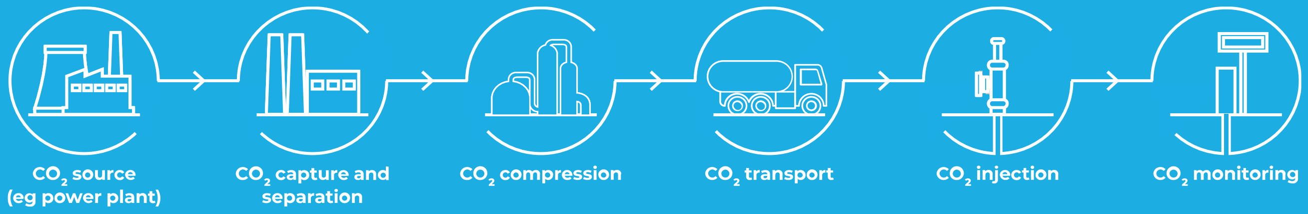
CTSCo
Carbon Transport & Storage

A GLENCORE Company



Surat Basin Carbon Capture and Storage Project

APPENDIX 9A: GROUNDWATER IMPACT ASSESSMENT TECHNICAL REPORT

REPORT

Surat Basin Carbon Capture and Storage (CCS) Project

Groundwater Impact Assessment Technical Report

Submitted to:

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28 September 2022

Distribution List

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1.0 INTRODUCTION

1.1 Background and purpose

Carbon Transport and Storage Corporation (CTSCo) Pty Limited is a wholly owned indirect subsidiary in Australia of Glencore Holdings Pty Limited (ABN 41 104 160 689), itself being a wholly owned subsidiary of Glencore plc. Glencore plc's headquarters are in Baar, Switzerland, and it is one of the world's largest diversified natural resource companies. Glencore has a significant presence in Australia through its coal, cobalt, copper, lead, nickel, zinc and agricultural businesses, with 25 active mining operations.

CTSCo was granted the greenhouse gas (GHG) Exploration Permit 10 (EPQ10) on the 9 December 2019, to explore the potential for GHG storage. EPQ10 is 1,200 sub-blocks (approximately 3,664 km^2). The existing environmental authority (EA EPPG00646913) for EPQ10 permits exploration and appraisal drilling within the tenement, but does not currently authorise the injection of a GHG stream.

The Department of Environment and Science (DES) has directed CTSCo to undertake an Environmental Impact Statement (EIS) for its Surat Basin Carbon Capture and Storage (CCS) Project (the Project) in the EPQ10. This being to authorise a three-year test injection of a GHG stream (comprising CO_2 and associated impurities SO_2, NO_2, and O_2). CTSCo is proposing to inject up to 330,000 tonnes (t) over a three-year period (110,000 tonnes per year (t/year)) into the Precipice Sandstone reservoir at an overburden depth of approximately 2.3 km.

CTSCo engaged WSP and Golder Associates Pty Ltd (WSP Golder) to complete a Groundwater Impact Assessment (GIA) for the Project's EIS. This GIA report has been prepared according to the requirements of the Project's Terms of Reference (ToR) for the EIS.

Key matters addressed in this GIA include, but are not limited to, the description of existing conditions, potential impacts and mitigation measures, particularly associated with:

- Groundwater quality
- Groundwater pressure
- Groundwater resources
- Cumulative impacts
- Containment of GHG stream.

1.2 Site overview

The injection site for the Project is located within EPQ10 (Figure 1), which is 44 km west of the Moonie township. The injection site was selected as it is in proximity to the deepest part of the Surat Basin and in a location where the Precipice Sandstone's *in situ* water quality is understood to be of poorer quality due to stagnant flow conditions in the reservoir. After years of research and baseline studies, CTSCo identified that the southern part of the basin would be more favourable for GHG stream injection into the Precipice Sandstone, provided that the Precipice Sandstone had suitable properties including adequate porosity and permeability at these deeper overburden depths for GHG stream injection and permanent storage. This GIA will present the supporting data to justify the suitability of the EPQ10 site for GHG stream test injection and assess any potential impacts to Environmental Values (EVs) as a result of the Project.

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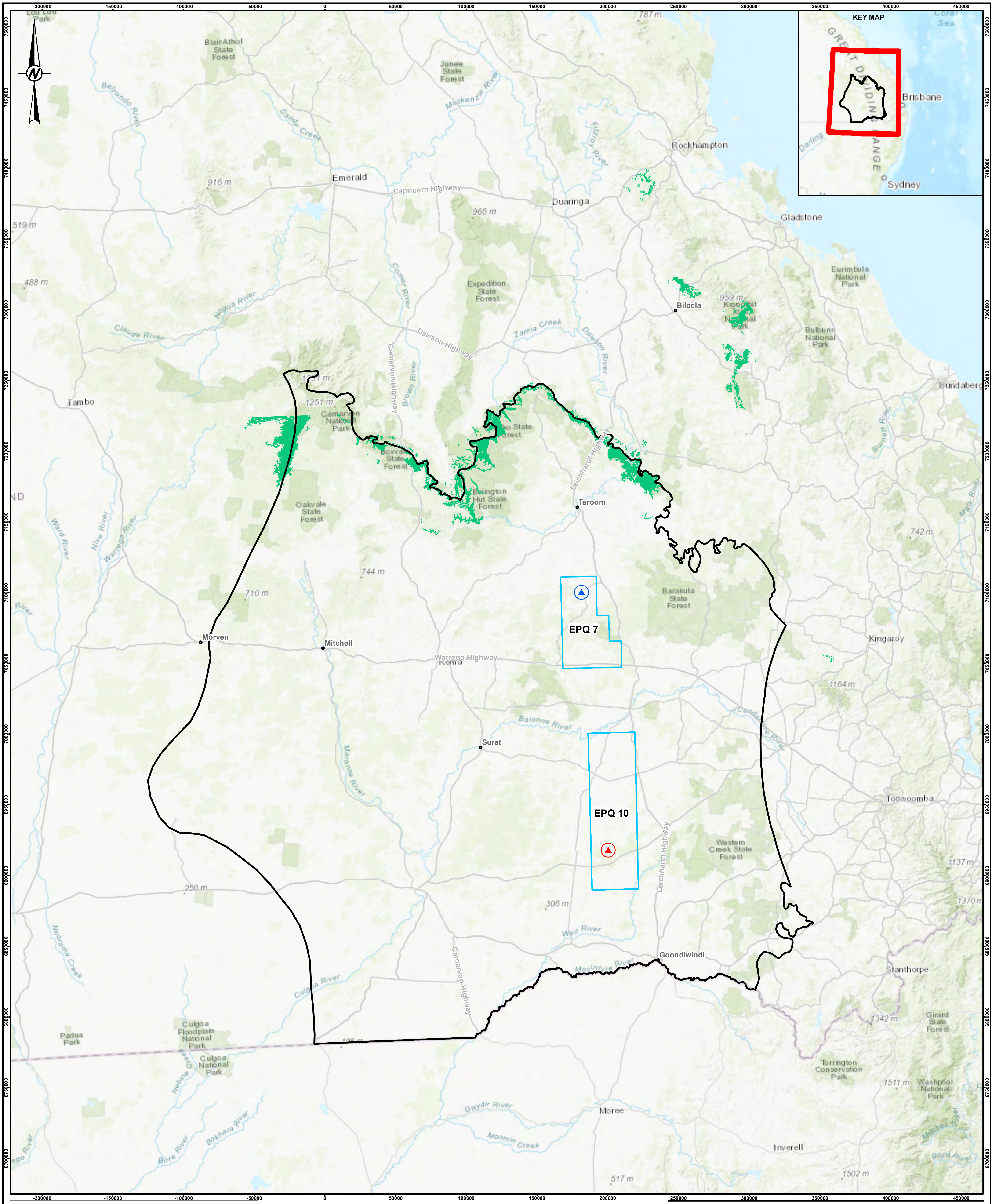

LEGEND

🔺 West Moonie-1

🔺 West Wandoan-1

☐ Surat Basin (Queensland extent)

☐ EPQ 7 and EPQ 10

🟩 Precipice Outcrop

0 80 160

1:2,500,000 @A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1.SPRINGS: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. EXPLORATION PERMITS FOR GREENHOUSE GAS & GEOLOGY SHAPEFILES: © STATE OF QUEENSLAND (DEPARTMENT OF RESOURCES) 2021
3. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP,

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

TITLE
SITE OVERVIEW

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	DW
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

PROJECT NO.	CONTROL	REV.	FIGURE
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2.0 METHODOLOGY OF ASSESSMENT

2.1 Legislation, policies and guidelines

Commonwealth and Queensland legislation need to be considered in terms of both gaining necessary approvals and undertaking an impact assessment for the test injection of a GHG stream into the Precipice Sandstone aquifer at West Moonie-1 Injection Well. A discussion of the legislation and how it relates to the Project is provided below.

2.1.1 Commonwealth legislation

2.1.1.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of Agriculture, Water and the Environment (DAWE) and protects Matters of National Environmental Significance (MNES), which are defined as:

- World Heritage
- National Heritage
- Wetlands of international importance
- Listed threatened species and communities
- Listed migratory species
- Protection of the environment from nuclear actions
- Commonwealth marine environments
- A water resource, in relation to coal seam gas development and large coal mining development.

Under the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES require approval from the DAWE and the relevant Minister. If it is determined that the proposed action will impact a MNES, then the action is declared a ‘controlled action’ and must go through an assessment and approval process. The nature, intensity and complexity of those impacts will determine the applicable level of assessment required by the Commonwealth.

CTSCo referred the Project under the EPBC Act to the Australian Government. On 9 February 2022, the authorised person of the Australian Government gave notice of their decision that the Project is not a controlled action under the EPBC Act, s. 75 (reference EPBC 2021/9122).

2.1.2 State legislation

2.1.2.1 Greenhouse Gas Storage Act 2009

As defined by s.3 of the *Greenhouse Gas Storage Act 2009* (GHG Act), the main purpose of the Act is to help reduce the impact of GHG emissions on the environment. This is achieved through facilitating the process called GHG storage through:

- Granting authority (called ‘GHG authorities’) to explore or use underground geological formations or structures to store carbon dioxide, or to carry out related activities; and
- Creating a regulatory system for carrying out activities relating to GHG authorities.

Other purposes are to ensure these activities:

- Minimise conflict with other land uses

- Allow constructive consultation with people affected by the activities
- Offer appropriate compensation for owners or occupiers adversely affected by the activities
- Follow responsible land and resource management.

The Act defines *GHG storage exploration* as carrying out an activity for the purposes of finding GHG stream storage sites. It also defines *GHG storage injection testing* as the evaluation or testing of an underground geological formation or structure for GHG storage by injecting carbon dioxide or water into it.

Under the GHG Act, CTSCo was granted EPQ10, effective from 9 December 2019, which authorises test injection of a GHG stream and associated activities. Prior to commencement of the Project, approval by the administering authority of an Injection Test Plan (ITP) and a Monitoring and Verification Plan (MVP) will be sought under the Act.

2.1.2.2 Environmental Protection Act 1994

The *Environmental Protection Act 1994* (EP Act) s.3 states that the objective of the Act is to protect Queensland's environment while allowing for developments that improve total quality of life, both now and in the future. This is to be done in a way that maintains the ecological processes on which life depends (ecologically sustainable development).

Under the EP Act, a proponent wishing to carry out an environmentally relevant activity (ERA) requires an EA. Activities under EPQ10 are subject to EA EPPG00646913 which authorises the drilling of GHG appraisal wells, water production, and geophysical surveys. However, the EA does not authorise the carrying out of GHG stream injection tests. Therefore, to proceed with the Project and undertake a GHG stream test injection, an amended EA requiring an EIS is needed.

The ToR for the Project and under the requirements for a site-specific resource activity EA, the GIA must address the requirements of section 126A of the EP Act. However, as the Project does not intend to extract groundwater, s.126A which relates to the exercising of underground water rights, does not apply to the Project.

The groundwater-related items from the ToR for the Project's EIS are outlined in Table 1 with references to where in this GIA each item is addressed.

Table 1: Groundwater-related items from the ToR

Terms of Reference	Report Reference
8. The Environmental Impact Assessment Process	
8.1 Environmental Values*	
For the purposes of the EIS process, 'environment' is defined in section 8 of the EP Act.	
Identify and describe the values that must be protected for all relevant matters including: EVs specified in the EP Act, the Environmental Protection Regulation 2019 (e.g., environmental objectives and performance outcomes as defined in schedule 8), environmental protection policies and associated guidelines Values under other State legislation, policies and guidelines, including the Vegetation Management Act 1999, the Nature Conservation Act 1992 and the Regional Planning Interests Act 2014 Values identified in the project specific matters in section 9.	Section 4

Terms of Reference	Report Reference
Consider all available baseline information relevant to the environmental risks of the proposed project, including seasonal and long-term variations. Describe the quality of all information, in particular the source of the information, how recent the information is, the reliability of the information that was tested, and any assumptions and uncertainties in the information.	Section 4
8.2 Impact Assessment*	
Assess the impacts of the proposed project on EVs.	Section 6
This includes demonstrating that the proposed project meets the environmental objectives and outcomes for each matter in section 9 and the environmental objectives and performance outcomes for any matters listed in Schedule 8 of the Environmental Protection Regulation.	Section 2.1.2.3 - Table 2 Section 8.1.6
8.3 Cumulative impacts*	
Assess the cumulative impacts of the proposed project on EVs. Every effort must be made to find information from all sources relevant to the assessment of cumulative impacts including other major projects or developments of which the proponent is reasonably aware. The EIS must outline ways in which the cumulative impact assessment and management could subsequently be progressed further on a collective basis.	Section 8.1.8
8.4 Avoidance and Mitigation*	
Propose and describe avoidance, mitigation and management strategies for the protection or enhancement of identified EVs.	Section 7
9.0 Project Specific Matters	
9.4.1 Water Quality - a Critical Matter – Impact Assessment	
Environmental objective and outcomes	
The activity will be operated in a way that protects EVs of waters. The activity will be operated in a way that protects the EVs of groundwater and any associated surface ecological systems. The activity will be managed in a way that prevents or minimises adverse effects on wetlands.	EIS – Project Description
Impact Assessment	
Conduct the impact assessment in accordance with the department's Water—EIS information guideline (ESR/2020/5312), Applications for activities with impacts to water (ESR/2015/1837), Water quality guidelines (Queensland Government, 2020), Monitoring and sampling manual (DES 2018), and the Groundwater quality assessment guideline (DSITI 2017). Demonstrate that the proposed project can meet the environmental objectives and performance outcomes in Schedule 8 of the Environmental Protection Regulation.	Section 2

Terms of Reference	Report Reference
With reference to the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 and section 9 the EP Act, identify the EVs of surface waters and groundwaters within the proposed project area and immediately downstream or downgradient (or influenced by the zone of potential water quality of impacts) that may be affected by the proposed project, including any human uses and cultural values of water.	Section 4.5
Define the relevant water quality objectives (WQOs) applicable to the EVs and demonstrate how these will be met by the proposed project during construction, operation, decommissioning and following proposed project completion. Where WQOs are not available, local WQOs must be derived according to the department's latest WQOs (Queensland Government, 2020) and include any semi-permanent or permanent streams and pools, relevant groundwater aquifers, and including stock water and domestic use. Present a baseline assessment for water quality in the local aquifers of relevance to the project, including but not limited to: cations; anions; dissolved and total metals and metalloids; pH; salinity (electrical conductivity (EC)); PAHs; BTEX; organics; petroleum; hydrocarbons; noble gases; and redox potential.	Section 4.5 and 4.4
Detail the chemical, physical and biological characteristics of groundwater within the area that may be affected by the proposed project and at suitable reference locations using sufficient data to define natural variation, including seasonal variation.	Sections 4.2.3 and 4.3.3
Describe the quantity, quality, location, duration, timing and environmental fate processes (chemical reactions, partitioning, hazard, chemical mobility, chemical persistence) of all potential and/or proposed releases of contaminants. Describe all likely chemical impurities within supercritical CO2 itself (such as BTEX, PAHs, and organics), chemical additives used and chemical by-products (including likely environmental degradation by-products of the likely chemical reactions in groundwater) and relevant environmental fate processes. Releases may include controlled water discharges to surface water streams, groundwater aquifers, uncontrolled discharges when the design capacity of storages is exceeded, spills or leaks of products during loading or transportation (including via pipeline transfers), contaminated run-off from operational areas of the site, including seepage to shallow groundwater from spills or leaks of supercritical CO2, comingled impurities, and any other potential chemical additives proposed to be used. Impact assessment should describe if supercritical CO2 storage and transport will require corrosion management, will form more hazardous chemical by-products once injected or if split, or if it will act as a solvent which may increase the transport of other contaminants.	Section 5 and Section 6
Assess the potential impact of any releases from point or diffuse sources on all relevant environmental WQOs of the receiving environment. The impact assessment must consider the resultant quality and hydrology of receiving waters and the assimilative capacity of the receiving environment.	Section 6 and Section 8
Describe how WQOs would be achieved and environmental impacts would be avoided or minimised through the implementation of management strategies that comply with the management hierarchy and management intent of the Environmental Protection (Water and Wetland Biodiversity) Policy 2019. Appropriate management strategies may include the use of erosion and sediment control practices, and the separation of clean storm water run-off from the run-off from disturbed and operational areas of the site.	Section 7

Terms of Reference	Report Reference
Describe how monitoring would be used to demonstrate that objectives were being assessed, audited and met. For example, provide measurable criteria, standards and/or indicators that will be used to assess the condition of the EVs and health of surface water and groundwater environments. Propose corrective actions to be used if objectives are not likely to be met. The impact assessment must also address changes in water quality, including other contaminants present, added or formed due to the transport, industrial processing and addition and interaction of supercritical CO2 to groundwaters and relevant geological formations. The EIS should provide critical data on GHG stream plume behaviour. Describe strategies to avoid, mitigate, adequately monitor and manage potential impacts. Detailed monitoring programs should be designed with sufficient baseline data and presented for assessing contaminants of potential concern outside, and downgradient of the predicted zones of GHG stream plume impact and or the injection well (to responsively monitor for potential well integrity issues in relevant aquifers). If any corrosive management chemicals, pH control, biocides or other chemical additives are planned, detail all Chemical Abstract Services (CAS) numbers and ingredients of any formulations, estimate rates of use, concentration applied and planned location/s of use. Where chemical additives are planned or chemical impurities likely to be present, fulfill all state and Australian Government requirements pertaining to ecological, environmental, and human health risk assessments.	Sections 5, 6, 7, 9 and 11.
9.4.2 Water resources – a critical matter – Impact Assessment	
Environmental objective and outcomes	
Equitable, sustainable and efficient use of water resources Maintenance of environmental flows and water quality to support the long-term condition and viability of terrestrial, riverine, wetland, lacustrine, estuarine, coastal and marine ecosystems Maintenance of the stability of beds and banks of watercourses, and the shores of waterbodies, estuaries and the coast Maintenance of supply to existing users of surface and groundwater resources.	
Impact Assessment	
Conduct the impact assessment in accordance with the department's Water—EIS information guideline (DES 2020) and DAFF Environmental impact assessment companion guide (DAFF 2014). Address the requirements of section 126A of the EP Act.	Sections 2.1.2.2, 2.1.3.1, and 2.1.3.3
Describe present and potential users and uses of water in areas potentially affected by the proposed project, including municipal, agricultural, industrial, recreational and environmental uses of water.	Section 4.4
Describe the quality, quantity and significance of groundwater in the proposed project area and any surrounding area potentially affected by the proposed project's activities. Include the following:	
Characterise: the nature, type, geology/stratigraphy and depth to and thickness of the aquifers; their hydraulic properties; and value as water supply sources	Section 4.5
Analyse the movement of underground water to and from the aquifer(s), including how the aquifer(s) interacts with other aquifers and surface water, and the effect of geological structures on this movement	Section 4.5

Terms of Reference	Report Reference
Characterise the quality and volume of the groundwater including seasonal variations of groundwater levels	Sections 4.2.3, 4.3.3, and 4.5.6
Provide surveys of existing groundwater supply facilities (e.g., bores, wells, or excavations) including a record of flow and recovery rates and water quality.	Section 4.4.8.1
Model and describe the inputs, movements, exchanges and outputs of groundwater that would or may be affected by the proposed project. The models used to estimate associated water take must take into account the climatic conditions at the site, assess the potential impacts on water resources and include a site water balance. The model should be peer-reviewed by an independent appropriately qualified person(s) consistent with the Australian groundwater modelling guidelines (Barnett, et al., 2012).	Section 5.0
Provide a description of the proposed project's impacts at the local scale and in a regional context including:	
describe values of all waters currently extracted from aquifers	Section 4.4 and 4.5
clearly identify the water resources (natural waters in aquifers) that will be permanently unavailable for access	Section 4.4, 4.5 and 6
by future generations of potential water users as a result of the proposed activity	Section 6 and 8
provide a detailed description of the physical aspects of the aquifer in terms of its separation from the surrounding aquifers	Section 4
modelled changes to the Precipice Sandstone aquifer's characteristics, geochemistry and hydrology from the GHG stream plume	Sections 5.0, 6.2
the mobilisation and fate of any heavy metals (such as lead and arsenic) or other contaminants released due to the interaction between the GHG stream and the Precipice Sandstone aquifer	Sections 6.2.3, 6.3.3, and 6.4.3
the modelled extent, pressure and movement of the GHG stream plume over time	Section 5.2
changes in flow regimes from diversions, water take and discharges	Not applicable to GIA
groundwater draw-down and recharge	Section 5.1
in addition to impacts on recharge, describe impacts on water resources including groundwater that would be temporarily or permanently lost or displaced as a result of the GHG storage process	Section 8
alterations to riparian vegetation and bank and channel morphology	Not applicable to GIA
direct and indirect impacts arising from the development.	Sections 6.0 and 8.0
describe an effective monitoring program for all aquifers and document impacts on all aquifers.	
Identify any approvals or entitlements that would be needed under the Water Act 2000. Specifically address whether or not the proposed project	Section 2.1.2.4

Terms of Reference	Report Reference
would take water from, or affect recharge to, aquifers of the Great Artesian Basin. Describe the practices and procedures that would be used to avoid or minimise impacts on water resources.	
Describe how ‘make good’ provisions would apply to any water users that may be adversely affected by the proposed project. Propose a network of groundwater monitoring bores before and after the commencement of the proposed project that would be suitable for the purposes of monitoring groundwater quality and hydrology impacts that may occur as a result of the activity. Include details on investigation timeframes and actions if exceedances are detected.	Sections 7.1.3, 7.1.5, 7.2.5, 7.3.5, 8.1.5
Include maps of suitable scale showing the location of water-related infrastructure in relation to the proposed project’s infrastructure. Detail any significant diversion or interception of overland flow, including the effects of subsidence.	Not applicable to GIA
Describe the options for supplying water to the proposed project and assess any potential consequential impacts in relation to the objectives and strategies of any water plan and associated planning documents that may apply.	Not applicable to GIA
Describe the proposed supply of potable water for the proposed project, including temporary demands during the construction period. Also describe on-site storage and treatment requirements for wastewater from accommodation and/or offices and workshops.	Not applicable to GIA
9.4.2.1 Proposed Projects Within the Surat Cumulative Management Area (CMA)	
Assess the changes to stream and aquifer hydrology that may occur due to the proposed project’s water take, transfer or recharge of surface water and groundwater. Identify any short-term or long-term adverse or beneficial impacts of the proposed project on surface and groundwater. The assessment must address the range of climatic conditions at the site, and the potential for cumulative impacts to surface water and also groundwater.	Section 6 and 8
As the proposed project is located within the Surat CMA, use the regional groundwater flow model developed by the Office of Groundwater Water Impact Assessment (OGIA) to assess any cumulative impacts of coal seam gas and mining developments on groundwater resources. Additional local-scale models may also be required in order to assess the proposed project’s impacts. The assessment must address the following matters:	Sections 5.0, and 6.4
changes to surface and groundwater flow regimes due to operations, diversions, water take (including dewatering) and discharges	Section 6.0
alterations to riparian vegetation, and bank and channel morphology	Not applicable to GIA
direct and indirect impacts arising from the development, including increased groundwater levels, and changes to water chemistry of the Precipice Sandstone aquifer	Section 6.0
measures to avoid or minimise impact on relevant aquifers, local wetlands, Groundwater Dependent Ecosystems (GDEs) and waterways	Section 7.0
monitoring during and after operations, and corrective actions that would be taken for any previously unforeseen unacceptable impacts.	Section 11

2.1.2.3 Environmental Protection Regulation 2019

Under the *Environmental Protection Regulation 2019* (EP Reg), the Project must demonstrate that it can meet the relevant objectives and performance outcomes as set out in Schedule 8. The objectives and the associated performance outcomes relevant to groundwater, as covered by the scope of this GIA are set out in Table 2 for the Schedule 8 objectives.

Section 41 of the EP Reg sets out provisions specifically in relation to activities involving the direct release of waste to groundwater. The section sets out circumstances where the authority administering the EP Act must refuse to grant an application for an approval. The provisions of s.41 are set out in Table 3.

A summary of how the Project meets each performance outcome and the requirements of Schedule 8 and s.41 is provided in Section 8.6 of this report.

Table 2: *Environmental Protection Regulation 2019*, Schedule 8, groundwater environmental objectives and performance outcomes summary

Section	Objectives and performance outcomes
Groundwater	
Objective	The activity will be operated in a way that protects the EVs of groundwater and any associated surface ecological systems.
Performance outcomes	
1	Each of the following apply —
(a)	There will be no direct or indirect release of contaminants to groundwater from the operation of the activity.
(b)	There will be no actual or potential adverse effect on groundwater from the operation of the activity.
2	The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.
	Note — Some activities involving direct releases to groundwater are prohibited under section 41 of this regulation.

Table 3: *Environmental Protection Regulation 2019*, section 41

Section 41	Activity involving direct release of waste to groundwater
1	This section applies to the administering authority for making an environmental management decision relating to an activity that involves, or may involve, the release of waste directly to groundwater (the **receiving groundwater**). Example of direct release of waste to groundwater – an activity involving the release of contaminated water to groundwater through a well, deep-well injection or a bore
2	The administering authority must refuse to grant the application if the authority considers:
a	for an application other than one relating to an EA for a petroleum activity – the waste is not being, or may not be, released entirely within a confined aquifer; or
b	the release of the waste is affecting adversely, or may affect adversely, a surface ecological system; or
c	the waste is likely to result in a deterioration in the EVs of the receiving groundwater.
	In this section – **confined aquifer** means an aquifer is contained entirely within impermeable strata.

2.1.2.4 *Water Act 2000*

The *Water Act 2000* regulates the planning, supply, and allocation management of water resources in Queensland. The *Water Act 2000* provides for Water Resource Plans to be prepared on a catchment-by-catchment basis, as part of a consultative process. These Water Resource Plans are developed to balance water allocations (that is, human use) with environmental flows (that is, leaving water in a watercourse or aquifer to maintain natural processes).

The *Water Act 2000* relates to the Project through its focus on maintaining the health of ecosystems, water-quality, and ecological processes relating to aquifers, as outlined in Chapter 3 of the Act. The *Water Act 2000* also includes an intention to reverse, where practicable, ecosystem degradation which has occurred in the past.

The *Water Act 2000* manages the impacts on groundwater caused by activities. This includes the preparation of impact reports that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs.

In the Project's Study Area, the relevant Water Resource Plan prepared under the *Water Act 2000* is the *Water Plan (Great Artesian Basin and Other Regional Aquifers) 2017* (GABORA). The purpose of the GABORA is to define the availability of water in the plan area, to provide a framework for sustainably managing water and for taking water in the plan area, to identify priorities and mechanisms for dealing with future water requirements, and to provide a framework for reversing, if practicable, the degradation of Groundwater Dependent Ecosystems (GDEs). The plan applies to water in or from underground water and spring water.

The proposed injection of the GHG stream into the Precipice Sandstone aquifer of the Great Artesian Basin (GAB), and any associated interference with groundwater quality that affects intended uses or any influence on GDEs, would need to take into consideration the framework of the GABORA.

The Project does 'interfere' with groundwater and as such, must demonstrate that it meets the specified outcomes of the GABORA, identified in Part 3, section 12. A summary of the outcomes for the management and allocation of water in the plan area and how the Project meets the outcomes is provided in Table 4.

Table 4: Summary of GABORA economic, social and environmental outcomes

Outcome	Project achievement measures
12 Water is to be managed and allocated in a way that:	
12(a)(i) to protect the flow of water to GDEs that support significant cultural or EVs;	The test injection of the GHG stream will not impact on the quality or quantity of groundwater flowing to GDEs.
12(a)(ii) to protect the continued use of authorisations to take or interfere with water;	The GHG stream test injection will not impact on the water availability within the aquifer, and therefore does not prevent the continued use of authorisations.
12(a)(iii) to maintain, and if practicable increase, water pressure in aquifers to preserve the supply of water to bores;	The GHG stream test injection is unlikely to result in a significant change or increase of pressure within the aquifer.
12(a)(iv) to make water available for future development and social and cultural activities that depend on water, including for the aspirations of Aboriginal peoples and Torres Strait Islanders;	The GHG stream test injection is unlikely to impact on water availability within the aquifer. There are no known existing water licenses or applications for taking of groundwater from the Precipice Sandstone aquifer within the Project area.
12(a)(v) to encourage the efficient use of water by requiring water bores to have watertight delivery systems or be controlled;	The Project does not propose to extract groundwater.
12(a)(vi) to facilitate the operation of efficient water markets and opportunities for the temporary or permanent movement of water; and	The Project will not have any interaction with the water market.
12(b) recognises the state of aquifers and GDEs has changed because of the taking of, and interfering with, water	The GIA identifies the existing state and potential changes from interfering with the groundwater within the lower Precipice Sandstone.

2.1.3 Relevant regulatory guidelines

2.1.3.1 Water–EIS information guideline (DES, 2020)

When preparing an EIS, the *Water–EIS information guideline* (ESR/2020/5312) provides details on assessment requirements and expected information to be presented in relation to water resources, water quality, and associated EVs, as mandated by the *Water Act 2000* and the *Environmental Protection Act 1994*. This guideline has been used to guide the structure and content of this report.

2.1.3.2 Groundwater Dependent Ecosystems-EIS information guideline (DES, 2022)

In addition to the *Water-EIS Information Guideline*, DES have developed guidelines for specific matters, including GDEs. The *Groundwater Dependent Ecosystems-EIS information guideline* (ESR/2020/5301) sets out clear expectations for how to identify, and classify GDEs, and assess potential impacts. As stated in this guideline, identifying GDEs may rely on terrestrial and aquatic ecology assessments. However, impacts to GDEs that are related to water resources need to be dealt with holistically. As such GDEs are discussed (Sections 4.5.8), and assessed for potential impacts (Sections 6.2.4, 6.3.4 and 6.4.4) within this GIA.

2.1.3.3 DAFF Environmental Impact Assessment Companion Guide (DAFF, 2014)

The *DAFF Environmental Impact Assessment Companion Guide*, published by the Queensland Department of Agriculture, Fisheries and Forestry (DAFF), aims to provide information about matters that should be addressed through the EIS process as they relate to the agriculture, fisheries and forestry sectors, and biosecurity.

The document lists the government's legislative responsibilities, policies and interests, in relationship with these sectors to ensure early consideration in the EIS processes with the intent that this will facilitate a more streamlined review and approval process.

This guideline has been used to consider the potential impacts on groundwater quality as they relate to farm supply use and other potential agricultural users.

2.1.3.4 Water Quality Guidelines

The following water quality and monitoring guidelines have been referenced within this GIA to characterise the existing water quality of the aquifers, determine impacts and appropriate ongoing water quality monitoring. Further discussion of the relevant EVs, and water quality objectives (WQOs) is provided in Section 4.4 and Section 4.5.

- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018)
- *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* scheduled EVs and WQOs as described in *Queensland Murray-Darling and Bulloo River Basins Groundwater Environmental Values and Water Quality Objectives.*
- *Groundwater Quality Assessment Guideline: Using monitoring data to assess groundwater quality and potential environmental impacts* (DSITIA, 2017)
- *Monitoring and Sampling Manual – Environmental Protection (Water) Policy 2009* (DES, 2018)

2.1.3.5 Office of Groundwater Impact Assessment Surat Cumulative Management Area

This Project falls within the Surat Cumulative Management Area (CMA). Groundwater in the CMA is generally extracted for stock and domestic water uses, as well as irrigation, agricultural and town water supplies. The EVs of the local area are discussed further in Section 4.5. The CMA also supports extensive coal seam gas (CSG) production, coal mining, and conventional oil and gas (O&G) production all of which have the potential to incidentally extract groundwater, or cause impact to groundwater quality. The Queensland Government's OGIA produces an Underground Water Impact Report (UWIR) for the CMA every three years, which presents an assessment of impacts from existing and proposed resource tenure holders. The UWIR also provides mitigation and monitoring strategies in response to identified impacts. Data from the OGIA has been used within this GIA. Additionally, the Surat CMA UWIR (OGIA, 2021) has been relied upon to inform the discussion on potential cumulative impacts in Section 6.4.

2.1.3.6 Australian Standard ISO 31000:2018 Risk Management – Guidelines (Standards Australia, 2018)

The *Australian Standard ISO 31000:2018 Risk Management – Guidelines* provides a framework on which to build and develop a risk management approach which meets international standards and best practice. Alignment with these guidelines ensures a rigorous and holistic risk management approach has been used to support analysis.

2.2 Consultation, field investigations and methodology

2.2.1 Consultation

WSP Golder consulted and worked with external parties including:

- Collaboration with the OGIA. WSP Golder briefed OGIA personnel on the Project on details on 21 May 2021. OGIA gave positive feedback to defer to The University of Queensland's (UQ) interpretations, given the extensive Australia National Low Emissions Coal (ANLEC) work that UQ has done on the Surat Basin.
- Ongoing collaboration with the University of Queensland Surat Deep Aquifer Appraisal Project (UQ-SDAAP) team who undertook the hydrodynamic modelling for this GIA. UQ-SDAAP provided WSP Golder with model results and a modelling report that WSP Golder used to complete the GIA technical report for the EIA submission.
- Ongoing collaboration with UQ professor Dr Sue Golding and her team who reviewed the geochemical modelling completed by WSP Golder.
- Ongoing collaboration and engagement with the work of technical experts in hydrogeology, including associate professor Phil Hayes, and his team. Their study results are referenced throughout this report.
- Ongoing collaboration with independent model reviewer Ryan Morris. CTSCo engaged Ryan Morris as an independent model reviewer as required by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). Workshops were conducted with Project reviewer Ryan Morris to review: a) work completed; b) discuss the modelling workflow in terms of the model build and domain, the model calibration, simulations and uncertainty analyses; and, c) discuss how multiphase, pressure and temperature effects will be accounted for with the Equivalent Porous Media (EPM) model. Ryan Morris provided numerous feedback before finalising the report.

2.2.2 Field investigations

CTSCo conducted exploration and appraisal activities at the proposed West Moonie injection site, which are associated with this GIA. These include:

- **2020:** CTSCo drilled and cored the West Moonie-1 Injection Well to a measured depth of 2,713 m. The well is currently suspended and will be used for injection of the GHG stream (comprising CO_2 and associated impurities, SO_2, NO_2, and O_2) into the Precipice Sandstone.
- **2021:** West Moonie-2 Monitoring Well was directionally drilled to a measured depth of 2,450 m. The Precipice Sandstone was intersected at a location 175 m east-north-east of the West Moonie-1 Injection Well location. Core was subsequently acquired in West Moonie-2 Monitoring Well. This well is currently suspended and will be used as a monitoring well for the Project. Plume modelling predicts this well can provide early monitoring data related to plume movement.
- **2021:** A West Moonie Shallow Monitoring Bore located within the West Moonie-1 Injection Well drill pad was drilled to a depth of 45 m to sample Griman Creek Formation water quality.
- **2021:** The Milgarra Bore, 14.5 km east of the West Moonie-1 Injection Well, was sampled to test the water quality of the Gubberamunda aquifer which is 1,156 m below ground level (bgl). This is approximately 1,100 m shallower than the Precipice Sandstone at the West Moonie-1 Injection Well.
- **2021:** CTSCo received additional triaxial test data from Stratum Reservoir (from both West Moonie-1 Injection Well and West Moonie-2 Monitoring Well), which was analysed by Tech Limit (2021) and incorporated into the post-drill model. Triaxial test results were used in preference when calibrating the model.

Groundwater quality sampling events were conducted by either CTSCo or UQ in West Moonie-1 Injection Well, West Moonie-2 Monitoring Well, Milgarra Bore, and West Moonie Shallow Monitoring Bore between 2020 and 2021. A summary of groundwater sampling details is presented in Table 5.

Table 5: Summary of groundwater sampling events.

Borehole ID	Sample Date	Sampled by	Analysed by
West Moonie-1 Injection Well	30/11/2020	Stratum Reservoir (CTSCo)	ALS*
West Moonie-1 Injection Well	16/07/2021	Stratum Reservoir (CTSCo)	ALS*
West Moonie-1 Injection Well	19/07/2021	UQ	ALS*
West Moonie Shallow Monitoring Bore (45 m)	19/07/2021	UQ	ALS*
Milgarra Bore (Gubberamunda)	14/06/2021	Stratum Reservoir (CTSCo)	ALS*

*Note: NATA certified laboratory.

The West Moonie wells were drilled for the purpose of acquiring specific geological and water quality data about the proposed injection site. These site-specific datasets supplement earlier regional studies, which include:

- Studies conducted by CTSCo and the UQ-SDAAP in the southern Surat Basin.
- CTSCo's Glenhaven site investigation conducted in EPQ7 between 2010 and 2020 in the northern Surat Basin. This included drilling the West Wandoan-1 Well and acquiring the high-resolution 3D Glenhaven Seismic Survey. This also included baseline monitoring. Four shallow bore holes were drilled and equipment installed for extended background monitoring of soil and near-surface CO_2 concentration levels.
- Australian National Low Emissions Coal Research and Development (ANLEC R&D) funded research projects.

This information has been used to calibrate the various models (GHG stream plume migration, geomechanical models, geochemical model and hydrodynamic models) that inform this GIA.

2.2.3 Methodology

2.2.3.1 Desktop assessment

A desktop assessment was carried out for the regional assessment area to establish the baseline groundwater conditions, potential connectivity between aquifers, EVs, and potential receptors. The desktop assessment used data and information provided by CTSCo, UQ, Queensland Government data portals, and publicly available reports and data.

This information was supplemented with site-specific groundwater quality data obtained specifically for the Project through drilling, instrumentation, and monitoring completed by CTSCo. Primary data and information used in this assessment are summarised in Table 6 and Table 7.

Table 6: Summary of key datasets used as input for the EV assessment

Dataset	Source
Geological maps for the region, including: - Detailed surface geology - Solid bedrock geology and structures of the GAB.	© State of Queensland (Department of Resources) 2021, Publication 2018-05-24 Geoscience Australia (2013) Great Artesian Basin major geological structural elements (Great Artesian Basin Water Resource Assessment (GABWRA)). Bioregional Assessment Source Dataset. http://data.bioregionalassessments.gov.au/dataset/8dbe0a37-408a-4458-b4cb-fb896b830cc5
Drilling information, drilling logs and wireline logs provided by CTSCo for West Moonie-1 Injection Well and West Moonie-2 Monitoring Well in the Project area.	CTSCo
Groundwater quality data provided by CTSCo from a series of sampling events conducted.	CTSCo
23 Modular Formation Dynamic Tester (MDT) tests carried out in the West Moonie-2 Monitoring Well by Schlumberger to determine pressure trends in the Hutton, Evergreen and Precipice formations.	CTSCo - Routine core analysis (RCA) was conducted on West Moonie-1 Injection Well
Groundwater database (GWDB) with registered bore data	GWDB: © State of Queensland (Department of Natural Resources, Mines and Energy) 2020. Publication 2021-01-05
Potential GDE mapping	Department of Environment and Science 2018, the Bureau of Meteorology and Queensland Globe.
Water quality data for the Moonie Oil Field	Hydrogeochemical investigation of the Precipice Sandstone aquifer in the Moonie Area, Southern Surat Basin, Australia - Assessing up-fault discharge potential (Mahlbacher, 2019)
Precipice Sandstone water quality data for the South Surat Basin, collected by UQ for ANLEC-funded Southern Surat Hydrogeology project.	UQ, 2021, *Precipice south Surat water chem JP.xlsx*, ANLEC-funded Southern Surat Hydrogeology project, Unpublished spreadsheet.

Table 7: Summary of key reports used as inputs for the EVs assessment

Reference and source
Hydrogeology of the Southern Surat Basin: Memo Report 1 (Wye, et al., 2019)
Groundwater Net Digital Report 2020 (DNRME, 2020)
Underground Water Impact Report for the Surat Cumulative Management Area (OGIA, 2019a; OGIA, 2021)

As described in Section 4.0, water quality data from the West Moonie-1 Injection Well was assessed against available water quality data for the Precipice Sandstone aquifer.

The WQOs defined for the identified EVs of the Precipice Sandstone aquifer were then compared with the water quality monitoring data, to determine the suitability of the aquifer for each EV. Based on the outcome of this comparison, sensitive receptors were identified.

The EVs and sensitive receptors associated with the Precipice Sandstone aquifer within the regional assessment area are described in Section 4.0.

2.2.3.2 Development of hydrogeological conceptual model

The hydrogeological conceptual model (HCM) is based on a combination of local well-scale data obtained from the West Moonie-1 Injection Well and regional- and basin-scale information obtained in the public domain. This includes GAB studies by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Surat CMA investigations by OGIA, and ANLEC-funded GHG stream injection studies for the UQ-SDAAP. A summary of key reports used to inform the HCM is provided in Table 8. Table 9 presents the publicly available datasets that were also used to inform the HCM.

Table 8: Summary of key reports used as input for the HCM

Feature	Reference and source
Geological setting	*Sequence stratigraphy of the Precipice Sandstone and Evergreen Formation in the Surat Basin* (La Croix et al., 2019) *Facies prediction from well logs in the Precipice Sandstone and Evergreen Formation in the Surat Basin* (La Croix et al., 2019) *Integrated facies analysis of the Precipice Sandstone and Evergreen Formation in the Surat Basin* (La Croix et al., 2019) *Regional geological study of the Hutton Sandstone* (Bianchi et al., 2019) *Updated Geology and Geological Model for the Surat Cumulative Management Area* (OGIA, 2019b) *Geological modelling - source data, information and method* (OGIA, 2021b) *Outcrop mapping and photogrammetry of the Precipice Sandstone* (Bianchi et al., 2016) *Regional static model* (Gonzalez et al., 2019)

Feature	Reference and source
Permeability and porosity values of Precipice and Evergreen formations	*Core data analysis* (Harfoush et al., 2019) *DST Analysis* (Honari et al., 2019a.) *Multiscale static and dynamic modelling of Precipice Facies* (Knackstedt et al., 2020) *Integrating petrophysics into modelling* (Harfoush et al., 2019)
Groundwater trends for Precipice and Hutton formations	*Underground Water Impact Report for the Surat Cumulative Management Area* (OGIA, 2021)
Structural elements	*Seismic interpretation – geophysics* (Gonzalez et al., 2019) *Updated Geology and Geological Model for the Surat Cumulative Management Area* (OGIA, 2019b) *Moonie oil field history match and re-evaluation* (Honari et al. 2019)
Recharge and discharge	*Precipice sandstone hydraulic property estimation from observed MAR responses* (Hayes et al. 2019) *Hydrogeology of the Southern Surat Basin: Memo report 1* (Wye et al., 2019)
Hydrochemistry	*Hydrogeochemical investigation of the Precipice Sandstone aquifer in the Moonie Area, Southern Surat Basin, Australia - Assessing up-fault discharge potential* (Mahlbacher, 2019)
Hydrogeology, and static reservoir models, as provided by CTSCo EPQ7 information	hydrogeology, and static reservoir models, as provided by CTSCo

Table 9: Datasets used as inputs for the HCM

Dataset	Source	Publication
Detailed surface geology	© State of Queensland (Department of Resources) 2021	2018-05-24
Detailed structure	© State of Queensland (Department of Resources) 2021	2018-05-24
Detailed solid geology	© State of Queensland (Department of Resources) 2021	2018-05-24
Major watercourses	© State of Queensland (Department of Natural Resources, Mines and Energy) 2020.	2021-02-09
Groundwater database	© State of Queensland (Department of Natural Resources, Mines and Energy) 2020	2021-01-05
Queensland petroleum exploration data	© State of Queensland (Department of Resources) 2021	2016-10-14
Thickness lower and upper Hutton Member, Evergreen Formation	UQ-SDAAP	Received on 2021-05-13

Dataset	Source	Publication
and Precipice Sandstone		
Queensland Petroleum Production Statistics	Queensland Government (https://www.data.qld.gov.au/dataset/petroleum-gas-production-and-reserve-statistics)	2020-10-21

2.2.3.3 Assessment of GHG plume migration using dynamic reservoir model

A detailed dynamic reservoir model was used to estimate near-field GHG stream plume migration and its impacts on groundwater pressure/head in the Precipice Sandstone during the test injection phase. CTSCo developed a static geological model for EPQ10 taking into account data from 193 wells, and available seismic data within an area of 25,066 km^2. This static model was developed in Petrel™ and formed the physical basis for the development of a 3D dynamic reservoir model in Rock Flow Dynamic's tNavigator™ software (Section 5.2).

The dynamic model covers a 2 km by 2 km area that is centred on West Moonie-1 Injection Well. This dynamic reservoir model takes into account reservoir pressure and temperatures, the influence of density and viscosity and models both liquid and gas phases as supercritical CO_2 is injected and becomes dissolved into the aquifer. The reservoir model uses a highly refined grid with over 3 million cells and a vertical resolution of approximately 15 cm. The reservoir model focuses on the lower Precipice Sandstone. It does not model the underlying or overlying geological formations. The model was run for a 3-year injection period followed by a 100-year shut-in period. This was done to determine when the plume will stabilise and reach its maximum extent, after injection has finished.

2.2.3.4 Assessment of far-field impacts of GHG stream injection

A regional hydrodynamic model was used to estimate far-field impacts on groundwater pressure/head in the Precipice Sandstone aquifer and adjacent formations as a result of injection of GHG stream at West Moonie-1 Injection Well for a test period of three years. The impacts on groundwater pressures were simulated using a single-phase groundwater numerical modelling code, MODFLOW 6™ and MODFLOW-USG-Transport™, by using outputs of the reservoir model to define the volume of fluid injected. The groundwater modelling approach used a relatively simple model in a conservative manner (Evergreen Formation hydraulic conductivity used in the hydrodynamic model is at the lower end of the calibrated OGIA model). It is acknowledged that there are some large uncertainties in hydrogeological knowledge of the reservoir and caprock seal (see Section 4.5.9), and a simple model enables more flexibility to undertake hypothesis testing of the implications of various conceptual assumptions. For example, whether the Precipice Sandstone groundwater flow system is stagnant at the West Moonie-1 Injection Well site, and whether the eventual discharge is to the south or to the east (Wye et al., 2019).

The groundwater model build, and modelling methodology is described further in Section 5.1. The regional model was used to predict the regional scale and long-term impact of GHG stream injection on the groundwater pressures/head. This model includes the lower Precipice Sandstone, the upper Precipice Sandstone, and the Evergreen Formation, as well as the overlying Hutton Sandstone and the underlying Moolayember Formation. The model was run for a 1,000-year period post shut-in to allow assessment of long-term plume migration.

The numerical modelling and the model results are described in more detail in Sections 5.1.

2.2.3.5 Geochemical modelling

Geochemical modelling was conducted to predict changes in water quality (such as major ions and pH) as well as the dissolution and precipitation of minerals due to injection of the GHG stream (CO_2 and associated impurities). The modelling results provide important insights in terms of geochemical processes within the plume extent.

The reaction path model was performed using the React module of The Geochemist's Workbench version 15 (GWB) and the thermo.com.V8.R6+ database (Bethke et al., 2021). The model was run for 100 years to predict the evolution of water quality and mineralogical composition caused by the injection of the GHG stream (CO_2 and associated impurities). The temperature of the model was conservatively set at 90°C throughout the modelling, consistent with the well completion report for West Moonie-1 Injection Well. A decrease in temperature could increase the concentration of dissolved gases (such as CO_2) and decrease the rate of mineral dissolution. Initial porosity was set at 17.75 % for the lower Precipice Sandstone reservoir. The initial mineralogical composition of the Precipice Sandstone is summarised in Table 10.

