



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

## Appendix A HFS Scientific Inquiry Recommendations

Rec.	Description	Resp. Industry (I)	Relevance to the Proposal	Further information
		Govt. (G)		
1	The cumulative impacts of landscape clearing and fragmentation depend on scale and duration. Such impacts should be anticipated and assessed prior to development approval, with the eventual rehabilitation and restoration of redundant infrastructure clearing meeting the expectations of both regulators and the community.	I	<p>Clearing and fragmentation impacts are discussed and assessed, with anticipated mitigations, for the Flora and Vegetation, and Terrestrial Fauna preliminary key environmental factors.</p> <p>The scope of the Proposal is limited to an exploration and appraisal program within the Development Envelope. No industry / industrial presence or social receptors are present in this area. Subsequently, no additional cumulative impacts are present.</p>	<p>Sections 5.1.5 and 5.1.7</p> <p>Sections 5.3.5 and 5.3.7</p>
2	The Western Australian Government, in consultation with the community, should identify places of iconic natural heritage and exclude those places from future exploration and development for unconventional oil and gas associated with hydraulic fracture stimulation, sufficient to protect their values from direct development or by proximity to increased traffic, noise, light or visual impacts. These consultations should be a formal part of the process by which the Western Australian Government releases acreage for potential development.	G	In accordance with the proposed Iconic natural heritage places (Government of Western Australia 2019b), the Proposal is not located within any of the proposed iconic natural heritage places (Figure 5-18).	Section 5.5.3.4.1
3	Access to productive land should require an agreement with the Traditional Owners, landholder or leaseholder regarding the location, maintenance, operation and remediation of infrastructure, as well as compensation for residual damage to the subsequent productive use of the land.	I	<p>Stakeholder consultation with the relevant landowners has been undertaken and will continue throughout the Proposal during each phase of the activity.</p> <p>Land use agreements are in place with the Native Title groups relevant to the Proposal.</p>	<p>Section 3</p> <p>Section 5.5.3.3.1</p>
4	An early warning system based on a 'traffic light scheme' should be implemented to prevent adverse geo-mechanical events reaching a size of any consequence to land or hydrogeology.	I / G	At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020. BNR will comply with all regulatory requirements.	Table 5-25
5	That baseline and routine surveillance groundwater quality monitoring, including methane concentrations, should be included in an enforceable Code of Practice and results made publicly available before commencement of drilling operations and thereafter.	G	<p>At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.</p> <p>BNR have taken the approach of developing a detailed Referral supporting document that can be made public to support the level of assessment decision. This document includes a large amount of baseline data that has been collected over an extended period of time.</p>	Section 5.4.3



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			In accordance with the PGER(E) Regulations, the proponent is required to report on environmental performance of activities carried out under an Environmental Plan to DMIRS annually. The annual report includes a summary of, and the details of environmental monitoring conducted for the activity over the course of the year.	
6	<p>The regulations governing the use and assessment of chemicals associated with hydraulic fracture stimulation should be strengthened and clarified, specifically:</p> <ul style="list-style-type: none"> <li>All chemicals proposed for use must be approved for use in Australia. It should be the regulator's responsibility to check that all the proposed chemicals are listed on the Australian Inventory of Chemical Substances (AICS), Australian Pesticides and Veterinary Medicines Authority (APVMA), Therapeutic Goods Administration (TGA) or Food Standards Australia and New Zealand (FSANZ) inventories prior to approval being granted;</li> <li>That a ruling is sought from APVMA on the need to register biocides used for hydraulic fracture stimulation in Western Australia (in line with the existing ruling on the use of these chemicals in the extraction of coal seam gas);</li> <li>The use of Benzene, Toluene, Ethylbenzene and Xylene (BTEX) in drilling and hydraulic fracturing fluids should be banned;</li> <li>Chemicals that are known or suspected carcinogens, mutagens, developmental toxicants and endocrine disruptors should be identified as part of the information disclosed on chemicals. Use of chemicals with these properties should</li> </ul>	G	<p>The composition of the proposed HFS fluid system is included in Appendix J.</p> <p>Further to this, all chemicals associated with the final downhole fluid system, including their individual components and toxicity data, will be fully disclosed in a Chemical Disclosure attached to the Proposal's Environmental Plan.</p> <p>Potential impact assessment of the chemicals, including formation water produced during well testing operations, along with mitigation measures, have been included in the Terrestrial Environmental Quality and Inland Waters preliminary key environmental factors.</p>	<p>Sections 5.2.5 and 5.2.7</p> <p>Sections 5.4.5 and 5.4.7</p> <p>Appendix J</p>



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	<p>be minimised or avoided in all operations;</p> <ul style="list-style-type: none"> <li>An enforceable Code of Practice should include the requirement to test for, and assess the risk from, a comprehensive list of analytes in groundwater, produced and flowback water, including geogenic chemicals and radon;</li> <li>The use of ecotoxicity testing should be considered to better assess the potential for impacts from the mixture of chemicals present in produced or flowback water;</li> <li>The Western Australian Department of Health (DoH) should review and provide advice on information and risk assessments provided on chemicals proposed to be used in hydraulic fracture stimulation, or expected to be present in produced or flowback water, and determine a list of low risk chemicals for hydraulic fracture stimulation, where detailed assessment of risk is not required to be provided. This would encourage industry to use lower risk chemicals instead of other chemicals that require more detailed risk assessment.</li> </ul>			
7	All hydraulic fracture stimulation operations should be preceded by a comprehensive geo-mechanical risk analysis according to an enforceable Code of Practice.	G	<p>At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020. BNR will comply with all regulatory requirements.</p> <p>Geo-mechanical risks have been assessed in the Inland Waters preliminary key environmental factor. More interpretation of seismic data will be undertaken prior to commencing the activity with a risk analysis undertaken prior to conducting the activity.</p>	<p>Section 5.4.5</p> <p>Section 5.4.6</p>



BENNETT RESOURCES

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		Industry (I) Govt. (G)		
8	A site water audit should be required, accounting for water produced, evaporated and disposed, to detect significant leakage of fluids and determine whether remedial action to track any contaminants is warranted.	I	Water wastes and emissions resulting from the Proposal, including formation water produced during well testing operations, will be recorded and monitored. Mitigation measures have been detailed in the Terrestrial Environmental Quality and Inland Waters preliminary key environmental factors.	Section 5.2.7 Section 5.4.7
9	A separation of 2,000 metres from oil and gas wells associated with hydraulic fracture stimulation to bores used for Public Drinking Water Sources is warranted under the precautionary principle, as recommended by the Department of Health (DoH) and the Water Corporation. This is necessary for public confidence, irrespective of a low risk.	I	The Proposal is located over 51 km from the closest PDWSA.	Section 5.4.3.6
10	Baseline measurements of atmospheric levels of greenhouse gas (GHG) should be acquired prior to the development of onshore wells employing hydraulic fracture stimulation, and should be the responsibility of the regulator. Atmospheric concentrations and process leakage of methane should subsequently be monitored over every well's entire life cycle, and detected leaks must be fixed by the operator, with GHG emission monitoring results publicly reported. These requirements should be part of an enforceable Code of Practice.	I / G	At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  Baseline air quality studies have been conducted previously within EP 371 (Section 6.2.3.1). Further to this, BNR plan to conduct additional air quality verification studies to support the existing understanding (Table 6-6).	Section 6.2.3.1 Table 6-6
11	The Western Australian Government should implement an emissions monitoring program of decommissioned wells with respect to well integrity in general and methane emissions specifically, complemented by a research program to give further confidence to their long-term containment.	G	Not relevant – Government Recommendation  BNR plan to conduct additional air quality verification studies to support the existing understanding (Table 6-6).	Table 6-6
12	Apart from the early exploratory phase of development, reduced emissions (green) completions should be a requirement, regulated and monitored as per the United States Environmental Protection Agency (U.S. EPA) New Source Performance Standards 2016.	I	Not relevant – The Proposal is for early exploration phase for the Laurel Formation.	N/a
13	Consideration should be given to offsetting the additional greenhouse gas (GHG) emissions from any onshore unconventional oil and gas production associated with hydraulic fracture stimulation. As a minimum, this should	I	Not relevant – The Proposal is limited to the exploration and appraisal of the Laurel Formation, not production phase as specified in the recommendation.  However in accordance with EPA guidance, BNR have provided a detailed account of the expected	N/a



