Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Project Order

Short Project Title

Laboratory Based Evaluation of Cement Degradation Processes in CSG Wells in Queensland

Long Project Title	Laboratory Based Evaluation of Cement Degradation Processes in CSG Wells in Queensland
GISERA Project Number	Oth.5
Start Date	01/05/2025
End Date	30/06/2026
Project Leader	Abbas Movassagh

GISERA State/Territory

- [x] Queensland
- [ ] New South Wales
- [ ] Northern Territory
- [ ] South Australia
- [ ] Western Australia
- [ ] Victoria
- [ ] National scale project

Basin(s)

☐ Adavale	☐ Amadeus	☐ Beetaloo
☐ Canning	☐ Western Australia	☐ Carnarvon
☐ Clarence-Morton	☐ Cooper	☐ Eromanga
☐ Galilee	☐ Gippsland	☐ Gloucester
☐ Gunnedah	☐ Maryborough	☐ McArthur
☐ North Bowen	☐ Otway	☐ Perth
☐ South Nicholson	☒ Surat	☐ Other (please specify)

GISERA Research Program

☐ Water Research	☐ Health Research	☐ Biodiversity Research
☐ Social & Economic Research	☐ Greenhouse Gas Research	☐ Agriculture Research
☒ Land and Infrastructure Management Research	☐ Other (please specify)	

1. Project Summary

Community and landholder groups in Queensland have expressed concerns about potential failures in the integrity of Coal Seam Gas (CSG) wells, and the possibility of failed wells providing a pathway for contamination of aquifers and gas leaks. Communities have asked for assurance as to how the construction of these wells ensures their integrity.

Well integrity is provided by barriers that are designed to prevent unintended flow of fluids (such as water or gas) into, out of or along the well bore. The two main structural barriers are well casing and annular cement. Well casing prevents the flow of fluids into or out of the well, keeps the well open through weak or broken rock layers, and provides a pathway to move gas and water from the reservoir to the surface. Casing is cemented into the well to provide support to the casing and the wellbore and to create a seal between the casing and the surrounding rock. These components act together as a multi-barrier system that greatly reduces the risk of loss of well integrity.

Cement plays a vital role as both a primary barrier and in providing support and protection to the casing throughout the well's lifecycle, continuing once a well has been decommissioned. Cement used in natural gas wells is distinctly formulated for the unique requirements of bonding to casing and geological formations, differing significantly from common construction materials like structural concrete. Unlike household concrete, which is designed primarily for strength and durability under everyday conditions, well cement must ensure a robust and impermeable seal, resisting extreme subsurface environments. It is engineered to withstand high pressures, corrosive fluids, and varying temperatures, ensuring well integrity and preventing leaks between underground layers or to the surface.

This project will investigate the potential for cement degradation and their processes in CSG wells in the Surat Basin under conditions (pressure, temperature, groundwater chemistry) typically encountered in this region. The project will be laboratory based, using ageing and accelerated ageing experiments to evaluate the extent of potential cement degradation. Cement samples are exposed to groundwater with compositions found in CSG fields at the pressures and temperatures representative of reservoir conditions for an extended period of time. These specimens will be examined to determine whether there has been degradation of cement along with the mechanisms and rates of any degradation detected. Geochemical modelling will be performed to analyse the experimental results and to investigate the potential for long-term cement degradation. Finally, the implications for long-term well integrity will be considered.