In the model, 1 kg of water was interacted with corresponding minerals from the reservoir. For the reservoir with a given porosity, the initial volume of the minerals was calculated accordingly. Specifically, for a porosity of 17.75% and a total volume of formation water (equivalent to water from the Precipice Sandstone) of 1,000 cm^3 (assuming formation water density is 1), the total volume of the minerals present is 4,634 cm^3.

The total mineral volume (Table 10) was calculated from the mineralogical analysis of the Precipice Sandstone, the porosity of the reservoir, the molar weights of the individual minerals and their molar volumes reported in the thermo.com.V8.R6+ database (Bethke and Yeakel, 2021).

Kinetic rate laws for mineral dissolution (Equation 1) were derived from Lasaga et al. (1994):

$$r_d = Ak_d \sum_i (a_i)^{n_i} \left[1 - \left(\frac{Q}{K}\right)^p\right]$$

Equation 1

Where r_d is the dissolution reaction rate (mol/s), A is the mineral surface area (cm^2), k_d is the dissolution rate constant ($mol/cm^2/s$), a_i is activity of catalytic or inhibitory species i, n_i is the reaction order (power for species i), Q is the ion activity product, K is the equilibrium constant for the dissolution reaction and p is the Temkin coefficient (assumed equal to 1 in this modelling work).

Table 10: Mineralogical composition of the Precipice Sandstone and kinetic parameters for reaction pathway modelling

Mineral	Formula	Wt%	Mineral volume (cm³)*	Parameters for kinetic rate law							
				Neutral mechanism		Acid mechanism			Base mechanism		
				$Log(k_{25})$	E_a	$Log(k_{25})$	E_a	n (H+)	$Log(k_{25})$	E_a	n (H+)
Quartz	SiO_2	98.2	4,575.46	-13.34	90.1	-	-	-	-	-	-
Illite	$K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$	0.1	4.47	-13.55	22.0	-11.85	22.0	0.37	-14.55	22.0	-0.22
Kaolinite	$Al_2Si_2O_5(OH)_4$	1.0	47.61	-13.18	22.2	-11.31	65.9	0.777	-17.05	17.9	-0.472
Siderite	$FeCO_3$	0.2	6.26	-8.65	48.0	-3.75	48.0	0.75	-	-	-

Note: * The mineral volume is the volume associated with 1,000 cm^3 of formation water

The parameters for quartz, kaolinite, and illite are derived from Palandri and Kharaka (2004), with parameters for muscovite used for illite. Parameters for siderite are from Duckworth and Martin (2004) and Golubev et al. (2009). Note that k_{25} is the rate constant at 25°C (mol/cm^2/s), E_a is activation energy (kJ/mol).

The rate constant, *k*, was calculated taking into account the impact of temperature and pH (acid, neutral and base mechanisms (Lasaga et al., 1994; Xu et al., 2014) and using Equation 2:

$$k = k_{25}^{nu} \exp\left[\frac{-E_a^{nu}}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right] + k_{25}^{H} \exp\left[\frac{-E_a^{H}}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right] a_H^{n_H} + k_{25}^{OH} \exp\left[\frac{-E_a^{OH}}{R}\left(\frac{1}{T} - \frac{1}{T_0}\right)\right] a_H^{n_{OH}}$$

Equation 2

Where k_{25} is the rate constant at 25°C, superscripts *nu*, *H* and *OH* represent the neutral, acidic and basic mechanisms, E_a is activation energy, T_0 and T are the reference and considered temperature, and a is activity of the catalysing species.

Where supersaturation (i.e., $Q/K \geqslant 1$) occurred, secondary minerals were allowed to precipitate without kinetic controls (i.e., no kinetic law was applied for precipitation). The secondary minerals allowed to form were smectites (i.e. nontronites), iron hydroxide ($Fe(OH)_3$) and amorphous silica. These minerals were selected based on preliminary modelling results, observations in natural analogues and modelling and laboratory studies cited below (Section 5.3.3). Kinetic parameters for mineral dissolution are presented in Table 10.

In the model, CO2 and associated impurities SO2, NO2, and O2 at target concentrations of 20, 33 and 400 parts per million by volume (ppmv), respectively, were considered (Table 11). The water-gas-rock interaction was modelled as interactions between dissolved CO2 and impurities and formation minerals. It was assumed that CO2 and impurity gases fully dissolve once injected into the reservoir and that the injected NO2 and SO2 are oxidised instantaneously by O2, forming carbonic, sulfuric acid and nitric acid, respectively, according to a reaction network (Equation 3 to Equation 6). To model this, the oxidation products of NO2 and SO2, which consist of dissolved NO3- and SO42-, respectively, were added to the measured background concentrations of NO3- and SO42- in the formation water (starting fluid). The dissolved NO3- and SO42- and remaining O2 (total O2 less the amount of O2 involved in the oxidation of NO2 and SO2) are presented in Table 11. In the model, CO2 was input as dissolved CO2(aq), with a solubility calculated using the model of Zhao et al. (2015).

Dissolution of Carbon Dioxide:

$$CO_{2(g)} + H_2O = H_2CO_{3(aq)} = 2H^+ + CO_3^{2-}$$

Equation 3

Dissolution and Speciation of Sulfur Dioxide:

$$SO_{2(g)} + H_2O = SO_{2(aq)} + H_2O = HSO_3^- + H^+$$

Equation 4

Oxidation of Sulfide:

$$HSO_3^- + 1/2O_{2(aq)} = SO_4^{2-} + H^+$$

Equation 5

Oxidative Dissolution of Nitrogen Dioxide:

$$NO_{2(g)} + 1/2H_2O + 1/4O_{2(aq)} = NO_3^- + H^+$$

Equation 6

The starting composition of formation water of the Precipice Sandstone was taken from Table 29 and is presented in Table 12. It is likely that measured dissolved SiO_2 concentration was atypical of the dissolved SiO_2 concentration in a 90°C reservoir. Thus, a speciation model was developed using the SpecE8 module of the Geochemist's Workbench version 15 and the thermo.com.V8.R6+ database (Bethke et al., 2021) to estimate the aqueous SiO_2 concentration. In the speciation model, chalcedony (SiO_2) was employed to determine dissolved SiO_2, resulting in an aqueous SiO_2 concentration of 78.1 mg/L.

Table 11: Injection gas composition

Component	Project target (impurity gas)	Added dissolved species (mg/L)
Carbon dioxide (CO_2)	> 98 vol%	-
Oxygen (O_2)	400 ppmv	14.90
Sulfur dioxide (SO_2)	20 ppmv	2.34
Nitrogen dioxide (NO_2)	33 ppmv	2.50

Note: Injection gas composition based on 2021 PCC plant output gas composition were used for geochemical modelling. WSP Golder notes that the concentrations of associated impurities are either the maximum or higher than the maximum of expected concentrations.

Table 12: Formation water composition from West Moonie-1 Injection Well – specific parameters used in the model

Parameter	Units	West Moonie-1 Injection Well
pH	pH units	8.35
Nitrate (NO_3)	mg/L	2.5
Sodium (Na)	mg/L	611
Potassium (K)	mg/L	150
Calcium (Ca)	mg/L	6
Magnesium (Mg)	mg/L	1
Chloride (Cl)	mg/L	318
Sulfate (SO_4)	mg/L	10.34
Bicarbonate Alkalinity (HCO_3^-)	mg/L	1,060
Lithium (Li)	mg/L	0.138
Fluoride (F)	mg/L	6.3
Aluminium (Al)	mg/L	0.05
Iron (Fe)	mg/L	2.78
Lead[1] (Pb)	mg/L	0.0005
Manganese (Mn)	mg/L	0.049

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[1] Results of less than detection limit (DL) were replaced as ½ DL (50% of DL).

Parameter	Units	West Moonie-1 Injection Well
Nickel (Ni)	mg/L	0.001
Zinc (Zn)	mg/L	0.0025
Silica (SiO_2)	mg/L	78.1

2.2.3.5.1 Assumptions and limitations

The following assumptions are associated with the geochemical modelling:

- Thermodynamic and kinetic data from the databases thermo.dat and thermo.com. V8.R6+ and cited reports are correct.
- The employed kinetic rate law (Transition State Theory) applies to mineral reactions (primary minerals).
- The precipitation of secondary minerals is controlled by saturation state (i.e., minerals are allowed to precipitate when the saturation index ≥ 1).
- CO_2 and impurity gases fully dissolve once injected into the reservoirs and the injected NO_2 and SO_2 are oxidised instantaneously by O_2, forming sulfuric acid and nitric acid, respectively.
- CO_2 solubility calculated by the model by Zhao et al. (2015) is correct and impurity gases (such as O_2) behave as ideal gases. Their solubilities are the same as CO_2 solubility under the conditions of the study.

Limitations of the geochemical modelling include:

- Due to the lack of kinetic controls on secondary mineral precipitation, formation of secondary minerals may be overestimated as, in reality, reaction kinetics may hinder such formation. Attempts have been made to control the mineral precipitation kinetically, such as by adding small volume fractions for secondary minerals, employing nucleus density and adopting the Burton-Cabrera-Frank crystal growth theory. However, these attempts resulted in convergence challenges.
- Mineral surface areas and kinetic rate constants are uncertainties in geochemical modelling. In this study, mineral surface areas were taken from the literature. To address this uncertainty, it is recommended that a sensitivity analysis regarding surface area be performed (by varying the surface areas relative to one another). Monitoring data from the Project will provide useful information for model validation and calibration.

2.2.3.6 Groundwater impact assessment

This GIA:

- Identifies current and potential water users and uses.
- Describes the quality, quantity, and significance of groundwater in the major aquifers of relevance, including identifying EVs.
- Assesses quantitative flow and movement of groundwater, as described by the regional hydrodynamic model.
- Assesses the Project impact on pressure and geochemistry, at the local and regional scale – including strategies to avoid, minimise and manage impacts.

- Develops a groundwater monitoring and management plan for the life of the Project.
- Identifies groundwater-related approvals or entitlements that are required under the *Water Act 2000*.
- Outlines the process for make-good provisions based on the *Water Act 2000*'s *Guideline – Make good obligations*.
- Assesses groundwater extraction required to supply the potable water demand for the Project.

The GIA is based on plume, hydrodynamic and geochemical modelling, as well as provided and publicly available reports (Table 13) and datasets (Table 14).

This GIA is described in more detail in Section 6.0.

Table 13: Reports used as inputs for the GIA

Feature	Reference and source
Water uses	*Underground Water Impact Report for the Surat Cumulative Management Area* (OGIA, 2021)
EVs	*EPP Water 2019 – Queensland Murray-Darling and Bulloo River Basins: Groundwater Environmental Values and Water Quality Objectives* (DES, 2020).
Groundwater approvals and make-good processes	*Water Act 2000* Guideline
GHG stream injection	*GHG stream injection sensitivity study* (Rodger et al., 2019), *CTSCo dual phase injection modelling; UQ hydrodynamic modelling; South Surat metal mobilisation and fate of heavy metals released (Dawson* et al.*, 2022); Potential for mobilisation of trace mentals at the EPQ10 Tenement, Southern Surat Basin* (Pearce et al., 2021).

Table 14: Datasets used as inputs for the GIA

Dataset	Source	Publication
Groundwater Database	© State of Queensland (Department of Natural Resources, Mines and Energy) 2020	2021-01-05
GDE springs	© State of Queensland (Department of Natural Resources and Mines)	2020-04-28
GDE Moonie River	© State of Queensland (Department of Resources) 2021	-
Major watercourses	© State of Queensland (Department of Natural Resources, Mines and Energy) 2020.	2021-02-09

2.2.3.7 System analysis

A system analysis approach was used to identify Project-related risks. System analysis has been used at nuclear waste repository sites worldwide to evaluate all possible impacts associated with storage of contaminants in deep geological reservoirs or formations. It is a logical and systematic approach to evaluate all potential outcomes by considering system processes, features and events. Each of these three components are described further below. The systems analysis approach provides a logical basis for formulating alternative scenarios to be evaluated using the dynamic pressure model.

Through system analysis, a base case scenario was developed which describes the most likely hydrogeological processes at the Project site during the injection trial and monitoring period. The HCM is presented in Section 4.5.9. It represents an estimation of the most plausible conceptual model using current geological, hydrogeological and Project information for guidance. However, it is WSP Golder's understanding that since the actual evolution of any system cannot be known with high certainty, in a deterministic way, alternative scenarios must be developed to map the system's range of possible future states.

As a first step, all present and likely future elements of the system were identified. In general, these elements can be classified into three main groups (Sandia National Laboratories, 2008):

- *Feature*: an object, structure or condition that has a potential effect on the studied system.
- *Event*: a natural or human-caused phenomenon that can potentially affect the system and that occurs during a short interval when compared to the investigation period.
- *Process*: a natural or human-caused phenomenon that can potentially affect the system and that operates during all or a significant part of the investigation period.

It is usually a reasonable approximation that events may define alternative scenarios, while features and processes are generally applicable across all scenarios. In order to support alternative scenario development, all system elements were compiled in a database for wholistic consideration. The key benefits of this approach are the following:

- *Transparency*: the basis for scenario development and assumptions are clear and accessible.
- *Comprehensiveness*: collecting all possible current and future system elements.
- *Openness*: the system is not closed. New elements can be added to the database as more information emerges, i.e., taking an adaptive management approach to understanding future behaviour of the groundwater system.

Once the Feature Event Process (FEP) database was established, scenario-defining FEPs and linking elements of the system were identified leading to the determination of several alternative scenarios that described possible future states of the site investigated.

In addition to the general objective of system analysis, which is to define the base case and alternative scenarios of system evolution, several additional benefits of system analysis can be formulated, including:

- Assessment of uncertainty over the system's future states, meaning a series of alternative scenarios can be developed and scenarios can be ranked based on their likelihood.
- Assessment of uncertainty about human behaviour/interactions with the system in the future.
- The use of alternative scenarios (in contrast to relying on a single potential future state) has the advantage that a range of possible evolutions of the system (even including low probability, but high consequence cases) can be explored.
- The underlying dataset (components (i.e., features, events, processes) and relationships) may assist CTSCo to prepare for alternative groundwater management scenarios. This may reduce risk and cost caused by using inappropriate water management scenarios.
- The matrix may guide CTSCo in its future modelling effort including model scenarios to be evaluated.
- The elements in the matrix can be linked to existing investigations, reports and models.
- The identification of gaps (if there are any) in the matrix may help CTSCo to define future investigation activities, modelling works, open questions to reduce Project-related risks and impacts.

- The matrix (existing and non-existing elements) can be compared with regulatory requirements.
- Qualitative assessment of cumulative impacts may be incorporated in the matrix.
- May support communication to Project stakeholders.

Development of a generic FEP catalogue was funded by the European Union in order to support the long-term safety and performance of a storage system during and after GHG stream injection (version 2, (Quintessa, 2014)). This generic catalogue contains 200 elements, grouped into eight categories. The database provides a central source of information on the geological storage of carbon dioxide and can be used as part of systemic assessments of safety and performance (Quintessa, 2014).

This generic FEP catalogue was used as a starting point to evaluate the EPQ10 system.

2.3 Previous studies and projects

2.3.1 Previous studies

Listed here are some earlier regional studies relevant to the Project:

- Studies and site investigations conducted by CTSCo in EPQ7 between 2010 to 2018, which included field work such as the drilling of West Wandoan-1 well, a high-resolution 3D Glenhaven Seismic Survey including acquisition processing and interpretation, field storage planning, baseline surface and shallow subsurface monitoring, and studies such as injected plume migration modelling and hydrogeological modelling.
- Studies conducted by the UQ-SDAAP in the southern Surat Basin, included sub-projects related to sedimentology, stratigraphy, petrophysics, and static and dynamic modelling. In more detail, these involve seismic interpretation – geophysics, a regional static model, wireline log analysis, core data analysis, integrating petrophysics into modelling, precipice sandstone hydraulic property estimation from observed MAR responses, DST analysis, Moonie Oil Field history match and re-evaluation, integrated facies analysis of the Precipice Sandstone and Evergreen Formation in Surat Basin, sequence stratigraphy of the Precipice Sandstone and Evergreen Formation in the Surat Basin, facies prediction from well logs in the Precipice Sandstone and Evergreen Formation in the Surat Basin, etc.
- The ANLEC R&D funded research projects.

2.3.2 Existing GHG injection projects

There are many commercial scale CCS projects that have been safely operating in other parts of Australia and the world for many years without compromising reservoir/aquifer containment. WSP Golder has reviewed five of those projects that have similar reservoir and geological conditions to the Project. These include:

- Boundary Dam Aquistore project in Canada – 1.5 million tonnes of CO_2 per year ($MtCO_2$/yr) (rate is 13.6 times greater than this trial).
- QUEST project in Canada – 1 $MtCO_2$/yr (rate is 9.1 times greater than this trial).
- Otway project in Australia – 45,000 t/year of CO_2 (rate is 40% of the rate for this trial).
- Decatur project in the USA – 0.3 $MtCO_2$/year (rate is approximately 3 times greater than this trial).
- Sleipner project in Norway – 1 $MtCO_2$/year (rate is 9.1 times greater than this trial).

A detailed review of these case studies, presented in Section 2.3.3, highlighted the following considerations for the Project:

- All case studies – a seismic survey is a reliable technique for safe containment of GHGs and monitoring of the plume location, but also to identify any induced seismic activity from the GHG injection process. Seismic survey forms a crucial part of adaptive management and provide early indication of unlikely leakage from the reservoir, before it would be detectable by shallow surface techniques.
- The Otway project is located in the Otway Basin in Victoria, Australia. The injection target is geologically comparable to the Project. It is also a sandstone reservoir at a similar depth (2,100 metres below ground level (m bgl)), with a similar mudstone/shale caprock seal. It has similar reservoir properties in terms of porosity, permeability and injectivity. This was the first GHG storage in Australia and injection started in 2008. Approximately 65,000 t of CO_2 was injected between 2008 and 2011 into a depleted natural gas reservoir. The groundwater samples collected before and after GHG injection showed no signs of statistically significant changes, including mobilisation of heavy and trace metals.
- The Sleipner project targets a similar saline sandstone formation but at a much shallower depth of 1,000 m, with an overlying shale seal up to 100 m thick (less than the Evergreen Formation thickness). The average permeability of the reservoir is 100 to 300 millidarcies (mD), which is three times less than the average measured at West Moonie-1 Injection Well. Overall, the reservoir for the Sleipner project is geologically similar (sedimentary basin with siliciclastic deposits) to the Project and provides operating data to verify that GHG injection is safe in this type of setting.
- The Boundary Dam Aquistore project in Canada has a projected maximum injection rate of 1.5 $MtCO_2$/yr into a saline sandstone reservoir 3 km below ground surface. It has similar reservoir properties (porosity, permeability and injectivity) to the Project. Post-injection chemical sampling has demonstrated all tracer analytes remained relatively consistent and unchanged, with no evidence of off-site mobilisation of heavy and trace metals.
- Since 2015, Shell’s Quest project in Canada injected over 5 Mt of CO_2 into a saline sandstone aquifer that is approximately 2 km deep. The caprock for the Quest project is a shale formation, similar to the Evergreen Formation. Post-injection water quality results suggest negligible change from baseline measurements and no evidence of off-site mobilisation of heavy and trace metals.
- The Decatur project in the USA injected over 1 Mt of CO_2 between 2011 and 2014 into a saline sandstone reservoir at approximately 2 km deep. The Decatur injection project is geologically similar to the Project in terms of reservoir and caprock lithology, similar depth and comparable porosities. Post-injection water quality results suggest negligible change from baseline measurements and no evidence of off-site mobilisation of heavy and trace metals.

2.3.3 Case studies assessment

The aim of the case studies presented here is to leverage existing CCS project knowledge to identify potential risks, mitigate those risks, and improve chances for Project success. For each case study, an overview is provided with a fact sheet illustrating the key geological properties, environmental impacts, information on the regulatory regime and approvals, and relevant learnings applicable to the Project.

Case studies relevant to the Project have been selected according to the following properties:

1) Availability of literature – specifically on water resources availability, water quality, plume characteristics and MMV programs to be able to create a useful case study for comparison with the Surat Basin.
2) Storage formation characterisation similarities – for example, storage formation descriptions (lithology, thickness, depth, average porosity and permeability, pressure temperature, geological structure), estimated storage capacity, estimated injectivity, projected maximum injection rate and

cap rock lithology. This was to ensure that any case studies selected showed a good geological comparison with the Surat Basin.

3) Location – preference has been given to Australian projects, as well as large-scale, similar projects globally.
4) Project scale – is the project a commercial project or demonstrator? Preference was given to projects with a projected injection rate of > 1 $MtCO_2$/yr.
5) Injectivity – preferred case studies have similar estimated injectivities to the Surat Basin, as estimated by Hoffman et al. (2015).

For geological comparisons to be made with the Precipice Sandstone of the Surat Basin, a very basic reservoir characterisation has been performed (Table 15).

Table 15: Storage formation characterisation of the Precipice Sandstone aquifer

Storage Formation Characterisation	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Saline aquifer/depleted oil and gas
Target Formation Lithology	Precipice Sandstone
Target Formation Thickness (m)	50 – 150 m; average 60 – 80 m
Target Formation Depth (m)	2,258 – 2,336 m
Target Formation Average Porosity (%)	Maximum: 36.9%; 17.9% in Mimosa Syncline (Bradshaw et al., 2009)
Target Formation Average Permeability (mD)	Average ~2,000 mD
Target Formation Pressure (Mpa)	22
Target Formation Temperature (°C)	75
Geological Structure (anticline, faults, etc.)	Intracratonic basin - faulted and folded
Estimated Storage Capacity ($MtCO_2$)	2,962 Mt
Estimated Injectivity (kh)	Kh of West Moonie-1 is high, 80 m rock with insitu permeability up to 3500 mD in a single core plug (Type I reservoir based on classification by Hoffman et al. (2015))
Projected Maximum Injection Rate ($MtCO_2$/yr)	1.00
Caprock Lithology	Capped by siltstone-dominated unit, the Evergreen Formation – acts as a seal for the reservoir

The injectivity of the case study reservoirs has been assessed based on the methodology of Hoffman et al. (2015). Table 16 shows a shortlist of prospective case studies and Figure 2 shows them plotted on the figure by Hoffman et al. (2015).

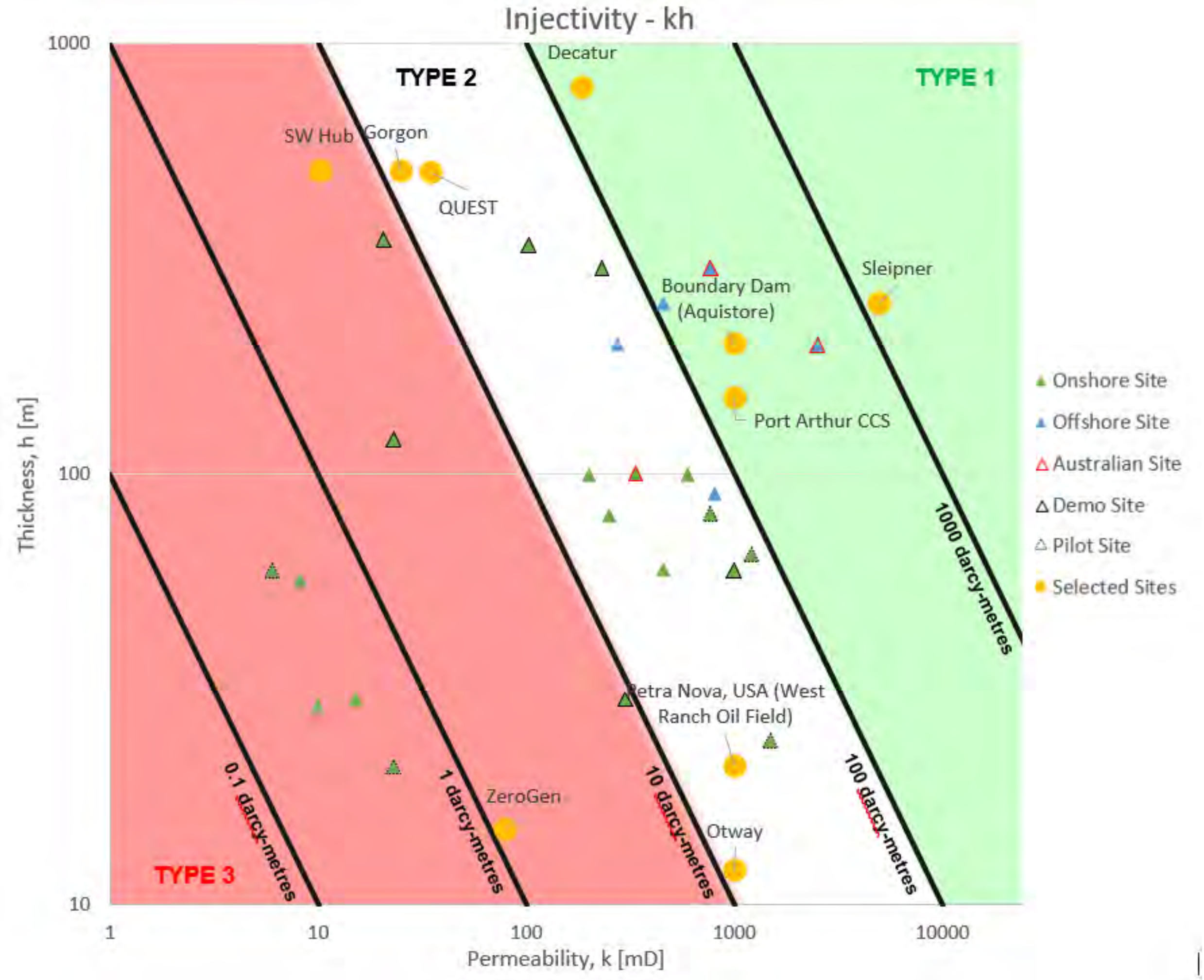


Figure 2: Injectivity of selected prospective case studies

Table 16: Shortlist of prospective case studies

Project	Country	Company	Status	Injection [MtCO2/yr]	Storage	Comments on viability as a case study
QUEST	Canada	Shell Canada	Operational	1.00	Saline Formation	Good amount of literature available, comparable to Surat Basin
Boundary Dam: Weyburn-Midale CO2 Project	Canada	SaskPower	Operational	3.00	Enhanced Oil Recovery (EOR) with Monitoring, Verification and Reporting (MVR)	Geology not comparable to Surat Basin
Boundary Dam: Aquistore	Canada	PTRC	Operational	1.50	Saline Formation	Good amount of literature available, comparable to Surat Basin
Petra Nova Carbon Capture Project	USA	NRG Energy, JX Nippon Oil and Gas Exploration	Cancelled/Dormant	1.60	EOR with MVR	Project cancelled due to funding issues. Very little in the literature
Air Products Port Arthur	USA	Air Products and Chemicals	Operational	1.00	EOR	Good amount of literature available, comparable to Surat Basin
Sleipner	Norway	Statoil with ExxonMobil, Total	Operational	1.00	Saline Formation	Type I reservoir (Hoffman, 2015) therefore not so comparable to

Project	Country	Company	Status	Injection [MtCO2/yr]	Storage	Comments on viability as a case study
						Surat Basin, however, vast amount of literature available over a long timeframe
Gorgon	Western Australia, Australia	Chevron, Shell, ExxonMobil	Operational	4.00	Saline Formation	Privacy issue – very little literature available
Otway Research Facility/ CO2CRC Otway Project	Victoria Australia	CO2CRC	Pilot	0.05	Depleted Oil and Gas	Good amount of literature available, comparable to Surat Basin
ZeroGen	Queensland Australia	ZeroGen	Cancelled/Dormant	--	Saline Formation	Project cancelled due to injectivity and economic issues. May be a good case study to include as a cancelled example, as there is some comparison with the Surat Basin
South West Hub (Collie South West CO2 Geosequestration Hub)	Western Australia, Australia	Western Australia State	In Planning	2.00	Saline Formation	Injectivity is an issue. Geology is not comparable to the Surat Basin

Project	Country	Company	Status	Injection [MtCO2/yr]	Storage	Comments on viability as a case study
Illinois Basin Decatur Project	USA	Archer Daniels Midland	Finished	0.30	Saline Formation	Good amount of literature available, comparable to Surat Basin

Case studies were reduced from 11 prospective cases to five based on the comments in Table 16, and following discussion with CTSCo. The selected case studies from the short list are shown in Table 17.

Table 17: Final case study short list

Following case study selection, the following objectives were identified:

Project	Location	Status	Injection Rate [MtCO2/yr]	Storage
Boundary Dam (Aquistore)	Canada	Operational	1.50	EOR
QUEST	Canada	Operational	1.00	Saline Formation
Otway	Australia	Operational	0.05	Depleted Oil and Gas
Decatur	USA	Cancelled/dormant	0.30	Saline Formation
Sleipner	Norway	Operational	1.00	Saline Formation

- Provide a basic geological comparison of case studies with Surat Basin and Precipice Sandstone as outlined in the fact sheets.
- Review the environmental impacts following injection operation:
  - Compare the prior and post availability of water resources for extraction, i.e., has the plume been contained and not impacted on prior water supply,
  - Compare the prior and post water quality in regard to the reactive chemistry and mobilisation of heavy and trace metals and any other contaminants, and
  - Compare the plume characteristics prior and post for pH, temperature and pressure, i.e., understand the impacts of injection into the aquifer.
- Review measurement, monitoring and verification (MMV) programs:
  - Discuss the measurement and monitoring techniques to ensure compliance with the environmental licence, i.e., leak detection and confirming the plume and geochemistry against what was predicted by the modelling pre-injection, and
  - Discuss how the above is verified/audited to ensure compliance and that impacts are within acceptable range.
- Provide learnings relevant to the Surat Basin and reporting.

2.3.3.1 Boundary Dam – Aquistore case study review and learnings

The Aquistore project is a MMV project in Canada with the key objective of demonstrating that GHG storage within a deep saline aquifer is a safe and workable solution to mitigate CO_2 from the atmosphere. CO_2 is captured from SaskPower's Boundary Dam Carbon Capture Facility near Estevan, Saskatchewan and is transported via pipeline to the Aquistore storage site where it is injected.

The fact sheet shows the key properties of the Aquistore storage site. The main target for GHG storage at the Aquistore site is the sandstones of the Winnipeg and Deadwood formations. The formations occur at 3,200 m and are approximately 150 m thick. They show good reservoir properties having porosities of 11 to 17 % and permeabilities ranging between 100 mD to over 1,000 mD, and injectivity estimated at between 1,500 and 15,000 kh. The estimated storage capacity of the Aquistore site is 34 $MtCO_2$, with projected maximum injection rates of 1.00 $MtCO_2$/yr. In terms of properties relating to geological characterisation of the sites, Aquistore compares well with the Surat Basin, being siliciclastic in lithology, having comparable thickness and good reservoir properties in terms of porosity, permeability and injectivity (Table 15).

2.3.3.1.1 Aquistore fact sheet

Table 18: Aquistore fact sheet

CASE STUDY SELECTION	
Project Name	Aquistore, Boundary Dam
Company	PTRC
Location	Saskatchewan, Canada
Demonstrator or Commercial Project?	Demonstrator
Project Status [Operational, Cancelled/Dormant, etc.]	Operational
Injection Rate [MtCO2/yr]	1.50

STORAGE FORMATION CHARACTERISATION	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Saline Aquifer
Target Formation Lithology	Sandstones (belonging to the Winnipeg and Deadwood formations)
Target Formation Thickness (m)	150
Target Formation Depth (m)	3,200
Target Formation Average Porosity (%)	11 - 17%
Target Formation Average Permeability (mD)	100 - 1,000
Target Formation Pressure (Mpa)	No published information
Target Formation Temperature (°C)	No published information
Geological Structure (anticline, faults, etc.)	Williston Basin - large intracratonic structural depression. Mostly structural traps with a minor stratigraphic component
Estimated Storage Capacity ($MtCO_2$)	34
Estimated Injectivity (kh)	1,500 - 5,000
Projected Maximum Injection Rate ($MtCO_2$/yr)	1
Caprock Lithology	Primary: Icebox Shale (15 m); Secondary: Prairie Evaporite (150 m)

ENVIRONMENTAL IMPACTS	
Water resources availability	Prior to injection, aquifers consist of water that is not drinkable and cannot be used for agricultural purposes
Water quality	

ENVIRONMENTAL IMPACTS	
> Reactive chemistry	Highly variable chemistry that is generally consistent over time (Klappstein and Rostron, 2014). Little seasonal variation. Post-injection sampling demonstrated all significant chemical tracers remained relatively consistent and unchanged
> Mobilisation of heavy and trace metals	Post-injection results remained consistent and unchanged from baseline measurements
> Mobilisation of contaminants	Post-injection results remained consistent and unchanged from baseline measurements
Plume characteristics	
> pH	No published information
> Temperature	No published information
> Pressure	No published information

MMV PROGRAMS		
Measurement and monitoring techniques to ensure compliance with the regulation	Atmosphere	Multi-species atmospheric surveys
	Biosphere	Soil-gas monitoring
	Hydrosphere	Groundwater chemistry monitoring, fluid recovery system
	Geosphere	Tiltmeters, InSAR satellite interferometry, Electromagnetics, GPS, Gravimeters, Inherent tracers, piezometers, soil-gas monitoring, time-lapse 3D seismic imaging, broadband seismography, permanent 650 geophone areal seismic array, vertical seismic profiling (VSP), accurately controlled routinely operated signal system (ACROSS)
	Deep Monitoring Wells	Fibre-optic distributed temperature systems (DTS), fibre optic distributed acoustic systems (DAS), fluid recovery system, pressure gauges, temperature gauges, pulsed neutron decay (PND) and cross dipole sonic logging, borehole gravity, cross-well seismic tomography, continuous passive microseismic monitoring
	Injection Wells	Pressure gauges, temperature gauges, fluid recovery system

MMV PROGRAMS	
Timescales of repeatability of measurement and monitoring techniques over the period of injection	Many MMV techniques adopted continually (but at least annually with respect to geophysical processes)

REGULATORY REGIME AND APPROVALS RELATED TO GROUNDWATER	
Regulatory regime	Saskatchewan, Canada
Impact assessment	No published information
Conclusions of risk assessment	Risk assessment available: www.globalccsinstitute.com Low risk - multiple sealing geological formations above and below the storage reservoir; absence of significant faults or fractures; absence of aging O&G wells in the area; effective initial risk treatments (Global Carbon Capture and Storage Institute Ltd, 2015; Hnottavange-Telleen, 2018; IEAGHG, 2015)

2.3.3.1.2 Learnings relevant to Surat Basin

The Project plans to capture CO_2 from the Milmerran Power Station in Queensland. This is a coal-fired power station and so analysis for $\delta^{13}C$ (dissolved inorganic carbon (DIC) and its stable isotope) may be of interest in the Surat Basin, as this would allow different sources of CO_2 to be distinguishable. That means should the injected CO_2 seep from the Precipice Sandstone, it may be identifiable from groundwater sample analysis (Klappstein and Rostron, 2014).

Similarly, soil gas monitoring might be of interest to the Project, again due to the source of the injected CO_2 being from a coal-fired power station. Radiocarbon-CO_2 ($^{14}CO_2$) has been used here as a tracer as it is not present in injected CO_2 at Aquistore. However, natural organic decay in surface soils have abundant levels. Thus, any contrast in isotopic signatures can provide a strong tracer signal of CO_2 seepage (Worth et al., 2017).

The Fluid Recovery System (FRS) adopted at Aquistore has become a valuable tool for collecting hydrogeological information from within the storage reservoir and bringing it to surface under *in situ* conditions (Worth et al., 2017). This would likely serve as an equally valuable downhole-instrumentation technique for the Surat Basin providing useful monitoring information on CO_2-brine interactions.

Due to the fact that some CO_2 is sent to an enhanced oil recovery (EOR) project, Saskatchewan was able to apply existing regulatory tools governing the injection of fluids into the subsurface – similar to what was seen at another project using subsurface injection of a solvent fluid to flush oil from a reservoir. In Australia, there are fundamental differences in the primary regulatory framework for CO_2-EOR projects and purely CCS projects (Allinson et al., 2017). CO_2-EOR projects are normally regulated under existing oil and gas or petroleum legislation, with the CO_2 being considered a typical EOR fluid, and the petroleum system considered to have a proven seal that could withhold hydrocarbons over geological timescales. Conversely, the primary regulatory framework for purely CCS projects ranges between: CCS/greenhouse gas storage-specific legislation; mining and mineral legislation; and general environmental management or impact assessment legislation.

2.3.3.2 Illinois Basin Decatur Project case study review and learnings

The Illinois Basin Decatur Project is located in Decatur, Illinois, USA. It marked the development, construction and operation of the largest saline storage project in the U.S. The project captured CO_2 from an ethanol plant and injected 0.3 MtCO_2/yr into the Mount Simon Sandstone Formation. GHG injection commenced in 2011 and finished in 2014 storing a total of 1 MtCO_2.

The main target for GHG storage at the Decatur site is the Mount Simon Sandstone Formation. The formation is on average 792.5 m thick, and occurs at over 2,130 m depth. There are good reservoir properties with average porosities of 20% and permeabilities averaging 185 mD. Injectivity is estimated at ~146,600 kh. In terms of properties relating to geological characterisation of the sites, Decatur compares well with the Surat Basin, being siliciclastic in lithology, the target reservoir occurring at a similar depth in the subsurface as the Precipice Sandstone, and comparable porosities.

2.3.3.2.1 Decatur fact sheet

Table 19: Decatur fact sheet

CASE STUDY SELECTION	
Project Name	Illinois Basin Decatur Project
Company	Archer Daniels Midland
Location	Decatur, Illinois
Demonstrator or Commercial Project?	Demonstration
Project Status (Operational, Cancelled/Dormant, etc.	Finished
Injection Rate ($MtCO_2$/yr)	0.30

STORAGE FORMATION CHARACTERISATION	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Saline Aquifer
Target Formation Lithology	Mount Simon Sandstone Formation
Target Formation Thickness (m)	792.5
Target Formation Depth (m)	2,130
Target Formation Average Porosity (%)	20
Target Formation Average Permeability (mD)	185
Target Formation Pressure (Mpa)	22
Target Formation Temperature (°C)	Unknown
Geological Structure (anticline, faults, etc.)	Very little in the way of faulting within 40 km of the site, relatively flat stratigraphic layering
Estimated Storage Capacity ($MtCO_2$)	1
Estimated Injectivity (kh)	146,600
Projected Maximum Injection Rate ($MtCO_2$/yr)	0.3
Caprock Lithology	Overlain by three thick impermeable shales and numerous thinner shale-rich strata including the Eau Claire, Maquoketa and New Albany shales (Leetaru et al., 2011)

ENVIRONMENTAL IMPACTS	
Water resources availability	Groundwater resources of primary concern above the Underground Source of Drinking Water (USDW)
Water quality	No Published Information
> Reactive chemistry	Post-injection results remained consistent and unchanged from baseline measurements

ENVIRONMENTAL IMPACTS	
> Mobilisation of heavy and trace metals	Post-injection results remained consistent and unchanged from baseline measurements
> Mobilisation of contaminants	Post-injection results remained consistent and unchanged from baseline measurements
Plume characteristics	
> pH	No published information
> Temperature	No published information
> Pressure	No published information

MMV PROGRAMS		
Measurement and monitoring techniques to ensure compliance with the regulation	Atmosphere	Not monitored
	Biosphere	Not monitored
	Hydrosphere	Groundwater quality monitoring, geochemical monitoring
	Geosphere	Visual inspection of flow meter to injection wellhead, geochemical monitoring, time-lapse VSP, 3D seismic surveys, seismic monitoring stations
	Deep Monitoring Wells	Plume/pressure front monitoring
	Injection Wells	Injection well monitoring and MIT, temperature sensing, pulse neutron logging
Timescales of repeatability of measurement and monitoring techniques over the period of injection	Mostly continually monitored except for geophysical techniques which may occur once every couple of years	

REGULATORY REGIME AND APPROVALS RELATED TO GROUNDWATER	
Impact assessment	Impact assessment available: https://netl.doe.gov/sites/default/files/environmental-assessments/Final-EA--ADM.pdf Can ensure relatively safe GHG storage within the Mt. Simon Sandstone. Any risk of contamination of groundwater above the USDW can be easily mitigated or remediated without causing significant harm.
Conclusions of risk assessment	No published information

2.3.3.2.2 Learnings relevant to Surat Basin

The Decatur project has adopted similar approaches to the Aquistore and Quest CCS projects, although the latter approaches seem far more comprehensive as both projects strive to set a precedent for future CCS projects. Again, shallow-subsurface, downhole instrumentation and seismic approaches have been used to ensure GHG containment and to protect groundwater sources. These approaches are suitable for the Project, as discussed previously.

2.3.3.3 Otway case study review and learnings

Otway is the first GHG storage demonstration project in Australia. The field is located at Nirranda South which is situated in the south-west of Victoria. The GHG injection trial began in 2008 to 2013, with 65,000 t of CO_2 injected successfully in the reservoir without any observed leakage. The CO_2-rich gas is compressed at extraction from a natural gas reservoir about 2.25 km from the injection site and piped to the injection well. The average injection rate has been 124 t/day (Dance, 2013).

The fact sheet included in Section 2.3.3.3.1, Table 20, shows the key properties of the Otway storage site. The reservoir is in the Waarre C Formation of Otway Basin, consisting mainly of sandstone with a porosity of 17% and permeability of 100 mD to 600 mD. The targeted area is 25 to 30 m thick with excellent flow properties. The reservoir is the basal unit of the Sherbrook Group of Late Cretaceous age approx. 2,100 m bgl. The reservoir is divided into three units on the basis of lithology. The base consists of fine-grained sandstone with low to moderate porosity. The sandstone is overlain by grey carbonaceous mudstone. The third upper most unit is the greatest gas producing reservoir in the area and contains poorly sorted very fine to coarse grain quartz sands and gravels. The main reservoir is about 14 m thick separated by thin mudstones below. The Waarre Formation is capped by the Flaxman Formation consisting of interbedded siltstone and fine-grained sandstone. The Flaxman Formation is then overlain by low porous and permeable Belfast Mudstone which is considered as the primary seal for the gas. At the top of Belfast Formation is another tight unit known as Skull Creek mudstone which served as a secondary sealing unit (Dance, 2013). In terms of properties relating to geological characterisation of the site, Otway compares well with the Surat Basin, being siliciclastic in lithology, the target reservoir occurring at a similar depth in the subsurface as the Precipice Sandstone, and good, comparable reservoir properties in terms of porosity, permeability and injectivity.

2.3.3.3.1 Otway fact sheet

Table 20: Otway fact sheet

CASE STUDY SELECTION	
Project Name	Otway Storage Project
Company	CO2CRC
Location	Nirranda South, south-west Victoria, Australia
Demonstrator or Commercial Project?	Demonstrator
Project Status [Operational, Cancelled/Dormant, etc.]	Operational
Injection Rate	124 t/day

STORAGE FORMATION CHARACTERISATION	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Depleted gas field
Target Formation Lithology	Sandstone
Target Formation Thickness (m)	25-30
Target Formation Depth (m)	2,100
Target Formation Average Porosity (%)	17
Target Formation Average Permeability (mD)	100 – 600
Target Formation Pressure (Mpa)	17
Target Formation Temperature (°C)	80
Geological Structure (anticline, faults, etc.)	Anticline, Structural Trapping
Estimated Storage Capacity ($MtCO_2$)	No published information
Estimated Injectivity (kh)	No published information
Projected Maximum Injection Rate ($MtCO_2$/yr)	45,260
Caprock Lithology	Belfast Mudstone

ENVIRONMENTAL IMPACTS	
Water resources availability	Port Campbell Limestone and the Dilwyn Formation Aquifers above the storage reservoir.
Water quality	Port Campbell Limestone is brackish, Dilwyn is fresh
> Reactive chemistry	The groundwater samples collected before and after CO_2 injection showed no sign of statistically significant changes
> Mobilisation of heavy and trace metals	No sign of statistically significant changes
> Mobilisation of contaminants	No sign of statistically significant changes
Plume characteristics	
> pH	5.2
> Temperature	No published information
> Pressure	No published information

MMV PROGRAMS		
Measurement and monitoring techniques to ensure compliance with the regulation	Atmosphere	Atmospheric CO_2 monitoring
	Biosphere	Not monitored
	Hydrosphere	Groundwater sampling
	Geosphere	Vertical seismic profile
	Deep Monitoring Wells	U-tube sampling
	Injection Wells	Wire Line Logging
Timescales of repeatability of measurement and monitoring techniques over the period of injection	Twice a year to yearly	

REGULATORY REGIME AND APPROVALS RELATED TO GROUNDWATER	
Regulatory regime	Environment Protection Authority Victoria, and the Planning and Environment Act
Conclusions of impact assessment	No published information
Conclusions of risk assessment	Risk assessment available: Watson, 2007; Jenkins et al., 2011 The combined leakage rate from all risks was estimated to be below 0.001% y−1

2.3.3.3.2 Learnings relevant to Surat Basin

The Otway project has successfully demonstrated the design of GHG storage, safely in a depleted gas field. Being a research and demonstration project, a wide range of monitoring techniques have been designed to confirm containment of injected GHGs and to understand natural variability over hours, day, months and seasons (Jenkins et al., 2011). Otway has also installed a u-tube system to sample fluids at reservoir temperature and pressure (Jenkins et al., 2011). It is a useful tool for geochemical monitoring and to characterise and monitor formation fluid compositions before and after GHG injection. Conventional time-lapse seismic surveying and soil-gas monitoring methods were used to detect CO_2 leakage that might occur into overlying aquifers. The project also showed how to secure and maintain the consent of the community. Their communication strategy and proactive engagement with the local communities and decision makers can be applied in future CCS projects.

2.3.3.4 Shell's QUEST Carbon Capture and Storage Project case study review and learnings

The Quest CCS facility is located near Edmonton, Alberta, Canada. The project demonstrates that large-scale GHG capture is a safe and effective measure to reduce GHG emissions from industrial sources (Shell, 2021). The project captures GHG from the Scotford Upgrader Facility in Fort Saskatchewan, Alberta, Canada and will inject approximately 1 $MtCO_2$/yr into the Basal Cambrian Sandstone saline aquifer over a period of 25 years (Brydie et al., 2014). GHG injection began in 2015, and to date, Quest has captured and stored over 5 $MtCO_2$ (Shell, 2021).

The fact sheet shows the key properties of the Quest storage site. The main target for GHG storage at the Quest site is the Basal Cambrian Sandstones. These are around 44 m thick, and are split into various saline aquifers. The sandstones occur at over 2,000 m depth. They have excellent reservoir properties with average porosities of 17% and permeabilities into the Darcy range (Harvey et al., 2021). Injectivity is estimated at ~ 44,000 kh. The estimated storage capacity of the Quest site is 25 measurement of water saturation (Shell, 2021), with projected maximum injection rates of 1.00 $MtCO_2$ per year. In terms of properties relating to geological characterisation of the sites, QUEST compares well with the Surat Basin, being siliciclastic in lithology, the target reservoir occurring at a similar depth in the subsurface as the Precipice Sandstone, and good, comparable reservoir properties in terms of porosity, permeability and injectivity.

