Project Order, Variations and Research Progress

Project Title: Creating a comprehensive water contamination risk assessment tool for examining borehole delamination and hydraulic fracturing activity in unconventional gas extraction

This document contains three sections. Click on the relevant section for more information.

GISERA, GPO Box 2583, Brisbane QLD 4001, Australia

1 Original Project Order

Project Order

Proforma 2016

1. Short Project Title (less than 15 words)

Water contamination risk assessment on hydraulic fracturing in unconventional gas extraction

Long Project Title	Creating a comprehensive water contamination risk assessment tool for examining borehole delamination and hydraulic fracturing activity in unconventional gas extraction
GISERA Project Number	W.10
Proposed Start Date	3 January 2017
Proposed End Date	29 January 2018
Project Leader	Raman Pandurangan, Zuorong Chen, James Kear Dane Kasperczyk

2. GISERA Region

☒ Queensland ☒ New South Wales ☐ Northern Territory

3. GISERA Research Program

☒ Water Research ☐ GHG Research ☒ Social & Economic Research

☐ Biodiversity Research ☐ Agricultural Land Management Research ☐ Health

4. Research Leader, Title and Organisation

Researcher	Time Commitment (project as a whole)	Organisation
Raman Pandurangan	40%	CSIRO
Zuorong Chen	20%	CSIRO
James Kear	20%	CSIRO
Dane Kasperczyk	20%	CSIRO

5. Background

Though Hydraulic Fracturing ('Fracking') has been a well-established technique for production of oil and gas from unconventional reservoirs, there is often a concern about its environmental implications, some of which include air pollution as a result of the construction and operation activities at the site, contamination of water bodies by the chemical additives used in fracking process, soil contamination due to oil spills and storage of waste water, and induced seismic events. Water pollution is particularly a key issue as communities fear that gas production will potentially negatively impact agricultural land through water quality (NSW Chief Scientist report).

It is therefore critical for communities living in oil and gas exploration and production regions to understand the potential contamination risk of surface and groundwater assets through transport of geogenic or introduced chemicals from drilling and hydraulic fracturing activities associated with onshore gas development. The stimulation of conductive pathways between the production depths to surface and groundwater assets is an area of significant concern for community groups who rely heavily on these water resources. Traditional risk assessment methods have relied on either analysis of historical data or the technical investigation of a specific case where high quality data exists. These traditional methods primarily rely on empirical models formulated based on existing data to generate the likelihood of potential contamination. However, when historical data is used for likelihood estimation, local conditions and operations are typically not considered. Alternatively, analysis of a specific case does not provide a range of potential outcomes at a local or field scale. So, while current methods have proven adequate in terms of judging the potential risks to humans and environment, there is virtually no quantification of the actual likelihoods of these risks. Without the quantitative information of risk likelihoods, it is difficult to prioritise expenditure into risk mitigation efforts (so that the most effective mitigation options can be implemented).

This project will introduce methods to combine hydraulic fracturing models and uncertainty quantification techniques and use past data to generate a likelihood of potential contamination events. Identification of these likelihoods yields specific information that can be acted on by industry and government to reduce risks of contamination events, and importantly inform communities of the actual risk to human health and the environment. This project will demonstrate the engineering processes that exist as part of hydraulic fracturing demonstrating the critical completion design parameters that are used to control risks.

Currently, much legislation and risk mitigation efforts are based on perceived risk, of possible contamination events, which are notoriously biased and inaccurate. This project will develop a tool to provide quantitative information on the contamination risk profile at a basin/sub-basin scale and identify key parameters that may increase or reduce the likelihood of stimulation of key conductive pathways of geogenic and hydraulic fracturing fluids to aquifers. The tool will focus on two key potential conductive pathways: wellbore delamination and hydraulic fracture stimulation.

This project will address the following concerns and recommendations from the NSW Chief Scientist Review.

- *Stakeholders Concerns (Page 7)* - How CSG development and particularly processes such as hydraulic stimulation ('fracking') will negatively affect agriculture land by depleting aquifers and ground water resources.

- *There are things we need to know more about (Page 10):* To understand the risk of pollution and potential short- or long-term environmental damage from CSG and related operations.
- *Risks can be managed (Page 10)*: Systems to predict, assess, monitor and act on risks at appropriate threshold conditions.
- *Recommendation 11:* centralised Risk Management and Prediction Tool for extractive industries in NSW. Improving prediction capability of risk likelihoods.
- *Recommendation 12:* On updating and refining the Risk Management and Prediction Tool. On whether or not other unconventional gas extraction (shale gas, tight gas) industries should be allowed to proceed in NSW and, if so, under what conditions
- *Recommendation 13:* Companies or organisations seeking to mine, extract CSG or irrigate as part of their initial and ongoing approvals processes should, in concert with the regulator, identify impacts to water resources, their pathways, their consequence and their likelihood, as well as the baseline conditions and their risk trigger thresholds before activities can start.

