GISERA
Gas Industry Social and Environmental Research Alliance

Air, water and soil impacts of hydraulic fracturing

Overview of Phases 1 and 2

Melita Keywood | Principal Senior Research Scientist | 5 December 2019

Air, water and soil impacts of hydraulic fracturing

- An intensive monitoring campaign to measure the impact on air, surface water, groundwater and soil of hydraulic fracturing of production wells in the Surat Basin
- In two parts
  - Phase 1 – Study design (externally peer-reviewed)
  - Phase 2 – Implementation
  - Project Leader Melita Keywood (O&A)
  - Air Quality Leader Erin Dunne (O&A)
  - Water Quality Leader Simon Apte (L&W)
  - Soil Quality Leader Rai Kookana (L&W)

Community concerns

- disclosure of the nature and type of chemicals used in the HF operations
- mobilization of native contaminants (radon, mercury, organic compounds) from the coal seam into groundwater, soil and air
- fugitive emissions of coal seam gas into groundwater and air
- the possible environmental fate of HF chemicals and native contaminants
- the potential for impacts on human health and the environment
- the ability of operators to control the fracturing processes and prevent or remediate accidents
- the potential for HF to cause seismic activity

Australia and world-first

What data exists to address these concerns?

- Application of overseas data to Australia? Shale v coal seam gas
- Only data available for Australia

To the best of our knowledge, only data globally where information on what was happening in the HF field has been incorporated

Use of data generated in this study

- Made publicly available on the CSIRO data access portal in late 2019
- Assist the assessment of human health risks from exposures via ambient air (NICNAS, 2017c) including the GISERA health study (Keywood et al., 2018) and other studies on environmental and health impacts of CSG development in Australia
- Provides a useful resource for policy makers, landholders and other stakeholders to inform decision making around future well development in the region and to inform improvements in industry practices.

What is Hydraulic Fracturing?

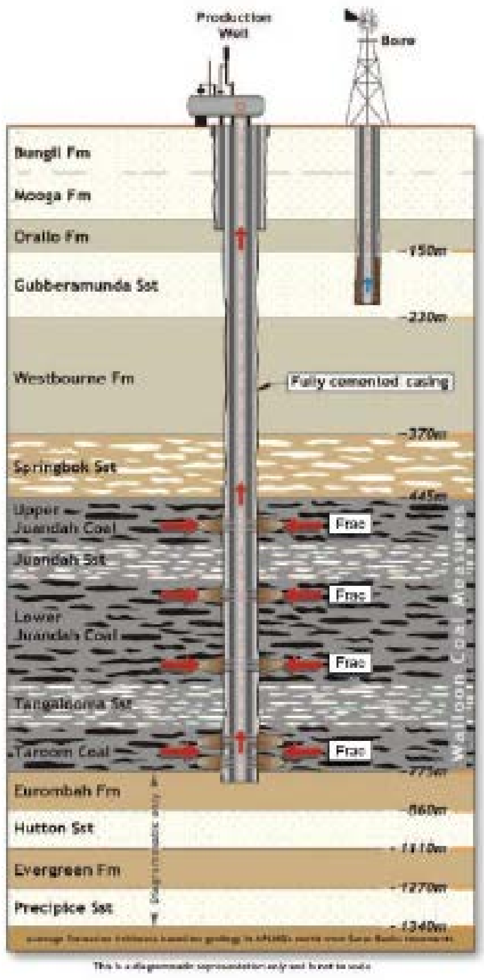
Fluids (> 500 KL / well) are pumped at high pressure (>3000 psi) down the well to fracture the target coal seam creating pathways for gas and water to flow back to the surface via the well.

Hydraulic Fracturing fluids:

- water - (84 – 96%),
- proppant - (sand) 3 – 15%
- Chemical additives - few percent

Typical duration ~2 days/well

Multi-zone CSG production well (APLNG, 2011)



Hydraulic Fracturing Fluids

- Water- post RO water/ local bore water (84 -96%)
- Sand (3 – 15%)

Chemical additives (> 20 KL /well):

- **Biocides**- methyl isothiazolones, sodium hypochlorite
- **Clay stabilisers-** KCl
- **Corrosion inhibitors-** gelatine
- **Acid Spearhead** – usually hydrochloric acid
- **Linear & crosslinked gels-** guar gum gelling agents, with crosslinkers (borate, ethylene glycol)
- **Gel breakers-** ammonium sulfates
- **Surfactants**- ethanol, nitroethanol
- **pH buffers-** sodium hydroxide, sodium carbonate

In this study, specific information about the HF chemicals used was provided in the relevant well completion reports.

