct (co-presenter) of lectures at the University of Sydney for the Risk Assessment (Human Health and Ecological) module for undergraduates, School of Geosciences. Ecological risk assessment lectures addressed basic principles and frameworks, stressors, fate and transport, bioaccumulation, uptake, derivation of ANZECC Guidelines, reviewing available ecotoxicological studies and conduct of statistical analysis using the CSIRO

Burrlioz software for establishing water guidelines.

- 2010 to 2011 – Expert witness in relation to ecotoxicological impacts of initial works proposed for the Barangaroo site in NSW.
- 2010 - Assessment and derivation of water criteria for petroleum hydrocarbons relevant to the protection of the terrestrial and aquatic environments from the reuse of urban run-off for irrigation or a public park and associated runoff into a lake. Assessment required a detailed assessment of not only phytotoxicity, but levels at which grass growth would be affected to the extent by which grass cover on an important AFL playing field would be affected.
- 2009 to 2011 – Detailed review of screening level risk ecological assessment (supporting studies and outcomes) for the discharge of contaminated groundwater into a sensitive marine environment in South Australia. Review required detailed consideration of the local environment, consideration that appropriate ecological indicator species have been selected, consideration of the range of urbanisation stressors within the environmental and potential for groundwater discharges to result in adverse effects to the aquatic environment, over and above those from urbanisation.
- 2008 to 2010 - Detailed evaluation of environmental fate and transport issues associated with a former chlor-alkali plant. The assessment involved detailed evaluation of mercury fate and transport with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered ecotoxicological risks associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment.
- 1992 to 2025 (and ongoing) - Determination of preliminary remediation goals for numerous contaminated sites based on risk criteria. In relation to environmental risk issues, this has included the identification of appropriate and screening level criteria that are protective of fresh and marine environments and phytotoxic effects. Where necessary more detailed evaluations of ecotoxicological effects have been considered. This has included the design of suitable surveys and sampling programs (including microtox, microalgae, fish, crustacean, amphipod (sediments), plant and earthworm), interpretation of information and data from these studies, discussion of results with relevant regulatory parties, uncertainty analysis and reporting. These studies have been conducted for the assessment of petroleum hydrocarbon, cyanide, inorganics, ammonia, chloride, phosphorous and nitrate concentrations in soil and discharges from groundwater.
- 2000 to 2008 - Detailed evaluation of risks to human health and the environment (particularly aquatic species and sediments) associated with redevelopment of large a number of gasworks sites in New South Wales and Victoria. The project in NSW involved collaboration with sediment experts to determine the nature and extent of sediment contamination, potential for adverse ecotoxicological effects and requirements for remediation. The process required liaison with relevant site auditors and the DECCW (formerly NSW EPA) as required.
- 2007 - Assessment of risks to terrestrial and aquatic (marine water) environments associated with the re-use of water from a groundwater treatment plant located in Sydney. Water is proposed to be reused for a range of proposes that include industrial water (where it may be directly discarded to the marine environment) and irrigation where the water may affect terrestrial species and runoff may enter local water ways. The assessment considered available ecotoxicological data and guidelines available from Australian and International studies (where relevant to Australian species).

Contaminant Transport

- All of the projects listed above have involved the assessment of contaminant transport in at least one media. More specific examples are listed below:
- Vapour partitioning and transport assessed for petroleum compounds, including the development of a national database of petroleum vapour data, related to over 300 petroleum impacted sites, and detailed review of the database in conjunction with technical specialists from the USEPA. The database developed has been peer-reviewed by the USEPA and has been incorporated into the USEPA technical review of data from both the US and Australia for the purpose of determining screening distances.
- Vapour partitioning and transport assessed for chlorinated compounds at numerous contaminated sites, including the assessment of vapour risk issues at the Orica Botany site from 1994 to 2024.
- Review and use of groundwater fate and transport modelling conducted in support of numerous detailed risk assessment outcomes. Reviews have been conducted for the purpose of ensuring these models adequately address the potential movement of contaminants from a source to a point of discharge, utilising appropriate inputs and site data.
- 2008 to 2014 - Detailed evaluation of mercury fate and transport in groundwater and air (mercury vapour) with use of specialised data collected and analysed by CSIRO and liaison with experts on mercury issues from the CSIRO. Assessment considered environmental issues associated with the presence of mercury in groundwater and discharge to an urban (highly modified) environment, as well as issues associated with mercury (elemental and inorganic) in soil and groundwater with respect to fate and transport, human health and environmental issues.

