November 2017

QGC - ADDENDUM TO HYDRAULIC STIMULATION CHEMICAL ASSESSMENT

Stimulation Fluid Hazard Assessment

Some parts of this report have been redacted to maintain the confidentiality of commercially sensitive information

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ADDENDUM

Report Number. 127635006-003-R-Rev1-05300 HSCA

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Golder Associates

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Document Number	Issue Date	Revisions
127635006-003-M-Rev0-53000	2 July 2013	-
127635006-003-R-Rev1-53000	November 2017	Some information redacted to maintain confidentiality. Report re-formatted.

1.0 INTRODUCTION

QGC has requested that Golder Associates Pty Ltd (Golder) undertake a hazard assessment of four stimulation chemicals listed in a stimulation fluid product. The assessment is in regards to the potential toxicity of the fluid to human health and ecological receptors in aquatic and terrestrial environments.

This document presents the hazard assessment of the four (4) chemicals, as identified in Table 1.

The chemical assessments presented in this document were undertaken and reported in July 2013 (Golder document: document 127635006-003-M-Rev0-05300, dated 2 July 2013). This addendum presents the 2013 assessments in an updated format (for consistency with addendums written in 2015 and 2016). The data used in 2013 has not been updated or modified (i.e. the content of this document remains generally the same as document 127635006-003-M-Rev0-05300), with the exception of addition of a mass balance discussion (Section 3.0).

1.1 Background

Golder has previously assessed a number of hydraulic stimulation chemicals for human health and ecological hazards for QGC. The assessments are documented in the report*: Human Health and Ecological Chemical Assessment – Hydraulic Stimulation Chemical Assessment – QGC Surat and Bowen Basin Operation* (Golder Ref. 127635006-004-R-Rev3) hereafter referred to as 'HSCA report'. This assessment is provided as an addendum to that report.

1.2 Chemicals to be assessed

QGC provided Golder with Chemical Abstract Service Registry Numbers (CAS RN) for four chemicals that were identified in a stimulation fluid product (*pers.comms*. Simon Kearney, QGC).

The chemicals provided by QGC were reviewed by Golder and found to have not been previously assessed. These four chemicals are shown in Table 1.

Table 1: Additional Stimulation Chemicals to be assessed

Chemical Type	Chemical Name	CASRN
Organic	Urea	57-13-6
	1-Propanesulfonic acid, 2-methyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer	35641-59-9
Inorganic	Ammonium sulphate	7783-20-2
	Sodium sulphate	7757-82-6

1.3 Scope of Work

The approach applied for chemical hazard assessment is documented in the HSCA report (Golder, 2016). This approach was applied to the hazard assessment of the chemicals listed in Table 1.

As a part of this assessment, the following scope of work was completed:

- Preparation of human health toxicological profiles (results presented in Appendix A).
- A review of environmental hazards (where possible) using measures of persistence (P), bioaccumulation (B) and toxicity (T) (PBT) and preparation of chemical information sheets and hazard summaries (results presented in Appendix B).
- Mass balance calculations.
- Preparation of this addendum.

2.0 HAZARD ASSESSMENT

The health and environmental hazard assessment for each of the four (4) chemicals identified in the stimulation fluid product are presented in the following sections.

2.1 Ammonium Sulphate

2.1.1 General

Ammonium sulphate is an inorganic salt, composed of white or brown crystals. It occurs naturally as the rare mineral mascagnite and as a by-product of coal fires. Ammonium sulphate can be produced by treating ammonia with sulfuric acid, and from adding finely divided gypsum to an ammonium carbonate solution (HSDB 2011).

Ammonium sulphate has a variety of uses including in cattle feed, in the chemical industry, for the production of fire extinguisher powder and flame proofing agents, in the production of metals, in wood working, in the pharmaceutical industry as a nutrient for microorganisms, in the textile industry, in shale stabilization and in drilling fluids (HSDB 2011).

In aqueous environments, ammonium sulphate has high solubility and is completely dissociated into the ammonium (NH_4^+) and the sulphate (SO_4^{2-}) ions (HSDB 2011).

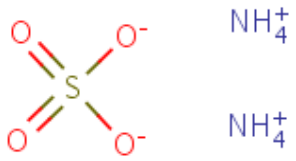

Figure 1: The structure of Ammonium sulphate (HSDB 2011).

2.1.2 Human Health Toxicity

Ammonium sulphate exhibits a Hazard Band Rating of 1 based on its low acute toxicity and reversible irritant properties. It is not flammable and it is not explosive. While there are some limitations in the toxicological literature (fertility and developmental toxicity) due to its ready dissociation into the component ions, ammonium and sulphate, analogies have been drawn with studies of ammonium ions and sulphate ions which support a lack of fertility and developmental effects. These comparisons reflect the use of "*supporting chemicals*", i.e chemicals of equivalent structure and function. High doses in humans following ingestion result in gastro-intestinal disturbances, while limited respiratory effects are observed even at inhalation concentrations of 1mg/m^3 in humans. Ammonium sulphate is "*generally recognized as safe (GRAS)"* and approved as a food additive in the U.S. and in Europe. Ammonium sulphate would dissociate rapidly in solution following environmental introduction and be subject to dilution and chemical transformation. Any transformation into nitrate may warrant closer attention due to potential impacts on drinking water supplies.

Hazards are thus primarily limited to occupational exposures. As a powder it may result in contact and inhalation exposures in occupational settings which may lead to irritant respiratory, skin and eye effects while inhalation of aerosols from urea melt and saturated solutions including eye or skin splashing should be risk managed. In confined environments where ammonia may be generated, these should be well ventilated to avoid inhalation exposures.

2.1.3 Ecotoxicology

2.1.3.1 Aquatic toxicity assessment

An environmental hazard assessment was undertaken on ammonium sulphate, based on persistence (P), bioaccumulation (B) and toxic (T) potential (hereafter referred to as PBT).

The environmental hazard assessment categorises a chemical as having potential to pose a high, moderate or low hazard to the environment. The approach for the aquatic hazard assessment of inorganic substances differs to that for organic substances. The approach for the assessment of inorganic substances was developed predominantly following Canadian guidance where reliance is placed on persistence and toxicity data.

The Chemical Information Sheet or Ecotoxicology Profile for ammonium sulphate (provided in Appendix B) presents the available physical and chemical information, in addition to selected ecotoxicological data for freshwater organisms from the information reviewed.

An overall score (the environmental hazard score) for ammonium sulphate (inorganic chemical) was calculated based on the potential for P and T. Table 2 summarises the overall hazard score for ammonium sulphate.

Table 2: Ammonium sulphate: Aquatic toxicity score

Chemical	Bioaccumulation Score^	Persistence Score	Toxicity Score	Overall Hazard Score
Ammonium sulphate	-	NA	3	3

Note: For further detail see Appendix B

NA – Not applicable: Not scored for persistence due to ready dissociation into naturally occurring ions in aquatic systems

^ - inorganic substances: reliance is placed on persistence and toxicity data

Based on the PBT assessment ammonium sulphate has been given an overall hazard score of 3, indicating that it poses high hazard to the aquatic environment. Ammonium sulphate is expected to readily dissociate in the environment. Ammonium sulphate dissociates and breaks down into nitrate (which may cause eutrophication effects when present in elevated concentrations, (and associated oxygen depletion and impacts of this on wildlife) where concentrations are sufficient. Based on the weight of evidence, notably that ammonium sulphate will readily dissociate in the environment, the potential to pose a toxic hazard is considered to be limited and so the hazard rating has been reduced to a moderate to low aquatic hazard. Effects to aquatic receptors are expected to be associated with increased salinity should a release of ammonium sulphate occur. However, given product represents 1 ppm (0.0001%) of the stimulation fluid, the potential for increased salinity effects following an accidental release are expected to be low.

2.1.3.2 Terrestrial toxicity assessment

The chemical information sheet (Appendix B) presents the physical and chemical information for ammonium sulphate, in addition to available ecotoxicological data for terrestrial organisms.

For ammonium sulphate terrestrial toxicity data were available for mammals. For chemicals with few or no data, a quantitative structure activity relationship (QSAR) approach has been used to predict toxicity to plants[1] and invertebrates[2]. As ammonium sulphate is an inorganic chemical it is not appropriate for QSAR modelling, therefore plant and invertebrate toxicity could not be predicted.

Table 3 below summarises the terrestrial toxicity for ammonium sulphate.

Table 3: Ammonium sulphate: Terrestrial toxicity data

Chemical	Mammalian LD50
	mg/kg
Ammonium sulphate	610

[1] The QSAR of Huzelbos et al. (1991) may be used to predict the toxicity of chemicals to lettuce is used to predict the toxicity of chemicals to plants.

[2] The QSAR of van Gestel (1992) may be used to predict the toxicity of organic chemicals to earthworms - this is the QSAR used in the ECOSAR programme.

Based on the review of the available physico-chemical and mammalian data, the potential hazard to the terrestrial environment posed by ammonium sulphate is low. Ammonium sulphate is expected to readily dissociate in the environment and so there is considered low potential for toxic effects to be realised.

2.2 Urea

2.2.1 General

Urea is an organic nitrogenous chemical and a natural product of nitrogen and protein metabolism and it is found in urine and animal waste. It occurs as white crystals or powder and has a slight ammonia odour with age. Urea has a number of uses including as a fertilizer, a chemical intermediate, a stabilizer in explosives, a viscosity modifier, and in animal feed, medicine, plastics, adhesives, pharmaceuticals, cosmetics, dentrifices and flameproofing agents (HSDB 2003).

