GasFields Commission Queensland

# Risk to farm operations from land slope changes predicted to result from CSG-induced subsidence on Priority Agricultural Areas

# Research Scoping Paper

March 2022

# Contents

## Purpose of proposed pilot project

Coal seam gas (CSG) operations will cause subsidence of the of land surface in and immediately adjacent to the CSG wellfields, commonly referred to as CSG-induced subsidence (subsidence). There is community concern that for intensively farmed land that relies on precision techniques such as laser levelling to optimise irrigation, even minor subsidence could impact farm operations.

The proposed project seeks to develop a framework for assessing, at a farm scale, the risk to farming operations on intensively farmed land, arising from predicted CSG-induced subsidence. It is intended that the framework will assist government to assess the suitability of existing legislative frameworks for managing farm impacts.

## Background

### *The concern about subsidence*

In the context of this research, 'subsidence' is a permanent lowering of the surface of the land. In the context of CSG activities, it occurs due to the lowering the water pressure in the underling coal seams which allows the seams to compress under the weight of the overlying formations[1].

Subsidence results in 'ground movement' at the land surface. Subsidence is one of the causes of ground movement, but there are other causes mostly related to the swelling and shrinking of soil due to changes in soil moisture content. Soil moisture content changes as a result of factors such as climatic or seasonal conditions, soil moisture profile, crop type and rotation. Ground movement due to soil moisture changes are significant but they are temporary. Ground movement due to subsidence is permanent.

Farmers manage temporary ground movement on a routine basis. However, those carrying out intensive farming on the western edge of the Condamine Alluvium, where the land has a low and managed slope, are concerned that even small amounts of permanent ground movement may impact their farming operations. Although there is some concern about changes in the way water moves more broadly over the landscape, the main concern is that any unevenness in subsidence at the farm scale may be sufficient to significantly impact on-farm drainage requiring additional farm management.

### *Current and predicted subsidence*

The resource tenure holders have estimated the potential risk of subsidence as a part of their Environmental Impact Statement (EIS) and Environmental Authority (EA) processes[2]. The Underground Water Impact Report 2021 for the Surat Cumulative Management Area – Consultation Draft (UWIR 2021), prepared by the Office of Groundwater Impact Assessment (OGIA), summarised the predictions made by the CSG tenure holders throughout the Surat Cumulative Management Area (Surat CMA). Arrow Energy (Arrow) is one of the CSG tenure

[1] Underground Water Impact Report 2021 for the Surat Cumulative Management Area – Consultation Draft
[2] Queensland Government - Environmental assessments and conditions

holder adjacent to the intensively farmed land on the western margin of the Condamine Alluvium. The UWIR 2021 noted that Arrow has predicted up to 150 mm of subsidence across its tenements.

OGIA used its updated regional groundwater flow model together with new geomechanical and analytical modelling techniques to make new predictions. In summary, the UWIR 2021 reported the following:

- the geographic pattern of subsidence will closely reflect the geographic pattern of water depressurisation in the underlying coal formation;
- subsidence associated with a CSG well will be highest in the first years of operation stabilising over the following 3 to 7 years;
- by 2060, subsidence is predicted to be less than 100 mm over most of the cropping lands, but up to 175 mm in some areas; and
- the predicted maximum change of land slope is predicted to be less than 0.001% (10 mm over 1 km) in most areas, but up to 0.004% (40 mm over 1 km) in some areas.

OGIA used satellite data to identify what ground movement has occurred since CSG development began. It assessed areas near to and far from CSG development to understand ground movement caused by background factors (such as variations in soil moisture content) and ground movement caused by subsidence. It found that the observed subsidence was broadly consistent with the predicted subsidence.