BENNETT RESOURCES

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<b>Revision:</b>	1
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	extend to the increase in 'fugitive' emissions over conventional upstream oil and gas production, plus reservoir carbon dioxide discharged to the atmosphere.		emissions associated with the Proposal (Section 6.3.5.2).	
14	An enforceable Code of Practice should include measures to minimise the generation of dust throughout all operations and require the regular maintenance of all vehicles.	G	At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  BNR have considered dust emissions caused by the Proposal (Section 5.1.5.4, Section 5.5.5.1) with mitigations provided in Section 5.5.7.	Section 5.5.7
15	Baseline air quality monitoring for volatile organic compounds and dust, and ongoing monitoring of air quality should be incorporated into an enforceable Code of Practice and be made publicly available.	G	At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  Air quality monitoring for dust (PM <sub>2.5</sub> and PM <sub>10</sub> ), VOC and methane have been included in Sections 5.5.5.1 and 6.2.5.1.  In accordance with the PGER(E) Regulations, the proponent is required to report on environmental performance of activities carried out under an Environmental Plan to DMIRS annually. The annual report includes a summary of, and the details of environmental monitoring conducted for the activity over the course of the year.	Section 6.2.7
16	Potential impacts to air quality and human health should be assessed in a site-specific risk assessment.	I	The Air Quality and Human Health Environmental Factor consider the Proposal's impact to air quality in Section 6.2 and Section 6.4 respectively. In addition, mitigation measures have been identified in Section 6.2.7 and Section 6.4.7.	Section 6.2.7 Section 6.4.7
17	Baseline noise levels should be established, a site-specific noise assessment completed and ongoing noise monitoring conducted over the life of a project, with the aim of minimising noise generated by hydraulic fracture stimulation and/or vehicular movements, especially in places within proximity to people and domestic animals.	I	The Social Surroundings preliminary key environmental factor has identified noise as a potential impact. Baseline noise levels within the Development Envelope have been detailed (Section 5.5.3.6) and a site specific impact assessment conducted in Section 5.5.5.2.	Section 5.5.3.6 Section 5.5.5.2
18	Site-specific health risk assessments, that have been peer-reviewed and provided to the Western Australian Department of Health, should be required for all unconventional oil and gas proposals associated with hydraulic fracture stimulation, addressing potential short and long-term health impacts.	G	BNR have taken the approach of developing a detailed Referral supporting document that includes information relevant for the Human Health environmental factor that can be made public to support the level of assessment decision.  The Department of Health submission for the HFS inquiry presented a number of recommendations, one of which was to provide adequate separation distances between operations and human	N/a



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			communities. The current EPA guideline for separation distances between oil and gas development and sensitive receptors (for example, residences and schools) is 2,000 metres (note that this is not embodied in regulation). Given the proximity from human communities is at least 20 km from the closest well site, BNR believe sufficient separation exists.	
19	As a precautionary approach is justified, and in the absence of a local health risk assessment indicating otherwise, unconventional oil and gas wells associated with hydraulic fracture stimulation and processing plants should be located at least 2,000 metres from sensitive receptors such as residences, schools and settlements, as reflected in current Environmental Protection Authority (EPA) guidelines.	I	BNR have described the Proposal's proximity to sensitive receptors in Table 5-29. The closest community is located 16.5 km away from the Development Envelope, and 20 km from the closest well site.	Section 5.5.3.2 Table 5-29
20	Risk assessments of impacts to the social surroundings from hydraulic fracture stimulation associated with unconventional oil and gas developments should be done on a case-by-case basis.	I	BNR have taken the approach of developing a detailed Referral supporting document that includes a specific impact assessment for the Social Surroundings preliminary key environmental factor (Section 5.5.5).  The risk assessment is specific to the Proposal and considers the existing social receptors and sensitivities.	Section 5.5.5
21	Risk assessments and accountable disclosure of risks should be transparent, timely and publicly available as a guiding principle underlying an enforceable Code of Practice.	I / G	At the time of writing this document, and per the Implementation Plan (Action 11 – Code of Practice) the WA code of practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  BNR have taken the approach of developing a detailed Referral supporting document that includes a specific impact assessment for all Environmental Factors to provide information to inform the public and support a level of assessment decision.	N/a
22	Communication and engagement with affected communities should be a priority at the earliest opportunity and at every stage of an unconventional oil and gas development associated with hydraulic fracture stimulation.	I	BNR have been involved in extensive consultation with communities that have the potential to be impacted by the Proposal. This information is summarised in Section 3.  Further to this, support for activities in the region is included in Section 5.5.5.4	Section 3 Section 5.5.5.4
23	Communication with Aboriginal people should be conducted by trusted informants in a language commonly used and understood by the local people. If English is not commonly used, then translators should be available to convey information.	I	BNR have been involved in consultation with communities that have the potential to be impacted by the Proposal. This information is summarised in Section 3. This has included the use of translators, where appropriate.  Further to this, support for activities in the region is included in Section 5.5.5.4	Section 3 Section 5.5.5.4



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24	Amenity and what constitutes aesthetic enjoyment, or a sense of place, as determined by people who live in the communities proximate to hydraulic fracture stimulation activities, should be systematically and scientifically documented from the commencement of a hydraulic fracture stimulation project involving multiple well sites (moving from the exploration phase into the development and production phases). Baseline information and site-specific data collection should be a priority and systematically monitored and updated.	I	BNR have been involved in consultation with communities that have the potential to be impacted by the Proposal. This information is summarised in Section 3.  Impacts arising from the Proposal that can contribute to amenity impacts include dust emissions, noise emissions and traffic movement. These impacts are evaluated respectively in Section 5.5.5.1, Section 5.5.5.2 and Section 5.5.5.3.	Section 5.5.5.1 Section 5.5.5.2 Section 5.5.5.3
25	Petroleum companies' commitment to building moral consent should be part of the assessment for licence procedures.	G	EP 371 is an existing title first issued in 1996.  As detailed in Section 3, BNR is committed to engaging with stakeholders and building trusting relationships.	Section 3
26	There should be a clear point of contact within Government for complaints or concerns to enhance social licence to operate.	G	Not relevant – Government recommendation	N/a
27	Baseline road use statistics measuring volumes of vehicle movements and the type of vehicles using road infrastructure should be undertaken before hydraulic fracture stimulation activities commence, and monitored at periodic intervals throughout the lifecycle of the development.	I	In the Social Surroundings preliminary key environmental factor, baseline road use statistics have been detailed in Section 5.5.3.7. Expected traffic movements for the Proposal have been assessed in Section 5.5.5.3, with traffic monitoring to be implemented as a mitigation measure (Section 5.5.7).	Section 5.5.3.7 Section 5.5.5.3 Section 5.5.7
28	Roads regularly used by heavy vehicles should be upgraded (widened and sealed if necessary), with recompense from the proponent directed to local government authorities to assist with monitoring traffic usage of road infrastructure, road maintenance and upgrades.	G	Given that the Proposal is associated with an exploration and appraisal program, BNR believe that existing infrastructure is sufficient to support the program. Any upgrades to infrastructure would likely be associated with a future development / operations stage should it be required.	N/a
29	Cultural orientation should be made regularly available to hydraulic fracture stimulation employees including contractors in addition to relevant government employees to raise heritage awareness, including issues specific to Aboriginal heritage. Cultural orientation regarding Aboriginal matters should be conducted by local Traditional Owner groups or their approved cultural awareness providers.	I	Inductions are a standard industry requirement for ensuring that all contractors and employees are aware of the values and sensitivities, and requirement mitigation measures for a Proposal.  As detailed in Section 5.5.7, inductions will include cultural awareness information. This information will be developed in consultation with the Traditional Owners and delivered by relevant Traditional Owners.	Section 5.5.7
30	An Aboriginal heritage management plan should be implemented at the earliest	I	Currently no heritage sites have been identified as being potentially impacted by the Proposal (Section	N/a