Air Emissions and Vapour Assessment

- Jackie Wright is experienced in all aspects of determining air quality, including monitoring, assessing and modelling soil gas, vapour emissions and emissions from stacks and other fugitive sources. Projects include analysing dust emissions from a number of quarries and coal mines, motor vehicle emissions; modelling vapour emissions from motor vehicles and sources such as creeks, ponds and waste areas; and assessing odour emissions from sewage treatment plants, landfills and other agricultural/industrial facilities.
- 2020 to 2025 – Assessment of inhalation exposures to drug residues derived from contaminated materials and within properties, prior to and post remediation.
- 2012 to 2013 – Development of petroleum vapour intrusion guidance for Australia in conjunction with CRC CARE. The project has involved the development of clear, prescriptive guidance that incorporates current science on the assessment of petroleum vapour intrusion. The guidelines being developed have been presented at a series of PVI training workshops (supported by ALGA and CRC CARE) run in Sydney, Melbourne and Perth.
- 2009 to 2022 - Development of a petroleum vapour database to assist in the interpretation and understanding of the behaviour of petroleum vapours in the subsurface environment. The database is unfunded and independent and has been interpreted by Jackie as well as industry experts in Australia and the US. The database has been peer-reviewed by the USEPA, and incorporated into the USEPA publication on the use of field data (from the US, Canada and Australia) to support and develop vertical exclusion/separation distances (refer to the following website for the USEPA review and access to the database developed: http://www.epa.gov/oust/cat/pvi/). This data has been used to support the development of screening distances that are being incorporated into guidance being developed in Australia and the US.

- 2005 to 2025 (ongoing) - Preparation of conceptual site models and completing screening level modelling (using published models such as Johnson & Ettinger) for the assessment of vapour migration and intrusion issues on a wide range of sites (over 200) affected by petroleum and chlorinated hydrocarbons.
- 2010 to 2025 – Detailed evaluation of community exposures and risks to PM_{10} and $PM_{2.5}$ derived from urban (combustion – associated with road and rail infrastructure) sources as well as crustal (mining) sources. A number of urban projects have also considered community exposures and risks to other criteria pollutants that include ozone, nitrogen oxides and sulphur dioxide. Projects have involved detailed review of current literature in relation to the health effects and appropriate dose-response relationships relevant to the quantification of relevant health endpoints, with consultation conducted with stakeholders, including state health departments.
- 1995 to 2025 (ongoing) - Development of methods and approaches for the sampling and assessment of vapour (e.g. soil gas, flux emissions, indoor and ambient air). Works conducted has involved the conduct of field activities for the purpose of collecting this data.
- 1995 to 2025 (ongoing) - Interpretation and assessment of vapour data for the purpose of characterising inhalation exposures in a range of scenarios. These include existing buildings and proposed developments.

Risk Communication

- 2000 to 2025 (ongoing) - Jackie Wright has experience in the preparation and presentation (communication) of risk outcomes from a number of key projects across Australia to a range of community groups. These groups include workers and unions, residents and community action groups. Successful communication with stakeholders and the community on controversial projects including infrastructure, coal seam gas and other mining projects has been required.