6. Project Description

The project will combine an engineering approach to risk assessment with mathematical models for conductive pathway stimulation to arrive at a quantitative estimate of the risk magnitude. The risk is defined as the probability of surface and groundwater contamination under different failure cases for parameter values unique to each basin/sub-basin.

<u>Importance and necessity</u>

While historical data suggests low barrier and well failure rates, community concern over the environmental impacts to groundwater resources due to wellbore delamination and hydraulic fracturing continues to be a challenge for the oil and gas industry to effectively address. This project will use CSIRO's expertise to predict hydraulic fracture growth and assist in quantifying the potential for conductive pathway stimulation through which geogenic or introduced chemicals could can reach a surface or groundwater. The objective is to convert the perceived risk over environmental impacts to groundwater resources due to hydraulic fracturing into a quantifiable risk magnitude by providing bounded estimates on the probability of contamination under the different scenarios. The actual risk given by the risk magnitude and the associated uncertainty can then be used to formulate appropriate risk management plans and address community concerns. The risk likelihood can also be used to further assess, like for example, attenuation pathways of chemicals and their derivatives into water bodies, in case the analysis show a higher probability of the fractures reaching an aquifer.

<u>Method</u>

Stochastic methods such as the probability bound analysis (PBA) will be used to assess the water pollution risk from hydraulic fracturing, and to compute the bounds on the probability of contamination under the best case and worst case scenarios, with the range representing the uncertainty. The method combines the prior probability distribution and interval arithmetic to compute the bounds or uncertainty in the predictions as a cumulative probability function that are represented in the form of probability boxes (p-boxes). This technique can compute the bounds on a complex function give the distribution of inputs, and is well suited for problems where the upper and lower bounds of the parameter are known, but limited information is available about its probability distribution. Recently Rozell et al.[1] have used this technique to study pollution risk associated with natural gas extraction from Marcellus Shale. This study uses empirical models for risk assessment and is mainly concerned with environmental risk due to gas extraction from Marcellus Shale in the United States, and considers water contamination risk from a number of external factors such as tanker spills, surface spill, and waste disposal.

This project will specifically focus on Australian onshore gas basins in NSW and QLD, and will be applicable to Shale, CSG and tight gas operations. Mathematical models will be used to predict the quantitative risks associated with hydraulic fracture growth and well rupture specific to each identified basin, as follows:

- The risks associated with hydraulic fracture growth will be assessed using simple mathematical models such as the PKN model, or the Pseudo 3D model. These models will used to predict the lateral and longitudinal fracture extent using the material properties relevant to a particular basin. Published data, where available will be used to arrive at reasonable bounds and prior distributions for the different variables used in the model. Probability bound analysis will then be used to predict the likelihood of potential contamination events occurring in the event of a fracture growth occuring, along with an estimate of the related uncertainty.
- The interface debonding model developed by Brice et al. [2] will be used to study and predict the fluid flux through the annulus in the event of well rupture. The model can predict the rate of growth of the debonding and the fluid flux through the annulus for various growth regimes

[1] Rozell DJ, Reaven SJ. Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale. Risk Anal. 2012 Aug 1;32(8):1382–9
[2] Lecampion B, Bunger A, Kear J, Quesada D. Interface debonding driven by fluid injection in a cased and cemented wellbore: Modeling and experiments. Int J Greenh Gas Control. 2013 Oct;18:208–23

Industry Benefits

- The study will provide likelihood of ground water contamination in a specific sub-region in NSW (wellbore delamination) and another in Queensland (planned hydraulic fracture and wellbore delamination) due to gas activity, along with an estimate of the related uncertainty. The likelihood estimates can be used by regulators to critically assess current projects and understand its impact on ground water resources, and accordingly come up with a mitigation plan to bring down the risks to acceptable levels. It can also be used by companies or organisations seeking to produce onshore gas from unconventional reservoirs as an initial high-level screening tool to identify impacts to water resources, their pathways, their consequence and their likelihood before starting a new activity.

Community Benefits

- Communities living in gas exploration and development regions want to know if onshore gas extraction activities will adversely affect the local water sources. In particular, this tool will provide communities a better understanding of potential impacts to local water resources from onshore gas hydraulic fracturing activities and wellbore delamination.