2. Project description

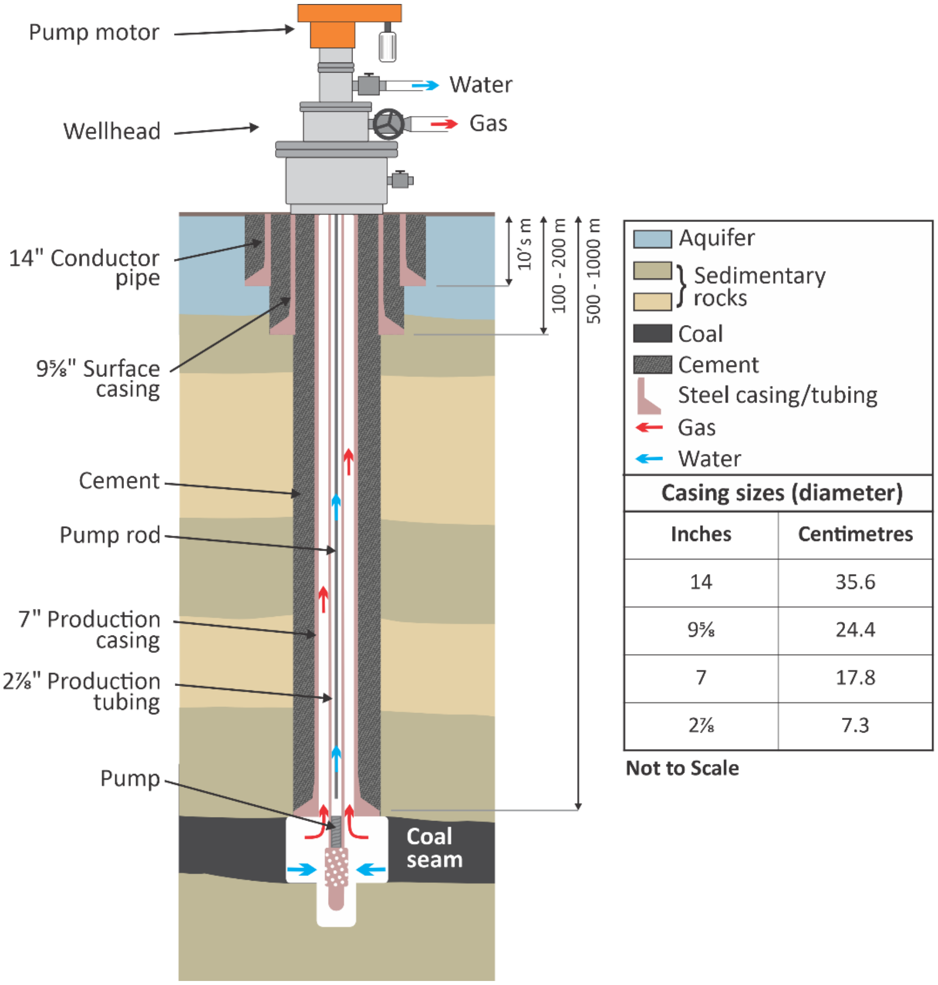
Introduction

South-east Queensland hosts the largest CSG producing fields in Australia where the key reservoirs comprise the Permian coals of the Bowen Basin and Jurassic coals of the Surat Basin. The development of these resources has seen the drilling of over 14,000 CSG wells so far. A commonly raised concern in the community is about the long-term integrity of these wells and whether they may provide a pathway for contamination of groundwater resources and unintended release of methane gas. An aspect of these concerns is about the longevity of cement used in well construction. This project will look at processes that may cause cement used in CSG wells to degrade using laboratory experiments that replicate *in-situ* conditions the cements are exposed to.

CSG wells are typically designed with multiple barriers to maintain well integrity and to prevent the unintended flow of fluids (such as water or gas) into, out of or along the well bore. The two main structural barriers are multiple levels of well casing, usually made of steel, and annular cement. Well casing prevents the flow of fluids into or out of the well, keeps the well open through weak or broken rock layers, and provides a pathway to move gas and water from the reservoir to the surface. Casing is cemented into the well to provide support to the casing and wellbore and to create a seal between the casing and the surrounding rock Figure 1. These components act together as a system. The key characteristics of the cement are:

- that it is strong enough to maintain mechanical integrity (so that it doesn't fracture),
- that it is impermeable so that fluids cannot flow through it, and
- its ability to form a seal against the rock formations (cement to rock) and the casing (cement to casing) so that fluids can't move along these interfaces.

A potential mechanism for well integrity issues is through the degradation of cement through time. Degradation may be caused by the pressure and temperatures and the formation fluids that the wells are exposed to. For example, Portland-based cement, when exposed to chemicals like chloride or sulphate, can undergo degradation (Santhanam et al, 2002). Additionally, cement degradation can occur due to attacks by corrosive substances like sulphates and sulphides found in formation fluids (Raiber and Suckow, 2017). Cement degradation may alter the chemical and mechanical structure of the cement, leading to increased porosity, permeability, and loss of density and strength, which ultimately could compromise the integrity of the cement barrier over time.



Casing sizes (diameter)	
Inches	**Centimetres**
14	35.6
9⅝	24.4
7	17.8
2⅞	7.3

Figure 1: A typical CSG well (Huddlestone-Holmes et al., 2018).

In order to evaluate the potential risk to well cement integrity within the Australian Coal Seam Gas (CSG) reservoirs, a series of ageing experiments will be conducted on cured cement samples. This evaluation will focus on subjecting cement (using cement mixtures that are representative of those used) to formation fluids under downhole conditions and analysing the cement for changes. This analysis will examine the effect of these conditions on the nature and rate of cement compositional changes. Ageing experiments replicate mid- to long-term environmental exposure by placing cement samples in carefully controlled laboratory conditions. This approach enables us to investigate cement degradation from the relatively short experiments (three to six months) to longer timeframes (years to decades).

The key objective of this new project is to incorporate the data collected from the cement section of Grigore et al (2024) regarding the previously employed cement class type and the types of additives in CSG wells and use this information to design cement degradation experiments while subjected to formation fluids.

Prior Research

This project will build upon the previous work of the GISERA Project "Queensland CSG well integrity: cements, steels and microbial activity[1]" (Grigore et al, 2024), which focused on reviewing Well Completion Reports (WCRs) for a randomly selected set of wells in Surat, Bowen, and Galilee basins. Grigore et al (2024) integrated data regarding casing and cementing materials utilised in the construction of CSG wells in Queensland and aimed to present this information in a user-friendly format accessible to non-technical readers as an information resource for the community. According to the aforementioned study, cement slurries are prepared by mixing dry cement with water and additives in specific proportions. Cement mixtures reported in the WCRs include Class A, general purpose (Type GP), blended (Type GB), shrinkage limited (Type SL), sulphate resisting (Type SR), and Class G. Approximately three-quarters of all cement reported were general purpose cement. Huddlestone-Holmes et al (2017) discussed the durability of cement used in well construction and abandonment, particularly under conditions related to Australia's shale gas wells.

