Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Project Order

Short Project Title

Groundwater connectivity between the CLA and the surface in the Eastern Beetaloo Sub-basin extension

Long Project Title	Groundwater connectivity between the CLA and the surface in the Eastern Beetaloo Sub-basin extension
GISERA Project Number	W.38
Start Date	01/05/2025
End Date	30/06/2026
Project Leader	Russell Crosbie

GISERA State/Territory

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

Basin(s)

- ☐ Adavale
- ☐ Amadeus
- ☒ **Beetaloo**
- ☐ Canning
- ☐ 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

Recent geological investigations in the central McArthur Basin have identified an eastern extension of the Beetaloo Sub-basin (Bruce and Garrad, 2021; Northern Territory Geological Survey and Geognostics Australia Pty Ltd, 2021). Investigations have highlighted the potential prospectivity of the marine shales of the Roper Group in the upper Beetaloo Sub-basin in this area for unconventional energy resources (Bruce and Garrad, 2021). However, adjacent to the eastern Beetaloo Sub-basin extension lies the boundary between the McArthur and Georgina basins, an area of geological complexity situated between the Mallapunyah and Batten fault zones which hosts numerous springs, waterholes and streams but is data sparse and poorly characterised.

Recent research such as the Strategic Regional Environmental and Baseline Assessment (SREBA) (Northern Territory Department of Environment Parks and Water Security Flora and Fauna Division, 2022), and the Geological and Bioregional Assessment (GBA) (Huddlestone-Holmes et al., 2021) programs, have provided new information to assist with water resource planning investment and management across the Beetaloo Sub-basin. However, this newly identified eastern extension of the Sub-basin was not entirely included in these research programs and the potential impacts on water resources and water dependent ecosystems from unconventional gas exploration and development in this area remains poorly understood.

The fault zones within the eastern extension host geological sequences that are folded, faulted and displaced and may host potential pathways for contaminants to leak into the overlying Cambrian Limestone Aquifer (CLA) hosted in the Georgina Basin. In addition, the boundary of the McArthur and Georgina basins coincide with numerous springs and waterholes amongst the headwaters of the Limmen Bight and McArthur rivers that are known to be ecologically and culturally important but are poorly characterised (Department of Environment Parks and Water Security, 2019; Northern Territory Geological Survey and Geognostics Australia Pty Ltd, 2021; Zaar, 2009). The previous work in the region has suggested that there is the potential for connectivity between the CLA and surface features, but the source aquifers of these springs and waterholes have not been previously investigated.

Collecting new baseline environmental data to better characterise groundwater flow processes governing inter aquifer-aquitard connectivity and groundwater–surface water connectivity in this area will provide new information to underpin future decision making on water and energy resource planning, investment and management. This includes information to guide water infrastructure planning and investment, and water management and regulation to ensure water availability to ecologically and culturally important water dependant ecosystems.

2. Project Description

Introduction

The Daly Roper Beetaloo Water Control District (DRBWCD) encompasses the major groundwater resource for the Northern Territory (NT), the regionally extensive CLA, which provides water for industry, communities and the environment across an area >400,000 km^2 (Department of Environment Parks and Water Security, 2019b; ELA, 2022). The CLA hosted in the interconnected Daly, Georgina and Wiso basins overlies the entire Beetaloo Sub-basin including the newly identified eastern extension of the Sub-basin prospective for unconventional energy resources. The eastern extension of the Beetaloo Sub-basin comprises 1103 km^2 of remote, sparsely populated pastoral country. The CLA is the major water supply for human consumption, agriculture and stock watering. Both the CLA and its unique ecologically and culturally important water dependant ecosystems have the potential to be impacted by exploration and development of unconventional energy resources. Characterising and conceptualising potential hydrogeological connectivity pathways for adversely affecting water quality and quantity in the CLA as well as water quality and water availability to its water dependant ecosystems is required to properly understand any potential impacts from an unconventional gas industry and put in place measures to mitigate those potential impacts.

Prior Research

The IESC (IESC, 2024) has recently given advice on unconventional gas exploration and appraisal activities in the Beetaloo Basin that was heavily based on the previous research from GBA and SREBA. This advice emphasised the importance of collecting adequate pre-development groundwater and surface water quality data, and local scale investigations of the connectivity from the surface to the gas bearing layers.

The GBA Program (Huddlestone-Holmes et al, 2021) assessed the potential environmental impacts of unconventional gas resource development in the Beetaloo Sub-basin to inform regulatory frameworks and appropriate management approaches. Most of the potential impacts that could occur are at the surface and can be mitigated by existing controls. The assessment found that groundwater is the most probable source of water for unconventional gas resource development and that aquifers in the region, such as the CLA, can supply this water without adverse regional impacts. However, the GBA program assessed the risks of unconventional gas development from the Beetaloo Sub-basin as it was defined at the time and the eastern extension was not considered.

