Project Order

Proforma 2019

1. Short Project Title

Improved approaches to long-term monitoring of decommissioned onshore gas wells

Long Project Title	Evaluating technology options for long-term monitoring of decommissioned onshore gas wells in the Northern Territory
GISERA Project Number	W.20
Proposed Start Date	02/09/2019
Proposed End Date	14/12/2020
Project Leader	Dr Cameron Huddlestone-Holmes

2. GISERA Region

- ☐ Queensland
- ☐ New South Wales
- ☒ **Northern Territory**
- ☐ South Australia
- ☐ Western Australia
- ☐ Victoria

3. GISERA Research Program

- ☒ **Water Research**
- ☐ GHG Research
- ☐ Social & Economic Research
- ☐ Biodiversity Research
- ☐ Agricultural Land Management Research
- ☐ Health Research

4. Project Summary

Objective

Uncertainty over the well integrity of decommissioned wells was raised by the NT Hydraulic Fracturing Inquiry [1]. There is not a significant amount of literature available on the long term integrity of decommissioned wells constructed using modern casing and cementing materials and practices [2] however there is some evidence that decommissioned wells, including the plugs and cement used to seal the wells at the end of production, could present a risk. For example, decommissioned wells with compromised cement or casing integrity could conceivably be a source of ongoing methane emissions or aquifer contamination. If appropriately designed and implemented, long-term monitoring of decommissioned wells would allow this risk to be assessed and properly managed.

The objective of this project is to investigate well integrity monitoring options for onshore gas wells in the Northern Territory. The project will develop an approach for assessing monitoring techniques against the risks of well integrity failure. Well decommissioning techniques and technology options that facilitate monitoring will also be assessed against the Northern Territory's regulatory requirements.

The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] sets out a stringent set of requirements for managing well integrity throughout a well's lifecycle, including specific requirements for decommissioning. The monitoring methods investigated will take the requirements of this code of practice into account.

The scope of this project is limited to onshore gas wells in the Northern Territory and will include the decommissioning of exploration and production wells.

Description

Decommissioning is the final step of a well's life cycle. Although the wells are sealed and cement plugs are designed to block any interaction between formation fluids and different layers of geologic strata [4], the integrity of decommissioned wells can still be compromised (noting though this appears to be unlikely). Thus, it is important to identify potential leakage pathways and subsequently monitor decommissioned well integrity to prevent any environmental risk i.e. aquifer contamination.

This project will:

1. Evaluate environmental risks presented by decommissioned wells and determine possible failure modes and their likelihoods;

2. Determine the critical parameters that contribute to well integrity risk in decommissioned wells, evaluate well integrity risk for decommissioned wells in the Northern Territory, and establish monitoring requirements;
3. Explore options for long-term monitoring of well integrity in decommissioned wells and assess the risks in their deployment. The likely effectiveness of monitoring techniques in detecting well integrity issues related to the failure modes will be a key component of this assessment;
4. Explore alternative decommissioning technologies and how they may impact long term monitoring requirements;
5. Develop an approach for assessing appropriate monitoring of wells; and
6. Identify any gaps in the available monitoring technologies and implications, including recommendations for further research.

Evaluating environmental risks presented by the decommissioning of wells

Leakage through decommissioned wells can impose potential hazards to the surrounding environment. Underground fluid and gas could flow upwards or downwards along decommissioned wells if the integrity of those wells was to be compromised and if there was a natural hydraulic pressure difference between different geological formations [5]. Consequently, in order to evaluate monitoring systems, it is first necessary to identify and rank the risks associated with decommissioned wells.

Determining critical parameters that contribute to well integrity risk in decommissioned wells

Following on from an evaluation of the risks associated with decommissioned well integrity failure, critical parameters can be identified that contribute to the risk profile for a well. These are likely to include factors such as geology (presence of corrosive fluids, stress conditions, presence of over-pressured formations), well construction methods, age of the well, and the decommissioning process used.

The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] requires a two stage decommissioning process for petroleum wells. In the first stage cement plugs are placed in the well to isolate deep formations from each other and the surface with the wellhead left in place to allow continued monitoring of the well. The second stage is the final removal of the wellhead and complete rehabilitation of the site. This study will also consider how a suitable timeframe between these two steps could be determined.

Exploring options for long term monitoring

Three broad approaches to monitoring decommissioned wells will be considered: direct monitoring of the well at the surface; direct monitoring of the well in the subsurface; and, indirect monitoring of the well. The effectiveness of these approaches will be considered and compared, along with the potential risks introduced from using them.