Huddlestone-Holmes et al. (2018) further contributed to the understanding of CSG well design, integrity, and decommissioning under GISERA Project S.9 'Decommissioning pathways for CSG projects'. Their report detailed the full life cycle of a coal seam gas well including site preparation and drilling to completion, decommissioning, and rehabilitation. This project also considered the views of local stakeholders through a series of workshops.

A critical component of their findings was the emphasis on maintaining well integrity throughout the operational life of the well and especially at abandonment. The study highlighted that effective decommissioning must ensure the safe and permanent isolation of the well to prevent any future movement of gas or water between geological formations or to the surface. This involves rigorous engineering design, including the installation of multiple casing strings, proper cement placement, and the use of mechanical and cement plugs during abandonment. It is emphasised that abandonment practices must ensure environmentally sound and safe isolation of wells, particularly to prevent vertical fluid migration. They also identified that abandonment relies heavily on the integrity of the casing-cement-rock system, highlighting the importance of proper initial cement placement, pressure testing, and the use of cement plugs and mechanical barriers to seal potential flow pathways across aquifers and hydrocarbon zones. The outcomes of this project underscore the need for continued evaluation of well cement durability and abandonment strategies under Australian CSG conditions. This includes targeted research into cement degradation specific to CSG wells. For local stakeholders, a key concern was the potential for long term legacy effects from decommissioned wells. While some of these concerns stem from a limited understanding of well decommissioning practices, they highlight the need for publicly accessible information on the materials and methods used.

[1] https://gisera.csiro.au/research/land-and-infrastructure/queensland-csg-well-integrity-cements-steels-and-microbial-activity/

Moreover, ageing tests are required to understand how hardened cement behaves over time under conditions that simulate real-world environments found in oil and gas wells. Lécolier et al. (2007) explored the long-term durability of hardened Portland cement used in well cementing. The study conducted aging tests on cement paste under varying experimental conditions, assessing its macroscopic properties in different fluids. The study highlights the complex interplay between chemical and physical ageing processes and their impact on the structural integrity of cementitious materials used in well construction. Similarly, Satoh et al. (2013) conducted ageing experiments to examine the long-term corrosion behaviour of cement in abandoned wells under reservoir conditions, such as in depleted gas fields with aquifers. It revealed that the long-term exposure of cement to corrosive environment may lead to alterations in the cement's structural and chemical properties. As such, the ageing tests are crucial for predicting the long-term behaviour of cement in wells, guiding improvements in cement formulations, and ensuring that the wells remain safe and environmentally secure throughout their operational life.

Need & Scope

Long term well integrity is required to prevent impacts to the environment. For annular cement to perform over the life of a well, including once it has been decommissioned, it must not degrade significantly over time spans of decades to centuries. There are community concerns about this aspect of well integrity.

There have been no publicly reported studies of long-term durability of well cements in the Surat and Bowen Basin CSG wells. This project will allow degradation processes in cements used in CSG wells in Queensland to be assessed. Using the cement compositions that are representative of those used in this area and subjecting them to the environmental conditions (pressure, temperature, groundwater geochemistry), this project will fill the existing knowledge gap about the long-term durability of cement.

The project’s scope will be limited to laboratory experiments on cement.

Objective

The primary aim of this project is to investigate the potential for cement degradation and cement degradation processes and rates while subjected to downhole conditions and formation fluids in CSG reservoirs in Queensland. The experimental phase will involve ageing and accelerated ageing experiments conducted at pressures and temperatures representative of reservoir conditions using cement mixtures typical of those used in the region. The cement specimens will undergo thorough characterisation before, during and after the experiments to assess the extent of degradation. Geochemical modelling will be implemented to further investigate the experimental results and to evaluate the long-term degradation.

Methodology

Discovery phase

The first task for this project will be to review reservoir conditions for the Surat Basin CSG fields. The pressures and temperatures that wells are exposed to, along with typical groundwater chemistry will be identified. Data on typical cement mixtures have been collected in Grigore et al (2024), and a range of water chemistry assessed data are available from other GISERA projects and data compiled by the Office of Groundwater Impact Assessment. As such, in this phase, the literature data will be reviewed regarding cement, reservoir, and groundwater for the Surat Basin. The results of this phase will be used to design the laboratory experiments. The final experimental plan will be discussed with the project's Technical Reference Group to ensure that the experimental parameters and cement mixtures are representative of those found in the field.

Experimental phase

Ageing and thermal accelerated ageing experiments (three to six months) will be conducted to study the interaction between cement and formation water, focusing on the degradation process in CSG wells. These experiments simulate mid- to long-term environmental exposure by subjecting cement samples to controlled laboratory conditions that accurately reflect field environments. The tests are designed to replicate relevant reservoir conditions, including pressure, temperature, groundwater chemistry and the presence of reservoir gas.