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

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	opportunity when potential risk is identified for a particular site of Aboriginal heritage or significance. The Aboriginal heritage management plan should have input from those Aboriginal people and groups whose land is under consideration for petroleum development using hydraulic fracture stimulation, and should identify the role Traditional Owners will play in monitoring the condition and protection of their cultural heritage. The Aboriginal heritage management plan should require the approval of local Traditional Owners.		5.5.3.3). Prior to the commencement of activities, a heritage survey will be conducted, the outcomes of which may require an Aboriginal Heritage Management Plan to be developed in consultation with the Traditional Owners.	
31	Governments and resource companies should invest more in understanding and measuring the social dimensions of change and its links to mental health: A comprehensive local social impact analysis should be undertaken prior to the commencement of any activities associated with hydraulic fracture stimulation occurring.	I	Social Surroundings has been identified as a preliminary key environmental factor and considers various social impacts including: <ul style="list-style-type: none"> <li>• Potential impacts to heritage sites;</li> <li>• Increased dust emissions;</li> <li>• Increased noise and vibration emissions;</li> <li>• Increased traffic movement; and</li> <li>• Social and economic benefits.</li> </ul>	Section 5.5.5
32	The Western Australian Government should develop a Code of Practice that adequately defines and prescribes the minimum standards and requirements for all onshore oil and gas activities involving hydraulic fracture stimulation, over the full development lifecycle. This Code of Practice should be made enforceable.	G	Currently the WA Code of Practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  BNR have reviewed the NT Code of Practice and identified the minimum standards which will be applied to the Proposal. Upon the release of the WA Code of Practice, the standards associated with the Proposal will be reviewed to ensure the WA Government requirements are met.	Section 5.4.5.5 Table 5-25
33	To further ensure well integrity and thus environmental protection and public safety, well design, construction and testing should be assessed by an independent, certified expert well examiner, reporting to the regulator as a required part of commissioning, licensing and decommissioning.	I	BNR have included the requirement for well design, construction and testing to be assessed by an independent, certified expert well examiner.	Section 5.4.7
34	The Environmental Protection Authority (EPA) should assess all onshore unconventional oil and gas developments associated with hydraulic fracture stimulation. To ensure issues of scale and cumulative impact are adequately considered, this should extend not only to individual wells during the exploratory phase of a development, but to the environmental assessment of proposed unconventional oil and gas fields if development may go forward.	G	Not relevant – Government recommendation  However, BNR have taken the approach of developing a detailed Referral supporting document that can be made public to support the level of assessment decision.	N/a





BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

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35	Appropriate standards for site rehabilitation and post-closure monitoring should be included in an enforceable Code of Practice.	G	Not relevant – Government recommendation  Currently the WA Code of Practice has not been released, with the Implementation Plan completion date scheduled for H2 2020.  BNR have reviewed the NT Code of Practice and identified the minimum standards which will be applied to the Proposal. Progressive rehabilitation has been identified as a mitigation measure that will be implemented at the end of asset life (Table 5-6). Rehabilitation monitoring will be actively conducted to ensure the sites meet required completion criteria. The criteria will be presented in the full published EP.	Table 5-6
36	Baseline and subsequent environmental monitoring data collected as a regulatory requirement in the licensing, approval and auditing of unconventional oil and gas developments associated with hydraulic fracture stimulation should be made publicly and easily available, by default.	I	In accordance with the PGER(E) Regulations, the proponent is required to report on environmental performance of activities carried out under an Environmental Plan to DMIRS annually. The annual report includes a summary of, and the details of environmental monitoring conducted for the activity over the course of the year.	N/a
37	Once the Environmental Plans required under the Petroleum and Geothermal Energy Resources Act 1967 (PGER Act) are deemed sufficient for consideration, they should be published in full at the time of assessment.	I	BNR will comply with all legislative requirements. Currently it is not a legislated requirement for Proponents to publish full EPs under the PGER(E) Regulations.	N/a
38	Reports of environmental and public safety non-compliance, incidents and their investigation, and government environmental performance audits, should be made routinely publicly available once they would otherwise be reasonably subject to a Freedom of Information request.	I	In accordance with the PGER(E) Regulations, the proponent is required to report on environmental performance of activities carried out under an Environmental Plan to DMIRS annually.	N/a
39	The Western Australian Government should require appropriate financial assurances or insurances to cover potential environmental liabilities, as well as contributions to a fund to cover liabilities defaulted by other unconventional oil and gas operations associated with hydraulic fracture stimulation in Western Australia.	G	Not relevant – Government recommendation  As described by the Implementation Plan (July 2019) the government is considering the mechanisms and requirements for financial assurance (Action 19 – Financial Assurance). BNR will provide assurances as required by the Government.	N/a
40	Environmental offences, and a system of penalties scaled for seriousness of harm and degree of deliberate intent, as per the Environmental Protection Act 1986 (EP Act), be incorporated into the Petroleum and Geothermal Energy Resources Act 1967 (PGER Act). These	G	Not relevant – Government recommendation	N/a



BENNETT RESOURCES

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BNR\_ENV\_RE\_002

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	penalties should extend to both the company and its directors.			
41	Future access to tenements should consider the past environmental record of the applicant.	G	Not relevant – Government Recommendation Not relevant – EP 371 is an existing title first issued in 1996.	N/a
42	The Western Australian Government should consider better separating environmental auditing and compliance of unconventional oil and gas development employing hydraulic fracture stimulation from the department that promotes and allocates resources to that industry.	G	Not relevant – Government Recommendation	N/a
43	The capability and capacity for the environmental auditing and compliance functions of government must be sufficient to assure environmental protection and safety, so this must be adequately resourced and include cost recovery from industry.	G	Not relevant – Government Recommendation	N/a
44	Stakeholder consultation on proposed releases of acreage for onshore unconventional oil and gas development should become a formalised and regular requirement.	G	Not relevant – Government Recommendation EP 371 is an existing title first issued in 1996.	N/a



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
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**Appendix B      Odin 2D and 3D Seismic Survey Flora and Fauna  
Assessment (Low Ecological Services 2020)**



