Technical Note

To:	Environment Agency	From:	Envireau Water
Ref:	P:\Third Energy KMA (1996)\40 - Reporting\SoM Parameters\SoM Tech Note.docx	Pages:	3 + Appendices
Re:	Surface water and groundwater monitoring parameters	Date:	15/02/2016

1 Introduction

The Environment Agency issued a mining waste and groundwater activity permit (Ref. EPR/DB3002HE) ('the permit') to Third Energy in April 2016, which permits a hydraulic fracturing operation on the KM8 well at the KMA wellsite.

Condition 3.5.1 (b) of the permit relates to the monitoring of surface water and groundwater and states that water samples need to be analysed for the parameters listed in Schedule 3, Table S3.5 of the permit. The list of required analysis parameters is reproduced as Appendix A, and has been split into three groups as follows:

Group 1: General Inventory

Group 2: Fracture Fluid Additives

Group 3: Other Chemical Inventory

2 Parameter Analysis

Envireau Water is assisting Third Energy with the water monitoring specified by the environmental permit and has collected water samples for field and/or laboratory analysis in accordance with the required list of analysis parameters in Schedule 3, Table S3.5 of the permit (Appendix A).

Unfortunately, it has not been possible to analyse for all the parameters listed in the permit. The list of parameters has been reproduced in Appendix B, with summary comments for alternative analysis and a justification where alternative analysis is not possible. These comments are based on research by Envireau Water supported by discussions between Envireau Water and laboratory staff from Jones Environmental Ltd. (EXOVA) a well-known UKAS/ILAC (ISO 17025) registered laboratory specialising in environmental analysis of soils and natural water. It can be seen from Appendix B that:

- All the parameters listed in Group 1 (General Inventory) can be analysed.

- There are 15 parameters in Group 2 (Fracture Fluid Additives); only 2 of which can be analysed (acetic acid, sodium persulphate). Of the remaining 13 parameters, it is possible to analyse for the ionic constituents of 9. In addition, analysis can be performed for anionic surfactants and ionic surfactants, as indicators of sodium lauryl sulphate and sorbitan monododecanoate poly(oxy 1,2-ethanediyl).

- There are 8 parameters in Group 3 (Other Chemical Inventory); only 2 of which can be analysed. Of the remaining 6 parameters, it is possible to analyse for the ionic constituents of 4.

Based on the summary in Appendix B, it is not possible to analyse (or perform alternative analysis) for, the following substances:

1. Citric acid triethyl ester
2. Hemicellulase enzyme
3. Maltodextrin
4. Sodium carboxymethyl cellulose
5. Sodium gluconate
6. Glycine
7. Triacine

These substances may be present in the hydraulic fracture fluid or utilised in associated activities at the surface of the wellsite.

3 Technical Justification

Envireau Water has undertaken background desk study research on the analysis of the substances listed above, and on the basis of that research engaged an independent expert from Xodus Ltd (Dr Anthony Millais). Dr Millais has 20 years' experience of working in the field of environmental chemistry and the analysis of complex compounds within environmental samples. Dr Millais has prepared a short independent report which is presented in Appendix C and explains that:

- There are no laboratory methods for the analysis of hemicellulase enzyme, which comprises an undefined mixture of enzymes. Whilst laboratory methods for analysis of the other substances exist, they are only applicable to defined sample matrices. There is no evidence to support these methods being applied to environmental samples such as groundwater.

- A pre-requisite for the laboratory analysis of complex environmental samples is 'sample preparation'. There are no sample preparation techniques for the analysis of any of the substances considered.

- Consequently, there are no validated 'off the shelf' analytical methodologies available for any of these substances, in groundwater. This conclusion is consistent with the outcome of the discussions between Envireau Water and laboratory staff from Jones Environmental Ltd.

In addition, Dr Millais considers that detecting hemicellulase enzyme, carboxymethyl cellulose, maltodextrin, sodium gluconate and glycine in groundwater would be highly unlikely, as these substances are likely to be degraded and will bind to soil or rock particles with which groundwater comes into contact.

4 Compliance with the Environmental Permit

To comply with the existing environmental permit, Third Energy requires the Environment Agency to approve a deviation from the requirement to monitor all the parameters listed in Schedule 3, Table S3.5 of the permit. For the reasons presented in this technical note, it is proposed that monitoring is carried out for the revised list of parameters presented in Appendix D.