Cement samples will be prepared using the mixtures formulated during the discovery phase. They will be placed in reaction chambers to cure while immersed in fluids that simulate formation water chemistry and reservoir pressure and temperature over an extended period. A comprehensive set of evaluations are conducted on cement samples before, after and during the ageing experiments. The evaluations may include XRD, SEM, Micro-CT, TGA, and cement properties measurements. Based on these findings, the cement degradation process in CSG wells is evaluated.

Cement preparation and curing

The cement will be prepared following the standards outlined by the API (American Petroleum Institute, 1997) and subjected to curing in reservoir conditions including the groundwater and reservoir gas. The groundwater chemical composition and composition of reservoir gas is obtained from the discovery phase of this project. Cement Class A is a likely candidate for ageing and accelerated ageing experiments. This cement primarily consists of ordinary Portland cement (OPC) and is widely regarded as a representative cement for most CSG wells in Queensland (Grigore et al, 2024). In this regard, the cement paste is prepared using deionized water with a consistent water to cement ratio. Cement samples are then cured at reservoir temperature and pressure while exposed to the groundwater.

Pre-experimental characterisation

After the cement samples are prepared and fully cured, comprehensive characterisation will be performed to establish baseline conditions prior to static ageing experiments involving saturation with formation fluids. A suite of analytical techniques will be applied to evaluate the composition, internal pore structure, surface topography, and properties of the cement samples. Establishing these baselines is critical to accurately quantify any changes resulting from subsequent cement-fluid interactions.

X-ray Fluorescence (XRF) analysis will be conducted to determine the elemental composition, while X-ray Diffraction (XRD) will be employed to identify and quantify the mineralogical phases present within the cured cement samples. Scanning Electron Microscopy (SEM) imaging will be utilised to evaluate surface structure and topography, providing high-resolution visualisation of the cement surface morphology. Thermalgravimetric analysis (TGA) will be utilised to evaluate the cement portlandite, dehydration status and thermal stability. Micro-computed tomography (Micro-CT) will be applied to characterise the internal pore network, offering insights into pore size distribution, connectivity, and overall porosity. Standard experimental measurements will be performed to directly quantify the cement samples' properties.

This integrated characterisation approach will provide robust baseline data, facilitating accurate assessment of geochemical and structural changes resulting from cement-brine-gas interactions during the experimental ageing phase.

Static batch reactor experiment

The first batch of cured cement specimens (6-12 samples) will undergo an ageing test for an extended period (3-6 months) under representative downhole pressure and temperature using a static batch reactor setup. The cement specimens will be immersed in CSG formation water, with a reservoir gas analogue used to pressurise the batch reactor. Additionally, a second batch (6–12 samples) will be subjected to an accelerated thermal ageing experiment at an elevated temperature to enhance the cement degradation process. Selected cement samples will be extracted during the tests to assess the evolution of cement properties over time. In addition, periodic samples of water will be collected from the batch reactors and analysed for changes in water chemistry. Some of the cement samples will undergo periodic replacement of formation water during the ageing experiments to assess the impact on cement properties of equilibrium between formation water in the batch reactor and immersed cement. Cement curing and cement ageing experiments will be undertaken in the CSIRO Clayton labs utilising the batch reactor rigs (Figure 2 and Figure 3). These rigs are capable of simulating pressures and temperatures found in CSG reservoirs, as well as periodic liquid sampling and use of reservoir gas mixtures to control pressure. Some liquid samples analysis (e.g. pH, conductivity, redox potential) will also be completed in the Clayton laboratory.

Figure 2: Batch reactor rig with 5 cells at the CSIRO Clayton laboratory

Figure 3: High pressure and temperature batch reactor rig with one cell at CSIRO Clayton laboratory

Post-experimental characterisation

Following the experimental ageing phase, all characterisation methods described above (XRF, XRD, SEM, Micro-CT, TGA, and cement properties) will be repeated. This post-experimental characterisation will enable a direct comparison with baseline data, providing clear insights into the geochemical, structural, and petrophysical changes induced by cement-brine-gas interactions.

The estimate of costs associated with the characterisation techniques and periodic water analysis are listed in Table 1. For each characterisation method such as XRD, XRF, Micro-CT, SEM, porosity, permeability, and TGA, we conduct analyses both before and after treatment, effectively doubling the interactions with each sample set. Given the batch size of a minimum of 2x6 samples, a total of minimum 12 individual samples undergo ageing experiments. In total an estimate of $60K is included to address the experimental characterisations. By conducting these tests both before and after the ageing, we ensure a robust dataset that captures the dynamics of cement behaviour under experimental conditions.

Table 1: Approximate cost of cement sample characterisation and groundwater analysis.