7. Budget Summary

Expenditure	2016/17	2017/18	2018/19	Total
Labour	160,939	118,684	-	279,624
Operating	4,500	6,500	-	11,000
Subcontractors	-	-	-	-
Total Expenditure	**165,439**	**125,184**	**0**	**$290,624**

Expenditure per Task	2016/17	2017/18	2018/19	Total
Task 1	55,178	-	-	55,178
Task 2	30,597	-	-	30,597
Task 3	18,207	-	-	18,207
Task 4	31,414	-	-	31,414
Task 5	30,043	15,066	-	45,109
Task 6	-	49,185	-	49,185
Task 7	-	12,601	-	12,601
Task 8	-	8,628	-	8,628
Task 9	-	39,704	-	39,704
Total Expenditure	**165,439**	**125,184**	-	**$290,624**

Source of Cash Contributions	2016/17	2017/18	2018/19	Total
GISERA Industry Partners (50%)	82,720	62,592	-	145,312
- Santos (12.5%)	20,680	15,648	-	36,328
- AGL (12.5%)	20,680	15,648	-	36,328
- APLNG (12.5%)	20,680	15,648	-	36,328
- QGC (12.5%)	20,680	15,648	-	36,328
NSW Government (10%)	16,544	12,518	-	29,062
Federal Government (20%)	33,088	25,037	-	58,125
Total Cash Contributions	**132,352**	**100,147**	-	**$232,499**

In-Kind Contribution from Partners	2016/17	2017/18	2018/19	Total
CSIRO (20%)	33,088	25,037	-	58,125
Total In-Kind Contribution from Partners	**33,088**	**25,037**	**-**	**$58,125**

	Total funding over all years	Percentage of Total Budget
GISERA Investment	$145,312	50%
NSW Government Investment	$29,062	10%
Federal Government Investment	$58,125	20%
CSIRO Investment	$58,125	20%
Total Other Investment	-	
TOTAL	**$290,624**	

Task	Milestone Number	Milestone Description	Start Date	Delivery Date	Fiscal Year Completed	Funded by	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Develop Mathematical model of Risk Assessment	3 Jan 2017	30 May 2017	2016/17	GISERA	$44,142
Task 2	2.1	Validation of Mathematical model with sample/synthetic data.	01 Mar 2017	30 May 2017	2016/17	GISERA	$24,478
Task 3	3.1	Identify a sub-region for risk assessment in NSW and QLD after a discussion with GISERA Director.	01 Mar 2017	30 May 2017	2016/17	GISERA	$14,566
Task 4	4.1	Review and collect all relevant data corresponding to the identified sub-regions.	01 Mar 2017	30 May 2017	2016/17	GISERA	$25,131
Task 5	5.1	Investigate one sub-region in QLD for water pollution risk from hydraulic fracturing and wellbore debonding, and one sub-region in NSW for wellbore debonding using the developed mathematical model.	01 Jun 2017	30 Sep 2017	2017/18	GISERA	$36,087
Task 6	6.1	Consolidate major findings and prepare a project report	01 Sep 2017	30 Sep 2017	2017/18	GISERA	$39,348
Task 7	7.1	Present key findings and project report to GISERA Director.	01 Oct 2017	10 Oct 2017	2017/18	GISERA	$10,081
Task 8	8.1	Project review and decision to progress to stage 3.	01 Oct 2017	10 Oct 2017	2017/18	GISERA	$6,902
Task 9	9.1	Package and deploy "Alpha version" of a GUI tool based on the tested models. To be used for concept demonstration covering a limited number of basins and scenarios.	01 Oct 2017	29 Jan 2018	2017/18	GISERA	$31,763

8. Other Researchers

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Zuorong Chen	20%	Hydraulic Fracturing, Mathematical modeling and Numerical Simulation	08	CSIRO
James Kear	20%	Hydraulic Fracturing, Project Management	08	CSIRO
Dane Kasperczyk	20%	Hydraulic Fracturing Experiments, Field Fracturing and Statistical Reporting	04	CSIRO

9. Subcontractors

Subcontractors (clause 9.5(a)(i))	Subcontractor	Role
	None	

10. Project Objectives and Outputs

The objective of the study is to provide quantitative information about the possibility of ground water contamination from planned hydraulic fracture and wellbore development activities associated with onshore gas development. This information will be made available to communities living in gas development regions in NSW and Queensland, and is expected to inform policy makers of possible risks specific to an individual region and help plan current and future developments.

It is hoped having a quantitate value on low or no risk areas will instill community confidence that onshore gas extraction activities will or will not cause any damage to local water source specific to that individual locations. Conversely, where high risk areas are identified, the results of this study will inform risk mitigation strategies that will reduce these risks to acceptably low levels.

11. GISERA Objectives Addressed

Carrying out of research and improving and extending knowledge of social and environmental impacts and opportunities of unconventional gas projects for the benefit of the Gas Industry, the relevant community and the broader public.

Informing government, regulators and policy-makers on key issues regarding policy and legislative framework for the Gas Industry.

