Shale Gas

North West - Monitoring of Flowback water

6th December 2011

Results

The Bowland Shale rock formation in Lancashire is a potential source of unconventional shale gas and is described by the British Geological Survey in work for the Department of Energy and Climate Change (DECC) as offering the best potential in the UK.

Cuadrilla Resources are licensed by DECC to explore in this area. They have planning permission to drill up to five exploratory wells. They have drilled two and are currently drilling a third. One of these has progressed to hydraulic fracturing - Preese Hall.

Environmental regulation

Our role is to help ensure that the environment is protected from the potential impacts of exploration and this includes ensuring that the disposal of the “flowback” water from the exploratory wells is managed properly.

What is flowback water?

Some of the water that is injected in to the shale rock during hydraulic fracturing returns to the surface through the drilled well. This is often called the “flowback” fluid or flowback water. Typically around a quarter of the water injected will return to the surface over a period of weeks to a few months. This flowback fluid is very saline, and contains minerals dissolved from the rocks as well as small particles of rock.

Because the water has a high mineral content it has to be disposed of carefully, with the appropriate permits granted, where necessary, for the chosen disposal route.

What analysis did we do and what did we find?

We took samples of the flowback fluid and sent them to our own laboratories for analysis.

The substances found are those which we would expect to find coming from shale rock and are naturally occurring. There are notably high levels of sodium, chloride, bromide and iron, as well as higher values of lead, magnesium and zinc compared with the local mains water that is used for injecting into the shale.

Analysis for us by other laboratories showed that they also contained very low levels of naturally occurring radioactive minerals - similar to the levels found in granite rock.

Where does the flowback water go?

The flowback water produced until the end of September from the Preese Hall exploration site was stored in double skinned tanks on site. It was then transported to a waste water treatment works at Davyhulme. The fluid is now stored on site.

The waste water treatment works already treats many other industrial effluents from the Manchester area and holds a permit from the Environment Agency to discharge to the Manchester Ship Canal. It is capable of dealing with the levels of minerals contained in the flowback water.

Does Cuadrilla need a permit?

The quantities of minerals present are not sufficient in themselves to require an environmental permit to store and dispose of the flowback water. However, from 1 October 2011, new limits for radioactive materials were specified in Schedule 23 of the Environmental Permitting Regulations 2010. These supersede previous limits. Cuadrilla now need a permit if they want to continue disposing of these fluids to the waste water treatment works because the levels measured combined with the expected quantities of flowback fluid exceed the new limits. We have told them that they need to apply to us for a permit and provide us with more information so we can assess their proposal.

What is happening to the flowback fluid now?

Currently the flowback fluid is being stored in double skinned tanks on site pending a permit application.

Appendix 1 A comparison of the mineralisation of this water with other waters

Different water sources have different levels of these chemicals. Below is a table to give an indication of how the maximum levels in the flowback fluid compare to those in other water sources.

	Sea Water (grams per litre)	**The Dead Sea** (grams per litre)	**Flowback** Fluid (grams per litre)
Sodium	10.1	36.3	34.8
Chloride	19.4	230.4 (for chloride plus bromide)	92.8
Bromide			1.0
Magnesium	1.3	45.9	2.1
Potassium	0.4	7.8	0.1

Appendix 2: Table of Environment Agency dissolved salts sample analysis

Notes to support table

- Mains water with small amounts of additives are injected into the exploratory well - this is the fracking fluid. We include a typical analysis for mains tap water in the Singleton area. (sourced from United Utilities web pages) as a comparison to the analysis of the flowback fluid that returned to the surface..
- The variation between this and the flowback analysis indicates the minerals which have been taken from the shale formation during the fracking process.
- The analysis of the flowback water is reported in either micrograms per litre (µg/l), or milligrams per litre (mg/l). (Note 1 mg/l = 1000 µg/l). Filtered means filtered to remove solids.
- In one sample we also analysed for acrylamide as an impurity arising from the fracking fluid injected into the rock or a possible breakdown product from the polyacrylamide in the fracking fluid. We found very low concentrations in the flowback fluid.