Characterisation	Cost per sample	Value Proposition
XRD	$1,600	Identifies crystalline changes, critical for phase transition analysis
XRF	$1,000	Determines elemental compositions, essential for chemical assessments
Micro-CT	$3,000	Provides high-resolution 3D structural imaging
SEM	$600	Enables detailed observation of surface morphologies
Porosity	$600	Assesses changes in material porosity, key for fluid dynamics studies
Permeability	$600	Evaluates fluid transmission through materials
TGA	$1000	Measures thermal stability and compositional changes
Water Analysis	$400	Evaluating water chemistry during the ageing tests

Geochemical modelling

Post-experimental data will be integrated into comprehensive geochemical modelling to further interpret experimental results. Two types of modelling approaches will be utilised:

i) Thermodynamic modelling: This equilibrium-based approach will help identify the ultimate stable mineralogical phases and composition of the cement-brine-gas system, providing insights into long-term equilibrium conditions.

ii) Kinetic modelling: This time-dependent approach will extend experimental findings from the relatively short experimental duration (three to six months) to significantly longer timeframes (e.g., 30-50 years).

Interpretation phase

In the final phase of the project the results of the laboratory experiments will be analysed, considering the implications for cement degradation in CSG wells. The focus will be on whether cement degradation occurs and if it does, what the mechanisms and potential rates of degradation are. The implications for well integrity will be considered.

Disclaimer: This project focuses on the cement behaviour within the context of well integrity. It is important to note that the project's scope does not encompass cement placement techniques or practices, which are also important contributors to well integrity.

3. Project Inputs

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organization
Abbas Movassagh	62 days	Project management, well integrity and reservoir geomechanics	>15 Years	CSIRO
Nicholas Lupton	22 days	Reservoir engineering and fluid analysis	>15 Years	CSIRO
Lingping Zeng	45 days	Geochemical modelling and characterisation	>10 Years	CSIRO
Elaheh Arjomand	15 days	Well integrity and cementing	>10 Years	CSIRO
Mihaela Grigore	5 days	Cement characterisation	>20 Years	CSIRO
Cameron Huddlestone-Holmes	5 days	CSG development, risk assessment	>20 Years	CSIRO
Michael Camilleri	3 days	Mechanical Engineering	>20 Years	CSIRO

Subcontractors (clause 9.5(a)(i))	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organization
Nil				

Technical Reference Group

The project will establish a Technical Reference Group (TRG) aimed at seeking peer-to-peer technical advice on contextual matters and to discuss research needs as well as outputs as the project progresses. The TRG will include the project leader and a group of different stakeholders as appropriate which may include:

- Resource Safety and Health Queensland
- Company well integrity representatives (Santos, Origin, Shell-QGC)
- Cementing service providers (Halliburton, Schlumberger)

Budget Summary

Source of Cash Contributions	2023/24	2024/25	2025/26	2026/27	% of Contribution	Total
GISERA	$0	$23,446	$266,080	$0	80%	$289,526
- Origin	$0	$12,177	$138,195	$0	41.55%	$150,372
- APLNG	$0	$11,137	$126,388	$0	38.00%	$137,525
- QGC	$0	$132	$1,497	$0	0.45%	$1,629
Total Cash Contributions	**$0**	**$23,446**	**$266,080**	**$0**	**80%**	**$289,526**

Source of In-Kind Contribution	2023/24	2024/25	2025/26	2026/27	% of Contribution	Total
CSIRO	$0	$5,861	$66,520	$0	20%	$72,381
Total In-Kind Contribution	**$0**	**$5,861**	**$66,520**	**$0**	**20%**	**$72,381**

TOTAL PROJECT BUDGET	2023/24	2024/25	2025/26	2026/27	-	TOTAL
All contributions	$0	**$29,307**	**$332,600**	**$0**	**-**	**$361,907**
TOTAL PROJECT BUDGET	**$0**	**$29,307**	**$332,600**	**$0**	**-**	**$361,907**

4. Communications Plan

Stakeholder	Objective	Channel (e.g. meetings/media/factsheets)	Timeframe (Before, during at completion)
Regional community stakeholders including landholders, traditional owners and wider public	To communicate project objectives, and key messages and findings from the research	A fact sheet at commencement of the project that explains in plain English the objective of the project.	At project commencement
		Project progress reported on GISERA website to ensure transparency for all stakeholders including regional communities.	Ongoing
		Public release of final reports. Plain English fact sheet summarising the outcomes of the research.	At project completion
		Preparation of article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.	At project completion
Gas Industry & Government	To communicate the outcome of the project.	Fact sheet that explains the objectives of the project.	At project commencement
		Project progress reporting (on GISERA website).	Ongoing
		Final project report and fact sheet.	At project completion
		Presentation of findings at joint gas industry/government Knowledge Transfer Session.	At project completion
Scientific Community	Provide scientific insight into well cement durability.	Peer-reviewed scientific publication. Dataset(s) available through CSIRO's data repository.	After completion of project
		Presentation of scientific results at conference.	After completion of project

In addition to project specific communications activities, CSIRO's GISERA has a broader communications strategy. This strategy incorporates activities such as webinars, roadshows, newsletters and development of other communication products.