The SREBA study (Northern Territory Department of Environment Parks and Water Security Flora and Fauna Division, 2022) included the eastern extension of the Beetaloo Sub-basin in their assessment but considered it to be part of the CLA discharging to the Roper River. The primary water resource management tool for the CLA is the DR2 model (Knapton, 2020); this model used a no flow boundary along this edge of the CLA and so forces the model to have a flow direction toward the Roper River.

The majority of the eastern extension of the Beetaloo Sub-basin lies within the Limmen Bight and McArthur river catchments flowing north and east, respectively. There are springs in the Upper McArthur River area with a carbonate signature and unknown source aquifer (Zaar, 2009):

> *"The upper McArthur River spring area warrants further investigation in terms of baseflow source. It may be completely sourced from a fractured and weathered carbonate aquifer or it could partly be sourced from the Gum Ridge Formation (Cambrian limestone) which hosts a fractured and karstic aquifer."*

The assessments conducted on the potential impacts of unconventional gas development have assumed a north-westerly groundwater flow direction to the Roper River and have not considered that there may be a northern or eastern component to the flow. Similar work to that proposed here has recently been undertaken on the western edge of CLA. This has demonstrated that not all flow in the Wiso Basin is toward the Flora River and that there is some local flow to the west feeding springs in the Victoria River catchment (Taylor et al., 2024). An environmental baseline assessment of springs in Hot Springs Valley, NT, showed a similar pattern in that some flow out of the region is to the NE rather than to the Roper River (GISERA, 2024).

The hydrostratigraphy of the Beetaloo Sub-basin, as currently understood, is shown in Figure 1 (Northern Territory Department of Environment Parks and Water Security Flora and Fauna Division (2022)). This shows that the main water supply for the region, the Gum Ridge Formation, is separated by aquitards from the overlying Cretaceous local-scale aquifer and the underlying Bukalara Sandstone intermediate- to regional-scale aquifer. Recent drilling has shown that the aquitards below the CLA are not present in the eastern Beetaloo Sub-basin extension leaving the CLA in direct connection with the underlying Bukalara Sandstone. There is uncertainty about the role that the Anthony Lagoon Formation leaky aquitard plays in separating the CLA from the overlying Cretaceous aquifer. In some areas it acts as a confining layer but, in other areas, the two layers of the CLA act as a single aquifer. The connection between these layers has not been established in the eastern Beetaloo Sub-basin extension. The gas resource is also considerably shallower in the eastern Beetaloo Sub-basin extension where the Carpentaria 5H well has 1336 m of vertical separation between the base of the CLA and the top of the primary gas target. The Tanumbirini 1 well has over 3000 m of separation in the eastern Beetaloo Sub-basin.

Era	Period	Group	Formations	Hydrogeologic relevance
Mesozoic	Cretaceous	*Ungrouped*	Unit A-C	Variably saturated local-scale aquifer
Palaeozoic	Cambrian	Daly River/Barkly	Jinduckin Formation	Intermediate-scale aquifer and leaky aquitard
			Anthony Lagoon Formation	
			Tindall Limestone	Regional-scale aquifer
			Montejinni Limestone	
			Gum Ridge Formation	
		Kalkarindji Igneous Province	Antrim Plateau Volcanics	Local-scale aquifer and aquitard
			Helen Springs Volcanics	
			Nutwood Downs Volcanics	
		Ungrouped	*Unnamed sandstone*	Local- to intermediate-scale aquifer
Neoproterozoic	Cryogenian	Kiana	Cox Formation	Aquitard
			Bukalara Sandstone	Intermediate- to regional-scale aquifer
Mesoproterozoic	Ectasian	Roper	Kyalla Formation	Aquitard
			Moroak Sandstone	Local- to intermediate-scale aquifer
			Velkerri Formation	Aquitard
			Bessie Creek Sandstone	Local- to intermediate-scale aquifer
			Corcoran Formation	Aquitard

Lithology key: Limestone | Dolomitic Sandstone/Siltstone | Sandstone | Shale | Igneous

Figure 1 Generalosed hydrostratigaphy of the Beetaloo sub-Basin (Northern Territory Department of Environment Parks and Water Security Flora and Fauna Division (2022)). The Jinduckin Formation, Anthony Lagoon Formation form the upper CLA and the Tindall Limestone, Montejinni Limestone and Gum Ridge Formations for the lower CLA. The CLA is a highly productive aquifer which provides water for industry, communities and the environment. Throughout most of the Beetaloo Sub-basin and the eastern extension there is over 1,000 m of separation between the CLA and the shales targeted for development.

