GISERA
Gas Industry Social and Environmental Research Alliance

MARCH 2020

Air, water and soil impacts of hydraulic fracturing (HF) in the Surat Basin, Queensland

This research program addresses community concerns about the potential environmental impacts of HF in coal seam gas (CSG) in the Surat Basin Queensland.

KEY POINTS

- This research is the most comprehensive investigation into HF activities in Australia to date and represents the leading edge of international onshore gas studies.
- This was a unique research opportunity to monitor the impacts of HF at six CSG wells prior to, during, and after HF operations in the Surat Basin.
- Governance, industry regulation and operational integrity are crucial in managing risk and potential impacts of HF.

Results

- HF operations had minimal to no impacts on air quality, and well development activity was not associated with significantly elevated levels of any air pollutants with the exception of soil dust.
- HF operations monitored did not have a detectable impact on nearby groundwater bore quality, adjacent soils or water samples from a local creek.
- At all monitored CSG wells the impacts of HF operations on water quality of water produced from the wells diminished over time and within 20 to 40 days HF chemicals reduced below detectable limits in the majority of samples.
- Water produced from the wells immediately after HF (flowback water) contained HF chemicals, elevated concentrations of major ions (salts), ammonia, organic carbon, some metals and organic compounds, with concentrations reducing to a pre-fractured state within 40 days.
- Current water treatment operations are effective in removing HF chemicals and geogenic chemicals and compounds either completely or reducing levels to within acceptable limits according to water quality guidelines.
- Some types of biocides used in HF fluids and geogenic chemicals present in produced water were completely degraded in soil samples within two to three days.

Communities in gas development areas of the Surat Basin in Queensland want their natural environment protected and have concerns about any adverse effects of the HF process in the region.

Community, government and industry seek more information on:

- the nature and type of chemicals used in HF and any impacts
- geogenic chemicals and compounds released from the coal seam during the HF process
- the fate of HF chemicals and geogenic chemicals
- potential impacts of HF on the environment.

The purpose of the study

This project investigated the environmental impacts from CSG production involving HF in the Surat Basin.

The three year research program comprised two phases – review, design and test best-practice sampling and monitoring techniques and methods; and an extensive field-based monitoring and sampling program for air, water and soils, and a laboratory analysis of soil samples exposed to HF chemicals.

The study team included researchers from CSIRO, the Australian Nuclear Science and Technology Organisation (ANSTO), Macquarie University and The University of Queensland.

Australia Pacific LNG's upstream operator, Origin Energy, provided researchers with access to production wells and HF operations during the research period.

CSIRO | Australia Pacific LNG | QGC | origin | Santos | NSW Government | Australian Government Department of Industry, Science, Energy and Resources | Supported by Government of South Australia | Queensland Government | Northern Territory Government | Pangaea Resources Pty Ltd

CSIRO scientist sets up a solar powered air quality monitoring station in the Surat Basin, Queensland.

What is hydraulic fracturing?

HF is a stimulation process used to increase the flow of gas and water from a gas well. It involves the high pressure injection of fluids and solids into a well, to fracture the coal seam and open pathways for gas and fluids to flow back into the well and to the surface.

What are HF fluids?

HF fluids are typically 90-91 per cent water, 7-8 per cent proppants (solids, like sand) and around 1-2 per cent chemical additives. The proppants help keep the fractures open for gas and fluids to flow into the well. The chemical additives are used for:

- water conditioning (biocides) to control microbial growth and pH
- preventing the swelling or migration of clays into the fluid stream
- inhibiting corrosion of well casings and equipment
- managing the viscosity of the fluids – ensuring the proppant remains in suspension.

What is flowback water?

Following HF, the coal seam is depressurised and a mixture of formation water and HF fluids flow back to the surface through the well. Flowback waters contain HF fluids used (water, proppant and chemical additives), in addition to naturally occurring (geogenic) chemicals that have been mobilised from the coal seam during the HF process.