Urea is expected to have very high mobility and low volatilization in soil. In aquatic systems biodegradation is the major fate process, with volatilization and bioconcentration in organisms both expected to be low (HSDB 2003).

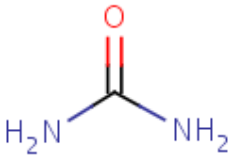

Figure 2: The structure of Urea (HSDB 2003).

2.2.2 Human Health Toxicity

Urea has a hazard rating of 1 based primarily on its low acute toxicity and potential for reversible irritant effects to the skin and eyes. It is excreted from the body following protein and amino acid metabolism. The human body is capable of tolerating elevated blood urea concentrations based on clinical evaluations with exposure generally associated with plant food and meat. As urea has not been extensively examined there are difficulties in identifying No-Observed-Adverse-Effect Levels and further issues with the reliability of reproductive and developmental toxicity studies. OECD (p6, 1996), however, report that "*chronic toxicity and carcinogenicity screening studies of urea in diet with mice and rats suggested that the NOAELs are of the order 2000-6000 mg/kg body weight/day*" and *"in a human female patient ingestion of 470 mg/kg body weight/day of urea over 5 years did not cause adverse effects.*" Furthermore clinical experience suggests much higher dose levels have resulted in limited or no adverse effects. OECD (1996) considers urea of low current concern. Taking this into account, and the potential dilution of urea in the fracturing operations, and the rapid expected biodegradation in the environment, it is considered that the environmental health concerns are expected to be limited. Should ammonia be generated, it is expected it will rapidly dilute and disperse in ambient air. It is not flammable and explosive in isolation, however, incompatibilities should be noted, particularly if urea nitrate is formed, as it is highly explosive. The main hazards for management relate to occupational exposures including skin and eye irritant effects.

2.2.3 Ecotoxicology

2.2.3.1 Aquatic toxicity assessment

The Chemical Information Sheet or Ecotoxicology Profile for urea provided in Appendix B presents the available physical and chemical information, in addition to selected ecotoxicological data for freshwater organisms from the information reviewed.

An overall score (the environmental hazard score) for urea (organic chemical) was calculated based on the potential for P, B and T. Table 4 summarises the overall hazard score for urea.

Table 4: Urea: Aquatic toxicity score

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
Urea	1	1	2	1

Note: For further detail see Appendix B

Based on the PBT assessment urea achieves an overall hazard score of 1, indicating that it poses a low hazard to the aquatic environment.

2.2.3.2 Terrestrial toxicity assessment

The quantitative-structure activity relationship (QSAR) models may not be reliable and may underestimate toxicity at log Kow < 1 mg/L. For urea the log Kow is 0.9 (refer Appendix B).

Table 5 below summarises the terrestrial toxicity for urea and Table 6 presents the physio-chemical assessment for urea.

Table 5: Urea: Terrestrial toxicity data

Chemical	Mammalian LD50	ECOSAR earthworm LC50	QSAR lettuce EC50 Huzelbos et al., 1991	QSAR earthworm LC50 Van Gestel 1992
	mg/kg	mg/L	mg/L	mg/kg
Urea	510[3]	244.03	4,653[1]	0.25[5]

[1] Hazardous Substances Data Bank (HSBD)
[5] ECOTOX (2012)
[3] IUCLID (2012)

Table 6: Urea: Physio-Chemical Assessments

Chemical	Soil Half Life t½ Classification	Potential to Biomagnify	Henry's Law Classification	Primary Exposure Route
Urea	Moderately Fast	Low	High volatility	Direct toxicity

Urea is assessed to present a low hazard based on the lowest reported concentration from the available data for invertebrates (earthworms), mammals and plants (lettuce).

Urea was assessed based on available half-life, Henry's Law Constant and persistence (via its octanol-water partitioning coefficient) data. The half-life of urea is 30 days which is moderately short, indicating that this chemical is moderately persistent. The Henry's Law constant is 1.74×10^{-12} which indicates high volatility and the Log Kow is -2.11 which indicates low persistence.

Using the three physico-chemical measures (half-life, Henry's Law Constant and Log Kow) in combination it is considered that urea presents a low hazard for persistence or bioaccumulation. The terrestrial toxicity data suggests urea presents a moderate hazard to mammals but high hazard to plants and invertebrates.

Based on the review of the available physico-chemical and terrestrial ecotoxicological data, the potential hazard to the terrestrial environment posed by urea is low.

2.3 Sodium Sulphate

2.3.1 General

Sodium sulphate is an inorganic salt that occurs in nature as a number of minerals including minerbilite, hanksite, sulphonalite, galubzrite, tychite and thenardite. It is relatively common in alkaline lakes, groundwater and seawater. It also occurs in the environment as a by-product of rayon, dichromate, phenol and german potash. The major uses of sodium sulphate include in medication (human and veterinary), in the manufacture of sodium salts, ceramic glazes, and glass, in tanning, freezing mixtures, laboratory reagents and as a food additive (HSDB 2002).

Sodium sulphate does not bioaccumulate or pose food chain contamination effects. A study on soil with sodium sulphate (cited in HSDB, 2002) showed that dilute solutions penetrated at rates similar to that of water. The soil aggregation properties changed significantly in the top 10 cm (when compared to water infiltration), whereas at depths greater than 10 cm, the effects were similar to water. The study showed that large amounts of calcium were leached downward (HSDB 2002).

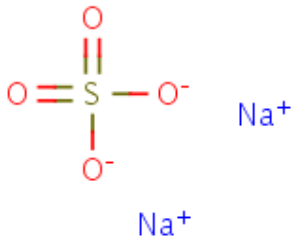

Figure 3: The structure of Sodium sulphate (HSDB 2002).

2.3.2 Human Health Toxicity

Sodium sulphate exhibits a Hazard Band Rating of 0 based on its limited toxicity. Although there are some data gaps and some studies have been considered to reflect poor validity, the overall consensus is that the "*weight of evidence, combined with previous assessments of both the sodium ion and sulfic ions lead to the conclusion that the identified data gaps need not necessarily be filled*" and that "*the chemical is of low priority for further work due to its low hazard profile*". (OECD, 2007 pp4-5).

It is not flammable and explosive (in isolation) but as a powder it may result in contact and inhalation exposures in occupational settings which may lead to adverse respiratory and dermal effects. These should be managed through the usual occupational health management protocols. In the environmental setting its solubility will result in dilution and as a neutral salt it will not result in a change of the aqueous pH that may subsequently influence aqueous environments such as aquifers.

2.3.3 Ecotoxicology

2.3.3.1 Aquatic toxicity assessment

The Chemical Information Sheet or Ecotoxicology Profile for sodium sulphate provided in Appendix B presents the available physical and chemical information, in addition to selected ecotoxicological data for freshwater organisms from the information reviewed.

Table 7 summarises the overall hazard score for sodium sulphate.

Table 7: Sodium sulphate: Aquatic toxicity score

Chemical	Bioaccumulation Score^	Persistence Score	Toxicity Score	Overall Hazard Score
Sodium sulphate	-	3	1	2

Note: For further detail see Appendix B

^ - inorganic substances: reliance is placed predominantly on persistence and toxicity data

Based on the PBT assessment sodium sulphate has been given an overall hazard score of 2, indicating that it poses a moderate hazard to the aquatic environment.

The high hazard classification (of 1, for toxicity) largely results from a fish study and because the PBT assessment is conservatively weighted towards toxicity. Sodium sulphate is expected to readily dissociate in the environment. Based on the weight of evidence, sodium sulphate is considered to present a moderate to low aquatic hazard. Effects to aquatic receptors are expected to be associated with increased salinity should a release of sodium sulphate occur. However, given product represents 1 ppm (0.0001%) of the stimulation fluid, the potential for increased salinity effects following an accidental release are expected to be low.

2.3.3.2 Terrestrial toxicity assessment

The chemical information sheet (Appendix B) presents the physical and chemical information for sodium sulphate in addition to available ecotoxicological data for terrestrial organisms.

For sodium sulphate terrestrial toxicity data were available for mammals. For chemicals with few or no data, where appropriate, a quantitative structure activity relationship (QSAR) model was used to predict toxicity to plants[3] and invertebrates[4]. As ammonium sulphate is an inorganic chemical it is not appropriate for QSAR modelling, therefore plant and invertebrate toxicity could not be predicted.

Table 8 below summarises the terrestrial toxicity for sodium sulphate

Table 8: Sodium sulphate: Terrestrial toxicity data

Chemical	Mammalian LD50	ECOSAR earthworm LC50	QSAR lettuce EC50	QSAR earthworm LC50
	mg/kg	mg/L	mg/L	mg/kg
Sodium sulphate	193[3]	NA	No data	No data

[3] IUCLID (2012)

NA - not applicable/not appropriate to model using ECOSAR QSAR

Sodium sulphate is considered to present a moderate hazard to the terrestrial environment, based on mammalian data only. Sodium sulphate is expected to readily dissociate in the environment and so there is considered low potential for toxic effects to be realised.

2.4 2-Acrylamido-2-methylpropane sulfonic acid Surrogate for 1-Propanesulfonic acid, 2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer

2.4.1 General

1-Propanesulfonic acid, 2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer is an organic polymer of the trade mark category of chemicals referred to as AMPS®, or Poly-AMPS. 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt (AMPS®, CASRN 5165-97-9) is the monomer. No data on 1-Propanesulfonic acid,

[3] The QSAR of Huzelbos et al. (1991) may be used to predict the toxicity of chemicals to lettuce is used to predict the toxicity of chemicals to plants.