- *Direct surface monitoring of decommissioned wells:* Monitoring of decommissioned wells at the surface, typically by looking for gas leaks or sustained casing pressure at the wellhead, is the most common method of monitoring the integrity of decommissioned wells. However, this option has limitations due to the removal process of the wellhead and loss of access to the well [6]. It also has limitations in determining the depth of any problems in the well.
- *Direct sub-surface monitoring of decommissioned wells; S*ubsurface monitoring of decommissioned wells has not been reported in the literature. Technologies such as including distributed fibre optic sensors, distributed acoustic sensing measurements, and other downhole sensing technologies may allow long term monitoring of the well at depth. Access to the well would need to be maintained to allow this type of monitoring to continue and this may limit the ability to fully decommission the well.
- *Indirect monitoring of decommissioned wells:* Indirect techniques that detect the impacts of well integrity issues in decommissioned wells will also be considered. These include shallow groundwater monitoring, surface water monitoring, soil gas sampling, soil gas flux measurements, and tracking the makeup of microbial communities in the soil [7].
- *The effectiveness of these technologies;* Determining the most effective technologies in order to detect and monitor well integrity issues in decommissioned wells will depend on the well integrity risks present in the well. The effectiveness of the different monitoring approaches in detecting different failure modes will be examined.
- *Risks to well integrity that may be presented by implementing any of these technologies;* Implementing permanent monitoring technologies may introduce additional environmental risks presented by the decommissioned well itself. For example, monitoring tools installed within decommissioned wells may introduce an additional failure path; long term monitoring bores will have their own risks. Understanding these risks will be important in evaluating the effectiveness of well monitoring approaches.

<u>Investigating decommissioning options (engineering to facilitate monitoring and to reduce well integrity risk)</u>

Alternative approaches will be investigated that facilitate the monitoring processes after decommissioning takes place. This will include consideration of the decommissioning process, including aspects of the well design and construction and the materials used for plugging and cementing wells.

Decommissioning methods that reduce the risk of integrity failure post-decommissioning, and therefore decrease the monitoring requirements, will also be investigated. Recent advances have produced materials which may outperform the cement slurries currently used for most wells (such as modifying the current design of the cement slurry with designs that: combine cement with resin [8]; incorporate pure resin instead of cement [9]; or use bismuth [10] to provide a physical seal in the downhole environment.

<u>Developing an approach to assess monitoring options</u>

Comprehensive assessments prior to decommissioning to investigate near wellbore geological conditions will be undertaken, particularly the well mechanical conditions to prepare wells for decommissioning. This component of the project will develop a workflow for evaluating well integrity risks and appropriate monitoring methods post decommissioning based on the well risk profile. It will also investigate different mechanical integrity tests and their significance to ensure wells are well-equipped to be decommissioned as part of the process. The requirements of The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] and the Schedule of Onshore Petroleum Exploration and Production Requirements for assessing well integrity and conducting decommissioning activities will form the basis for this workflow.

<u>Identifying gaps in available monitoring technologies and the implications of those gaps</u>

This study may identify gaps where existing monitoring techniques are not able to adequately address long term post-decommissioning well integrity risks. This project will report on any gaps identified and make recommendations for integration of new techniques or highlight areas where additional development is required.

Need & Scope

There is not a significant amount of literature available on the long term integrity of wells post decommissioning [1,2,11]. There is some evidence that abandoned wells present a risk and may be a source of methane emissions or aquifer contamination [12–14]. However this evidence is limited to observations at the surface and does not address the integrity of the well at depth (although it is the impacts at surface or to shallow aquifers that is of concern) [13].

A significant challenge is that by its very nature, decommissioning of a well limits access for the methods currently used for assessing well integrity at depth. Installation of permanent monitoring equipment in a well may compromise the integrity of a well (observer effect), and there would also be questions about the longevity of such equipment.

NT Hydraulic Fracturing Inquiry Recommendations

The long-term integrity of abandoned wells was raised as a significant issue by the Inquiry, which made the following recommendations:

Recommendation 5.1

That prior to the grant of any further exploration approvals, the Government mandates an enforceable code of practice setting out minimum requirements for the decommissioning of any onshore shale gas wells in the

NT. The development of this code must draw on world-leading practice. It must be sufficiently flexible to accommodate improved decommissioning technologies.