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

## Appendix C Soil Quality 2012 Baseline Data

Parameter <sup>16</sup>	Units	Asgard 1 drill site	
		30 cm below	
		30/07/2012	Asgard 1 sump site 30 cm below 30/07/2012
Moisture	%	0.65	2.0
pH 1:5 soil:water	pH units	6.8	7.0
Electrical Conductivity Soil	µS/cm	12	10
<b>Volatile TRH and BTEX in Soil</b>			
vTRH C <sub>6</sub> – C <sub>9</sub>	mg/kg	<25	<25
Benzene		<0.2	<0.2
Toluene		<0.5	<0.5
Ehtylbenzene		<1.0	<1.0
m+p-xylene		<2.0	<2.0
o-xylene		<1.0	<1.0
Surrogate aaa-Trifluorotoluene	%	85	76
<b>Soluble TRH in Soil (C<sub>10</sub> – C<sub>36</sub>)</b>			
TRH C <sub>10</sub> – C <sub>14</sub>	mg/kg	<50	<50
TRH C <sub>15</sub> – C <sub>28</sub>		<100	<100
TRH C <sub>29</sub> – C <sub>36</sub>		<100	<100
Surrogate o-Terphenyl	%	94	98
<b>Polycyclic aromatic hydrocarbons in soil</b>			
Naphthalene	mg/kg	<0.1	<0.1
Acenaphthylene		<0.1	<0.1
Acenaphthene		<0.1	<0.1
Fluorene		<0.1	<0.1
Phenanthrene		<0.1	<0.1
Anthracene		<0.1	<0.1
Fluoranthene		<0.1	<0.1
Pyrene		<0.1	<0.1
Benzo(a)anthracene		<0.1	<0.1
Chrysene		<0.1	<0.1
Benzo(b+k+)fluoranthene		<0.2	<0.2
Benzo(a)pyrene		<0.05	<0.05
Indeno(1,2,3-c,d)pyrene		<0.1	<0.1
Dibenzo(a,h)anthracene		<0.1	<0.1
Benzo(g,h,i)pyrene		<0.1	<0.1

<sup>16</sup> Soil samples analysed at a NATA accredited laboratory.



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Parameter <sup>16</sup>	Units	Asgard 1 drill site	
		30 cm below	
		30/07/2012	
		Asgard 1 sump site	
		30 cm below	
		30/07/2012	
p-Terphenyl-D <sub>14</sub>	%	94	98
<b>Acid-extractable metals in soil</b>			
Arsenic	mg/kg	2	4
Cadmium		<1	<1
Chromium		27	32
Copper		4	6
Lead		4	6
Mercury		<0.1	<0.1
Nickel		4	6
Zinc		2	3
<b>Metals in ASLP (reagent water)</b>			
pH of final Leachate	pH units	7.35	7.68
Arsenic in ASLP	mg/L	<0.05	<0.05
Cadmium in ASLP		<0.01	<0.01
Chromium in ASLP		0.02	0.02
Copper in ASLP		<0.01	<0.01
Lead in ASLP		<0.03	<0.03
Mercury in ASLP		<5 x 10 <sup>-5</sup>	<5 x 10 <sup>-5</sup>
Nickel in ASLP		<0.02	<0.02
Zinc in ASLP		<0.02	<0.02



BENNETT RESOURCES

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## Appendix D Soil Quality 2016 Monitoring

Parameter	Units	Ecological / Health Investigation Levels for soils (mg/kg) (DEC 2010)	Valhalla North 1 soil sample	
			28/01/2016 20/04/2016 <sup>17</sup>	25/02/2016
Moisture	%w/w	-	8.5	8.0
pH	pH Units	-	7.8	8.1
Conductivity of extract (1:5 as received)	µS/cm	-	300	3100
Bicarbonate Alkalinity as HCO <sub>3</sub> in Soil <sup>18</sup>	mg/kg	-	<25	200
Carbonate Alkalinity as CO <sub>3</sub> in Soil <sup>18</sup>		-	<5	<5
Hydroxide Alkalinity as OH in Soil <sup>18</sup>		-	<25	<25
Total Alkalinity as CaCO <sub>3</sub> in Soil <sup>18</sup>		-	18	160
Total Dissolved Solids Dried at 180°C <sup>18</sup>		-	2900	8300
Chloride (water extractable 1:5) <sup>18</sup>		-	390	4400
Sulphate (water extractable) <sup>18</sup>		-	94	570
Water Soluble Fluoride		-	3.2	2.4
Total Kjeldahl Nitrogen <sup>18</sup>		-	190	200
Total Nitrogen <sup>18</sup>		-	190	270
Water Soluble Nitrate Nitrogen, NO <sub>3</sub> as N <sup>18</sup>		-	1.9	70
Water Soluble Nitrate/Nitrite Nitrogen, NO <sub>x</sub> as N <sup>18</sup>		-	2.1	70
Water Soluble Nitrite Nitrogen, NO <sub>2</sub> as N <sup>18</sup>		-	0.17	0.075
Water Soluble Nitrate as NO <sub>3</sub> <sup>18</sup>		-	8	310
Water Soluble Nitrite, NO <sub>2</sub> <sup>18</sup>		-	<3	<3
Water Soluble Ammonia Nitrogen, NH <sub>3</sub> as N <sup>18</sup>		-	<0.1	0.8
Water Soluble Ammonia Nitrogen, NH <sub>3</sub> as NH <sub>3</sub> <sup>18</sup>	-	0.1	1.0	
Reactive Silica, Si <sup>18</sup>	mg/L	-	8.9	5.7
Reactive Silica, SiO <sub>2</sub> <sup>18</sup>		-	19	12
Calcium, Ca	mg/kg	-	600	1900
Magnesium, Mg		-	340	610
Sodium, Na		-	560	2400
Potassium, K		-	770	1100
Aluminium, Al		-	6800	6500
Arsenic, As		20 / 100	7	7

<sup>17</sup> Soil samples were collected on two dates as hydrocarbons were not included in the initial analysis of soil samples on 28/01/2016.

<sup>18</sup> NATA accreditation does not cover the performance of this service.



BENNETT RESOURCES

**Document No:**

BNR\_ENV\_RE\_002

**Revision:**

1

**Issue Date:**

24/12/2020

Parameter	Units	Ecological / Health Investigation Levels for soils (mg/kg) (DEC 2010)	Valhalla North 1 soil sample	
			28/01/2016 20/04/2016 <sup>17</sup>	Valhalla 1 soil sample 25/02/2016
Barium, Ba		300 / 15,000	170	1300
Boron, B		- / 3,000	<5	<5
Cadmium, Cd		3 / 20	0.6	0.6
Chromium, Cr		Cr III: 400 / 120,000 Cr VI: 1 / 100	66	50
Copper, Cu		100 / 1,000	15	28
Lead, Pb		600 / 300	45	43
Manganese, Mn		500 / 1,500	760	990
Nickel, Ni		60 / 600	20	25
Selenium, Se		-	<3	<3
Zinc, Zn		200 / 7,000	8	15
Phosphorous, P		2,000 / -	32	43
Silver, Ag <sup>18</sup>		-	<1	<1
Iron, Fe		-	62000	56000
Strontium, Sr		-	7.0	47
Mercury		1 / 15	<0.05	<0.05