[4] The QSAR of van Gestel (1992) may be used to predict the toxicity of organic chemicals to earthworms - this is the QSAR used in the ECOSAR programme.

2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer were found during the preparation of this Technical Memorandum. Hence a suitable surrogate was sought.

AMPS® (or 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt, CASRN 5165-97-9) has the same chemical name, molecular formula and molecular weight to the polymer identified in the stimulation fluid product and has been used a as a surrogate to assess the environmental hazard of 1-Propanesulfonic acid, 2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer.

AMPS® is a reactive, hydrophilic, sulfonic acid acrylic monomer solid with high water solubility and negligible vapour pressure. It is expected to have high mobility in soil, low volatilisation and low bioaccumulation potential (USEPA 2009). AMPS® are prepared by reacting acrylonitrile, isobutylene, and oleum in the presence of water (USEPA 2009).

The early uses of this monomer were for acrylic fiber manufacturing. The major uses of AMPS® are in a number of areas including in water treatment, oil fields, as construction chemicals, and for medical applications, personal care products, emulsion coatings, adhesives, and rheology modifiers (USEPA 2009).

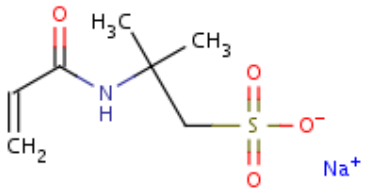

Figure 4: The structure of surrogate 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt (ChemIDplus 2013).

2.4.2 Human Health Toxicity

2-Acrylamido-2-methylpropane sulfonate, sodium salt (Na-AMPS) exhibits a Hazard Band Rating of 1 based on limited data supporting a position of low acute and chronic toxicity in animal studies with some evidence of skin irritancy in rabbits. Although these data have been based on the monomer rather than the homopolymer it is expected that the homopolymer being water soluble would be subject to degradation and release of its monomeric units. It is noted the latter exhibit a low degree of biodegradation. There are no data on its flammable or explosive potential but this would be expected to be low in aqueous solutions. Based on evidence of skin irritant properties occupational exposures should limit dermal contact through suitable transport and handling management methods.

2.4.3 Ecotoxicology

2.4.3.1 Aquatic toxicity assessment

The Chemical Information Sheet or Ecotoxicology Profile for 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt (provided in Appendix B) presents the available physical and chemical information, in addition to selected ecotoxicological data for freshwater organisms from the information reviewed.

An overall score (the environmental hazard score) for 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt (organic chemical) was calculated based on the potential for P, B and T. Table 9 summarises the overall hazard score for 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt.

Table 9: 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt: Aquatic toxicity score

Chemical	Bioaccumulation Score	Persistence Score	Toxicity Score	Overall Hazard Score
2-Acrylamido-2-methylpropane sulfonic acid, sodium salt	1	2	1	1

Note: For further detail see Appendix B

Based on the PBT assessment 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt, has been given an overall hazard score of 1, indicating that it poses a low hazard to the aquatic environment.

2.4.3.2 Terrestrial toxicity assessment

The chemical information sheet (Appendix B) presents the physical and chemical information for 2-acrylamido-2-methylpropane sulfonic acid, sodium salt, in addition to available ecotoxicological data for terrestrial organisms.

The low Kow for 2-acrylamido-2-methylpropane sulfonic acid, sodium salt is -4.34 (Appendix B) indicating predicted effects using QSAR models may not be reliable, and for chemcials with Log Kow < 1mg/L, may under-predict toxicity.

Table 10 below summarises the terrestrial toxicity for 2-acrylamido-2-methylpropane sulfonic acid, sodium salt

Table 10: 2-acrylamido-2-methylpropane sulfonic acid, sodium salt: Terrestrial toxicity data

Chemical	Mammalian LD50	ECOSAR earthworm LC50	QSAR lettuce EC50 Huzelbos et al., 1991	QSAR earthworm LC50
	mg/kg	mg/L	mg/L	mg/kg
2-Acrylamido-2-methylpropane sulfonic acid, sodium salt *	>16,000[4]	No data	716,261	No data

"*"Surrogate for 1-Propanesulfonic acid, 2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer (CASRN 35641-59-9)
[4] USEPA (2009)

Table 11: 2-acrylamido-2-methylpropane sulfonic acid, sodium salt: Physio-Chemical Assessments

Chemical	Soil Half Life t½ Classification	Potential to Biomagnify	Henry's Law Classification	Primary Exposure Route
2-Acrylamido-2-methylpropane sulfonic acid, sodium salt *	No data [1]	Low	Low volatility	Direct toxicity

Note

"*" - Surrogate for 1-Propanesulfonic acid, 2-mthyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer (CASRN 35641-59-9)

[1] – biodegradation rates of <10% in 44 days (measured) reported in USEPA (2009)

2-Acrylamido-2-methylpropane sulfonic acid, sodium salt is considered to pose a low hazard, based on mammalian and plant (lettuce) data.

Soil half-life data were not available for 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt. Considering the bioaccumulation and volatility data 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt is considered to present a low hazard for bioaccumulation. 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt and has been assigned a moderate hazard for persistence based on the biodegradation data available in USEPA (2009) – noting that biodegradation data for half-life in soil were not available.

Based on the available physico-chemical data and review of the toxicological data the potential hazard to the terrestrial environment of 2-Acrylamido-2-methylpropane sulfonic acid, sodium salt is considered to be moderate to low.

3.0 MASS BALANCE CALCULATIONS

A Fluid Disclosure Sheet (FDR) for these chemicals was not available. However, QGC indicated that the fluid "was included in the mixture at 1 ppm (0.0001%)" (S. Kearney pers. comm. QGC, November 2017). As the concentrations of the individual chemicals in the stimulation fluid is not known, to be conservative, it is assumed each chemical is present at a concentration of 1 ppm (assumed to be mg/L).

Assuming an injected fluid volume of 800,000 L (0.8 ML) (estimated volume based on review of the volume of other fluids), the following was estimated:

- Injected mass of each of the chemicals during a stimulation event
- Residual mass of each of the chemicals following a stimulation event.

However, the mass balance calculations have not been include to maintain the confidentiality of commercially sensitive information. As a summary, the following is provided.

Following completion of the hydraulic stimulation process, a percentage fraction of the injected hydraulic stimulation fluids are recovered upon flowback and production of the well. However, it should be noted that most of the additives would have undergone chemical transformations in the sub-surface. In addition, the formation also contributes a certain amount of water and dissolved salts to the flowback and production of the well. If it is conservatively assumed that 20% of the hydraulic stimulation fluid volume remains in the formation (reasonable "worst case") this would correspond to the estimated "Residual Mass" of 1 kg or less for each of the chemicals, per injection event.

4.0 UNCERTAINTY ANALYSIS

The evaluation of the human health and ecological hazards of the chemicals assessed in this document is limited by the quantity and quality of information available in the sources reviewed and the literature received by Golder from QGC. A measure of the data completeness across the toxicological and hazard parameters used has been estimated expressed as a percentage of the parameters for which data were available. These are presented in each summary in Appendix A and Appendix B.

An assessment of the quality of the available data is beyond the scope of this report. In the absence of such a review Golder has relied on primary literature sources from established, robust and reputable sources such as European Chemicals Agency (ECHA), Australia's National Industrial Chemicals Notification and Assessment Scheme (NICNAS) and United States Environmental Protection Agency (US EPA), where available. As new toxicological data are generated and become available in the published literature, the information presented in this hazard evaluation and the associated conclusions may be subject to change. On this basis the hazard profiles are dated to enable future review as may be appropriate. This is particularly pertinent across human health parameters within the highest Hazard Band category (4) which includes such areas as endocrine disruption potential and carcinogenicity (noting, no chemicals assessed in this document were assigned a Hazard Band category of 4).

5.0 EXCLUSIONS

This document provides a hazard assessment which reflects the potential concerns associated with the intrinsic toxicity of the substances reviewed. A hazard assessment does not include exposure assessment considerations that may or may not realise the expression of the hazards, however, comment is made to place exposures into perspective associated with fate and transport properties and specific physico-chemical properties, e.g. the residual nature of metals. A comprehensive exposure assessment and risk characterisation is available in the HSCA report (Golder Ref. 127635006-004-R-Rev3).

6.0 CONCLUSIONS

Table 12 and Table 13 summarise the outcomes of the human health and ecological toxicity reviews, respectively.

Table 12: Summary of Human Health Toxicity Hazard Band Ranking

Compound	Human Health Hazard Band[1]	Comment
Urea	1	Based on low acute toxicity and potential for reversible irritant effects to the skin and eyes
1-Propanesulfonic acid, 2-methyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer	1	Based on limited data supporting a position of low acute and chronic toxicity in animal studies with some evidence of skin irritancy in rabbits. Although these data have been based on the monomer rather than the homopolymer it is expected that the homopolymer being water soluble would be subject to degradation and release of its monomeric units.
Ammonium sulphate	1	Based on low acute toxicity and reversible irritant properties
Sodium sulphate	0	Based on limited toxicity (although noting some data gaps exist). It is not flammable and explosive (in isolation) but as a powder it may result in contact and inhalation exposures in occupational settings which may lead to adverse respiratory and dermal effects. These should be managed through the usual occupational health management protocols.

Note: 1. A ranking of 0 represents the lowest toxicity and 4 represents the highest toxicity.