Air Quality Assessment

- 1990 to 1995 – Air dispersion modelling and air quality impact assessment conducted for various mining (coal mining and quarry activities) and transport (major roadways) in NSW and Victoria. Projects included the development of emissions inventories, setting up and running air dispersion models and reporting.
- 2011 to 2015 - Air dispersion modelling conducted for the assessment of exposures (and risks to human health) to crop, grain and timber fumigants. The assessment have been undertaken based on trial data, with scaling to address commercial application.
- 2010 to 2018 - Air dispersion modelling conducted for the assessment of exposures (and risks to human health) to grain fumigants, timber fumigants, hydrogen sulphide, chlorinated compounds, silica and dust (particulate) emissions from a range of facilities. Modelling has been conducted using Screening level and mode detailed Ausplume and Calpuff dispersion modelling packages.
- 2010 to 2025 - Review of air dispersion modelling undertaken for a range of projects. The reviews have been undertaken to determine if the assessments are adequate for the purpose of understanding and characterising community health impacts. In some cases, the review has been undertaken as part of a larger assessment of public health impacts. Projects have included communication of the air quality assessment and health impact assessment to community groups.

Noise Impact assessment

- 2019 to 2022 - Systematic review of health impacts of transport noise for Waka Kotahi NZ Transport Agency in New Zealand. The work has involved a detailed systematic review of the evidence in published and grey literature in relation to the health effects of transport noise (road, rail and air) and whether the evidence is sufficient to support quantification of health impacts using exposure-response functions. The review has considered recent literature and the GRADE system of review to establish the robustness of the available publications and strength of evidence. This review considered the most recent reviews completed by the WHO and enHealth in 2018.
- 2014 to 2021 - Detailed Evaluation of Community Exposure and Risk to impacts associated with transport infrastructure projects for Transport for NSW and Transurban/Western Distributor Authority/ North East Link Authority in Victoria, Australia. Health impact assessments have included a detailed assessment of impacts from noise during construction and operation. This included a detailed review of current science in relation to health impacts of construction noise, as well as road transport noise sources. In some assessments quantitative risk assessment was required to be undertaken to address impacts on community health. Projects have included: NorthConnex (road - NSW); WestConnex projects - M4 East, New M5, M4-M5 Link (road - NSW); F6 Stage 1 (road - NSW); Gateway project (road and rail – NSW); Western Harbour Tunnel and Beaches Link (road - NSW); West Gate Tunnel (road -Victoria); North East Link (road – Victoria).
- 2016 to 2017 - Brisbane Airport Corporation, Queensland, Australia. Conduct of a review of the health impacts of aircraft noise as these relate to the identification and use of exposure response relationships for assessing health impacts, particularly related to flight paths near major airports.

Expert Witness

- Expert witness at Inquiry and Advisory Committee (IAC) hearings for mining projects in Victoria, specifically:
    - Avonbank Mineral Sands Project (2023), expert in relation to wellbeing
    - Goschen Rare Earths and Mineral Sands Project (2024), expert in relation to human health and wellbeing
    - Fosterville Sustained Operations Project (2024), expert in relation to human health and wellbeing.
- Long Term Containment Facility at Nowingi, case presented in VCAT. The proponent was Major Projects Victoria, approvals application WA58772.
- Lend Lease (Millers Point) Pty Ltd and Orsats Australians for Sustainable Development Inc., Land and Environment Court Proceedings, 40965 of 2010 (NSW).
- Seppanen&Seppanen v Ipswich City Council, Minister for Economic Development Queensland and Queensland Urban Utilities (2016).
- Westgate Tunnel Project, Expert Witness, Inquiry and Advisory Committee (IAC) hearings (Victoria, August-September 2017).
- Child care centre project, Provision of advice as expert witness for ACT Government Solicitor (2017).
- Caltex Petroleum Pty Ltd v Campbelltown City Council Environment, Resources and Development Court Proceedings No 258 of 2015 (2017 to 2019) (SA).
- North East Link Expert Witness, Inquiry and Advisory Committee (IAC) hearings, Expert Witness (Victoria, 2019).
- Clermont Quarries Pty Ltd v Isaac Regional Council, ECL Dalby Pty Ltd, Chief Executive, Department of State Development, Manufacturing, Infrastructure and Planning and Environment Court (Qld), Expert witness (2019 - 2020).