12. Project Development

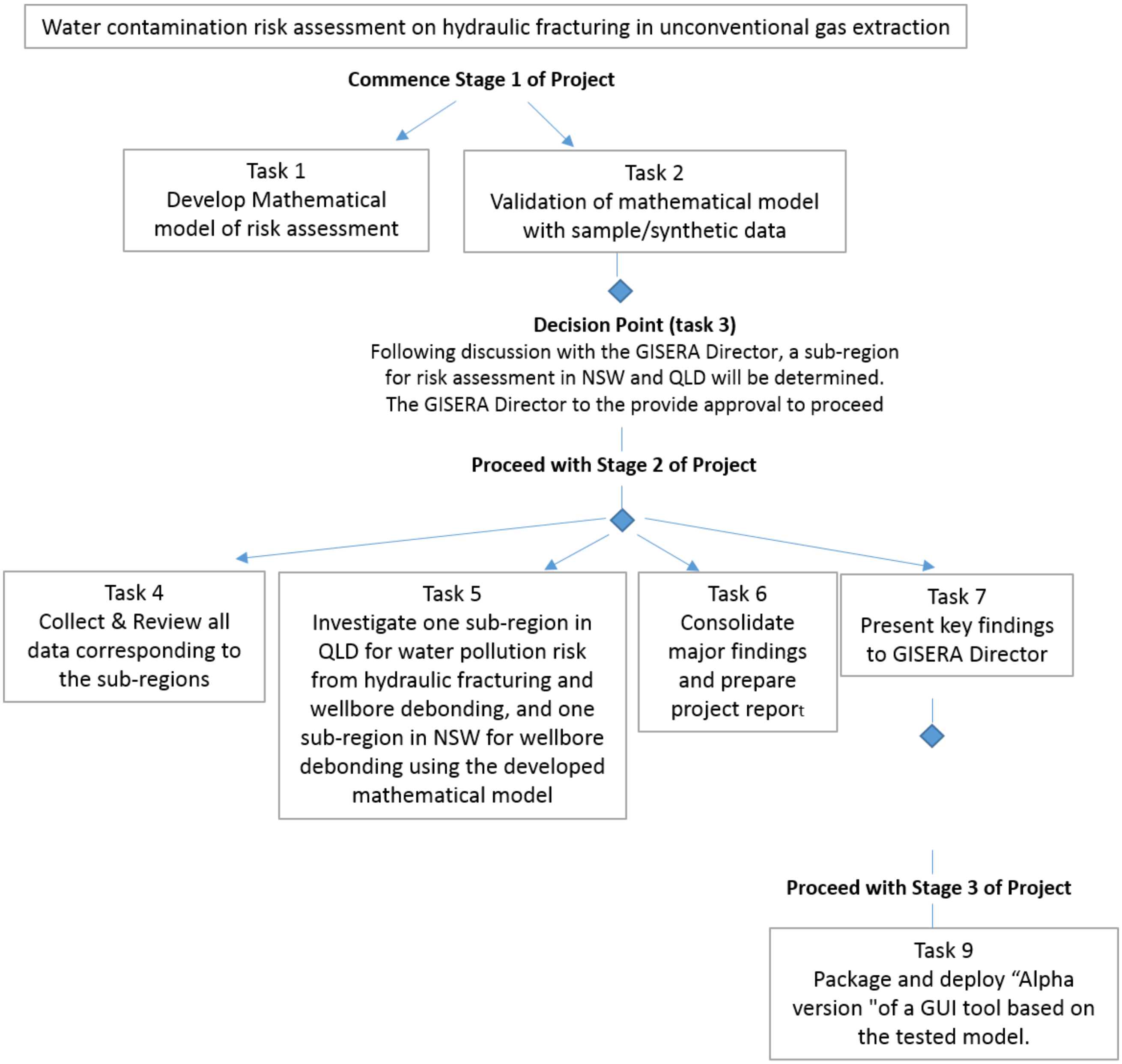
This project was developed from a discussion in June 2016 with the Office of Water Science, Department of the Environment and Energy in Adelaide. The Office of Water Science is leading the Australian Government's efforts to improve understanding of the water-related impacts of coal seam gas and large coal mining developments.

This project addresses stakeholder concerns and recommendations 11, 12 and 13 from the NSW Chief Scientist Review centred on the risk prediction and management in Australian onshore gas industries.

CSIRO's expertise can help predict hydraulic fracture growth and assist in quantifying the potential for conductive pathway stimulation or groundwater resources. The resulting risk magnitude and uncertainty can then be used to formulate appropriate risk management plans and address community concerns.