The revised list excludes the substances which cannot be specifically analysed but includes sulphate, bicarbonate alkalinity, anionic surfactants, non-ionic surfactants and phosphate, which are not currently specified. As discussed in Section 2, the inclusion of these substances will provide an alternative analysis for the constituents of some of the fracture fluid additives and/or other chemical inventory.

5 Impact Analysis

Effective monitoring of the hydraulic fracturing operation is not dependent on the analysis of the seven substances discussed above; the nature and mobility of which means they are unlikely to be detectable in groundwater. As justified in this technical note, the revised parameter analysis presented in Appendix D will therefore allow effective monitoring of the hydraulic fracturing operation.

6 Future Monitoring Arrangements

Subject to obtaining the Environment Agency's agreement to the proposed deviation, three rounds of baseline water samples will be collected and analysed in accordance with the revised parameter list (Appendix D). The results of the analysis will then be presented to the Environment Agency as part of the updated Emissions Monitoring Plan (EMP) required to discharge pre-operational condition PO3 of the permit.

Third Energy is keen to ensure that the scheme of water monitoring remains fit for purpose and compliant with the requirements of the environmental permit. The data collected during the baseline and subsequent operations will be interpreted and, where appropriate, the scheme of monitoring will be reviewed. Any proposed changes to the scheme of monitoring will be presented, discussed and agreed with the Environment Agency.

Envireau Water
15/02/2016

APPENDIX A

Water Monitoring Parameters – Permit Requirements

No	Parameter
	General Inventory:
1	Methane
2	Acrylamide
3	Alkalinity as $CaCO_3$
4	Ammoniacal Nitrogen as N
5	Arsenic
6	Aluminium
7	Antimony
8	Barium
9	Beryllium
10	BOD (settled)
11	Boron
12	Bromide
13	$\delta^{13}C$-CH_4
14	$\delta^{13}C$-CO_2
15	Cadmium
16	Calcium
17	Carbon Dioxide
18	Chloride
19	Chromium (total)
20	Cobalt
21	COD (Settled)
22	Copper
23	Dissolved Butane
24	Dissolved Propane
25	Dissolved Ethane
26	Dissolved Methane
27	Fluoride
28	Iron (total)
29	Lead
30	Lithium
31	Magnesium
32	Mercury
33	Nickel
34	Nitrate as NO_3
35	Nitrite as NO_2
36	Oxygen Reduction Potential
37	pH
38	Potassium
39	Salinity
40	Selenium
41	Silver
42	Sodium
43	Strontium
44	TPH (including Benzene, DRO (nC10 ro nC24), GRO (nC5 ro nC10), m/p Xylenes, o Xylene, MTBE, Toluene, Xylene, Ethylbenzene)
45	Total Dissolved Solids
46	Total Suspended Solids
47	Vanadium
48	Zinc

No	Parameter
	Fracture fluid additives:
49	Acetic acid;
50	Aluminium sulphate;
51	Aluminium sulphate octadecahydrate;
52	Citric acid triethyl ester;
53	Hemicellulase enzyme;
54	Maltodextrin;
55	Potassium chloride;
56	Sodium bicarbonate;
57	Sodium carboxymethyl cellulose;
58	Sodium chloride;
59	Sodium gluconate;
60	Sodium lauryl sulphate;
61	Sodium persulphate;
62	Sorbitan monododecanoate poly (oxy1,2-ethanediyl);
63	Sulphuric acid
	Other chemical inventory:
64	Triacine;
65	Glycine;
66	Formaldehyde;
67	Ammonium Bisulphate;
68	Ethylene glycol;
69	Hydrochloric acid;
70	Sodium hydroxide;
71	2-ethylhexyl zinc ditiophosphate