Teaching

- 2009, 2010, 2012, 2013 to 2024 – Conduct of lectures at the University of Technology Sydney as part of the Contaminated Site Assessment and Management (CSARM) Professional Development Short Course, Risk Based Site Assessment.
- 2023 and 2024 – Human Health Risk Assessment module for ENV3016, Pollution in Practice. Fenner Lecture – Australian National University
- 2020 and 2022 – Toxicological Risk Assessment lecture to UNSW School of Business.
- 2017 – ALGA Risk Assessment Training Course: New Zealand
- 2010 to 2012 – Conduct of lectures at the University of Sydney for the Risk Assessment (Human Health and Ecological) module for undergraduates, School of Geosciences.
- 2014 – ACLCA (Qld) Training Course on Vapour Intrusion and Landfill Gas Assessment (organising and teaching) – May 2014.
- 2014 and 2015 – ACLCA (SA and VIC) Training Course on Vapour Intrusion (teaching) – June 2014.
- 2013 and 2015 – ALGA Training Course on Vapour Intrusion (teaching).
- 2013 and 2015 – Vapour Intrusion Short Course. Training Course conducted at CleanUp 2013 and 2015, CRC CARE (teaching).
- 2016 – Clandestine laboratories – risk assessment (teaching) ALGA and ACTRA (separate workshops).
- 2014-2018 – Short courses/branch forums for ALGA – various issues regarding PFAS assessment, vapour intrusion, bioaccessibility methods, clandestine laboratories.
- 2016 and 2018 – Short course for WasteMINZ – bioaccessibility methods.

- 2010-2011 – Basic and Advanced Risk Assessment Course for Queensland Branch of the Australian Contaminated Land Consultants Association.

Work History

Principal/Director/ Owner	Environmental Risk Sciences Pty Ltd	2008 (current)
Adjunct Lecturer	Flinders University	2016 (current)
Principal Environmental Scientist	URS Australia, North Sydney, NSW (formerly Woodward-Clyde)	1992 to 2008
Project Engineer	Sydney Water, Sydney, NSW	1991-1992
Environmental Scientist	Nigel Holmes & Associates, Sydney NSW	1990-1992
Assistant	Dames & Moore, Crows Nest, NSW	1988-1990

Education

BE (Hons)	University of Sydney, Bachelor of Engineering (Hons)	1989
PhD	Public Health, Health and Environment, Flinders University	2016

Professional Accreditation

Fellow of the Australasian College of Toxicology and Risk Assessment (ACTRA)

Professional Development

American College of Toxicology - Virtual Advanced Comprehensive Toxicology Online training course (25 modules) (2021)

Invited member of task force - WA EPA scientific inquiry into fracking in WA (2018)

Clandestine laboratory safety and investigator training and synthesis run by the Clandestine Laboratory Investigators Association (8-hour course, 2011)

Ecological Risk Assessment Course run through AEHS and credited by University of Massachusetts Boston (2010)

Mid-America Toxicology Course (35 hours, 2010)

Dose-Response Boot Camp run by Toxicology Excellence for Risk Assessment (TERA) (5 day course, 35 hours, 2008)

Vapor Intrusion Assessment and Mitigation Short Course run by Air & Waste Management Association (4 hours, 2006)

USEPA Human Health Risk Assessment Short Course (24 hours, 1995)

Affiliations

Member and Fellow (former committee member, remains co-opted committee member), Australasian College of Toxicology and Risk Assessment (since 2007).

Member, Australian Land and Groundwater Association (ALGA) (since 2010, now Life Member).

Clean Air Society of Australia and New Zealand (re-joined 2015)

Member, Environmental Health Australia (since 2011).

Member, SETAC (Asia Pacific) (since 2011).

Member, Air & Waste Management Association (since 2006).

Member, Association for Environmental Health and Sciences Foundation (since 1997).