2.3.3.4.1 Quest fact sheet

Table 21: QUEST fact sheet

CASE STUDY SELECTION	
Project Name	QUEST Carbon Capture and Storage Project
Company	Shell
Location	Alberta, Canada
Demonstrator or Commercial Project?	Demonstrator
Project Status [Operational, Cancelled/Dormant, etc.]	Operational
Injection Rate $MtCO_2$/yr	1.00

STORAGE FORMATION CHARACTERISATION	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Saline Aquifer
Target Formation Lithology	Basal Cambrian Sandstone
Target Formation Thickness (m)	44
Target Formation Depth (m)	2,000
Target Formation Average Porosity (%)	17
Target Formation Average Permeability (mD)	1,000
Target Formation Pressure (Mpa)	21
Target Formation Temperature (°C)	60
Geological Structure (anticline, faults, etc.)	Generally flat geology, little to no faults, stratigraphic trapping mechanism
Estimated Storage Capacity ($MtCO_2$)	25
Estimated Injectivity (kh)	44,000
Projected Maximum Injection Rate ($MtCO_2$/yr)	1
Caprock Lithology	Middle Cambrian Shale and Lotsberg Salts

ENVIRONMENTAL IMPACTS	
Water resources availability	Groundwater resources of primary concern above the BGWP
Water quality	No Published Information

STORAGE FORMATION CHARACTERISATION	
> Reactive chemistry	Post-injection results remained consistent and unchanged from baseline measurements
> Mobilisation of heavy and trace metals	Post-injection results remained consistent and unchanged from baseline measurements
> Mobilisation of contaminants	Post-injection results remained consistent and unchanged from baseline measurements
Plume characteristics	
> pH	No published information
> Temperature	No published information
> Pressure	No published information

MMV PROGRAMS		
Measurement and monitoring techniques to ensure compliance with the regulation	Atmosphere	Laser CO_2 monitoring, eddy covariance flux, daily operator rounds
	Biosphere	CO_2 natural tracer monitoring, flux monitoring, soil gas monitoring, remote sensing (brine and normalised difference vegetation index (NDVI))
	Hydrosphere	Shell groundwater wells: continuous EC and pH, discrete chemistry and isotopes analysis
	Geosphere	Time-lapse walkaway VSP surveys, time-lapse surface seismic, InSAR
	Deep Monitoring Wells	Downhole Pressure & Temperature (DHPT) above storage complex, downhole microseismic monitoring
	Injection Wells	Injection rate metering, PnX and temperature logging, DHPT, pressure integrity test (PIT), DTS, annulus pressure monitoring, operational integrity assurance, casing inspection and cement bond log
Timescales of repeatability of measurement and monitoring techniques over the period of injection	Many techniques continual throughout storage lifetime	

Regulatory regime and approvals related to groundwater	
Impact assessment	Impact assessment available: https://open.alberta.ca/dataset/7fc3495c-4659-4712-9ee4-8fe7e39f03b8/resource/bae2d1e1-d2e6-4e0f-a779-c05912254bdb/download/01-Quest-Vol-1-Project-Description.pdf Both natural and project-specific mitigation measures exist to limit potential environmental effects on groundwater. These measures are sound enough that no further cumulative environmental effects assessment was required prior to the onset of CO_2 storage at the site
Conclusions of risk assessment	No published information

2.3.3.4.2 Learnings relevant to Surat Basin

The Quest project has adopted a comprehensive MMV approach similar to that of the Aquistore project, and again, many techniques which are relevant to the Surat Basin including hydrogeological monitoring and soil-gas monitoring in the shallow subsurface to protect non-saline groundwater, pressure and temperature monitoring from downhole instrumentation and seismic methods to ensure security of storage (Shell, 2021).

Additionally, Shell has established a Community Advisory Panel of local leaders, regulatory agencies and members from the academic community. The panel reviews MMV data and receives regular updates from Shell (Shell, 2021). This has been a useful approach, particularly in terms of public acceptance, and could be easily implemented for the Project.

Furthermore, Quest underwent a comprehensive third-party expert audit of its storage development plan and is the first project globally to have received certification of fitness for safe GHG storage by DNV (Den Norske Veritas) of Norway (Shell, 2021). This might be of interest to explore for the Surat Basin.

2.3.3.5 Sleipner case study review and learnings

The Sleipner GHG storage project is operated by Statoil and is situated in the North Sea, approximately 250 km west of Norway. It is considered to be in one of the first commercial scale GHG storage projects of the world. The GHG injection in Sleipner is in operation since 1996. More than 16 Mt of CO_2 have been successfully injected in the reservoir by 2016 with a yearly CO_2 injection rate of approximately 0.9 Mt (Furre et al., 2017).

Table 22 shows the key properties of the Sleipner storage site. The reservoir is situated approx. 1,000 m beneath the ocean floor in the Utsira Sand which is a major saline aquifer in the region. The sand is of Pliocene age with an extent of 400 km north-south and 100 km east-west with a porosity of 30% to 42% and permeability of 1,000 mD to 3,000 mD (Chadwick, 2004; Arts et al., 2008). Potentially, the reservoir has a reasonable areal extent with the thickness of 900 m at the Sleipner injection point. The Sleipner injection point is located beneath a small domal feature which rises about 12 m above the surrounding area. The reservoir pore pressure in the Utsira Sand varies within 8 to 11 MPa from top to bottom and reservoir temperature is approximately 35.5°°C. The storage capacity of the entire aquifer is 42,356 $MtCO_2$ with an assumption that storage volume representing 3% the pore volume (Bøe et al., 2002). The total pore volume of the aquifer is, however, estimated differently by other workers, 6.05 by 1,011 m^3 (Kirby et al., 2001) and 5.5 by 1,011 m^3 (Chadwick et al. 2000). The cap rock above Utsira Sand is divided into three main units, upper, middle and lower respectively. The lower seal is fine grain shale with a thickness of approx. 50 to 100 m. It extends more than 50 km west and 40 km east beyond the area currently occupied by the GHG injection at Sleipner, thus forming a primary sealing unit. The middle seal consists of a bit coarse grain sand facies and the upper seal is formed by glacio-marine sediments. In terms of properties relating to geological characterisation of the sites, Sleipner compares well with the Surat Basin, being siliciclastic in lithology but the target reservoir occurs at a shallower depth in the subsurface than the Precipice Sandstone.

2.3.3.5.1 Sleipner fact sheet

Table 22: Sleipner fact sheet

CASE STUDY SELECTION	
Project Name	Sleipner
Company	STATOIL
Location	Norwegian North Sea
Demonstrator or Commercial Project?	Commercial
Project Status (Operational, Cancelled/Dormant, etc.)	Operational
Injection Rate ($MtCO_2$/yr)	1.00

STORAGE FORMATION CHARACTERISATION	
Target Formation Type (e.g., saline aquifer, EOR, depleted oil/gas)	Saline Aquifer
Target Formation Lithology	Sandstones (Utsira Formation)
Target Formation Thickness (m)	900
Target Formation Depth (m)	1,000
Target Formation Average Porosity (%)	35-40%
Target Formation Average Permeability (mD)	100 - 300

STORAGE FORMATION CHARACTERISATION	
Target Formation Pressure (Mpa)	10.1
Target Formation Temperature (°C)	31.7
Geological Structure (anticline, faults, etc.)	anticline
Estimated Storage Capacity ($MtCO_2$)	42,356
Estimated Injectivity (kh)	N/A
Projected Maximum Injection Rate ($MtCO_2$/yr)	1
Caprock Lithology	Nordland Shales

ENVIRONMENTAL IMPACTS	
Water resources availability	Prior to injection, aquifers consist of water that is not drinkable and cannot be used for agricultural purposes
Water quality	NaCl brine with a TDS around 31 to 32 g/l. Major species includes Na, K, Ca, Mg, Cl, HCO_3, SO_4 and some trace elements such as Sr.
> Reactive chemistry	Laboratory experiments showed rapid increases in concentrations of Group II metals (and in particular Ca, Sr and Fe), as well as slow and slight increases in silica concentrations.
> Mobilisation of heavy and trace metals	No published information
> Mobilisation of contaminants	No published information
Plume characteristics	The pressure and temperature were modelled to be 64 bar and 25°C respectively, in two-phase flow.
> pH	No published information
> Temperature	31.7
> Pressure	10.1

MMV PROGRAMS		
Measurement and monitoring techniques to ensure compliance with the regulation	Atmosphere	N/A undersea injection
	Biosphere	Not monitored
	Hydrosphere	Not monitored
	Geosphere	3D Seismic Controlled Source Electromagnetic (CSEM) Gravity monitoring.
	Deep Monitoring Wells	Not monitored
	Injection Wells	No Data Reported

MMV PROGRAMS	
Timescales of repeatability of measurement and monitoring techniques over the period of injection	Once every two years.

REGULATORY REGIME AND APPROVALS RELATED TO GROUNDWATER	
Regulatory regime	Norwegian Petroleum Law
Impact assessment	No published information
Conclusions of risk assessment	Risk assessment available: Ulfsnes et al., 2015 Bayesian Net estimate of propensity to leak to seabed was 60.1% very unlikely, 38.5% possible and 1.5% very likely.

2.3.3.5.2 Learnings relevant to the Surat Basin

The data from the Sleipner GHG project have been widely used as constraints for reservoir flow modelling since project inception (Singh, 2010; Cavanagh, 201; Furre et al., 2017) and thus, can be useful to develop a reservoir scale model of long-term GHG containment in the Surat Basin. There is also a wide range of geophysical methods used to monitor CO_2 containment in the Utsira Formation which includes a total of ten 3D seismic surveys and approximately four gravimetric surveys (Alnes et al., 2008; Furre et al., 2017). An important outcome from the project has been the wealth of knowledge that has evolved through monitoring, and which has been shared with the scientific community over the 25 years of operation (Furre et al., 2017). Statoil and the Sleipner Licence partners have released all the seismic, gravity, and CSEM data acquired up to and including 2009. These data are available upon request and have been used for a wide range of applications, such as improving reservoir characterisation, constraining flow modelling, and developing new techniques for seismic inversion and spectral decomposition (Furre et al., 2017).

2.3.3.6 Summary

The aim of the case studies presented here is to leverage existing CCS project knowledge to identify potential risks, mitigate those risks, and improve chances for success of for CTSCo's Surat Basin Carbon Capture and Storage Project (the Project).

All the case studies reviewed here have shown that protection of groundwater resources is of high importance, and in terms of regulation, mitigation and remediation measures, need to be considered for any identified risks. One aspect that was overwhelmingly comparable in several case studies with respect to groundwater protection was the geological control necessary in site selection (Quest, Decatur). Of primary importance was:

1) Number of intervening confining layers that occur between the injection zone and the base of protected groundwater
2) Thickness of confining layers
3) Permeability and porosity of confining layers
4) Potential for fractures to occur in the confining layers

Without these critical aspects in place, and without them having adequate properties, the first line of defence for a geological GHG storage site is likely insufficient to ensure safe storage, and as such most likely will be a problem in terms of regulation and environmental compliance (Shell, 2011).

For the most part, the case studies have shown that any risk of slow leakage of CO_2 out of the target reservoir can be quickly identified using MMV methods (measurement, monitoring and verification), such as continual groundwater sampling and comparison with baseline datasets (most notably from the impact assessments for the Decatur and Quest CCS projects). Should such leakage occur, any contamination would likely be very localised and quickly remediated (see the Decatur Impact Assessment).

Similarly, the risk assessments documented for most case studies concluded that it is highly unlikely that catastrophic leakage would occur, either through escape through a mis-managed wellbore, or through leakage via faults. In terms of wellbore management, teams have been used who demonstrate technical expertise in these matters, mitigating the risk of leakage (see relevant impact and risk assessments). In addition, all sites here have been identified as tectonically quiet, with limited fracturing and faulting, which has made them ideal demonstrators for secure GHG storage.

Sleipner, being one of the oldest case studies here, has much published on MMV programs and ensuring security of storage. However, most of the methods used are related to geophysical processes (seismic, etc.). In comparison, Aquistore, a more recent case study has taken the route of adopting many modern MMV techniques to serve as an example for future CCS projects (Halladay et al., 2018). Aquistore is a good, almost academic example of which MMV techniques are proving better than others. There are many publications pertaining to their MMV program, some of which have been discussed and referenced here.

Of critical importance to groundwater protection are MMV methods including:

Table 23: Types of MMV Methods

Monitoring location	Mmv method	Purpose
Atmosphere	Flux	Differentiate between atmospheric CO_2 and possible ground emissions
Shallow Subsurface Techniques	Piezometers, groundwater chemistry monitoring, soil gas monitoring	To monitor groundwater and soil changes which might indicate leakage of CO_2 and groundwater contamination
Downhole Instrumentation	Fluid recovery system, pressure gauges, temperature gauges	To monitor rock-fluid properties and reservoir fluid chemistry which might indicate loss of containment
Seismic	Seismic tomography, broadband seismography, geophone areal seismic array, time-lapse 3D seismic imaging, continuous passive microseismic monitoring, vertical seismic profiling	To monitor CO_2 plume location, any induced seismic activity and any geological changes, which might indicate lack of security of storage

The technologies in Table 23 would be suitable for deployment in the Surat Basin and would help to maintain the protection of groundwater resources, as well as to maintain safe containment of GHGs in the Precipice Sandstone. The shallow subsurface techniques are more applicable in terms of protecting groundwater resources. They would require baseline surveys during the pre-injection phase to be conducted so that results from continual monitoring of the site during the injection phase are directly comparable. Continual monitoring would demonstrate that any deviation from the baseline could be identified quickly and, should the results indicate contamination or CO_2 leakage from the target reservoir, mitigation or remediation procedures could be put into place.

Downhole instrumentation technologies are required to identify any changes in the groundwater at the reservoir, particularly in terms of fluid chemistry, temperature or pressure. Any chemical changes demonstrating an issue for containment could be identified early; likewise any pressure increases that might affect the caprock integrity can be closely monitored. Should leakage from the reservoir occur, particularly after injection has occurred for some time, any fluid chemistry changes would be known and so contamination of protected groundwater resources would be easily identifiable and mitigatable. Likewise, should any unfavourable pressure changes occur in the target reservoir that may lead to implications for caprock integrity (e.g., exceeding the capillary entry pressure) the problem can be identified quickly and mitigated.

Based on the case studies, learnings implemented by CTSCo for the Project have included the following (refer to 7.1):

- All case studies – seismic processes demonstrate useful techniques to ensure the safe containment of CO_2 and monitoring of the plume location, but also for identifying any induced seismic activity from the GHG injection process. These may provide the first indication of leakage from a reservoir, possibly before they become detectable by shallow surface techniques, and so can be the first line of defence in an MMV program relating to groundwater protection.
- Aquistore – specific analyses such as for $\delta^{13}C$ (Dissolved inorganic carbon (DIC) and its stable isotope) would allow different sources of CO_2 to be distinguishable and identifiable from groundwater sample analysis should leakage from the storage reservoir occur (Klappstein and Rostron, 2014). Similarly, soil-gas monitoring could be of use due to the source of CO_2 being from a coal-fired power station, in order to use radiocarbon-CO_2 as a natural tracer to identify any CO_2 seepage (Worth et al., 2017).
- Aquistore – their Fluid Recovery System has the ability to collect fluid from the storage reservoir and bring it to surface under *in situ* conditions (Worth et al., 2014) and has provided useful monitoring information on CO_2-brine interactions.
- Otway – installed a u-tube system to sample fluids at reservoir temperature and pressure (Jenkins et al., 2011). It is a useful tool for geochemical monitoring and *in situ* formation fluid sampling before and after GHG injection.
- Otway – has demonstrated how to secure and maintain the consent of the community. Their communication strategy and proactive engagement with the local communities and decision makers can be applied Surat Basin project to gain public acceptance.
- Sleipner – data have been widely used as constraints for reservoir flow modelling since project inception (Singh, 2010; Cavanagh, 201; Furre et al., 2017) and thus, can be useful to develop a reservoir scale model of long-term GHG containment in the Surat Basin. Statoil and the Sleipner Licence partners have released all the seismic, gravity, and CSEM data acquired up to and including 2009. These data are available upon request and have been used for a wide range of applications, such as improving reservoir characterisation, constraining flow modelling, and developing new techniques for seismic inversion and spectral decomposition (Furre et al., 2017).
- Quest – established a Community Advisory Panel of local leaders, regulatory agencies and members from the academic community. The panel reviews MMV data and receives regular updates from Shell (Shell, 2021). This has been a useful approach, particularly in terms of public acceptance, and could be easily implemented for the Project.
- Quest – underwent a comprehensive third-party expert audit of its storage development plan and is the first project globally to have received certification of fitness for safe GHG storage by DNV (Den Norske Veritas) of Norway (Shell, 2021). Again, this might be of interest to explore for the Project.

2.3.3.7 *Overall implications for the Project*

- The Project has comparable geological and reservoir properties to a number of existing and operational CCS projects. It is therefore expected to respond to injection in a similar manner. Those analogous settings have been exposed to orders of magnitude higher injection rates without compromising plume containment or impact to EVs. It is noted however that these projects have not injected a GHG stream into water of similar salinity as Precipice Sandstone at West Moonie.

- The Project is injecting into aquifers at similar depths to those used in CCS projects elsewhere. Injecting at these depths is not unique to the Project.
- Seismic survey is a reliable technique to monitor and confirm the safe containment of GHG stream and observe the localised plume extents.
- Operational water quality monitoring has shown that no statistically significant deviations in trace or heavy metals have occurred outside of the plume area in the five case study CCS projects. This is consistent with the predictions for EPQ10.

3.0 PROPOSED PROJECT DESCRIPTION

The Project aims to demonstrate the feasibility of permanent storage of a GHG stream within the Precipice Sandstone in the deepest parts of the Surat Basin. CTSCo has been working with the Millmerran Power Station (MPS) to supply a GHG stream for the Project.

CTSCo is the holder of the GHG exploration tenement EPQ10. The key components of the Project in relation to groundwater include:

- Test injection of a GHG stream at the West Moonie-1 Injection Well into the lower Precipice Sandstone aquifer, between 2,250 m bgl and 2,350 m bgl
- Monitor the lateral spread of the plume via the West Moonie-2 Monitoring Well and using a buried 2D seismic array.

In summary, the Project proposes to inject up to 330,000 t (up to 110,000 t/year) of a GHG stream into the lower Precipice Sandstone at a depth of 2,320 mRT via a 2 m perforated interval in the West Moonie-1 Injection Well. A range of monitoring and verification technologies will be deployed to address the key risks and consequences of the GHG stream injection.

The proposed Project activities of relevance to the GIA can be divided into three phases: 1) pre-injection; 2) injection; and 3) post-injection.

3.1 Pre-injection phase

Activities relevant to the GIA include:

West Moonie-1 Injection Well

- The West Moonie-1 Injection Well was drilled in August and September 2020 to appraise the porosity and permeability of the Precipice Sandstone at the West Moonie-1 Injection Well site. The well encountered 78 m of 'good to excellent reservoir' sandstone at overburden depths of 2,258 m to 2,336 m, with porosity greater than 15% and permeability up to 4.5 Darcys. The West Moonie-1 Injection Well was constructed as a future GHG stream injection well.
- 309 m of core was recovered from the lower Evergreen Formation, the Precipice Sandstone and the Moolayember Formation in the West Moonie-1 Injection Well. Routine core analysis was conducted on 24 samples.
- Wireline logging was conducted on the West Moonie-1 Injection Well to assess geological conditions and confirm well integrity.
- Groundwater samples were collected from the Precipice Sandstone in the West Moonie-1 Injection Well.

West Moonie-2 Monitoring Well

- The West Moonie-2 Monitoring Well was drilled in July 2021. The West Moonie-2 Monitoring Well was directionally drilled from the West Moonie-1 Injection Well pad with a bottom hole location 175 m west of the West Moonie-1 Injection Well's bottom-of-hole location. The West Moonie-2 Monitoring Well was designed and constructed to be located within the predicted GHG stream plume within the reservoir. The well has been suspended ready for fit-out of monitoring equipment prior to commencement of injection testing.
- Both West Moonie-1 Injection Well and West Moonie-2 Monitoring Well are cased with corrosion-resistant alloy casing (with metal-to-metal, gas-tight connections) across flow-wet zones. A CO_2 resistant cement was used for cementing the production casing. Cement integrity was confirmed via cement bond logging. Regionally important aquifers such as the Gubberamunda Sandstone also have a second tested casing/cement barrier (surface casing).
- The West Moonie-2 Monitoring Well was drilled for monitoring purposes during the injection trials for Precipice Sandstone. The well encountered 65 m of measured depth thickness (true vertical thickness (TVT)) of 'good to excellent reservoir' sandstone at depths of 2,245 m bgl to 2,360 m bgl. West Moonie-2 Monitoring Well was constructed as monitoring for future GHG stream injection activities.
- Wireline logging was conducted on West Moonie-2 Monitoring Well to assess geological conditions and confirm well integrity.

West Moonie Shallow Monitoring Bore

- A 48 m deep monitoring bore (i.e., the West Moonie Shallow Monitoring Bore) was drilled in 2021 into the Griman Creek Formation and a groundwater sample was collected on 19 July 2021.

Milgarra Bore sampling

- Two groundwater samples from the Gubberamunda Sandstone aquifer were collected and analysed on 17 June 2021 and 25 August 2021 from the Milgarra Bore (RN23075).

Summary details of the West Moonie-1 Injection Well, West Moonie-2 Monitoring Well, West Moonie Shallow Monitoring Bore and Milgarra Bore are presented in Table 24.

Table 24: Summary of Project bores

Bore ID	Latitude	Longitude	Drilling completed	Bore depth (m)	Formation targeted
West Moonie-1 Injection Well	-27.830241	149.958100	14-Sep-2020	2,710.5	lower Precipice Sandstone
West Moonie-2 Monitoring Well	-27.830185	149.957972	22-July-2021	2,445.0	lower Precipice Sandstone
West Moonie Shallow Monitoring Bore	-27.830019	149.958352	26-May-2021	48.0	Griman Creek
Gubberamunda Monitoring Bore	-27.829854	149.957577	Yet to be drilled, planned April 2024	Approximately 1,400.0	Gubberamunda
Milgarra Bore	-27.829854	149.957577	October-1982	1,242.6	Gubberamunda

Seismic surveys and equipment installation

- West Moonie seismic survey, a 3D seismic survey with an approximately 40 km^2 (5 km by 8 km) area around West Moonie-1 Injection Well is scheduled for Q1 2023.
- Installation of 2D seismic survey lines buried in a grid pattern around the West Moonie-1 Injection Well, at an approximately 4 km radius, is scheduled for 2024.

Modelling and other studies

- A Petrel™ static geological model has been constructed using regional seismic reflection and well data. This static model is the basis for subsequent local-scale dynamic multiphase reservoir models to predict plume migration associated with the test injection.
- A geomechanical model (1DMEM) has been built for the West Moonie injection site to model *in situ* stress and geomechanical impacts of the injection using specific datasets acquired from the West Moonie-1 Injection Well and West Moonie-2 Monitoring Well.
- The West Moonie regional hydrodynamic model was developed to test various plume migration scenarios to inform short-term and long-term impacts of test injection on the Precipice Sandstone aquifer.
- Geochemistry studies have been completed to predict the potential water quality impacts of injecting the GHG stream during the test injection.

3.2 Injection phase

Activities relevant to the GIA include:

- Down-hole pulse neutron logging every 6 months at both West Moonie-1 Injection Well and West Moonie-2 Monitoring Well. This is to determine plume migration in the Precipice Sandstone aquifer and to detect if there is any leakage of the GHG stream, including at the Gubberamunda Sandstone and Griman Creek Formation aquifers.
- 2D seismic monitoring every 6 months during the test injection phase to assess for vertical leakage and lateral movement of the GHG stream plume over time.
- Pressure and water quality monitoring from West Moonie-2 Monitoring Well, prior to arrival of the plume at the well monitoring point, then every 6 months during injection after arrival of the plume.
- Continuous monitoring of atmospheric CO_2 concentration at the surface near West Moonie-1 Injection Well.

3.3 Post-injection phase

Activities relevant to the GIA include:

- Monitoring and verification of the test injection reservoir will continue after the test injection is completed (i.e., the shut-in phase), until the GHG stream plume has stabilised and reached quasi-equilibrium conditions plus two seismic surveys at a 6-monthly interval after the plume as ceased to expand, or 2 years, whichever is longer. This includes:
  - Ongoing down-hole pulse neutron logging every 6 months at both West Moonie-1 Injection Well, West Moonie-2 Monitoring Well and Gubberamunda Monitoring Well to detect for wellbore leakage of the GHG stream, including at the Hutton Sandstone, Gubberamunda Sandstone and Griman Creek Formation aquifers.
  - Ongoing 2D seismic monitoring every 6 months post injection to assess for vertical leakage and lateral migration of the GHG stream plume over time.
  - Ongoing pressure and water quality monitoring from West Moonie-2 Monitoring Well every 6 months after injection has ceased.
  - Ongoing continuous monitoring of atmospheric CO_2.

4.0 EXISTING ENVIRONMENT

4.1 Project location in the Surat Basin

The Project is located in the Surat Basin, which is infilled with Jurassic to Cretaceous-aged sediments, consisting of a heterogeneous mix of alternating layers of sandstones, siltstones, mudstones and coal lenses up to 2,500 m thick.

The extents of the Surat Basin in Queensland are shown in Figure 3 which illustrates the following key features of the basin boundaries:

- The northern boundary of the Surat Basin is well defined by the outcrop areas of the deeper sediments.
- The Surat Basin's current south-western boundary with the Eromanga Basin is along the Eulo-Nebine Ridge, which is a broad basement high with very shallow GAB sediments (Ransley & Smerdon, 2012).
- The GABWRA (Ransley & Smerdon, 2012) identified the western edge of the ridge as the boundary between the Eromanga and Surat basins.

- To the north-east, the boundary between the Surat and Mulgildie Basins is defined by a basement high over which the Evergreen Formation thins out, forming a natural hydrogeological divide between these basins (OGIA, 2021).
- The Cecil Plains Sub-basin is divided from the remainder of the Clarence-Moreton Basin in the east by the Toowoomba Strait – a hydrologic divide coinciding with the present-day line of the Great Dividing Range (Day, Bubendorfer & Pinder, 2008; Smerdon & Ransley, 2012).

Figure 3 shows the Queensland extent of the Surat Basin. This figure shows that the Precipice Sandstone outcrops along the northern edges of the basin, over 235 km to the north of the Project site at West Moonie in EPQ10. The figure also shows that the springs supported by the Precipice Sandstone occur exclusively in the northern part of the Surat Basin near the outcrop. The structural features of the Bowen Basin are generally reflected, but subdued in the Surat Basin structures (OGIA, 2021). The Mimosa Syncline (Figure 3) is near the main depositional centre of the basin and is bounded to the east by the north-south trending Burunga-Leichhardt Fault System in the north and the Moonie-Goondiwindi Fault System in the south (OGIA, 2021).

OGIA (2021) identified the four main groundwater systems in the Surat CMA as being:

- The GAB which includes the formations of the Surat Basin
- The underlying Bowen Basin
- The surficial Cenozoic basalt aquifer
- The alluvium aquifer.

The general groundwater divide for the various groundwater flow systems is:

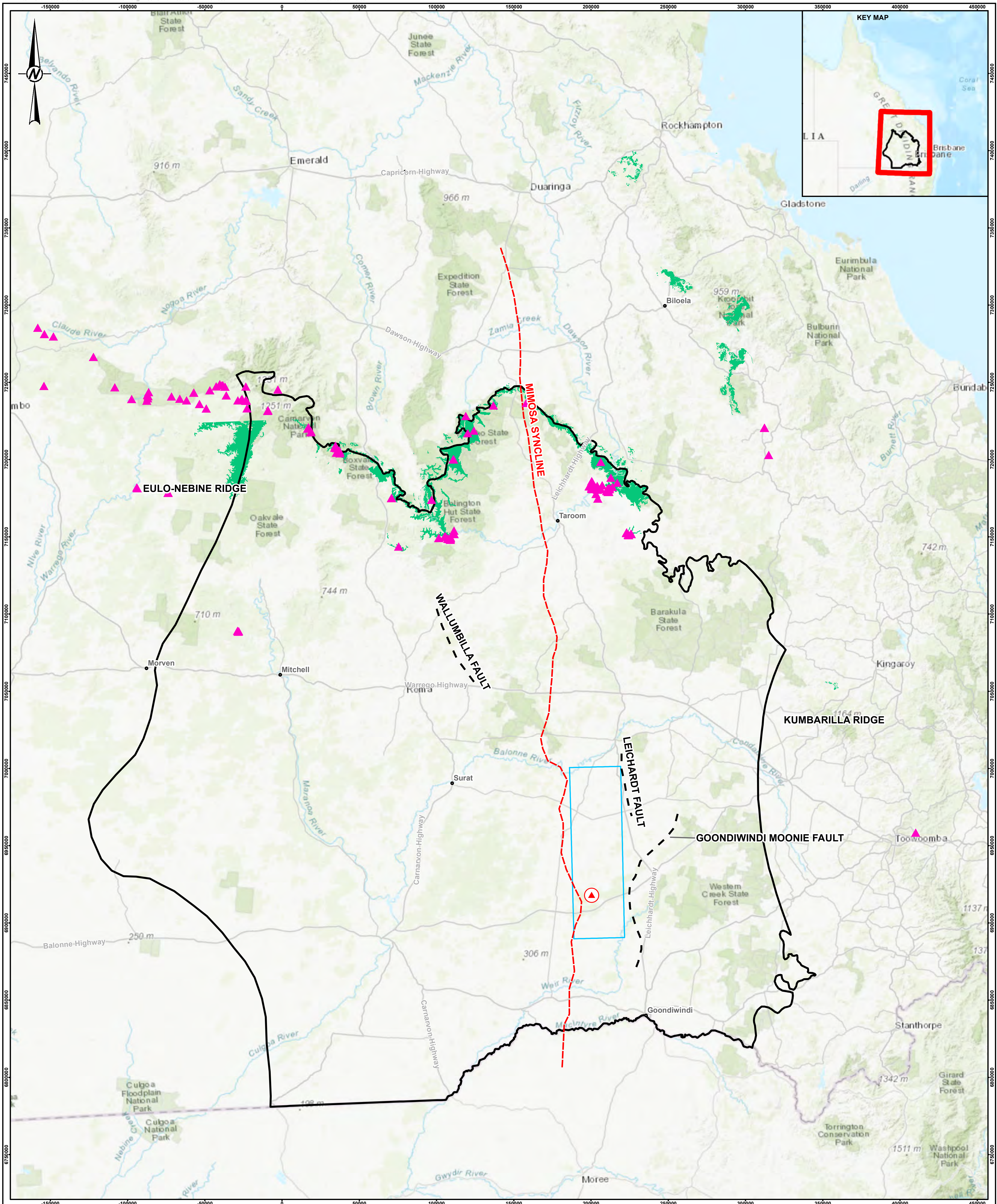
  - North of the Great Dividing Range groundwater flow is generally northward, with groundwater discharging into the Dawson River catchment.
  - South of the Great Dividing Range groundwater flow is generally southward, broadly consistent with the dip of the formation.

The UQ-SDAAP report used terms that differ to other reports published on the Surat Basin, with the terms used summarised in Table 25.

Table 25: The terms used in the UQ-SDAAP report

Lithostratigraphy	UQ-SDAAP zone
upper Evergreen Formation	Top Ultimate Seal (US)
Westgrove Ironstone Member	Top Ultimate Seal (US)
Boxvale Sandstone Member	Transition Zone (TZ)
lower Evergreen Formation	Transition Zone (TZ)
upper Precipice Sandstone	Transition Zone (TZ)
lower Precipice Sandstone	Blocky Sandstone Reservoir (BSR)
Base Jurassic Unconformity	sub-Surat Unconformity (BU)

PATH: V:\CTSCo\21456840 CTSC GW ESIA Moonie\GIS\99_PROJECTS\21456840-011-Rev3-F035-SuratBasinExtent.mxd PRINTED ON: 2022-08-05 AT: 1:29:38 PM



LEGEND

◬ West Moonie-1

▲ Springs supported by the Precipice Sandstone

- - - Mimosa Syncline

☐ Surat Basin (Queensland extent)

☐ EPQ10

🟩 Precipice Outcrop

0 40 80
1:2,300,000 @A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1.SPRINGS: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. EXPLORATION PERMITS FOR GREENHOUSE GAS & GEOLOGY SHAPEFILES: © STATE OF QUEENSLAND (DEPARTMENT OF RESOURCES) 2021
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CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

TITLE
EXTENT OF THE SURAT BASIN, OUCTROP OF THE PRECIPICE SANDSTONE AND SPRINGS SUPPORTED BY THE PRECIPICE

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	DW
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	003

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4.2 Regional geology and hydrogeology

4.2.1 Geology of the Precipice Sandstone

The Precipice Sandstone is dominated by braided river deposits (La Croix et al., 2019c) and has high-quality reservoir sands. La Croix et al. (2019b) identified that the Precipice Sandstone and lower Evergreen Formation onlap the underlying basement along the western and eastern margins of the Surat Basin, hence the Precipice Sandstone is confined to the central part of the Surat Basin. The closest mapped contiguous outcrop of the Precipice Sandstone is approximately 235 km to the north of the proposed injection location (Figure 4). This figure shows that the Precipice Sandstone is continuous from the outcrop in the north through to EPQ10, and that within EPQ10 the Precipice Sandstone is up to 100 m thick.

The Precipice Sandstone is made up of two unique sedimentary layers: the lower Precipice Sandstone (a tidally influenced meandering fluvial deposit) and the upper Precipice Sandstone (a sand-dominated formation).

Moonie Oil Field is the primary conventional O&G field, producing oil (and associated water) from the Precipice Sandstone and lower Evergreen / upper Precipice Formation, with the upper Evergreen Formation acting as the seal that trapped the hydrocarbons over geological time scales. About 95% of conventional associated water extraction within the CMA (around 1,000 ML/year in the CMA) is from the Precipice Sandstone and Evergreen Formation in the Moonie Oil Field (OGIA, 2021a).

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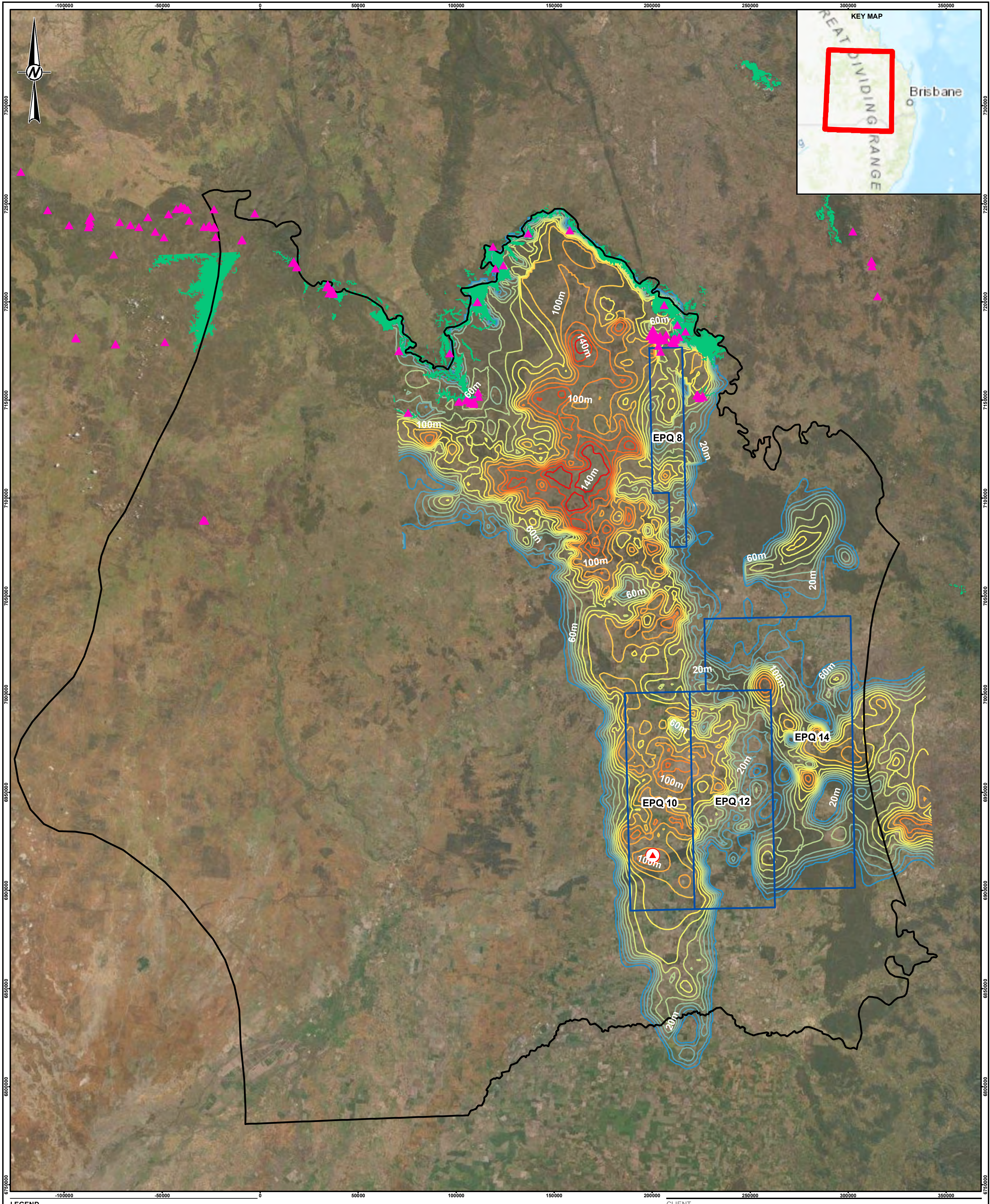

LEGEND

Precipice Thickness
- 10 m
- 20 m
- 30 m
- 40 m
- 50 m
- 60 m
- 70 m
- 80 m
- 90 m
- 100 m
- 110 m
- 120 m
- 130 m
- 140 m

- ▲ West Moonie-1
- ▲ Springs related to Precipice
- 🟩 Precipice Outcrop
- ☐ Exploration Permits for Greenhouse Gas
- ☐ Surat Basin (Queensland extent)

0 30 60
1:1,800,000 @A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
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3. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

TITLE
PRECIPICE SANDSTONE EXTENT AND THICKNESS

CONSULTANT

YYYY-MM-DD	2022-09-02
DESIGNED	DW
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

PROJECT NO.	CONTROL	REV.	FIGURE
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4.2.2 Hydrogeology of the Precipice Sandstone

Groundwater from the Precipice Sandstone is used for both the petroleum and gas (P&G) industry, i.e., specifically for the conventional P&G industry and for non-P&G related purposes. OGIA (2021) estimates that 186 non-P&G related water bores extract groundwater from the Precipice Sandstone, of which the majority of bores (164) are used for stock and domestic water supply. The 15 bores that are not used for stock and domestic supply extract a total of 1,742 ML/year, which are used for irrigation, town water supply and industrial purposes, while the stock and domestic bores only extract 299 ML/year. Seven non-associated water supply bores extracted a total of 184 ML/year for the purposes such as camp water supply or road construction.

Origin Energy has established two treated-CSG water reinjection facilities at Spring Gully and Reedy Creek/Combabula gas fields in the northern Surat Basin. At these facilities, treated associated groundwater (that is extracted from the Walloons Subgroup as part of P&G operations) is injected into the Precipice Sandstone, in a process called Managed Aquifer Recharge (MAR). Since January 2015, more than 30,000 ML of water has been injected into the Precipice Sandstone, currently averaging around 4,500 ML/year (OGIA, 2021). Hayes et al. (2019a) reports a head rise of around 40 m near the Reedy Creek MAR, with the head rise diminishing with radial distance from the injection sites and is generally around 3 to 4 m of rise near the basin margins to the north and east. In the far south, south of Chinchilla, there is a declining trend in head pressure in the aquifer. This is inferred to arise either from the MAR effects not having reached this area, or local water abstraction has overprinted those effects (Hayes et al., 2019a). Figure 5, created by OGIA (2021), shows a summary of observed groundwater level changes in the Precipice Sandstone before and after 2015.

OGIA (2016b) identified 22 spring complexes with 151 vents and 8 watercourse springs that are sourced from the Precipice Sandstone. The total discharge from the Precipice Sandstone in the north-east outcrop areas near the Dawson River is approximately 16,000 to 18,000 ML/year (OGIA, 2016a). Most of these springs are located in the northern Surat Basin, where the Precipice Sandstone outcrops (Figure 3). The Lockyer Creek spring in the Clarence-Moreton Basin is located approximately 213 km east of the Surat Basin. All springs associated with the Precipice Sandstone are more than 235 km away from the West Moonie test injection site and are further separated by the groundwater divide that is situated to the south of the Great Dividing Range.

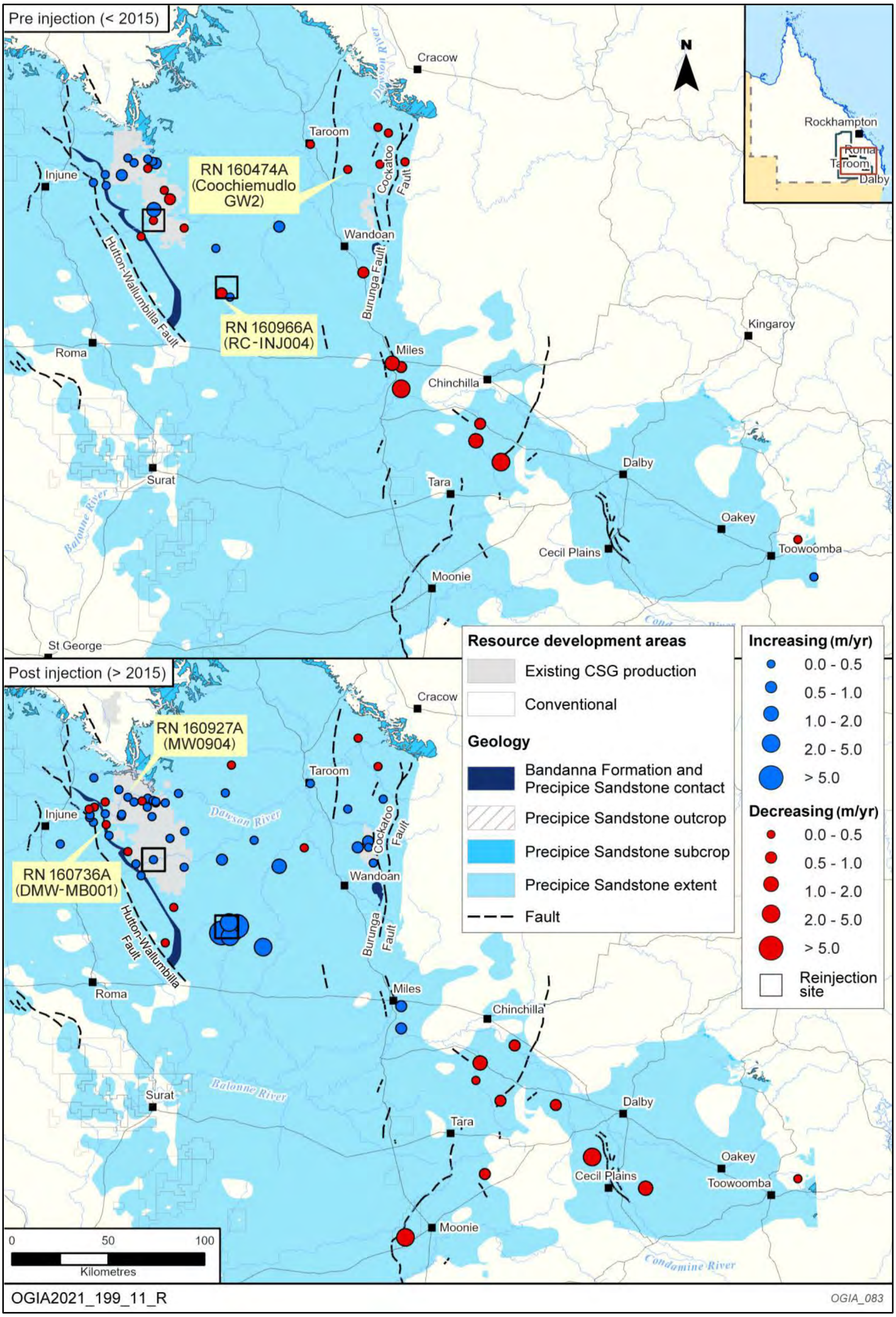


Figure 5: Summary of observed groundwater changes in the Surat Precipice Sandstone before and after 2015 (OGIA, 2021)

4.2.3 Water quality in the Precipice Sandstone

4.2.3.1 Major analytes

OGIA (2021) assessed groundwater quality for most formations in the Surat CMA with the major analytes for the relevant hydrostratigraphic units (HSUs) (summarised in Table 26). The water quality parameters in Hutton and Precipice Sandstone aquifers from OGIA (2021) are compared to the data from the Moonie Oil Field, the regional Surat Basin samples taken by UQ, and from West Moonie-1 Injection Well (Table 26).

Groundwater is generally fresher near recharge areas and evolves when it moves through the formations (OGIA, 2021). The OGIA (2021) data is dominated by samples from north of the groundwater divide, whereas the groundwater quality in the Moonie Oil Field is less fresh compared to the data presented by OGIA. This is potentially due to the location in the deeper part of the basin, further from the recharge area, and in an area where there is no throughflow. The water quality of West Moonie-1 Injection Well is described in Section 4.4.1 and is compared to the water quality in the southern Surat Basin and the Moonie Oil Field in Figure 16 and Figure 17. The West Moonie-1 Injection Well sample compares reasonably well to the water quality in the Moonie Oil Field (Table 26).

Table 26: Median values of water quality parameters in Hutton and Precipice HSU aquifers from OGIA (2021), the Moonie Oil Field (Mahlbacher, 2019), UQ samples and West Moonie-1 Injection Well

Analyte	Hutton Sandstone	Precipice Sandstone			
	OGIA, 2021	OGIA, 2021	Moonie Oil Field (Mahlbacher, 2019)	UQ South Surat Samples	West Moonie-1
	Based on 1,748 samples	Based on 662 samples	Based on 18 samples	Based on 8 samples	Based on 3 samples
Calcium (mg/L)	27	3	12	49	6
Magnesium (mg/L)	14	1	2	9	1
Sodium (mg/L)	357	47	770	1,200	598
Potassium (mg/L)	3	2.1	20	55	150
Alkalinity (mg/L)	399	112	1,860 (HCO3-)	1,075	1,080
Chloride (mg/L)	400	15	153	1,240	319
Sulfate (mg/L)	16	1	21	<1	8
Fluoride (mg/L)	0.3	0.2	5.1	0.85	6

Analyte	Hutton Sandstone	Precipice Sandstone			
	OGIA, 2021	OGIA, 2021	Moonie Oil Field (Mahlbacher, 2019)	UQ South Surat Samples	West Moonie-1
	Based on 1,748 samples	Based on 662 samples	Based on 18 samples	Based on 8 samples	Based on 3 samples
TDS (mg/L)	1,160	184	2,843	3,740	1,850
pH	8.0	7.5	-	6.6	8.16

Mahlbacher (2019) analysed 18 water chemistry samples from 14 different wells in the Moonie Oil Field. Of those 18 samples, 7 wells were sampled in 2018 and the remaining samples were sampled in the early 1960s. The water quality in the Precipice Sandstone, as reported by OGIA (2021), is fresher than the water quality in the Moonie Oil Field (Table 26). Mahlbacher (2019) recorded a total dissolved solids (TDS) content of above 2,500 mg/L in the Precipice Sandstone in the Moonie Oil Field, while the wells that produce from the lower Evergreen Formation encountered a TDS content of about 3,500 mg/L. The TDS content from West Moonie-1 Injection Well sample is about 1,850 mg/L, which is very close to the TDS in the 2018 samples ranging from 887 to 1,550 mg/L, indicating fresher groundwater.

Rodger et al (2020) analysed pre-existing groundwater chemistry data of the southern Surat Basin in 60 wells for the Hutton Sandstone, 37 wells for the Evergreen Formation and 37 wells for the Precipice Sandstone. Note that not all wells have data for all parameters, and there are major gaps in the dataset (Rodger et al., 2020). For example, fluoride content was not often measured in water samples, so the absence of fluoride cannot be assumed for samples where it was not analysed.

The different stratigraphic interpretations for the Evergreen – Precipice boundary might have also caused inconsistencies in the dataset.

Based on this analysis, Rodger et al (2020) conclude that groundwater across the three formations consist of sodium-chloride-bicarbonate (Na-Cl-HCO_3) to Na-HCO_3 type water, with low to moderate salinity. The exception is for the Precipice Sandstone, where the salinity is slightly higher. The TDS ranges are summarised in Table 27. The wells in the Moonie Oil Field encountered relatively low TDS in the Precipice Sandstone. This might be explained by the decades of water production from high permeability sandstone, freshening a once-stagnant deep groundwater flow system (Rodger et al., 2020).

Table 27: TDS ranges from pre-existing groundwater chemistry data (Rodger et al., 2020)

Formations	TDS minimum (mg/L)	TDS median (mg/L)	TDS maximum (mg/L)
Hutton Sandstone	217	1,501	6,350
Evergreen Formation	190	1,247	27,241
Precipice Sandstone	210	2,110	5,700

Rodger et al. (2020) plotted the major ion concentrations, TDS and selected ion ratios for the three formations (Figure 6). The Na/Cl molar ratio shows high Na compared to sea water and rainfall recharge (Na/Cl molar ratio ~ 1), this is likely caused by ion exchange, minor mineral weathering, and the addition of CO_2 from microbial activity (Rodger et al., 2020). The Precipice Sandstone also has a high HCO_3 content.