Need & Scope

The source aquifers of springs in the Upper McArthur and Limmen Bight catchments have not yet been identified. The springs occur in many types of surface geology within this complex geological setting (Figure *2*). Some of the springs are located at the contact of the Carpentaria Basin or Georgina Basin and the older Roper Group (e.g. Paradise Pool Rockhole, Figure 3a), which may have a direct

connection to the water resources of the CLA. Other springs occur within the Roper Group (e.g. Cockatoo Spring) or at the contact of the Roper Group and McArthur and Balma Groups (e.g. Wee-ak, Figure 3b), and have unknown potential for connection to the gas resource. The geographical scope of the proposed project is a 25 km buffer around the eastern extension of the Beetaloo Sub-basin (grey dashed line in Figure 2). This buffer incorporates the closest 10 mapped springs to the gas resource in the Limmen Bight and McArthur catchments.

Elsewhere in the Beetaloo Sub-basin, the aquifers of the Carpentaria Basin, CLA and Roper Group are separated by aquitards. In the eastern extension, these aquitards are absent and therefore new research is required to determine whether mixing of these water sources does occur and whether this needs to be considered further if the unconventional gas industry is developed in this region.

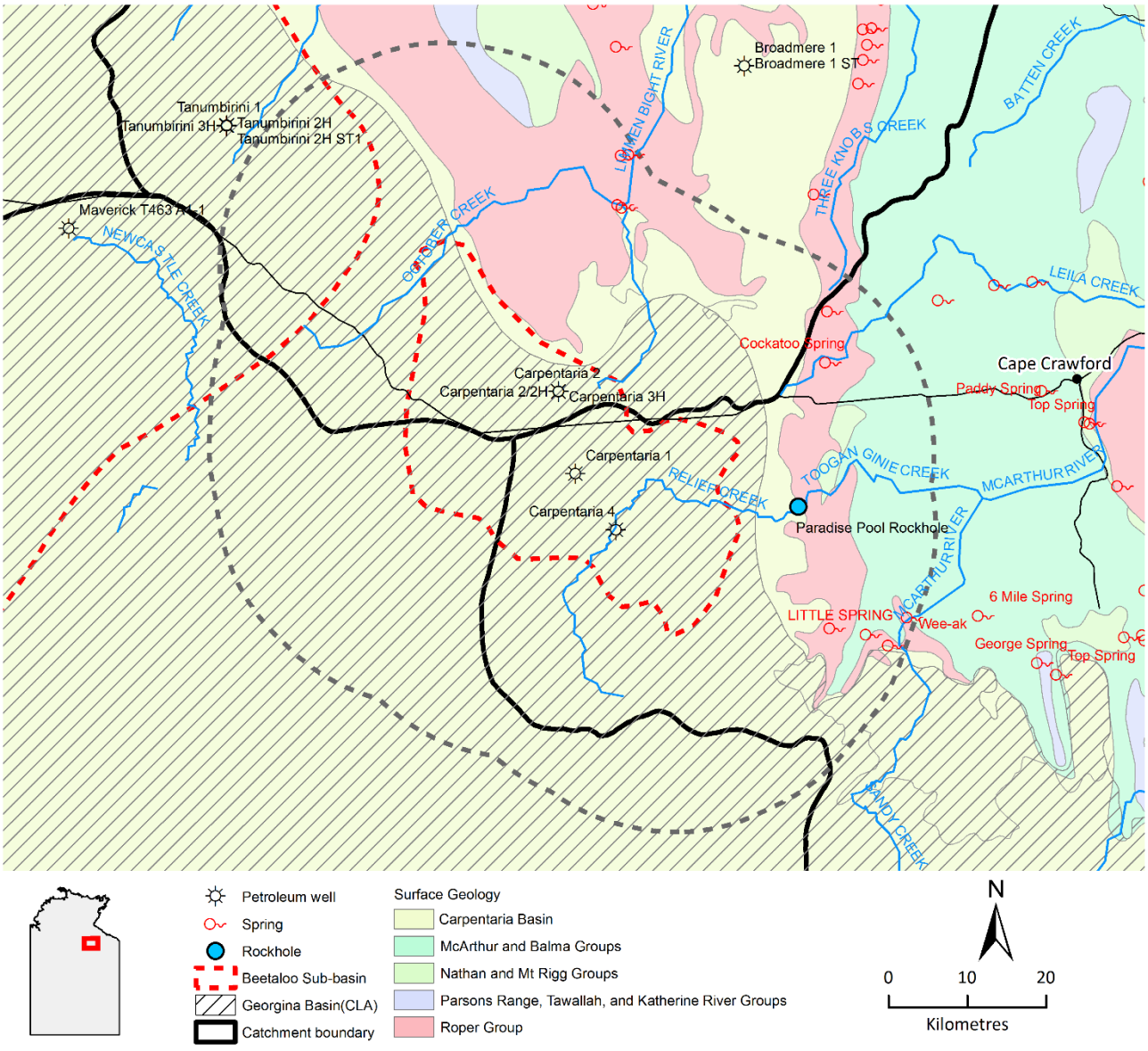

Figure 2 Location of the eastern extension of the Beetaloo Sub-basin and its geological context