### *Farm scale assessment and management*

To deal with the landholder concerns, there is a need to carry out assessment and management at the farm scale. This is not something that can be fully addressed under the UWIR framework because there are differences in the way legislative frameworks deal with CSG impacts on groundwater supply water, and CSG impacts on farm operations. These differences are summarised as follows:

- For groundwater supply impacts, the UWIR framework deals with modelling, monitoring as well as management of impact on individual groundwater supplies. The UWIR operates in the following way:
    - it makes predictions about water level impacts over the whole of the Surat CMA;
    - it assigns responsibilities to individual tenure holders to carry out specified parts of regional monitoring strategies; and
    - it specifies areas where trigger thresholds of impact are predicted to be exceeded within 3 years, thereby the triggering obligations for individual tenure holders to enter into ‘make good’ agreements with individual affected bore owners.
- For subsidence impacts, the UWIR framework deals with modelling, monitoring of subsidence, but does not provide for management of impacts. Under the UWIR

framework, subsidence impacts are modelled and monitored because of the potential for impacts on environmental values, which includes the use of water for irrigation. However, because subsidence impacts on farm operations are not about water supply, they are managed under legislative frameworks dealing with land impacts. The suitability of those frameworks for dealing with farm management issues arising from subsidence is a matter currently being considered by government.

The Gasfields Commission Queensland (GFCQ) and OGIA have worked with landholders to better understand the farm management issues associated with change of land slope because of subsidence.

It is appropriate that OGIA develop predictions of subsidence that are suited to assessing farm management impacts, and thereby enable GFCQ to better advise government about the suitability of existing legislative frameworks to manage on-farm impacts.

## Potential consequences for farm operations

Through ongoing engagement with landholders on the Condamine Alluvium, GFCQ and OGIA have developed the following understanding of the primary concerns in relation to subsidence.

### *Potential for farm scale change of land slope*

The slope of farmland is critical for intensive farming operations that rely on precision techniques to optimise irrigation practices. The land needs to slope uniformly enough to enable irrigation water to run along furrows and for drains at the end of furrows to collect runoff. For dryland farms there needs to be enough slope to allow runoff to drain from the land. Farmers carry out levelling to achieve and maintain optimal land slope.

Although CSG-induced subsidence will be relatively uniform at a broad scale, there could be some lateral variations at the farm scale. This is primarily because individual CSG wells come online at different times, are constructed in a variety of configurations, and are located in slightly different locations relative to individual nearby farms.

Landholders are concerned that the combined effect of the multiple CSG wells near their farms could mean that the amount and timing of subsidence could vary over the area of individual farm fields. They are concerned that difference in subsidence within a farm field could result in high and low areas, disrupting drainage which would affect farm productivity.

### *Managing changes in farm slope*

Land slope changes do occur in the absence of subsidence. There are seasonal changes due to variations in moisture content, but these are temporary. There can also be changes to erosion or sedimentation associated with flooding. The regular movement of machinery access tracks can also cause some heaving of the ground over time.

These types of changes to land slope are managed by periodic levelling to re-establish the optimal slope. The frequency of this maintenance activity varies from farm-to-farm, with some

carrying out some management annually and others carrying out work far less frequently. On land with a very low natural slope drainage is more critical, and maintenance is likely to be needed more frequently.

Although maintenance by levelling is needed to some extent, both irrigators and dryland farmers seek to minimise levelling because, in addition to the direct cost of levelling, there are flow on costs such as:

- levelling involves running heavy machinery over farmland which causes compaction which can damage soil structures;
- repairing soil structure takes time, requiring multiple wetting and drying cycles and may involve cultivation and the application of compost;
- apart from the cost of levelling and restoration of soil structure, there is a period of loss of productivity from the land during levelling and restoration activities. Restoration times of up to 18 months have been reported; and
- dryland farms potentially face greater difficulty because drainage is not engineered and may be less efficient at removing additional pondage. Also, they may face potentially longer restoration times after levelling because wetting and drying cycles are limited to natural cycles. Also, levelling is inconsistent with the 'zero tillage' methods employed by some farmers.

The concern for landholders is that CSG-induced subsidence will either cause levelling to be needed more frequently, or to be more extensive. The increased frequency in levelling ultimately poses a potential of increased costs of management and a loss of production (yield) during and immediately after levelling. Both of these factors have financial implications on farming enterprises.

There are concerns expressed by some that on land with very low natural slope and therefore naturally poor drainage, changes due to uneven subsidence may not be able to be managed adequately through levelling resulting in a permanent reduction in productivity.