13. Project Plan

This project will be executed in three stages with stage gates between each of them. Following stage 1 (the development and validation of the mathematical model of risk assessment) there will be a stage gate to identify a sub-region for risk assessment in NSW and another in QLD in consultation with the GISERA Director. Following stage 2 of the project there will be a further stage gate to get the GISERA Director's approval to proceed to stage 3 which is the development of the GUI tool.



13.1 Project Schedule

ID	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Develop Mathematical model of Risk Assessment	Raman Pandurangan & Zuorong Chen	03 Jan 2018	30 May 2017	
Task 2	Validation of Mathematical model with sample/synthetic data.	Raman Pandurangan & Zuorong Chen	01 Mar 2017	30 May 2017	Task 1
Task 3	Identify a sub-region for risk assessment in NSW and QLD after a discussion with GISERA Director.	Dane Kasperczyk & James Kear	01 Mar 2017	30 May 2017	
Task 4	Review and collect all relevant data corresponding to the identified sub-regions.	Dane Kasperczyk & James Kear	01 Mar 2017	30 May 2017	
Task 5	Investigate one sub-region in QLD for water pollution risk from hydraulic fracturing and wellbore debonding, and one sub-region in NSW for wellbore debonding using the developed mathematical model.	Raman Pandurangan & Zuorong Chen	01 June 2017	31 Sep 2017	Task 1-4
Task 6	Consolidate major findings and prepare a project report	Raman Pandurangan & Dane Kasperczyk	01 Sep 2017	31 Sep 2017	Task 5
Task 7	Present key findings and project report to GISERA Director.	Raman Pandurangan & James Kear	01 Oct 2017	10 Oct 2017	Task 6
Task 8	Project review and decision to progress to stage 3.	Raman Pandurangan & James Kear	01 Oct 2017	10 Oct 2017	Task 7
Task 9	Package and deploy "Alpha version" of a GUI tool based on the tested models. To be used for concept demonstration covering a limited number of basins and scenarios.	Raman Pandurangan & Dane Kasperczyk	01 Oct 2017	29 Jan 2018	Task 8

Task 1

TASK NAME: Develop mathematical model of Risk Assessment.

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 05 Months

BACKGROUND: Combine hydraulic fracturing models and uncertainty quantification techniques together with past data to generate a likelihood of potential contamination events occurring.

TASK OBJECTIVE: Develop mathematical models for conductive pathway stimulation to arrive at a quantitative estimate of the risk magnitude.

TASK OUTPUTS: Mathematical model/tool to estimate the risk associated with planned hydraulic fracture and wellbore development.

SPECIFIC DELIVERABLES: Mathematical model of risk assessment.

Task 2

TASK NAME: Validation of Mathematical model

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 03 Months

BACKGROUND: Combine hydraulic fracturing models and uncertainty quantification techniques together with past data to generate a likelihood of potential contamination events occurring.

TASK OBJECTIVE: Validate the developed mathematical model with synthetic data.

TASK OUTPUTS: Mathematical model/tool to estimate the risk associated with planned hydraulic fracture and wellbore development

SPECIFIC DELIVERABLES: Validated mathematical model.

Task 3

TASK NAME: Identify a sub-region for risk assessment in NSW and in QLD after a discussion with GISERA Director.

TASK LEADER: Dane Kasperczyk, James Kear

OVERALL TIMEFRAME: 03 Months

BACKGROUND: Identify an area for risk assessment using the proposed model that would be of interest to GISERA.

TASK OBJECTIVE: Identification of a sub-region in NSW and QLD for risk assessment.

TASK OUTPUTS: Identification of a sub-region for risk assessment that would be of interest to GISERA.

SPECIFIC DELIVERABLES: Identified sub-region in NSW and QLD for risk assessment

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Task 4

TASK NAME: Review and collect all relevant data corresponding to the identified sub-regions.

TASK LEADER: Dane Kasperczyk, James Kear

OVERALL TIMEFRAME: 03 Months

BACKGROUND: To generate a likelihood of potential contamination events occurring in the specific sub-region.

TASK OBJECTIVE: Collect all data specific to the identified sub-region for carrying out the risk assessment.

TASK OUTPUTS: Tabulated values containing all the relevant parameter required for running the risk assessment model.

SPECIFIC DELIVERABLES: Key finding for the final report

Task 5

TASK NAME: Investigate one sub-region in QLD for water pollution risk from hydraulic fracturing and wellbore debonding, and one sub-region in NSW for wellbore debonding using the developed mathematical model.

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 04 Months

BACKGROUND: To generate a likelihood of potential contamination events in the identified sub-regions.

TASK OBJECTIVE: To generate a likelihood of potential contamination events in the identified sub-regions.

TASK OUTPUTS: Likelihood of potential contamination events occurring.