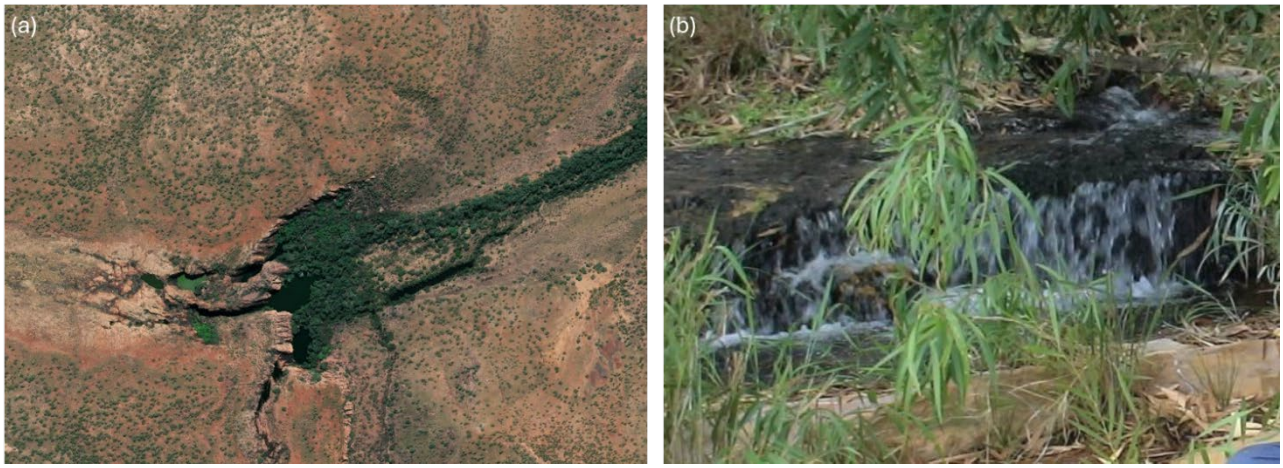

Figure 3 Examples of the springs of the region, (a) Paradise Pool Rockhole, (b) Wee-ak Spring [photo from Zaar (2009)]

Zaar (2009) interviewed many of the traditional owners of the springs and waterholes throughout the region, documenting the stories and the cultural importance that the springs hold. The risks that the unconventional gas industry poses to these springs and waterholes can only be properly assessed with a conceptual understanding of their source of water. If there is a connection from the Carpentaria or Georgina Basin to the springs, then drawdown due to extraction from the CLA as a water supply for the unconventional gas industry, and/or agriculture, could decrease spring flow. Similarly, the complex faulting history of the area could (however unlikely) provide a connection between the gas resource and the springs that could be activated by hydraulic stimulation. The conceptual model and data collected during this project will allow the characteristics of these possible pathways for connectivity to be assessed. Furthermore, similar to an on-going assessment and characterisation of source aquifers at Hot Spring Valley in the eastern Beetaloo Sub-basin (GISERA, 2024), the collection of baseline environmental data will provide an important evidence base for protection and management of this environmentally and culturally significant area. These data are required to not only extend the existing knowledge of these environmentally and culturally significant springs but to also provide a baseline prior to any potential development of gas resources in this area.

In the eastern extension of the Beetaloo Sub-basin, the Antrim Plateau Volcanics (APV) are absent leaving the CLA in direct hydraulic connection with the Bukalara Sandstone beneath (Tickell, 2022). There are few bores intersecting the Bukalara Sandstone and so little is known about its flow characteristics. If this is to be used as an alternate water supply for the unconventional gas industry, then the impacts of groundwater extraction upon the CLA and possible discharge points need to be assessed.

The gas resource is shallower in the eastern extension of the Beetaloo Sub-basin than the rest of the Beetaloo Sub-basin (Bruce and Garrad, 2021), which decreases the separation between the CLA and the gas resource. The absence of the APV also removes a key confining layer (Tickell, 2022). The assessments made of aquitard integrity and well integrity during GBA largely relied on the separation

distance between the gas resource and the CLA. These assessments need to be reviewed to determine if the different conditions in the eastern extension of the Beetaloo Sub-basin represent any greater risk of the unconventional gas industry causing an increase in the hydraulic connections between the gas resource and the CLA leading to an increased risk of contamination or not.

The Georgina Wiso Water Allocation Plan (Northern Territory Government, 2023) makes the assumption that all water north of the Alexandria - Wonarah basement high flows to the north-west to discharge to the Roper River and that the CLA is isolated from the layers below by the APV. These assumptions are reasonable at the regional scale of the Georgina Basin but may not be accurate at the local scale of the eastern Beetaloo Sub-basin extension. The risks to water related assets from unconventional gas developments that have been assessed by GBA, SREBA and IESC are based on these same assumptions. If the assumptions are not accurate then the risk profile for the eastern Sub-basin extension may need to be reconsidered.