Table 13: Summary of Ecotoxicology Ranking

Compound	Aquatic Toxicity	Comment	Terrestrial Toxicity	Comment
Urea	Low	Based on the PBT assessment	Low	Based on available physico-chemical and terrestrial ecotoxicological data
1-Propanesulfonic acid, 2-methyl-2-[(1-oxo-2-propen-1-yl)amino], homopolymer	Low	Based on the PBT assessment	Moderate to low	Based on available physico-chemical and terrestrial ecotoxicological data
Ammonium sulphate	Moderate to low	Based on the weight of evidence, ammonium sulphate is considered to	Low	Based on ammonium sulphate being expected to readily dissociate in the environment

Compound	Aquatic Toxicity	Comment	Terrestrial Toxicity	Comment
		present a moderate to low aquatic hazard. However, it is expected to readily dissociate in the environment.		
Sodium sulphate	Moderate to low	Based on the PBT assessment, sodium sulphate is considered a moderate hazard. However, it is expected to readily dissociate in the environment.	Moderate to Low	Moderate hazard is based on mammalian data only. Sodium sulphate is expected to readily dissociate in the environment and so there is considered low potential for toxic effects to be realised

The overall conclusions of the *Human Health and Ecological Chemical Assessment – Hydraulic Stimulation Chemical Assessment – QGC Surat and Bowen Basin Operation* report (Golder Ref. 127635006-004-R-Rev3) are not changed by the outcomes of this assessment.

7.0 IMPORTANT INFORMATION

Your attention is drawn to the document titled - “Important Information Relating to this Report”, which is included in Appendix C of this report. The statements presented in that document are intended to inform a reader of the report about its proper use. There are important limitations as to who can use the report and how it can be used. It is important that a reader of the report understands and has realistic expectations about those matters. The Important Information document does not alter the obligations Golder Associates has under the contract between it and its client.

8.0 REFERENCES

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Report Signature Page

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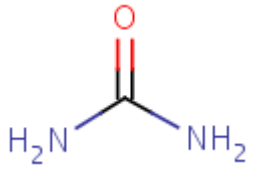
APPENDIX A

Human health toxicological profiles

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Name	Urea
Synonyms	Carbamide, carbonyl diamide, nimin, isourea, urea perhydrate
CAS number	57-13-6
Molecular formula	CH_4N_2O
Molecular Structure	

Overview	References
Urea is colourless to white, and a nearly odourless crystal or powder. It is a natural product of nitrogen and protein metabolism and is found in urine and animal waste. It has a wide range of commercial and industrial applications including in animal feed and plastics, as a stabilizer in explosives, in medicine, adhesives, pharmaceuticals, cosmetics, flame-proofing agents, paper coatings and in other chemical manufacture. It is widely used in solid and liquid complex fertilizers and in the textile industry. Cyanates may be present in urea as an impurity. Urea is effectively eliminated by the kidney. Urea is an excretory end-product of amino acid metabolism in mammals (HSDB, 2003). The formation of urea takes place in the liver. In a review of human and animal toxicological data, it was concluded that the use of urea at levels of up to 3% in chewing-gum was of no toxicological concern. No epidemiology studies have identified an association between urea exposure and development of cancer. The International Agency for Research on Cancer (IARC) has not classified the carcinogenic potential of urea.	HSDB (2003); JECFA (1993); US FDA (2013).

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC. Carcinogenicity data are questionable. Both negative and positive studies have been reported according to HSDB (2003). OECD (1996) reports one mouse and one rat study, both of which concluded that no carcinogenic effects were found. The US EPA (2005) concluded that there is inadequate information to access the carcinogenic potential of urea.	IARC (2013); HSDB (2003); OECD (1996); US EPA (2005).
Mutagenicity/Genotoxicity Mutagenicity/genotoxicity assays were a mixture of positive and negative results. Positive results were obtained with high urea concentrations.	JECFA (1993); OECD (1996).
Reproductive Toxicity The studies cited under repeated dose toxicity did not indicate any toxic effects on the reproductive organs of mice and rats.	OECD (1996).

Developmental Toxicity/Teratogenicity No adequate mammal studies available.	OECD, (1996).
Endocrine Disruption NDF.	All proposed data sources.
Neurotoxicity NDF.	All proposed data sources.
Acute Toxicity (oral, dermal, inhalation) Adverse reactions in humans include headache, nausea, vomiting, syncope, disorientation, transient confusion and electrolyte depletion (hyponatraemia). High urea levels will produce diuresis. Urea causes little to no toxicity in most mammalian species (including humans) with the exception of ruminants. It is general recognized as safe (GRAS) by the US Food and Drug Administration (formulation/fermentation aid in yeast -raised bakery products, alcoholic beverages, and gelatin products) and was declared safe for use in cosmetics by the Cosmetic Ingredient Review Panel. No toxic effects were found in humans if the blood urea-nitrogen was below 45 mg/100 ml (approx. blood urea of 96 mg/100 ml). Loss of appetite, nausea and vomiting developed at about 70 mg/100 ml (approx. blood urea of 150 mg/100 ml). In ruminants unaccustomed to urea, ingestion of 0.3-0.5 g urea/kg may be toxic .The toxic dose of urea in (presumably unaccustomed) cattle is 0.45 g/kg (50 g total dose) but that animals can ingest more urea than this if the dose is increased gradually. Lambs given 2 g/kg of urea died in 90-200 min while adult sheep given the same dose exhibited almost continuous convulsions after 165 minutes. Oral administration of 50 g of urea killed 4 out of 5 goats within 30 minutes. Single doses of 16 g/kg body weight and 10% of urea in the feed have been reported to have no apparent effect on ten week old piglets. Administration of 450 g of urea, which caused the death of seven of eight ponies, resulted in an increase in blood urea, ammonia, alpha-ketoglutarate, glucose and pyruvate concentrations. In sheep and cattle, clinical effects, included pronounced muscle fasciculation, trembling, grinding teeth, dysrhythmias, ataxia, lateral, recumbency, anuria, dry mouth, frothy salivation, dyspnea, bloating, abdominal pain, regurgitation, hyperesthesia, mydriasis and convulsions. The primary cause of death was respiratory arrest. Laboratory examination showed increased glucose, ammonia and urea levels. Massive occupational exposure to carbamide (urea) produced chronic respiratory insufficiency in one adult. Concentrations under 50% are not likely to cause tissue damage.	HSDB (2003); Hall and Rumack (2013); Andersen (2005); JECFA (1993); US FDA (2013); OECD (1996).
Chronic/repeat dose toxicity (oral, dermal, inhalation) NDF	-
Sensitisation of the skin or respiratory system Urea causes redness and irritation of skin and eyes. However, it was also reported by OECD to be a component (10% or less) of hand creams or ointments to treat dry skin.	HSDB (2003); OECD, (1996).
Corrosion (irreversible and reversible)/irritation of the skin or eye Urea causes redness and irritation of skin and eyes.	HSDB (2003)
Flammable Potential Not flammable but when heated to decomposition it emits toxic fumes of nitrogen oxides.	HSDB (2003)
Explosive Potential Not at STP and in isolation. Should urea nitrate be formulated this is highly explosive. Reacts with sodium hypochlorite or calcium hypochlorite to form the explosive nitrogen trichloride. Reacts violently with gallium perchlorate.	HSDB (2003)

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
LC_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Sheep, oral	510 mg/kg	OECD (1996)
Rat, oral	8471 mg/kg	HSDB (2003)
Rat, subcutaneous	8200 mg/kg	HSDB (2003)
Rat, iv	5300 mg/kg	HSDB (2003)
Rat, subcutaneous	9200 mg/kg	HSDB (2003)
Rat, iv	4600 mg/kg	HSDB (2003)
LOAEL	NDF	-
LD_{100}		
Sheep	500 mg/L	HSDB (2003)
LC_{50}		
Rat	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEL	NDF	-

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	Not classified by IARC. (IARC, 2013). Data inconclusive (HSDB, 2003; US EPA, 2005).
Mutagenicity/Genotoxicity	Inconclusive	Assays had mixed results (negative and positive).
Reproductive Toxicity	No	OECD (1996)
Developmental Toxicity/ Teratogenicity	NDF	-
Endocrine Disruption[1]	NDF	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	-	-
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	-
Corrosive (irreversible damage)	No	OECD (1996)
Respiratory sensitiser	No	OECD (1996)
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	NDF	-
Skin Sensitiser	No	OECD (1996)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	Yes	510 mg/kg (sheep)
Irritant (reversible damage)	Eye and skin irritant	HSDB (2003)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	-

Explosive potential	No	Not in isolation. If formulated to urea nitrate highly explosive. May react with sodium hypochlorite or calcium hypochlorite to form the explosive nitrogen trichloride. Reacts violently with gallium perchlorate.
Hazard Evaluation (highest band) not including physical hazards	**Band 1**	Eye and skin irritant, low toxicity.
Uncertainty analysis /data confidence	14 parameters, 10/14 x 100 =	**71%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3	HSDB (2003)
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	SCEW (2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	SCEW (2013)
Soil, commercial/industrial	NDF	SCEW (2013)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF - No data found within the limits of the search strategy.

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Qualifying Summary Comments

Urea has a hazard rating of 1 based primarily on it low acute toxicity and potential for reversible irritant effects to the skin and eyes. It is excreted from the body following protein and amino acid metabolism with the human body tolerating elevated blood urea concentrations based on clinical evaluations with exposure generally associated with plant food and meat. As urea has not been extensively examined there are difficulties in identifying No-Observed-Adverse-Effect Levels and further issues with the reliability of reproductive and developmental toxicity studies. OECD (p6, 1996), however, report that "*chronic toxicity and carcinogenicity screening studies of urea in diet with mice and rats suggested that the NOAELs are of the order 2000-6000 mg/kg body weight/day*" and *"in a human female patient ingestion of 470 mg/kg body weight/day of urea over 5 years did not cause adverse effects.*" Furthermore clinical experience suggests much higher dose levels have resulted in limited or no adverse effects. OECD (1996) considers urea of low current concern.