Awards

2024: Honorary Life Member ALGA

2020: Winner of Best Case Study (principal author), Australia New Zealand Policing Advisory Agency and National Institute of Forensic Science

2017: Winner of Best Case Study (principal author), Australia New Zealand Policing Advisory Agency and National Institute of Forensic Science

2017: Winner of ALGA Outstanding Leadership by a Woman in the Contaminated Land & Groundwater Industry

2017: Finalist of ALGA Outstanding Individual in the Contaminated Land & Groundwater Industry

Publications

Peer-reviewed journal articles:

Kerry, G.L., Ross, K.E., Walker, G.S. and Wright, J., 2025. Determining extent and distribution of methamhetamine in cars: Air vs. surface vs. fabrics. Forensic Chemistry 42 (2025) 100628.

Burgoon, L. D. et al 2023, Range of the perfluorooctanoate (PFOA) safe dose for human health: An international collaboration, Regulatory Toxicology and Pharmacology, online 29 October 2023.

Kuhn, E.J., Ross, K.E , Walker, G.S., Whiley, H. and Wright, J., 2023. Thirdhand Exposure to Methamphetamine Syndrome: Symptoms Resulting from Environmental Exposure to Methamphetamine Contamination Arising from Manufacture or Use. Journal of Environmental Health, Volume 86, No. 3, October 2023.

Kuhn, E.J., Walker, G.S., Whiley, H. Wright, J. and Ross, K.E., 2023. Evaluation of commercially available methamphetamine presumptive tests for site contamination. Toxicology Communications, Volume 7, No. 1.

Kerry, G.L., Ross, K.E., Wright, J.L. and Walker, G.S., 2022. A Review of Methods UUsed to Detect Methamphetamine from Indoor Air and Textiles in Confined Spaces. Toxics, 10, 710.

Kuhn, E.J., Walker, G.S., Whiley, H. Wright, J. and Ross, K.E., 2021. Overview of Current Practices in the Methamphetamine Testing and Decontamination Industry: An Australian Case Study. International Journal of Environmental Research and Public Health 18, 8917.

Wright, J., B. Symons, J. Angell, K. E. Ross and S. Walker, 2021. Current practices underestimate environmental exposures to methamphetamine: inhalation exposures are important. Journal of Exposure Science & Environmental Epidemiology 31: 45-54.

Kuhn, E.J., Walker, G.S., Wright, J., Whiley, H. and Ross, K.E., 2021. Public health challenges facing Environmental Health Officers during COVID-19: methamphetamine contamination of properties. Australian and New Zealand Journal of Public Health, 45: 9-12.

Wright, J., M. Kenneally, K. Ross and S. Walker, 2020. Environmental Methamphetamine Exposures and Health Effects in 25 Case Studies. Toxics 8 (3): 61.

Wright, J., G. S. Walker and K. E. Ross, 2019. Contamination of Homes with Methamphetamine: Is Wipe Sampling Adequate to Determine Risk? International Journal of Environmental Research and Public Health 16 (19): 3568.

Kuhn, E. J., G. S. Walker, H. Whiley, J. Wright and K. E. Ross, 2019. Household Contamination with Methamphetamine: Knowledge and Uncertainties. International Journal of Environmental Research and Public Health 16(23): 4676.

Capon, A. and J. Wright, 2019. An Australian incremental guideline for particulate matter ($PM_{2.5}$) to assist in development and planning decisions. Public Health Research & Practice 29 (4).

Wright, J., Kenneally, M. E., Edwards, J.W. and Walker, S., 2017. Adverse Health Effects Associated with Living in a Former Methamphetamine Drug Laboratory — Victoria, Australia, 2015. Morbidity and Mortality Weekly Report (MMWR) January 6, Vol.65, No. 52, p1470-1473

Wright, J., Edwards, J. and Walker, S., 2016. Exposures associated with clandestine methamphetamine drug laboratories in Australia. Reviews on Environmental Health, 31(3): 329-352.

Lahvis, M.A., Hers I., Davis, R.V., Wright, J. and DeVaull G.E., 2013. Vapor Intrusion Screening at Petroleum UST Sites. Groundwater Monitoring & Remediation.