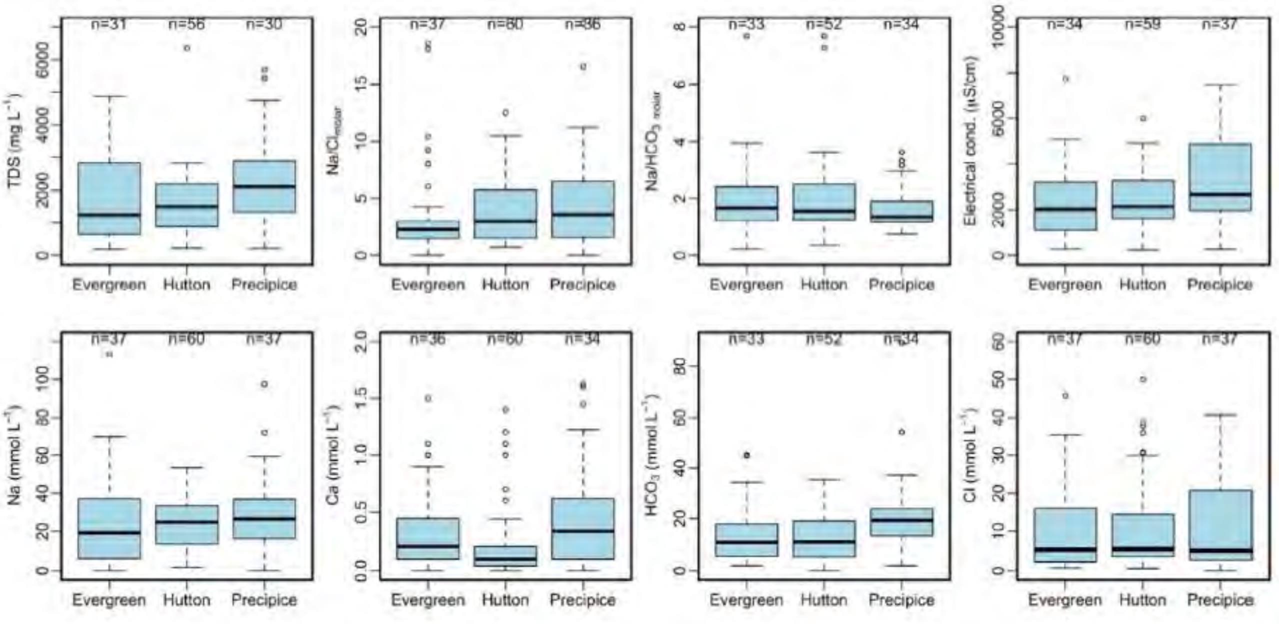
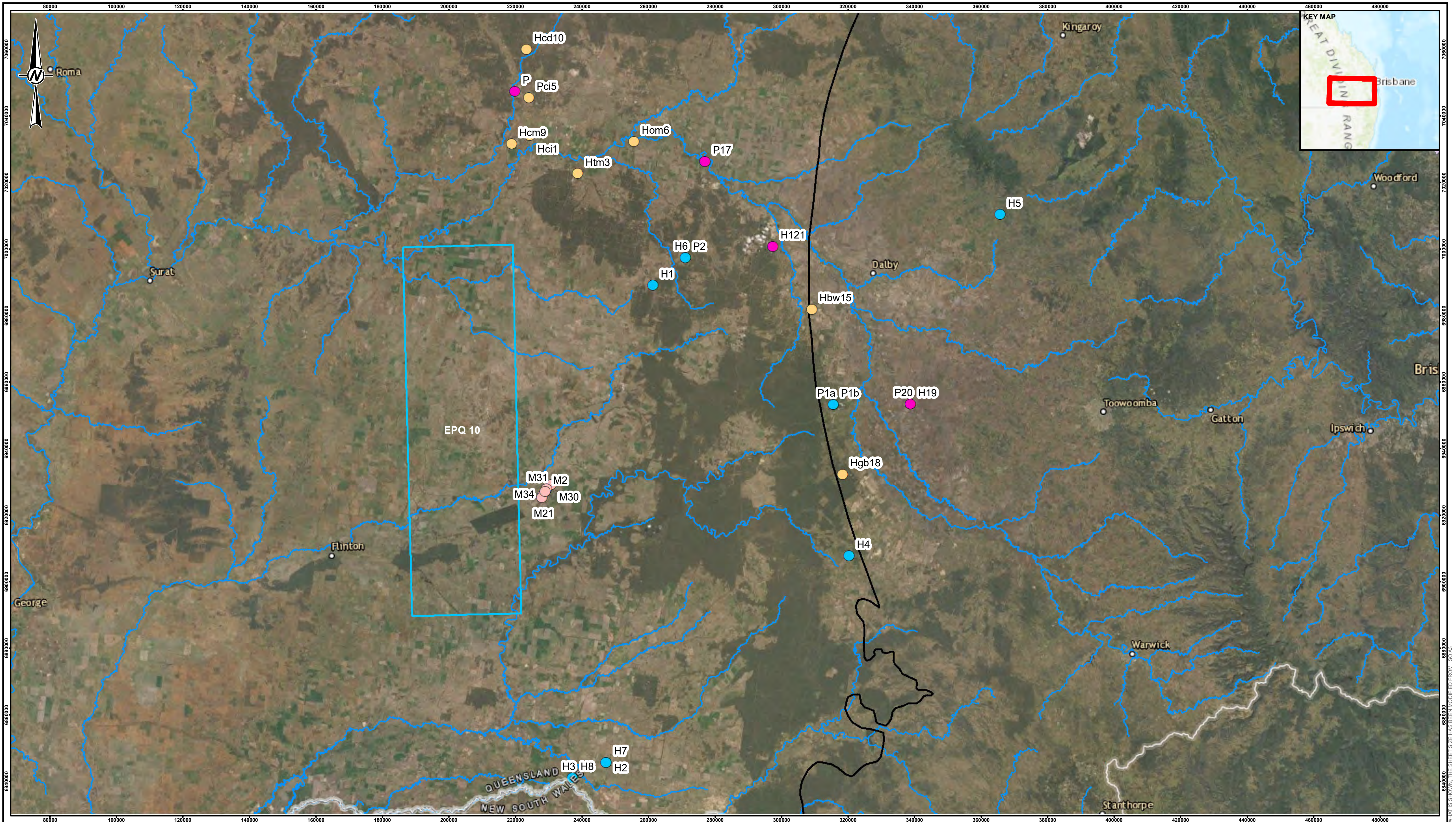


Figure 6: Box plots for pre-existing chemical data (Rodger et al., 2020)

Rodger et al. (2020) analysed an additional 14 new samples from the Precipice Sandstone, of which seven were taken from the Moonie Oil Field (of these 7 samples, 4 samples co-produce from the lower Evergreen Formation), and 17 new samples were taken from the Hutton Sandstone. The location of the samples is shown in Figure 7. The electrical conductivity (EC) and the Na concentration show a general increase with depth in the Hutton Formation, while this trend is not observed for the Precipice Sandstone (Figure 8) (Rodger et al, 2020). The samples from the Moonie Oil Field are very distinctive from the other samples, and the Precipice Sandstone samples in the north (P17 and Pci5) show the highest EC values (Figure 8) (Rodger et al., 2020).



LEGEND

- ▭ Surat Basin (Queensland extent)
- — Major watercourse
- ▭ Exploration permits for greenhouse gas

Bores used in hydrochemistry analysis

- ● CSG
- ● GA 2014
- ● Moonie
- ● South Surat

0 20 40

1:1,100,000 @ A3 KILOMETRES

NOTE(S)

1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)

1. MAJOR WATERCOURSES & BORES: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. EXPLORATION PERMITS FOR GREENHOUSE GAS: © STATE OF QUEENSLAND (DEPARTMENT OF RESOURCES) 2021
3. ESRI, HERE, GARMIN, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY

CLIENT

CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT

SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT

WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE

BORES USED IN HYDROCHEMISTRY ANALYSIS

PROJECT NO.	CONTROL	REV.	FIGURE
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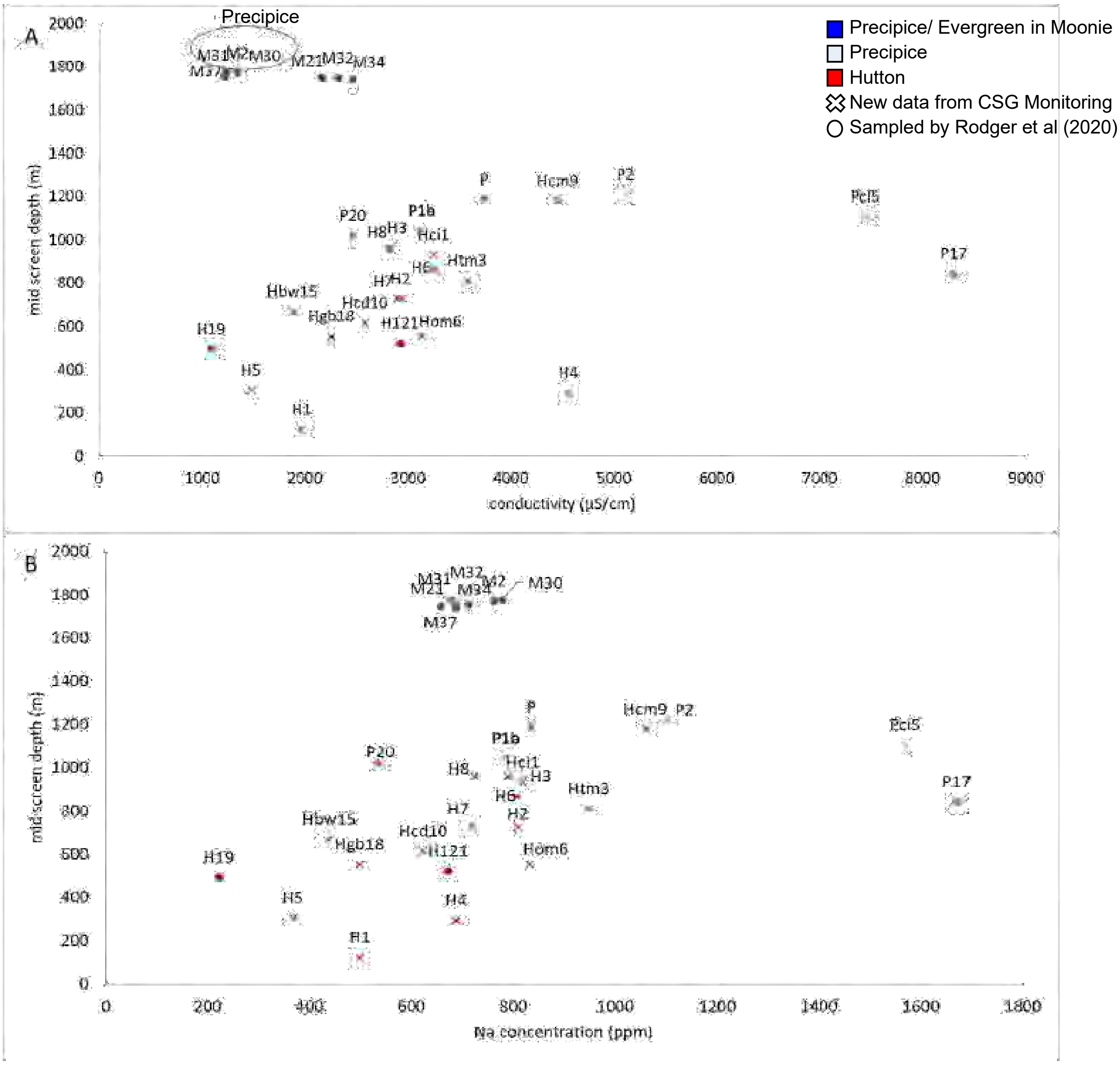


Figure 8: A) Mid-screen depth vs EC; B) Mid-screen depth vs Na concentration (modified from Rodger et al, 2020)

4.2.3.2 Isotope data

Isotope data is available for the southern Surat Basin. IsoTube mud gas analyses were undertaken by ANLEC at West Moonie-1 Injection Well and West Moonie-2 Monitoring Well. Furthermore, the West Moonie Shallow Monitoring Bore (Griman Creek Formation) and West Moonie-1 Injection Well (Precipice Sandstone) have been independently sampled for isotopic values by UQ.

As described below, where data is available, it tends to support hydraulic disconnection between the Hutton Sandstone and Precipice Sandstone aquifers, supporting the effectiveness of the Evergreen Formation aquitard.

Rodger et al. (2020) plotted the available Deuterium (δ^2H) and delta-O-18 (δ^{18}O) isotope data for the Precipice and Hutton Sandstone, together with the global meteoritic water line (GMWL) and the local meteoric water line (LMWL) (Figure 9). Generally, the Hutton samples are closer to the LMWL while the Precipice samples fall closer to the GMWL. The depleted δ^2H and δ^{18}O values close to the meteoric water line indicated there is recharge under colder climate conditions and little influence of evaporation prior to drainage (Rodger et al, 2020).

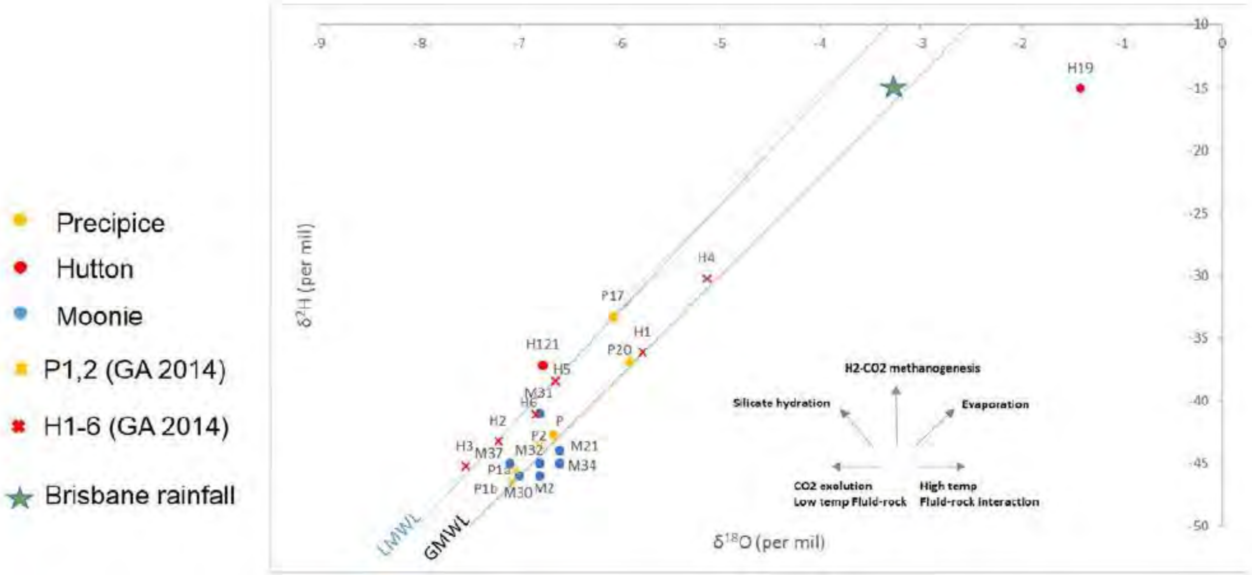


Figure 9: Plot of δ²H vs δ¹⁸O of water. The GMWL and LMWL are shown (Rodger et al., 2020)

The Strontium ratio ($^{87}Sr/^{86}Sr$) indicates a clear difference between the Hutton and the Precipice Sandstone (Figure 10). The radiogenic values in the Hutton are unusually low, possibly indicating recharge through a geochemical equilibrium with volcanic rock formations, where the $^{87}Sr/^{86}Sr$ ratio in the Precipice Sandstone is between that of modern seawater, modern recharge and Jurassic seawater (Rodger et al., 2020).

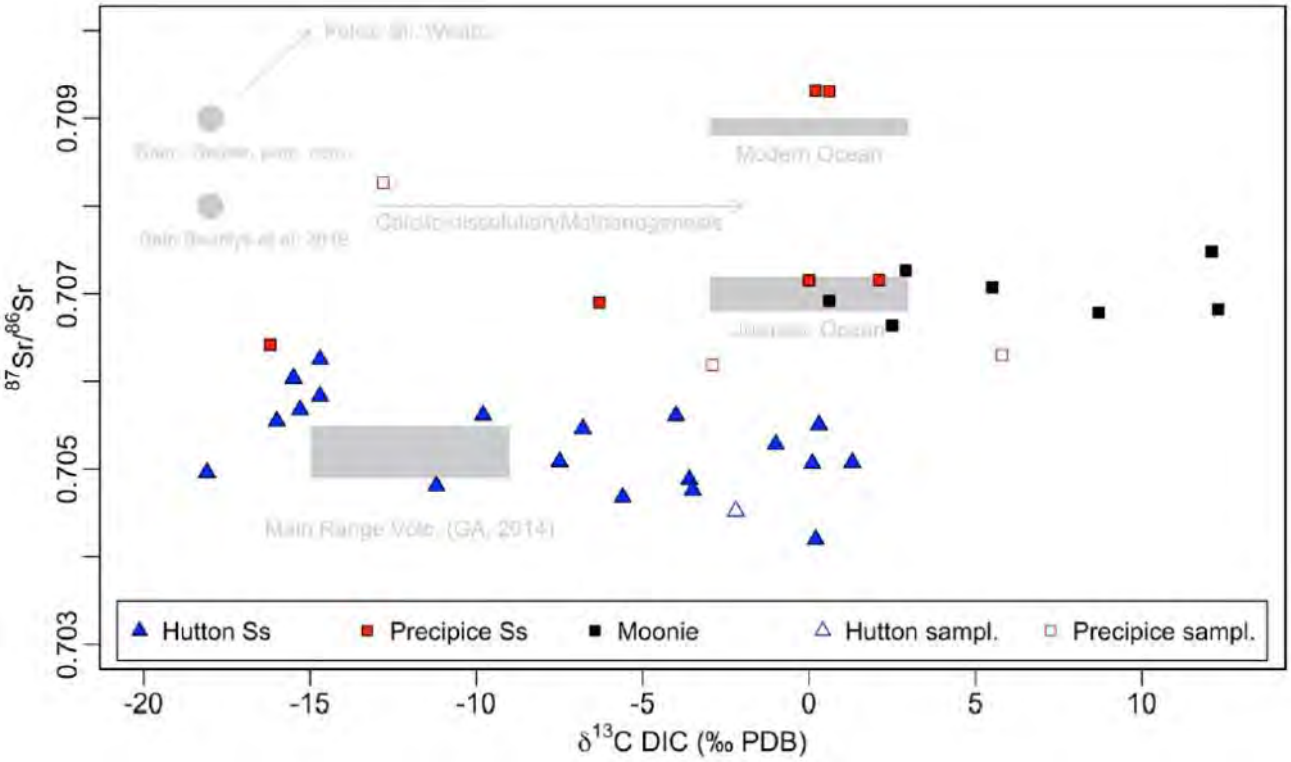


Figure 10: $^{87}Sr/^{86}Sr$ isotope ratios as a function of C (open symbols are sampled by UQ, full symbols represent data from Geoscience Australia (2014), from Rodger et al. (2020)

Low Carbon-14 (^{14}C) activities and low Chlorine-36 (^{36}Cl) ratios indicate residence times of more than 30,000 years in the basin (Figure 11) (no correction for rock/ water interactions applied) (Rodger et al., 2020).

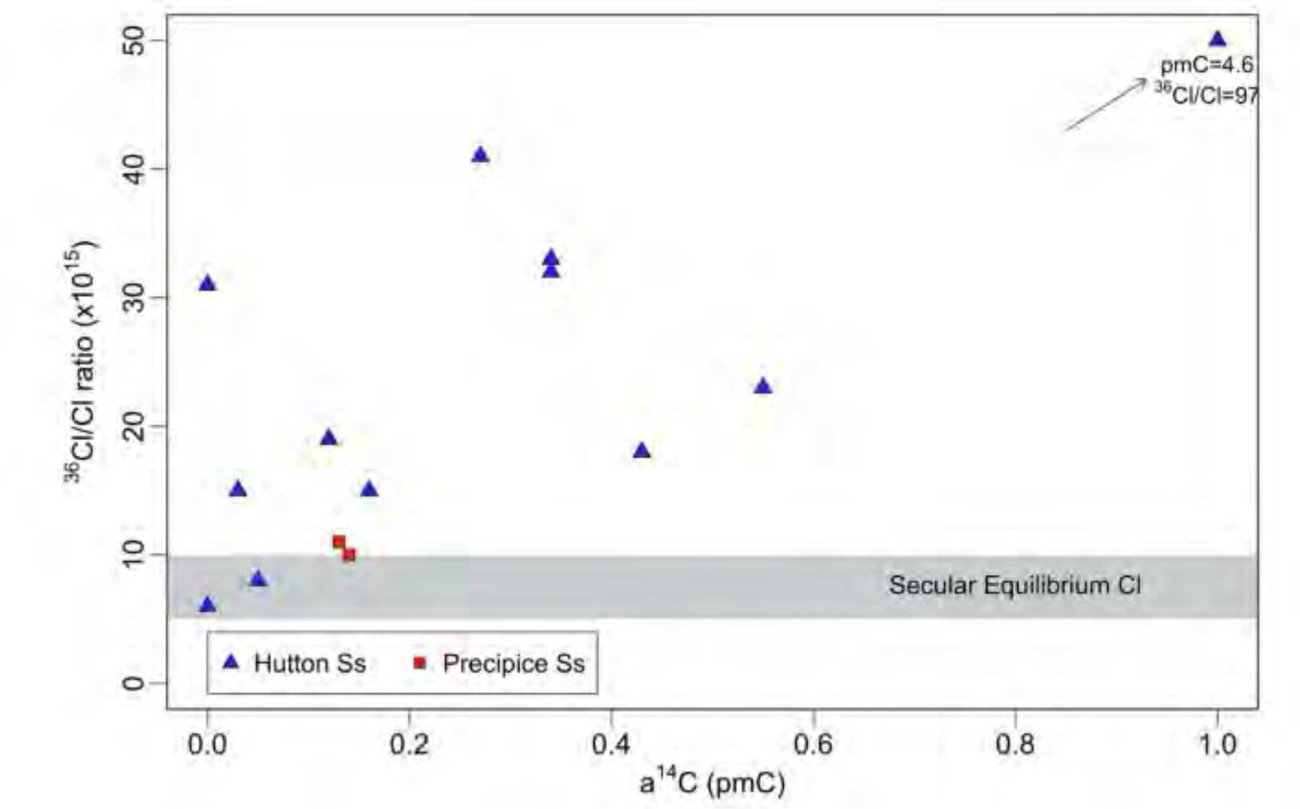


Figure 11: $^{36}Cl/Cl$ and ^{14}C activities for Hutton and Precipice Sandstone in the southern Surat Basin (Rodger et al., 2020)

4.3 Local geology and hydrogeology at EPQ10 Project area

The proposed test injection is at West Moonie-1 Injection Well is in the southern portion of EPQ10 (Figure 12). At this location the Surat Basin sediments are thicker than 2 km due to its central and southern location in the basin and proximity to the Mimosa Syncline.

4.3.1 Precipice Sandstone

Figure 13 presents a conceptual schematic of the geological layers of the Surat Basin at the West Moonie-1 Injection Well showing that the Surat Basin is made up of a number of aquifers and aquitards.

The Precipice Sandstone is the target storage reservoir at the West Moonie-1 Injection Well. West Moonie-1 Injection Well penetrated two shallower Surat Basin regional aquifers being 125 m of Mooga Sandstone at 925 m bgl, and 248 m of Gubberamunda Sandstone at 1,156 m bgl. There are six basin-scale tight aquitards present between the Precipice Sandstone and the shallow aquifers that support EVs such as GDEs.

The Precipice Sandstone is a regional aquifer in the Surat Basin and it is made up of two layers:

- The upper Precipice Sandstone which contains a relatively high proportion of reactive minerals, such as muscovite, feldspar, kaolinite, chlorite and calcite. At West Moonie-1 Injection Well, it is approximately 10 m thick, and the sediment is considered to be a tidally influenced meandering fluvial deposit.

- The lower Precipice Sandstone which has a very high quartz content (approximately 96%) and few reactive minerals making it relatively inert. This layer also has relatively high porosity and permeability and is 78 m thick at this location. It is, therefore, a good target for GHG stream injection testing. The lower Precipice Sandstone is a sand-dominated formation deposited from a multi-channel braided to meandering fluvial system that is approximately 80 m thick at West Moonie-1 injection Well.

4.3.2 Evergreen Formation

The Precipice Sandstone is directly overlain and sealed by the Evergreen Formation – a regional aquitard – made up of interbedded sandstone, siltstone, mudstone and occasional thin coal stringers. Evergreen Formation is approximately 160 m thick. General integrity of the seal, particularly around the gas field, is demonstrated by the fact that it has trapped fluids (oil, gas and groundwater) over a long geological period (OGIA, 2021).

The Evergreen Formation is comprised of the lower Evergreen Formation, the Boxvale Sandstone Member, the Westgrove Ironstone Member, and the upper Evergreen Formation. OGIA (2021) classified the Boxvale Sandstone Member as a partial aquifer, while it recognised the upper Evergreen Formation as a tight aquitard. The upper Evergreen Formation will act as the primary lithological seal that will prevent vertical migration of the injected GHG stream into any of the younger aquifers above the Precipice Sandstone.

The Evergreen Formation is not the only aquitard above the Precipice Sandstone in this deep part of the Surat Basin. Four additional aquitards exist (OGIA, 2021), each of which will provide significant vertical resistance to upwards migration of the GHG plume from the Precipice Sandstone.

The primary seal, being the Evergreen Formation, separates the Precipice Sandstone from the overlying Hutton Sandstone. Regional connection of the two aquifers through faults cannot be excluded at the basin-scale (Rodger et al., 2020). However, there is no hydraulic connection between these two aquifers at the West Moonie-1 Injection Well as evidenced from the significant pressure head differences, obtained via drill stem test pressure measurements and acquisition of Modular Formation Dynamic Tester (MDT) pressure profiles at West Moonie-2 Monitoring Well. Further, pressure data from West Wandoan-1 Well showed significant water pressure gradients between Hutton and Precipice Sandstone indicating that the Evergreen Formation is a regional seal that extends north into EPQ7.

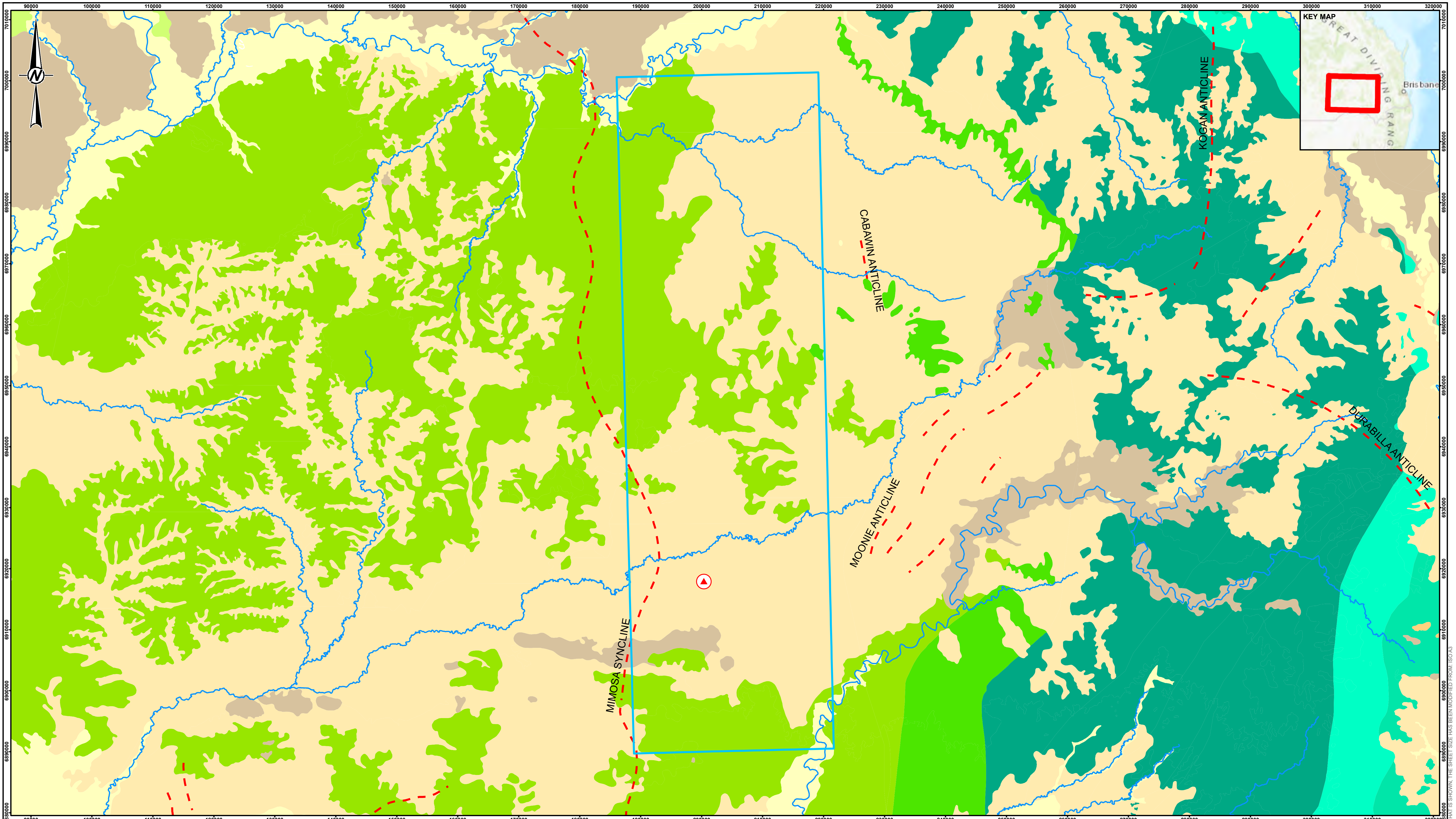
4.3.3 Moolayember Formation

The Precipice Sandstone unconformably overlies the Moolayember Formation. The Moolayember Formation is the youngest Bowen Basin formation at this locality. The Moolayember Formation is composed mainly of mudstones and lithic sandstones and is classified as a tight aquitard. Therefore, it will not allow the Precipice Sandstone groundwater to interact with groundwater in the underlying Bowen Basin.

Approximately 370 m of Moolayember Formation was intersected in West Moonie-1 Injection Well. Total depth was reached at 2,714.7 mRT, still within the Moolayember Formation.

4.3.4 Structural geology

Structural elements are discussed in Section 4.6.4. However, it is important to note that West Moonie-1 Injection Well is located close to the axis of a major syncline. Therefore, the Precipice Sandstone aquifer is relatively deep and unlikely to be used as a source of groundwater.



LEGEND

- 🔺 West Moonie-1
- — Major watercourse
- ▭ EPQ10

Detailed Structure

- - - Fold

Surface Geology

- 🟨 Qa-QLD
- 🟨 Qs-SQ
- 🟫 TQr\b-SEQ
- 🟫 Ts-QLD
- 🟧 Main Range Volcanics
- 🟩 Griman Creek Formation
- 🟩 Surat Siltstone, Wallumbilla Formation
- 🟩 Coreena Member
- 🟩 Bungil Formation
- 🟩 Springbok Sandstone
- 🟩 Walloon Coal Measures
- 🟩 Kumbarilla beds

0 10 20
1:600,000 @ A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
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3. SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION
(CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ADT
APPROVED	RH

TITLE
EPQ10 GEOLOGY

PROJECT NO.	CONTROL	REV.	FIGURE
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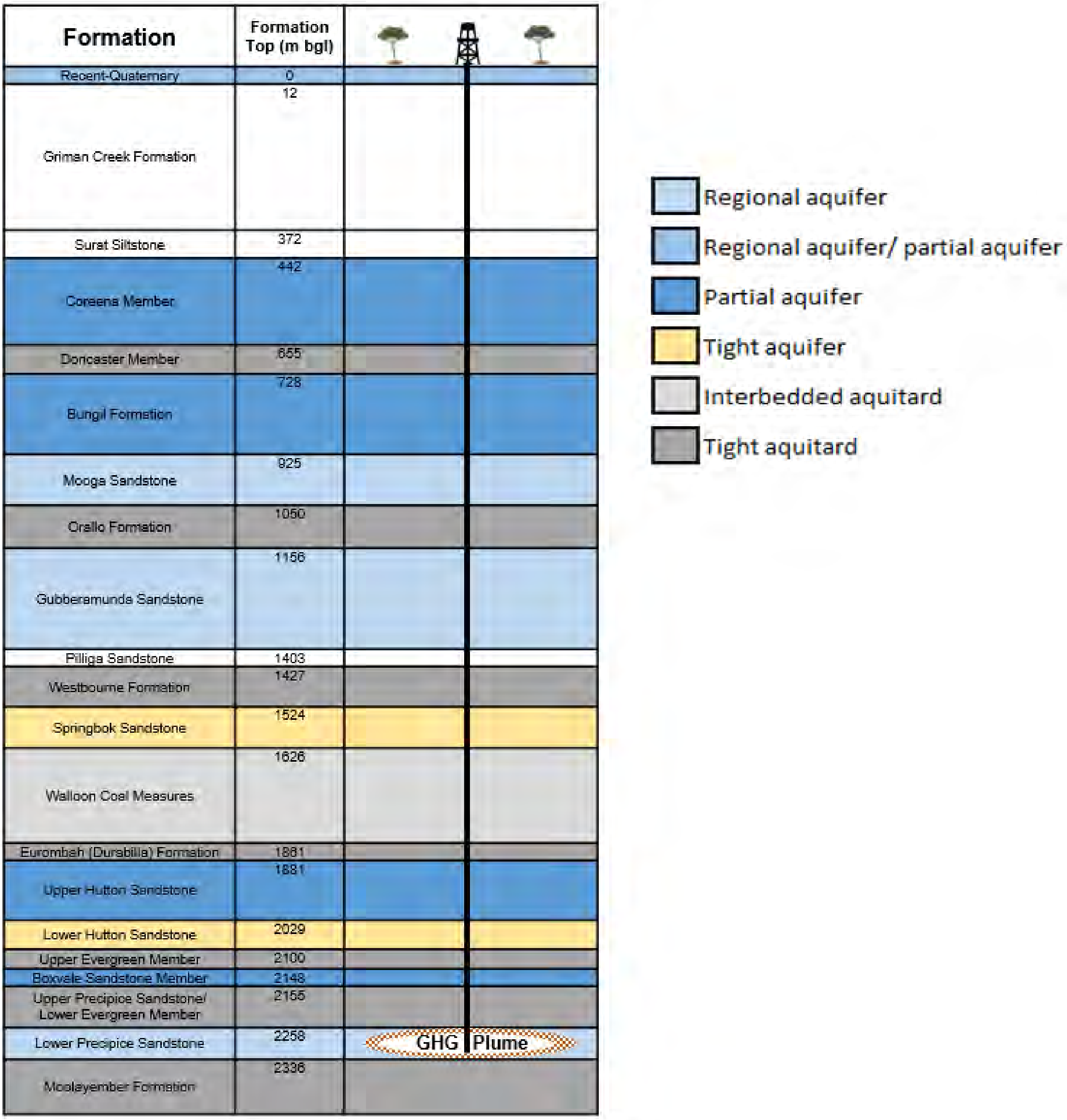

Formation	Formation Top (m bgl)
Recent-Quaternary	0
Griman Creek Formation	12
Surat Siltstone	372
Coreena Member	442
Doncaster Member	655
Bungil Formation	728
Mooga Sandstone	925
Orallo Formation	1050
Gubberamunda Sandstone	1156
Pilliga Sandstone	1403
Westbourne Formation	1427
Springbok Sandstone	1524
Walloon Coal Measures	1626
Eurombah (Durabilla) Formation	1881
Upper Hutton Sandstone	1881
Lower Hutton Sandstone	2029
Upper Evergreen Member	2100
Boxvale Sandstone Member	2148
Upper Precipice Sandstone/ Lower Evergreen Member	2155
Lower Precipice Sandstone	2258
Moolayember Formation	2336

Figure 13: Simplified schematic overview of the basin-scale aquitards that separate the test injection at West Moonie-1 Injection Well from the overlying GAB aquifers. Formation tops as encountered in West Moonie-1 Injection Well.

4.4 Water quality

4.4.1 EPQ10 Precipice Sandstone groundwater quality

Groundwater quality sampling events were conducted by CTSCo and UQ in the Project wells West Moonie-1 Injection Well, West Moonie-2 Monitoring Well, West Moonie Shallow Monitoring Bore and registered nearby bores (i.e., Milgarra Bore) between 2020 and 2021. Laboratory analysis results and certificates are shown in Appendix E.

A summary of groundwater sampling details is presented in Table 5 and additional information in Table 28.

Table 28: Summary of groundwater sampling details.

Borehole	Sample Date	Sample Reference ID
West Moonie-1 Injection Well	30/11/2020	WM1_Water01 at 450 bbls (~71,545 L)
West Moonie-1 Injection Well	30/11/2020	WM1_Water02 at 500 bbls (~79,490 L)
West Moonie-1 Injection Well	30/11/2020	WM1_Water03 at 520 bbls (~82,670 L)
West Moonie-1 Injection Well	30/11/2020	WM1_Water04 at 540 bbls (~85,855 L)
West Moonie-1 Injection Well	30/11/2020	WM1_Water05 at 560 bbls (~89,030 L)
West Moonie-1 Injection Well	19/07/2021	West Moonie 1
West Moonie Shallow Monitoring Bore	19/07/2021	West Moonie Shallow
West Moonie-1 Injection Well	16/07/2021	West Moonie 1 Flow back water 1
West Moonie-1 Injection Well	16/07/2021	West Moonie 1 Flow back water 2
West Moonie-1 Injection Well	16/07/2021	West Moonie 1 Flow back water 3
Milgarra Bore	14/06/2021	Milgarra Bore 1
Milgarra Bore	25/08/2021	Milgarra Bore 2

Note: Bbls = barrels

Water quality sampling within EPQ10 was undertaken on 30 November 2020 after the purging of 89,000 litres (L) of water during appraisal of West Moonie-1 Injection Well. The water quality sample was potentially contaminated by drilling muds, indicated by elevated concentrations of potassium (K) and chloride (Cl).

Potassium chloride is used as an additive to drilling muds to stabilise clays. Contamination with drilling fluid filtrate is a common issue when developing deep wells (APLNG, 2016). As such, CTSCo took three additional samples from West Moonie-1 Injection Well on 16 July 2021. These three new samples were collected after pumping an additional 129,000 L, 137,000 L and 145,000 L from the well.

Figure 14 shows the evolution and eventual stability of TDS, total alkalinity, chloride, sodium and potassium. Figure 15 shows the evolution of iron and stability of fluoride. The water quality data for the samples collected on 16 July 2021 is presented in Table 29.

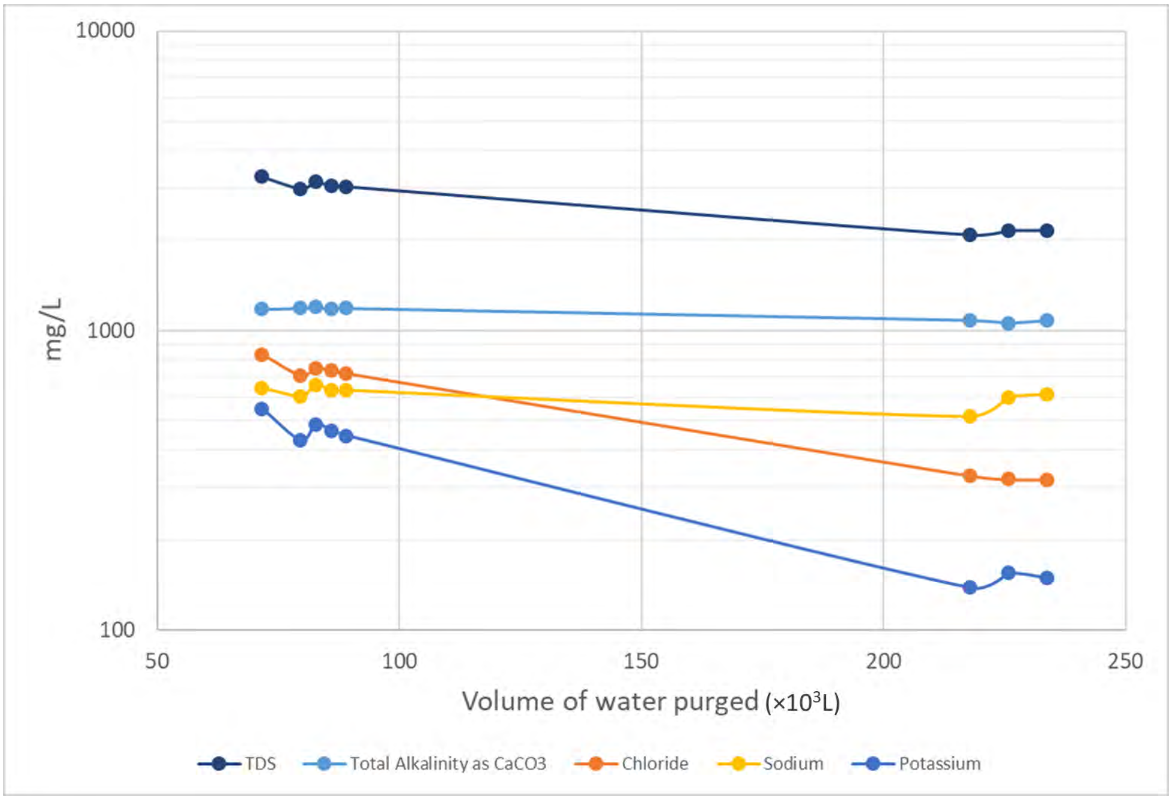

Figure 14: Evolution of TDS, total alkalinity, chloride, sodium and potassium in West Moonie-1 Injection Well compared with produced water volume

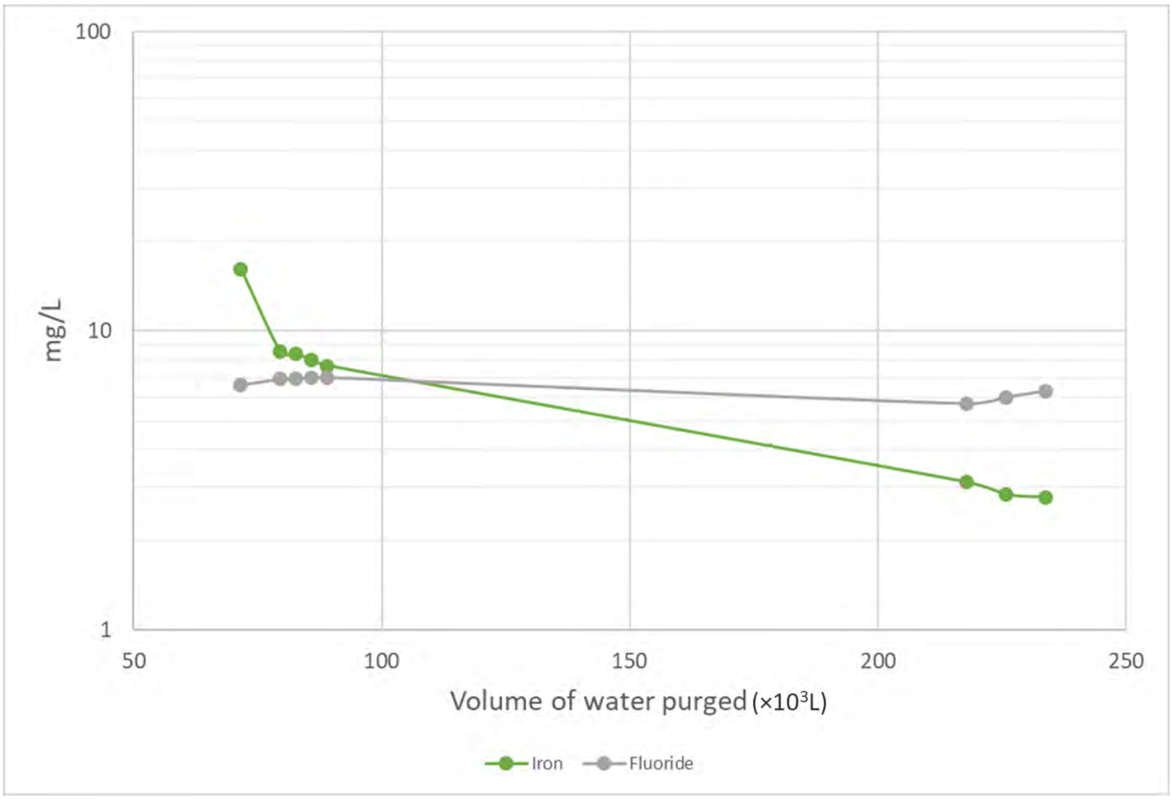

Figure 15: Evolution of iron and fluoride in West Moonie-1 Injection Well compared with produced water volume

Table 29: West Moonie-1 Injection Well water quality data sampled on 16 July 2021

Group	Parameter	Units	Sample 1 at 129,000 L	Sample 2 at 137,000 L	Sample 3 at 145,000 L
Physiochemical and major ions	EC	µS/cm	2,930	2,910	2,920
	pH	pH Units	8.12	8.16	8.35
	TDS	mg/L	1,880	1,850	1,850
	Dissolved Oxygen	mg/L	1.1	5.1	2.1
	Ammonia	mg/L	0.92	0.84	0.70
	Nitrate	mg/L	<0.01	<0.01	<0.01
	Sodium	mg/L	518	598	611
	Potassium	mg/L	139	155	150
	Calcium	mg/L	5	6	6
	Magnesium	mg/L	1	1	1
	Chloride	mg/L	328	319	318
	Sulphate	mg/L	8	8	8
	Bicarbonate Alkalinity	mg/L	1,080	1,060	1,060
	Carbonate Alkalinity	mg/L	<1	<1	19

Group	Parameter	Units	Sample 1 at 129,000 L	Sample 2 at 137,000 L	Sample 3 at 145,000 L
	Hydroxide Alkalinity	mg/L	<1	<1	<1
	Total Alkalinity	mg/L	1,080	1,060	1,080
	Silicon as SiO2	mg/L	38.6	38.6	38.8
	Fluoride	mg/L	5.7	6.0	6.3
	Total Organic Carbon	mg/L	6	----	8
	Reactive Phosphorus	mg/L	0.01	0.01	0.01
	Total Anions	meq/L	31.0	30.3	30.7
	Total Cations	meq/L	26.4	30.4	30.8
Heavy Metals (Total)	Aluminium	mg/L	0.14	0.03	0.05
	Arsenic	mg/L	<0.001	<0.001	<0.001
	Beryllium	mg/L	<0.001	<0.001	<0.001
	Boron	mg/L	0.68	0.83	0.73
	Cadmium	mg/L	<0.0001	<0.0001	<0.0001
	Chromium	mg/L	0.003	<0.001	<0.001
	Cobalt	mg/L	0.003	0.002	0.016
	Copper	mg/L	<0.001	<0.001	<0.001
	Iron	mg/L	3.12	2.84	2.78
	Lead	mg/L	<0.001	<0.001	<0.001
	Lithium	mg/L	0.126	0.157	0.138
	Manganese	mg/L	0.048	0.047	0.049
	Mercury	mg/L	<0.0001	<0.0001	<0.0001
	Molybdenum		0.003	0.003	0.003
	Nickel	mg/L	<0.001	0.001	0.001
	Selenium	mg/L	<0.01	<0.01	<0.01
	Silver	µg/L	0.34	0.24	0.07
	Uranium	mg/L	<0.001	<0.001	<0.001
	Vanadium	mg/L	<0.01	<0.01	<0.01
	Zinc	mg/L	<0.005	<0.005	<0.005
Total Petroleum Hydrocarbons	TPH C6 - C9 Fraction	µg/L	----	<20	<20
	TRH C6 – C10 Fraction	µg/L	----	<20	<20
	Methane	µg/L	1,640	1,420	----

Group	Parameter	Units	Sample 1 at 129,000 L	Sample 2 at 137,000 L	Sample 3 at 145,000 L
BTEXN	Benzene	µg/L	----	<1	<1
	Toluene	µg/L	----	3	<2
	Ethylbenzene	µg/L	----	<2	<2
	meta- & para-Xylene	µg/L	----	2	<2
	ortho-Xylene	µg/L	----	<2	<2
	Total Xylenes	µg/L	----	2	<2
	Sum of BTEX	µg/L	----	5	<1
	Naphthalene	µg/L	----	<5	<5
TPH(V)/BTEX Surrogates	1.2-Dichloroethane-D4	%	----	116	122
	Toluene-D8	%	----	111	118
	4-Bromofluorobenzene	%	----	110	120

The West Moonie-1 Injection Well water quality data was then compared with two sources of water quality data for the Precipice Sandstone aquifer in the southern Surat:

Source 1 – Southern Surat Regional Data

The water quality from eight regional Precipice Sandstone bores (referred to herein as ‘South Surat regional bores’), which were sampled by UQ for the ANLEC ‘Regional hydrogeology of the southern Surat Basin’ project (Reference: 7-0918-C316). These bores are located in the central and southern parts of the basin at overburden depths between 800 m and 1,300 m. The statistical comparison with the West Moonie-1 Injection Well sample is shown in Figure 16.