SPECIFIC DELIVERABLES: Key finding for the final report

Task 6

TASK NAME: Consolidate major findings and prepare a project report

TASK LEADER: Dane Kasperczyk, Raman Pandurangan

OVERALL TIMEFRAME: 01 Month

BACKGROUND: To generate a likelihood of potential contamination events occurring in the specific sub-regions and report key findings.

TASK OBJECTIVE: Report the key finding with detailed information on the risk assessment model formulation, validation and results from risk assessment exercise pertaining to the specific sub-regions.

TASK OUTPUTS: Project report with key findings.

SPECIFIC DELIVERABLES: Project summary report.

Task 7

TASK NAME: Present Key findings and project report to GISERA Director.

TASK LEADER: Raman Pandurangan & James Kear

OVERALL TIMEFRAME: 10 days

BACKGROUND: NA

TASK OBJECTIVE: To present the major finding to the GISERA Director.

TASK OUTPUTS: Prepare presentation slides and project summary.

SPECIFIC DELIVERABLES: Presentation of key findings and delivery of final report

Task 8

TASK NAME: Project review and decision to progress to stage 3.

TASK LEADER: Raman Pandurangan, James Kear

OVERALL TIMEFRAME: 10 days

BACKGROUND: NA.

TASK OBJECTIVE: Review of the project.

TASK OUTPUTS: Decision to progress to stage 3.

SPECIFIC DELIVERABLES: Decision from GISERA Director.

Task 9

TASK NAME: Package and deploy "Alpha version" of a GUI tool based on the tested models, for concept demonstration.

TASK LEADER: Dane Kasperczyk, Raman Pandurangan

OVERALL TIMEFRAME: 04 Months

BACKGROUND: NA.

TASK OBJECTIVE: Package the risk assessment model into GUI tool that can be used for concept demonstration covering a limited number of basins and scenarios

TASK OUTPUTS: Development of software product that is suitable for use by engineers and geotechnical professionals.

SPECIFIC DELIVERABLES: Risk Assessment software.

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14. Communications Plan

Communication of the results of the project will be managed in accordance with GISERA's communication strategy. This may include presentations at community and industry meetings, conferences and publication of reports, scientific articles and factsheets. In addition, communication with relevant state and federal government departments including NSW Department of Natural Resources, QLD Department of Natural Resources and Mines (Office of Groundwater Impact Assessment) and NSW Chief Scientist's office will be maintained to ensure that they are aware of the outcomes of the research and possible policy implications.

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 (noting NSW Chief Scientist Office have been approached and declined).

15. 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 Commercialisation 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="6">Commercialisation Interest (clause 1.1)</td><td colspan="2">Party</td><td colspan="2">Commercialisation Interest</td></tr>
<tr><td colspan="2">Santos</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">AGL</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">QGC</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">CSIRO</td><td colspan="2">N/A</td></tr>
</table>

2 Variations to Project Order

Changes to research Project Orders are approved by the GISERA Director, acting with authority provided by the GISERA National Research Management Committee, in accordance with the National GISERA Alliance Agreement.

The table below details variations to research Project Order.

Register of changes to Research Project Order

Date	Issue	Action	Authorisation
20/6/17	Due to delays in obtaining data, milestones 3.1 and 4.1 have been pushed back by 3 months.	Milestone 3.1 pushed back to Jul 17, milestone 4.1 pushed back to Aug 17	
9/10/17	Due to delays in obtaining data, milestones 5.1 and 6.1have been pushed back by 2 months.	Milestone 5.1 pushed back to Nov-17, milestone 6.1 pushed back to Nov-17.	
15/2/18	Due to the departure of the lead researcher on this project the final milestone has changed to complete a specific demonstration of results with cumulative probability distributions from the study.	Milestone 9 pushed back to Apr-18	

3 Progress against project milestones

Progress against milestones are approved by the GISERA Director, acting with authority provided by the GISERA National Research Management Committee, in accordance with the National GISERA Alliance Agreement.

Progress against project milestones/tasks is indicated by two methods: Traffic Light Reports and descriptive Project Schedule Reports.

1. Traffic light reports in the Project Schedule Table below show progress using a simple colour code:
   - Green:
     - Milestone fully met according to schedule.
     - Project is expected to continue to deliver according to plan.
     - Milestone payment is approved.
   - Amber:
     - Milestone largely met according to schedule.
     - Project has experienced delays or difficulties that will be overcome by next milestone, enabling project to return to delivery according to plan by next milestone.
     - Milestone payment approved for one amber light.
     - Milestone payment withheld for second of two successive amber lights; project review initiated and undertaken by GISERA Director.
   - Red:
     - Milestone not met according to schedule.
     - Problems in meeting milestone are likely to impact subsequent project delivery, such that revisions to project timing, scope or budget must be considered.
     - Milestone payment is withheld.
     - Project review initiated and undertaken by GISERA Research Advisory Committee.