Taking this into account and the potential dilution of urea in the fracturing operations and the rapid expected biodegradation in the environment, it is considered that the environmental health concerns are expected to be limited. Should ammonia be generated it is expected these will dilute rapidly in ambient air.

It is not flammable and explosive in isolation, however, incompatibilities should be noted, particularly if urea nitrate is formed which is highly explosive.

Hazards are thus primarily limited to occupational exposures. As a powder it may result in contact and inhalation exposures in occupational settings which may lead to irritant respiratory, skin and eye effects while inhalation of aerosols from urea melt and saturated solutions including eye or skin splashing should be risk managed. In confined environments should ammonia be generated these should be well ventilated.

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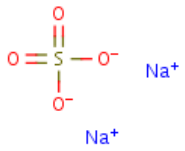
Created by:	**MER**	Date: **27/06/2013**
Reviewed and edited by:	**LT**	Date: **01/07/2013**

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Name	Sodium Sulphate
Synonyms	Disodium sulphate, Disodium mono-sulphate
CAS number	7757-82-6
Molecular formula	Na_2SO_4
Molecular Structure	

Overview	References
Sodium sulphate is used as a saline laxative and antihypercalcaemic in medical and veterinary settings. It is found as an odourless white power or crystals with a bitter taste. It is an ingredient in pharmaceuticals; an additive in foods and a laboratory reagent. In manufacturing, it is used in the production of kraft or brown paper, detergents and glass. It is an odourless hydroscopic white solid in the form of powder or crystals. It is approved as a direct food additive in chewing gum base. It occurs in nature in alkali lakes, groundwater and sea water as well as in minerals such as mirabilite and thenardite. Sulphates are found in all body cells and play a role in several important metabolic pathways. Sodium sulphate may persist indefinitely in the environment and does not show bioaccumulation or food chain contamination effects. Sodium sulphate falls into a class of compounds called saline laxatives along with citrate, sulfate, and tartrate salts of potassium or sodium. In small doses, near complete absorption occurs and excretion occurs mainly in the urine. High dietary doses may result in a cathartic or laxative effect. In cases of mild to moderate toxicity from saline laxatives, patients experience nausea, vomiting, and diarrhea associated with abdominal cramping. Due to poor gastrointestinal absorption, systemic toxicity is unlikely unless massive amounts have been ingested. Severe toxic effects may include dehydration, hypotension, hypernatraemia, and electrolyte abnormalities. Toxicity from overdose is rare in humans. No epidemiology studies have identified an association between sodium sulfate exposure and development of cancer. The International Agency for Research on Cancer (IARC) has not classified the carcinogenic potential of sodium sulphate. The United States Environment Protection Agency (US EPA) has stated that sodium sulphate is not classifiable as to its carcinogenic potential due to inadequate data.	HSDB (2002); IPCS (2012); US FDA (2013); Hall and Rumack (2013); US EPA (2013); OECD (2007).

Human Health Toxicity Summary	Reference
Carcinogenicity No reported effects. Not classified by IARC. Unlikely to be carcinogenic due to abundance in human body.	Hall and Rumack (2013); IARC (2013); OECD (2007).
Mutagenicity/Genotoxicity No data found apart from a negative Ames test.	OECD (2007).
Reproductive Toxicity The magnesium sulphate, potassium sulphate, and sodium sulphate combination is classified as pregnancy category C (Animal reproduction studies have shown an adverse effect on the fetus and there are no adequate and well-controlled studies in humans). INCHEM reports that data is limited and due to abundance in body, sodium sulphate is unlikely to exhibit reproductive toxicity.	HSDB (2002); OECD (2007).
Developmental Toxicity/Teratogenicity Of Kraft pulp mill waste constituents, sodium sulphate was the least toxic constituent to Gambusia affinis (fish) in one study. No human data available.	HSDB (2002).
Endocrine Disruption NDF	All proposed data sources.
Neurotoxicity NDF	All proposed data sources.
Acute Toxicity (oral, dermal, inhalation) Acute oral exposure of humans to water with sulphate concentrations above 500 mg/L may result in gastrointestinal irritation (laxative effects). This is the only known acute oral effect in humans. Sulphate levels of 7000 mg/L resulted in weight loss in cattle. Rats were not harmed by 15,000 mg/L. Poultry mortality was 33% after drinking water containing 7500 mg/L sodium sulphate for 15 days. Excessive absorption of sodium may aggravate congestive heart failure. When guinea pigs were dosed for 1 hour with aerosols various sodium salts, all with the exception of sodium sulphate caused pulmonary effects. Overdosed pigs exhibited nervous signs, twitching, tremors and convulsions and in post-mortem examinations exhibited widespread vacuolation and necrosis of the cerebral cortex. The sodium concentration of cerebrospinal fluid was in some cases higher than normal. The condition was reproduced experimentally by drenching 8 week old pigs with 50 g anhydrous sodium sulphate daily for 3 days and restricting their water supply. When the bronchial tree of rabbits was examined after 1 hour oral inhalation exposures to sub-micrometer aerosols of sodium sulphate, no significant effects were observed with sodium sulphate at levels up to approximately 2000 micrograms/m^3. In a human inhalation study with an aerosol, no adverse effects were found at 10 mg/m^3. Respiratory irritation has never been reported. Human clinical experience indicates that very high oral doses of sodium sulphate, 300 mg/kg bw up to 20 grams for an adult, are well tolerated.	HSDB (2002); Hall and Rumack (2013); OECD (2007).

Chronic/repeat dose toxicity (oral, dermal, inhalation) Workers from surface sodium sulphate mines measured for lung function, serum sulphate, calcium and electrolytes showed no abnormalities that could be related to occupational exposure.	HSDB (2002).
Sensitisation of the skin or respiratory system Based on wide practical experience with sodium sulphate, in combination with the natural occurrence of sulfate in the body, sensitising effects are highly unlikely.	OECD (2007).
Corrosion (irreversible and reversible)/irritation of the skin or eye Non-irritating to the skin. Slight irritating to the eyes.	OECD (2007).
Flammable Potential Not flammable but when heated in fire, may emit toxic fumes of sulphur oxides	HSDB (2002).
Explosive Potential Not explosive in isolation. Sodium sulphate reacts violently with magnesium. Will explode when mixed with aluminium and heated to a temperature of 800°C.	HSDB (2002).

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
LC_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Mouse, oral	5989 mg/kg	OECD (2007)
Rabbit, percutaneous	>4.0 g/kg	HSDB (2002)
Rat, dermal	NDF	-
LOAEL	NDF	-
LOAEC Rat (Sprague-Dawley)	>10 mg/m^3	OECD (2007)
LC_{50}		
Rat	NDF	-
High Chronic/Repeat Dose Toxicity		
NOAEL Rat (Sprague-Dawley)	2000 mg/kg/d	OECD (2007)
LOAEL	NDF	-

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	Not classified by IARC. Unlikely to be carcinogenic (IPCS).
Mutagenicity/Genotoxicity	No	No data found apart from a negative Ames test.
Reproductive Toxicity	No	Data are limited but toxicity unlikely due to abundance in body.
Developmental Toxicity/ Teratogenicity	No	One fish study reports low toxicity.
Endocrine Disruption[1]	NDF	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic • oral LD_{50} ≤ 300 mg/kg[3] • dermal LD_{50} ≤ 1000 mg/kg • inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	Lower acute toxicity observed.
High Chronic/repeat dose toxicity • oral LOAEL ≤ 10 mg/kg/d[3]; • dermal LOAEL ≤ 2 0 mg/kg/d; • inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	Lower acute toxicity observed.
Corrosive (irreversible damage)	NDF	-
Respiratory sensitiser	NDF	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity • oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d • dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d • inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	No	Oral NOAEL reported in Sprague-Dawley rats of 2000mg/kg/d (OECD, 2007)
Skin Sensitiser	No	OECD (2007)
Hazard Band 1		
Acute Toxicity-Harmful • oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg • dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; • inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Has not been reliably established but is likely above 5000 mg/kg. (OECD, 2007)
Irritant (reversible damage)	Slight eye irritant	OECD (2007)

Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**	Yes	
Physical Hazards		
Flammable potential	No	-
Explosive potential	Not at STP and without additional substances.	Only via incompatibilities - sodium sulphate reacts violently with magnesium. Will explode when mixed with aluminium and heated to a temperature of 800°C.
Hazard Evaluation (highest band) not including physical hazards	**Band 0**	Limited toxicological impact potential
Uncertainty analysis /data confidence	14 parameters, 10/14 x 100 =	**71%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	10 mg/m^3	OECD (2007)
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Food	453 mg/person (in US)	OECD (2007)
Water, potable	NDF	SCEW (2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	SCEW (2013)
Soil, commercial/industrial	NDF	SCEW (2013)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

Sodium sulphate exhibits a Hazard Band Rating of 0 based on its limited toxicity. Although there are some data gaps and some studies have been considered to reflect poor validity, the overall concensus is that the "*weight of evidence, combined with previous assessments of both the sodium ion and sulfic ions lead to the conclusion that the identified data gaps need not necessarily be filled*" and that "*the chemical is of low priority for further work due to its low hazard profile*". (OECD, 2007 pp4-5).

It is not flammable and explosive (in isolation) but as a powder it may result in contact and inhalation exposures in occupational settings which may lead to adverse respiratory and dermal effects. These should be managed through the usual occupational health management protocols. In the environmental setting its solubility will result in dilution and as a neutral salt it will not result in a change of the aqueous pH that may subsequently influence aqueous environments such as aquifers.