Source 2 – Moonie Oil Field

The water quality from seven Moonie Precipice Sandstone bores, as described in UQ-SDAAP. Four of these co-produce from the lower Evergreen Formation (Mahlbacher, 2019). These seven bores produce from overburden depths of between 1,700 and 1,800 m and are situated approximately 30 km to the east of the West Moonie-1 Injection Well. The statistical comparison with the West Moonie-1 Injection Well sample is shown in Figure 17.

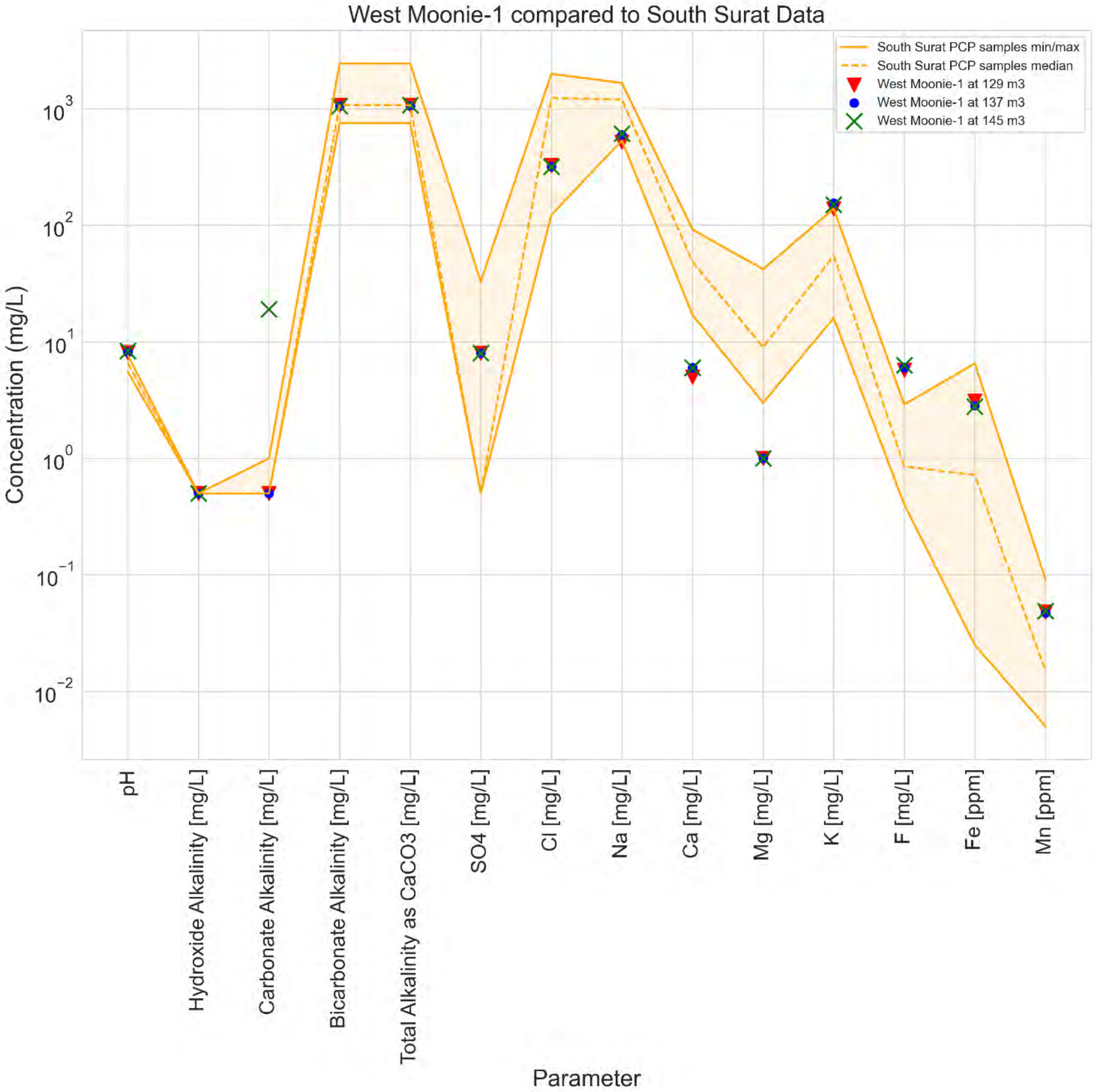

Figure 16: Semi-log plot of southern Surat regional bore groundwater quality data (minimum, maximum and median) compared to West Moonie-1 Injection Well

The comparison against the UQ southern Surat Basin regional groundwater data indicates that:

- West Moonie-1 Injection Well samples are within range (or lower) of regional samples for: hydroxide alkalinity, bicarbonate alkalinity, total alkalinity, sulfate, sodium, chloride, calcium, magnesium, iron and manganese.
- West Moonie-1 Injection Well samples are above the range of regional samples for: pH, carbonate alkalinity, and fluoride.
- West Moonie-1 Injection Well samples are proximal to the upper range for potassium.

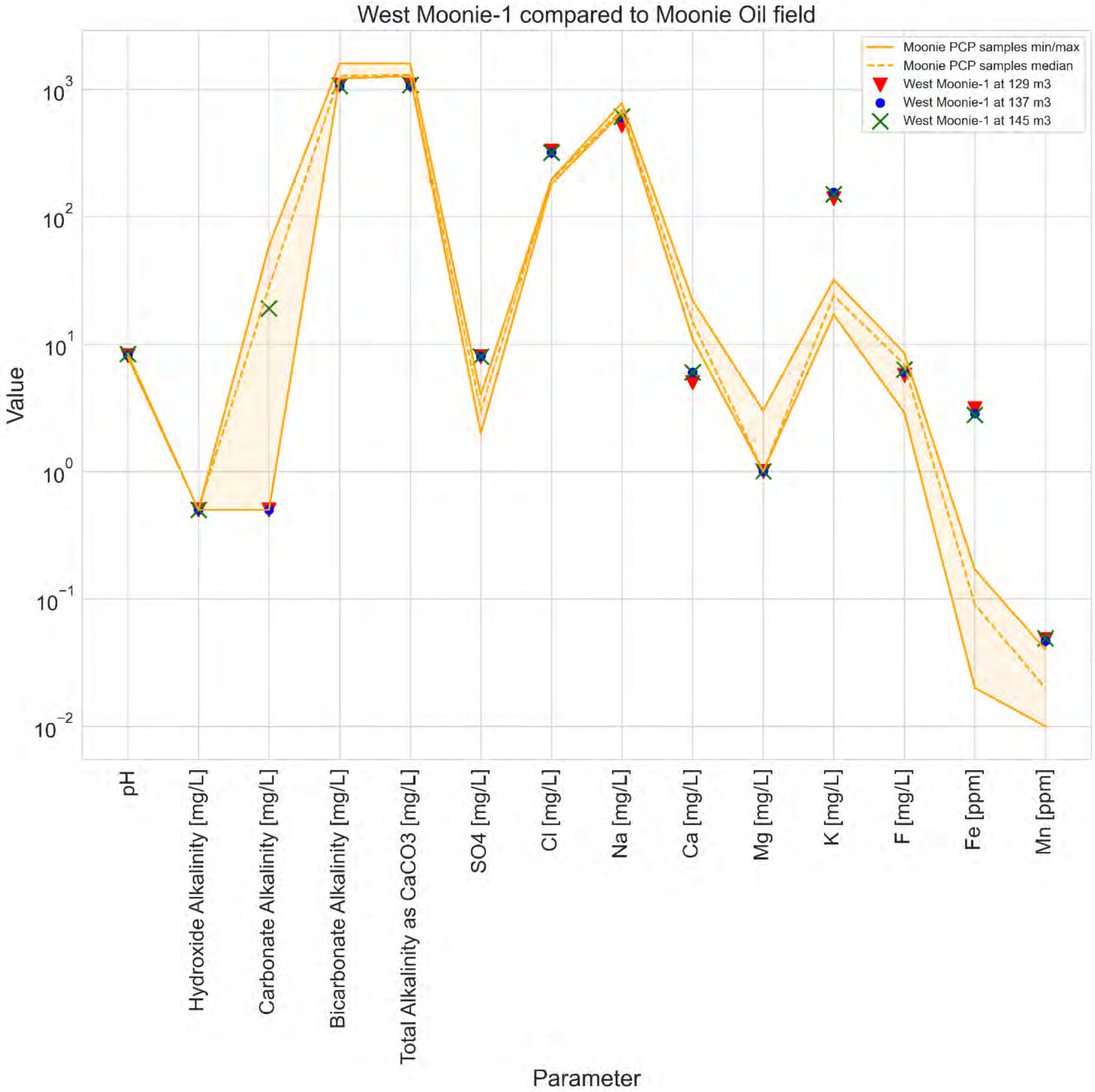

Figure 17: Semi-log plot of Moonie Oil Field groundwater quality data (minimum, maximum and median) compared to West Moonie-1 Injection Well

The comparison against the Moonie Oil Field groundwater data indicated that:

- West Moonie-1 Injection Well samples are within range (or lower) of Moonie Oil Field samples for: pH, hydroxide alkalinity, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, sodium, calcium, magnesium, and fluoride.
- West Moonie-1 Injection Well samples are above the range of Moonie Oil Field samples for sulphate, chloride, potassium, iron and manganese.

All of the analytes are either similar or below the measured ranges in at least one of the two figures (Figure 16 or Figure 17) indicating that the West Moonie-1 Injection Well groundwater quality aligns with concentrations observed for the Precipice Sandstone across the south of the Surat Basin.

4.4.2 EPQ10 baseline water quality in overlying aquifers

Three overlying aquifers in the southern Surat Basin are important sources of freshwater supply for aquatic ecosystem functions, irrigation, stock, domestic, commercial and/or industrial purposes:

- The Gubberamunda Sandstone is the regional aquifer within the southern Surat Basin at approximately 1,200 m bgl. Due to its depth and good freshwater quality, makes it economically viable to drill and extract groundwater for agricultural, commercial and/or industrial uses.
- The Hutton Sandstone is a tight/partial aquifer overlying the Evergreen Formation. It is the most extensive aquifer in the GAB (OGIA, 2016a) and extends westward into the Eromanga Basin (Green, 1997). The Hutton Sandstone is generally between 150 m and 200 m thick and can be up to 400 m thick within the axis of the Mimosa Syncline (OGIA, 2016a).
- The shallow Griman Creek Formation is the likely source aquifer supporting many of the regional EVs such as GDEs and stygofauna.

As part of the baseline water quality investigations, these three aquifers have been sampled and analysed. Table 30 presents the baseline water quality.

Table 30: Baseline water quality for Gubberamunda Sandstone and Griman Creek Formation aquifers

Group	Parameter	Units	Hutton Sandstone (OGIA, 2021)	Milgarra Bore (Gubberamunda) 14/06/2021	West Moonie Shallow Monitoring Bore 19/07/2021
Physiochemical and major ions	EC	µS/cm	-	1,240	48,316
	pH (lab)	pH Units	8.0	8.74	7.75
	TDS	mg/L	1,160	826	-
	Turbidity	NTU	-	0.5	-
	Dissolved Oxygen	mg/L	-	7.9	0.3
	Ammonia	mg/L	-	0.33	-
	Nitrate	mg/L	-	<0.01	-
	Sodium	mg/L	357	330	10,600
	Potassium	mg/L	3	2	65
	Calcium	mg/L	27	<1	1,320
	Magnesium	mg/L	14	<1	1,150
	Chloride	mg/L	400	68	17,700
	Sulphate	mg/L	16	7	1,250
	Total Hardness	mg/L	-	<1	-
	Bicarbonate Alkalinity	mg/L	-	521	11
	Carbonate Alkalinity	mg/L	-	59	<1
	Hydroxide Alkalinity	mg/L	-	<1	<1

Group	Parameter	Units	Hutton Sandstone (OGIA, 2021)	Milgarra Bore (Gubberamunda) 14/06/2021	West Moonie Shallow Monitoring Bore 19/07/2021
	Total Alkalinity	mg/L	399	581	11
	Silicon	mg/L	-	24.9	-
	Fluoride	mg/L	0.3	0.5	<0.1
	Total Organic Carbon	mg/L	-	5	-
	Free Carbon Dioxide	mg/L	-	2	-
	Total Carbon Dioxide	mg/L	-	486	-
	Reactive Phosphorus	mg/L	-	<0.01	-
	Total Anions	meq/L	-	13.7	526
	Total Cations	meq/L	-	14.4	623
Heavy Metals (Total)	Aluminium	mg/L	-	<0.01	-
	Arsenic	mg/L	-	<0.001	-
	Beryllium	mg/L	-	<0.001	-
	Boron	mg/L	-	0.13	-
	Cadmium	mg/L	-	<0.0001	-
	Chromium	mg/L	-	<0.001	-
	Cobalt	mg/L	-	<0.001	-
	Copper	mg/L	-	<0.001	-
	Iron	mg/L	-	0.06	7.19
	Lead	mg/L	-	<0.001	-
	Lithium	mg/L	-	0.011	-
	Manganese	mg/L	-	0.002	3.75
	Mercury	mg/L	-	<0.0001	<0.00004
	Molybdenum	mg/L	-	0.005	-
	Nickel	mg/L	-	<0.001	-
	Rubidium	mg/L	-	-	0.057
	Selenium	mg/L	-	<0.01	-
	Silver	µg/L	-	<0.01	-
	Strontium	mg/L	-	-	37.1
	Uranium	mg/L	-	<0.001	-
	Vanadium	mg/L	-	<0.01	-

Group	Parameter	Units	Hutton Sandstone (OGIA, 2021)	Milgarra Bore (Gubberamunda) 14/06/2021	West Moonie Shallow Monitoring Bore 19/07/2021
	Zinc	mg/L	-	<0.005	-
Hydrocarbons	TPH C6 - C9 Fraction	µg/L	-	<20	-
	TPH C10 – C14 Fraction	µg/L	-	<50	-
	TPH C15 – C28 Fraction	µg/L	-	<100	-
	TPH C29 – C36 Fraction	µg/L	-	<50	-
	TPH C10 – C36 Fraction	µg/L	-	<50	-
	TRH C6 – C10 Fraction	µg/L	-	<20	-
	TRH C6 – C10 Fraction minus BTEX	µg/L	-	<20	-
	TRH >C10 – C16 Fraction	µg/L	-	<100	-
	TRH >C16 – C34 Fraction	µg/L	-	<100	-
	TRH >C34 – C40 Fraction	µg/L	-	<100	-
	TRH >C10 – C40 Fraction	µg/L	-	<100	-
	TRH >C10 – C16 Fraction minus Naphthalene	µg/L	-	<100	-
	Methane	µg/L	-	-	2
	Ethene	µg/L	-	-	<1
	Ethane	µg/L	-	-	<1
	Propene	µg/L	-	-	<1
	Propane	µg/L	-	-	<1
	Butene	µg/L	-	-	<1
	Butane	µg/L	-	-	<1
BTEXN	Benzene	µg/L	-	<1	-
	Toluene	µg/L	-	<2	-
	Ethylbenzene	µg/L	-	<2	-
	meta- & para-Xylene	µg/L	-	<2	-
	ortho-Xylene	µg/L	-	<2	-
	Total Xylenes	µg/L	-	<2	-
	Sum of BTEX	µg/L	-	<1	-
	Naphthalene	µg/L	-	<5	-
	1.2-Dichloroethane-D4	%	-	96.0	-

Group	Parameter	Units	Hutton Sandstone (OGIA, 2021)	Milgarra Bore (Gubberamunda) 14/06/2021	West Moonie Shallow Monitoring Bore 19/07/2021
TPH(V)/BTEX Surrogates	Toluene-D8	%	-	99.1	-
	4-Bromofluorobenzene	%	-	99.4	-

4.5 Environmental Values based on Precipice Sandstone water quality

The Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld) (EPP Water and Wetland Biodiversity) sets the broad environmental protection measures for Queensland waters and provides a framework for identifying EVs for Aquatic Ecosystems, for human uses and for determining water quality guidelines and objectives to enhance or protect the EVs.

The EPP Water and Wetland Biodiversity states the relevant EVs and WQOs for water, as well as the relevant water quality guidelines and indicators for protecting these values. The EVs of specific waters to be protected or enhanced, such as those within the vicinity of the Project, are defined in Schedule 1 of the EPP Water and Wetland Biodiversity.

These values encompass direct uses including water supply for drinking water, irrigation and stock watering, as well as recreational, aesthetic uses and the inherent cultural and spiritual values of waterways. The EPP Water and Wetland Biodiversity defines EVs and WQOs for the surface and groundwater environment in Queensland as a measure for maintaining and/or improving the long-term provision of these services.

The Project is located within the Murray-Darling catchment. EPQ10 spans the Balonne-Condamine, Moonie and Border Rivers drainage basins. West Moonie-1 Injection Well is within the Moonie drainage basin. The EVs for this area are set out in the *Queensland Murray-Darling and Bulloo River Basins Groundwater Environmental Values and Water Quality Objectives* (DES, 2020). Specifically, the Precipice Sandstone aquifer, where the GHG stream is proposed to be injected, is within the Eastern Central Area of the Basal Zone of the GAB. The EVs attributed to this zone are:

- Aquatic Ecosystems
- Water supply:
  - Irrigation
  - Farm supply/use
  - Stock water
  - Drinking water
  - Industrial use
- Cultural, spiritual and ceremonial values.

A comparison of the groundwater quality sampled from West Moonie-1 Injection Well, with the WQOs for the listed EVs is discussed below. Generally, the water quality at West Moonie-1 Injection Well indicates that the aquifer is naturally not consistent with the WQOs for the identified EVs. Additionally, the depth to the aquifer would be a limiting factor for most users. Shallower aquifers with better water quality would be used instead as a source of water.

4.5.1 Aquatic Ecosystems

The Aquatic Ecosystems EV applies to all Queensland waters by default, even if no human-use EVs are identified. The WQOs associated with the Aquatic Ecosystem EV represent the baseline WQOs applied across the state.

The specific objectives associated with the Aquatic Ecosystems EV vary for each basin, catchment, management intent, and flow regime. As stated above, the aquifer targeted by the Project is in the Eastern Central Area of the Basal Zone of the GAB, approximately 2.3 km below the surface.

The groundwater quality of the Precipice Sandstone aquifer at the West Moonie-1 Injection Well naturally exceeds the WQOs set for this zone (DES, 2020), as presented in Table 31, indicating that the *in situ* groundwater quality is poorer than the WQOs for Aquatic Ecosystems. Specifically, the groundwater is more saline, alkaline, and high in chloride and sodium compared to the WQOs for Aquatic Ecosystems.

Table 31: Comparison of Aquatic Ecosystem WQOs and groundwater quality within Precipice Sandstone Aquifer at West Moonie-1 Injection Well

Parameter	Units	WQO – (80th percentile, except where indicated)	Water Quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
			Sample 1	Sample 2	Sample 3
Sodium (Na)	mg/L	342	518	598	611
Calcium (Ca)	mg/L	8.0	5	6	6
Magnesium (Mg)	mg/L	1.0 – 50th %ile 5.0 – 80th %ile	1	1	1
Bicarbonate Alkalinity (HCO_3)	mg/L	673	1,080	1,060	1,060
Chloride (Cl)	mg/L	163	328	319	318
Sulphate (SO_4)	mg/L	28	8	8	8
Nitrate (NO_3)	mg/L	1	<0.01	<0.01	<0.01
EC	µS/cm	1,484	2,930	2,910	2,920
pH	pH units	8.6	8.12	8.16	8.35
Total Alkalinity	mg/L	568	1,080	1,060	1,080

Note Orange shading indicates exceedance for the 80th percentile.

4.5.2 Irrigation and farm use/supply

The Irrigation EV aims to ensure that water is of sufficient quality for crops and does not limit crop yields or cause soil degradation. The Farm Use/Supply EV ensures that water for farm supply is of sufficient quality for produce preparation and domestic uses other than drinking.

When compared to the WQOs relating to heavy metals and metalloids for agricultural irrigation (Table 32), from the EPP Water and Wetland Biodiversity, the aquifer water quality data exceeds the trigger values for a range of different elements, including sodium, chloride, fluoride, boron and iron. The use of this water for irrigation poses a risk of soil degradation, potentially causing sodic soils. This indicates that the groundwater is unlikely to support use for irrigation purposes.

The main consideration for farm supply is limiting corrosion and fouling of farm water supply equipment. For this, pH and water hardness are used as indicators of the corrosion and fouling potential. The pH of the Precipice Sandstone aquifer water from West Moonie-1 Injection Well indicates that the water has an increased fouling potential (as per Table 9.2.25 of ANZECC 2000), and the water hardness (average of 17.4 mg/L calculated) suggests an increased corrosion potential (less than 60 mg/L) (as per Table 9.2.24 of ANZECC 2000). These parameters are also indicators for other water quality related issues such as elevated levels of bicarbonate and sodium, which is already evident in the groundwater. This can lead to unwanted reactions with other farm chemicals reducing their efficiency (ANZECC, 2000). Again, the quality of groundwater indicates these EVs are unlikely to be supported.

Table 32: Comparison of Irrigation WQOs and groundwater quality from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	Units	WQO long-term trigger value	WQO short-term trigger value	Water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
				Sample 1	Sample 2	Sample 3
pH	pH units	6 to 8.5	6 to 8.5	8.12	8.16	8.35
Sodium	mg/L	115		518	598	611
Chloride	mg/L	40		328	319	318
Fluoride	mg/L	1	2	5.7	6.0	6.3
Aluminium	mg/L	5	20	0.14	0.03	0.05
Arsenic	mg/L	0.1	2	<0.001	<0.001	<0.001
Beryllium	mg/L	0.1	0.5	<0.001	<0.001	<0.001
Boron	mg/L	0.5		0.68	0.83	0.73
Cadmium	mg/L	0.01	0.05	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.1	1	0.003	<0.001	<0.001
Cobalt	mg/L	0.05	0.1	0.003	0.002	0.016
Copper	mg/L	0.2	5	<0.001	<0.001	<0.001
Iron	mg/L	0.2	10	3.12	2.84	2.78
Lead	mg/L	2	5	<0.001	<0.001	<0.001
Manganese	mg/L	0.2	10	0.048	0.047	0.049
Mercury	mg/L	0.002	0.002	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.2	2	<0.001	0.001	0.001
Selenium	mg/L	0.02	0.05	<0.01	<0.01	<0.01
Uranium	mg/L	0.01	0.1	<0.001	<0.001	<0.001
Vanadium	mg/L	0.1	0.5	<0.01	<0.01	<0.01
Zinc	mg/L	2	5	<0.005	<0.005	<0.005

Note: Orange shading indicates exceedance of the short-term trigger value, while yellow shading indicates exceedance of the long-term trigger value.

4.5.3 Stock water

This EV aims to ensure that water provided to livestock is of sufficient quality to prevent any deterioration in the health or condition of watered livestock. The natural occurring fluoride concentrations from the samples may be hazardous to livestock health (particularly young livestock). This is likely to render the *in situ* groundwater from the Precipice Sandstone aquifer in the location of West Moonie-1 Injection Well unsuitable for livestock consumption (Table 33).

No other metals or metalloids exceeded their respective WQOs.

Table 33: Exceedances of stock water WQOs from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	WQO	Water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
		Sample 1	Sample 2	Sample 3
TDS (No adverse effects threshold)	5,000 mg/L for sheep 4,000 for beef cattle, horses and pigs 2,500 mg/L for dairy cattle 2,000 mg/L for poultry	1,880	1,850	1,850
Fluoride	2 mg/L	5.7	6.0	6.3

Note: Orange shading indicates exceedance.

The groundwater is unsuitable for livestock consumption and would present a risk to stock based on the fluoride concentration. In addition, as discussed in Section 4.4, the water is likely to be corrosive and foul equipment used to pump water to troughs for drinking. Overall, on this basis, the water is unlikely to be suitable for the purposes of stock water.

4.5.4 Drinking water

The management goals relating to this EV are to reduce the risks of adverse human health effects, maintain palatability of water, as well as to avoid offensive odours.

The existing Precipice Sandstone aquifer groundwater quality at West Moonie-1 Injection Well exceeds the drinking water WQO’s aesthetic values for TDS and sodium (Table 34). There are no health-based limits within the Australian Drinking Water Guidelines for the parameters listed. This is unlikely to affect human health, although may render the water unpalatable. The groundwater would require further treatment to be suitable for this EV. Additionally, reticulation of groundwater is likely to lead to corrosion of water infrastructure.

The depth of the groundwater (approximately 2.3 km deep) would also preclude the economic viability of using groundwater for drinking water. There are other aquifers (e.g., Gubberamunda) at much shallower depths that are more economically viable to drill and access fresher groundwater for use as drinking water.

Table 34: Comparison of drinking water WQOs and groundwater quality from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	WQO	Water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
		Sample 1	Sample 2	Sample 3
pH	6.5-8.5	8.12	8.16	8.35
TDS	600 mg/L (post treatment)	1,880 mg/L (pre-treatment)	1,850 mg/L (pre-treatment)	1,850 mg/L (pre-treatment)
Sodium	180 mg/L (and 20 mg/L for at risk groups)	518 mg/L	598 mg/L	611 mg/L
Sulphate	250 mg/L	8 mg/L	8 mg/L	8 mg/L

Note: Orange shading indicates exceedance.

4.5.5 Industrial use

There are no overarching WQOs relating to industrial use, as industry-specific requirements are case specific and industries usually treat water supplies to meet their needs.

Regardless of the GHG stream injection or not, the *in situ* groundwater in the Precipice Sandstone at the West Moonie-1 Injection Well is brackish, alkaline and has high concentrations of fluoride, chloride and metals. Therefore, it would likely require treatment before industrial use. The depth of the groundwater (approximately 2.3 km deep) would also preclude the economic viability of industrial use of groundwater. There are other aquifers (e.g., Gubberamunda) at much shallower depths that are more economically viable for industrial use.

4.5.6 Cultural, spiritual and ceremonial values

The management goal of this EV is for the basin water resources to remain of a quality which is sufficient to support the cultural, spiritual, and ceremonial values and use of the water. More specifically, this relates to the water-related practices and customs, symbols and landmarks (flora, fauna, and waterways), as well as lifestyles (agriculture and fishing). As described in Section 4.5.8 there are no GDEs or waterways connected to the Precipice Sandstone in the south of the basin. The nearest water bodies connected to the Precipice Sandstone are the springs situated 200 to 300 km to the north of the West Moonie-1 Injection Well. The springs closest to West Moonie-1 Injection Well, attributed to the Precipice Sandstone, is the Cockatoo Creek complex which is approximately 235 km to the north. These will not be affected by the proposed test injection.

This EV does not include specified triggers but implies a more holistic approach to water quality assessment.

4.5.7 Groundwater users

Groundwater in the Surat Basin is extracted for both consumptive purposes and for P&G-related purposes. OGIA (2021) refers to the groundwater that is extracted as part of the P&G industry as ‘associated water’, whereas consumptive water includes water used for agricultural, industrial, town water supply, and stock and domestic use. OGIA (2021) estimates that there are approximately 8,000 water supply bores with the Surat CMA, extracting 58,531 ML/year of groundwater for consumptive use, of which about 38,774 ML (66%) is from the surficial alluvium and basalts, and 19,757 ML is from deeper Surat Basin aquifers. Total water production from existing CSG wells in Surat Basin is around 45,000 ML/year, extracted from the Walloon sub-group coal measures. Water extraction associated with conventional P&G production in the Surat CMA is around 1,000 ML/year, about 95% of which is from Moonie Oil Field (OGIA, 2021).

There are 167 existing registered groundwater bores within 50 km of West Moonie-1 Injection Well (Figure 18). The assigned aquifer attribution is listed in Table 35. Where bores are assigned to multiple aquifers, it has been assumed that the bore is attributed to the formation that is stratigraphically closest to the Precipice Sandstone.

However, as shown on Figure 19, there are only six registered bores accessing the Precipice Sandstone within a 50 km radius of the West Moonie-1 Injection Well. This limited number reflects the deep nature (over 2 km) of the formation and the costs of drilling to these depths. The closest registered bore accessing the Precipice Sandstone is over 24 km from West Moonie-1 Injection Well. All six of the registered Precipice bores are petroleum exploration wells that failed to find commercial volumes of hydrocarbons. The closest non-petroleum Precipice Sandstone registered bore identified is over 75 km to the north-east of West Moonie-1 Injection Well, being registered bore RN160672 and is a monitoring bore required under the Surat CMA UWIR. The overburden depth of the Precipice Sandstone at this location is approximately 1,376 m.

The closest registered water supply bore is approximately 10 km south-east of West Moonie-1 Injection Well and accesses the upper Cretaceous Formation. This water supply bore is RN7764, and the depth from surface is approximately 300 m.

Table 35: Aquifer attribution of registered water bores within 50 km of West Moonie-1 Injection Well

Aquifer attribution[2]	Number of registered water bores within 50 km radius[3]
Alluvium, Basalt and lower Cretaceous	27
Wallumbilla Formation	34
Bungil Formation	6
Mooga Sandstone	29
Orallo Formation	13
Gubberamunda Sandstone	17
Westbourne Formation	7
Springbok Sandstone	1
Walloon Coal Measures	1
Evergreen Formation	1
Precipice Sandstone	6
Clematis Sandstone	2
upper Permian	11
Unassigned	12

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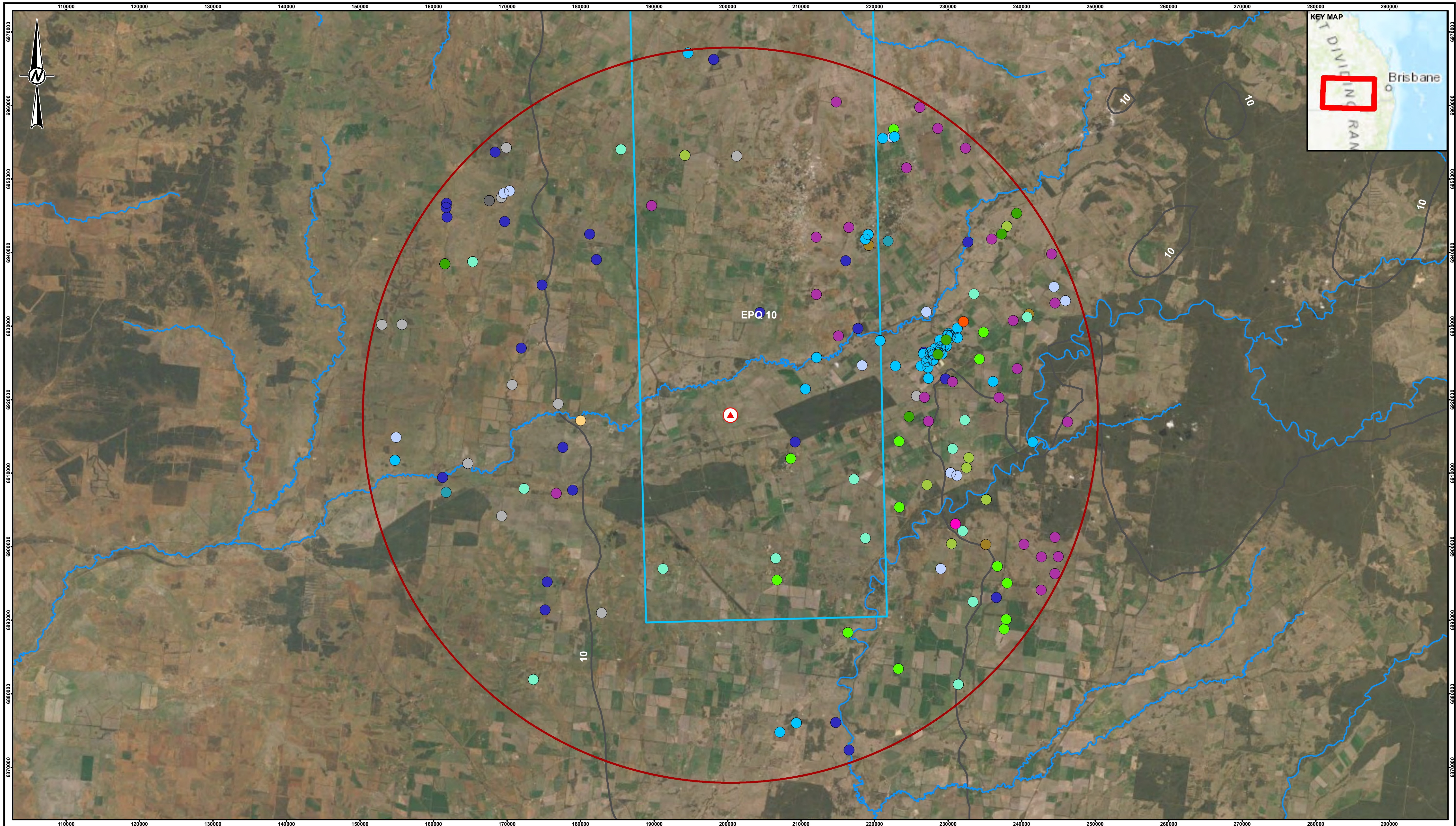
[2] Based on review of GWDB depths versus geological surfaces and GWDB aquifer attribution

[3] Note that some bores have multiple aquifers assigned – in this case the formation closest to the Precipice Sandstone is listed



LEGEND

- 🔺 West Moonie-1
- — Major watercourse
- — Precipice 10 m contour
- ▭ EPQ10
- ▭ 50 km buffer zone

Registered groundwater bores within 50 km

- ● ALLUVIUM AND BASALT
- ● UPPER CRETACEOUS FORMATIONS
- ● WALLUMBILLA FORMATION
- ● BUNGIL FORMATION
- ● MOOGA SANDSTONE
- ● ORALLO FORMATION
- ● GUBBERAMUNDA SANDSTONE
- ● WESTBOURNE FORMATION
- ● SPRINGBOK SANDSTONE
- ● WALLOON COAL MEASURES
- ● DURABILLA FORMATION
- ● HUTTON SANDSTONE
- ● EVERGREEN FORMATION
- ● PRECIPICE SANDSTONE
- ● MOOLAYEMBER FORMATION
- ● CLEMATIS SANDSTONE
- ● UNDIVIDED PERMIAN UPPER
- ● UNASSIGNED

0 10 20
1:500,000 @ A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES & GWDB: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. PRECIPICE CONTOUR: UQ
3. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO,

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION
(CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
REGISTERED EXISITING GROUNDWATER BORES
WITHIN 50 KILOMETERS OF WEST MOONIE-1

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	018

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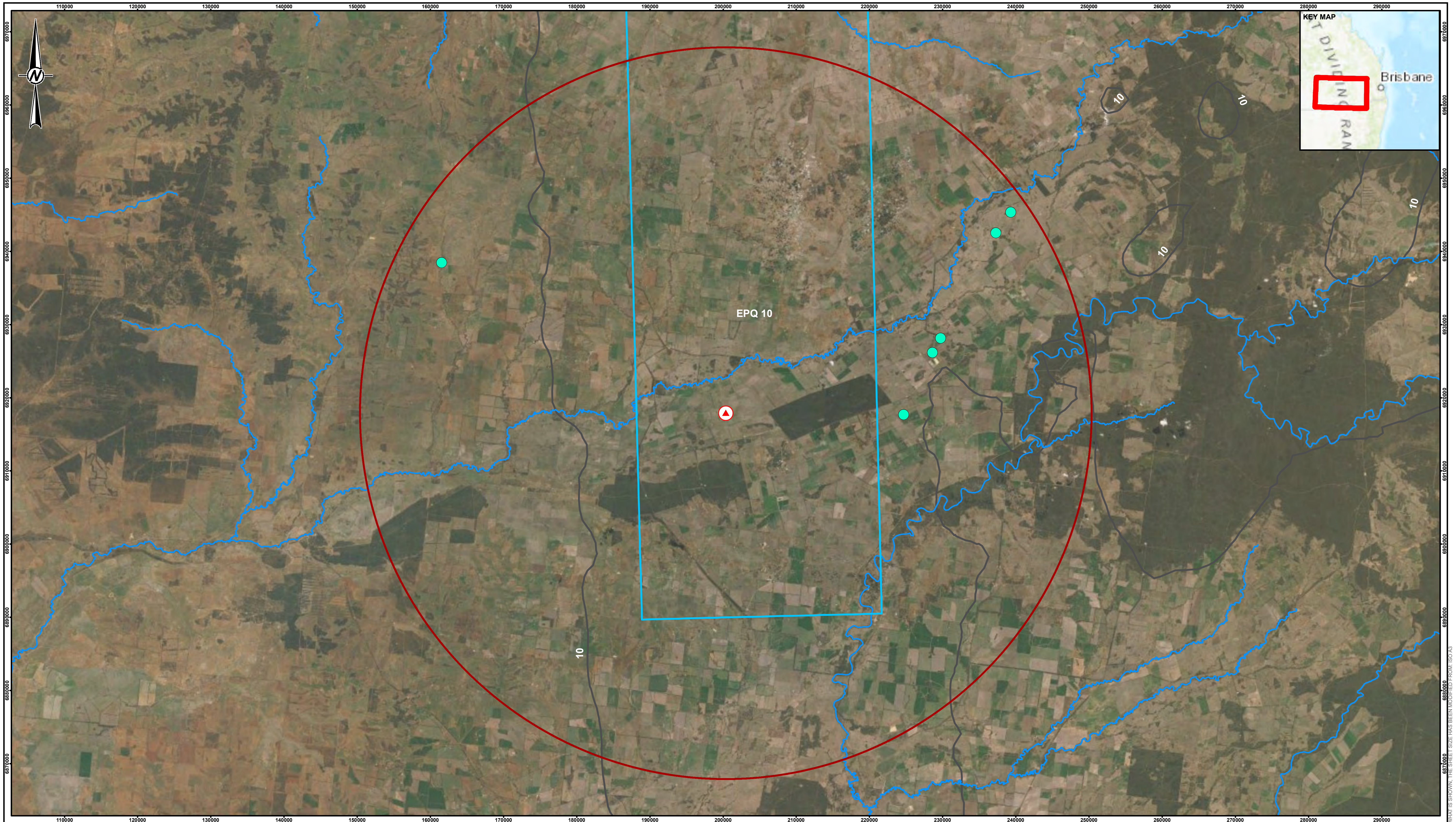

LEGEND

- West Moonie-1
- Major watercourse
- Precipice 10 m contour
- EPQ10
- 50 km buffer zone
- ● Registered precipice groundwater bores within 50 km

0 10 20
1:500,000 @ A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES & GWDB: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. PRECIPICE CONTOUR: UQ
3. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP

CLIENT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

PROJECT
CARBON TRANSPORT AND STORAGE CORPORATION
(CTSCO) PTY LIMITED

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
REGISTERED EXISITING PRICIPICE GROUNDWATER BORES WITHIN 50 KILOMETERS OF WEST MOONIE-1

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	019

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4.5.8 Groundwater Dependent Ecosystems

For discussion on GDEs, refer to the aquatic ecology technical report for the Project, prepared by frc environmental.

4.5.9 Summary

The Project is located within the Murray-Darling catchment. EPQ10 spans the Balonne-Condamine, Moonie and Border Rivers drainage basins. The West Moonie-1 Injection Well is within the Moonie drainage basin. The EVs for this area are set out in the *Queensland Murray-Darling and Bulloo River Basins Groundwater Environmental Values and Water Quality Objectives* (DES, 2020). Specifically, the Precipice Sandstone aquifer, where the GHG stream is proposed to be injected, is within the Eastern Central Area of the Basal Zone of the GAB. The EVs attributed to this zone are:

- Aquatic Ecosystems, including GDEs
- Water Supply:
  - Irrigation
  - Farm supply/use
  - Stock water
  - Drinking water
  - Industrial use
- Cultural, spiritual and ceremonial values.

The water quality analysed from Precipice Sandstone aquifer groundwater recovered from West Moonie-1 Injection Well indicates that at this location the existing groundwater is not consistent with the WQOs for the identified EVs. Additionally, the depth to the aquifer would be a limiting factor for most users. Shallower aquifers such as the Gubberamunda Sandstone (at approximately 1,200 m below surface), having better water quality, would be used instead.

Griman Creek Formation groundwater was sampled from 48 m below surface from a shallow bore drilled in 2021 near the West Moonie-1 Injection Well. The analysed water sample is saline (chloride 17,700 mg/L)[4] and unusable for water supply purposes.

Groundwater in the Surat Basin is extracted for both consumptive purposes and for P&G-related purposes.

OGIA (2021) estimates that there are approximately 8,000 water supply bores with the Surat CMA, extracting 58,531 ML/year of groundwater for consumptive use.

Total water production from existing CSG wells in Surat Basin is around 45,000 ML/year. Water extraction associated with conventional oil and gas production in the Surat CMA is around 1,000 ML/year.

There are 167 existing registered groundwater bores within 50 km of West Moonie-1 Injection Well. However, there are only six registered bores accessing the Precipice Sandstone within a 50 km radius of the West Moonie-1 Injection Well.

The closest registered bore accessing the Precipice Sandstone is over 24 km from West Moonie-1 Injection Well. However, the closest registered water supply bore is approximately 10 km south-east of West Moonie-1 Injection Well and the depth from surface is approximately 300 m.

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[4] ALS Sample Number EB2129349002. Sample date 19/07/21

For discussion on GDEs, refer to the aquatic ecology technical report for the Project, prepared by frc environmental.

4.6 Hydrogeological conceptual model

4.6.1 Background

A HCM is a descriptive representation of a specific groundwater system that incorporates knowledge and interpretation of the geological and hydrogeological systems. A HCM consolidates the hydrogeological understanding of key processes such as recharge and discharge, and the influence of any boundaries and stresses that may be present. The conceptualisation process involves simplifying an inherently complex groundwater system to a simplified version that describes the main features controlling groundwater flow. The degree of simplification is usually guided by the objectives and timescale of the study, and the amount and quality of data available (Anderson and Woessner, 1992; Barnett et al., 2012).

The HCM for this GIA is focused on the reservoir, the lower Precipice Sandstone, as well as the underlying Moolayember Formation, the overlying Evergreen Formation, and the Hutton Sandstone which is a tight/partial aquifer overlying the Evergreen Formation. The HCM takes a regional scale approach when looking at geology, hydrodynamics and structural characteristics, while considering both local and regional scales with respect to the reservoir properties themselves. These reservoir properties will govern the injection characteristics of the GHG stream locally and how the reservoir will respond to pressure changes, both locally and regionally.

The HCM includes the main structural elements, the hydraulic properties of the formations, the conceptual boundaries, groundwater levels and interactions including recharge and discharge processes, water density, and hydrochemistry.

Figure 20 presents the basin-scale surface geology and inferred groundwater flow directions, as interpreted by OGIA (2021). This figure shows that the Precipice Sandstone outcrops 235 km to the north of West Moonie-1 Injection Well, and that the Surat Basin strata dip to the south. As such, the Precipice Sandstone is shallow and outcropping in the north of the basin, and at depths of greater than 2 km in the south within EPQ10. Figure 20 also shows that the groundwater flow directions are broadly aligned with the south-dipping strata.

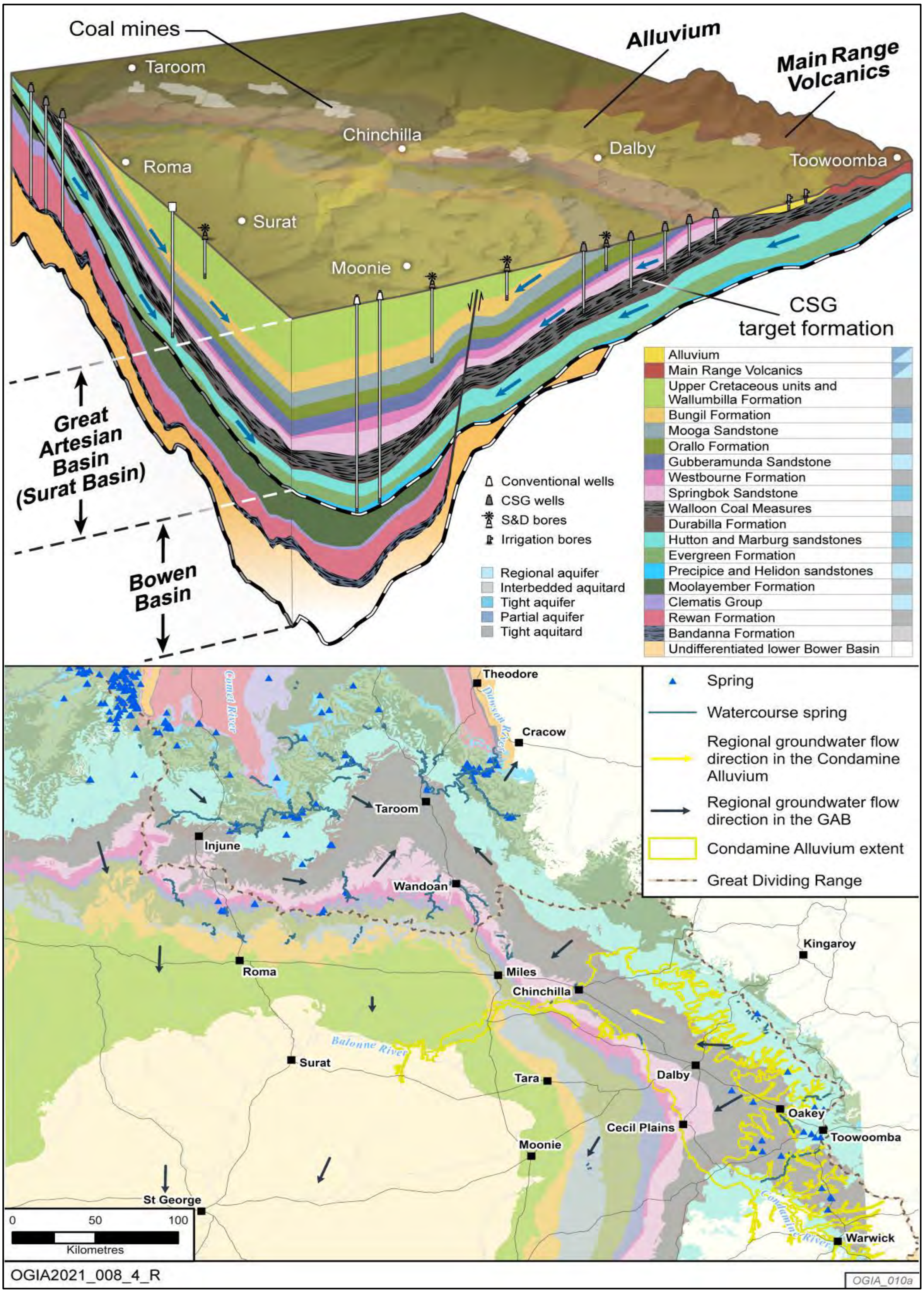

Figure 20: Representation of the main groundwater flow systems in the Surat CMA from OGIA (2021)

4.6.2 Description and extents of the hydrogeology study areas

The hydrogeology study area (HSA) includes (i) a *local study area* for assessing plume migration and water quality impacts within the Precipice Sandstone at EPQ10 and (ii) a *regional study area* to assess broader pressure impacts of GHG stream injection both laterally and vertically. These HSUs form the basis of the predictive numerical modelling used to estimate environmental impacts potentially arising for the Project.

Table 36: Key parameters for the various HSAs considered in this GIA

Study Area	Lateral extents	Vertical extents	HSUs	Focus
Local HSA	2 km by 2 km centred on West Moonie-1 Injection Well	78 m	lower Precipice Sandstone	Near-field GHG stream plume extents during injection and 100 years post-injection
				Near-field reaction path geochemical modelling to assess hydrochemistry processes within plume
Regional HSA	150 km by 400 km	~650 m	All Surat Basin HSUs for baseline characterisation	To assess the basin context for EPQ10 injection
			1. upper Hutton Sandstone 2. lower Hutton Sandstone 3. upper Evergreen 4. lower Evergreen 5. lower Precipice Sandstone 6. Moolayember Formation	Far-field hydrodynamic pressure modelling to predict pressure impacts at nearby bores and to assess plume migration into the long-term future (i.e., 1,000 years).

