

Australian Government

Department of the Environment and Energy

Deeper groundwater hazard screening for chemicals used in coal seam gas extraction - Overview

In summary, the deeper groundwater hazard screening research found that chemicals remaining underground after hydraulic fracturing are unlikely to reach people or groundwater dependent terrestrial ecosystems in concentrations that would cause concern. Risks are therefore likely to be very low. Risks from naturally-occurring chemicals in the coal seam mobilised by hydraulic fracturing are likely to be very low for the same reasons. Note that strict regulatory controls apply to the handling and use of chemicals in coal seam gas extraction.

This research complements the *National assessment of chemicals associated with coal seam gas extraction,* which focussed on risks to human health and the environment from surface handling of chemicals used in coal seam gas extraction.

The research developed methods that can be used on a project-by-project basis to assess risks to human health and the environment from chemicals remaining deep underground as a result of hydraulic fracturing in coal seam gas operations. It did not assess the risks associated with any existing or proposed coal seam gas project.

The movement of chemicals underground depends on the local geology and the properties of the chemicals. The project therefore used two case study areas, one in the Surat Basin and one in the Gunnedah Basin, to develop the methods. It used information about the chemical and physical properties of 13 chemicals chosen because they represent the range of chemicals used in coal seam gas extraction. Whenever the method made assumptions, care was taken they were always conservative (that is, likely to overestimate rather than underestimate risk factors) so that risks would not be underestimated.

Chemicals in deeper groundwater

Hydraulic fracturing leaves a fraction of the chemicals injected deep underground, and can cause chemicals that occur naturally in the coal seam to move through the underground environment.

This research identified four potential pathways for chemicals to move from a hydraulic fracturing site to places where people or ecosystems might come into contact with them. The project found that all four pathways are either unlikely or extremely unlikely to exist in the study areas, which have similar geology to other areas where coal seam gas extraction is taking place or proposed in Australia.



Figure 1: Plausible pathways for chemicals in Deeper Groundwater¹. First, a fracture might spread from the coal seam targeted by hydraulic fracturing to an aquifer used by people or the environment (pathway A). The second pathway requires a rupture in the casing of the CSG well to result in hydraulic fracturing fluid being injected into an aquifer (pathway C). The other pathways involve chemicals travelling along the targeted coal seam until they encounter either a water bore (pathway B) or a fault leading to an aquifer (pathway D).

¹ Based on Figure 2-31 from deeper groundwater report



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Chemicals become less concentrated as they move underground

Where a chemical requires more detailed assessment it will often be useful to calculate how much of it people or ecosystems might come into contact with. This research developed a method to do this.

This method involves calculating how far a chemical must travel to reach a place where people or ecosystems might come into contact with it, how long it will take to get there, and how much its concentration will be reduced when it arrives. The longer a chemical takes to reach a place where people or ecosystems might come into contact with it and the further it has to travel, the more its concentration will be reduced. For most locations investigated, chemicals would not reach people or ecosystems in detectable concentrations.

How long will it take for the chemical to reach a place where people and ecosystems might come into contact with it?

The project used a groundwater model to calculate how fast a chemical could travel along the pathways that might link it to places where people and ecosystems might come into contact with it. The project found that chemicals tend to move extremely slowly underground. In most cases the chemicals would take decades or centuries to reach a place where people and ecosystems might come into contact with it; by this time they are unlikely to do harm.

The time taken to reach a given location depends on the local geology and the properties of the chemical. The properties of the chemical are important because some chemicals 'stick' more strongly to surfaces and therefore move more slowly. Most organic chemicals will partially or completely degrade (break down) prior to reaching people or ecosystems.

How far does the chemical need to travel to reach a place where people and ecosystems might come into contact with it?

In each study area, the research identified coal seam gas wells and water-dependent assets such as water bores, surface water features, and vegetation. The project then calculated the distances between each well and each asset. This gave an indication, based on a straight distance, of how far a chemical would need to travel in order to reach an asset. For example, in the Surat Basin there were twenty groundwater bores within 500 metres of a CSG well; all these bores were used to water stock.