APPENDIX B

Alternative Analysis Parameters

No	Parameter	Analysis Available?		Alternative Analysis
		Y	N	
	General Inventory:			
1	Methane	x		
2	Acrylamide	x		
3	Alkalinity as $CaCO_3$	x		
4	Ammoniacal Nitrogen as N	x		
5	Arsenic	x		
6	Aluminium	x		
7	Antimony	x		
8	Barium	x		
9	Beryllium	x		
10	BOD (settled)	x		
11	Boron	x		
12	Bromide	x		
13	δ13C-CH_4	x		
14	δ13C-CO_2	x		
15	Cadmium	x		
16	Calcium	x		
17	Carbon Dioxide	x		
18	Chloride	x		
19	Chromium (total)	x		
20	Cobalt	x		
21	COD (Settled)	x		
22	Copper	x		
23	Dissolved Butane	x		
24	Dissolved Propane	x		
25	Dissolved Ethane	x		
26	Dissolved Methane	x		
27	Fluoride	x		
28	Iron (total)	x		
29	Lead	x		
30	Lithium	x		
31	Magnesium	x		
32	Mercury	x		
33	Nickel	x		
34	Nitrate as NO_3	x		
35	Nitrite as NO_2	x		
36	Oxygen Reduction Potential	x		
37	pH	x		
38	Potassium	x		
39	Salinity	x		
40	Selenium	x		
41	Silver	x		
42	Sodium	x		
43	Strontium	x		
44	TPH (including Benzene, DRO (nC10 ro nC24), GRO (nC5 ro nC10), m/p Xylenes, o Xylene, MTBE, Toluene, Xylene, Ethylbenzene)	x		
45	Total Dissolved Solids	x		
46	Total Suspended Solids	x		
47	Vanadium	x		
48	Zinc	x		

No	Parameter	Analysis Available?		Alternative Analysis
		Y	N	
	Fracture fluid additives:			
49	Acetic acid;	x		
50	Aluminium sulphate;		x	Ionic consitituents: Aluminium, Sulphate
51	Aluminium sulphate octadecahydrate;		x	Ionic consitituents: Aluminium, Sulphate
52	Citric acid triethyl ester;		x	Not for groundwater samples - see Appendix C
53	Hemicellulase enzyme;		x	Not for groundwater samples - see Appendix C. Hemicellulose binds to soil and is relatively immobile
54	Maltodextrin;		x	Not for groundwater samples - see Appendix C. Maltodextrin is quickly degraded
55	Potassium chloride;		x	Ionic consitituents: Potassium, Chloride
56	Sodium bicarbonate;		x	Ionic consitituents: Sodium, Bicarbonate
57	Sodium carboxymethyl cellulose;		x	Ionic consitituents: Sodium. Carboxymethyl cellulose cannot be analysed in groundwater - see Appendix C. Carboxymethyl cellulose is quickly degraded
58	Sodium chloride;		x	Ionic consitituents: Sodium, Chloride
59	Sodium gluconate;		x	Ionic consitituents: Sodium. Gluconate cannot be analysed in groundwater - see Appendix C. Sodium gluconate is rapidly degraded
60	Sodium lauryl sulphate;		x	Ionic consitituents: Sodium. Also anioinic surfactants
61	Sodium persulphate;	x		
62	Sorbitan monododecanoate poly (oxy1,2-ethanediyl);		x	Nonionic sufactants
63	Sulphuric acid		x	Ionic consitituents: Sulphate. Also pH
	Other chemical inventory:			
64	Triacine;		x	Not for groundwater samples - see Appendix C.
65	Glycine;		x	Not for groundwater samples - see Appendix C. Glycine is quickly degraded and binds to soil
66	Formaldehylde;	x		
67	Ammonium Bisulphate;		x	Ionic consitituents: Ammonium, Sulphate
68	Ethylene glycol;	x		
69	Hydrochloric acid;		x	Ionic consitituents: Chloride. Also pH
70	Sodium hydroxide;		x	Ionic consitituents: Sodium. Also pH, Alkalinity
71	2-ethylhexyl zinc ditiophosphate		x	Ionic consitituents: Zinc, phosphate

APPENDIX C

XODUS Technical Report

Ad hoc Support

Groundwater analysis

Envireau Ltd

Assignment Number: L300444-S00
Document Number: L-300444-S00-NOTE-001

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Groundwater analysis

L300444-S00

Client: Envireau Ltd
Document Type: Note
Document Number: L-300444-S00-NOTE-001

A02	20/2/2017	Issued for Use	AM	SI	AM	
A01	14/02/2017	Issued for Use	AM	LS	AM	
R01	14/02/2017	Issued for Review	AM	LS	AM	-
Rev	**Date**	**Description**	**Issued By**	**Checked By**	**Approved By**	**Client Approval**

CONTENTS

EXECUTIVE SUMMARY

This note details a short review of the available information on the feasibility of analysing groundwater samples for various substances that are to be used in hydraulic fracturing activities. Many of these substances were found to have analytical methods in existence, however there was no evidence that any of these methods had been applied to samples from complex environmental matrices.