The code must include a requirement that:

- wells undergo pressure and cement integrity tests as part of the decommissioning process, with any identified defects to be repaired prior to abandoning the well; and
- cement plugs be placed to isolate critical formations and that testing must be conducted to confirm that the plugs have been properly set in the well.

Recommendation 5.2

That the Government:

- implements a mandatory program for regular monitoring by gas companies of decommissioned onshore shale gas wells (including exploration wells), with the results from the monitoring to be publicly reported in real-time. If the performance of a decommissioned well is determined to be acceptable to the regulator then the gas company may apply for relinquishment of the well to the Government, and
- implements a program for the ongoing monitoring of all orphan wells.

Methodology

This project will primarily be a desktop study, although some experimental work on monitoring technologies will also be considered (fibre-optic sensors, other sensors left in the hole). The methodologies to be employed in each stage of the project are as follows.

<u>Literature review on risk assessment analyses and wellbore failure mechanisms</u>

A thorough risk assessment is to be performed to identify the risks (associated with wells post-decommissioning) to the environment. A literature review in the context of the controls provided by The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] will be carried out on the failure mechanisms of the well integrity barrier system particularly the mechanisms which lead to mechanical failures within the barrier system of the decommissioned wells. Different risk analysis approaches including Failure Modes and Effect Analysis (FMEA)[15][16] will be studied to choose a suitable approach for risk analyses assessment presented by decommissioning wells in Northern Territory.

<u>Review of well integrity risks for decommissioned wells in the Northern Territory and selection of monitoring parameters</u>

The contributing factors to well integrity failure risks in the NT will be examined for a selection of existing wells and considering the characteristics of conventional and unconventional gas resources in the NT. Subsequently, these contributing factors will be utilised to perform a risk assessment based on the approach developed in Task 1. Technical experts' points of view on the occurrence, severity of the risks for decommissioned wells will be incorporated. The requirements of The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] will also be part of this assessment. The risk assessment outcome will determine the likelihood of the different scenarios leading to the creation of the leakage pathways and accordingly highlight the monitoring parameters in the NT context.

Investigations on long-term monitoring methods for decommissioned wells

A broad literature review will be carried out on the different categories of monitoring technologies for decommissioned wells and their efficiency in relation to the parameters elucidated in Task 2. Additional potential risks involved with the installation of monitoring tools within the decommissioned wells to the surrounding environment/well barrier system will be identified and discussed with technical experts.

Three categories of monitoring will be considered: surface monitoring; downhole monitoring within the well itself; and offset monitoring bores. The effectiveness of different approaches to monitoring will be considered alongside the risks and an estimate of costs posed by implementing them.

The effectiveness of surface monitoring technologies is still a matter of controversy due to different issues involved including lack of intact wellhead [6], poor resolution, being labour-intensive, complex data processing and to some extents limited ability to detect methane leakage [7].

The studied subsurface monitoring technologies (deployed downhole and in offset monitoring bores) will include conventional techniques along with emerging techniques such as: fibre-optic distributed temperature and strain sensing system (DTSS) to monitor casing deformation [17], casing conveyed permanent gauge (CCPG) [18] and fibre-optic distributed acoustic system (DAS) [19]. These subsurface monitoring approaches will be analysed to estimate their effectiveness and efficiency to identify well integrity issues in decommissioned wells in the Northern Territory.

The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] mandates a two-stage process for well decommissioning which includes leaving the Wellhead in place to allow continued monitoring until "successful validation of no well integrity issues" can be achieved. This study will consult government and gas industry experts along with published literature [20] to make a recommendation on what "successful validation" might entail in the Northern Territory context.

Seeking alternative approaches to decrease post-decommissioning well integrity risks

Alternative approaches will be workshopped to consider novel designs for well construction and decommissioning either utilising novel materials or techniques which may reduce the risk of mechanical failure within barrier systems of decommissioned wells. The impact of adopting these alternative decommission approaches on monitoring effectiveness and requirements will also be assessed.

Development of a workflow for long-term monitoring of decommissioned wells

This component of the project aims to develop a workflow (a sequence of tasks or steps to follow) in relation to selecting long-term monitoring techniques suitable for decommissioned wells in the NT. The workflow will take into account the risk assessment (performed in Task 2), monitoring methods (identified in Task 3) along with the key stakeholder insights.