2. Progress Schedule Reports outline task objectives and outputs and describe, in the 'progress report' section, the means and extent to which progress towards tasks has been made.

Project Schedule Table

ID	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Develop Mathematical model of Risk Assessment	Raman Pandurangan & Zuorong Chen	Jan-17	May-17	
Task 2	Validation of Mathematical model with sample/synthetic data.	Raman Pandurangan & Zuorong Chen	Mar-17	May-17	Task 1
Task 3	Identify a sub-region for risk assessment in NSW and QLD after a discussion with GISERA Director.	Dane Kasperczyk & James Kear	Mar-17	Jul-17	
Task 4	Review and collect all relevant data corresponding to the identified sub-regions.	Dane Kasperczyk & James Kear	Mar-17	Aug-17	
Task 5	Investigate one sub-region in QLD for water pollution risk from hydraulic fracturing and wellbore debonding, and one sub-region in NSW for wellbore debonding using the developed mathematical model.	Raman Pandurangan & Zuorong Chen	Jun-17	Nov-17	Task 1-4
Task 6	Consolidate major findings and prepare a project report	Raman Pandurangan & Dane Kasperczyk	Sep-17	Nov-17	Task 5
Task 7	Present key findings and project report to GISERA Director.	Raman Pandurangan & James Kear	Oct-17	Oct-17	Task 6

Task 8	Project review and decision to progress to stage 3.	Raman Pandurangan & James Kear	Oct-17	Oct-17	Task 7
Task 9	Package and deploy concept demonstration material covering a limited number of basins and scenarios	Raman Pandurangan & Dane Kasperczyk	Feb-18	Apr-18	Task 8

Project Schedule Report

Task 1

TASK NAME: Develop mathematical model of Risk Assessment.

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 05 Months

BACKGROUND: **C**ombine hydraulic fracturing models and uncertainty quantification techniques together with past data to generate a likelihood of potential contamination events occurring.

TASK OBJECTIVE: Develop mathematical models for conductive pathway stimulation to arrive at a quantitative estimate of the risk magnitude.

TASK OUTPUTS: Mathematical model/tool to estimate the risk associated with planned hydraulic fracture and wellbore development.

SPECIFIC DELIVERABLES: Mathematical model of risk assessment.

PROGRESS REPORT:

For wellbore delamination, we are using the model developed by Brice et al. We have implemented the model in Matlab and can confirm it works as reported. In regards to the hydraulic fracturing element we have used simple analytical PKN model which also has been implemented in Matlab.\

Task 2

TASK NAME: Validation of Mathematical model

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 03 Months

BACKGROUND: **C**ombine hydraulic fracturing models and uncertainty quantification techniques together with past data to generate a likelihood of potential contamination events occurring.

TASK OBJECTIVE: Validate the developed mathematical model with synthetic data.

TASK OUTPUTS: Mathematical model/tool to estimate the risk associated with planned hydraulic fracture and wellbore development

SPECIFIC DELIVERABLES: Validated mathematical model.

PROGRESS REPORT:

For wellbore delamination we have used the sample data in the published paper "Lecampion B, Bunger A, Kear J, Quesada D. Interface debonding driven by fluid injection in a cased and cemented wellbore: Modelling and experiments. Int J Greenh Gas Control. 2013 Oct;18:208–23" and have verified that we receive similar outputs from our model. For the hydraulic fracture model we have checked the model for sample data and compared the results with our calculations.

Task 3

TASK NAME: Identify a sub-region for risk assessment in NSW and in QLD after a discussion with GISERA Director.

TASK LEADER: Dane Kasperczyk, James Kear

OVERALL TIMEFRAME: 03 Months

BACKGROUND: Identify an area for risk assessment using the proposed model that would be of interest to GISERA.

TASK OBJECTIVE: Identification of a sub-region in NSW and QLD for risk assessment.

TASK OUTPUTS: Identification of a sub-region for risk assessment that would be of interest to GISERA.

SPECIFIC DELIVERABLES: Identified sub-region in NSW and QLD for risk assessment

PROGRESS REPORT:

We had three meetings with the Technical Reference Group members on 18th May, 19th June and 28th July 2017, to review the models used for the study and to identify a sub-region for risk assessment in NSW and QLD. Based on the recommendations of the TRG members, we have in principle agreed to focus the study on the Bowen and Surat basins in QLD and NSW respectively, for both hydraulic fracture growth and wellbore delamination study respectively. The minutes of the meeting has been circulated to all team members and the GISERA director for records.