## Changes across farm boundaries

Although the primary concern is the potential for changes in land slope to affect drainage within individual farm fields, there is some concern that changes in land slope will affect the way water moves onto or off individual farm fields and into farm dams.

At an even broader landscape scale, some are concerned that long-term maximum subsidence will change the directions of overland flow and minor watercourses, affecting the opportunities for water harvesting. **For the purpose of clarity, this pilot research project will only consider properties within the tenure boundary**.

## Broad Strategy for Proposed Project

### *Scope of proposed project*

Primary questions for any farmer in the areas of predicted subsidence area are:

- What land slope changes are predicted for my farm fields?
- Will those changes cause a material risk of increased farm maintenance?

The proposed project will seek to answer those questions for the most at-risk farm fields, and then use findings from those pilot sites to reach broader conclusions. For the pilot sites the strategy is to:

- express the land slope change predicted from subsidence in a way that best relates to the flow of water, having regard to matters such as irrigation furrow, drainage ditch, and the directions of overland flow;
- make predictions about the likelihood of those land slope changes occurring;
- work with the landholder of the pilot site to characterise the consequences for farm operations; and
- on the basis of the assessment of likelihood and consequences develop a risk matrix suitable for application across the intensively farmed land on Condamine Alluvium.

Although the primary focus will be on changes of slope within farm fields, movement of water onto and away from the fields, into farm dams, and across property boundaries will also be assessed.

### *Linkages to management frameworks*

As mentioned previously, the GFCQ is considering the effectiveness of existing legislative frameworks to manage any impacts of subsidence on farm operations. Output from the project will inform those considerations.

### *Out of scope matters*

GFCQ and OGIA engagement with landholders shows that the primary concern for landholders is the potential for change to land slope and the way it could affect farm management. However, there is some concern that changes to the broader landscape could possibly change the way water flows over land, irrespective of land slope changes on an individual farm.

Because the proposed project deals with detail on pilot sites, it will not directly assess landscape scale effect. However, learnings taken from the proposed project will inform the need for a future landscape scale assessment and assist in the design of a future project to assess those risks – should such a study be necessary.

## Pilot site selection

Pilot sites will be identified by using the current predictions of subsidence developed by OGIA and application of the following selection criteria:

- Proximity to CSG development
    - Farm fields that are close to the margins of the predicted subsidence area, because those areas are likely to experience the greatest eventual change in land slope over relatively small distances.
- Density, time sequencing and configuration of planned CSG wells
    - At the farm field scale these factors, including whether wells are configured as vertical or lateral wells, affects depressurisation and associated subsidence particularly in the early stages of the development.
- Maturity of nearby CSG development
    - Farm fields close to early CSG development will allow past changes to land slope to inform predictions about future changes.
- Low existing land slope
    - Farm fields that have the low existing land slope, as small changes to slope within those fields would be more likely to disrupt drainage.
- Maximum predicted subsidence
    - Farm fields located in the area of greatest long-term predicted subsidence because higher total subsidence could be associated with higher variability in changes to land slope.
- Maximum predicted rate of subsidence
    - Farm fields that, on the basis of current industry development planning, will experience the greatest initial rate of subsidence, because high rates of subsidence could be associated with higher variability in changes to land slope.

Although site selection will be based primarily on the specified criteria, selection will include both irrigated and dryland farm fields, consideration of differences in soil characteristics and consideration of the movement overland flow on the sites, including into overland flow storages.

At this stage it is envisaged that between 4 to 8 sites will be selected.

## Project Plan

The project is planned to proceed in five (5) essentially sequential stages. In addition to engagement with the pilot site landholders, there is provision for three group workshops at strategic points. Estimates of the time required to complete each stage are given, however engagement outcomes may lead to the need for adjustments. It is estimated that the project will take 6 months to complete. The 5 stages are as follows:

### *Stage 1 – Select pilot sites (week 1 – 2)*

#### Overview:

The objective is to identify pilot sites according to the previously mentioned selection criteria and obtain landholder agreement to participate.