Objectives

The objective of this proposal is to investigate potential connections between the gas targets hosted within the eastern extension of the Beetaloo Sub-basin, the CLA (and its sub-units) and to the surface. This will involve:

- Development of an initial conceptual hydrogeological model of the aquifer systems and potential pathways to the surface through integration of multiple lines of evidence (e.g. geological, hydrogeological, hydrochemical and geophysical data).

- A field campaign will be conducted to demonstrate and refine this conceptual hydrogeological model, and to collect baseline hydrochemistry and isotope data from selected springs, groundwater bores and water holes prior to any potential development of gas resources.

- Identification and discussion of the potential impacts caused by the development of unconventional gas resources on the water resources of the region, based on the refined conceptual hydrogeological model.

Methodology

Task 1 – Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension

This task will review all existing information to develop a conceptual understanding of the groundwater flow within the eastern Beetaloo Sub-basin extension. This will involve building a 3D geological model and/or cross-sections from existing spatial geological mapping and point geological logs from petroleum wells, exploration drill holes and groundwater bores to investigate the potential

for hydraulic connection between the different layers. In particular, the connection between the Carpentaria Basin sediments, the CLA (and sub-units Gum Ridge Formation and Anthony Lagoon Formation), the Bukalara Sandstone and other formations in the Proterozoic aged Roper Group that outcrop to the east of the Gum Ridge Formation in the study area.

The connection between the Anthony Lagoon and Gum Ridge formations will be a focus of the conceptual understanding part of this task. Point source information from drill logs will be collated and combined with an analysis of the linear AusAEM (https://www.eftf.ga.gov.au/ausaem) data to produce a new understanding of the architecture of these layers in relation to aquifers and aquitards (and those above and below in the Carpentaria Basin and Bukalara Sandstone). The architecture defines the potential for connection. Actual hydraulic connection between different layers will be assessed through groundwater levels and hydrochemistry differences from bores screened in different layers. The water level and chemistry data collected by the petroleum interest holder from their monitoring bores developed will be a key dataset for this work.

Elsewhere within the CLA it has been shown that sinkholes and waterholes can be preferential recharge pathways from the surface to the underlying CLA (Bruwer and Tickell, 2015; Deslandes et al., 2019; Taylor et al., 2023; Yin Foo and Matthews, 2001). Conversely, impediments to recharge have been shown where the thickness of the Cenozoic cover is greater than 30 m (ELA, 2022). The geological model created within this task will be used to inform an investigation of recharge processes and develop a conceptual understanding of flow from the surface to the CLA.

The groundwater flow directions will be evaluated using a water table map. The water table map will be developed using existing water level data from monitoring bores and water level data in water bore reports for existing stock and domestic bores in the region. This will have a regional focus, greater than the extent of the Beetaloo Sub-basin extension, to include bores in the Limmen Bight and McArthur river catchments to identify if a groundwater flow divide exists within the eastern Beetaloo Sub-basin extension or if all flow is toward the Roper River as currently assumed. If sufficient data exists, this task will also look at the vertical gradients between aquifers to ascertain flow directions.

A modelled watertable map will be used to investigate groundwater discharge processes. If a groundwater divide exists within the eastern Beetaloo Sub-basin extension, then there is some component of the flow that could discharge to the springs in the Limmen Bight and McArthur river catchments. Springs will be identified from existing literature and an analysis of remotely sensed actual evapotranspiration data from CMRSET. Watertable mapping, geological modelling and any existing water quality measurements will be used to develop a conceptual hydrogeological understanding of the discharge processes that can be tested through a targeted field campaign.

The initial conceptual model developed using existing information will be revised using the results of the fieldwork (Task 2).

Task 2 – Fieldwork

A field campaign will be conducted to test the conceptual model of groundwater flow developed in task 1 above. This will consist of two parts: (i) sampling of groundwater bores near existing gas wells, as well as other groundwater bores near the springs (assuming permission from landholders and Traditional Owners can be obtained, and the bores are operational); and, (ii) sampling of surface water from spring discharge and waterholes in the Limmen Bight and McArthur river catchments (similar to above, assuming permission from landholders and Traditional Owners can be obtained). The springs and waterholes to be sampled will be determined from the initial work in Task 1 after gaining a conceptual understanding of potential groundwater flow pathways away from the Eastern Beetaloo Sub-Basin extension.

As part of preparation for the fieldwork a priority will be negotiating access to bores, springs and waterholes to take water samples. Many of the springs and waterholes are on Aboriginal land. The lessons learnt through the Environmental baseline characterisation of the springs in Hot Springs Valley project will help enable access within the tight timeframes of this project. Access to field sites is a key risk for the project, early engagement with Traditional Owners (through the NLC) will be important to ensure access issues are resolved to carry out field campaign as per schedule.