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

## Appendix E

## Hydrogeological Assessment (Rockwater 2016)





BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

**Appendix F Yulleroo and Valhalla Passive Seismic Monitoring Report (Hasting Micro-Seismic Consulting 2013)**



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

## Appendix G Laurel Formation Water Characterisation

Analyte	Unit	Onsite management levels (mg/L)	Asgard 1 pond pre-well test (bore water)	Asgard 1 pond post-well test	Valhalla North 1 pond pre-well test (bore water)	Valhalla North 1 pond post-well test
			Date	09/2015	09/2015-10/2015	09/2015
Arsenic	mg/L	0.5 <sup>19</sup>	<0.02	<0.02	<0.02	<0.02
Barium	mg/L	2 <sup>20</sup>	3.8	20	0.054	12
Boron	mg/L	4 <sup>20</sup>	0.88	9.4	0.43	14
Cadmium	mg/L	0.002 <sup>20</sup>	<0.001	<0.002	<0.001	<0.002
Chloride	mg/L	30,000	570	16,000	400	17,000
Chromium VI	mg/L	0.05 <sup>20</sup>	<0.02	<0.02	<0.005	<0.02
Copper	mg/L	1 <sup>19</sup>	<0.005	<0.02	<0.005	<0.02
Lead	mg/L	0.1 <sup>19</sup>	<0.02	<0.02	<0.02	<0.02
Manganese	mg/L	0.5 <sup>20</sup>	0.2	0.15	0.01	0.51
Mercury	mg/L	0.002 <sup>19</sup>	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	1 <sup>19</sup>	0.018	<0.02	0.006	<0.02
Selenium	mg/L	0.01 <sup>20</sup>	<0.05	<0.02	<0.05	<0.02
Zinc	mg/L	20 <sup>19</sup>	0.12	<0.1	0.01	<0.1

<sup>19</sup> Stock water: Australian and New Zealand guidelines for fresh and marine water quality (ANZECC and ARMCANZ 2000).


<sup>20</sup> Health values: Australian Drinking Water Guidelines 6, Version 3.5 (NHMRC and NRMCC 2011).



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Sample Number	Date	Unit	Radionuclides						Metals		
			Uranium Series			Thorium Series			Uranium	Thorium	
			Uranium-238	Radium-226	Lead-210	Thorium-232	Radium-228	Thorium-228			Unit
Valhalla North 1 #8	09/09/2015	Bq/L	0.14 ±0.01	1.38 ±0.2	<0.57	<0.005	1.55 ±0.26	<0.16	mg/L	0.011 ±0.001	<0.001
Valhalla North 1 #118	26/11/2015	Bq/L	<0.02	1.37 ±0.13	<0.75	<0.005	1.44 ±0.15	<0.12	mg/L	<0.001	<0.001
Valhalla North 1 #136	13/12/2015	Bq/L	<0.02	0.257 ±0.07	<1.1	<0.005	0.31 ±0.13	<0.17	mg/L	<0.001	<0.001
Asgard 1 #5	31/08/2015	Bq/L	0.02 ±0.01	0.80 ±0.10	<0.54	<0.005	0.79 ±0.15	<0.11	mg/L	0.002 ±0.001	<0.001
Asgard 1 #122	30/11/2015	Bq/L	<0.02	3.44 ±0.29	<1.4	<0.005	4.5 ±0.4	<0.23	mg/L	<0.001	<0.001
Asgard 1 #160	02/01/2016	Bq/L	<0.02	3.76 ±0.29	<0.29	<0.005	5.18 ±0.39	<0.053	mg/L	<0.001	<0.001
Asgard 1 Flowback Pond	25/02/2016	Bq/L	0.01 ±0.01	1.113 ±0.093	<0.22	<0.005	1.35 ±0.12	<0.034	mg/L	0.001 ±0.001	<0.001
Valhalla North 1 Flowback Pond	28/01/16	Bq/L	<0.02	1.046 ±0.085	<0.14	<0.005	1.32 ±0.11	<0.025	mg/L	<0.001	<0.001

 BENNETT RESOURCES	<b>Document No:</b>	BNR_ENV_RE_002
	<b>Revision:</b>	1
	<b>Issue Date:</b>	24/12/2020

Appendix H      **PMST and NatureMap Reports**



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

## Appendix I Liveringa Group Water Quality

Analyte	Unit	Bore	AB1	AB1	AB2	AB2	AB3	AB4	AB2	VNB	VNB	VNB	VNB	VNB	VNB
		S	S	D	D	S	S	S	D	1S	1D	2S	3S	4S	4D
Date		25/06	25/06	25/06	25/06	25/06	25/06	25/06	29/11	26/06	26/06	26/06	26/06	26/06	26/06
EC	µS/cm	4,800	4,800	1,100	4,800	5,500	2,900	4,800	2,300	2,000	1,600	1,800	2,300	1,900	
Chloride	mg/L	920	920	42	940	920	260	950	280	300	110	170	290	300	
Fluoride	mg/L	0.8	0.7	1.8	0.7	0.9	1.1	-	1.0	0.3	0.8	0.9	1.0	0.3	
Silica	mg/L	20	20	25	23	23	23	-	30	26	30	32	31	25	
SO4	mg/L	660	650	18	650	1,200	560	660	310	280	130	210	320	250	
NO3	mg/L	0.14	0.08	2	0.06	0.13	0.05	-	0.05	<0.05	<0.05	<0.05	0.06	0.44	
Ca	mg/L	70	69	20	75	160	57	71	95	58	62	76	110	58	
K	mg/L	49	49	19	50	64	38	45	26	15	18	19	22	15	
Mg	mg/L	95	95	14	94	160	69	87	70	54	46	57	73	52	
Na	mg/L	770	780	200	790	780	500	720	300	280	240	260	290	290	
Ag	mg/L	0.004	0.003	<0.001	0.002	0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Al	mg/L	0.34	0.020	0.042	0.019	0.59	0.12	0.096	1.2	0.016	0.078	0.56	0.25	0.33	
As	mg/L	0.002	<0.001	0.002	<0.001	0.006	0.005	0.002	0.002	0.006	0.005	0.002	0.010	0.002	
Ba	mg/L	0.036	0.024	0.075	0.078	0.053	0.068	0.078	0.081	0.13	0.15	0.11	0.084	0.17	
B	mg/L	0.94	0.96	0.45	0.81	1.0	0.84	0.89	0.28	0.34	0.30	0.28	0.29	0.33	



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

Analyte	Unit	Bore	AB1	AB1	AB2	AB2	AB3	AB4	AB2	VNB	VNB	VNB	VNB	VNB	VNB
		S	D	S	D	S	S	D	1S	1D	2S	3S	4S	4D	
Date		25/06	25/06	25/06	25/06	25/06	25/06	25/06	29/11	26/06	26/06	26/06	26/06	26/06	26/06
Cd	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Cu	mg/L	0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	0.004	0.002	<0.001	<0.001	<0.001	<0.001	0.001
Cr	mg/L	0.004	<0.001	0.001	0.001	0.007	0.002	0.021	0.006	<0.001	0.001	0.004	0.004	0.009	
Fe	mg/L	2.2	0.18	0.33	0.15	2.2	1.2	-	2.3	1.6	1.6	0.92	2.0	0.46	
Hg	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Mn	mg/L	0.080	0.006	0.16	0.63	1.6	0.67	0.73	0.34	0.18	0.87	0.72	0.77	0.88	
Ni	mg/L	0.002	<0.001	0.001	<0.001	0.013	0.001	0.015	0.004	<0.001	0.001	0.003	0.003	0.006	
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Se	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Sr	mg/L	2.2	2.4	0.28	2.7	3.8	0.97	-	0.99	1.7	0.82	1.0	1.3	1.5	
Zn	mg/L	0.009	0.006	0.009	<0.005	0.006	0.006	0.014	0.008	<0.005	<0.005	<0.005	0.008	0.010	
Benzene	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Ethylbenzene	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
m,p-Xylene	ug/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	
ortho xylene	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
Toluene	ug/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
TRH C6-C9	ug/L	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002


Revision:

1

Issue Date:

24/12/2020

Bore	AB1	AB1	AB2	AB2	AB3	AB4	AB2	VNB	VNB	VNB	VNB	VNB	VNB	
	S	D	S	D	S	S	D	1S	1D	2S	3S	4S	4D	
Date	25/06	25/06	25/06	25/06	25/06	25/06	29/11	26/06	26/06	26/06	26/06	26/06	26/06	
Analyte	Unit													
TRH C10-C14	ug/L	<50	<50	50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
TRH C15-C28	ug/L	<200	<200	210	210	450	<200	<200	210	<200	210	<200	<200	<200
TRH C29-C36	ug/L	<200	<200	220	250	450	510	<200	200	390	<200	<200	<200	<200
Dissolved ethane	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved methane	mg/L	0.028	0.010	0.022	0.020	0.018	0.038	-	0.026	0.008	0.032	0.011	0.021	0.050
Dissolved propane	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

 BENNETT RESOURCES	<b>Document No:</b>	BNR_ENV_RE_002
	<b>Revision:</b>	1
	<b>Issue Date:</b>	24/12/2020

Appendix J

**HFS Fluid Composition**





BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

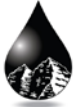
Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
Water		93.98564%	No Hazard
Water in products		1.67%	No Hazard
Acetic Acid - 60%	Buffer	0.00802%	CONSTITUENT 1 ( $\leq 100\%$ ): Acute Fish Toxicity 96h LC50: 75 mg/L (Lepomis macrochirus) Acute Crustacean Toxicity 24h LC50: 47 mg/L (Daphnia magna) Acute Algae Toxicity 24h EC50: 156 mg/L (Chlorococcales) Biodegradation: Readily Biodegradable (99% degradation in 7d) Bioaccumulation: Not Bioaccumulative (based on Log Kow: -0.17) CONSTITUENT 2 ( $\leq 60\%$ ): No Hazard - Water makes up the remainder of this product
BE-9	Biocide	0.00842%	CONSTITUENT 1 ( $\leq 10\%$ ): Acute Fish Toxicity of degradation product 96h LC50: <700 mg/L (goldfish, zebrafish) Test: Closed Bottle (OECD 301D) Biodegradability/Bioaccumulation: Duration: 28 day Procedure: Ready biodegradability. Ref. LOLI Desktop Component is classified by Korea MOE using GHS Criteria "Hazardous to the Aquatic Environment - Acute: Category 1" and "Hazardous to the Aquatic Environment - Chronic: Category 1". CONSTITUENT 2 ( $\leq 100\%$ ): No Hazard-Water makes up the remainder of this product
CLBXTAU121	High Temp Breaker	0.00935%	Acute Toxicity: Acute Fish Toxicity 48h LC50: 450 mg/L (Leuciscus idus) Fish: Leuciscus idus: EC50=2300-2700 mg/L; LD 50 ORAL (RAT): 5900 mg/kg LD 50 INTRAPERITONEAL (RAT): 4000 mg/kg



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>LD 50 SUBCUTANEOUS (RAT): 6600 mg/kg</p> <p>LD 50 INTRAPERITONEAL (MOUSE): 1750 mg/kg</p> <p>Listed as a permitted food additive in multiple jurisdictions (including Australia).</p> <p>Component is defined by Germany's Federal Environment Agency as "Hazard Class 1 - Low Hazards to Waters" (Water Classification Annex 3).</p> <p>Readily Biodegradable</p>
CLLAU301	Crosslinker	0.09354%	<p>CONSTITUENT 1 (<math>\leq 10\%</math>):</p> <p>Acute Fish Toxicity 96h LC50: 3.6 mg/L (<i>Salvelinus fontinalis</i>);</p> <p>Acute Crustacean Toxicity 48h EC50: 3.2 mg/L (<i>Daphnia magna</i>);</p> <p>Acute Algae Toxicity 22h EC50: &gt;25 mg/L (<i>Aphanizomenon flos-aquae</i>);</p> <p>Biodegradation: Not Applicable (Inorganic); CONSTITUENT 2 (<math>\leq 10\%</math>):</p> <p>Acute Fish Toxicity 96h LC50: 42 mg/L (<i>Gambusia affinis</i>);</p> <p>Acute Crustacean Toxicity 24h EC50: 29 mg/L (<i>Daphnia magna</i>);</p> <p>Acute Algae Toxicity: No Data Available;</p> <p>Biodegradation: Not Applicable (Inorganic); Bioaccumulation: Not Applicable (Inorganic) CONSTITUENT 3 (<math>\leq 100\%</math>):</p> <p>No Hazard- Water makes up the remainder of this product</p>
CLWGAU421	Gelling Agent	0.02804%	<p>Acute Toxicity:</p> <p>Acute Fish Toxicity 96h LC50: 20,000 mg/L (<i>Oncorhynchus mykiss</i>);</p> <p>Acute Crustacean Toxicity 48h EC50: 87.26 mg/L (<i>Ceriodaphnia dubia</i>)</p>
DCA 30001 (FDP-S1085-13)	Scale Inhibitor	0.04677%	<p>CONSTITUENT 1 (<math>\leq 30\%</math>):</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>Acute Toxicity:</p> <p>48h LC50: &gt;200 mg/L (Daphnia Magna)</p> <p>96 h LC50: &gt;1000 mg/L (Brachydanio)</p> <p>28d LC50: &gt; 450 mg/L (Brachydanio rerio)</p> <p>21d EC50: = 450 mg/L (Daphnia Magna)</p> <p>96h EC50: =180 mg/L (Selenastrum capricornutum)</p> <p>Component is defined by Germany's Federal Environment Agency as "Hazard Class 1, Low Hazards to Water" (Water Classification Annex 1).;</p> <p>Component is classified by Cosmetic Ingredient Review as a "Safe Ingredient With Qualifications";</p> <p>Component is classified by the US EPA - FIFRA as a "Inert Ingredient Permitted for Use in Nonfood Use Pesticide Products";</p> <p>Component is classified by the US EPA - Design for the Environment (DfE) as part of the "Safer Chemical Ingredients List - Polymer";</p> <p>Component is classified by the US FDA as a "Direct Food Additive" and an "Indirect Food Additive". Component was classified (out of 229 notifiers) by one notifier as an Aquatic Chronic Cat. 3</p> <p>CONSTITUENT 2 (≤10%):</p> <p>Acute Toxicity:</p> <p>48h LC50: 1.94 mg/L (Ceriodaphnia dubia)</p> <p>96h LC50: 26.2 mg/L (Pimephales promelas)</p> <p>CONSTITUENT 3 (≤1%):</p> <p>Acute Toxicity:</p> <p>96h LC50: 45.4 mg/L (Oncorhynchus mykiss)</p> <p>48h EC50: 40.38 mg/L (Ceriodaphnia dubia)</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>Biodegradation: Not Applicable (Inorganic)</p> <p>Bioaccumulation: Not Applicable (Inorganic)</p> <p>CONSTITUENT 4 (<math>\leq 100\%</math>):</p> <p>No Hazard- Water makes up the remainder of this product</p> <p>96h EC50: =180 mg/L (Selenastrum capricornutum)</p> <p>Component is defined by Germany's Federal Environment Agency as "Hazard Class 1, Low Hazards to Water" (Water Classification Annex 1).;</p> <p>Component is classified by Cosmetic Ingredient Review as a "Safe Ingredient With Qualifications";</p> <p>Component is classified by the US EPA - FIFRA as a "Inert Ingredient Permitted for Use in Nonfood Use Pesticide Products";</p> <p>Component is classified by the US EPA - Design for the Environment (DfE) as part of the "Safer Chemical Ingredients List - Polymer";</p> <p>Component is classified by the US FDA as a "Direct Food Additive" and an "Indirect Food Additive".</p> <p>Component was classified (out of 229 notifiers) by one notifier as an Aquatic Chronic Cat. 3</p> <p>CONSTITUENT 2 (<math>\leq 10\%</math>):</p> <p>Acute Toxicity:</p> <p>48h LC50: 1.94 mg/L (Ceriodaphnia dubia)</p> <p>96h LC50: 26.2 mg/L (Pimephales promelas)</p> <p>CONSTITUENT 3 (<math>\leq 1\%</math>):</p> <p>Acute Toxicity:</p> <p>96h LC50: 45.4 mg/L (Oncorhynchus mykiss)</p> <p>48h EC50: 40.38 mg/L (Ceriodaphnia dubia)</p> <p>Biodegradation: Not Applicable (Inorganic)</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			Bioaccumulation: Not Applicable (Inorganic) CONSTITUENT 4 (≤100%): No Hazard- Water makes up the remainder of this product
FE-2	Buffer	0.00118%	Acute Toxicity: 96h LC50: 440 mg/L (Leuciscus idus) 24h EC50: 85 mg/L (Daphnia magna) Biodegradation: Readily Biodegradable (98% degradation in 48 (OECD 302B)) Bioaccumulation: Not Bioaccumulative (based on Log Pow: -1.72)
DCA-23001 (FR-50D)	Friction Reducer	0.01371%	CONSTITUENT 1 (≤30%): Acute Toxicity: 48h LC50: =218.1 mg/L (Ceriodaphnia dubia) 48h LC50: < 1 mg/L (Daphnia Magna) 72h EC50: = 4310 mg/L (Skeletonema Costatum) 48h LC50: = 2202 mg/L (Acartia Tonsa) 96h LC50: =9051 mg/L (Scophthalmus Maximus) Component is classified by the US FDA as a "Direct Food Additive" and an "Indirect Food Additive". CONSTITUENT 2 (≤1%): Acute Toxicity: 96h LC50: 4.96 mg/L (Ctenopharyngodon idella) 48h LC50: 7.4 mg/L (Daphnia magna) Biodegradation: Persistent (<10% degradation in 28d (OECD 301D))