Flowback fluids and Coal Seam Gas (CSG)

Once HF is complete, the well is depressurised and the fluids will flow back to the surface

Flowback fluids

- Injected HF fluids and sand
- Groundwater from the coal seam – containing natural **geogenic** contaminants
- Products of interactions between HF fluids and the coal seam
- Samples of flowback collected and analysed as part of this study

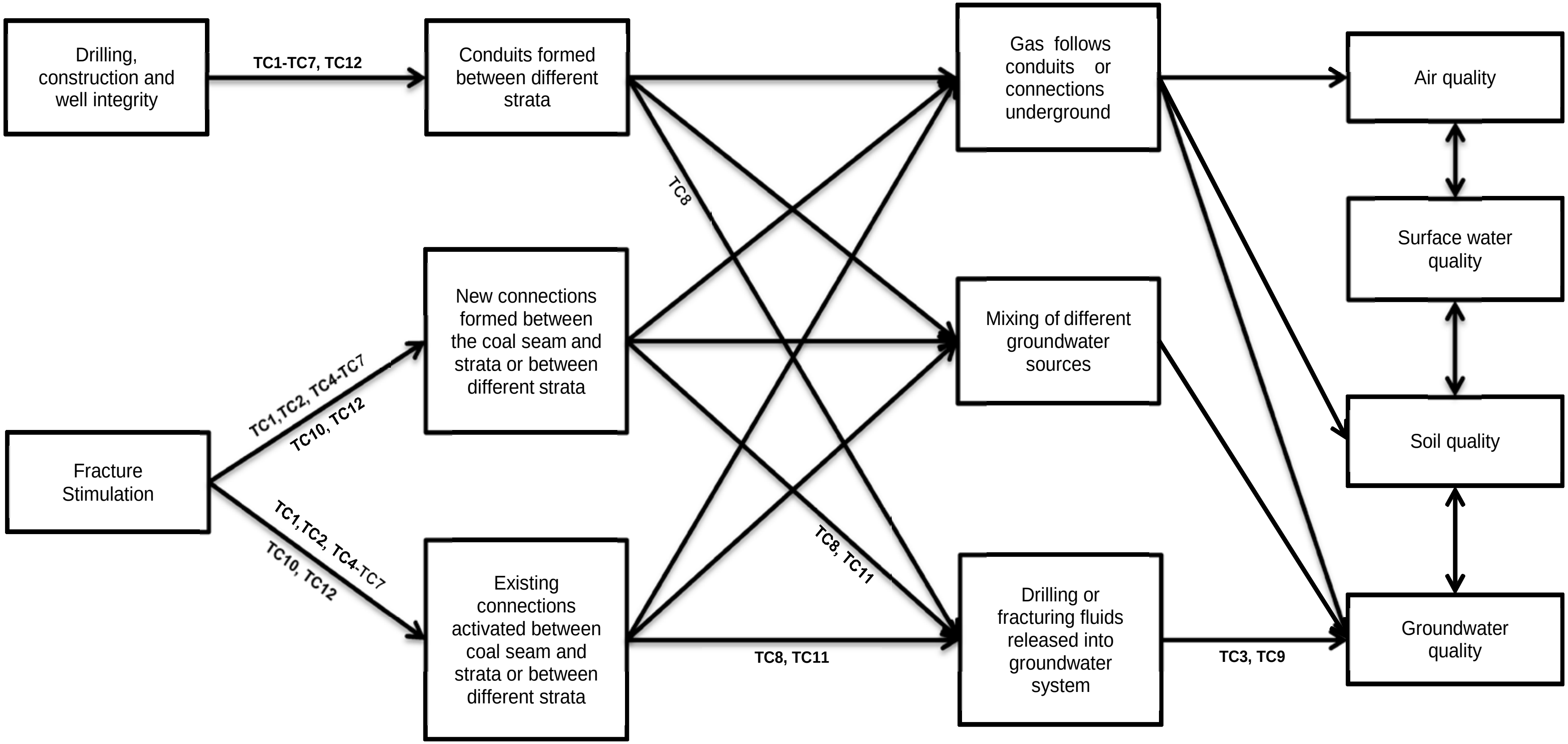
Geogenic contaminants

- trace elements (e.g. arsenic, manganese, barium, boron and zinc)
- radionuclides (e.g. isotopes of radium, thorium and uranium)
- organic compounds such as hydrocarbons, phenols, PAHs

Higher volatility, lower solubility geogenic contaminants are also present in CSG

- methane 96 – 98% of CSG
- Volatile organic compounds (VOCs) – hydrocarbons
- Semi-volatile organic compounds (SVOCs) e.g. Poly aromatic hydrocarbons (PAHs)
- Mercury (Hg), Radon (Rn), Hydrogen sulfide (H_2S)

Potential pollution pathways



NSW Chief Scientist & Engineer (2014)

Phase 1 Deliverables

Task 1	**Establishment of Review Panel (AQ)**
Task 2	**Review of state of knowledge about potential sources of air pollutants associated with CSG extraction using HF (AQ)**
Task 3	**Combabula site familiarization visit (WQ)**
Task 4	**Study design for measurement program to provide enhanced information of impacts of HF on air quality (AQ)**
Task 5	**Study design for measurement program to provide enhanced information of impacts of HF on soil, surface water and groundwater quality (WQ, SQ)**
Task 6	**Analysis of measurements of air made before HF commenced (i.e. October 2016 to April 2017) AQ**
Task 7	**Collection of baseline soil and water samples at Combabula and a reference stream location (WQ,SQ)**