The bores and springs will be sampled for major and minor ion chemistry, and a range of environmental tracers including dissolved gases and isotopes (e.g. methane, stable noble gases, selected age tracers and strontium and stable isotopes). These tracers will enable us to determine if the springs and waterholes contain water that has been in contact with gas target formations, differentiate whether the source of the springs is a shallow or deep aquifer (or a mix between different aquifers) and lead to a possible revision of the initial conceptual model developed in Task 1. It will also provide a comprehensive baseline prior to any potential development of gas resources in this region. The field campaign and sample analyses will take up a significant component of the resources for this project due to the remote location.

Task 3 – Potential impacts from gas industry on water resources

The revised conceptual hydrogeological model developed from Tasks 1 and 2 will be used to determine potential impacts from the development of unconventional gas resources in the eastern Beetaloo Sub-basin extension. This will be an update based on the methods used in GBA with the updated conceptual model for the eastern Beetaloo Sub-basin extension. This will involve looking at surface spills, well and aquitard integrity and drawdown propagation.

In the sub-surface there were several potential hydrogeological connections between unconventional gas reservoirs and aquifers, such as through well casing failure, geological faults, direct stratigraphic contacts and diffuse solute transport through low permeability units that were considered during the GBA project. These connections will be revisited for the specific geological conditions encountered in the eastern Beetaloo Sub-basin extension than those used during GBA for the areas they considered.

This will also consider the isolation of sub-units of the CLA (Gum Ridge Formation and Anthony Lagoon Formation).

The surface sources of possible contamination to the aquifers or surface waters are through accidental releases to the environment of chemicals in liquid or solid state. The calculations of surface spills reaching the water table conducted in GBA will be re-evaluated for the different conditions encountered in the eastern Beetaloo Sub-basin extension than those encountered during the GBA project.

Drawdown can be estimated from analytical equations where the drawdown is dependent upon the aquifer properties, pumping rate and distance to the point of interest. The CLA aquifer geometries are different in the eastern Beetaloo Sub-basin extension than modelled during the GBA project so different outcomes would be expected for drawdown in the CLA. Drawdown in the Bukalara Sandstone was not modelled during GBA, as it was not considered a viable water resource in the areas considered, but it could be an alternate water source to the CLA in the eastern extension.

Task 4 – Project reporting

The project reporting will be a single report at the conclusion of the project documenting the findings from Tasks 1, 2 & 3 above.

Task 5 - Communicate project objectives, progress and findings to stakeholders

CSIRO's GISERA considers the communication of research an essential component of all research projects. The dissemination of project objectives, key findings and deliverables to relevant and diverse audiences helps to raise awareness, enable understanding, and thus allow discourse and decision making within and across multiple stakeholder groups.

Communicating the intent of this research project and its findings to community stakeholders has been identified as highly important for the success of this project. The project team will leverage the resources and local connections of the GISERA communications team throughout the lifecycle of the project to ensure that appropriate communication materials are developed and stakeholder engagement takes place.

3. Project Inputs

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Russell Crosbie	50 days	Groundwater hydrology	20+	CSIRO
Andrew Taylor	40 days	Hydrogeology, hydrochemisty	20+	CSIRO
Matthias Raiber	40 days	Geology, hydrochemisty	20+	CSIRO
Karen Barry	45 days	Fieldwork	30+	CSIRO
Paula Campos Teixeira Travalloni	45 days	Groundwater hydrology	5+	CSIRO

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

- Regulators: *Petroleum Operations, Department of Mining and Energy; Petroleum Regulation, Department of Lands, Planning and Environment; Water Resources Division, Department of Lands, Planning and Environment.*
- Company representatives: *Santos. Tamboran and Empire Energy*
- Technical expertise (from CSIRO, other research institutions, industry, consultants)
- Indigenous groups: *Northern Land Council*

Budget Summary

Source of Cash Contributions	2024/25	2025/26	2026/27	% of Contribution	Total
GISERA	$40,458	$349,086	$0	80%	$389,543
- NT Government	$15,172	$130,907	$0	30%	$146,079
- Santos	$15,172	$130,907	$0	30%	$146,079
- Tamboran	$7,586	$65,454	$0	15%	$73,039
- Empire	$2,529	$21,818	$0	5%	$24,346
Total Cash Contributions	**$40,458**	**$349,086**	**$0**	**80%**	**$389,543**

Source of In-Kind Contribution	2024/25	2025/26	2026/27	% of Contribution	Total
CSIRO	$10,114	$87,271	$0	20%	$97,386
Total In-Kind Contribution	**$10,114**	**$87,271**	**$0**	**20%**	**$97,386**