In addition, a number of the substances are complex mixtures of biological origin and therefore a marker residue is difficult to define whilst it is also likely that these substances would be readily assimilated into the soil matric as either humic substances, soil enzymes or nutrients.

There are therefore no validated “off-the-shelf” analytical methodologies available for the analysis of the suite of compounds in groundwater. Development of methodologies to demonstrate they were robust and precise for application to the routine regulatory assessment of the substances in groundwater would require a large amount of research and development by an analytical chemist. The time and cost for such a development programme would be very high.

1 SCOPE OF WORK

Envireau Water Ltd. has retained the services of Xodus Group Ltd to provide *ad hoc* technical support on questions relating to chemicals in groundwater. This report details advice on the feasibility of analysing groundwater samples for various substances that are to be used in hydraulic fracturing activities. These substances are presented in Table 1.1.

Table 1.1 Substances

Name	Registry number
Citric acid triethyl ester	CAS: 77-93-0
Hemicellulase enzyme	CAS: 37288-54-3
Maltodextrin	CAS: 9050-36-6
Sodium carboxymethyl cellulose	CAS: 9000-11-7
Triacine[1]	CAS: 290-87-9
Glycine	CAS: 56-40-6
Sodium Gluconate	CAS: 527-07-1

With the exception of triacine all of these substances are commonly used in the food, cosmetic and or pharmaceutical industry. With hemicellulose enzyme, maltodextrin sodium carboxymethyl cellulose and glycine all common biomolecules.

Citric acid triethyl ether is a derivative of naturally occurring citric acid. It is commonly used as *"a plasticizer permitted in the field of food additive, food contact material, medical, and pharmaceutical. It is used as a plasticiser and humectant for cigarette filters. It is widely used in cosmetics, lacquers and as a fragrance carrier*"1.

A search for triacine yielded few results however one reference[2] indicated that this name was synonymous with the IUPAC name triazine. Triazine is commonly used in the oil and gas industry as a hydrogen sulphide scavenger which is converted to a different chemical form by reaction with the hydrogen sulphide.

Sodium Gluconate is a widely used in the animal and human food, personal care and pharmaceutical industry as well as having a range of other industrial uses[3]. It is readily biodegradable, achieving 98% degradation in 2 days. In addition Sodium gluconate is exempted from the requirement to register under the EU directive on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) by means of Commission Regulation (EC) No. 987/2008 of 8 October, 2008 (amending Annex IV) i.e. sufficient information on the substance exists for them to be considered as causing minimum risk because of its intrinsic properties[4].

[1] Triacine is synonymous with the IUPAC name Triazine

2 ANALYSIS

There are 2 issues with the analysis of majority of the substances listed in Table 1.1:

- Defining a suitable sample preparation technique (to clean-up, and or concentrate and or change the carrier solvent) prior to analysis; and
- The fate of the molecules in the environment and the likelihood of them being present in the groundwater.

2.1 Sample Preparation

Groundwater samples, potentially contains a range of both natural and added substances (organics, inorganics, particles of silt and clay (and possibly sand), microbes and other unknowns) present at varying concentrations. Whilst chromatographic techniques are designed to separate mixtures of substances it does not follow that some level of preliminary sample preparation and clean-up is not required. Indeed a pre-requisite of being able to quantitatively analyse complex environmental samples is the preliminary sample preparation step. Commonly sample preparation will require one or more of the following procedures: filtering of particulates, removal of interfering substances, concentration of the sample to improve limits of detection and quantification, change the solvent to one compatible with the analytical method, derivatisation of the analyte to aid detection. Each of these steps can affect both the limit of detection and the limit of quantification for the analytical methods.

From a quality assurance point of view, quantitative analytical results not only require an understanding of the process of sample preparation, but it is also important to understand the efficiency of the extraction process and the variability in precision and accuracy of the method. Ideally this is done either by adding a chemical as an internal standard to the sample before sample reparation that behaves in a similar manner to the analyte but does not interfere with the final analysis, thus this can be used to assure the efficiency of the method. Alternatively, procedural check samples containing high and low concentration of the analyte can be prepared with laboratory reagents and put through the same procedure of clean-up and analysis to assure the methodology as a whole is precise and accurate[5].