Pilot sites will be proposed using the selection criteria and current predictions of changes to slope which are summarised at a regional scale in the UWIR 2021.

#### Components of Stage 1:

- Identify potential pilot sites
- Contact potential pilot site landholders
- Explain project and seek agreement to participation
- Confirm pilot sites
- Group Workshop 1: Site Selection
    - Initial group workshop with pilot site landholders and GFCQ Stakeholder Committee to discuss how the pilot sites were selected and how the project is planned to proceed.

#### Stage Outcome:

Key landholders understand and support for the project.

### *Stage 2 – Assess the likelihood of slope change associated with subsidence (Week 2 – 16)*

#### Overview:

The objective is to assess the likelihood of land slope change associated with subsidence at a scale, and expressed in a form, that is relevant to the subsequent assessment of the consequence of the slope change for farm operations.

The primary tool for predicting subsidence is OGIA's regional groundwater flow model. The model will need to be modified in the area potentially affected by subsidence to provide the resolution necessary to support farm scale predictions for the project.

In order to subsequently assess the consequence of likely subsidence, the background ground motion will need to be characterised as clearly as possible. OGIA will develop new analytical tools for this purpose.

Although the initial technical work will be carried out within OGIA, as results are produced there will be a need to engage with the pilot site landholders to develop output in a form that landholders believe is relevant to the later assessment of how those changes would affect farm operations.

Therefore, although the initial work will be carried out within OGIA, there will be increasing engagement with pilot site landholders as Stage 2 of this project progresses.

### Components of Stage 2:

- Modify the groundwater flow model
  - Subsidence predictions are made using depressurisation output from the OGIA regional groundwater flow model. The current model generates output at a 1.5 km grid spacing which may not be sufficient to support farm scale assessment
  - OGIA will modify part of the regional groundwater model to provide a 200 m grid in the potentially affected area, which is expected to be sufficient for the project
  - Subsidence predicted using the modified model will include expression as land slope change
  - Predictions of subsidence made with the modified model will be assessed against subsidence to date, which will be informed by the characterisation of natural ground movement as discussed below
- Characterise natural ground movement
  - OGIA will use data analytic tools to identify any correlation of natural ground movement with underlying factors (e.g. soil types etc.)
  - Identified correlations will be used to establish zones of natural variations of land slope at the pilot sites
  - The character of ground movement for each of the zones will then be used to better identify past ground movement
- Review the assessment of the likelihood of slope change assessment with pilot site landholders
  - Engage with pilot site landholders to ensure that the assessment of the likelihood of change of slope is expressed in a way that has relevance for assessing the consequences for farm operations. This engagement will be progressive through Stage 2.

Stage Outcome:

A methodology for assessing likelihood of change of land slope that is relevant for farm operations.

### *Stage 3 – Assess the consequences and risk (Week 17 – 18)*

Overview:

The objective is to use output from Stage 2 to assess the consequences of predicted farm slope changes for farm operations.

Components of Stage 3:

- Group Workshop 2 – Risk to farm operations
  - Group workshop with pilot site landholders and GFCQ Stakeholder Committee to discuss the consequence for farm operations of predicted changes to slope
  - Presentations to workshop:
    - OGIA – findings of change in slope and variation in natural ground movement
    - Hydrologist – hydrological context and likely on-farm changes
    - Agronomist – background on impacts to farm practices from slope changes
  - Output sought
    - What should be considered in in assessing the consequences for farm operations?
    - Are additional model scenarios required?

Stage Outcome:

Sufficient understanding of both the likelihood and consequence at a farm level to enable the development a risk matrix that would have a high level of community support.

### *Stage 4 – Develop and apply of a risk matrix (Week 19 – 24)*

Overview:

Synthesise the outcomes of Group Workshop 2 to develop a risk matrix and then apply the matrix across the potentially affected area.