4.6.2.1 Spatial boundaries

As described above, the predicted GHG plume extents have been evaluated (numerically modelled) at two different spatial scales and extents:

- A local-scale and detailed 2 km x 2 km static and dynamic model (tNavigator) is used to simulate the GHG stream injection centred around the West Moonie-1 Injection Well to model the physical and chemical extent and behaviour of the plume.
- A regional scale single-phase groundwater model (MODFLOW), approximately 150 km by 400 km covering the regional extents of the Hutton Sandstone and Precipice Sandstone aquifers has been used to simulate the pressure propagation and long-term plume migration.

Wye et al. (2019) noted a number of key hydrogeological uncertainties in the southern Surat Basin including:

- Uncertainty in regional Precipice Sandstone groundwater flow paths.

- Uncertainty with respect to the Precipice Sandstone being connected to the Clarence Moreton Basin in the east.
- Uncertainty with Precipice Sandstone and Hutton Sandstone connectivity associated with regional faults such as the Burunga-Leichhardt Fault system.
- Uncertainty in hydrochemistry of the Precipice Sandstone deeper in the basin.

Given the spatial uncertainty in flow paths and basin connectivity, a conservatively sized regional study area has been used that allows for testing and modelling of the influence of these key uncertainties.

4.6.2.2 Temporal boundaries

The GIA considers four temporal boundaries:

- **Baseline** – covers the EVs prior to GHG stream injection. This boundary describes the groundwater quality, sensitive receptors, groundwater users and GDEs in the current situation (Section 4.0).
- **Injection period** – covers the proposed three-year test injection period with up to 110,000 t of supercritical GHG stream injected per year.
- **Post-injection pressure equilibration** – covers the groundwater pressure recovery after shut-in of GHG stream injection. Modelling indicates that pressure equilibration is expected to occur 3 years after shut-in.
- **Long-term effects** – covers the potential long-term extents of the plume migration under natural pressure gradients deep in the Surat Basin. Forward projections out to 1,000 years have been considered in the MODFLOW™ model.

4.6.3 Hydrostratigraphic units

Figure 13 presented the entire hydrostratigraphic profile at the proposed West Moonie-1 Injection Well, confirmed by the West Moonie-1 Injection Well and West Moonie-2 Monitoring Well drilling results. The presence of five tight aquitards throughout that profile precludes the need to assess the entire hydrostratigraphy in detail. Rather, the basal aquifers (Hutton Sandstone, Precipice Sandstone) and aquitards (Evergreen Formation and Moolayember Formation) are the focus of this HCM. The OGIA has subdivided the deeper HSUs in the Surat Basin into eight layers: one layer for the Durabilla/Eurombah Formation, two layers in the Hutton Sandstone, three in the Evergreen Formation and a single unit for each of the Precipice Sandstone and the underlying Moolayember Formation. Table 37 provides a summary of OGIA's most recent hydrostratigraphic interpretation for the deeper Surat Basin HSUs incorporated into the UWIR model. Note that OGIA includes the upper Precipice Sandstone in the lower Evergreen Formation. This same hydrostratigraphic division for the deeper units in the basin has been adopted for this GIA. Further, the layering in Table 35 from the upper Hutton Sandstone to the Moolayember Formation have been adopted for the hydrodynamic modelling of regional impacts described later in Section 5.1.1.

Table 37: OGIA (2021) HSUs in the deeper part of the Surat Basin (excludes units above the Durabilla aquitard)

Basin	HSU	Hydrogeologic class	OGIA definition	OGIA model layer (2021)
Surat Basin	Durabilla/Eurombah Formation	Tight aquitard	Predominantly low permeability, regionally extensive and thick formation	17
	upper Hutton Sandstone	Partial aquifer	Medium transmissivity, high to medium bore yields that are vertically and laterally inconsistent at a regional scale and exhibiting a high degree of heterogeneity	18
	lower Hutton Sandstone	Tight aquifer	Medium to low transmissivity, low bore yields that are regionally inconsistent and exhibiting a high degree of heterogeneity	19
	upper Evergreen Formation	Tight aquitard	Predominantly low permeability, regionally extensive and thick formation	20
	Boxvale Sandstone	Partial aquifer	Medium transmissivity, high to medium bore yields that are vertically and laterally inconsistent at a regional scale and exhibiting a high degree of heterogeneity	21
	lower Evergreen Formation	Tight aquitard	Predominantly low permeability, regionally extensive and thick formation	22
	Precipice Sandstone	Regional aquifer	High transmissivity, high bore yields that are vertically and laterally consistent at a regional scale	23
Bowen Basin	Moolayember Formation	Tight aquitard	Predominantly low permeability, regionally extensive and thick formation	24

4.6.3.1 Hutton Sandstone

The Hutton Sandstone overlies the Evergreen Formation. OGIA (2021) interprets two main HSUs for the Hutton Sandstone: (i) a lower section classified as a tight aquifer and (ii) an upper section classified as a partial aquifer. The Hutton Sandstone is the most extensive aquifer in the GAB (OGIA, 2016a) and extends westward into the Eromanga Basin (Green, 1997).

The Hutton Sandstone is generally between 150 m and 200 m thick and can be up to 400 m thick within the axis of the Mimosa Syncline (OGIA, 2016a). The lower Hutton Sandstone tends to have a higher percentage of shale and siltstone in the south of the basin, than the equivalent section in the north (Green, 1997) an observation supported by the results from the West Moonie wells. The upper Hutton Sandstone is characterised by thick sandstones that have a sharp base and top (OGIA, 2019b). Bianchi et al (2019) states that the nature of the base of the Hutton Sandstone is still under discussion in the literature; some authors describe it as a regional unconformity (Hoffmann et al., 2009), while others state that it is conformable with the underlying Evergreen Formation (Turner et al., 2009; Ziolkowski et al., 2014). This interpretation difference is important as it influences interpretation of the hydraulic connectivity across and between systems that act as aquifers and aquitards (Bianchi et al., 2019). If the Hutton Sandstone erodes into the underlying Evergreen Formation, this has a negative impact on the thickness of the aquitard, separating the Precipice Sandstone and the Hutton Sandstone. The physical nature of the contact can also vary geographically across the basin (Bianchi et al., 2019). However, pressure data acquired in West Moonie-2 Monitoring Well and the West Wandoan-1 Well in EPQ7 indicates that there is no hydraulic connectivity between the Precipice Sandstone and the Hutton Sandstone at these locations.

The Hutton Sandstone is interpreted as a fluviatile to deltaic depositional system. It is considered to be the transition between the restricted shallow marine to lacustrine Evergreen Formation and the overlying swampy freshwater Walloon Coal Measures (Bianchi et al., 2019).

West Moonie-1 Injection Well encountered 219 m of Hutton Sandstone consisting of interbedded sandstone and siltstone beds with minor coal. The Hutton Sandstone at the site has a net-to-gross ratio of 0.35, meaning that 35% of the interval consists of permeable rock. Net reservoir thickness is defined as having an effective porosity exceeding 10% and a clay content below 50%. The average porosity for the net reservoir interval is 14%. The individual sandstone beds in West Moonie-1 Injection Well are up to 10 m thick and are separated by up to 35 m of fine-grained material that would limit fluid migration or pressure propagation.

4.6.3.2 Evergreen Formation

The Evergreen Formation conformably overlies the Precipice Sandstone, and where the Precipice Sandstone is absent, unconformably overlies the Bowen Basin strata or pre-Permian Basement (Green, 1997). The Evergreen Formation is traditionally divided into a lower Evergreen Formation, Boxvale Sandstone Member, Westgrove Ironstone Member and the upper Evergreen Formation. OGIA (2016a) identifies the Boxvale Sandstone Member, where present, as a thin blocky sandstone unit occurring just below the Westgrove Ironstone Member. The Boxvale Sandstone is generally thin, and only significant in the north-west Roma Shelf (OGIA, 2016b). The Westgrove Ironstone Member is a regionally consistent marker bed comprising of interbedded mudstone, chamositic pelletal or oolitic mudstone, and minor sandstone (OGIA, 2016a). The Evergreen Formation often has a basal sandy interval characterised by mainly sublabile sandstones (Green, 1997).

The Evergreen Formation in West Moonie-1 Injection Well is 158 m thick and consists of interbedded sandstone and siltstone. Log interpretation shows that only 10% of this interval may have sufficient permeability for fluid flow (aquifer properties), the rest of the interval has a high shale content and/or low porosity, which are properties akin to a tight aquitard. The Evergreen Formation in West Moonie-1 Injection Well includes the lower Evergreen Formation (including the meandering channel facies that are sometimes referred to as upper Precipice Sandstone), the Boxvale Sandstone Member and the upper Evergreen Formation. The Evergreen Formation surfaces that have been interpreted at West Moonie-1 Injection Well are summarised in Table 38. The Westgrove Ironstone Member was not identified in West Moonie-1 Injection Well, but it was positively identified from drill cuttings in West Moonie-2 Monitoring Well. There is significant vertical hydraulic resistance throughout the profile with 90% (142 m) of the 158 m profile in West Moonie-1 Injection Well being fine-grained material with a high clay content. The high fines content is evident on the gamma ray logs presented in Figure 22.

Table 38: West Moonie-1 Injection Well interpreted Evergreen Formation contact surfaces (based on CTSCo stratigraphic nomenclature)

Formation top	Depth (m bgl)
Top of upper Evergreen Formation	2,100
Top of Boxvale Sandstone Member	2,148
Top of lower Evergreen Formation	2,155
Top of upper Precipice Sandstone	2,251
Top of lower Precipice Sandstone	2,258

The Evergreen Formation is recognised as a significant tight aquitard (OGIA, 2021) and will act as a hydraulic seal to underlying reservoirs (La Croix et al., 2019b), including the Precipice Sandstone.

4.6.3.3 Precipice Sandstone

The lower Precipice Sandstone reservoir is dominated by braided river deposits (La Croix et al., 2019c). As shown schematically in Figure 24, the Precipice Sandstone is continuous along the deeper parts of the Surat Basin including the Mimosa Syncline. La Croix et al. (2019b) identified that the Precipice Sandstone and lower Evergreen Formation onlap the western and eastern margins of the Surat Basin. Therefore, the Precipice Sandstone is not a continuous formation throughout the basin and is particularly confined to the central axis of the Mimosa Syncline in the southern extents of the basin (Figure 21). Given the high energy depositional environment, the sandstone channels are expected to be highly continuous over tens to hundreds of kilometres. Evidence of this is provided by the pressure responses from aquifer injection by Australia Pacific Liquefied Natural Gas (APLNG) (APLNG, 2016).

West Moonie-1 Injection Well encountered 78 m of Precipice Sandstone with good reservoir properties. The gamma ray signature shows a clean sandstone interval with a sharp base which gradually fines upward over the upper 50 m (Figure 22). Based on core descriptions (the interval was fully cored at West Moonie-1 Injection Well), the sandstone varies in grain size from fine to very coarse. Based on geophysical log interpretation, 84% of the Precipice Sandstone has good reservoir properties and the average porosity of the net sandstone is 14%. The clean blocky sandstone facies, as encountered in the lower Precipice Sandstone, is not seen in the overlying upper Precipice Sandstone or Evergreen Formation, where the gamma ray count is significantly higher and individual sand beds are thinner (Figure 22).

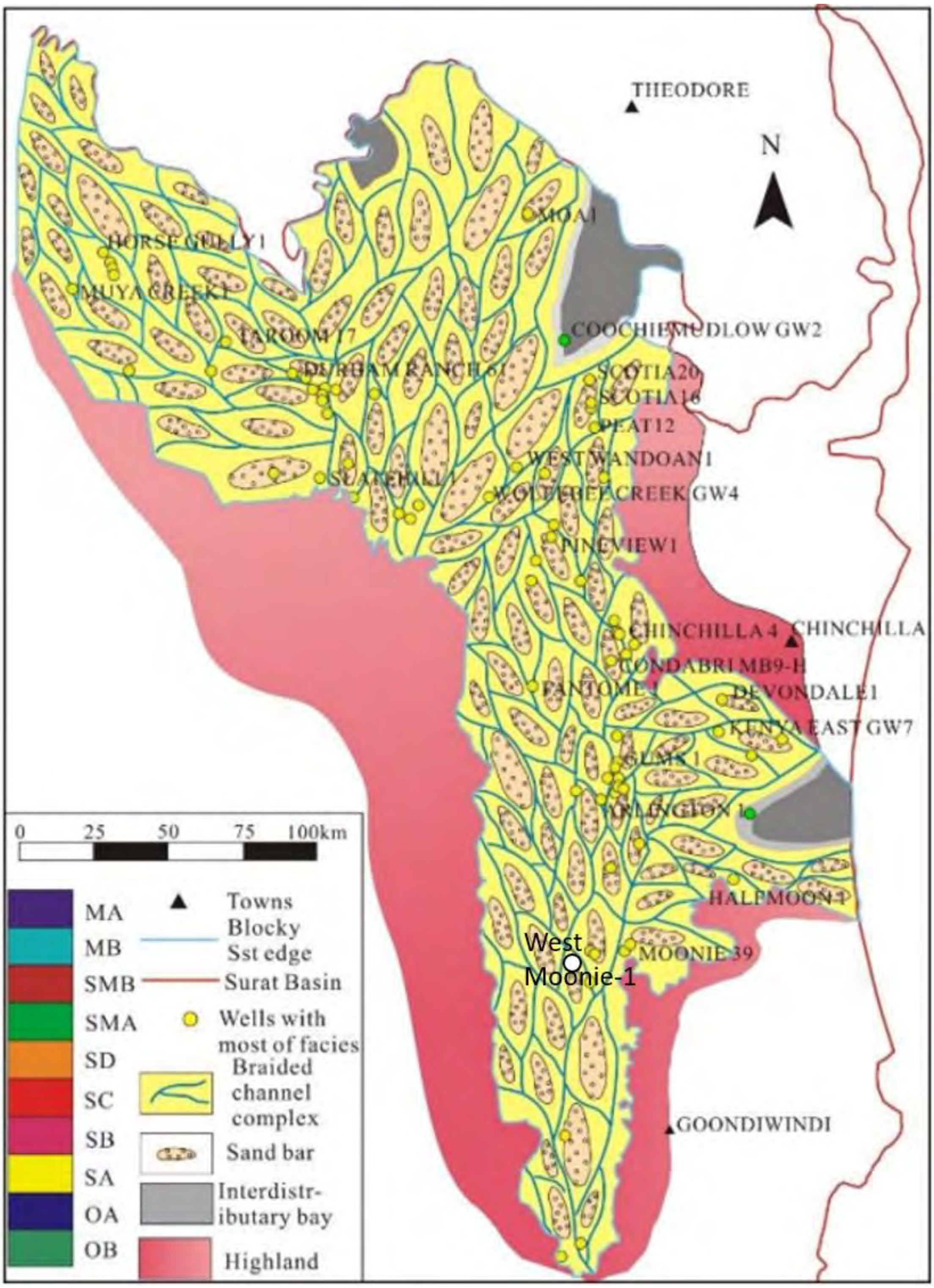

Figure 21: Schematic conceptual facies map of the lower Precipice Sandstone showing high interconnectivity of coarser grained sand channels (La Croix et al., 2019c)

4.6.3.4 Moolayember Formation

The Late Triassic Moolayember Formation is deposited in the Bowen Basin and unconformably underlies the Precipice Sandstone. The Moolayember Formation is primarily a fine-grained siltstone and mudstone formation which provides hydraulic separation from the more permeable formations of the Bowen Basin (e.g., Clematis Group) from the Surat Basin sediments above (OGIA, 2019a). The Moolayember Formation is truncated by the Base Jurassic Unconformity and is completely eroded from some basement highs but can be up to 2,000 m thick in the centre of the Taroom Trough (OGIA, 2016a). The eastern extent of the Moolayember Formation is limited by the Goondiwindi – Moonie and Burunga – Leichhardt Faults (Green, 1997).

The Moolayember Formation consists dominantly of interbedded mudstones and medium- to coarse-grained sandstones, with minor inclusion of grey to black carbonaceous shale, siltstone, mudstone, coal, conglomerate, tuff and limestone (Australian Stratigraphic Units Database). OGIA classifies the Moolayember Formation as a tight aquitard.

Figure 22 shows a good gamma ray correlation between West Moonie-1 Injection Well and West Moonie-2 Monitoring Well. West Moonie-1 Injection Well a total of 375 m of the Moolayember Formation was drilled and cored. The Moolayember Formation in West Moonie-1 Injection Well is interpreted by CTSCo as lower delta plain and delta front facies with significant tidal and rarer wave influence. Analysis of 206.5 m of core taken from the Moolayember Formation in West Moonie-1 Injection Well shows that the majority of the lithofacies are comprised of laminated mudrock (24%), horizontally bedded sandstone (24%), massive sandstone (11%) and low-angle cross-bedded sandstone (9%). Based on the West Moonie-1 Injection Well petrophysics interpretation, the net-to-gross ratio is 11%, with an average porosity of 12%. Meaning that 11% of the penetrated Moolayember Formation has a clay volume below 50% and porosity above 10%. The gamma ray response of the Moolayember Formation shows the consistently dominant finer grained interbeds, compared to the cleaner sandstones within the overlying Precipice Sandstone (Figure 22).

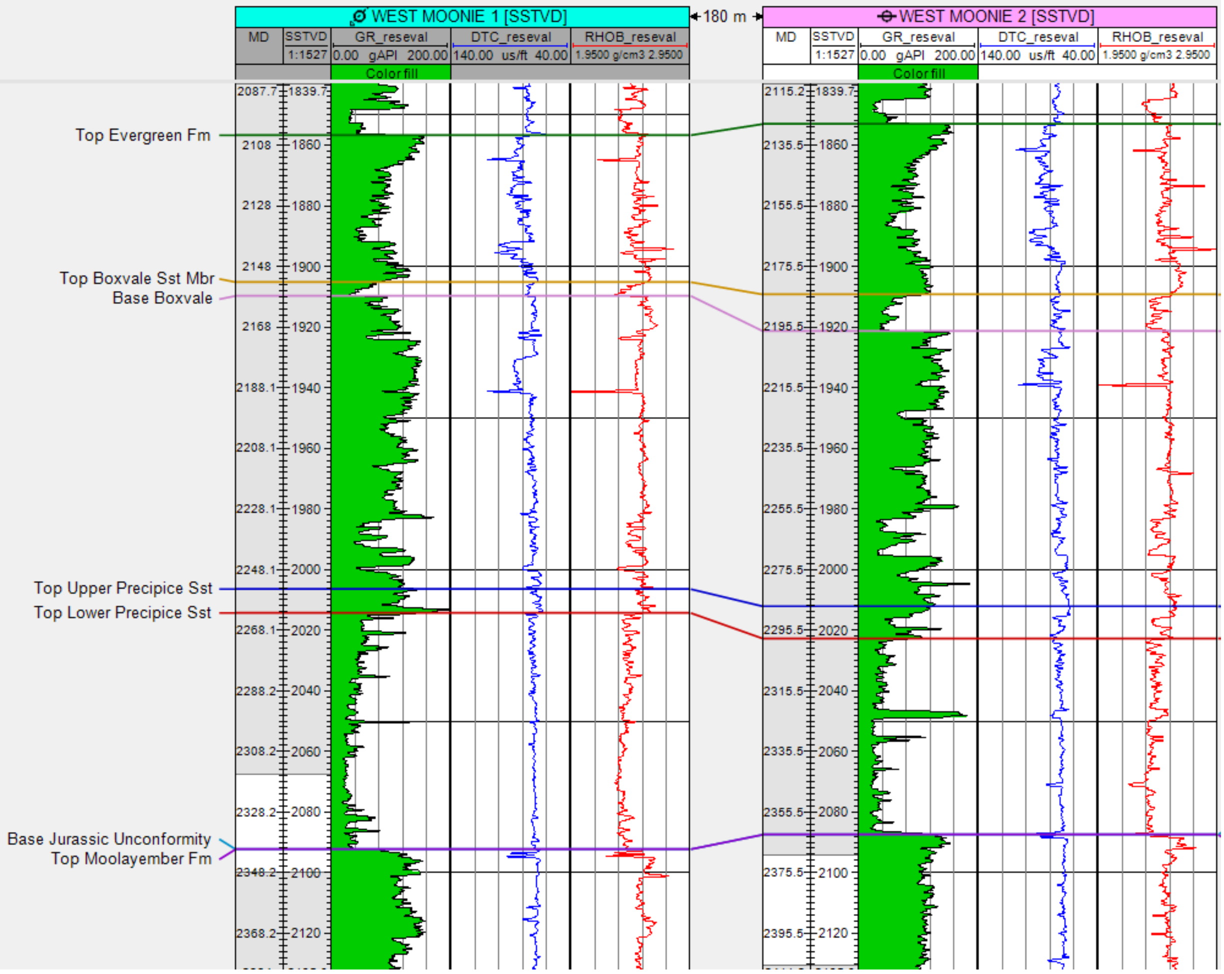

Figure 22: West Moonie-1 Injection Well and West Moonie-2 Monitoring Well gamma ray log (modified from CTSCo. Measured Depth as MD)

4.6.4 Structure elements

Faults in the Surat Basin may increase the permeability of the host rock due to fracturing in the damage zone and may affect connectivity by juxtaposing aquifers which would not otherwise be in direct contact (OGIA, 2021).

According to OGIA (2019b), the structure of the Bowen Basin controls the shape and structure of the Surat Basin, such that structural features of the Bowen Basin are generally reflected but subdued in the Surat Basin. Seismic data supports the interpretation that pre-existing basement fault geometries have an influence on the location of deposition and subsequent folding of the overlying sedimentary succession (Gonzalez et al., Figure 2019a). Figure 23 (modified from OGIA, 2019b) shows the main structural elements of the Bowen Basin. The Bowen Basin is bounded to the east by four major structures, including from south to north: the Goondiwindi-Moonie Fault, Leichardt Fault and Burunga Fault (Copley et al. 2017) (Figure 23). These Bowen Basin structures influenced the overlying Surat Basin structures. It should be noted that coverage of seismic data for the Surat Basin is highly clustered and concentrated on the flanks of the basin (Gonzalez et al., 2019a), while the West Moonie-1 Injection Well is towards the centre of the Surat Basin. A future work program, including the West Moonie 3D seismic survey, will reduce structural uncertainty within at West Moonie-1 Injection Well area and confirm the current interpretation that faulting within this area is extremely unlikely.

Figure 24 shows a west-east cross-section from Gonzalez et al (2019) through the southern Surat Basin and the underlying Bowen Basin in the vicinity of EPQ10. The lower Precipice Sandstone, indicated in yellow on the cross-section, is the oldest formation of the Surat Basin and unconformably overlies the Bowen Basin sediments. The continuous nature of the Precipice Sandstone reflector suggests that faulting has not offset this formation in this part of the basin. The Moonie Oil Field is located east of the Goondiwindi-Moonie Fault System (see Moonie-1 Injection Well in Figure 24), with the West Moonie-1 Injection Well situated 30 km south-west of the Moonie Oil Field.

The approximately 75 km long north-south trending Goondiwindi Fault System intersects with the north-east to south-west trending Moonie Fault in the north. The transition of the Goondiwindi to the Moonie Fault System is poorly covered with seismic data, and Figure 25 shows the Goondiwindi Fault System near the transition to the Moonie Fault.

The Goondiwindi-Moonie Fault System is located 23 km east of the West Moonie-1 Injection Well and is the eastern bounding fault of the southern Bowen Basin (Figure 23). The underlying Triassic and Permian formations are tightly folded with major deformation of the Bowen Basin. Tertiary reactivation resulted in modest to gentle folding with no significant faulting of the Surat Basin strata in the Moonie area (Copley et al, 2017). A dip azimuth fault analysis by UQ-SDAAP of the Moonie Oilfield 3D seismic reveals that the geometry of the Moonie Fault System, which is approximately 15 km long, comprises of six discrete segments ranging in length from 2 to 5 km (Gonzalez et al., 2019a). The individual segments have a marked variation of fault dip and azimuth along the fault trace ranging from 15 degrees to 35 degrees and the Base Jurassic Unconformity as shown in Figure 26 (Gonzalez et al., 2019a).

West Moonie-1 Injection Well is located 23 km from the Goondiwindi-Moonie Fault System. However, understanding the hydraulic nature of the Goondiwindi-Moonie Fault System in this region is one of the important uncertainties for de-risking the carbon storage potential at a basin scale (Mahlbacher, 2019). Honari et al. (2019) states that the aquifer support seen in the Precipice Sandstone Reservoir within Moonie Oil Field indicates that, at a regional scale, the Moonie Fault does not act as a major flow barrier. Mahlbacher (2019) assessed the potential for up-fault discharge along the Moonie Fault into the surface environment using water chemistry data. No evidence of gas or fluid rising along the Moonie Fault into surface water was found.

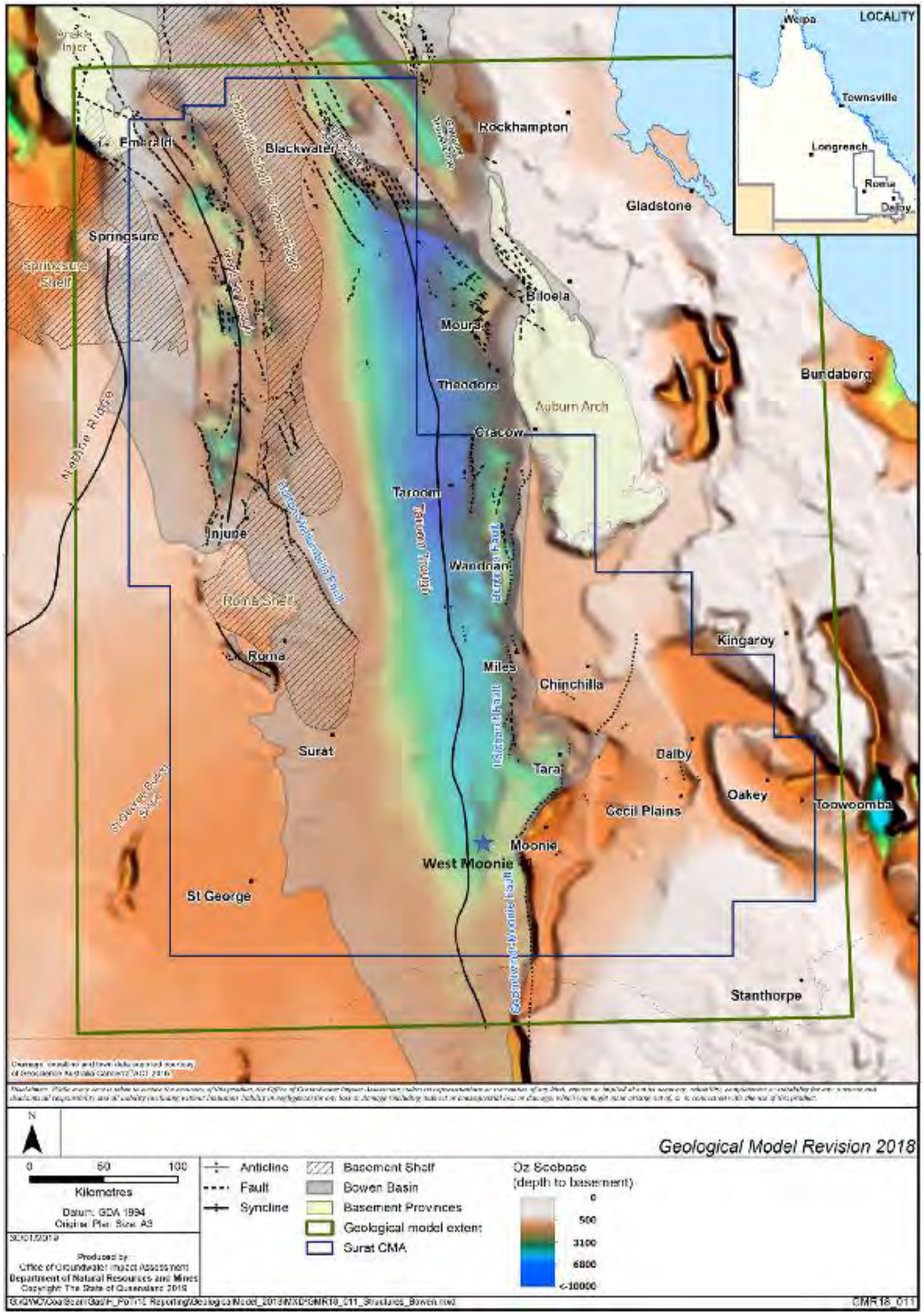

Figure 23: Structural elements of the Bowen Basin (Esterle & Sliwa, 2002; FROGTECH, 2014; Geological Survey of Queensland, 2012; Ransley & Smerdon, 2012; SRK Consulting, 2008) (modified from OGIA, 2019b)

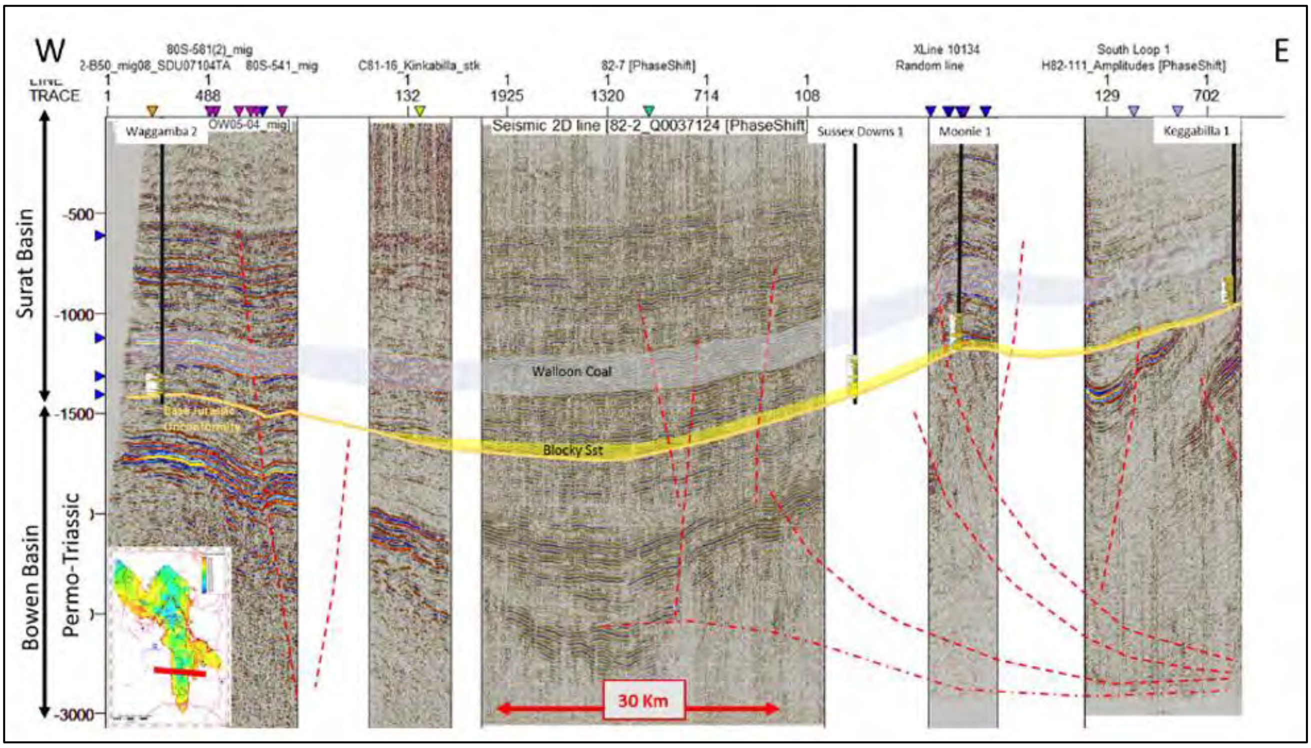

Figure 24: A composite west-east seismic line across the southern Surat Basin showing the major faults and structures affecting the Bowen and Surat Basins (red dashed lines, the yellow shade means the Precipice Sandstone) (Gonzalez et al., 2019a)

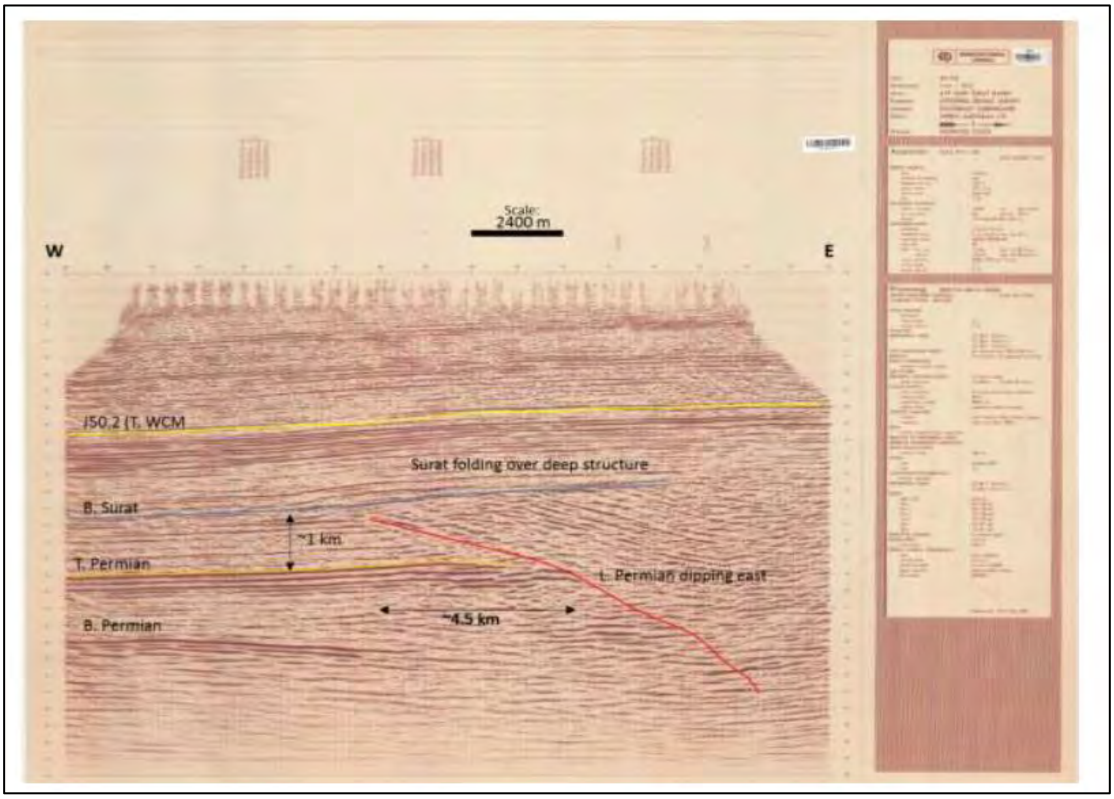

Figure 25: Seismic section through Goondiwindi fault system near transition to Moonie Fault System (Copley et al., 2017)

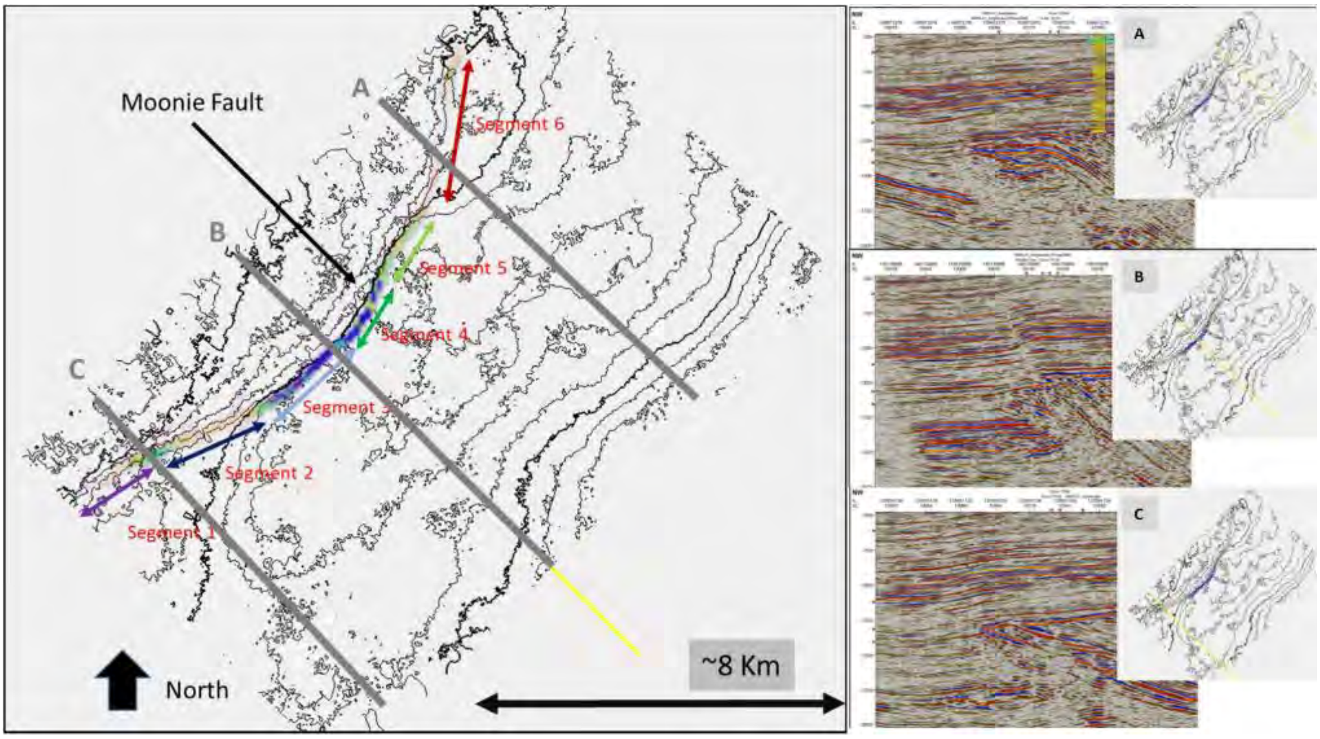

Figure 26: Seismic sections illustrating the various fault geometries of the Moonie Fault System. Plan view: contours are from the top of the Precipice Sandstone; the fault plane is colour coded by dip-azimuth with dark colours indicating a higher dip (Gonzalez et al., 2019a)

4.6.5 Hydraulic properties

4.6.5.1 Local-scale hydraulic properties

Routine core analysis (RCA) was conducted on 23 plugs taken from West Moonie-1 Injection Well. The RCA results are summarised in Table 39 and plotted in Figure 27. This table indicates that the Precipice Sandstone has favourable reservoir quality in terms of high porosity and permeability. Of note, the permeability is orders of magnitude lower in the overlying lower Evergreen and the underlying Moolayember Formation compared with the Precipice Sandstone.

Table 39: Summary of RCA results for West Moonie-1 Injection Well

Formation	Number of plugs	Helium porosity [%]			Permeability to air (mD)		
		Min	Median	Max	Min	Median	Max
lower Evergreen Formation	4	8.2	12.5	18.9	0.06	0.68	51.9
Precipice Sandstone	16	12.3	15.3	19.6	13.6	127	4408
Moolayember Formation	3[5]	5.8	11.3	13.3	0.36	1.48	2.59

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[5] One of the three plugs was fractured and therefore unsuitable for determination of permeability

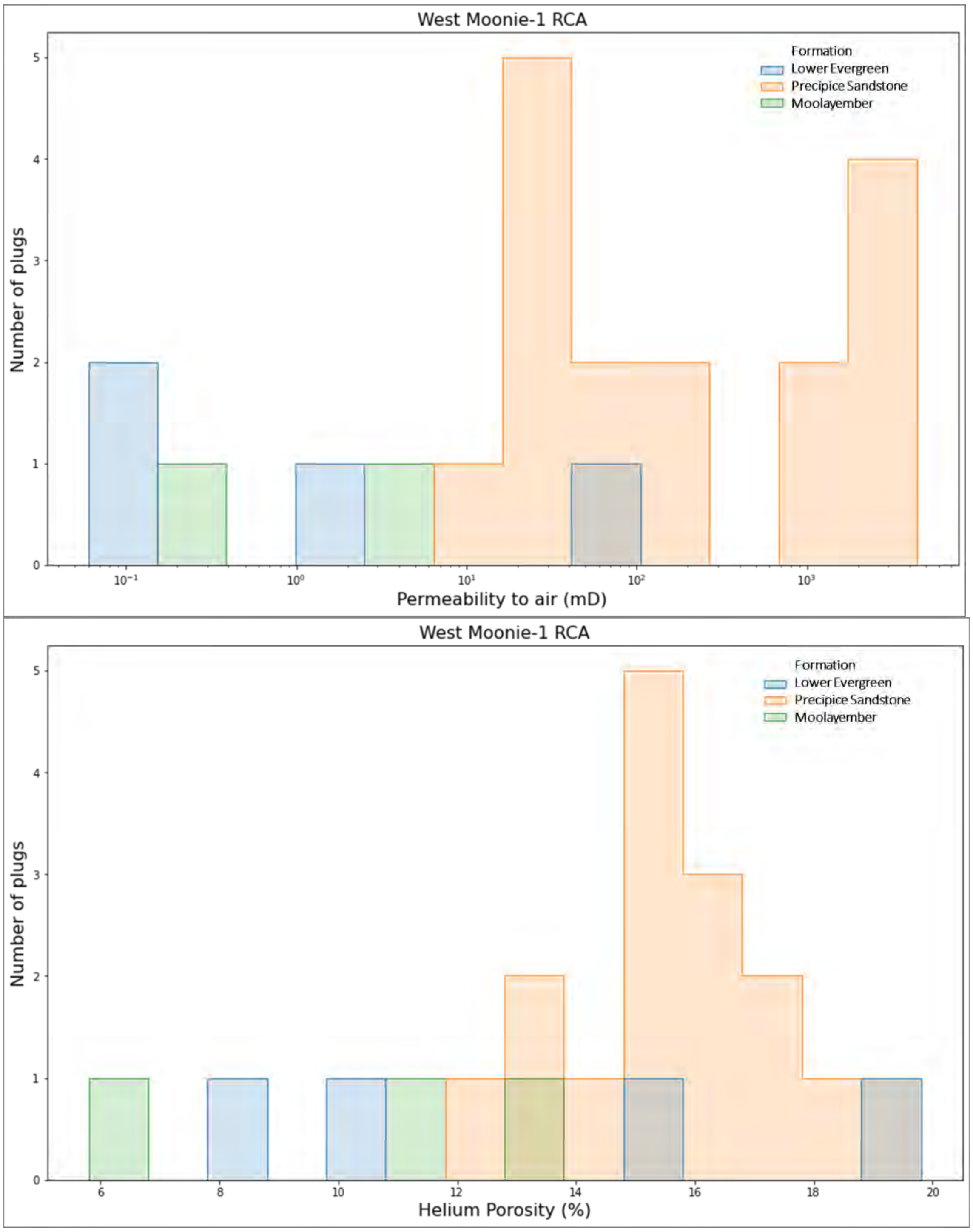

Figure 27: RCA results for West Moonie-1 Injection Well

Pressure tests were carried out in the West Moonie-2 Monitoring Well by Schlumberger. This included 23 Modular Formation Dynamic Tester (MDT) tests, six in Hutton Sandstone, five in Evergreen Formation and 12 in Precipice Sandstone. MDT test results clearly show a different pressure gradient in the Precipice Sandstone compared to the overlying formations (Figure 28). This indicates a hydraulic disconnect between the Precipice Sandstone and the Hutton Sandstone. Figure 29 shows the pressure versus time plot for one of the tests conducted in the Precipice Sandstone.

Figure 28: Pressure depth plot showing MDT results of West Moonie-2 Monitoring Well. The Precipice Sandstone is shown in orange

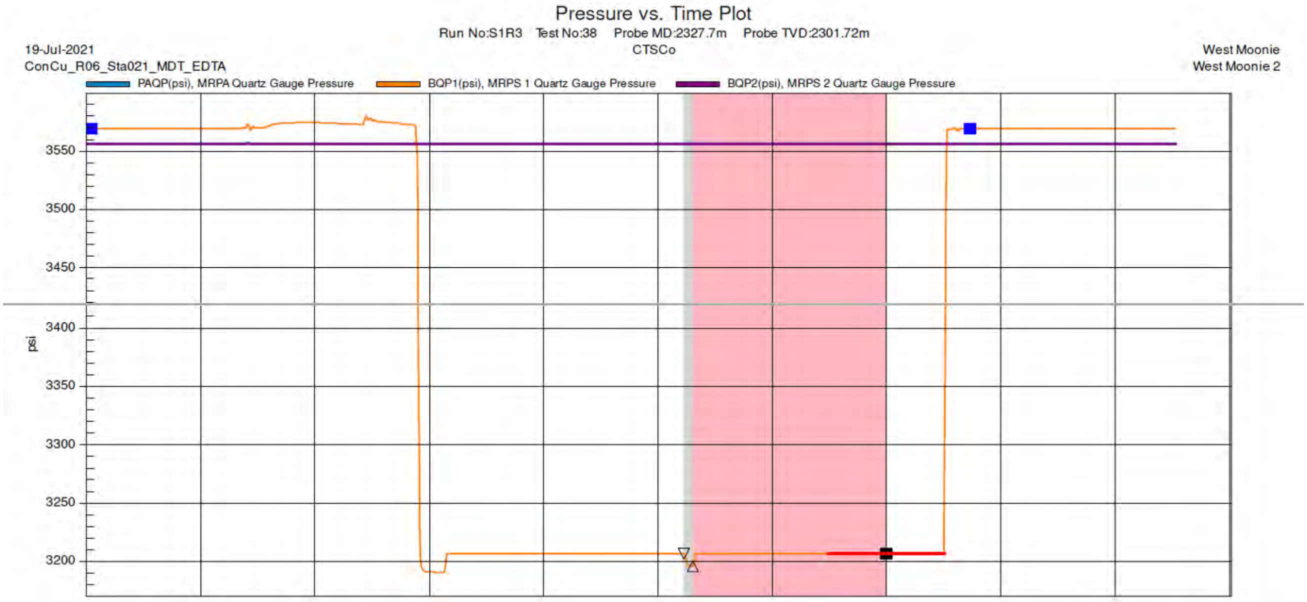

Figure 29: West Moonie-2 Monitoring Well MDT results of testing in Precipice Sandstone (Schlumberger, 2021)

OGIA (2019a) conducted a comprehensive review of Surat Basin core test data, drill stem test data and aquifer pumping test data to estimate hydraulic conductivity ranges in the Surat Basin CMA formations. These data are shown in Figure 30 together with model calibrated values (OGIA, 2019a). The calibrated model shows 3 to 4 orders of magnitude higher hydraulic conductivity in the Precipice Sandstone, compared to the overlying Evergreen Formation.