References

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Created by:	**MER**	Date: **27/06/2013**
Reviewed and edited by:	**LT**	Date: **28/06/2013**

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Name	Ammonium Sulphate
Synonyms	Ammonium sulphate plus various trade names
CAS number	7783-20-2
Molecular formula	$H_8N_2O_4S$
Molecular Structure	

Overview	References
Ammonium sulphate has a wide variety of uses and applications including as a lawn insecticide/herbicide, fertilizer, in cattle feed, in fire extinguisher agents, insulation, metal production and as a wood curing agent. It is also used as a nutrient for organisms in the pharmaceutical industry, dye bath additive, in wadding and wicks, as a body wash, in cleaning agents and disinfectants, and as an agent for caramel food colouring. Ammonium sulphate occurs as white or brown orthorhombic crystals at room temperature. It is an odourless compound with a high melting point and is stable at room temperature (HSDB 2011). In aqueous media, ammonium sulfate dissociates to form the ammonium and sulfate ions which are taken up by the body via the oral or respiratory routes. It is of relatively low toxicity. No epidemiology studies have identified an association between ammonium sulphate exposure and development of cancer. The International Agency for Research on Cancer (IARC) has not classified the carcinogenic potential of ammonium sulphate.	HSDB (2011); OECD (2007); US FDA (2013); IARC (2013).

Human Health Toxicity Summary	Reference
Carcinogenicity Two human studies found no relationship between ammonium sulfate and increased occurrence of cancer. In three rat studies and one hamster study, no carcinogenic effects were observed.	HSDB (2011).
Mutagenicity/Genotoxicity Ammonium sulfate was not mutagenic in bacteria (Ames test) and yeasts with and without metabolic activation systems. It did not induce chromosomal aberrations in mammalian or human cell cultures. No in-vivo genotoxicity tests are available.	HSDB (2011).
Reproductive Toxicity Fertility toxicity studies with ammonium sulfate are not available for humans. . In a 13-week feeding study of ammonium sulfate in rats, no histological changes of testes were observed.	HSDB (2011).
Developmental Toxicity/Teratogenicity Developmental toxicity studies with ammonium sulfate are not available for humans. In a screening teratogenicity study in chickens, ammonium sulfate injected into the air cells of eggs caused no developmental abnormalities	HSDB (2011).
Endocrine Disruption NDF.	All proposed data sources.

Neurotoxicity NDF.	All proposed data sources.
Acute Toxicity (oral, dermal, inhalation) Exposure through inhalation at concentrations of 1 mg ammonium sulfate/m^3 was observed in three studies on humans. In one study after 120 minutes at this concentration, healthy volunteers had pulmonary flow resistance and decreased dynamic lung compliance. The two other studies had conflicting results. Both studies exposed healthy and asthmatic individuals for 16 minutes, but in one study the healthy subjects had a significant effect on respiratory flow with no effect seen for the asthmatics and in the other study the opposite was observed. In the nine other studies reported for humans exposures, concentrations below 0.7 mg/m^3 produced no toxic effects were observed. Acute effects noted in animal studies (rats and cows) have included staggering, prostration, apathy and laboured and irregular breathing. In rabbit's exposure to high concentrations decreased mucociliary clearance, convulsions, respiratory failure and cardiac arrest were observed. In humans exposed to water polluted with ammonium sulfate, acute stomach pains resulted and male rats exposed to high levels in food experienced diarrhea.	HSDB (2011).
Chronic/repeat dose toxicity (oral, dermal, inhalation) Rats exposed to high concentrations via inhalation for four or eight months developed increased alveolar fibrosis and increased emphysema, however, the effect was only mild and transient. A 14-day inhalation study on rats exposed to 300 mg/m^3 (the only tested dose), did not report histo-pathological changes in the lower respiratory tract. As the respiratory tract is the target organ for inhalation exposure, the NOEL for toxicity to the lower respiratory tract was reported as 300 mg/m^3. The NOAEL after feeding diets containing ammonium sulfate for 13 weeks to rats was 886 mg/kg bw/day. The only toxicity observed was diarrhea in male animals of the high-dose group (LOAEL, 1792 mg/kg).	IHCP (2013); OECD (2007).
Sensitisation of the skin or respiratory system NDF.	All proposed data sources.
Corrosion (irreversible and reversible)/irritation of the skin or eye The substance is potentially irritating to the eyes and skin although in a couple of experiments, neat ammonium sulfate was not irritating to the intact skin of rabbits after various exposure regimes. Exposure to the eyes of rabbits, however, while causing slight irritation (redness), was reversible on cessation of exposure.	HSDB (2011).
Flammable Potential Not flammable.	IHCP (2013).
Explosive Potential Not explosive.	IHCP (2013).

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
LC_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Mouse (ip)	610 mg/kg	HSDB (2011)
Mouse (oral)	640 mg/kg	HSDB (2011)
Rat (oral)	2,840 mg/kg	HSDB (2011)
Rat (NS)	4,250 mg/kg	IHCP (2013)
Rat (NS)	>2000 mg/kg	IHCP (2013)
Rat (NS)	3000-4000 mg/kg	IHCP (2013)
NOAEL	NDF	-
LC_{50}		
Rat	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEL (Rats)	886 mg/kg	OECD (2007)

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	No	HSDB (2011)
Mutagenicity/Genotoxicity	No	Not mutagenic in Ames test. No genotoxic data available (HSDB 2011)
Reproductive Toxicity	NDF	-
Developmental Toxicity/ Teratogenicity	No	No effects in animals. No human data (HSDB 2011)
Endocrine Disruption[1]	NDF	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic oral LD_{50} ≤ 300 mg/kg[3] dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m^3) (vapour)	No	HSDB(2011)
High Chronic/repeat dose toxicity oral LOAEL ≤ 10 mg/kg/d[3]; dermal LOAEL ≤ 2 0 mg/kg/d; inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	No	HSDB(2011)
Corrosive (irreversible damage)	No	HSDB(2011)
Respiratory sensitiser	NDF	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes [4]	No	HSDB(2011)
Skin Sensitiser	NDF	-
Hazard Band 1		
Acute Toxicity-Harmful oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	Yes	Mouse (oral) = 640 mg/kg (HSDB 2011)
Irritant (reversible damage)	Yes	Slight eye and skin irritant HSDB (2011)
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	No	IHCP (2013)
Explosive potential	No	IHCP (2013)
Hazard Evaluation (highest band) not including physical hazards	**Band 1**	Acute toxicity and irritation

Uncertainty analysis /data confidence	14 parameters, 9/14 x 100 =	**64%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

"[1]*Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	All proposed data sources
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	SCEW (2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	SCEW (2013)
Soil, commercial/industrial	NDF	SCEW (2013)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF - No data found within the limits of the search strategy.

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Qualifying Summary Comments

Ammonium sulphate exhibits a Hazard Band Rating of 1 based on its low acute toxicity and reversible irritant properties. It is not flammable and it is not explosive. While there are some limitations in the toxicological literature (fertility and developmental toxicity) due to its ready dissociation into the component ions, ammonium and sulphate, analogies have been drawn with studies of ammonium ions and sulphate ions which support a lack of fertility and developmental effects. High doses in humans following ingestion result in gastro-intestinal disturbances while limited respiratory effects are observed even at inhalation concentrations of 1mg/m^3 in humans. Ammonium sulphate is "*generally recognized as safe (GRAS)"* and approved as a food additive in the U.S. and in Europe.

Ammonium sulphate would dissociate rapidly in solution following environmental introduction and be subject to dilution and chemical transformation. Any transformation into nitrate may warrant closer attention due to potential impacts on drinking water supplies.
The main immediate hazard is associated with worker exposures to dusts during production and storage of fracturing fluids and loading and unloading of trucks. As a powder it may result in contact and inhalation exposures in occupational settings which can lead to adverse irritant respiratory and dermal effects. These exposures should be managed through occupational health risk measures.

References

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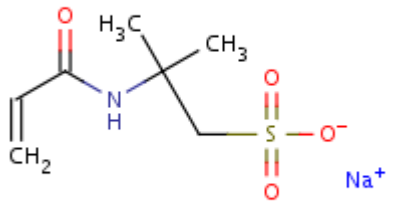
Created by:	**MER**	Date: **28/06/2013**
Reviewed and edited by:	**LT**	Date: **01/07/2013**

Project number: 127635006
Project name: Hydraulic Stimulation Chemicals Assessment, Bowen Basin CSG Wells
Client name: QGC Limited

Name	2-Acrylamido-2-methylpropanesulfonic acid, sodium salt (Surrogate for 1-Propanesulfonic acid,2-methyl-2-[(1-oxo-2-propen-1-yl)amino]-,sodium salt (1:1),homopolymer)
Synonyms	-
CAS number	5165-97-9, surrogate for 35641-59-9 (the monomer)
Molecular formula	$C_7H_{12}NNaO_4S$
Molecular Structure	

Overview	References
2-Acrylamido-2-methylpropane sulfonate, sodium salt (Na-AMPS) is available as a crystalline solid or as an aqueous salt solution. This chemical is the monomer for Poly-AMPS. Poly-AMPS has limited available reference data. AMPSs (comprising sodium and ammonium salts of AMPS as well as the sulfonic acid) are prepared by reacting acrylonitrile, isobutylene, and oleum in the presence of water. The reactive sites on the monomer are the unsaturated vinyl group and the terminal sulfonic acid. The three members of the AMPS category (Na-AMPS, ammonia-AMPS, and AMPS-acid) are virtually homologous, characterized by a 2-acrylamido-2-methylpropanesulfonic parent anion, distinct only by the corresponding H+, Na+ or NH4+ counter-ion (Lubrizol Corp, 2000). While the only use of Na-AMPS as a monomer is, in a derivatised form, as a surfactant in fire-fighting foams, there are several thousand patents and publications involving use of poly-AMPS. These cover many areas including water treatment, oil field, construction chemicals, for medical applications, personal care products, emulsion coatings, adhesives, and rheology modifiers. The sodium and ammonium salts of AMPS monomer are prepared as 50% aqueous solutions. AMPS monomers are highly reactive and hydrophilic. AMPS monomers are primarily used for the preparation of high molecular weight water-soluble polymers. The monomers can be polymerized in solution using conventional vinyl moiety polymerization. No epidemiology studies have identified an association between the three AMPS monomers exposure and development of cancer. The International Agency for Research on Cancer (IARC) has not classified the carcinogenic potential of Na-AMPS or its polymer.	US EPA (2009); IARC (2013); Lubrizol Corp (2000).