Flowback waters are stored and transported according to Queensland Government regulations and treated at a licenced waste treatment facility.

What is produced water?

Produced water is the water that is extracted from the well under normal operating conditions. Produced water is transported by pipelines for storage and treatment via reverse osmosis technogy prior to beneficial re-use.

Current water treatment operations are effective in removing geogenic and HF chemicals either completely or reducing levels to within acceptable water quality guideline limits. Following treatment, around 80 per cent of produced water is available for beneficial use, such a crop irrigation or aquifer re-injection.

Governance and regulation

CSG and liquefied natural gas (LNG) operations in Queensland are subject to strict laws to minimise impacts on the environment. The Queensland Government has monitoring and compliance regimes in place, including laws that protect groundwater and the Great Artesian Basin, impose conditions and controls around the treatment and use of produced water, prohibit harmful chemicals, protect landholders' water quality, and protect regional interests. Overall, the handling, transport and storage of HF fluids, flowback fluids and CSG determines the impacts on air, water and soil quality.

Research relevant to Queensland operations

Prior to this study, the only HF data available to Australia was from overseas sources and mainly involved shale gas rather than CSG developments.

Independent and relevant scientific research in Australia provides the necessary information for communities, industry and government to make long-term decisions around future well development in our region.

The data from this study will provide a resource for policy makers, landholders and other stakeholders to understand the management of onshore gas development and operations, and assist ongoing improvement to industry practice and regulation.

Air quality

Potential sources of air pollutants associated with HF include the proppant, HF chemicals, flowback fluids, coal seam gas and vehicles/equipment on site. In the air quality study continuous measurements were undertaken for common pollutant gases and airborne particle concentrations at two sites. In the laboratory over 1000 gas samples collected across 13 sites were analysed for up to 45 different pollutants along with concentrations of 25 chemicals present in 180 samples of airborne particles collected across six sites.

The ambient air quality measurement program had three main objectives:

1 Compare air quality at a HF site with non-HF sites, and with Australian state and federal air quality objectives.

2. Quantify changes in air pollutant levels during HF operations.

3. Identify the contribution of HF and non-HF sources of air pollutants at the study site.

CSIRO researchers collecting water samples at a well site temporary water storage facility.

Key results

- The levels of most air pollutants were well below relevant air quality objectives for the majority of the study period.
- Occasional high airborne particle concentrations were observed that exceeded national air quality objectives, however, similar events were also observed at sites not impacted by HF activities.
- Dust associated with the movement of heavy vehicles and equipment on site was the dominant source of airborne particles during exceedance events.
- Emissions from diesel-powered vehicles and equipment on site during well development contributed to small increases (above background levels) in NO_2, CO, $PM_{2.5}$, formaldehyde, BTX and PAHs but were still well within relevant ambient air quality objectives.
- The dominant sources of air pollutants in the background atmosphere were fires, regional transport of pollutants from industry and agriculture, secondary production in the atmosphere, and natural sources, such as soil, and fungi and biota in the soil.

Water and soil quality

The water and soil quality study aimed to:

1 Quantify the impacts of HF operations on nearby surface water, groundwater and soils.

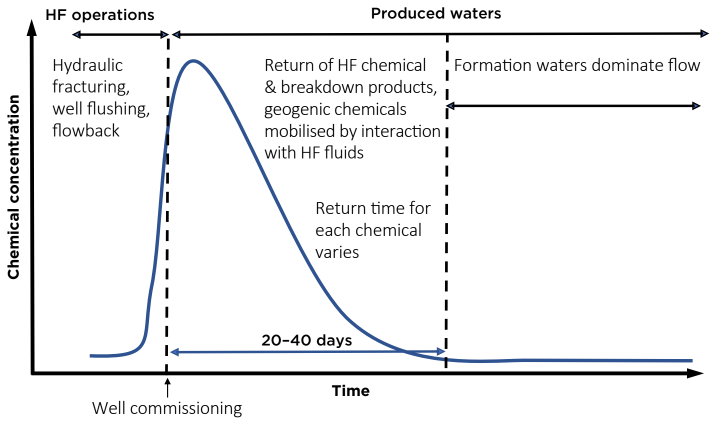
2. Assess concentrations of any HF chemicals and geogenic chemicals in flowback and produced waters.