How much will the concentration of the chemical be reduced?

The concentration of a chemical can be reduced by dilution ('watered down') or degradation ('broken down').

All chemicals moving though deeper groundwater are diluted. The degree of dilution depends on the volume of hydraulic fracturing fluid injected and how far the chemical travels. The research found that dilution alone reduces the concentration of chemicals that travel 500 metres by a factor of about a thousand (when one million litres of fracturing fluid is injected). Dilution is greater for travel over longer distances.

Organic chemicals are degraded (broken down) by chemical reactions and biological processes. The degree of degradation depends on the chemical, the conditions underground, and how long it takes to reach the location of interest. The conditions underground are important because many chemicals break down faster when temperatures are higher or oxygen is present. Some micro-organisms, which may be found underground, can also speed up the breakdown of some chemicals.

The research calculated how fast sample chemicals break down under the range of conditions found at the study sites. It found that degradation reduces the concentration of many chemicals close to zero over relatively short travel distances. Other chemicals – mostly inorganics – do not degrade at all.

The combined effect of dilution and degradation reduces the concentration of chemicals that travel 500 metres by factors ranging from a thousand (for slowly degrading chemicals) to ten billion (for quickly degrading chemicals). The smaller values are for chemicals that do not degrade. The larger values are for chemicals that degrade quickly and travel through environments conducive to degradation.

Using this research to improve risk assessments

The methods developed in this research can be used to estimate the concentration of a chemical when it reaches a water-dependent asset, such as a water bore or a groundwater-dependent ecosystem. These *predicted environmental concentrations* can be used to assess risks to human health and/or the environment. See the box for an example. More details about assessing risks of chemicals used in coal seam gas extraction can be found in the risk assessment guidance manual.

Dilution alone might reduce the concentration of chemicals reaching places where people and the environment may come into contact with them to an acceptable level. When dilution over short distances is considered, differences in regional geology do not make much difference to how much chemicals are diluted as they travel underground. This means risk assessments over short distances can use the information from the deeper groundwater hazard screening research without any further modelling.

If risk assessors also wish to include degradation for calculating concentrations, differences in regional geology can make a difference to how fast chemicals degrade, so it may be necessary to do some modelling using the approaches set out in the deeper groundwater hazard screening research.

Using the research to calculate predicted environmental concentrations: an example

Suppose a CSG well was hydraulically fractured using one million litres of a fluid containing 525 milligrams per litre of acetic acid and 2600 milligrams per litre of guar gum. There is unlikely to be a pathway for the chemicals to move from the well site to a place where people or ecosystems might come into contact with them. But supposing there was a pathway, would the concentrations of acetic acid and guar gum at a site 1000 metres from the well be a risk to aquatic ecosystems?

Dilution alone would reduce the concentration of acetic acid to 0.2 milligrams a litre. This is well below the concentration of 15 milligrams a litre that has been found to have no effect on aquatic ecosystems. There is no need to consider degradation, which would reduce concentrations further. Note that the chemical would be further diluted if it entered a stream, wetland or other water body.

Dilution alone would reduce the concentration of guar gum to 1 milligram a litre. This is higher than the concentration of 0.22 milligrams a litre that has been found to have no effect on aquatic ecosystems. However, if we take degradation into account (based on an estimation of the time typically taken for a chemical to be carried 1000 metres) the concentration of guar gum falls to 0.001 milligrams a litre. This result holds in the two case study regions. Because local geology can affect degradation, additional modelling might be needed in other regions. Note that the chemical would be further diluted if it entered a stream, wetland or other water body.

The methods developed in this research can be also be used to calculate:

- the maximum concentration of a chemical in hydraulic fracturing fluid that will be reduced to an acceptable concentration at a given distance from the well, and
- the minimum distance between a hydraulically fractured well and a water body, water bore or groundwater-dependent ecosystem needed to reduce a given concentration of a chemical to an acceptable level.