The workflow will also consider mechanical integrity tests which ensure the wells are in a suitable condition for commencement of the decommissioning process. For instance, examination of the integrity of the cement sheath and the cement bonds which may highlight where cement squeezing is required or if annular casing pressure is exceeding the leak off test value, it should be remedied prior to final abandonment [20].

Final report preparation

The final report covers the outcomes of task 1 to 5. Additionally, the report will incorporate the identified gaps with the current monitoring technologies and their implementation procedures along with recommendations.

7. Project Inputs

Research

The two senior researchers on this project (Huddlestone-Holmes and Kear) prepared a review [21] of shale gas well integrity for the NT hydraulic fracturing inquiry. This review found a limited amount of information was available on the integrity of wells post-decommissioning, and this observation was part of the evidence base the Inquiry used in making its recommendations around abandoned wells. Huddlestone-Holmes and Kear were also involved with the development of The Code of Practice: Onshore Petroleum Activities in the Northern Territory [3] and have a good understanding of the regulatory requirements for decommissioning of wells in the NT.

There is not a significant amount of literature available on the long term integrity of wells post decommissioning [1,2,11]. There is some evidence that abandoned wells present a risk and may be a source of methane emissions or aquifer contamination [12–14]. However this evidence is limited to observations at the surface and does not address the integrity of the well at depth (although it is the impacts at surface or to shallow aquifers that is of concern) [13]. This gap in our knowledge of the long term integrity of wells post-decommissioning is the motivation for the risk assessment component of this project. Gaining a better understanding of the risks is fundamental to selecting appropriate monitoring strategies.

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Dr Cameron Huddlestone-Holmes	40	Resource geology, risk assessment, well integrity	>20 years	CSIRO
Mr James Kear	30	Petroleum engineering	8 years	CSIRO
Dr Elaheh Arjomand	125	Petroleum engineering, well integrity	2 years	CSIRO
Dr Amir Soroush	25	Engineering, monitoring and measurement	8 years	CSIRO

Subcontractors (clause 9.5(a)(i))	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Paul Groves	20 days	Well integrity management	>15 years	Private consultant

Budget Summary

Source of Cash Contributions	2019/20	2020/21	2021/22	% of Contribution	Total
GISERA	$129,312	$135,015	$0	75%	$264,327
- Federal Government	$63,794	$66,607	$0	37%	$130,401
- NT Government	$17,242	$18,002	$0	10%	$35,244
- Origin Energy	$17,242	$18,002	$0	10%	$35,244
- Santos	$17,242	$18,002	$0	10%	$35,244
- Pangaea Resources	$13,793	$14,402	$0	8%	$28,195
Total Cash Contributions	**$129,312**	**$135,015**	**$0**	**75%**	**$264,327**
Source of In-Kind Contribution	**2019/20**	**2020/21**	**2021/22**	**% of Contribution**	**Total**
CSIRO	$43,104	$45,005	$0	25%	$88,109
Total In-Kind Contribution	**$43,104**	**$45,005**	**$0**	**25%**	**$88,109**

Cultural Monitoring Program

The cultural monitor program is considered mutually beneficial, increases engagement and participation of the local traditional owners and provides additional safeguards against the research proponent or other fieldworkers inadvertently entering into a sacred site or other culturally sensitive area. Cultural monitors are engaged via the NLC whenever a company or operator goes out in the field.

In GISERA projects where CSIRO researchers are being escorted onto leases by company representatives who have organised permit access, those company procedures will apply.

For all other GISERA projects (particularly environmental and social projects) where CSIRO researchers are not being escorted by industry, CSIRO will work with the NLC to apply this practice.

8. Project Impact Pathway

Activities	Outputs	Short term Outcomes	Long term outcomes	Impact
• Assessment and application of risk assessment methods to decommissioned wells. • Assessment of well integrity risk in decommissioned wells. • Assessment of monitoring approaches for decommissioned wells. • Development of a workflow for the evaluation of well integrity risks post-decommissioning and the selection of appropriate monitoring approaches.	Technical report including the findings of tasks 1 to 5 along with recommendations from the project. Fact sheets for the broader community. Stakeholder workshop and knowledge sharing sessions.	Knowledge on: • the risks associated with decommissioned wells • available monitoring approaches. A consistent approach for assessing well integrity risks post-decommissioning and the selection of appropriate monitoring approaches. Recommendations for future research and development.	The project will inform Governments, regulators & policy-makers on issues regarding the requirements for long term monitoring of decommissioned wells The project will provide information on the risks associated with decommissioned wells in the NT.	*Long term environmental:* • Reduced risk of well integrity issues for decommissioned wells; • Detection of well integrity issues in decommissioned wells. *Long term social:* • Increased knowledge and confidence in well decommissioning processes in the NT. *Long term economic:* • Monitoring approaches that are appropriate to the level of risk • Reduced need for intervention long term