### Components of Stage 4:

- Develop a draft risk matrix
    - Synthesise outputs from Group Workshop 2 to develop a risk matrix in terms of likelihood and consequence
    - The matrix to provide a basis for assessing risk at the farm level, based on factors such as initial land slope, soil type etc.
- Test the draft risk matrix on pilot sites
    - Engage with the pilot site landholders individually to assess the suitability of the draft risk matrix for use on the pilot sites
    - If necessary, reconvene project teams for each pilot site comprising the landholder, OGIA, hydrologist and agronomist
    - Adjust draft matrix if necessary
- Apply risk matrix more broadly
    - Assess risk across the potentially affected area of the Condamine Alluvium
- Group Workshop 3 – Review project outcomes
    - Project team present the synthesised findings to the group of pilot site landholders, and the GFCQ Stakeholder Committee
    - Seek feedback to finalise.

### Stage Outcome:

An assessment of risk across the potentially affected area.

## *Stage 5: Project Reporting (Week 25 – 26)*

### Produce a draft report on the project.

Community engagement on the draft report would be a matter for consideration by government having regard to other processes that may be in progress around the suitability of management frameworks

## Project Outcomes

The project report will provide:

- a framework for assessing the risk to farm operations from CSG-induced subsidence, in terms of likelihood of predicted changes to land slope on farms and consequences for farm operations;
- an assessment of risk across the potentially affected part of the Condamine Alluvium, made using the risk assessment framework; and
- if appropriate, commentary on how the risk assessment framework might be integrated into a regulatory framework.

## Project Governance

- Project Sponsor
    - commission and manage the project
    - promote action arising from outcomes of project
    - manage engagement with Project Reference Group.
- Project Director
    - lead implementation of the project
    - project reporting
    - facilitate landholder engagement.
- Project Team
    - core members comprises
        - Project Director
        - GFCQ Project Officer
        - OGIA as the primary provider of subsidence modelling and slope estimation
        - Hydrologist (Department of Regional Development, Manufacturing and Water [DRDMW] or Department of Environment and Science [DES]) and an agronomist (Department of Agriculture and Fisheries [DAF]) as required from time to time to provide input to workshops.
- Landholders of pilot sites
    - appointed by project owner by agreement
    - role:

        - engage with the project team and participate in workshops
        - provide information about farm operations and management
        - agree to publication of farm information as necessary for project outcome transparency. Agreement would be by negotiation, and always respecting privacy to the greatest practicable extent.

- Project Reference Group
    - appointed and convened by project owner
    - briefings led by project director and OGIA
    - role is to receive project briefings, provide feedback and contribute to discussion about project issues and directions
    - membership
        - agricultural industry – (to be determined in consultation with peak bodies)
        - CSG industry – (to be determined in consultation with peak bodies)
        - two landholders
        - government agencies - (Department of Resources [Resources], DRDMW, DES)
    - Frequency of briefings – flexible, depending on progress, outcomes and issues arising. Notionally there would be a briefing at commencement then after each group workshop.
- Community Engagement
    - Engagement with an appropriate cross section of landholders will be important to the success of the project.
    - It is proposed to utilise GFCQ's established 'Surat Stakeholder Advisory Group' network for community engagement on issues related to CSG development activities in the Surat Basin.
    - For previous engagement around subsidence undertaken by OGIA, the SSAG group had be augmented with additional landholders from the project area. It is proposed to also utilise an extended landholder group during consultations.
    - It is proposed that community engagement be through that group on an as-needs basis, including where appropriate involving members in relevant project-based workshops.

## Glossary

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| **Arrow** | Arrow Energy |
| **CSG** | Coal Seam Gas |
| **CSG-Induced** | Coal Seam Gas Induced Subsidence |
| **DAF** | Department of Agriculture and Fisheries |
| **DES** | Department of Environment and Science |
| **DRDMW** | Department of Regional Development, Manufacturing and Water |
| **EA** | Environmental Authority |
| **EIS** | Environmental Impact Statement |
| **GFCQ** | Gasfields Commission Queensland |
| **OGIA** | Office of Groundwater Impact Assessment |
| **Resources** | Department of Resources |
| **Surat CMA** | Surat Cumulative Management Area |
| **UWIR 2021** | Underground Water Impact Report 2021 for the Surat Cumulative Management Area – Consultation Draft |

GasFields Commission Queensland

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