5. Project Impact Pathway

<table>
<tr><th>Activities</th><th>Outputs</th><th>Short term Outcomes</th><th>Long term outcomes</th><th>Impact</th></tr>
<tr><td>Literature review</td><td>• Compilation of existing data on cements used in CSG wells in Queensland, groundwater chemistry and cement ageing.
• Design of ageing experiments</td><td>• Ageing experiments designed to be representative of actual cements and conditions in Queensland CSG fields.</td><td rowspan="4">• Evidence base to allow for the prediction of long-term integrity of annular cement in CSG wells in Queensland.
• Increased knowledge about cement’s contribution to well integrity.</td><td rowspan="4">• Increased understanding and awareness of cement degradation processes that provides assurance to community and information for industry and regulators to use to manage long term well integrity.</td></tr>
<tr><td>Ageing experiments and sample characterisation</td><td>• Records of ageing experiment parameters.
• Characterisation of cement samples and brine before, during and after the ageing experiments.</td><td>• Insights into the geochemical, structural, and petrophysical changes induced by cement-brine-gas interactions.</td></tr>
<tr><td>Geochemical modelling</td><td>• Results of comprehensive geochemical modelling to extend the experimental results to longer time frames.</td><td>• Extrapolation of experimental results to longer time frames.</td></tr>
<tr><td>Analyses and reporting</td><td>• Final report including discussion of implications for long term well integrity.</td><td>• Publicly available information on cement degradation processes and implications for long term well integrity.</td></tr>
</table>

6. Project Plan

Project Schedule

ID	Activities / Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Literature review	Abbas Movassagh	1 May 2025	31 Aug 2025	
Task 2	Cement samples and groundwater preparation	Nicholas Lupton	1 Jul 2025	30 Sep 2025	Task 1
Task 3	Ageing/Accelerated experiments	Nicholas Lupton	1 Sep 2025	28 Feb 2026	Task 2
Task 4	Cement Characterisation	Lingping Zeng	1 Aug 2025	31 May 2026	Task 2 & 3
Task 5	Geochemical modelling	Lingping Zeng	1 Dec 2025	31 Mar 2026	Task 2, 3 & 4
Task 6	Final report compilation	Abbas Movassagh	1 Jan 2026	31 May 2026	Task 1, 2, 3, 4 & 5
Task 7	Communicate project objectives, progress and findings to stakeholders	Abbas Movassagh	1 May 2025	30 Jun 2026	Task 1, 2, 3, 4 & 5

Task description

Task 1: Literature review

OVERALL TIMEFRAME: 1 May 2025 - 31 Aug 2025

BACKGROUND: Typical reservoir conditions in the Surat Basin CSG fields are reviewed. This includes identifying the pressures, temperatures, and groundwater chemistry that wells are exposed to. Relevant data on common cement mixtures will be investigated following the previous studies such as Grigore et al (2024). Ageing and thermal accelerated ageing experiments on cement will be reviewed. The insights from this phase will inform the design of laboratory experiments. In this regards, a preliminary geochemical review will be conducted to ensure the experimental design meets the required conditions. The Technical Reference Group will be consulted to get their perspective on the validity of the cement composition(s) and experimental conditions.

TASK OBJECTIVES:

- Selecting an appropriate cement for subsequent tests
- Designing the ageing experiments
- A preliminary geochemical review considering the reservoir condition and groundwater specifications

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- This task will identify the cement composition, reservoir conditions (pressures, temperatures, and groundwater chemistry) and provides the design of ageing experiments.

Task 2: Cement samples and groundwater preparation

OVERALL TIMEFRAME: 1 Jul 2025 – 30 Sep 2025

BACKGROUND: During this task, the project team will obtain representative cement ingredients, and representative gas and formation water mixtures for use in cement curing and the ageing experiments. Cement components and gas mixture composition will be based on reported data for the Surat Basin from Task 1. Formation water will be collected from the field where possible through liaison with operators, or an analogue will be produced based on literature in Task 1. Modification and commissioning of the equipment to be used for the ageing experiments will also take place, as well as manufacture of the required cement moulds. Cement samples will be cured under reservoir conditions for use in subsequent tasks.

TASK OBJECTIVES:

- Obtain cement ingredients, reservoir gas, and formation water samples for use in curing and ageing experiments.
- Cure cement samples required for Task 3 under representative CSG reservoir conditions. Undertake necessary modification and commissioning of equipment for use in Task 3.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- This Task will deliver the modified and commissioned equipment as well as the materials, including cured cement samples, required for the ageing and accelerated ageing experiments in Task 3.

Task 3: Ageing/Accelerated experiments

OVERALL TIMEFRAME: 1 Sep 2025 – 31 Mar 2026

BACKGROUND: To investigate the interaction between cement and formation water in CSG wells, ageing and thermally accelerated ageing experiments will be conducted over a period of three to six months. These experiments aim to simulate mid- to long-term environmental exposure by subjecting cement samples to controlled laboratory conditions that closely replicate field environments. By incorporating key reservoir factors such as pressure, temperature, groundwater chemistry, and the presence of reservoir gases, the study will provide insights into the degradation processes affecting cement integrity in CSG wells.