9. Project Plan

Project Schedule

ID	Activities / Task Title (should match activities in impact pathway section)	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Review of well integrity risks for decommissioned wells	Elaheh Arjomand	September 2019	December 2019	Project start
Task 2	Assessment of decommissioned wells in the Northern Territory and establishment of monitoring parameters	Elaheh Arjomand	December 2019	April 2020	Task 1
Task 3	Evaluation of long-term monitoring methods for decommissioned wells	Elaheh Arjomand	March 2020	August 2020	Task 1
Task 4	Alternative decommissioning approaches to reduce post-decommissioning well integrity risks	Elaheh Arjomand	June 2020	July 2020	Task 1
Task 5	Develop an approach for assessing the appropriate monitoring to implement on a well	Cameron Huddlestone-Holmes	July 2020	October 2020	Tasks 2 to 4
Task 6	Final reporting	Cameron Huddlestone-Holmes	October 2020	December 2020	All other tasks

Task description

Task 1

TASK NAME: Review of the contributing factors and their impacts on the integrity of decommissioned wells and develop a risk assessment approach

TASK LEADER: Elaheh Arjomand

OVERALL TIMEFRAME: September to December 2019

BACKGROUND: Decommissioning wells at the end of their lifecycle may impose a risk to the surrounding environment due to the probability of creation of leakage pathways. Therefore, it is of utmost importance to determine the crucial factors which contribute to the creation of leakage pathways and subsequently compromise the integrity of the decommissioned wells. The associated risks of leakage pathways formation should be identified to be able to perform risk assessment analyses.

TASK OBJECTIVES:

1) Review worldwide literature on well integrity failure mechanisms;
2) Review worldwide literature on well integrity failures for decommissioned wells;
3) Review risk assessment methodologies appropriate for well integrity, particularly post-decommissioning;
4) Develop a generic risk assessment approach for assessing post-decommissioning well integrity risks, possible failure modes, and key parameters that determine risk.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: An internal report summarizing the literature and risk assessment approach. This internal report will be incorporated into the project's final report.

Task 2

TASK NAME: Review of well integrity risks for decommissioned wells in the Northern Territory and establishment of monitoring parameters

TASK LEADER: Elaheh Arjomand

OVERALL TIMEFRAME: December 2019 to April 2020

BACKGROUND: The NT has a range of petroleum resources including shale resources that are under active exploration and conventional resources that have been produced for a long period of time. This task will use existing wells as case studies for applying the risk assessment methodology to a number of wells to determine well integrity risks post-decommissioning. Based on this risk assessment, the critical parameters that contribute to well integrity risk in decommissioned wells will be used to determine parameters that could be monitored. Consideration will be given to whether any parameters provide a warning of potential well integrity.

TASK OBJECTIVE:

1) Using the approach developed in Task 1, performing a risk assessment to gain a better understating of the potential hazards concerning decommissioned wells in the Northern Territory using example wells;
2) Develop monitoring criteria based on failure modes identified in the risk assessment;
3) Conduct a workshop with regulator, industry and technical experts to ground truth the risk assessment and monitoring criteria.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: An internal report summarising the results of the risk assessment and monitoring criteria. This internal report will be incorporated into the project's final report.

Task 3

TASK NAME: Evaluation of long-term monitoring methods for decommissioned wells

TASK LEADER: Elaheh Arjomand

OVERALL TIMEFRAME: March 2019 to August 2020

BACKGROUND: In this task available technologies for monitoring of decommissioned wells will be evaluated, with consideration given to:

1) Direct monitoring of the well at the surface;
2) Direct monitoring of the well in the subsurface; and
3) Indirect monitoring (through monitoring bores for example).

The effectiveness of these monitoring techniques will be reviewed against the potential failure modes identified in Task 2. The implementation of monitoring methods may also introduce additional risks, either to the integrity of the well itself or as a potential additional source of environmental harm (a monitoring bore for example). The risks presented by the different monitoring methods will also be assessed, along with the practicality of their deployment.