3. Compare water quality in sampled waters with relevant Australian water guidelines.

The water quality study collected samples from creek waters, groundwater, flowback water, produced water, samples of HF fluid, and soil cores from well pads. 113 water samples and 40 soil samples were collected, and subject to 22 analytical procedures to determine the concentration of over 150 chemicals including organics, inorganics and radionuclides.

Key results

- No HF chemicals were detected in soil samples, groundwater samples or samples from a local creek.
- Water produced from the wells immediately after HF contained HF chemicals, elevated concentrations of major ions (salts), ammonia, organic carbon, some metals and organic compounds, with concentrations reducing over time.
- At all monitored CSG wells the impacts of HF activities on water quality diminished over time.
- Within 20 to 40 days of completion of HF operations, concentrations of the majority of HF chemicals reduced to below detectable limits.
- Within 20 to 40 days of completion of HF operations, concentrations of geogenic chemicals returned to levels assumed to reflect coal seam formation water i.e. returned to a pre-fractured state.
- In line with Government regulation industry have monitoring systems and processes in place to prevent flowback water and produced water from entering groundwater or surface waterways.
- Current water treatment operations are effective in removing geogenic chemicals and compounds and HF chemicals either completely or reducing levels to within acceptable water quality guideline limits.



HF and geogenic chemical concentrations in water produced from the well reduced over time.

Laboratory soil spill experiments

The phase one review identified laboratory testing under controlled conditions as the most effective way to assess the potential impact of spills of HF fluids, flowback water and produced water on surface and sub-surface soils.

To assess the potential effects of HF fluid, flowback water and produced water spills on soils, three aspects were covered:

1. Degradation rate of selected chemicals.
2. Mobility of selected chemicals through soils (sorption).
3. Potential impacts on soil microbial health.

Key results

- Soil microbial communities were effective in degrading some types of biocides and geogenic chemicals.
- Two biocides added to the HF fluid degraded rapidly (more than 90 per cent within 24 hours) and were not detectable in soil samples after 72 hours.
- Three organic geogenic compounds detected in the produced water showed rapid degradation in soils and were not detectable within 48 hours.
- TEA (Triethanolamine – used as a 'breaker') degraded rapidly in soils treated with pure water, however, degradation rates were much slower in soils treated with HF fluid.
- Overall, soil microbial activity was reduced by the addition of HF fluids and produced water, with HF fluid having a greater impact.
- There was an impact on nitrifying microorganisms – with a greater impact from HF fluids than produced waters. These microorganisms are important in the nitrogen cycle as converters of soil ammonia to nitrates, which can then be used by plants.

Approximate locations of the Origin Energy study sites (Condabri – blue; Combabula – red).

A CSG well undergoing hydraulic fracturing.

MORE INFORMATION

- Read the air, water and soils reports: https://gisera.csiro.au/project/air-water-and-soil-impacts-of-hydraulic-fracturing-phase-2/
- Review all GISERA research in Queensland: https://gisera.csiro.au/project/states/qld

ABOUT CSIRO's GISERA

The Gas Industry Social and Environmental Research Alliance (GISERA) is a collaboration between CSIRO, Commonwealth and state governments and industry established to undertake publicly-reported independent research. The purpose of GISERA is to provide quality assured scientific research and information to communities living in gas development regions focusing on social and environmental topics including: groundwater and surface water, biodiversity, land management, the marine environment, and socio-economic impacts. The governance structure for GISERA is designed to provide for and protect research independence and transparency of research. Visit gisera.csiro.au for more information about GISERA's governance structure, projects and research findings.

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