SITE	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Cuadrilla Drill Rig	Mains water average concentration
DATE	7 April 2011	14 April 2011	28 April 2011	18 May 2011	14 June 2011	1 Aug 2011	17 Aug 2011	
TIME	13:20	13:30	11:10	14:00	09:55	11:00	09:30	
Conductivity at 25oC µs/cm	–	–	–	150614	133730	176000	_	299
pH	–	–	–	6.35	7.06	6.33	_	7.54
Acrylamide µg/l							0.05	
Lead (filtered) µg/l	179	<20	<2	<40	<40	<20	< 100	
Lead - as Pb µg/l	600	<10	<10	<40	44.9	80.5	< 100	<0.417
Mercury (filtered)	0.01	<0.01	0.013	<0.01	<0.01	<0.01	< .01	

µg/l								
Mercury - Hg µg/l	0.024	<0.01	<0.01	<0.01	0.012	0.09	0.038	<0.013
Cadmium (filtered) µg/l	0.674	<1	1.47	<2	<2	<1	< 5	
Cadmium - Cd µg/l	1.29	<0.5	<0.5	<2	<1	6.02	< 5	<0.04
Bromide mg/l	–	–	242	854	608	673	1020	<0.444
Chloride Ion mg/l	15400	34400	22200	75000	64300	58000	92800	13.5
Sodium (filtered) mg/l	7950	15100	9330	28400	>200	21400	33300	
Sodium - Na mg/l	no bottle	15100	9380	28400	23600	21700	34800	22.9
Potassium (filtered) mg/l	23.2	46.4	37.8	82.1	>20	64.9	90.7	
Potassium - K mg/l	28.8	52.3	40.6	–	–			
Magnesium (filtered) mg/l	177	>50	397	–	–			
Magnesium - Mg mg/l	no bottle	586	401	1470	1350	1370	2170	9.21
Phosphorus - P mg/l	1.28	0.0771	<0.02	<0.1	<0.5	0.532	< 0.2	
Chromium (filtered) µg/l	< 3	<5	0.565	28	<10	<5	40	
Chromium - Cr µg/l	25	4.03	<3	20.5	53.9	222	42.9	<0.349
Zinc – (filtered) µg/l	297	<50	53.6	142	411	107	<300	
Zinc - as Zn µg/l	565	51.5	<30	173	435	382	<300	

Nickel – (filtered) µg/l	13.8	<10	21.5	<20	<20	<50	<50	
Nickel - Ni µg/l	20.3	<5	<5	<20	<20	<20	<50	1.20
Silver (filtered) µg/l	< 10	<5	<10	<20	<10	<1	<50	
Silver µg/l	–	–	<1	<20	<10	<20	99.4	
Aluminium (filtered) µg/l	< 50	<100	<10	<200	<200	<100	<500	
Aluminium-Al µg/l	596	<50	<50	<200	<100	1590	<500	<8.04
Arsenic (filtered) µg/l	5.1	<1	<1	<1	<1	2.3	<1	
Arsenic – As µg/l	6.2	<1	<1	1.2	2.6	14.5	<1	0.309
Iron (filtered) µg/l	36600	82800	35800	70700	106000	74200	80200	
Iron - as Fe µg/l	66600	80700	51800	78600	112000	137000	88200	<7.62
Cobalt (filtered) µg/l	< 10	<5	<10	<20	13.3	<1	< 50	
Cobalt µg/l	–	–	4.96	<20	<50	<20	< 50	
Copper (filtered) µg/l	27.5	<10	12.4	36	<20	13.3	< 50	
Copper - Cu µg/l	936	8.04	<5	37.6	34.4	215	< 50	0.025
Nitrogen - N mg/l	10.7	52.5	33.4	98.8	77.8	47.9	121	
Vanadium - Filtered µg/l	< 20	<10	<20	<40	<20	<2	< 100	
Vanadium - V µg/l	< 4	<10	<2	<40	<100	<40	< 100	

Appendix 3: Analysis for low level naturally occurring radioactivity

We sent samples to an external laboratory for an analysis of any radioactivity. The analysis showed the presence of naturally occurring radioactive materials (commonly called "NORM") at levels similar to that in many rocks throughout the UK, granite being a common example.

Naturally occurring radioactive materials have been present in rocks since their formation, perhaps billions of years ago. All radioactive materials undergo decay to become more stable, eventually ceasing to be radioactive. Some radioactive materials decay over very long time periods and others more quickly, and so naturally occurring radioactive materials will contain many different radioactive isotopes in differing amounts. The radioactive materials with very long decay times are usually present in larger amounts. Commonly this is radium-226.