Human Health Toxicity Summary	Reference
Carcinogenicity Not classified by IARC.	IARC (2013).
Mutagenicity/Genotoxicity Four mutagenic assays on similar compound (ammonium salt of AMPS) were negative. For similar compound (AMPS-acid), two negative results and one inconclusive result were obtained from genetic toxicity tests.	US EPA (2009).
Reproductive Toxicity In a combined reproductive/developmental toxicity screening test, CASRN 58374-69-9 (supporting chemical- ammonium salt) showed no evidence of systemic, reproductive, maternal, or developmental toxicity following oral exposure in rats; the NOAEL was 1000 mg/kg-bw/day (highest dose tested).	US EPA (2009); Lubrizol Corp (2000).
Developmental Toxicity/Teratogenicity In a combined reproductive/developmental toxicity screening test, CASRN 58374-69-9 (supporting chemical – ammonium salt) showed no evidence of systemic, reproductive, maternal, or developmental toxicity following oral exposure in rats; the NOAEL was 1000 mg/kg-bw/day (highest dose tested).	US EPA (2009); Lubrizol Corp (2000).
Endocrine Disruption NDF.	All proposed data sources.
Neurotoxicity NDF.	All proposed data sources.
Acute Toxicity (oral, dermal, inhalation) When administered to Sprague-Dawley rats in dosages ranging from 1000-8000 mg/kg, no unscheduled deaths were recorded and no unusual clinical or behavioral signs were observed. Animals receiving 16000 mg/kg appeared ruffled and lethargic within 3-4 hours of test material administration. All animals appeared normal by day 5.	US EPA (2013).
Chronic/repeat dose toxicity (oral, dermal, inhalation) No effects were seen in Sprague-Dawley rats exposed to similar compound ammonia-AMPS at up to 1000 mg/kg-bw/day 7 days/week for 28 days.	US EPA (2009).
Sensitisation of the skin or respiratory system NDF.	All proposed data sources.
Corrosion (irreversible and reversible)/irritation of the skin or eye Slight erythema was seen in New Zealand albino rabbits exposed to similar compound ammonia-AMPS at 2000 mg/kg-bw for 24 hours. The dermal irritation subsided after day 11.	All proposed data sources.
Flammable Potential NDF.	All proposed data sources.
Explosive Potential NDF.	All proposed data sources.

Toxicity Values	Value	Reference
Human Toxicity Data		
Acute Toxicity		
LD_{50}	NDF	-
LC_{50}	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEC	NDF	-
Animal Toxicity Data		
Acute Toxicity		
LD_{50}		
Rats (oral)	> 16000 mg/kg	US EPA 2009
LD_{100}		
	NDF	-
LC_{50}		
	NDF	-
High Chronic/Repeat Dose Toxicity		
LOAEL/NOAEL	1000 mg/kg/day	US EPA 2009

Footnotes:
LD_{50} – lethal dose for 50% of experimental population
LC_{50} – lethal air concentration for 50% of experimental population
LOAEL – Lowest Observed Adverse Effect Level
LOAEC – Lowest Observed Adverse Effect Concentration
NOAEL – No-Observed-Adverse-Effect-Level

Human Health Toxicity Ranking*		
	Hazard data	**Comment**
Hazard Band 4		
Carcinogenicity	NDF	-
Mutagenicity/Genotoxicity	No	US EPA (2009).
Reproductive Toxicity	No	US EPA (2009; Lubrizol Corp (2000). Based on analogous ammonium salt.
Developmental Toxicity/ Teratogenicity	No	US EPA (2009; Lubrizol Corp (2000). Based on analogous ammonium salt.
Endocrine Disruption[1]	NDF	-
Neurotoxicity[2]	NDF	-
Hazard Band 3		
Acute Toxicity (oral, dermal or inhalation) Very Toxic/Toxic oral LD_{50} ≤ 300 mg/kg[3] dermal LD_{50} ≤ 1000 mg/kg inhalation LC_{50} ≤ 10 mg/L[4] (or mg/m[3]) (vapour)	No	Oral LD_{50} in rats >16,000 mg/kg body weight. For similar compounds AMPS-acid, oral LD_{50} in rats 1,830 mg/kg body weight. US EPA (2009; Lubrizol Corp (2000).
High Chronic/repeat dose toxicity oral LOAEL ≤ 10 mg/kg/d[3]; dermal LOAEL ≤ 2 0 mg/kg/d; inhalation LOAEC (6 h/d) ≤ 50 ppm/d for gases, ≤ 0.2 mg/L/d for vapours or ≤ 0.02 mg/L/d for dust/mists/fumes[4]	NDF	-
Corrosive (irreversible damage)	NDF	-
Respiratory sensitiser	NDF	-
Hazard Band 2		
Harmful chronic/repeat dose toxicity oral LOAEL > 10 mg/kg and ≤ 100 mg/kg/d dermal LOAEL > 20 mg/kg/d and ≤ 200 mg/kg/d inhalation (6-h/d) LOAEC > 50 mg/L ≤ 250 mg/L/d for gases, > 0.2 mg/L ≤ 1 .0 mg/L/d for vapours or > 0.02 mg/L ≤ 0.2 mg/L/d for dust/mists/fumes[4]	No	Oral NOAEL of 1000 mg/kg/day. US EPA (2009). Based on supporting chemical.
NDF	NDF	-

Hazard Band 1		
Acute Toxicity-Harmful oral LD_{50} > 300 mg/kg ≤ 2000 mg/kg dermal LD_{50} >1 000 mg/kg ≤ 2000 mg/kg; inhalation LC_{50} (6 h/d) > 10 mg/L ≤ 20 mg/L for vapours)[4]	No	Oral LD_{50} in rats >16,000 mg/kg body weight. For similar compounds AMPS-acid, oral LD_{50} in rats 1,830 mg/kg body weight.
Irritant (reversible damage)	Yes	US EPA (2009; Lubrizol Corp (2000).
Hazard Band 0 **All indicators outside criteria listed in Hazards 1-4**		
Physical Hazards		
Flammable potential	NDF	-
Explosive potential	NDF	-
Hazard Evaluation (highest band) not including physical hazards	**Band 0**	Low toxicity implied by available data.
Uncertainty analysis /data confidence	14 parameters, 6/14 x 100 =	**43%**

* Based on IMAP Framework [NICNAS (2013) Inventory Multi-tiered Assessment and Prioritisation (IMAP) Framework. National Industrial Chemicals Notification and Assessment Scheme. Department of Health and Aging, Canberra].

[1] *Based on list of endocrine disrupting chemicals from the European Commission's Endocrine Disrupters website.*

[2] *Based on list of neurotoxic chemicals from US Agency for Toxic Substances and Disease Registry (ATSDR).*

[3] *milligrams per kilogram body mass (mg/kg) or milligrams per kilogram body mass per day (mg/kg/d)*

[4] *Based on GHS cut-offs for hazard classification. For chronic/repeat dose toxicity, GHS cut-offs are provided as guidance values (i.e. the dose/concentration at or below which significant health effects are observed"). (p 18, NICNAS 2013).*

Human Health Guidelines		
Media	**Concentration (mg/m^3; mg/L; mg/kg)**	**Reference**
Occupational Exposure Limits		
Air (OEL)		
8-h TWA	NDF	All proposed data sources
STEL	NDF	All proposed data sources
Peak Limitation	NDF	All proposed data sources
Environmental Exposure		
Air, ambient	NDF	All proposed data sources
Air, indoor	NDF	All proposed data sources
Water, potable	NDF	NEPM (1999; amended 2013)
Water, recreational	NDF	All proposed data sources
Soil, residential	NDF	NEPM (1999; amended 2013)
Soil, commercial/industrial	NDF	NEPM (1999; amended 2013)

Footnotes:
OEL = Occupational Exposure Limit
TWA= 8 h Time-Weighted Average
STEL = (15 min) Short-term Exposure Limit
NDF - No data found within the limits of the search strategy.

Qualifying Summary Comments

2-Acrylamido-2-methylpropane sulfonate, sodium salt (Na-AMPS) exhibits a Hazard Band Rating of 1 based on limited data supporting a position of low acute and chronic toxicity in animal studies with some evidence of skin irritancy in rabbits. Although these data have been based on the monomer rather than the homopolymer it is expected that the homopolymer being water soluble would be subject to degradation and release of it monomeric units. It is noted the latter exhibit a low degree of biodegradation.

There are no data on its flammable or explosive potential but this would be expected to be low in aqueous solutions. Based on evidence of skin irritant properties occupational exposures should limit dermal contact through suitable transport and handling management methods.