TOTAL PROJECT BUDGET	2024/25	2025/26	2026/27	-	TOTAL
All contributions	**$50,572**	**$436,357**	**$0**	**-**	**$486,929**
TOTAL PROJECT BUDGET	**$50,572**	**$436,357**	**$0**	**-**	**$486,929**

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 the GISERA website to ensure transparency for all stakeholders including regional communities.	Ongoing
		Public release of final report. Plain English fact sheet summarising the outcomes of the research.	At project completion
		Preparation of an article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.	At project completion
		Presentation of research findings to regional community stakeholders such as business and/or community groups (e.g., NLC) (virtual or face-to-face) to learn of research results	At completion or within 6 months of completion of the project.
Gas Industry & Government	To communicate the objectives and outcomes 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 Plain-English fact sheet summarizing the outcomes of the research.	At project completion
		Presentation of findings at joint gas industry/government Knowledge Transfer Session.	At project completion
Scientific Community	Provide scientific insight into groundwater flows in the vicinity of the eastern Beetaloo Sub-basin extension	Peer-reviewed scientific publication. Dataset(s) available through CSIRO's data repository.	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, presentations, attendance at regional shows, newsletters and development of other communication products where relevant.

5. Project Impact Pathway

Activities	Outputs	Short term Outcomes	Long term outcomes	Impact
Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension	Hydrogeological conceptual model of the groundwater flow in the region surrounding the eastern Beetaloo Sub-basin extension	An improved knowledge of the groundwater flow in the study area and the source water of the springs and waterholes	A greater understanding of the groundwater flow patterns and sources of water to the springs and waterholes will allow more effective management of the potential impacts of unconventional gas development.	The impact of this research will enable the protection of the environmental, cultural and economic values associated with the CLA, springs and waterholes.
Fieldwork	Interpretation of hydrochemical and tracer data sets to identify source aquifers for discharge to springs and waterholes			
Potential impacts from gas industry on water resources	An update of the analyses conducted during GBA for the eastern Beetaloo Sub-basin extension	An improved knowledge of the potential impacts of gas development in the region		
Project reporting	Project final report	Knowledge and data available about the source of water to springs and waterholes		
Communicate project objectives, progress and findings to stakeholders	Knowledge transfer session with industry and government	Knowledge and data available about the source of water to springs and waterholes		

6. Project Plan

Project Schedule

ID	Activities / Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension	Russell Crosbie	1 May 2025	30 June 2026	
Task 2	Fieldwork	Russell Crosbie	1 July 2025	31 December 2025	Task 1
Task 3	Potential impacts from gas industry on water resources	Russell Crosbie	1 March 2026	30 April 2026	Task 1
Task 4	Project reporting	Russell Crosbie	1 January 2026	30 June 2026	Task 1, 2 & 3
Task 5	Communicate project objectives, progress and findings to stakeholders	Russell Crosbie	Full duration of project		

Task description

Task 1: Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension

OVERALL TIMEFRAME: 14 months (May 2025 – June 2026)

BACKGROUND: The current conceptual model of groundwater flow in the CLA in this region is that all groundwater flows toward the Roper River, despite the eastern Beetaloo Sub-basin being predominantly in the Limmen Bight and McArthur River catchments. Zaar (2009) speculated that some springs in the Upper McArthur catchment could be sourced from the CLA as they have a carbonate signature.

TASK OBJECTIVES:

- Determine the flow direction of the groundwater within the region of the eastern Beetaloo Sub-basin extension
- Determine if the potential exists for any flow from the CLA to discharge to springs and waterholes in the Limmen Bight and McArthur catchments
- Investigate the potential for vertical mixing of groundwaters from the Carpentaria Basin, CLA and Bukalara Sandstones

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- Collation of existing datasets
- Initial hydrogeological conceptual model of the groundwater flow in the region surrounding the eastern Beetaloo Sub-basin extension
- Refined conceptual model (to be updated iteratively throughout the project through incorporation of the findings from the fieldwork (Task 2))

Task 2: Fieldwork

OVERALL TIMEFRAME: 6 months (July 2025 – December 2025)

BACKGROUND: The source waters of the springs and waterholes in the Upper Limmen Bight and McArthur catchments are currently unknown. Task 1 will use existing information to determine if there is the possibility of those springs being sourced from the CLA and this task will provide new information from fieldwork to prove or disprove the conceptual model developed in Task 1. A key step at the commencement of Task 2 will be negotiating access to field sites with relevant landholders. This will include owners of bores and traditional owners of springs and waterholes (many of which are on Aboriginal land).