Whilst it may be possible for a suitably experienced analytical chemist to develop and sample preparation techniques for samples in environmental matrices, the scale or research and subsequent validation (both intra and inter laboratory) to produce a methodology suitable for regulatory purposes would be very large. Initial searches of the scientific literature via Science Direct[6] and the Waters Inc. product catalogues did not yield any applicable off the shelf sample preparation methods for the groundwater samples potentially containing the substances listed in Table 1.1.

2.2 Analytical methodology

The biological macromolecules listed in Table 1.1 (**carboxymethyl cellulose, maltodextrin and hemicellulase enzyme**) are all amenable to separation by gel permeation chromatography / size exclusion chromatography[7,8,9]. These are standard methods in the biosciences and application notes are available on the web for these substances. It should be noted that none of these substances consist of a single pure substance but a group or range of molecules e.g. hemicellulase enzyme is defined as "an undefined mixture of glycolytic enzymes usually containing xylanase, mananase and other activities". Similarly maltodextrin is composed of an oligo / poly saccharide of varying chain length and carboxy methylcellulose is made up of varying chain length polymers with varying degrees of saturation of the individual monomer units.

Glycine, the simplest amino acid and one of the monomers that occurs in proteins, has a number of high performance liquid chromatography methods referenced on the internet[10] (generally for amino acids) all of these methods require a sample derivatisation step to aid detection.

The review of the scientific literature on the web also identified that **Citric acid triethyl ester** has a gas liquid chromatography method published on the web[11]. Again the key would be the sample preparation step that would allow the sample to be dissolved in a solved that is suitable for this type of analysis (i.e. not water)

Owlstone have published a method for **triazine** on its website[12] and its reaction products with H_2S that has been applied to oil and process waters. When contact regarding the applicability of this method to groundwater samples, Owlstone response was "*please note that our Lonestar analyzer is able to measure VOCs in liquid, solid and gas matrices…and specifically triazines in water. However, when analyzing groundwater, the challenge surrounds the matrix variability. We need to program the Lonestar analyzer to look for specific compounds and then report out the concentration. Given the potential presence of so many unknown chemicals, the sampling and measurement approach will be challenging* "[13]

Commonly reported methods for the quantification of **sodium gluconate** in the food industry are titration[14] , although there are some that describe high performance liquid chromatography (HPLC) methodologies using various detection methodologies[15,16]. The titration methodologies are applicable to manufacturing quality control situations, where as the HPLC methodologies would be appropriate for groundwater; subject to suitable sample preparation steps and validation of a specific detection methodology.

Thus, although a chromatographic analytical method exists for each of these substances, the key to applying these methodologies to environmental samples would be to develop the method such that matrix interferences are minimised and specificity of the method relevant substances is assured. As with the sample preparation step a large amount of research work would need to be conducted to demonstrate that a robust, precise and reproducible analytical method could be derived that was suitable for regulatory purposes.

2.3 Other considerations

Application of quantitative analytical methods to groundwater samples for added chemicals must be based on the understanding that the molecule of interest is:

> Stable in the environmental medium;

> Does not exist in the environmental medium as a result of natural process; or

> May be quantified a levels above natural background levels.

For a number of the substances listed in Table 1.1 there are potential issues with this fundamental basis:

> Hemicellulase enzyme presence in groundwater would become part of the pool of already existent soil enzymes derived from dead organisms and excreted by micro-organisms. Therefore it would be very unlikely they could be recovered from groundwater as they would be bound to clay, humin and other organic material, and as a result it would be difficult to determine that any detected were from the operation being carried out and not derived from some other natural source.

> Glycine (and other amino acids) are commonly taken up by both plants and bacteria. Some bacteria produce exoenzymes that break up the amino acids before their constituents are assimilated in to the cells. Additionally amino acids are zwitterions and thus depending on soil pH may bind to clay via electrostatic interactions with charged groups and metals.

> Sodium gluconate is readily biodegradable and is therefore likely to be rapidly degraded by soil micro-organisms if it were to enter the groundwater.