TASK OBJECTIVES:

1) Review literature for available monitoring techniques for abandoned well;
2) Investigate possible methods for monitoring parameters identified in Task 2
3) Assessment of the practicality, effectiveness and risks of deploying monitoring techniques identified.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: An internal report summarizing the literature on long-term monitoring techniques and their effectiveness according to wellbore characteristics. This internal report will be incorporated into the projects final report.

Task 4

TASK NAME: Alternative decommissioning approaches to reduce post-decommissioning well integrity risks and monitoring requirements.

TASK LEADER: Elaheh Arjomand

OVERALL TIMEFRAME: June 2020 to July 2020

BACKGROUND: The monitoring requirements for wells post-decommissioning may be reduced if the risks of well integrity failure can be reduced through the design, operation and eventual decommissioning of the well. Additionally, the way a well is decommissioned may facilitate different types of monitoring

TASK OBJECTIVE:

To conduct a high-level review of well decommissioning approaches that

1) reduce the risk of decommissioned wells losing integrity, based on the risk assessment conducted in Task 2; and
2) facilitate monitoring of well integrity long term.

The current requirements of the NT Code of Practice for Petroleum Activities for well decommissioning will be used as a baseline for this assessment.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: An internal report summarizing alternative approaches to well decommissioning. This internal report will be incorporated into the projects final report.

Task 5

TASK NAME: Develop an approach for assessing the appropriate monitoring to implement on a decommissioned well.

TASK LEADER: Cameron Huddlestone-Holmes

OVERALL TIMEFRAME: July 2020 to October 2020

BACKGROUND: The implementation of long-term monitoring for decommissioned wells is likely to be most effective if that monitoring is designed according to the risk profile presented by the well. A workflow for assessing the risks and selecting appropriate monitoring will help to ensure a consistent approach and consideration of all relevant factors.

TASK OBJECTIVE: Development of a workflow for assessing the post-decommissioning well integrity risks for wells in the NT and the selection of appropriate monitoring methods will be developed. This task will include a workshop with key stakeholders to discuss this workflow.

TASK OUTPUTS and SPECIFIC DELIVERABLES: The workflow developed in this task will be incorporated into the final report for the project.

Task 6

TASK NAME: Final report

TASK LEADER: Cameron Huddlestone-Holmes

OVERALL TIMEFRAME: October 2020 to November 2020

BACKGROUND: The final report for this project will collate the outputs from task 1 to 5. The report will also include a section on identifying any gaps in the available monitoring technologies and the implications of those gaps, including recommendations for further research.

TASK OBJECTIVE: Synthesize the outputs of tasks 1 to 5.

TASK OUTPUTS and SPECIFIC DELIVERABLES: A final report bringing together the outputs from all tasks.

Project Gantt Chart

Task	Task Description	Task Leader	Sep-19	Oct-19	Nov-19	Dec-19	Jan-20	Feb-20	Mar-20	Apr-20	May-20	Jun-20	Jul-20	Aug-20	Sep-20	Oct-20	Noc-20	Dec-20
1	Review of well integrity risks for decommissioned wells	Elaheh Arjomand																
2	Assessment of decommissioned wells in the Northern Territory and establishment of monitoring parameters	Elaheh Arjomand																
3	Evaluation of long-term monitoring methods for decommissioned wells	Elaheh Arjomand																
4	Alternative decommissioning approaches to reduce post-decommissioning well integrity risks	Elaheh Arjomand																
5	Develop an approach for assessing the appropriate monitoring to implement on a well	Cameron Huddlestone-Holmes																
6	Final reporting	Cameron Huddlestone-Holmes																

10. 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 most likely be composed of:

- The project leader (chair)
- A representative from the Petroleum Branch, NT Department of Environment and Natural Resources
- A representative from NT Department of Primary Industry and Resources
- Two representatives (drilling and completions engineers) from operating companies in the NT
- A representative from a regulator outside of the NT (South Australia, Queensland or WA)
- An industry expert on well integrity (consultant)
- An academic expert on well integrity (university based)

The project team members will also participate in TRG meetings to present results and to discuss the project directly with the TRG.