Tasks 4 & 5 Externally peer reviewed

Phase 2 Deliverables

Task 1	Air quality measurement program report
Task 2	Air quality draft report
Task 3	Air quality final report
Task 4	Water and soil quality field measurement report
Task 5	Water and soil quality analysis report
Task 6	HF chemical fate in soils lab study report
Task 7	Water and soil quality final report

Tasks 3, 6 &7 Externally peer reviewed

Air Quality

Air Quality Measurements

- 200 aerosol filter samples
- > 600 VOC adsorbent tube samples;
- > 350 DNPH aldehyde & carbonyl samples;
- continuous VOCs by PTRMS
- > 8 weeks of continuous data (O_3, NOx, CO, SO_2, CH_4, Radon, >, mercury)

Analysis

- comparisons of measurements taken before, during & after HF
- detailed analysis to provide info on sources
- comparisons with Australian federal & state air quality objectives (NEPM, Qld EPP)
- comparison with simultaneous regional air pollutant levels – Surat Basin AQ Study
- detailed analysis to provide info on sources

Water and Soil Quality

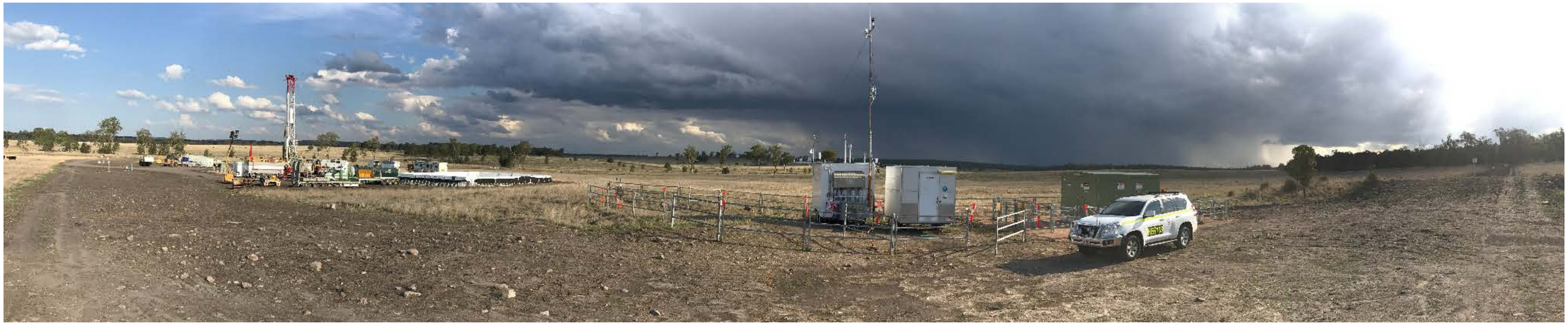
Water Quality Measurements

- Water sampling from six wells during & after HF (6 months)
- Samples of HF fluids
- Surface water sampling in a nearby creek during & after HF
- Groundwater bore water sampling before, during & after HF, incl. measurements of fluorobenzoic acid tracers added to HF fluids
- In total: > 100 water samples subjected to > 20 analytical techniques, measuring >150 potential contaminants

Soil Spill Experiments

- Exposure of soil samples to HF fluids in the laboratory
- Degradation & stability of contaminants measured over time
- Biological indices (respiration, nitrification) also measured over time to determine impact on soil ecosystem health

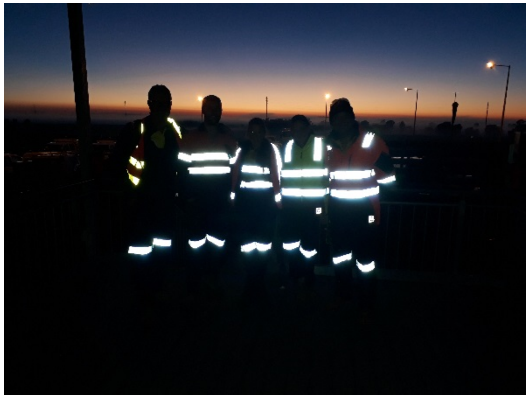
Project Team



CSIRO Climate Science Centre team: Melita Keywood, Erin Dunne, Jennifer Powell, Jason Ward, James Harnwell, Paul Selleck, Min Cheng, Suzie Molloy, Max Desservettaz, Scott Henson

CSIRO Land & Water team: Simon Apte, Rai Kookana, Mike Williams, Adelle Craig, Josh King, Brad Angel

Project research partners:
ANSTO (Radon): Sylvester Werczynski, Ot Sisoutham, Alistair Williams
ANSTO (Aerosol composition): Armand Atanacio
Macquarie University (Mercury): Grant Edwards, Tony Morrison
University of Queensland (PAHs): Fisher Wang
Origin Energy
Ecotech & SGS Leeder (under contract from Origin Energy)



GISERA
Gas Industry Social and Environmental Research Alliance

Thank you

Melita Keywood
Principal Senior Research Scientist

t +61 2 9123 4567
e melita.keywood@csiro.au
w gisera.csiro.au