Task 4

TASK NAME: Review and collect all relevant data corresponding to the identified sub-regions.

TASK LEADER: Dane Kasperczyk, James Kear

OVERALL TIMEFRAME: 03 Months

BACKGROUND: To generate a likelihood of potential contamination events occurring in the specific sub-region.

TASK OBJECTIVE: Collect all data specific to the identified sub-region for carrying out the risk assessment.

TASK OUTPUTS: Tabulated values containing all the relevant parameter required for running the risk assessment model.

SPECIFIC DELIVERABLES: Key finding for the final report

PROGRESS REPORT:

Based on advice from the Technical Reference Group (TRG) meeting held on July 28, a request was sent to industry partners for data pertaining to two identified sub-regions. Data has been received for the Surat Basin only. Due to delays in obtaining the remaining data, the project team has instead decided to use publically available data for the Camden Basin in NSW.

Task 5

TASK NAME: Investigate one sub-region in QLD for water pollution risk from hydraulic fracturing and wellbore debonding, and one sub-region in NSW for wellbore debonding using the developed mathematical model.

TASK LEADER: Raman Pandurangan, Zuorong Chen

OVERALL TIMEFRAME: 04 Months

BACKGROUND: To generate a likelihood of potential contamination events in the identified sub-regions.

TASK OBJECTIVE: To generate a likelihood of potential contamination events in the identified sub-regions.

TASK OUTPUTS: Likelihood of potential contamination events occurring.

SPECIFIC DELIVERABLES: Key finding for the final report

PROGRESS REPORT:

The water pollution risk from hydraulic fracturing and wellbore de-bonding have been completed for the Surat basin in QLD and the Sydney basin. The data from these sub-regions have been analysed using the probability bounds analysis and the mathematical models.

Task 6

TASK NAME: Consolidate major findings and prepare a project report

TASK LEADER: Dane Kasperczyk, Raman Pandurangan

OVERALL TIMEFRAME: 01 Month

BACKGROUND: To generate a likelihood of potential contamination events occurring in the specific sub-regions and report key findings.

TASK OBJECTIVE: Report the key finding with detailed information on the risk assessment model formulation, validation and results from risk assessment exercise pertaining to the specific sub-regions.

TASK OUTPUTS: Project report with key findings.

SPECIFIC DELIVERABLES: Project summary report.

PROGRESS REPORT:

A detailed project report with key finding has been prepared and submitted to e-publish for review. One reviewer has returned with approval with minor changes completed, with one reviewer outstanding. Discussions with the GISERA director will be undertaken during January to further discuss the details required within the report.

Task 7

TASK NAME: Present Key findings and project report to GISERA Director.

TASK LEADER: Raman Pandurangan & James Kear

OVERALL TIMEFRAME: 10 days

BACKGROUND: NA

TASK OBJECTIVE: To present the major finding to the GISERA Director.

TASK OUTPUTS: Prepare presentation slides and project summary.

SPECIFIC DELIVERABLES: Presentation of key findings and delivery of final report

PROGRESS REPORT:

A meeting with the GISERA director, Dane Kasperczyk and James Kear was held in Clayton, Melbourne on 31 January 2018. The meeting discussed details of the report, explained some of the technical terms in the report, discussed reviewers' comments from Task 6 and presented major findings.

Task 8

TASK NAME: Project review and decision to progress to stage 3.

TASK LEADER: Raman Pandurangan, James Kear

OVERALL TIMEFRAME: 10 days

BACKGROUND: NA.

TASK OBJECTIVE: Review of the project.

TASK OUTPUTS: Decision to progress to stage 3.

SPECIFIC DELIVERABLES: Decision from GISERA Director.

PROGRESS REPORT:

A meeting with the GISERA director, Dane Kasperczyk and James Kear was held in Clayton, Melbourne on 31 January 2018 to discuss direction of Stage 3/Task 9. The decision would be to either proceed or not proceed with Task 9. The GISERA director agreed with reviewers comments from Task 6 to include specific demonstrations of the results and decided to continue with Task 9 to include concept demonstration to include in final report but not to deploy GUI.

Task 9

TASK NAME: Specific demonstration of results added to final report. (Stage 3)

TASK LEADER: Dane Kasperczyk, James Kear

OVERALL TIMEFRAME: 04 Months

BACKGROUND: NA.

TASK OBJECTIVE: Specific demonstration of model results.

TASK OUTPUTS: Project final report

SPECIFIC DELIVERABLES: Probability-likelihood distributions / Project Final Report

PROGRESS REPORT:

The final report has been submitted to GISERA and approved. A Knowledge Transfer Session is being held on the 28th of August, alongside another NSW project. This session will explore the key outcomes and recommendations from both projects. A factsheet will also be released to accompany the completion of this project.