11. Communications Plan

Stakeholder	**Objective**	**Channel** (e.g. meetings/media/factsheets)	**Timeframe** (Before, during at completion)
Traditional Owner communities	To pursue relations with Traditional Owner communities (via cultural monitors)	Engagement with TO communities – as a wider context as part of CSIRO communications (considered mutually beneficial)	Ongoing
Government and industry	To facilitate a deeper understanding of research findings and implications for policy, programs, planning, and other initiatives	Knowledge transfer sessions and through stakeholder workshops and meetings.	From commencement of project and with updates as they come to hand.
Regional community/wider public	To communicate project objectives and key messages from the research	Fact sheets (including development of one at commencement of project which will explain in plain English the objective of the project – this will be updated periodically as project progresses). Project progress reported on GISERA website to ensure transparency for all stakeholders including regional communities.	From commencement of project and with updates as they come to hand. As required

		Participation in roadshows, community workshops and meetings and other engagements where appropriate. Maps and visuals - Key findings communicated with the use of maps and visual cues incorporated. Media release (optional)	As required Towards completion At completion
Regional community/wider public, government, scientific community and industry	To report on key findings	Final Report	At completion
Scientific community	To publish results in international peer-reviewed journals	Manuscript for submission to journals	At completion

12. Budget Summary

Expenditure	2019/20	2020/21	2021/22	Total
Labour	$142,416	$148,020	$0	$290,436
Operating	$18,000	$14,000	$0	$32,000
Subcontractors	$12,000	$18,000	$0	$30,000
Total Expenditure	**$172,416**	**$180,020**	**$0**	**$352,436**

Expenditure per Task	2019/20	2020/21	2021/22	Total
Task 1	$54,299	$0	$0	$54,299
Task 2	$64,260	$0	$0	$64,260
Task 3	$42,577	$36,730	$0	$79,307
Task 4	$11,280	$35,476	$0	$46,756
Task 5	$0	$59,850	$0	$59,850
Task 6	$0	$47,964	$0	$47,964
Total Expenditure	**$172,416**	**$180,020**	**$0**	**$352,436**

Source of Cash Contributions	2019/20	2020/21	2021/22	Total
Federal Government (37%)	$63,794	$66,607	$0	$130,401
NT Government (10%)	$17,242	$18,002	$0	$35,244
Origin Energy (10%)	$17,242	$18,002	$0	$35,244
Santos (10%)	$17,242	$18,002	$0	$35,244
Pangaea (8%)	$13,793	$14,402	$0	$28,195
Total Cash Contributions	**$129,312**	**$135,015**	**$0**	**$264,327**

In-Kind Contributions	2019/20	2020/21	2021/22	Total
CSIRO (25%)	$43,104	$45,005	$0	$88,109
Total In-Kind Contributions	**$43,104**	**$45,005**	**$0**	**$88,109**

	Total funding over all years	Percentage of Total Budget
Federal Government Investment	$130,401	37%
NT Government Investment	$35,244	10%
Origin Energy	$35,244	10%
Santos	$35,244	10%
Pangaea Resources	$28,195	8%
CSIRO Investment	$88,109	25%
TOTAL	**$352,436**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year Completed	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Review of well integrity risks for decommissioned wells	GISERA	Sep-2019	Dec-2019	2019/20	$40,724
Task 2	2.1	Assessment of decommissioned wells in the Northern Territory and establishment of monitoring parameters	GISERA	Dec-2019	Apr-2020	2019/20	$48,195
Task 3	3.1	Evaluation of long-term monitoring methods for decommissioned wells	GISERA	Mar-2020	Aug-2020	2020/21	$59,480
Task 4	4.1	Alternative decommissioning approaches to reduce post-decommissioning well integrity risks	GISERA	Jun-2020	Jul-2020	2020/21	$35,067
Task 5	5.1	Develop an approach for assessing the appropriate monitoring to implement on a well	GISERA	Jul-2020	Oct-2020	2020/21	$44,888
Task 6	6.1	Final reporting	GISERA	Oct-2020	Dec-2020	2020/21	$35,973

13. Intellectual Property and Confidentiality

Background IP (clause 11.1, 11.2)	**Party**	**Description of Background IP**	**Restrictions on use (if any)**	**Value**
				$
				$
Ownership of Non-Derivative IP (clause 12.3)	CSIRO			
Confidentiality of Project Results (clause 15.6)	Project Results are not confidential.			
Additional Commercialisation requirements (clause 13.1)	Not Applicable			
Distribution of Commercialisation Income (clause 13.4)	Not Applicable			
Commercialisation Interest (clause 1.1)	**Party**		**Commercialisation Interest**	
	CSIRO		N/A	
	Origin Energy		N/A	
	Santos		N/A	
	Pangaea Resources		N/A	

14. References

[1] Pepper R, Hart B, Jones D, Smith R, Priestly B, Andersen A, et al. Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory. Darwin: 2018.