TASK OBJECTIVES:

- Obtain permission to access field sites
- Sample a range of bores to get end-member hydrochemical signatures from Carpentaria, CLA, Bukalara and Roper Group groundwaters
- Sample multiple springs and waterholes with potential to source their water from key groundwater systems (budget will allow for up to about 10 sites to be sampled)
- Analyse water samples to determine the source waters of the springs and waterholes

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- Permission to access field sites
- Samples collected from a range of groundwater bores, springs and waterholes to be analysed by commercial laboratories
- Interpretation of hydrochemical and environmental tracer data sets to identify source aquifers for discharge to springs and waterholes

Task 3: Potential impacts from gas industry on water resources

OVERALL TIMEFRAME: 2 months (March 2026 – April 2026)

BACKGROUND: The analysis of potential impacts from the unconventional gas industry on water resources undertaken during the GBA project did not incorporate the eastern Beetaloo Sub-basin extension and some of the assumptions made may not be applicable in the study region. These analyses will be revisited with the updated conceptual model from Task 1.

TASK OBJECTIVES:

- Investigate the potential for drawdown to propagate to the springs and waterholes from extraction in the CLA or Bukalara Sandstone as a water supply for the unconventional gas industry
- Investigate the potential for surface spills to contaminate the CLA
- Investigate the potential for aquitard or well integrity failures to contaminate the CLA

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- An update of the analyses conducted during GBA for the eastern Beetaloo Sub-basin extension

Task 4: Project Reporting

OVERALL TIMEFRAME: 6 months (January 2026 – June 2026)

BACKGROUND: Information from this project is to be made publicly available after completion of standard CSIRO publication and review processes.

TASK OBJECTIVES: To ensure that the information generated by this project is documented and published after thorough CSIRO internal review.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

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

2) Following CSIRO ePublish review, the report will be submitted to the GISERA Director for final approval; and

3) Provide 6 monthly progress updates to GISERA office.

Task 5: Communicate project objectives, progress and findings to stakeholders

OVERALL TIMEFRAME: Full duration of project

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, presentations, Knowledge Transfer Session, fact sheets, project reports and journal article/s, in collaboration with the GISERA Communication Team.

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

1) Knowledge Transfer Session with relevant government/gas industry representatives.

2) Presentation of findings to community stakeholders such as business and/or community groups (virtual or face-to-face) to learn of research results.

3) Preparation of an article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.

4) 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.

5) Peer-reviewed scientific manuscript ready for submission to relevant journal

Project Gantt Chart

Task	Task description	2024-25		2025-26											
		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.	Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension														
2.	Fieldwork														
3.	Potential impacts from gas industry on water resources														
4.	Project reporting														
5.	Communicate project objectives, progress and findings to stakeholders														

7. Budget Summary

Expenditure	2024/25	2025/26	2026/27	Total
Labour	$50,572	$336,357	$0	$386,929
Operating	$0	$100,000	$0	$100,000
Subcontractors	$0	$0	$0	$0
Total Expenditure	**$50,572**	**$436,357**	**$0**	**$486,929**

Expenditure per task	2024/25	2025/26	2026/27	Total
Task 1	$40,728	$127,203	$0	$167,931
Task 2	$0	$153,927	$0	$153,927
Task 3	$0	$60,975	$0	$60,975
Task 4	$0	$84,090	$0	$84,090
Task 5	$9,844	$10,162	$0	$20,006
Total Expenditure	**$50,572**	**$436,357**	**$0**	**$486,929**

Source of Cash Contributions	2024/25	2025/26	2026/27	Total
NT Govt (30%)	$15,172	$130,907	$0	$146,079
Santos (30%)	$15,172	$130,907	$0	$146,079
Tamboran (15%)	$7,586	$65,454	$0	$73,039
Empire (5%)	$2,529	$21,818	$0	$24,346
Total Cash Contributions	**$40,458**	**$349,086**	**$0**	**$389,543**

In-Kind Contributions	2024/25	2025/26	2026/27	Total
CSIRO (20%)	$10,114	$87,271	$0	$97,386
Total In-Kind Contributions	**$10,114**	**$87,271**	**$0**	**$97,386**

	Total funding over all years	Percentage of Total Budget
NT Government investment	$146,079	30%
Santos investment	$146,079	30%
Tamboran investment	$73,039	15%
Empire investment	$24,346	5%
CSIRO investment	$97,386	20%
Total Expenditure	**$486,929**	**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	Development of conceptual hydrogeological model of CLA over the Eastern Beetaloo Sub-basin extension	GISERA	May-25	Jun-26	2024/25	$134,345
Task 2	2.1	Fieldwork	GISERA	Jul-25	Dec-25	2024/25	$123,142
Task 3	3.1	Potential impacts from gas industry on water resources	GISERA	Mar-26	Apr-26	2025/26	$48,780
Task 4	4.1	Project reporting	GISERA	Jan-26	Jun-26	2025/26	$67,272
Task 5	5.1	Communicate project objectives, progress and findings to stakeholders	GISERA	May-25	Jun-26	2025/26	$16,005

8. 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 13.1)	**Party**	**Commercialisation Interest**		
	CSIRO	N/A		
	Santos	N/A		
	Tamboran	N/A		
	Empire	N/A		

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