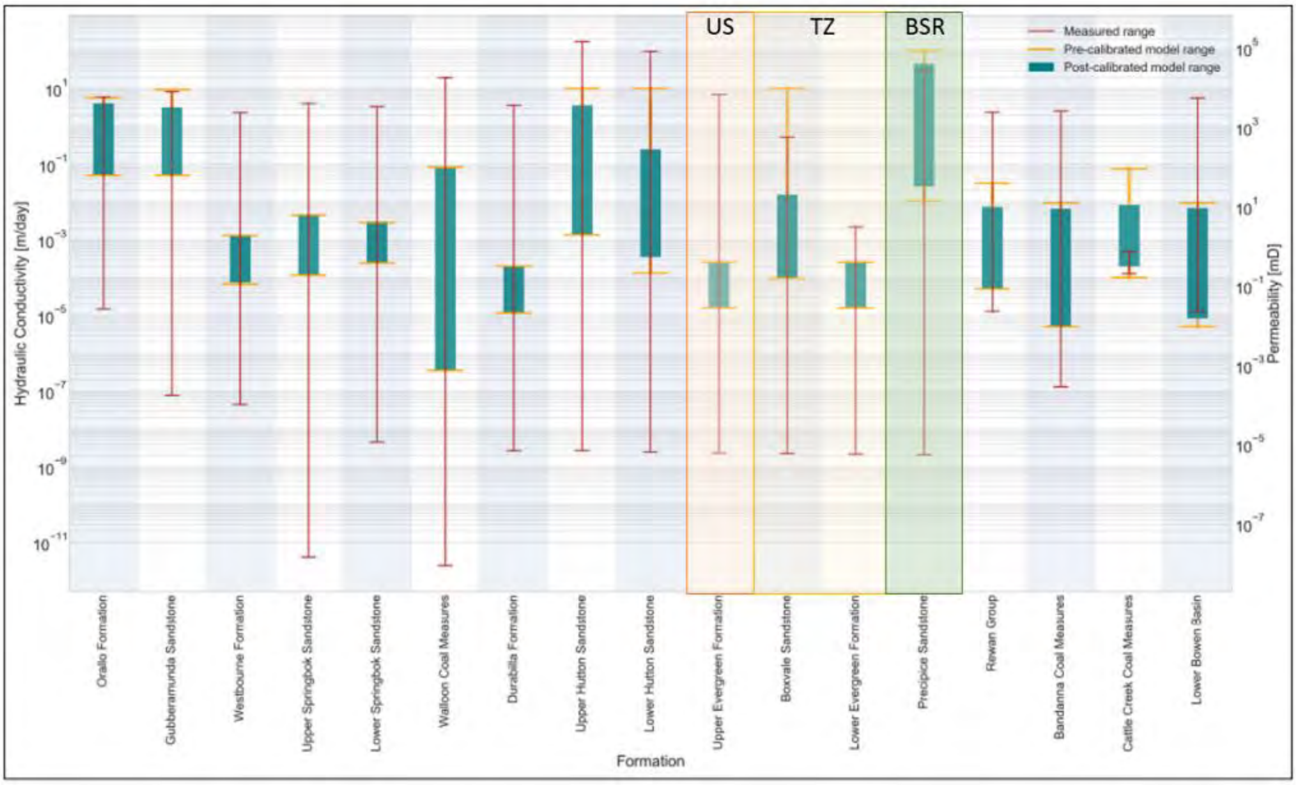

Figure 30: OGIA's estimates of horizontal hydraulic conductivity and permeability ranges in the Surat CMA (modified from UWIR, OGIA 2019a)

4.6.5.2 *Regional drill stem test analysis*

Drill stem test (DST) data (73 tests) from 60 different wells were analysed for the Precipice Sandstone and Evergreen Formation as part of the UQ-SDAAP project (Honari et al., 2019). This included 23 DSTs for the Precipice Sandstone, 40 DSTs in the lower Evergreen Formation and 10 DSTs across both the Precipice Sandstone and lower Evergreen Formation (Figure 31). Most of the DSTs are associated with exploration/ appraisal activities in the 1960s and 1970s and had issues with data quality and uncertain test logistics. Those poorer quality tests were deemed to be unreliable and were disregarded. Pressure transient analysis (PTA) of DST data has resulted in derivation of the permeability of the test interval.

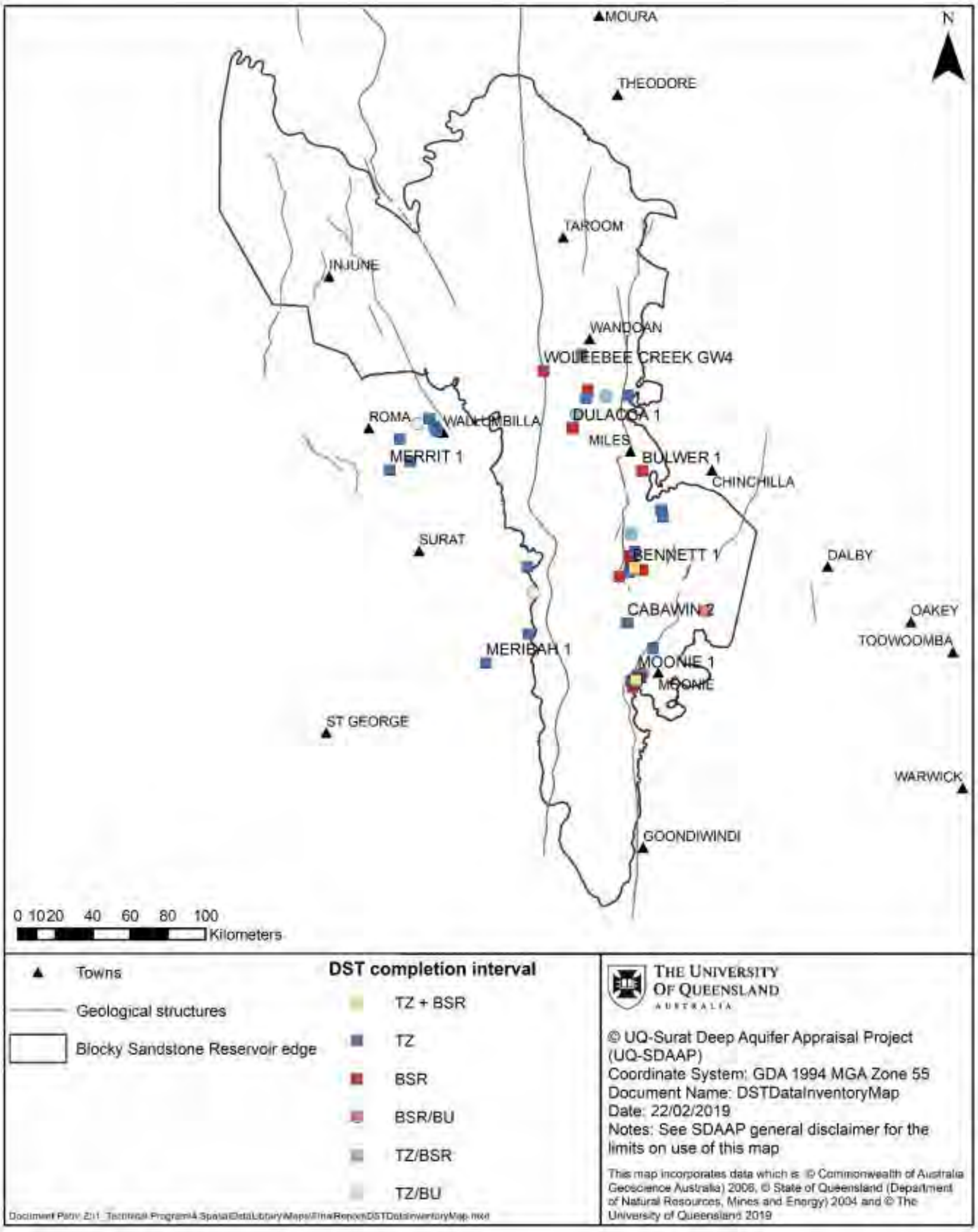

Figure 31: DSTs analysed by UQ-SDAAP, classified by HSU (Honari et al., 2019)

Lower Precipice Sandstone

The DST permeability values in the Leichhardt Fault Area range from 20 mD to 170 mD (K of ~ 10^{-2} to 10^{-1} m/d). Further south, the Moonie Oil Field shows DST permeability ranging from 51 mD to 1,400 mD (K of ~10^{-2} to 1 m/d), reflecting relatively high heterogeneity (Honari et al., 2019a) and good reservoir potential.

Lower Evergreen Formation

The DST permeability values in the lower Evergreen Formation vary from 0.01 mD to 270 mD (K of ~ 10^{-5} to 10^{-1} m/d). There is uncertainty regarding the permeability values in the lower Evergreen Formation in the centre of the basin due to a lack of well data (Honari et al., 2019a) at that location.

4.6.5.3 Regional wireline log analysis

As part of the UQ-SDAAP program, Harfoush et al. (2019a) evaluated wireline logs of 285 wells divided over four zones based on spatial location to assess petrophysical properties (Figure 32). Of these, 208 wells were used to calculate total and effective porosity, and 73 wells were used to calculate permeability. Log quality control was applied prior to analysis, and more detail can be found in the Wireline Log Analysis UQ-SDAAP report by (Harfoush et al., 2019a).

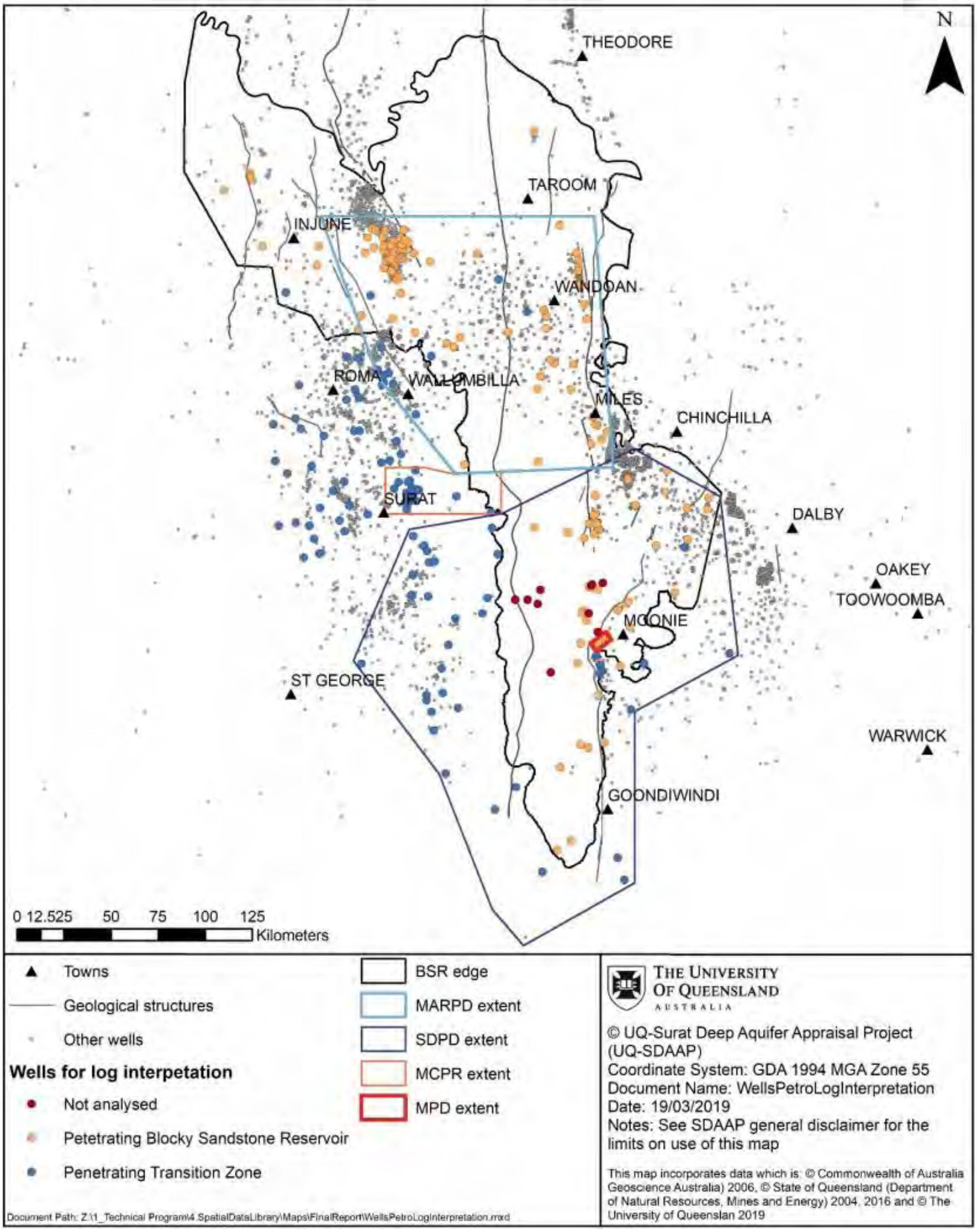

Figure 32: Wells selected for petrophysical log interpretation

Lower Precipice Sandstone

The effective porosity in the lower Precipice Sandstone from the wireline logs ranges from 9% to 23% and decreases with depth. Permeability ranges from 5 mD to 3,943 mD (K of ~ 10^{-3} to > 1 m/d), with the northern part of the reservoir exhibiting highest permeability (Harfoush et al., 2019a), although reasonable reservoir potential is exhibited across the basin.

Lower Evergreen Formation

The effective porosity in the lower Evergreen Formation and the Boxvale Sandstone Member ranges from 0.1% to 15%. Generally, the permeability in the lower Evergreen Formation and the Boxvale Sandstone Member is low. Higher permeability values of more than 1,000 mD (K of more than 1 m/d) are encountered in the sandier section that overlies the Precipice Sandstone and in the Boxvale Sandstone Member (Harfoush et al., 2019a).

Upper Evergreen Formation

The upper part of the Evergreen Formation is above the Boxvale Sandstone. Effective porosity ranges from less than 1% to 20% with an average of 7%. Permeability ranges from less than 0.01 mD (K of less than ~10^{-5} m/d) to 1,391 mD (K of ~1 m/d) with an average of 105 mD (K of ~10^{-1} m/d). The upper Evergreen Formation is cored in the recently drilled West Moonie-2 Monitoring Well, and the coring results suggests that the upper Evergreen Formation is a seal.

4.6.5.4 Regional core data analysis

Harfoush et al. (2019b) undertook core data analysis of 59 regional wells (Figure 33) that intersected the Precipice Sandstone and the Evergreen Formation. The core data was obtained from the Queensland petroleum exploration data (QPED) database and core analysis reports from the QDEX database. Several key assumptions were made regarding accuracy of measurements of porosity and permeability, and the reader is directed to Harfoush et al. (2019) for further details, with a brief summary below.

Core data was correlated with wireline depth using gamma ray measurements and corrected for *in situ* reservoir conditions. Core porosity was corrected for the effect of *in situ* overburden pressure considering the core compressibility at Woleebee Creek-GW4 (a well inside of the regional HSA defined in Table 36). Core air permeability was also corrected to liquid *in situ* reservoir permeability using the Klinkenberg permeability approach (Klinkenberg, 1941) at selected wells (Harfoush et al., 2019). A histogram with the average core permeability per well is shown in Figure 34.

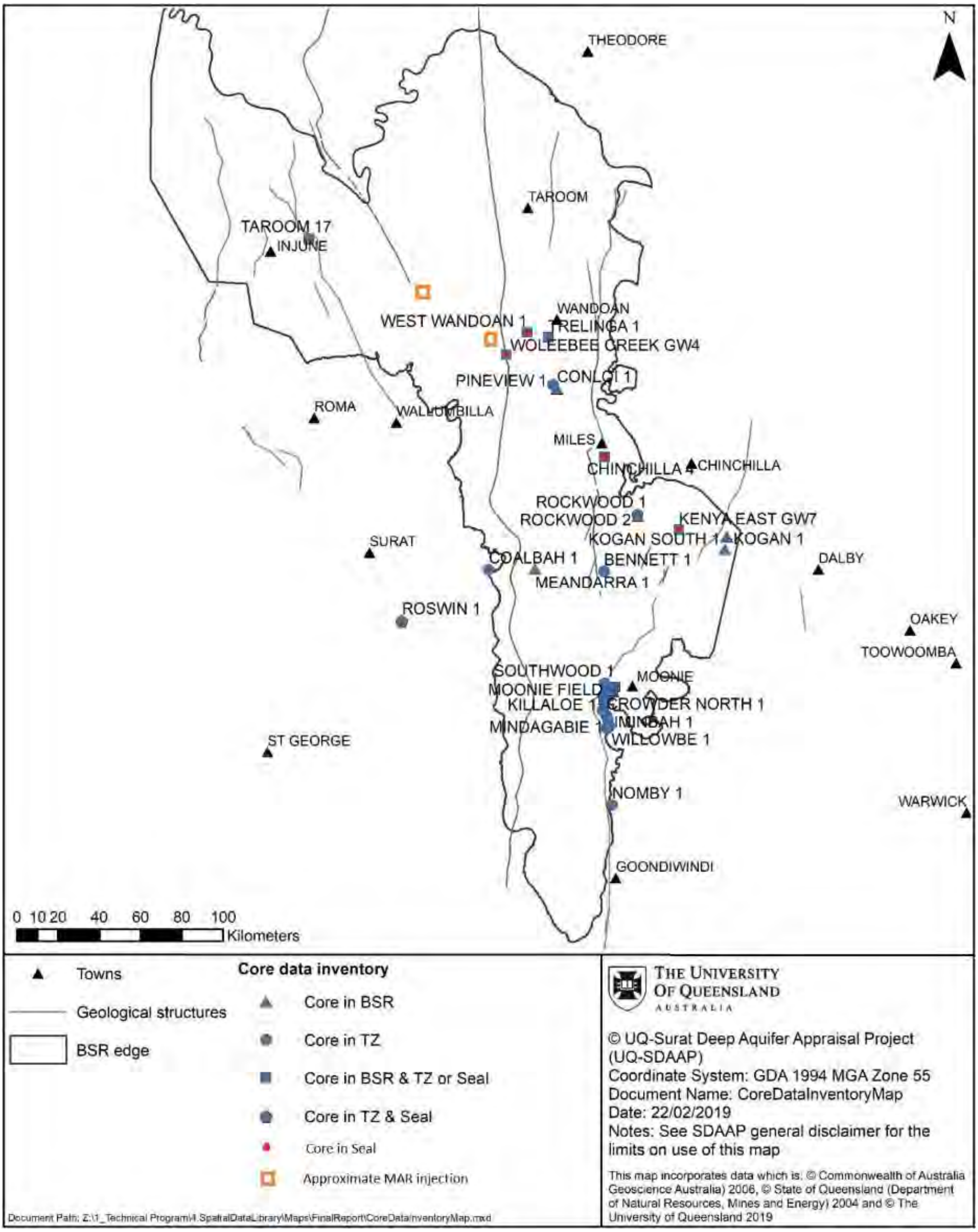

Figure 33: Distribution of wells used in the UQ-SDAAP core analysis study. Shows locations of core analysis data for the Precipice Sandstone and Evergreen Formation (after Harfoush et al., 2019b)

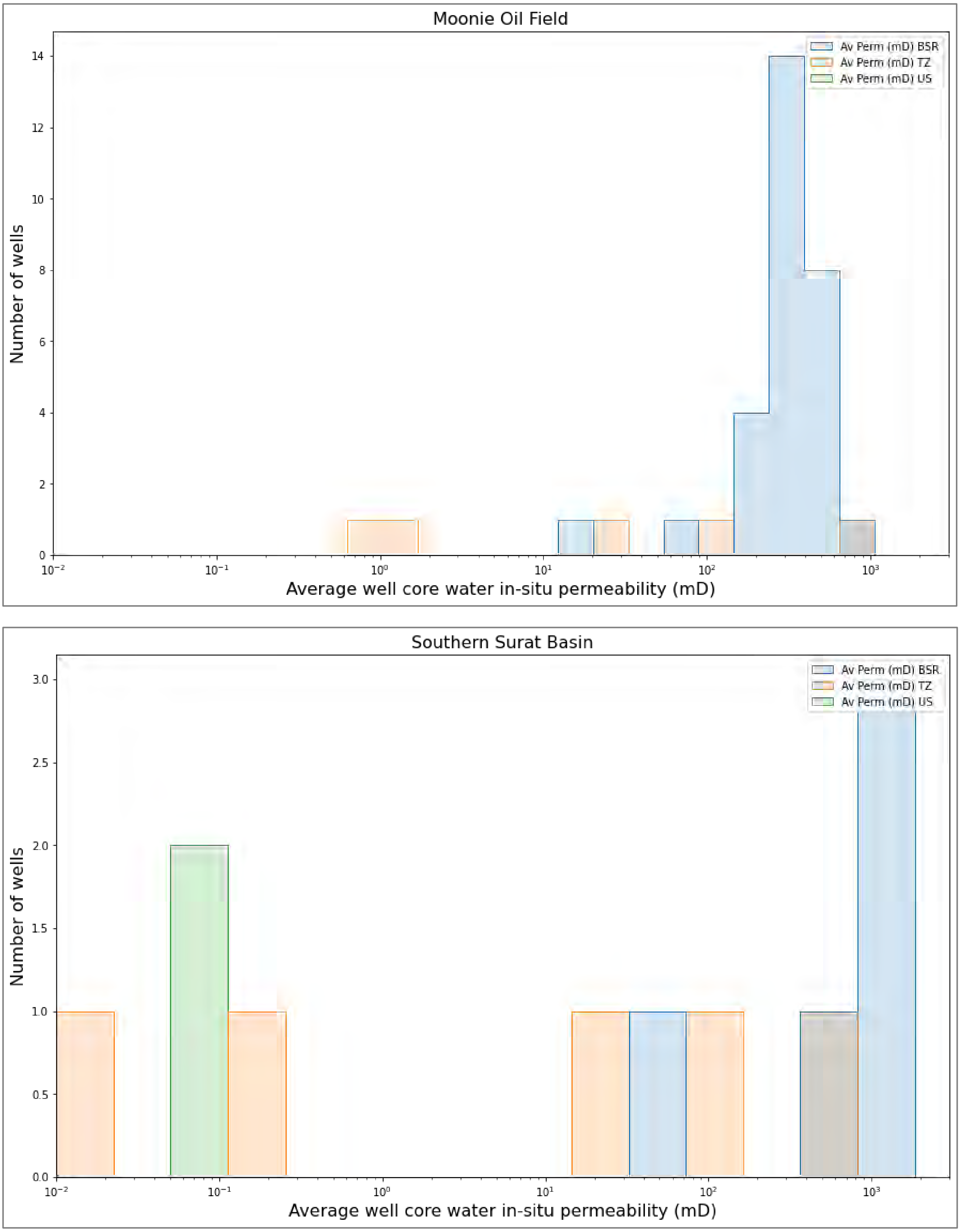

Figure 34: Histogram of average core water *in situ* permeability per well. Top figure shows the Moonie data; bottom figure shows core data from the other Southern Surat wells (based on data from Harfoush et al., 2019b)

Harfoush et al. (2019c) estimated the gross lithological anisotropy, as characterised by the vertical-to-horizontal permeability ratio (kv/kh) for each lithology, that is used for regional model input, using core vertical and horizontal permeability data from five wells (Table 40). The lower Precipice Sandstone consists mainly of sandstone, while the Evergreen Formation is more heterogeneous with an alternation of shale, siltstone and silty sandstone.

Table 40: kv/kh approximations (Harfoush et al., 2019c)

Lithology	kv/kh
Sandstone	0.2
Silty Sandstone	0.02
Siltstone	0.003
Shale	0.02

Precipice Sandstone

The core data analysis has shown that the lower Precipice Sandstone exhibits good reservoir qualities in terms of high permeability and porosity. Average core porosity ranges from 20.4% in the north of the basin to an average of 16.4% in the south of the basin at the Moonie Oil Field (Harfoush et al., 2019b). *In situ* reservoir permeability within the Moonie Oil Field varies between 14 mD and 1,057 mD (K of ~10^{-2} to 1 m/d).

Harfoush et al. (2019c) cross-plotted core porosity and permeability data for the trough cross-stratified sandstone facies (SA), which is the main facies of the Precipice Sandstone (Figure 35). There is a distinct difference between the data points from the northern part of the Surat Basin (the MAR area, displayed in red) and the Woleebee Creek-GW4 well (displayed in blue)) and the data in the south and south-eastern section of the Surat Basin (the Moonie Oil Field (displayed in yellow) and Rockwood-2 and Kogan South-1 wells (displayed in black)). The porosity and permeability from wells in the northern part of the Surat Basin tends to plot on the high end of the data cloud, while the porosity and permeability from the southern section of the Surat Basin shows more spread. The centre of mass of the Moonie Oil Field data (yellow) indicates a slightly lower porosity and permeability than that of the MAR sector area in the north of the Surat Basin (red) and Woleebee Creek-GW4 well in the north (Figure 33) (blue), although still demonstrating good reservoir potential (Figure 35).

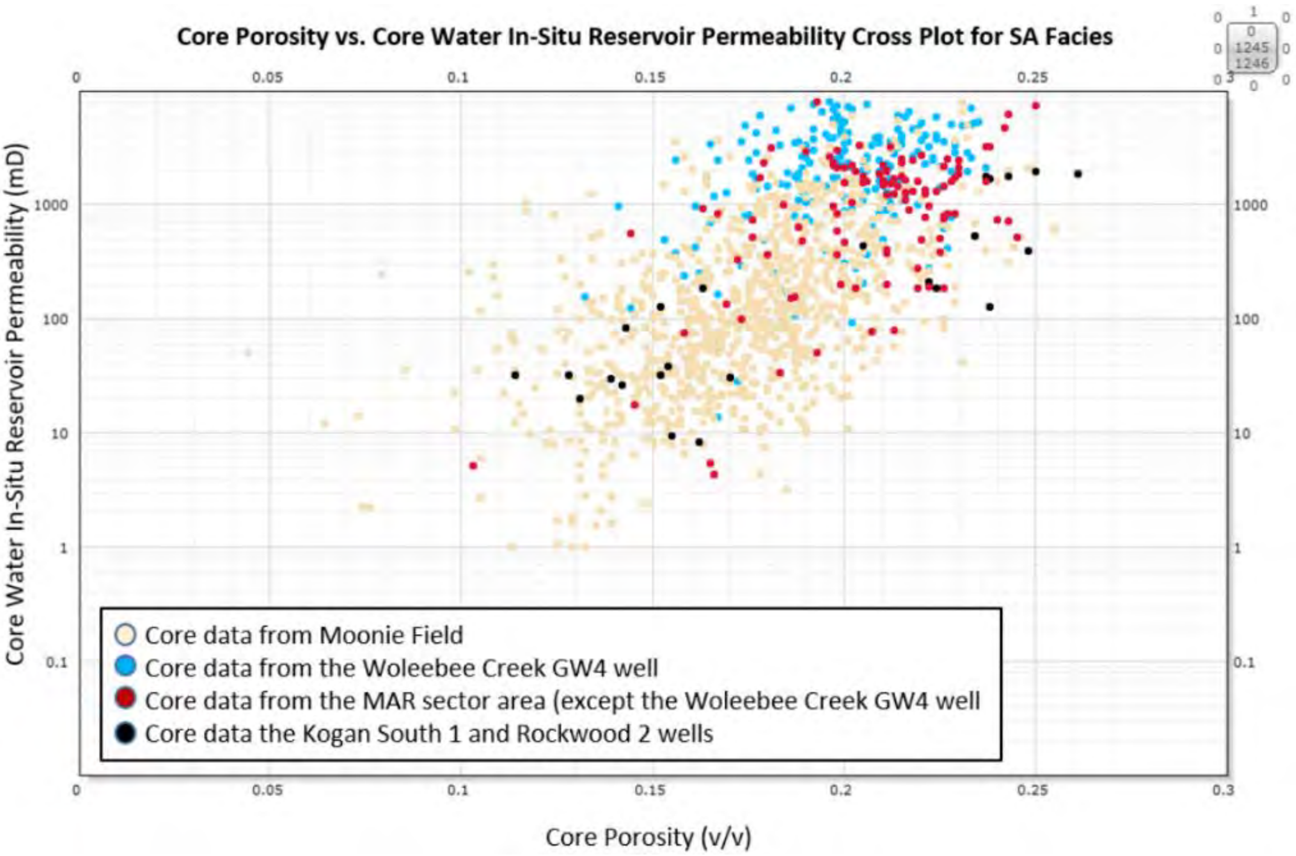

Figure 35: Core porosity vs core water *in situ* reservoir permeability, for cross-stratified sandstone facies (Harfoush et al., 2019c)

Lower Evergreen Formation

The basin-wide core data analysis has shown that the average core porosities of the lower Evergreen Formation and Boxvale Sandstone Member vary between 7% and 21% with average core water *in situ* reservoir permeability ranges from 0.01 mD to 829 mD (K of ~10^{-5} to 10^{-1} m/d), reflecting the high degree of heterogeneity in this unit (as described in Section 4.6.3 and shown in the gamma ray response (Figure 22).

Upper Evergreen Formation

Only five cored wells with core plugs were available to inform the upper Evergreen Formation, with porosity varying between 9% and 10% and core water *in situ* reservoir permeability of less than 0.1 mD (K < ~10^{-4} m/d). Only five cored wells with core plugs were available to inform the upper Evergreen Formation, with porosity varying between 9% and 10% and core water *in situ* reservoir permeability of less than 0.1 mD (K < ~10^{-4} m/d). The bores are indicated with red in Figure 33. Core has subsequently acquired in West Moonie-2 Monitoring Well and results from geomechanical analysis, petrology, mercury injection capillary pressure (MICP) and MDT pressure data show that it is a seal.

4.6.5.5 Overview of porosity and permeability properties

The average porosity and permeability properties in the lower Precipice Sandstone and the Evergreen Formation, based on regional studies are summarised in Table 41 and Table 42, and compared to the local-scale results of West Moonie-1 Injection Well and West Moonie-2 Monitoring Well. It should be noted that only routine core analysis results are included for West Moonie-1 Injection Well and average porosity from wireline log analysis is average net porosity (porosity over the net reservoir interval). The tables broadly shows that the West Moonie-1 Injection Well hydraulic properties align with the regional analysis. The average porosity and permeability are highest in the lower Precipice Sandstone, while the properties in the upper Precipice

Sandstone and lower Evergreen Formation are variable. There are some high permeability values encountered in the upper Evergreen Formation, due to sandy sections above the ironstone beds in some of the wells (Harfoush et al., 2019a.).

There is also some regional variation, with analysis of the core plug *in situ* water permeability of the Precipice Sandstone showing relatively high permeability values, ~2,500 mD (K of ~1 m/d) in the MAR Sector Area (north of the basin), while the average permeability in the Moonie Oil Field area is ~360 mD (K of ~ 10^{-1} m/d) (Harfoush et al., 2019b.).

Table 41: Range of average porosity data per well from UQ-SDAAP regional studies and West Moonie-1 Injection Well data

Porosity	Lower Precipice Sandstone	Upper Precipice Sandstone and lower Evergreen	Upper Evergreen
Regional core data analysis (Harfoush et al., 2019b)	13 – 25%	7 – 21%	9 – 10%
Regional wireline log analysis[6] (Harfoush et al., 2019a)	9 – 23%	0.1 – 15%	<1 – 20%
West Moonie-1 Injection Well core data analysis[7]	16%	13%	No data
West Moonie-1 Injection Well wireline log analysis[8]	14% (net/gross 84%)	14% (net/gross 10%)	12% (net/gross 9%)

Table 42: Range of average permeability data per well from UQ-SDAAP regional studies and West Moonie-1 Injection Well data

Permeability	Lower Precipice Sandstone	Upper Precipice Sandstone and lower Evergreen Formation	Upper Evergreen Formation
Regional Core data analysis[9] (Harfoush et al., 2019b)	14 – 2,545 mD (K of ~ 10^{-2} to 1 m/d)	0.01 – 829 mD (K of ~ 10-5 to 10-1 m/d)	< 0.1 mD (K of < ~ 10^{-4} m/d)
Regional DST analysis (Honari et al., 2019a)	20 – 1,400 mD (K of ~ 10^{-2} to 1 m/d)	0.01 – 270 mD (K of ~ 10^{-5} to 10^{-1} m/d)	No data
Regional Wireline log analysis	5 – 3,943 mD (K of ~ 10^{-3} to 1 m/d)	<0.01 – 1,060 mD (K of <~ 10^{-5} to 1 m/d)	< 0.01 – 1,391 mD (K of < ~ 10^{-5} to 1 m/d)

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[6] Effective porosity

[7] Helium porosity

[8] Average net total porosity (cut off: phie>10% & Vcl<50%)

[9] Core water *in situ* reservoir permeability

Permeability	Lower Precipice Sandstone	Upper Precipice Sandstone and lower Evergreen Formation	Upper Evergreen Formation
(Harfoush et al., 2019a)			
West Moonie-1 Injection Well core data analysis[10]	984 mD (K of ~ 1 m/d)	13.3 mD (K of ~ 10^{-2} m/d)	No data

4.6.6 Groundwater levels, potentiometrics and groundwater flow systems

To assess basin-scale hydrodynamics, OGIA (2021) studied the available groundwater level data for the Precipice Sandstone. OGIA (2021) identified two dominant groundwater flow directions separated by a groundwater divide. Groundwater flow in the northern part of the aquifer is most likely towards the north-east due to groundwater discharge into the Dawson River near Taroom (Figure 20). Groundwater gradients are generally very low in this area reflecting the high aquifer transmissivity of the lower Precipice Sandstone. An exception to this includes the Hutton-Wallumbilla Fault (east of Injune), suggesting a reduction in transmissivity across this structure (Hayes et al., 2019a). The direction of the groundwater gradient south of the divide, where EPQ10 is located, is more uncertain due to limited available data, but is likely to the east or south depending on which datasets are considered. OGIA considered very few data points south of the CSG fields in their regional-scale potentiometric interpretation, while Rodger et al (2020) focused more on the southern Surat Basin area. Both publications acknowledge the uncertainty of the groundwater flow in the Precipice Sandstone in this deeper part of the basin. Both interpretations are presented in this section for transparency and acknowledgement of that uncertainty.

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[10] Permeability to air

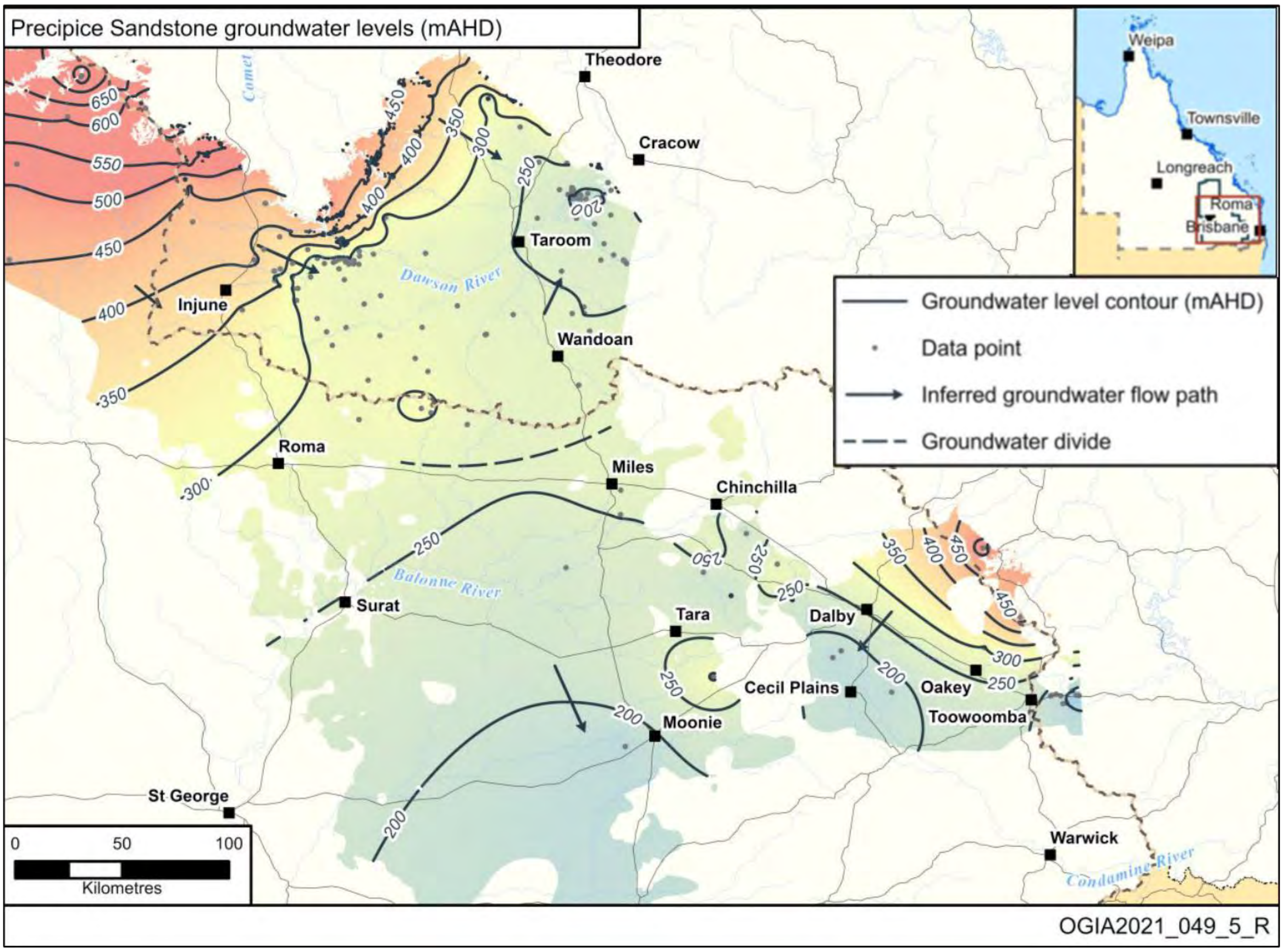


Figure 36: Interpreted groundwater flow directions in the Precipice Sandstone (OGIA, 2021)

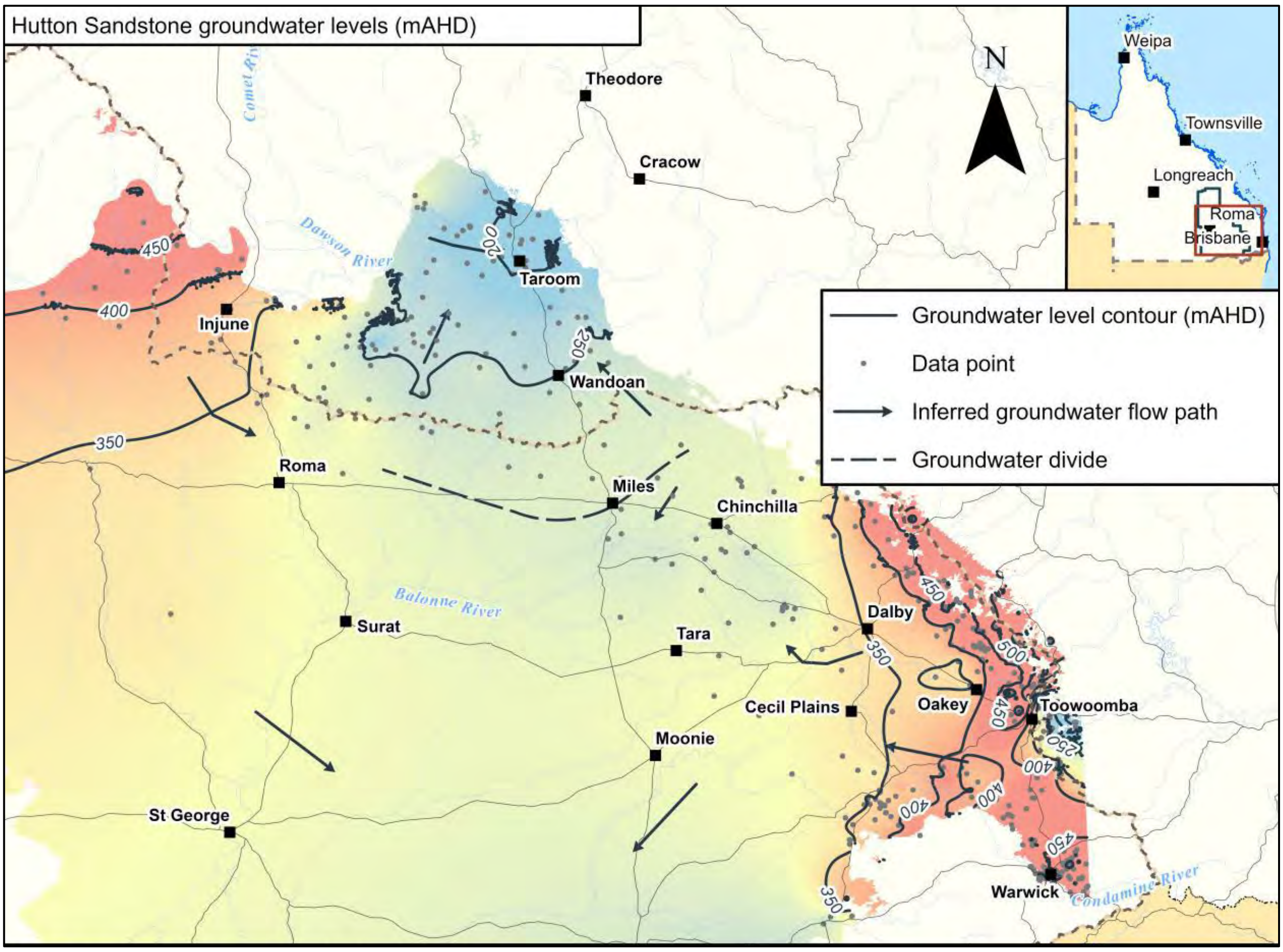


Figure 37: Interpreted groundwater flow directions in the Hutton Sandstone (OGIA, 2021)

Rodger et al. (2020) analysed DST and pressure data for the Hutton Sandstone, Evergreen Formation and Precipice Sandstone and calculated equivalent hydraulic heads (Figure 38 and Figure 39). The hydraulic head in the Precipice Sandstone is lowest in the east of the basin. Hydraulic heads are higher in the Hutton Sandstone by more than 50 m when compared with the Precipice Sandstone, which indicates a general downward gradient (Rodger et al., 2020). The hydraulic head difference indicates that overall hydraulic connectivity between the Hutton Sandstone and the Precipice Sandstone is likely low otherwise the heads would have equilibrated over geologic time, although there may be potential for localised connectivity along faults and fracture zones (Rodger et al., 2020). A connection between the Hutton and Precipice Sandstone near the Burunga - Leichhardt Fault was suggested by Raiber et al (Rodger et al., 2020). Rodger et al.'s (2020) analysis shows three wells south of Moonie that have high groundwater elevations (Figure 39). These higher heads might be caused by connectivity to the Hutton Sandstone via nearby faults (Rodger et al., 2020). However, the source of these data points is unknown, it might also be caused by misassignment of formations. Figure 39 shows these anomalously high heads in the Precipice Sandstone are not supported by pressures elsewhere in the basin, strengthening the hypothesis of incorrect aquifer attribution.

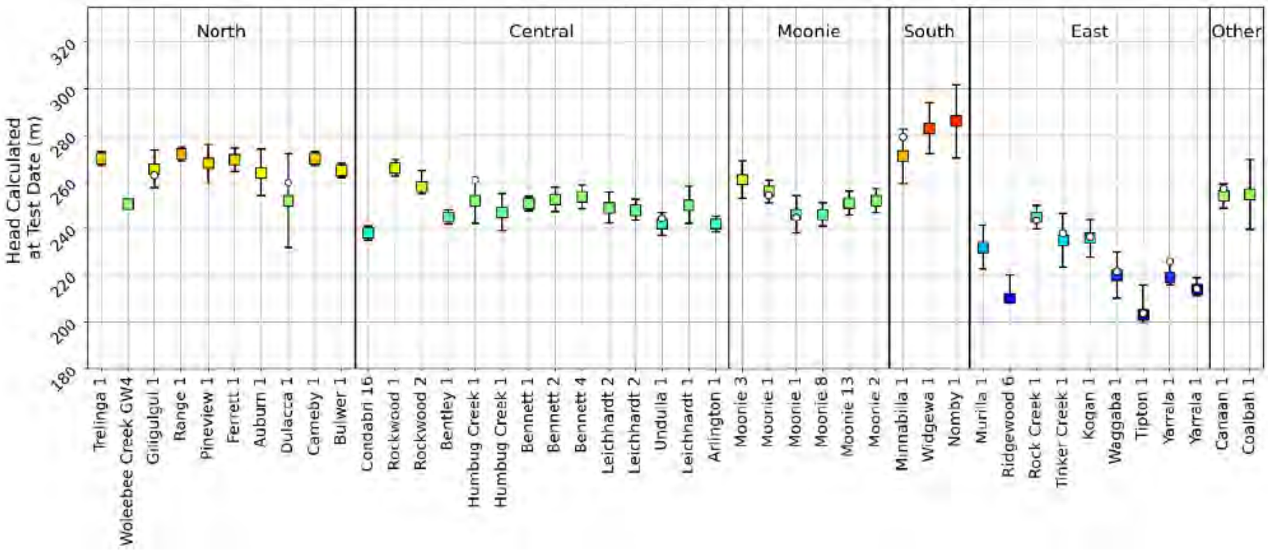


Figure 38: Estimated heads in the Precipice Sandstone (coloured by head) with confidence range. White dots are estimates from Scorer (1966) (from Rodger et al., 2020)

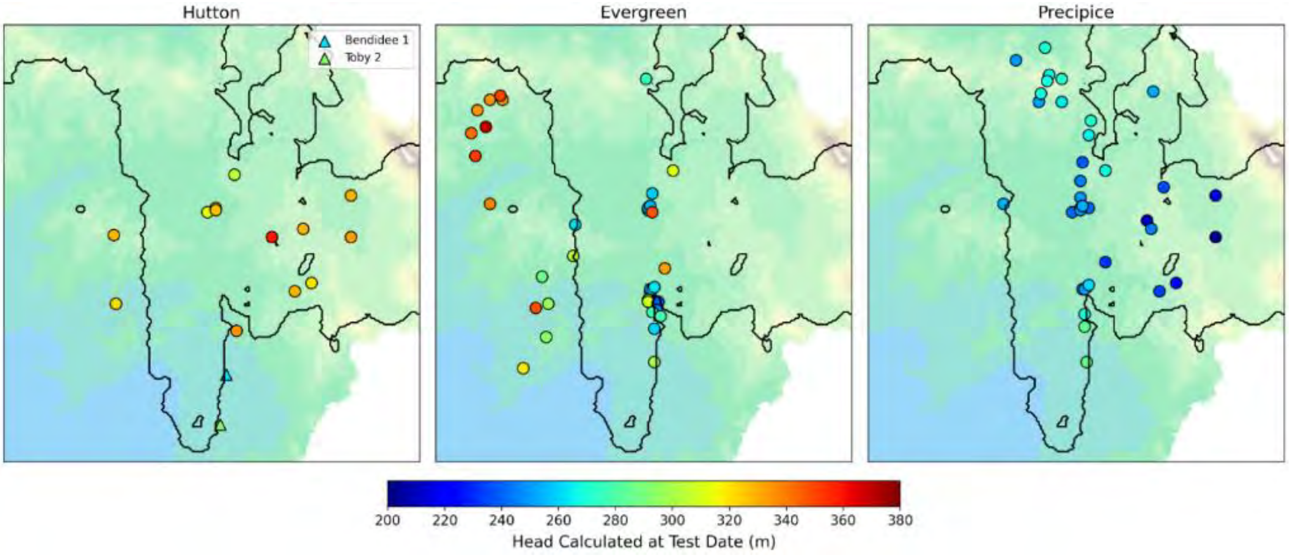


Figure 39: Calculated hydraulic heads in the Hutton Sandstone, Evergreen Formation and Precipice Sandstone. Coloured background shows surface elevation, black outline shows Precipice extent. The two triangles on the Hutton Sandstone show wells that flowed while drilling (from Rodger et al., 2020)

The Moonie Oil Field, located 30 km east of West Moonie-1 Injection Well, produces oil from the Precipice Sandstone and the lower Evergreen Formation. The Moonie Oil Field has been in production since the early 1960s, and the associated water production is currently about 1,000 ML per year. Production of oil and formation water at Moonie have decreased the heads in the southern and central portion of the Precipice Sandstone (Rodger et al., 2020). This can be seen on the potentiometric surface presented in Figure 36, where there is a potentiometric low over the Moonie Oil Field. In comparison with Figure 37, there is not a similar potentiometric low in the Hutton Sandstone. This provides evidence of the effectiveness of the upper Evergreen Formation as an aquitard when significant pressure changes have been imparted over approximately 50 years of oil and water production in the Moonie Oil Field.

This pressure offset is measured in West Moonie-2 Monitoring Well with Modular Formation Dynamic Tester (MDT) pressure gradients. MDT at West Moonie-2 Monitoring Well shows 100 psi offset between Hutton (higher pressure) and Precipice (lower pressure). The proposed three-year test injection of GHG stream (110,000 t/year) may assist in restoring the head to pre-petroleum and gas production level.