> Once entering into groundwater, carboxymethyl cellulose and maltodextrin are likely to be degraded by the extant bacteria and fungi with much of these substances being as humic substances in soil. Thus these substances are unlikely to be extracted from soil in their original form and neither could any residues be ascribed to the parent material

3 CONCLUSIONS

- Laboratory methods for many of the substances exist and have been developed for use in either the food, cosmetic, bioscience or pharmaceutical industries. These methods are therefore commonly applied to defined sample matrices containing relatively large quantities of the substance of interest. No evidence has been found of these methods being applied to samples from complex environmental matrices.
- The development of methodologies for the routine analysis of the mixture of compounds from complex environmental matrices such as groundwater would require a large amount of research and development. Once the method was developed, further validation would be required to demonstrate it was suitable for regulatory use. The time and cost required to develop these methods would be very high.
- Hemicellulase enzyme, carboxymethyl cellulose and maltodextrin are not pure substances but mixtures on molecules derived from natural sources. Along with glycine it is highly unlikely that these substances could be reliably detected in groundwater as they are likely to be degraded by soil microorganisms and become assimilated into the soil background as either humic substances, soil enzymes or nutrients.

4 ENDNOTES

1 http://www.chemicalland21.com/specialtychem/perchem/TRIETHYL%20CITRATE.htm

2 Cheremisinoff, NP (1999) Handbook of Industrial Toxicology and Hazardous Materials

3 http://www.jungbunzlauer.com/en/products/gluconates/sodium-gluconate.html

4 http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32008R0987&from=EN

5 http://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf

6 http://www.sciencedirect.com/

7 http://cn.agilent.com/cs/library/applications/5991-5792EN.pdf

8 http://cn.agilent.com/cs/library/applications/5991-5797EN.pdf

9 https://www.agilent.com/cs/library/eseminars/Public/Column%20Choices%20for%20proteins_037214.pdf

10 https://www.agilent.com/cs/library/slidepresentation/Public/Amino%20Acid%20Analysis_062410_Rita%20Steed.pdf

11 http://www.sciencedirect.com/science/article/pii/S0021967301802545

12 http://www.owlstonenanotech.com/sites/default/files/PDF/H2S%20Scavengers%20Whitepaper.pdf

13 Pers comms Freshman S to Millais A by email 25/1/2017 4:35pm

14 http://www.fao.org/ag/agn/jecfa-additives/specs/Monograph1/Additive-406.pdf

15 https://www.linkedin.com/pulse/content-testing-method-sodium-gluconate-christy-wang

16 http://www.vitis-vea.de/admin/volltext/w0%2009%2020.pdf

APPENDIX D

Revised Water Monitoring Parameters

No	Parameter	Analysis Available?	
		Y	N
	General Inventory:		
1	Methane	x	
2	Acrylamide	x	
3	Alkalinity as $CaCO_3$	x	
4	Ammoniacal Nitrogen as N	x	
5	Arsenic	x	
6	Aluminium	x	
7	Antimony	x	
8	Barium	x	
9	Beryllium	x	
10	BOD (settled)	x	
11	Boron	x	
12	Bromide	x	
13	δ13C-CH_4	x	
14	δ13C-CO_2	x	
15	Cadmium	x	
16	Calcium	x	
17	Carbon Dioxide	x	
18	Chloride	x	
19	Chromium (total)	x	
20	Cobalt	x	
21	COD (Settled)	x	
22	Copper	x	
23	Dissolved Butane	x	
24	Dissolved Propane	x	
25	Dissolved Ethane	x	
26	Dissolved Methane	x	
27	Fluoride	x	
28	Iron (total)	x	
29	Lead	x	
30	Lithium	x	
31	Magnesium	x	
32	Mercury	x	
33	Nickel	x	
34	Nitrate as NO_3	x	
35	Nitrite as NO_2	x	
36	Oxygen Reduction Potential	x	
37	pH	x	
38	Potassium	x	
39	Salinity	x	
40	Selenium	x	
41	Silver	x	
42	Sodium	x	
43	Strontium	x	
44	TPH (including Benzene, DRO (nC10 ro nC24), GRO (nC5 ro nC10), m/p Xylenes, o Xylene, MTBE, Toluene, Xylene, Ethylbenzene)	x	
45	Total Dissolved Solids	x	
46	Total Suspended Solids	x	
47	Vanadium	x	
48	Zinc	x	

No	Parameter	Analysis Available?	
		Y	N
	Fracture fluid additives:		
49	Acetic acid;	x	
50	Sodium persulphate;	x	
	Other chemical inventory:		
51	Formaldehylde;	x	
52	Ethylene glycol;	x	
	Indicators of Fracture Fluid additives:		
53	Sulphate	x	
54	Bicarbonate alkalinity	x	
55	Anionic surfactants	x	
56	Nonionic surfactants	x	
	Indicators of other chemical inventory:		
57	Phosphate	x	