The initial analysis of the flowback fluid has shown radium-226 as the radioactive material present at the highest levels, between 14 and 90 Becquerel per litre. Other naturally occurring isotopes present included potassium-40 and radium-228. In comparison the average values for natural radioactivity in soil in western Europe are, potassium-40 - 547 Bq/kg and radium-226 - 40 Bq/kg.

The results of this preliminary analysis have to be viewed with caution, they are only indicative of the radioactivity present. As part of Cuadrilla's application for a permit a radiological impact assessment will be required. In determining the application we will review the radiological impact assessment with regard to public dose constraints as set out in legislation.

Results of Analysis

Gross Alpha and Beta Activity

LGC Ref	Sample	Count date	Gross Alpha Activity as 241plutonium (Bq/kg)	Gross Beta Activity as 40potassium (Bq/kg)
L3004800	Water Sample 14/04/11 A	03-05-11	10.4 ± 3.5	2.7 ± 0.47
	Solids from sample L3004800	03-05-11	1.1 ± 0.3	0.33 ± 0.05
L3005183	Water Sample 03/05/11 A	16-05-11	12.1 ± 4.0	6.2 ± 1.0
	Solids from sample L3005183	16-05-11	2.2 ± 0.6	1.5 ± 0.1
L3005770	Bottle A received 23/05/11	31-05-11	15.8 ± 5.3	12.1 ± 2.0
	Solids from sample L3005770	31-05-11	10.1 ± 2.8	3.4 ± 0.5
L3009542	Water Sample 19/08/11 A	31-08-11	200 ± 59	47 ± 7.8
	Solids from sample L3009542	31-08-11	0.77 ± 0.22	0.27 ± 0.04

Gamma Spectrometry (Bq / kg or Bq / kg equivalent for solids)

LGC Ref.	L3004801		L3005184		L3005769		L3009542	
Sample Ref	Water Sample B 14/04/11	Solids from Sample	Water Sample B 03/05/ 11	Solids from Sample	Bottle A Rec'd 23/05/11	Solids from Sample	Water Sample Rec'd 19/08/11	Solids from Sample
Analysis Date	21/04/11	21/04/11	09/05/11	18/05/11	24/05/11	31/05/11	30/08/11	30/08/11
40Potassium	< 1.0	< 1.0	3.5 ± 1.1	< 1.0	3.3 ± 1.9	< 1.0	< 3.0	< 1.0
60Cobalt	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1
137Caesium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.2	< 0.1
228Actinium	1.7 ± 0.4	< 0.1	2.6 ± 0.5	0.4 ± 0.1	2.9 ± 0.6	1.4 ± 0.3	12 ± 2.5	< 0.2
228Thorium	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 10	<2.0
224Radium	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0	< 1.0
212Lead	0.4 ± 0.1	< 0.5	0.9 ± 0.1	< 0.5	0.7 ± 0.1	< 0.5	< 0.5	< 0.5
212Bismuth	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 2.0	< 0.5
208Thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
234Thorium	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0	< 6.0	< 1.0
226Radium	14 ± 2.1	< 0.2	16 ± 2.1	2.5 ± 0.4	17 ± 2.3	7.2 ± 1.5	90 ± 12	< 1.0
214Lead	1.4 ± 0.2	< 0.5	6.0 ± 0.7	1.6 ± 0.2	2.3 ± 0.3	2.6 ± 3.3	50 ± 5.6	< 0.5
214Bismuth	0.9 ± 0.2	< 0.5	5.1 ± 0.6	1.3 ± 0.2	2.1 ± 0.3	2.3 ± 0.3	41 ± 4.6	< 0.5
235Uranium	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.3	< 0.1
227Thorium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 2.0	< 0.5
223Radium	< 0.5	< 0.5	2.1 ± 0.6	< 0.5	< 0.5	< 0.5	< 2.5	< 0.5
241Americium	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.5	< 0.1

Glossary

- Fracking fluid - fluid injected in to the exploration well
- Flowback fluid - water with dissolved and suspended minerals that comes back out of a exploratory well (this can also be called return fluid, or return fracking fluid)