[2] Hawke A. Report of the Independent Inquiry into Hydraulic Fracturing in the Northern Territory. 2014.

[3] Northern Territory Government. Code of Practice : Onshore Petroleum Activities in the Northern Territory. 2019.

[4] Kiran R, Teodoriu C, Dadmohammadi Y, Nygaard R, Wood D, Mokhtari M, et al. Identification and evaluation of well integrity and causes of failure of well integrity barriers (A review). J Nat Gas Sci Eng 2017;45:511–26. doi:10.1016/j.jngse.2017.05.009.

[5] Avci CB. Evaluation of flow leakage through abandoned wells and boreholes. Water Resour Res 1994;30:2565–78.

[6] Schout G, Griffioen J, Hassanizadeh SM, Cardon de Lichtbuer G, Hartog N, Grif J, et al. Occurrence and fate of methane leakage from cut and buried abandoned gas wells in the Netherlands. Sci Total Environ 2019;659:773–82. doi:10.1016/j.scitotenv.2018.12.339.

[7] Feitz AJ, Leamon G, Jenkins C, Jones DG, Moreira A, Bressan L, et al. Looking for leakage or monitoring for public assurance? Energy Procedia 2014;63:3881–90. doi:10.1016/j.egypro.2014.11.418.

[8] Campos G, Piedade TS, Ramos AC, Anjos JL, Azevedo AC, Abdu JPS, et al. Special P&A with Resin and Microcement Pumped from Interception Well Due to Multi-String Collapse. Offshore Technol Conf 2019:1–16. doi:10.4043/29281-ms.

[9] Beharie C, Francis S, Øvestad KH. Resin: An Alternative Barrier Solution Material 2015:1–10. doi:10.2118/173852-ms.

[10] Vrålstad T, Saasen A, Fjær E, Øia T, Ytrehus JD, Khalifeh M. Plug & abandonment of offshore wells: Ensuring long-term well integrity and cost-efficiency. J Pet Sci Eng 2019;173:478–91. doi:10.1016/j.petrol.2018.10.049.

[11] Council of Canadian Academies. Environmental Impacts of Shale Gas Extraction in Canada. Ottawa (ON): Council of Canadian Academies.; 2014.

[12] Cook P, Beck V, Brereton D, Clark R, Fisher B, Kentish S, et al. Engineering Energy: Unconventional Gas Production. Rep Aust Counc Learn Acad 2013:252.

[13] Atherton F, Bradfield M, Christmas K, Dalton S, Dusseault M, Gagnon G, et al. Report of the Nova Scotia Independent Review Panel on Hydraulic Fracturing. 2014.

[14] The Royal Society and The Royal Academy of Engineering. Shale gas extraction in the UK : a review of hydraulic fracturing. London: 2012.

[15] Liu HC, Liu L, Liu N. Risk evaluation approaches in failure mode and effects analysis: A literature review. Expert Syst Appl 2013;40:828–38. doi:10.1016/j.eswa.2012.08.010.

[16] Babaleye AO, Kurt RE, Khan F. Safety analysis of plugging and abandonment of oil and gas wells in uncertain conditions with limited data. Reliab Eng Syst Saf 2019;188:133–41. doi:10.1016/j.ress.2019.03.027.

[17] Wu Q, Nair S, Oort E van, Guzik A, Kishida K. Concurrent Real-Time Distributed Fiber Optic Sensing of Casing Deformation and Cement Integrity Loss. SPE/IADC Int Drill Conf Exhib Soc Pet Eng 2019. doi:10.2118/194159-ms.

[18] Brechan B, Sangesland S, Naaden C. Well Integrity - Next Developments 2018. doi:10.2118/189403-ms.

[19] Boone K, Ridge A, Crickmore R, Onen D. Detecting Leaks in Abandoned Gas Wells with Fibre-Optic Distributed Acoustic Sensing 2016. doi:10.2523/iptc-17530-ms.
[20] Watson TL, Bachu S. Evaluation of the Potential for Gas and CO2 Leakage Along Wellbores. SPE Drill Complet 2009;24:115–26. doi:10.2118/106817-PA.
[21] Huddlestone-Holmes CR, Wu B, Kear J, Pandurangan R. Report into the shale gas well life cycle and well integrity 2017:77–168. doi:10.4225/08/5a3802273ed86.