References

IARC (2013). Agents Classified by the *IARC Monographs*, Volumes 1–107. Available at http://monographs.iarc.fr/ENG/Classification/ClassificationsAlphaOrder.pdf. [Accessed 26 June 2013].

Lubrizol Corporation (2000). Test Plan for AMPS category, August 1, 2000. Available at http://www.epa.gov/oppt/chemrtk/pubs/summaries/amps/c12958.pdf. [Accessed 28 June 2013].

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US EPA (2009). Hazard Characterization Document. Screening-Level Hazard Characterization AMPS® Category. Accessed 28 June 2013. Available at http://www.epa.gov/hpvis/hazchar/Category_AMPS_Sept2009.pdf. [Accessed 28 June 2013].

US EPA (2013) Aggregated Computational Toxicology Resource (ACToR) database. Chemical: sodium 2-methyl-2-[(1-oxoallyl)amino]propanesulphonate. [Accessed 28 June 2013].

Created by:	**MER**	Date: **28/06/2013**
Reviewed and edited by:	**LT**	Date: **01/07/2013**

APPENDIX B

Chemical information sheets

Project number: 127635006

ORGANIC

Name	Urea
Synonyms	Aquadrate, Carbamide, Isourea, Pseudourea, Urevert
CAS Number	57-13-6
Molecular Formula	CH4N2O

Physical Properties	Value	Reference
PhaseState:	Solid, white crystals or powder	HSDB 2012
Molecular Weight (g/mol):	60.06	HSDB 2012
Melting Point (°C):	132.70	HSDB 2012
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):	1.32	HSDB 2012
Vapour Pressure (mm Hg at 25°C):	0.000012	HSDB 2012
Solubility (mg/L):	545,000.00	HSDB 2012
Henry's Law Constant (atm m³/mole):	0.00000000000174	HSDB 2012
Organic carbon partition coefficient (Koc):	8.00	HSDB 2012
Log organic carbon partition coefficient (log Koc):	0.90	HSDB 2012
Log octanol - water partition coefficient (log Kow):	-2.11E+00	HSDB 2012

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):	3.0665	EPISUITE 2011 v4.1
Biowin 4 (Primary Biodegradation):	3.7611	EPISUITE 2011 v4.1
EPISUITE Ready Biodegradability:	Biodegrades fast	EPISUITE 2011 v4.1
Biowin 7 (Anaerobic Model Prediction):	0.8361	
Fugacity_Air: (%)	0.0000394	EPISUITE 2011 v4.1
Fugacity_Water: (%)	35	EPISUITE 2011 v4.1
Fugacity_Soil: (%)	64	EPISUITE 2011 v4.1
Fugacity_Sediment: (%)	0.0696	EPISUITE 2011 v4.1
Bioconcentration factor (BCF):	3.162	EPISUITE 2011 v4.1
Biotransformation half - life (Days):	0.0002544	EPISUITE 2011 v4.1

Project number: 127635006

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Colisa fasciata	Giant Gourami	Fish LC50	Mortality	Mortality	4	5	ECOTOX 2012
Daphnia magna	Water flea	Invertebrate LC50	Intoxication	Imobilization	2	3910	ECOTOX 2012

Chronic toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Biomphalaria alexandrina	Snail	Invertebrate NOEC	Reproduction	Progeny Counts/Number	14	100	ECOTOX 2012
	Green algae	Plant EC50			4	6031.6	ECOSAR 2012

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Earthworm	1	Mortality	Mortality	14	244.03	ECOSAR 2012	

Created By: Naomi Cooper Date: 26/06/2013

Checked By: Kirsten Broadgate Date: 28/06/2013

Name	Sodium Sulphate
Synonyms	Bisodium sulphate, disodium monosulfate, disodium sulphate,
CAS Number	7757-82-6
Molecular Formula	H2O4S2Na

Physical Properties	Value	Reference
PhaseState:	White powder or orthorhombic bipyramid crystals	HSDB 2011
Molecular Weight (g/mol):	142.06	HSDB 2011
Melting Point (°C):	888.00	HSDB 2011
Boiling Point (°C):	890	IUCLID 2000a
Solubility (mg/L):	190,000.00	OECD SIDS 2005

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline	Sodium salt of sulphuric acid	IUCLID 2000a
pH (10% solution)		

Aquatic Ecotoxicological Data

Acute toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Hyalella azteca	Scud	Invertebrate LC50	Mortality	Mortality	4	512	ECOTOX 2011
Pimephales promelas	Fathead minnow	Fish LC50	Mortality	Mortality	7	1355.48	ECOTOX 2012

Chronic toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Navicula seminulum	Diatom	Plant EC50	Population	Population growth rate	4	1900	ECOTOX 2011
Pimephales promelas	Fathead minnow	Fish NOEC	Growth	Weight	7	220	ECOTOX 2011
Ceriodaphnia dubia	Water flea	Invertebrate NOEC	Reproduction	Progeny counts	7	780	ECOTOX 2011
Pseudokirchneriella subcapitata	Green algae	Plant NOEC	Population	Abundance	3	1060	ECOTOX 2011
Pimephales promelas	Fathead minnow	Fish LOEC	Growth	Weight	7	220	ECOTOX 2011

ceriodaphnia dubia	Water flea	Invertebrate LOEC	Reproduction	Progeny counts	7	899	ECOTOX 2011
pseudokirchneriella subcapitata	Green algae	Plant LOEC	Population	Population	14	3000	ECOTOX 2011

Project number: 127635006

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Mouse	Mammalian LD50	Mortality	Mortality		193 mg/kg bw	IUCLID 2012	

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 28/06/2013

Project number: 127635006

ORGANIC

Name	2 - acrylamido-2-methylpropanesulfonic acid (Surrogate for)
Synonyms	
CAS Number	5165-97-9 (Surrogate for)
Molecular Formula	C7H12NNaO4S

Physical Properties	Value	Reference
PhaseState:	Solid	USEPA 2009
Molecular Weight (g/mol):	229.23	USEPA 2009
Melting Point (°C):	260.35	USEPA 2009
Boiling Point (°C):		
Density / Specific Gravity (Enter Unit):		
Vapour Pressure (mm Hg at 25°C):	0.000000000000172	USEPA 2009
Solubility (mg/L):	1,000,000.00	USEPA 2009
Henry's Law Constant (atm m³/mole):	5.2E-15	USEPA 2009
Organic carbon partition coefficient (Koc):		
Log organic carbon partition coefficient (log Koc):		
Log octanol - water partition coefficient (log Kow):	-4.34E+00	USEPA 2009

Persistance / Bioaccumulation	Value	Reference
Biowin 3 (Ultimate Survey Biodegradation):		
Biowin 4 (Primary Biodegradation):		
EPISUITE Ready Biodegradability:		
Biowin 7 (Anaerobic Model Prediction):		
Fugacity_Air: (%)		
Fugacity_Water: (%)		
Fugacity_Soil: (%)		
Fugacity_Sediment: (%)		
Bioconcentration factor (BCF):		
Biotransformation half - life (Days):		

Project number: 127635006

ORGANIC

Aquatic Ecotoxicological Data

Acute toxicity data							
SpeciesName	**Common Name**	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc mg/L**	**Reference**
Lepomis macrochirus	Bluegill	Fish LC50	Mortality	Mortality	4	>1000	USEPA 2009
Daphnia magna	Cladoceran	Invertebrate EC50	Mortality	Mortality	2	>1000	USEPA 2009

Common Name	**Endpoint**	**Effect**	**Effect Measure**	**Test Time (Days)**	**Conc**	**Reference**	**Units**
Sprague-Dawley Rats	2	Mortality	Mortality	14	>16000	USEPA 2009	

Created By: Naomi Cooper Date: 2/07/2013

Checked By: Kirsten Broadgate Date: 2/07/2013

Name	Ammonium Sulphate
Synonyms	Diammonium sulfate, Dolamin, Mascagnite, Sulphuric acid - diammonium salt.
CAS Number	7783-20-2
Molecular Formula	H8N2O4S

Physical Properties	Value	Reference
PhaseState:	White or brown orthorhomic crystals	HSDB 2012
Molecular Weight (g/mol):	132.14	HSDB 2012
Melting Point (°C):	280.00	HSDB 2012
Boiling Point (°C):		
Solubility (mg/L):	76,700.00	HSDB 2012

Other Relevant Factors	Value	Reference
Reactivity		
Species:		
Reaction type:		
pH / Acidity		
acid / alkaline		
pH (10% solution)	5.5	HSDB 2012

Aquatic Ecotoxicological Data

Acute toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Ceriodaphnia dubia	Water flea	Invertebrate LC50	Mortality	Mortality	2	2.6	ECOTOX 2012
Oncorhynchus mykiss	Rainbow trout	Fish LC50	Mortality	Mortality	1	0.068	ECOTOX 2012

Chronic toxicity data

SpeciesName	Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc mg/L	Reference
Ceriodaphnia dubia	Water flea	Invertebrate LOEC	Reproduction	Reproduction, general	10	51	ECOTOX 2012

Project number: 127635006

INORGANIC

Terrestrial Ecotoxicological Data

Common Name	Endpoint	Effect	Effect Measure	Test Time (Days)	Conc	Reference	Units
Mouse	Mammalian LD50	Mortality	Mortality		610 mg/kg	IUCLID 2012	

Created By: Lisa Brookes Date: 31/07/2012

Checked By: Kirsten Broadgate Date: 28/06/2013

APPENDIX C

Important Information

IMPORTANT INFORMATION RELATING TO THIS REPORT

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