Wright J. and Howell M., 2003. “Volatile Air Emissions from Soil or Groundwater – Are They as Significant as Model Say They Are?”. In Contaminated Soils, Volume 8, Edited by Edward J. Calabrese, Paul T. Kostecki and James Dragun, p375-393.

Gorman J., Mival K., Wright J. and Howell M., 2003, Developing Risk-Based Screening Guidelines for Dioxin Management at a Melbourne Sewage Treatment Plant. Water, Science and Technology, Vol 47 No 10, pp 1-7.

Wright J., and Howell M., 1995, “Health Risk Assessment - Practical Applications Related to Air Quality Issues”. Clean Air, Volume 29, No. 2, May 1995.

Government and industry publications:

Environmental Health Australia, 2019. Australian Voluntary Code of Practice, Assessment, remediation and validation: Former clandestine drug laboratories and other methamphetamine contaminated properties. Principal author.

CRC CARE, 2018. Weathered Petroleum Hydrocarbons (Silica Gel Clean-up), CRC CARE Technical Report no. 40, CRC for Contamination Assessment and Remediation of the Environment, Newcastle, Australia. Principal author.

CRC CARE, 2013. Petroleum Vapour Intrusion (PVI) Guidance. CRC Care Technical Report No 23, CRC for Contamination Assessment and remediation of the Environment, Adelaide, Australia. Principal author.

NEPM 2013 Revision (released in 2013), Schedule B4 (Guideline on Site-Specific Health Risk Assessment Methodology) and Schedule B7 (Guideline on Derivation of Health-Based Investigation Levels). Primary author of toxicological evaluations and derivation of health investigation levels and contributing author to the Schedules (conducting full revision/rework of both Schedules, including responding to public comments and comments from state health agencies).

Australian Government, 2011. Guidelines for Environmental Investigations, Remediation and Validation of former Clandestine Drug Laboratory Sites [Guidelines], April 2011. Primary author of toxicological evaluations and derivation of remeidation guidelines using risk based approach and listed contributor to main document.

Davis G.B., Wright J. and Patterson B.M., 2009. Field Assessment of Vapours, CRC CARE Technical Report no. 13, CRC for Contamination Assessment and remediation of the Environment, Adelaide, Australia.

Invited lectures

Wright, J. 2020 to 2022. Toxicological risk assessment. Guest lecture to University of New South Wales School of Business.

Wright, J., 2013. Petroleum Vapour Intrusion Guidance in Australia. AEHS 23rd Annual International Conference on Soil, Water, Energy, and Air and AEHS Foundation Annual Meeting, March 18-21, 2013, Mission Valley Marriott, San Diego, California. Invited lecture

Wright, J., 2012. Evaluation of the Australia Hydrocarbon VI Data Base: Exclusion Criteria. AEHS 22nd Annual International Conference on Soil, Water, Energy, and Air and AEHS Foundation Annual Meeting, March 19-22, 2012, Mission Valley Marriott, San Diego, California. Invited lecture.

Conference Proceedings (Oral Presentations):

Wright, J. (2021) Weathered Petroleum – Assessing the toxicity of polar metabolites vs petroleum hydrocarbons. ACTRA Annual Scientific Meeting, Sydney 26-27 August 2021

Wright, J. (2021) Risk Assessment and CSMs? Presentation to ACLCA – Western Australian branch meeting

Wright, J. (2020) Clan labs and meth contaminated properties - Risks and issues. Environmental Health Australia, Professional Development Workshop

Wright, J. and Manning, T. (2020) Basements, Really, you thought THAT was a good idea !!!!. ALGA Ecoforum 2020

Wright, J. (2020) Attenuation Factors and VI. ACLCA Webinar, 29 April 2020

Wright, J. and Manning, T. (2020) Chlorinated Hydrocarbons - Myths and Realities. ACTRA webinar (industry training) 27 February 2020

Wright J. and Stratford, M. (2020) Methamphetamine Risk Management Industry Voluntary Code of Practice. ACTRA webinar (industry training) 20 February 2020