TASK OBJECTIVES:

- Conducting ageing experiments aim to investigate the long-term degradation of cement in CSG wells by simulating ageing and thermally accelerated ageing under controlled laboratory conditions while replicating key reservoir conditions.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- This task will generate experimental data and information about cement degradation which is required for following characterisation (Task 4) and geochemical modelling (Task 5).

Task 4: Cement Characterisation

OVERALL TIMEFRAME: 1 Aug 2025 – 31 May 2026 (Pre-tests: Aug-Sep 2025, During tests: Dec 2025-Jan 2026, Post-tests: Apr-May 2026)

BACKGROUND: To precisely monitor and interpret any change of cement from mineralogical, petrophysical and internal structure aspects as a result of fluid-cement interactions during the aging experiments (Task 3), a comprehensive set of evaluations are necessary to be conducted on cement samples before and after the ageing experiments. The evaluations may include XRD, SEM, Micro-CT, TGA, and cement properties measurements.

TASK OBJECTIVES:

- The integrated characterisation which will provide robust baseline data, facilitating accurate assessment of geochemical and structural changes resulting from cement-brine-gas interactions during the experimental ageing phase.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- The post-experimental characterisation will enable a direct comparison with baseline data, providing clear insights into the geochemical, structural, and petrophysical changes induced by cement-brine-gas interactions.

Task 5: Geochemical modelling

OVERALL TIMEFRAME: 1 Dec 2025 – 31 Mar 2026

BACKGROUND: Post-experimental data (Task 3 and 4) will be integrated into comprehensive geochemical modelling to further interpret experimental results.

TASK OBJECTIVES:

- To further understand the nature behind the experimental observations and extend the prediction from short-term aging experiments to longer timeframes.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

Two types of modelling will be conducted:

- Thermodynamic modelling: This equilibrium-based approach will help identify the ultimate stable mineralogical phases and composition of the cement-brine-gas system, providing insights into long-term equilibrium conditions.
- Kinetic modelling: This time-dependent approach will extend experimental findings from the relatively short experimental duration (three to six months) to significantly longer timeframes (e.g., 30-50 years).

Task 6: Project Reporting

OVERALL TIMEFRAME: 1 Jan 2026 – 31 May 2026

BACKGROUND: This project will investigate the cement degradation process in CSG wells in the Surat Basin in conditions (pressure, temperature, groundwater chemistry) typically encountered in this region. The project will be laboratory based, using ageing and accelerated ageing experiments to evaluate the extent of cement degradation. The project scope, methods, experimental results and analysis, and technical reports are provided in this task.

TASK OBJECTIVES:

- Integrating the data and analysis from Task 1, 2, 3, 4 and 5 into a cohesive document as final project report

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- Preparation of a final report outlining the scope, methodology, scenarios, assumptions, findings and any suggestions/options for future research;

- Following CSIRO ePublish review, the report will be submitted to the GISERA Director for final approval; and
- Provide 6 monthly progress updates to GISERA office.

Task 7: Communicate project objectives, progress and findings to stakeholders

OVERALL TIMEFRAME: 1 May 2025 – 30 Jun 2026

BACKGROUND: Communication of GISERA's research is an important component of all research projects. The dissemination of project objectives, key findings and deliverables to relevant and diverse audiences allows discourse and decision making within and across multiple stakeholder groups.

TASK OBJECTIVES:

- Communicate project objectives, progress and findings to stakeholders through meetings, Knowledge Transfer Session, fact sheets, project reports and journal article(s), in collaboration with GISERA Communication Team.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Communicate project objectives, progress and results to GISERA stakeholders according to standard GISERA project procedures which may include, but not limited to:

- Knowledge Transfer Session with relevant government/gas industry representatives.
- Preparation of an article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.
- Two project fact sheets: one developed at the commencement of the project, and another that will include peer-reviewed results and implications at completion of the project. Both will be hosted on the GISERA website.
- Presentation of scientific results at conference.

Project Gantt Chart

		2024/2025		2025/2026											
Task	Task Description	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25	Nov-25	Dec-25	Jan-26	Feb-26	Mar-26	Apr-26	May-26	Jun-26
1	Literature review	■	■	■	■										
2	Cement sample and groundwater preparation			■	■	■									
3	Ageing/Accelerated experiments					■	■	■	■	■	■	■			
4	Cement Characterization				■	■			■	■			■	■	
5	Geochemical modelling								■	■	■	■			
6	Final report compilatoin									■	■	■	■	■	
7	Communicate project objectives, progress and findings to stakeholders	■	■	■	■	■	■	■	■	■	■	■	■	■	■

7. Budget Summary

Expenditure	2023/24	2024/25	2025/26	2026/27	Total
Labour	$0	$27,307	$221,538	$0	$248,845
Operating	$0	$2,000	$111,062	$0	$113,062
Subcontractors	$0	$0	$0	$0	$0
Total Expenditure	**$0**	**$29,307**	**$332,600**	**$0**	**$361,907**