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			Bioaccumulation: Not Bioaccumulative (based on BCF = 48) CONSTITUENT 3 ( $\leq 100\%$ ): Acute Toxicity: 96h LC50: 1000 mg/L (Morone saxatilis) 48h EC50: 402.6 mg/L (Daphnia magna) 96h EC50: 2430 mg/L (Navicula seminulum) Biodegradation: Not Applicable (Inorganic) Bioaccumulation: Not Applicable (Inorganic)
DCA-17004 (HAI-150E)	Corrosion Inhibitor	0.000537%	No Hazard - natural product REACH ANNEX V: Exempt for OSPAR OCNS Group CEFAS Registration Number 25119 Component is naturally-occurring and is generally not classified by notifiers.
Hydrochloric Acid - 32%	Acid	0.10200%	CONSTITUENT 1 ( $\leq 60\%$ ): Acute Toxicity: 96h LC50: 4.92 mg/L (Cyprinus carpio) 48h EC50: 0.492 mg/L (Daphnia magna) 72h EC50: 0.097 mg/L (Selenastrum capricornutum); Biodegradation: Not Applicable (Inorganic); Bioaccumulation: Not Applicable (Inorganic); CONSTITUENT 2 ( $\leq 100\%$ ): No Hazard-Water makes up the remainder of this product.



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			48 h LC50: > 430 mg/L – (Marine Copepod <i>Acartia tonsa</i> ) Oral, mouse: LD50 = 300 mg/kg; Oral, rabbit: LD50 = 3200 mg/kg; Oral, rat: LD50 = 980 mg/kg. Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.) CONSTITUENT 2 (>60%): No Hazard-Water makes up the remainder of this product.
Sodium Chloride	Clay Stabilizer	0.86515%	Acute Toxicity: 96h LC50: 1000 mg/L ( <i>Morone saxatilis</i> ) 48h EC50: 402.6 mg/L ( <i>Daphnia magna</i> ) 96h EC50: 2430 mg/L ( <i>Navicula seminulum</i> ) Biodegradation: Not Applicable (Inorganic) Bioaccumulation: Not Applicable (Inorganic)
100 Mesh Sand	Proppant	0.28216%	No Hazard – Natural Product
40/70 Sand	Proppant	2.88206%	No Hazard – Natural Product
Water	Dissolution medium + flush fluid	0.000008357%	No Hazard – Natural Product
T-140a	Chemical Water Tracer	0.0000000348%	CONSTITUENT 1 (10-30%): sodium 2-fluorobenzoate Acute Toxicity: 96h LC50 440mg/L – Marine Fish <i>Scophthalmus maximus</i>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>Oral, Mouse: LD50 = 300 mg/kg;</p> <p>Oral, rabbit: LD50 = 3200 mg/kg;</p> <p>Oral, rat: LD50 = 980 mg/kg.</p> <p>Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-140b	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (1-10%):</p> <p>sodium 3-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 298 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>EC50: 934 mg/L – (Fish toxicity marine fish <i>Cryrinodon variegatus</i>)</p> <p>EC50: &gt; 10000 mg/L – (Algal toxicity marine unicellular algae <i>Skeletonema costatum</i>)</p> <p>EC50: 9344 mg/L (Marine <i>Acartia tonsa</i>)</p> <p>EC50 &gt; 14185 mg/L – (Marine crustacean <i>Corophium volutator</i>)</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-140c	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (1-10%):</p> <p>sodium 4-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 430 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 = 300 mg/kg; Oral, rabbit: LD50 = 3200 mg/kg;</p> <p>Oral, rat: LD50 = 980 mg/kg.</p> <p>Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.)</p>





BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-158a	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (1-10%):</p> <p>sodium 2,4-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 460 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 = 830 mg/kg; .</p> <p>Other: oral rat LD50 &gt; 5000</p> <p>Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-158b	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):</p> <p>sodium 2,5-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 460 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 = 830 mg/kg;</p> <p>Other: oral rat LD50 &gt; 5000</p> <p>Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-158c	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):</p> <p>sodium 2,6-fluorobenzoate Acute Toxicity:</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>48 h LC50: &gt; 1521 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 &gt;1000 mg/kg;</p> <p>Other: oral rat LD50 &gt; 5000 Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-158d	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):</p> <p>sodium 3,4-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 1521 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 &gt;1000 mg/kg;</p> <p>Other: oral rat LD50 &gt; 5000 Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-176c	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):</p> <p>sodium 3,4-fluorobenzoate Acute Toxicity:</p> <p>48 h LC50: &gt; 254 mg/L – (Marine Copepod <i>Acartia tonsa</i>)</p> <p>Oral, mouse: LD50 &gt;1000 mg/kg;</p> <p>Other: oral rat LD50 &gt; 5000 Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.</p> <p>CONSTITUENT 2 (&gt;60%):</p> <p>No Hazard-Water makes up the remainder of this product.</p>
T-190a	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>sodium 2 (trifluoromethyl) benzoate Acute Toxicity:            48 h LC50: &gt; 443 mg/L – (Marine Copepod Acartia tonsa)            LD 50 &gt; 3000 mg/kg (oral rat)            Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.            CONSTITUENT 2 (&gt;60%):            No Hazard-Water makes up the remainder of this product.</p>
T-190b	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):            sodium 3 (trifluoromethyl) benzoate Acute Toxicity:            48 h LC50: &gt; 167 mg/L – (Marine Copepod Acartia tonsa)            LD 50 &gt; 3000 mg/kg (oral rat)            Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.            CONSTITUENT 2 (&gt;60%):            No Hazard-Water makes up the remainder of this product.</p>
T-190c	Chemical Water Tracer	0.0000000348%	<p>CONSTITUENT 1 (10-30%):            sodium 4 (trifluoromethyl) benzoate Acute Toxicity:            48 h LC50: &gt; 134 mg/L – (Marine Copepod Acartia tonsa)            10d LC 50: 283 mg/L – (Marine crustacean Corophium volutator)            72h EC50 &gt;695 mg/L – (Algal toxicity marine unicellularn algae Skeletonema costatum)            96h LC50 &gt;3200 mg/L – (Marine Fish Scopththalmus Maximus)            Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA.            CONSTITUENT 2 (&gt;60%):</p>