Wright, J. and Manning, T. (2018) Perplexing guidelines: What it means for measurement, RACI PFAS Symposium, November 2018

Wright, J. (2018) Contrasting current contamination issues: Inside the home – methamphetamine, ALGA Regional Conference, Townsville October 2018

Wright, J. (2018) Contrasting current contamination issues: Outside the home – PFAS, ALGA Regional Conference, Townsville October 2018

Capon, A. and Wright, J. (2018) An Australian incremental guideline for particulate matter less than or equal or 2.5 micrometres (PM2.5). ACTRA Conference, October 2018

Manning, T. and Wright, J. (2018) Contaminated Land Risk Assessment and the Building Code of Australia, Ecoforum October 2018

Jarman, R., Wright, J., Manning, T. and Pendergast, D. (2016). Using oral bioaccessibility testing to refine exposure assessment for carcinogenic PAHs in soil. EcoForum, October 2016.

Manning, T., Wright, J., Jarman, R. and Bowles, K. (2016) Per and poly fluorinated alkyl substances – where are we, ecologically speaking? SETAC AU October 2016.

Jarman, R., Manning, T., and Wright J. (2016). Setting toxicity reference values for PFAS – what can we learn from TOXCAST and TOX21. ACTRA Annual Scientific Meeting, September 2016.

Manning, T., Wright, J., Jarman, R. and Bowles, K. (2016) Per and poly fluorinated alkyl substances – the Australian Story. EmCon 2016 September 2016.

Manning, T. and Wright, J. (2016). Particulate Risk Assessments – Issues and Challenges. EcoForum, October 2016.

Manning, T. and Wright, J. (2015). Review of Ecological Investigation Levels for Total Petroleum Hydrocarbons. 6th International Contaminated Site Remediation Conference (Cleanup 2015), September 2015.

Manning, T. and Wright, J. (2015). Particulate Risk Assessments – Issues and Challenges. 22nd Clean Air and Environment Conference, September 2015.

Wright, J. and Manning, T. (2015). Bioavailability/Bioaccessibility – Practical Considerations. ALGA Workshop, Use of Bioavailability and Bioaccessibility Techniques to Refine Assessment of Human Health Risk, November 2015.

Wright, J. and Manning, T. (2015). PAHs and Bioaccessibility. ALGA Workshop, Use of Bioavailability and Bioaccessibility Techniques to Refine Assessment of Human Health Risk, November 2015.

Manning, T. and Wright, J. (2014). Contaminated Land – How do environmental guidelines get used? SETAC-AU Conference Adelaide September 2014.

Manning, T. and Wright, J. (2014). Use of Health Impact Assessment in Environmental Impact Statements. Ecoforum Conference Gold Coast October 2014.

Wright J., 2014. Particulate Risk Assessments – Issues and Challenges. ACTRA Annual Scientific Meeting, Sydney October 9-10 2014.

Wright J. and Manning T., 2014. Health Impact Assessment – Role in EIS. Keynote presentation. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J. and Manning T., 2014. Addressing Risk Perceptions through Risk Assessment. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J. and Manning T., 2014. Vapour Assessment for TCE. Ecoforum, 29-31 October 2014, Gold Coast.

Wright J., Howell J. and Newell P., 2014. Assessment and Remediation of Illegal Drug Laboratories. Ecoforum, 29-31 October 2014, Gold Coast.

Wright, J., 2014. Clandestine Drug Laboratories – Understanding Exposures and Public Health. The Second International Conference on Law Enforcement and Public Health, Amsterdam 5-8 October 2014.

Wright, J. 2014. ASC NEPM – Implementation. AEBN (Australian Environment Business Network) Conference on Managing Contaminated Land, September 2014.

Wright, J. 2014. Managing Vapours – The Issues to Consider for Developers and Councils. AEBN (Australian Environment Business Network) Conference on Managing Contaminated Land, September 2014.