Expenditure per task	2023/24	2024/25	2025/26	2026/27	Total
Task 1	$0	$29,307	$19,991	$0	$49,298
Task 2	$0	$0	$38,351	$0	$38,351
Task 3	$0	$0	$55,414	$0	$55,414
Task 4	$0	$0	$100,613	$0	$100,613
Task 5	$0	$0	$50,150	$0	$50,150
Task 6	$0	$0	$49,320	$0	$49,320
Task 7	$0	$0	$18,761	$0	$18,761
Total Expenditure	**$0**	**$29,307**	**$332,600**	**$0**	**$361,907**

Source of Cash Contributions	2023/24	2024/25	2025/26	2026/27	Total
Origin (41.55%)	$0	$12,177	$138,195	$0	$150,372
APLNG (38.00%)	$0	$11,137	$126,388	$0	$137,525
QGC (0.45%)	$0	$132	$1,497	$0	$1,629
Total Cash Contributions	**$0**	**$23,446**	**$266,080**	**$0**	**$289,526**

In-Kind Contributions	2023/24	2024/25	2025/26	2026/27	Total
CSIRO (20%)	$0	$5,861	$66,520	$0	$72,381
Total In-Kind Contributions	**$0**	**$5,861**	$66,520	**$0**	**$72,381**

	Total funding over all years	Percentage of Total Budget
Origin investment	$150,372	41.55%
APLNG investment	$137,525	38.00%
QGC investment	$1,629	0.45%
CSIRO investment	$72,381	20.00%
Total Expenditure	**$361,907**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Start Date	Delivery Date	Fiscal Year Completed	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Literature review	GISERA	May-25	Aug-25	2025/26	$39,438
Task 2	2.1	Cement samples and groundwater preparation	GISERA	Jul-25	Sep-25	2025/26	$30,681
Task 3	3.1	Ageing/Accelerated experiments	GISERA	Sep-25	Feb-26	2025/26	$44,331
Task 4	4.1	Cement Characterisation	GISERA	Aug-25	May-26	2025/26	$80,490
Task 5	5.1	Geochemical modelling	GISERA	Dec-25	Mar-26	2025/26	$40,120
Task 6	6.1	Final report compilation	GISERA	Jan-26	May-26	2025/26	$39,456
Task 7	7.1	Communicate project objectives, progress and findings to stakeholders	GISERA	May-25	Jun-26	2025/26	$15,009

8. Intellectual Property and Confidentiality

<table>
<tr><td rowspan="3">Background IP (clause 11.1, 11.2)</td><td>Party</td><td>Description of Background IP</td><td>Restrictions on use (if any)</td><td>Value</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td>Ownership of Non-Derivative IP (clause 12.3)</td><td colspan="4">CSIRO</td></tr>
<tr><td>Confidentiality of Project Results (clause 15.6)</td><td colspan="4">Project Results are not confidential.</td></tr>
<tr><td>Additional Commercialization requirements (clause 13.1)</td><td colspan="4">Not Applicable</td></tr>
<tr><td>Distribution of Commercialisation Income (clause 13.4)</td><td colspan="4">Not applicable</td></tr>
<tr><td rowspan="5">Commercialisation Interest (clause 13.1)</td><td colspan="2">Party</td><td colspan="2">Commercialisation Interest</td></tr>
<tr><td colspan="2">CSIRO</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">APLNG</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">Origin</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">Shell-QGC</td><td colspan="2">N/A</td></tr>
</table>

9. References

Abid, K., Gholami, R., Choate, P., & Nagaratnam, B. H. (2015). A review on cement degradation under CO2-rich environment of sequestration projects. *Journal of Natural Gas Science and Engineering*, *27*, 1149-1157.

American Petroleum Institute. (1997). API Specification 10A: Specification for cements and materials for well cementing (23rd ed.).

Satoh, H., Shimoda, S., Yamaguchi, K., Kato, H., Yamashita, Y., Miyashiro, K., & Saito, S. (2013). The long-term corrosion behavior of abandoned wells under CO2 geological storage conditions:(1) Experimental results for cement alteration. *Energy Procedia*, *37*, 5781-5792.

Huddlestone-Holmes, C. A., & Elaheh, K. J. (2018). Decommissioning coal seam gas wells—Final Report of GISERA Project S. 9: Decommissioning CSG wells. *Brisbane: CSIRO*

Huddlestone-Holmes, C. R., Wu, B., Kear, J., & Pandurangan, R. (2017). Report into the shale gas well life cycle and well integrity. EP179028.

Grigore M, Movassagh A, Crooke E, Huddlestone-Holmes C, Arjomand E, Tran-Dinh N, Midgley D, Czapla J and Faiz M (2024) Queensland CSG well integrity: cements, steels and microbial activity. GISERA, CSIRO, Australia.

Raiber, M. and Suckow, A. (2017) Hydrochemical assessment of the Hutton and Precipice sandstones in the northern Surat Basin. CSIRO, Australia

Santhanam, M., Cohen, M.D., & Olek, J. (2002). Mechanism of sulfate attack: A fresh look: Part 1. Cement and Concrete Research, 32(6), 915-921.