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			No Hazard-Water makes up the remainder of this product.
T-194a	Chemical Water Tracer	0.0000000348%	CONSTITUENT 1 (10-30%): sodium 2,3,4,5 tetrafluoro benzoic acid Acute Toxicity: 48h LC50: >305 mg/L – (Marine Copepod Acartia tonsa) 10d LC50: 407 mg/L – (Marine crustacean Corophium volutator) 72h EC50 >2075 mg/L – (Algal toxicity marine unicellular algae Skeletonema costatum) 96h LC50 440 mg/L – (Marine Fish Scopthalmus Maximus) Carcinogenicity: Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA. CONSTITUENT 2 (>60%): No Hazard-Water makes up the remainder of this product.
T-300	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scopthalmus maximus unicellular) 72h LC50 >10000 mg/L – (Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
T-300a	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scopthalmus maximus unicellular) 72h LC50 >10000 mg/L – (Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
T-350	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – ( Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
T-400b	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – ( Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
T-400c	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – ( Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
T-400d	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – ( Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)



BENNETT RESOURCES

Document No:

BNR\_ENV\_RE\_002

Revision:

1

Issue Date:

24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
T-412	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod <i>Acartia tonsa</i> ) 96h LC50 >5600 mg/L – (Fish <i>Scophthalmus maximus unicellular</i> ) 72h LC50 >10000 mg/L – ( Algae <i>Skeletonema costatum</i> ) 10d LC50 >12710 mg/L (Marine crustacean <i>Corophium volutator</i> )
T-438	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod <i>Acartia tonsa</i> ) 96h LC50 >5600 mg/L – (Fish <i>Scophthalmus maximus unicellular</i> ) 72h LC50 >10000 mg/L – ( Algae <i>Skeletonema costatum</i> ) 10d LC50 >12710 mg/L (Marine crustacean <i>Corophium volutator</i> )
T-450a	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod <i>Acartia tonsa</i> ) 96h LC50 >5600 mg/L – (Fish <i>Scophthalmus maximus unicellular</i> ) 72h LC50 >10000 mg/L – ( Algae <i>Skeletonema costatum</i> ) 10d LC50 >12710 mg/L (Marine crustacean <i>Corophium volutator</i> )
T-450b	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod <i>Acartia tonsa</i> ) 96h LC50 >5600 mg/L – (Fish <i>Scophthalmus maximus unicellular</i> ) 72h LC50 >10000 mg/L – ( Algae <i>Skeletonema costatum</i> ) 10d LC50 >12710 mg/L (Marine crustacean <i>Corophium volutator</i> )



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
T-450c	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – (Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
T-462a	Chemical Gas Tracer	0.000001175%	Acute Toxicity: 48h LC50: >10,000 mg/L – (Marine Copepod Acartia tonsa) 96h LC50 >5600 mg/L – (Fish Scophthalmus maximus unicellular) 72h LC50 >10000 mg/L – (Algae Skeletonema costatum) 10d LC50 >12710 mg/L (Marine crustacean Corophium volutator)
Iridium Zero Wash Bead Tracer	Proppant Tracer	0.0000000139%	CONSTITUENT 1 > 5% : Silicon Dioxide & Aluminium Oxide; Acute Toxicity: Oral, mouse: LD50 >8000 mg/kg; Oral, rabbit: LD50 > 5000 mg/kg; Oral, rat: LD50 > 10000 mg/kg. CONSTITUENT 2 <5% : Iridium 192 Oxide; Titanium Oxide; Potassium Oxide; Iron Oxide; Calcium Oxide; Sodium Oxide Acute Toxicity: Oral LD50 Rat: >10000 mg/kg. CONSTITUENT 3 <5% : Methanol; Dipropylene glycol methyl ether; Xanthanum gum



BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
			<p>Acute Toxicity:</p> <p>Oral, rat: LD50 &gt;5000 mg/kg</p> <p>Biodegradation: Not Applicable (Inorganic);</p> <p>CONSTITUENT 4</p> <p>&gt;90 %: No Hazard-Water makes up the remainder of this product.</p>
Antimony Zero Wash Bead Tracer	Proppant Tracer	0.000000139%	<p>CONSTITUENT 1</p> <p>&gt; 5% : Silicon Dioxide &amp; Aluminium Oxide;</p> <p>Acute Toxicity:</p> <p>Oral, mouse: LD50 &gt;8000 mg/kg;</p> <p>Oral, rabbit: LD50 &gt; 5000 mg/kg;</p> <p>Oral, rat: LD50 &gt; 10000 mg/kg.</p> <p>CONSTITUENT 2</p> <p>&lt;5% : Antimony<sup>124</sup> Oxide ; Titanium Oxide; Potassium Oxide; Iron Oxide; Calcium Oxide; Sodium Oxide</p> <p>Biodegradation: Not Applicable (Inorganic);</p> <p>Acute Toxicity:</p> <p>Oral LD50 Rat: &gt;10000 mg/kg.</p> <p>CONSTITUENT 3</p> <p>&lt;5% : Methanol; Dipropylene glycol methyl ether; Xanthanum gum</p> <p>Acute Toxicity:</p> <p>Oral, rat: LD50 &gt;5000 mg/kg</p> <p>CONSTITUENT 4</p> <p>&gt;90 %: No Hazard-Water makes up the remainder of this product.</p>





BENNETT RESOURCES

<b>Document No:</b>	BNR_ENV_RE_002
<b>Revision:</b>	1
<b>Issue Date:</b>	24/12/2020

Product Name	Purpose	Product in system fluid (%)	Toxicity and Ecotoxicity Information
Scandium Zero Wash Bead Tracer	Proppant Tracer	0.000000139%	<p>CONSTITUENT 1</p> <p>&gt; 5% : Silicon Dioxide &amp; Aluminium Oxide; Acute Toxicity:</p> <p>Oral, mouse: LD50 &gt;8000 mg/kg;</p> <p>Oral, rabbit: LD50 &gt; 5000 mg/kg;</p> <p>Oral, rat: LD50 &gt; 10000 mg/kg.</p> <p>CONSTITUENT 2</p> <p>&lt;5% : Scandium Oxide ; Titanium Oxide; Potassium Oxide; Iron Oxide; Calcium Oxide; Sodium Oxide</p> <p>Biodegradation: Not Applicable (Inorganic);</p> <p>Acute Toxicity:</p> <p>Oral LD50 Rat: &gt;10000 mg/kg.</p> <p>CONSTITUENT 3</p> <p>&lt;5% : Methanol; Dipropylene glycol methyl ether; Xanthanum gum</p> <p>Acute Toxicity:</p> <p>Oral, rat: LD50 &gt;5000 mg/kg</p> <p>CONSTITUENT 4</p> <p>&gt;90 %: No Hazard-Water makes up the remainder of this product.</p>