Wright, J., 2012. Exposure and Risk Issues associated with Clandestine Drug Laboratories – development of guidelines. British Occupational Hygiene Society (BOHS), Occupational Hygiene 2012 Conference, 24-26 April 2012, Mercure Holland House Hotel, Cardiff.

Wright, J., 2012. Risks of Not remediating Clandestine Drug Laboratories. 66th Annual Western Australian Environmental Health Australia (WA) State Conference Environmental Health: Imagine Life Without Us, 28-30 March 2012.

Wright, J, 2011. Establishing exclusion criteria from empirical data for assessing petroleum hydrocarbon vapour intrusion. CleanUp 2011: Proceedings of the 4th International Contaminated Site Remediation Conference, 11-15 September, Adelaide, Australia.

Wright, J., 2010. Review of Petroleum Vapour Data from Australia. Abstract presented at Ecoforum 2010, 3rd ALGA Annual Conference 23-24 February 2010.

Wright, J., 2010. Interpretation and Use of Soil Gas and other Vapour Data. Abstract presented at Ecoforum 2010, 3rd ALGA Annual Conference 23-24 February 2010.

Weaver T., Hassell T., Wright J., Stening J. and Apte S., 2009. Speciation and Geochemical Modelling as a Tool to Refine a Risk Assessment for Mercury in Groundwater. Presented at EcoForum, Sydney 28-30 April 2009.

Wright J. and Robinson C., 2009. The Reality of Sampling and Assessing Vapour Intrusion on Petroleum Sites. Presented at Air &Waste Management Association’s Vapor Intrusion 2009, January 27-29 2009, San Diego CA.

Wright J., Lee A. and Howell M., 2008. Role of Risk-Based Concentrations in Assessment and remediation of Contaminated Sites. Presented at EcoForum, Gold Coast, 27-29 February 2008.

Wright J., Howell M. and Barnes J., 2006. Risk Assessment – Important Tool for Managing Issues on Contaminated Sites or Just a Task. Presented at Enviro06, Melbourne 2006.

Hall, A, Wright J. and Calabrese N, 2006. Ray Street Landfill – Audit Acceptance Levels for CO_2 in Redeemed Soils. Presented at Enviro06, Melbourne 2006.

Wright J. and Howell M., 2004. "Evaluation of Vapour Migration Modelling in Quantifying Exposure". Presented at Enviro04, Sydney March 2004.

Lee A., Howell M., and Wright J. 2004. "TPH – Analysis, Guidelines and Risk Assessment" Presented at Enviro04, Sydney March 2004.

Pershke D., van Merwyk T., Graham-Taylor S., Wright J., Mitchell T., and Elliot P., 2004. "Health Risk Assessment: Broadening the Horizons of the Traditional Health and Safety Approach", Presented at Enviro04, Sydney March 2004.

Wright J., Buchanan V., and Howell M., "Health Risk Assessment using Probability Density Functions". Presented at the AWWA Waste and Wastewater Conference, Brisbane 1998.

Wright J. and Buchanan V., 1996, "Uptake of Organics and Inorganics into Edible Fruit and Vegetable Crops". Presented at Intersect-96 International Symposium on Environmental Chemistry and Toxicology, Royal Australian Chemical Institute and the Australian Society for Ecotoxicology, 14-16 July 1996.

Wright J. and Howell M., 1995, "Risk Based Approach to Assessment and Management of Air Quality Issues Associated with Contaminated Sites and Hazardous Waste". Presented at Waste Management Institute (New Zealand) Inc., 7th Annual Conference and Exhibition, 31 October - 3 November, 1995.

Harrington J F, Clark L T and Wright J, 1994, "The Incineration of Sludge and its Effect on Ambient Air Quality in the Evaluation of Risk Factors for Primary School Children". Presented at Australia and New Zealand Clean Air Conference, Perth 1994.

Royston D, Clark L T and Wright J, 1993, "Chlorinated Dioxins and Furans from Combustion Sources: A review". Poster presented at the Sixth Conference of Asia Pacific Confederation of Chemical Engineering, Melbourne, 1993.