4.6.7 Precipice Sandstone conceptual flow pathways

Rodger et al. (2020) investigated potential pathways for groundwater within and vertically into and out of the Precipice Sandstone aquifer, as summarised in Figure 40. A short explanation of the potential pathways and the supporting evidence for each is outlined below (based on Rodger et al., 2020):

1) **North-south flow:** Hydraulic head pressures indicate a hydraulic gradient from the north into the central part of the basin (Rodger et al., 2020) within the Precipice Sandstone unit. This is a pathway for flow into the Precipice Sandstone aquifer.
2) **East flow to/from the Clarence Moreton Basin:** Hydraulic head data indicates a consistent hydraulic gradient from the north into the central part of the basin. There is some evidence of an eastern flow pathway towards the Clarence Moreton Basin, based on Strontium isotope analysis and a decreasing head towards the east (Rodger et al., 2020). The problem with this pathway is the lower hydraulic head in the Precipice Sandstone and the increasing topographic elevation. Ransley and Smerdon (2012a; 2021b) identified a possible connection across 'Helidon Ridge', and this pathway is subject to ongoing research (Rodger et al., 2020).
3) **Westward flow to/from the Roma Shelf:** This pathway is unlikely as the Precipice Sandstone pinches out to the west and onto the Roma Shelf. Also, the observation wells at Santos Roma CSG field show no response to the MAR at Reedy Creek, which is less than 40 km away. This suggests that the Precipice Sandstone on the Roma Shelf may not be hydraulically connected to the lower Precipice Sandstone as mapped by La Croix et al. (2019c) into which injection at Reedy Creek occurs.
4) **Southward flow to/from northern New South Wales:** There are insufficient wells to the south of Moonie (see Figure 39) to conclusively evaluate the southern flow mechanism. The DST data presented in Figure 38 show a gradual reduction in head from north to south in the central basin. Although the heads in the far south are higher again which makes interpretation in the deepest parts of the basin uncertain.
5) **Interaction with overlying sediments:** Upward flow from the Precipice Sandstone into the Hutton Sandstone is unlikely since vertical hydraulic pressure gradients are in the opposite direction, that is, downward (Figure 39). The downward hydraulic gradient is also confirmed by strontium isotope analysis. Vertical flow might also occur via faults or leaky well bores. The only evidence for flow via faults is high pressures in three wells in the Precipice Sandstone 17 km to 52 km south of the Moonie Oil Field, where the calculated heads are similar to those observed in the Hutton Sandstone (Rodger et al., 2020). However, as described earlier, it is likely that an incorrect stratigraphic attribution of the aquifer may also be responsible for these anomalous pressures.
6) **Interactions with underlying sediments:** The Moolayember Formation of the Bowen Basin underlies the Precipice Sandstone and has a low permeability with limited potential for groundwater exchange with the basal Surat Basin HSUs.
7) **Abstraction and injection:** Groundwater abstraction and injection have locally altered flow paths.

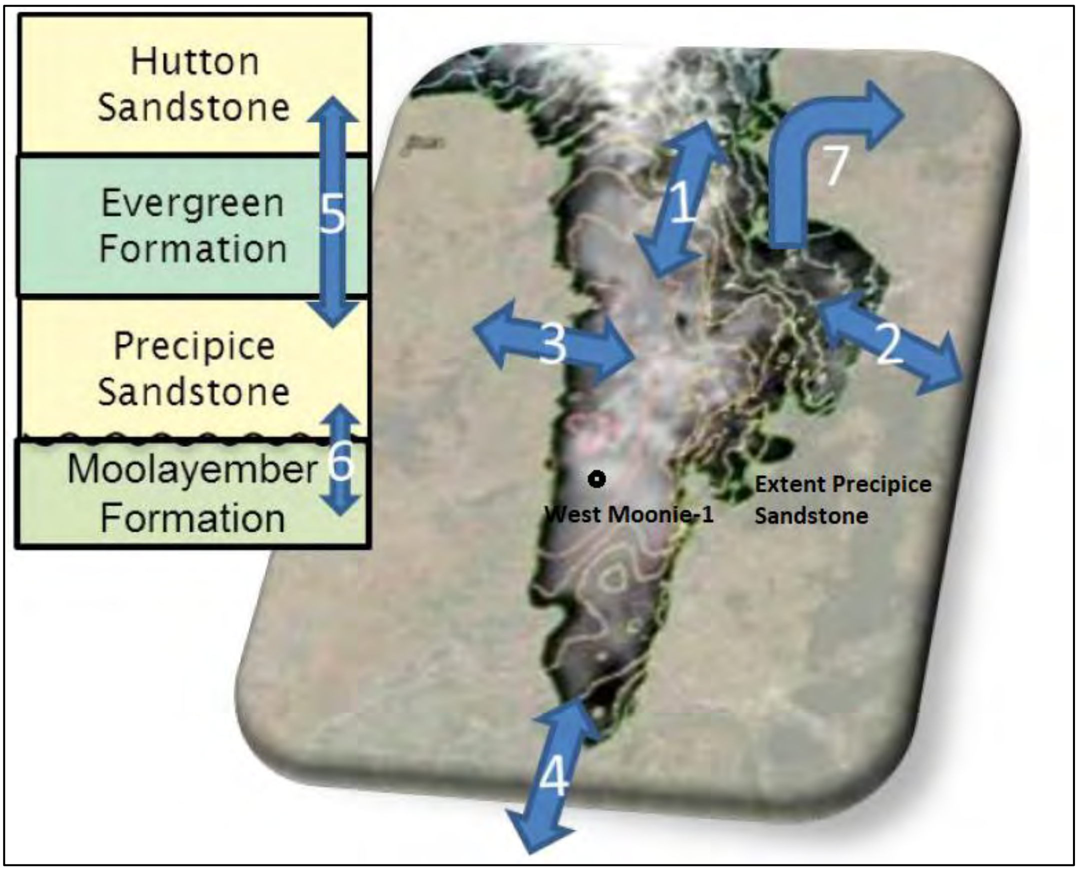


Figure 40: Potential pathways for flow into and out of the Precipice Sandstone aquifer (modified from Rodger et al., 2020)

4.6.8 Temperature

West Moonie-2 Monitoring Well encountered a temperature of 75°C in the Precipice Sandstone at a depth of 2,330 m and a pressure of 22,380 kPa. With this pressure and temperature, the estimated temperature gradient is 2.4ºC/100 m (Figure 41). Modelling work presented in Section 5.2 is based in the temperature as encountered in West Moonie-2 Monitoring Well.

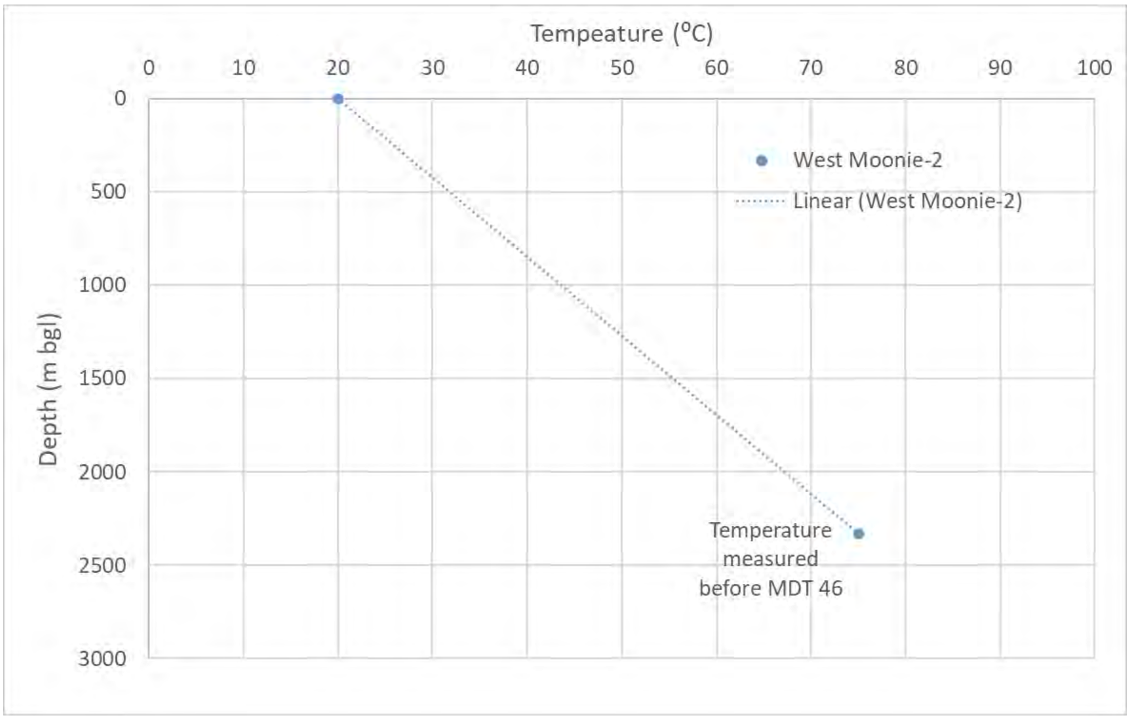


Figure 41: Temperature gradient measured at West Moonie-2 Monitoring Well

4.6.9 Recharge and discharge processes

OGIA (2019a) identified three main recharge processes in the Surat CMA, which are localised recharge, preferential pathway flow and diffuse recharge. Of these, preferential pathway flow through high permeability zones is believed to be the major recharge mechanism in the GAB (OGIA, 2019a).

OGIA (2016a) estimated groundwater recharge rates using a chloride mass balance method. They inferred that the majority of recharge occurs within formation outcrop areas, predominantly via rainfall, either by direct infiltration, or indirectly via leakage from streams or overlying aquifers. OGIA's recharge estimates range from 4.8 mm/year to 20.6 mm/year for most aquifers (Precipice, Hutton and Gubberamunda sandstones), and from 1.2 mm/year to 3 mm/year for aquitards (Hayes et al., 2019a). Numerical modelling suggests that most surficial recharge discharges locally to streams and rivers (OGIA, 2021).

Natural discharge occurs via creeks, rivers and springs. Most springs are located along and near the northern and central outcrop area of the Surat and Bowen Basins and are associated with the Gubberamunda, Hutton, Clematis and Precipice Sandstones (OGIA, 2016b). The closest springs attributed to the Precipice Sandstone are the Cockatoo Creek spring complex, located approximately 235 km to the north of West Moonie-1 Injection Well.

Where shallow and accessible, the Precipice Sandstone aquifer is a heavily used and impacted groundwater system. OGIA (2021) reported an impacted area in the Precipice Sandstone in the southern Surat Basin, resulting from groundwater extraction for conventional P&G production in the area. There is groundwater extraction from the Moonie Oil Field and from non-CSG groundwater use that is not associated with the petroleum industry. Positive pressure impacts occur from MAR in the north of the basin and natural recharge at the Precipice outcrop in the north of the Surat Basin. Injection has been occurring since 2015 at Reedy Creek (17.5 ML/day average) and Spring Gully (2 ML/day average).

The pressure impacts on the Precipice Sandstone are tabulated in Table 43.

Due to the high porosity and permeability, it is expected that the Precipice Sandstone will react rapidly to pressure changes before establishing a new equilibrium.

Table 43: Impacts on Precipice Sandstone groundwater system

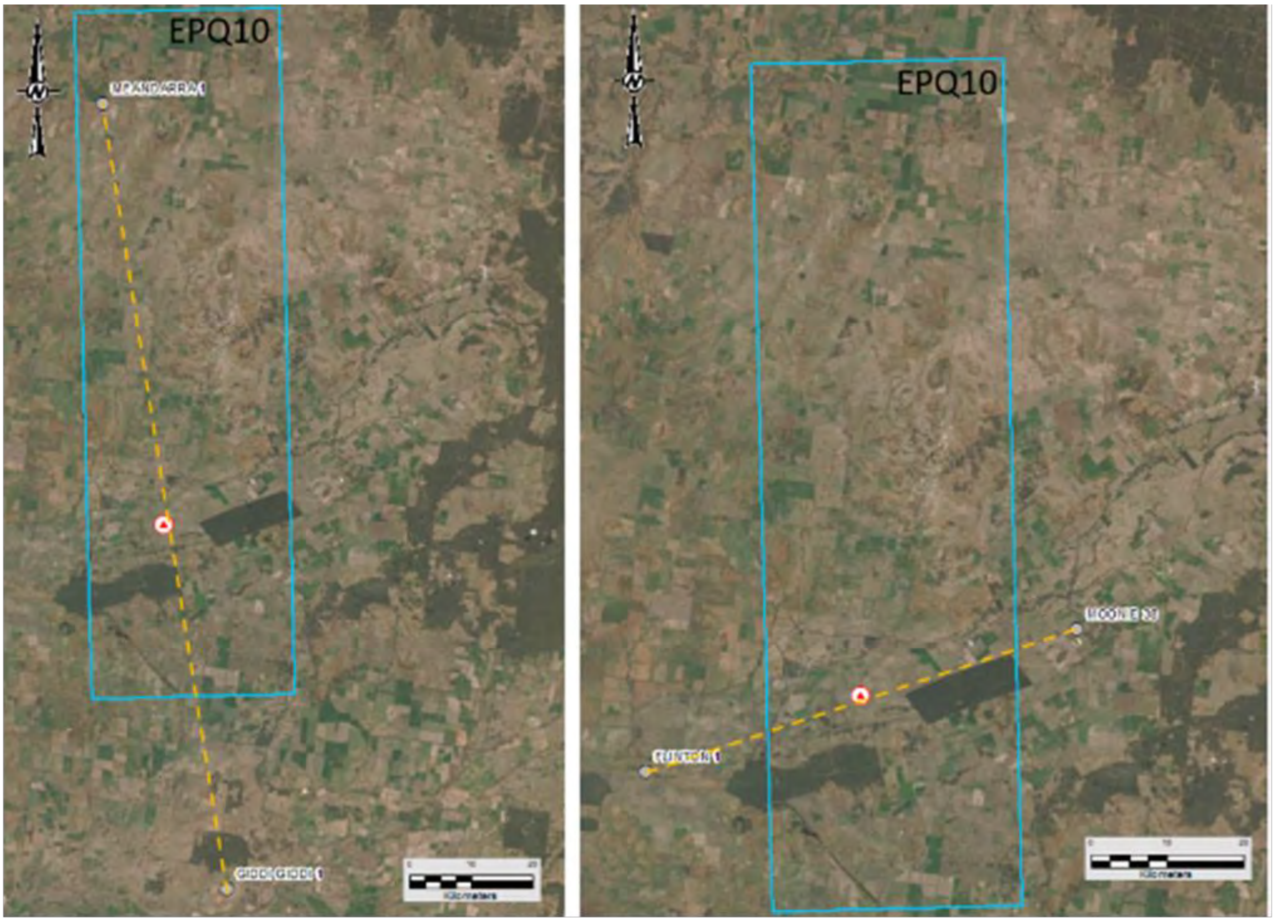
Inflows	Outflows
Recharge	Springs
MAR (currently ~ 5,000 ML/yr)	Non-associated groundwater use (~ 6,125 ML/yr)
	Groundwater production by Moonie (~ 1,000 ML/yr)

4.6.10 Summary of Hydrogeology Conceptual Model

The key features identified in the HCM, described in Section 4.6, that are pertinent to quantification of impacts through the numerical modelling undertaken, are:

- The lower Precipice Sandstone is a well-connected sandstone aquifer. Regional potentiometrics suggest a flow divide just south of the Great Dividing Range. This separates the aquifer into a shallow northern flow system with many EVs and a more saline southern zone with limited to no EVs.
- The Evergreen Formation is heterogeneous but consists predominantly of fine-grained lithologies, leading to an effective tight aquitard with significant vertical resistance to groundwater flow.
- Most hydraulic head data indicates a downward hydraulic gradient from the Hutton Sandstone to the Precipice Sandstone. There is limited to no evidence of connectivity though faulting between the Hutton Sandstone and Precipice Sandstone. Where there is data, there is some uncertainty related to the quality of this data and aquifer misattribution.
- The flow direction in the southern Surat Basin is uncertain, but it most likely flows towards the south or east.
- The nearest regional fault structures are 20 km to the east of the West Moonie-1 Injection Well. MDT at West Moonie-2 Monitoring Well shows 100 psi offset between Hutton (higher pressure) and Precipice sandstone (lower pressure), so no connectivity is interpreted across the nearest major fault, being the Moonie-Goondiwindi fault system.
- Recharge of the Precipice Sandstone occurs in the north of the Surat Basin, through rainfall as well as MAR.
- The Moonie Oil Field is the main feature of groundwater discharge from the Precipice Sandstone in the southern Surat Basin.

Figure 43 and Figure 44 show a NNW-SSE and SW-NE conceptual model cross-section through EPQ10, intersecting West Moonie-1 Injection Well. The location of the conceptual cross-sections is indicated in Figure 42.



Base map: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/AIrbus DG, USDA, USGS, AeroGRID, IGN, and the GIS User Community.
Bores & EPQ10 outline @State of Queensland (Department of Resources) 2021

Figure 42: Location of cross-sections

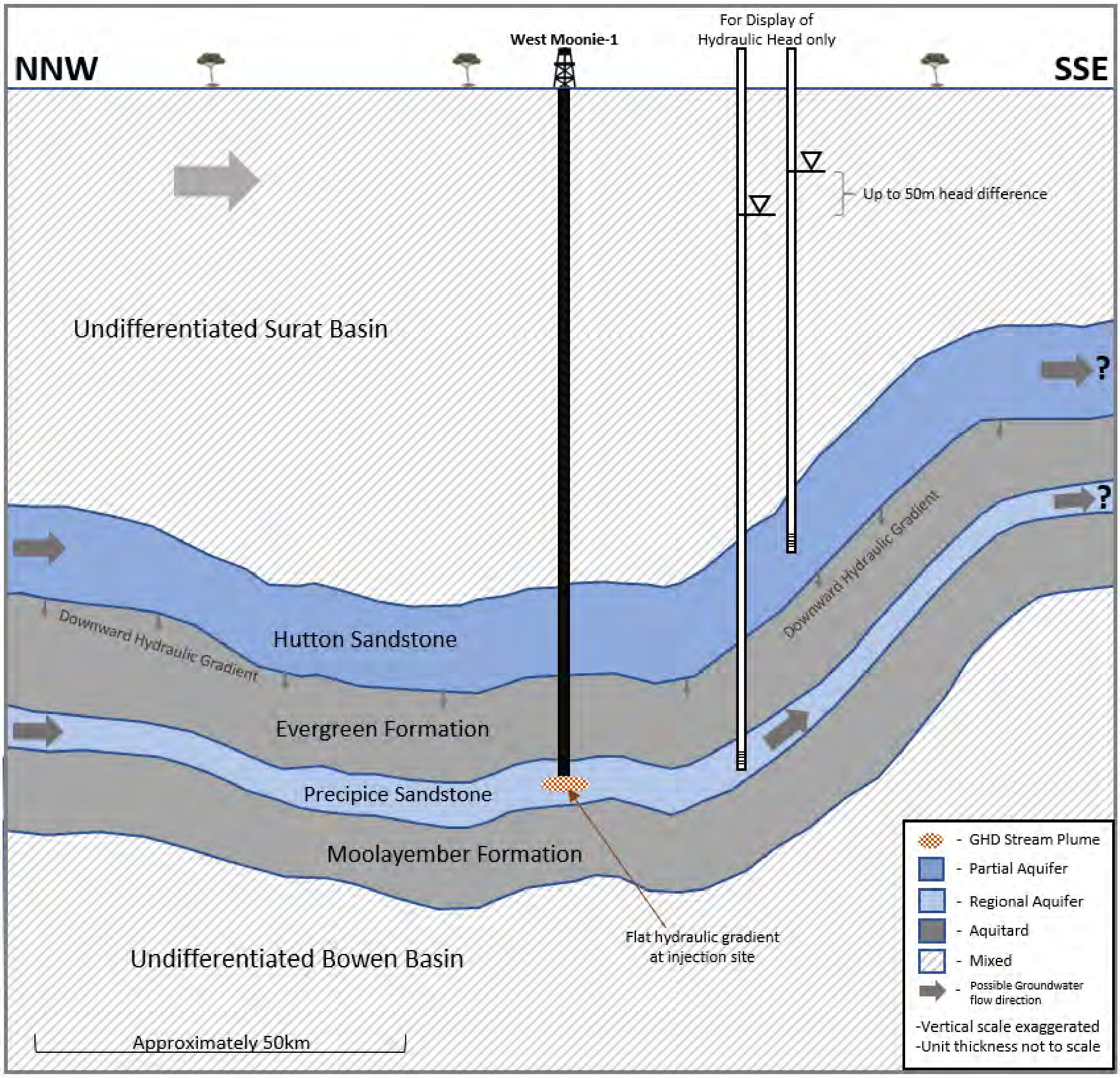


Figure 43: NNW-SSE Section from CTSCo regional model through EPQ10 (modified from CTSCo data)

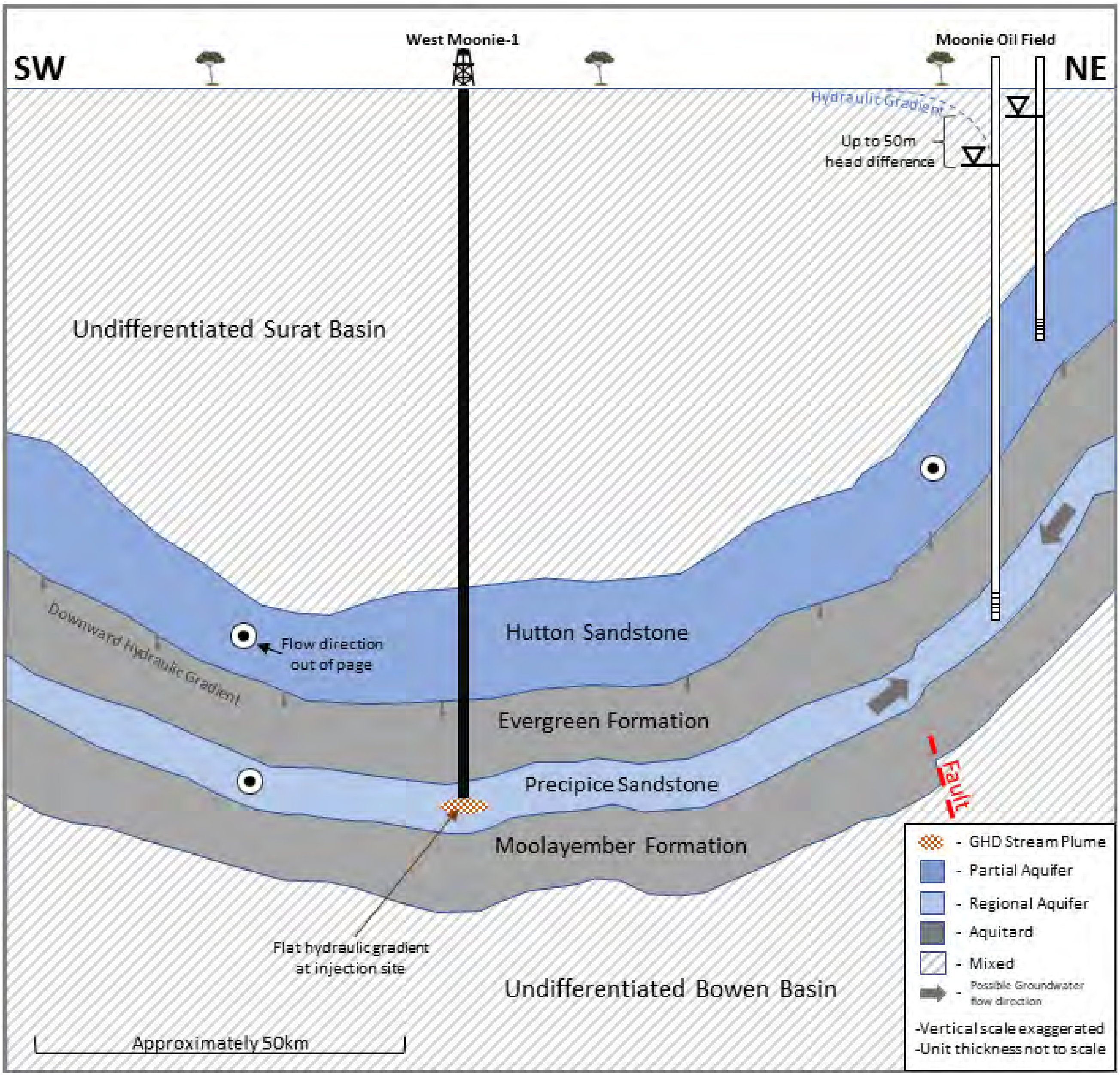


Figure 44: SW-NE section from CTSCo regional model through EPQ10 (modified from CTSCo data)

5.0 MODELLING OF GHG STREAM INJECTION

5.1 Regional hydrodynamic modelling

As noted in Section 2.2.3.4, the pressure propagation caused by the GHG stream injection has been numerically modelled on a regional scale (i.e., the pressure propagation beyond the local-scale 2 km by 2 km reservoir model), to predict: 1) the pressure change due to GHG stream injection; and 2) the groundwater movement away from the West Moonie-1 Injection Well. Modelling was conducted using a single-phase model in MODFLOW 6™. The injected GHG stream is incorporated in the model as a similar volume of water to simulate the pressure impact in the southern Surat Basin.

This section described the setting up and the results of the regional numerical modelling, and the assumption and limitations of the modelling.

5.1.1 Model setup

5.1.1.1 Base case model setup

The hydrodynamic model was set-up in MODFLOW 6™, using an unstructured mesh with regional grid cells of 1.5 km x 1.5 km, refined locally to cells of 187.5 m x 187.5 m around West Moonie-1 Injection Well. The model extent is approximately 150 km by 400 km. The model includes the upper Hutton Sandstone, lower Hutton Sandstone, the Evergreen Formation, and the Precipice Sandstone underlain by a layer of Triassic/ basement formation. The Precipice Sandstone and the Evergreen Formation are subdivided into multiple layers, while the other formations are represented as one model layer. The vertical discretisation is summarised in Table 44.

The hydraulic properties selected for the base case model are summarised in Table 44. Figure 45 shows how the hydraulic conductivity used in the hydrodynamic model compare to OGIA's (2019a) regional model properties. The hydraulic conductivity used in the base case model is within the range predicted by OGIA, except for the Boxvale Sandstone Member. It is not included as a separate layer in the hydrodynamic model but contained within the Evergreen Formation. The Evergreen Formation hydraulic conductivity used in the hydrodynamic model is at the lower end of the calibrated OGIA model. This is expected as the hydrodynamic model reflects the deeper Evergreen Formation aquitard in the southern Surat Basin, while OGIA's model considers the whole Evergreen Formation from shallow outcrop to deep in the basin.

Table 44: Base case properties of the hydrodynamic model, porosity is constant at 13.5%

Name	Model layer(s)	Specific storage Ss (1/m)	kh (m/day)	kv (m/day)
upper Hutton	1	1.0×10^{-6}	3.0×10^{-2}	4.0×10^{-6}
lower Hutton	2	1.0×10^{-6}	1.0×10^{-2}	1.0×10^{-6}
Evergreen	3-5	1.0×10^{-6}	6.0×10^{-5}	5.0×10^{-8}
Precipice	6-10	1.0×10^{-6}	4.0×10^{-1}	4.0×10^{-3}
Underlying	11	1.0×10^{-6}	1.0×10^{-4}	1.0×10^{-8}

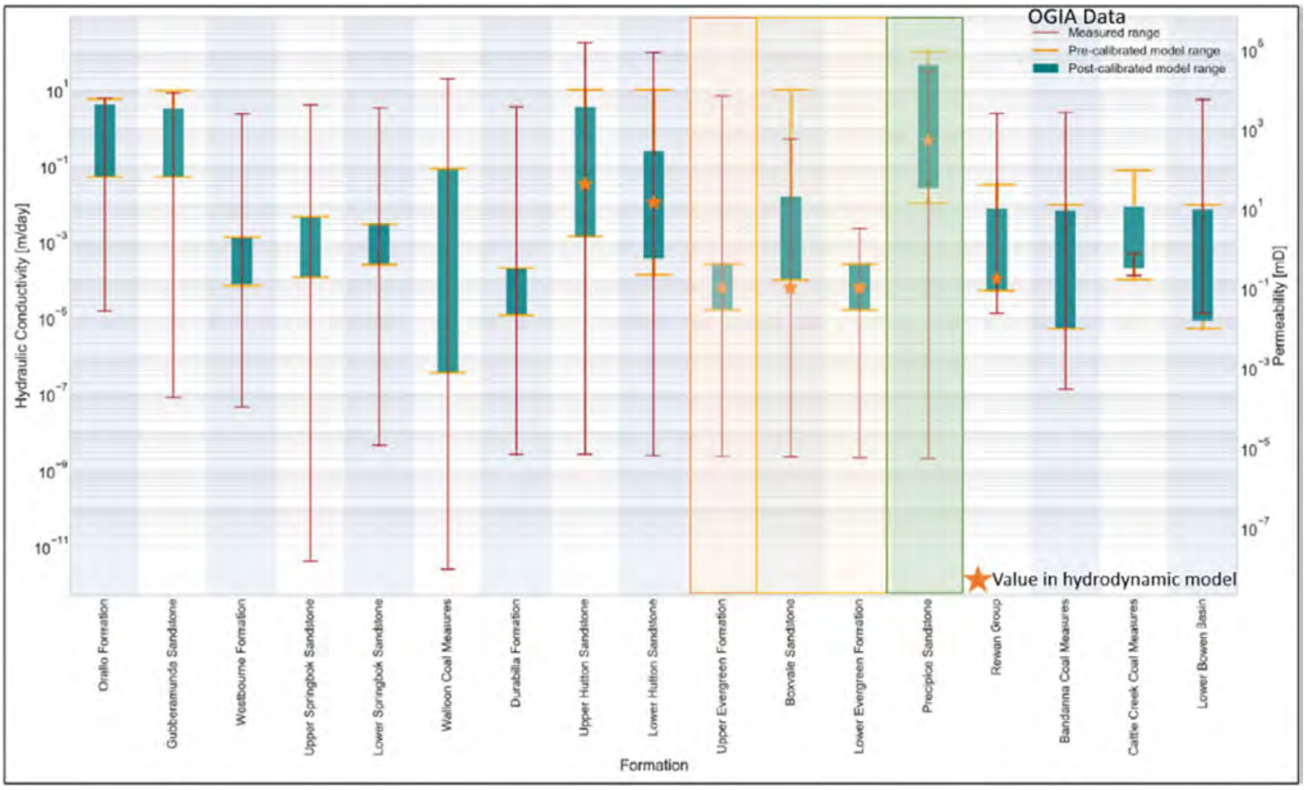


Figure 45: Hydraulic conductivity of the hydrodynamic model (indicated with an orange star) compared with OGIA's model ranges (modified from OGIA, 2019a)

The hydrodynamic model has been simulated to inform: 1) change in hydraulic head due to GHG stream injection (*hydraulic head impact model*); and 2) movement of GHG-impacted groundwater over time (*particle tracking model*).

The *hydraulic head impact model* was set up with closed boundary conditions, which is a conservative approach, as the added pressure cannot leave the model domain.

The boundary conditions for the *particle tracking model* are shown in Table 45 and Table 46. The head boundary conditions are based on reinterpreted head data from regional wells. The Hutton Sandstone boundary conditions are very uncertain in the south-west due to limited and conflicting data. The Precipice Sandstone boundary condition in the north is difficult to quantify owing to the large amount of recharge and discharge features in the north of the basin.

Despite uncertainty in the boundary conditions, the simulated steady-state heads match the observed heads reasonably well. Therefore, the model is expected to reasonably reflect the flow velocities in the southern Surat Basin.

Table 45: Boundary conditions for base case model (particle tracking model)

Area	Boundary condition (m)	Boundary condition (type)	Note
Precipice North	350	General head boundary	Conductance = thickness x 0.03
Precipice East	140	General head boundary	Conductance = thickness x 0.006
Hutton North	340	Time-variant specified head boundary	

Area	Boundary condition (m)	Boundary condition (type)	Note
Hutton East	350	Time-variant specified head boundary	
Hutton South	300	Time-variant specified head boundary	

Groundwater extraction from the Moonie Oil Field and Kogan Creek Power Station has been included in the particle tracking realisations with a combined extraction rate of 5,000 m^3/day from the regional hydrodynamic model (Table 46). Kogan Creek is expected to close in 2042 (based on the expected closure year as defined in the National Electricity Rules (NER)). While the abandonment date of the Moonie Oil Field is uncertain, OGIA (2019a) expects production to cease in 2030. However, the lifetime of the field could be extended by using EOR techniques.

For the injection test, West Moonie-1 Injection Well will inject a volume of 510 m^3/day for a 3-year period, which is the volumetric equivalent of 110,000 t/year of GHG stream, assuming a GHG-to-water density ratio of 0.6 and a groundwater density of 985 kg/m^3. The GHG stream volume is based on the temperature as measured in West Moonie-1 Injection Well. However, the recently drilled West Moonie-2 Monitoring Well found a lower reservoir temperature. Because of the lower temperature, the density of GHG stream in the reservoir is likely to be higher and the GHG stream volume is lower (approximately 450 m^3/ day) than what is used in the model. Therefore, the simulations likely overpredict the pressure impact.

Table 46: Abstraction and injection wells included in the hydrodynamic model, with years relative to start of the injection

Name	Start (year)	Stop (year)	Extraction / Injection rate (m^3/d)[1]
Moonie Oil Field	-55	10	-2,500
Kogan Creek	-14	20	-2,500
West Moonie-1 Injection Well	0	3	510

Note: [1] Negative number represents extraction and positive number represents injection

5.1.1.2 Sensitivity analysis setup

As part of the sensitivity analysis, nine variations on the base case model were setup, of which four simulations were defined to analyse the impact on hydraulic head, and five simulations to analyse the particle tracking results.

Impact on hydraulic head

Four different model realisations were run in addition to the base case to analyse the sensitivity of the GHG stream impact on hydraulic head. The different model cases are presented in Table 47. Scenario 1.2 is set up as an extreme (poor) case example and represents a specific storage on the lower end of OGIA's (2019a) calibrated model. Scenario 1.4 is set up to test the impact of a hypothetical fault or leakage window in the general vicinity of the West Moonie-1 Injection Well.

Table 47: Model realisations for sensitivity analysis

Case	Name	Comment
1.0	Base case	Properties as in Table 44
1.1	Low storage	Ss in Precipice 5.0 x 10-7
1.2	Low hydraulic conductivity	kv and kh in Precipice x 0.5
1.3	High hydraulic conductivity	kv and kh in Precipice x 2.0
1.4	Fault at 7 km from West Moonie-1 Injection Well	1,125 m long strip of Cells with Kv increased to 1.0 x 10-2 m/d in all layers

Figure 46 provides a plan view of the model griding and gridding density, together with the location of the fault for model case 1.4:

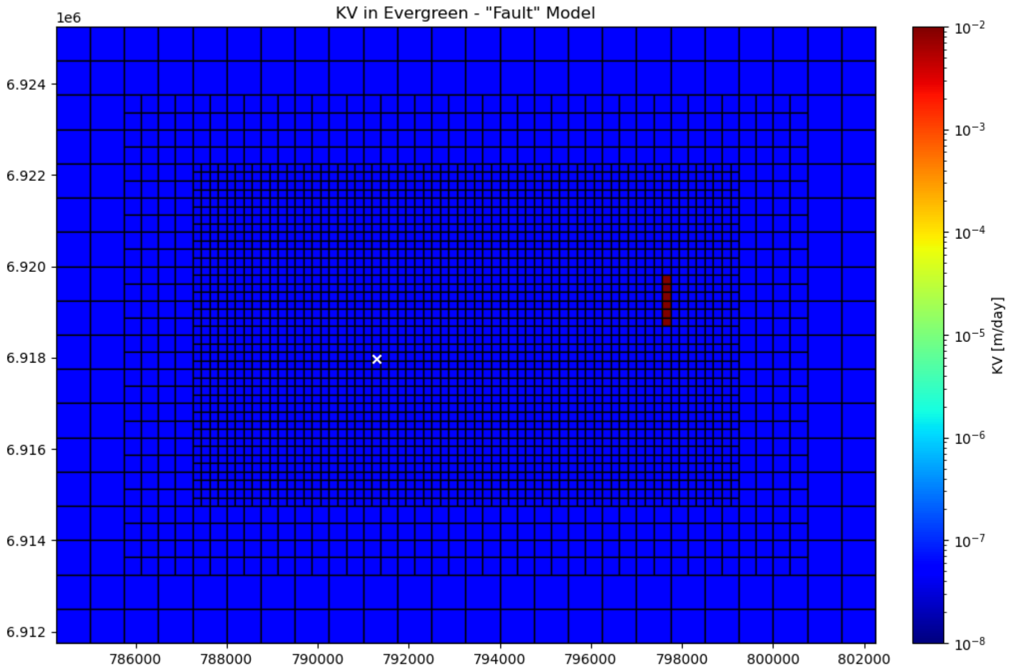


Figure 46: Plan view showing the location of the fault (red cells) in model case 1.4, West Moonie-1 Injection Well is indicated with a white cross

Impact on groundwater movement

Additionally, five model cases were completed to analyse the sensitivity of different conceptualisations on particle (plume) movement, with the different realisations summarised in Table 48. The uncertainties of conceptual boundaries were previously described in Section 2.2.3.1.

Table 48: Model realisations for particle tracking sensitivity analysis

Case	Name	Comment
2.0	Base case	Properties and boundaries as in Table 44 to Table 46
2.1	Low southern head	Southern Hutton boundary set to 100 m (instead of 300 m) – to force flow towards the south
2.2	Low southern head & high kv in south	As 2.1, and Evergreen kv increased to 1.0 x 10^{-5} m/d in the south of the model – to force flow towards the south
2.3	Early Moonie/ Kogan Creek decommissioning	Moonie Oil Field and Kogan Creek power station stop producing as soon as injection ends
2.4	Low porosity	Porosity reduced to 4.5% (instead of 13.5%) to represent flow occurring through only one third of reservoir
2.5	High hydraulic conductivity	Precipice kv and kh doubled

Case 2.3 was set up to address the uncertainty in closure time of the Moonie Oil Field, as discussed in Section 5.1. Case 2.1 and Case 2.2 are set up to force flow to the south, as there is still uncertainty around the flow direction in the southern part of the Surat Basin as explained in more detail in Section 2.2.3.1.

5.1.2 Regional model results

5.1.2.1 Base case model results

The simulated head change through time in the Precipice Sandstone is shown in Figure 47 and Figure 48, with years being relative to the start of the three-year test injection period. The boundary for EPQ10 is provided on each figure for geospatial reference.

The model results show that during the GHG stream injection, the change in head at the injection well is +8.4 m at the end of the 3-year injection period, which is comparable to the maximum pressure predicted by the near-field model described in Section 5.2, with the head pressure spreading laterally at a much faster rate, due to the high hydraulic conductivity of the Precipice Sandstone reservoir (Figure 48 and Figure 51). The 0.2 m head change contour is largely restricted to within the EPQ10 boundary across all time periods in the 100-year assessment period. At the end of year 50 (after 47 years of shut-in) the pressure change only exceeds 0.2 m in the southernmost section of the model, and after 100 years (97 years shut-in), the change in pressure is below 0.2 m in the entire 2 km by 2 km model domain.

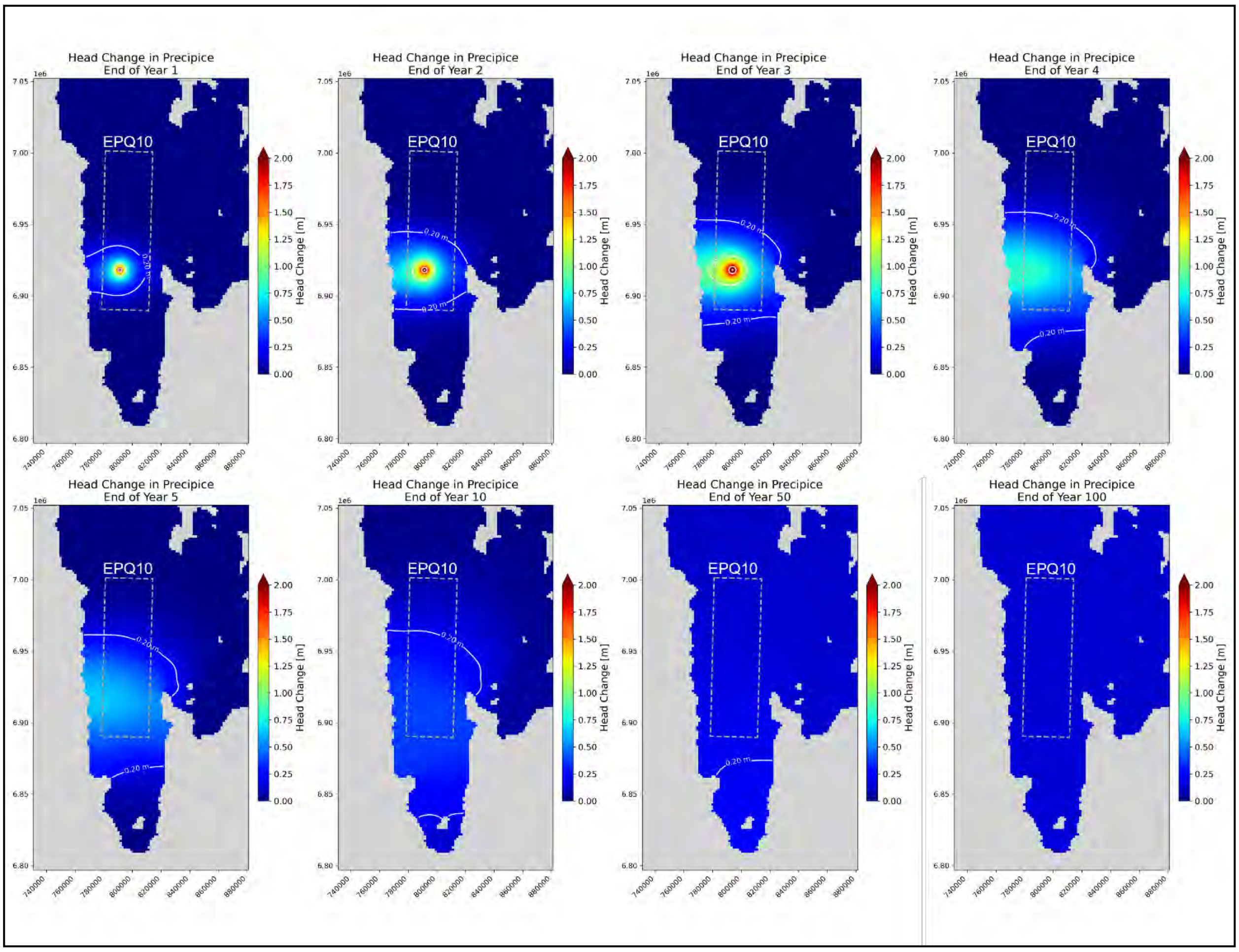


Figure 47: Simulated head change in the base case head impact model (1.0) (figures provided by UQ)

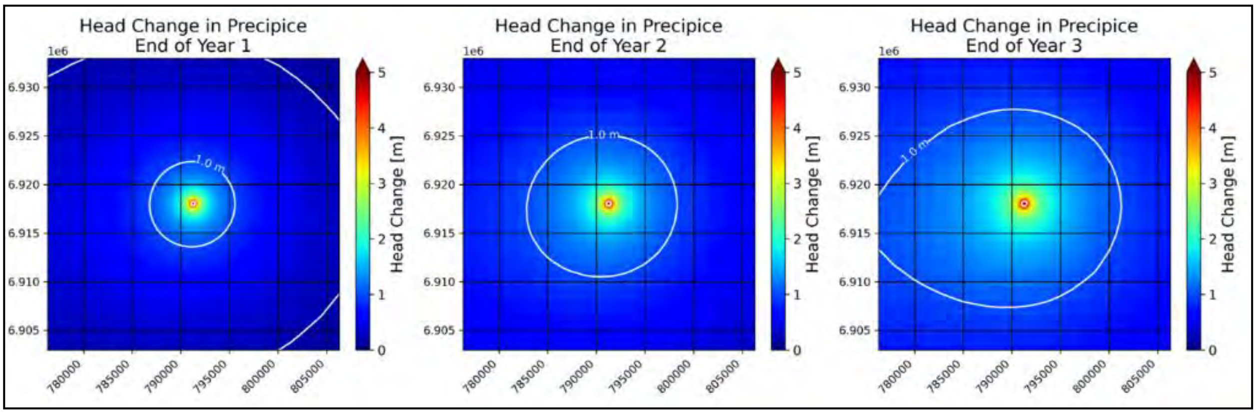


Figure 48: Simulated head change in base case head impact model (1.0), zoomed in at injection well (figures provided by UQ)

The simulated hydraulic head in the Precipice Sandstone for the base case (particle tracking) simulation is shown in Figure 49. The hydraulic head at -55 years represents the hydraulic head at virgin pressure, before the Moonie Oil Field started production. The head shows limited change during the three years of injection (Year 1 to Year 3, Figure 49) followed by two years recovery (Year 5, Figure 49), indicating the limited impact of the GHG stream injection on hydraulic head (see also Figure 47). At Year 10 the water extraction from the Moonie Oil Field is turned off and at 20 years Kogan Creek power station extraction is stopped. The figure for 120 years (Figure 49) shows how the head recovers from all extraction and injection activities.

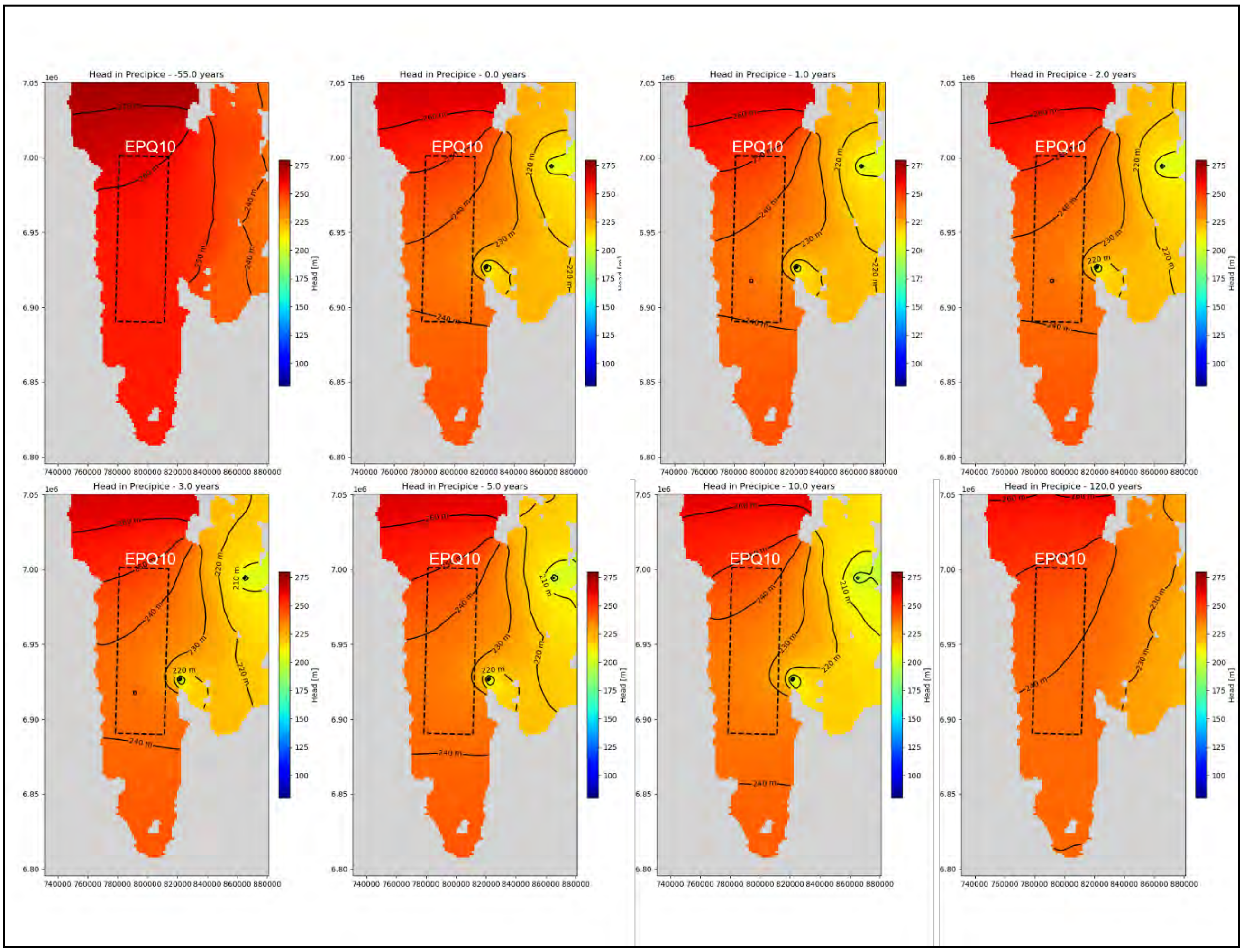


Figure 49: Simulated head for base case particle tracking model (2.0) (years relative to start injection, figures provided by UQ)

The particle tracking results for the base case simulation (described in Section 5.1.1.1) are shown in Figure 50. Four particles in total are released from the corners of a 750 m by 750 m square around West Moonie-1 Injection Well. Figure 50 shows that the particles are expected to travel less than 20 m in 1,000 years. This figure clearly indicates the change in travel direction after the injection stops (at the end of Year 3, mid-blue colour on time scale) and when the Moonie Oil Field stops production (at Year 10). Take the Southeast particle movement for example, during the injection period, particle travels towards Northeast, then change to Southeast at the end of Year 3. The particle travels towards Northeast again when the Moonie Oil field stops production (at Year 10).

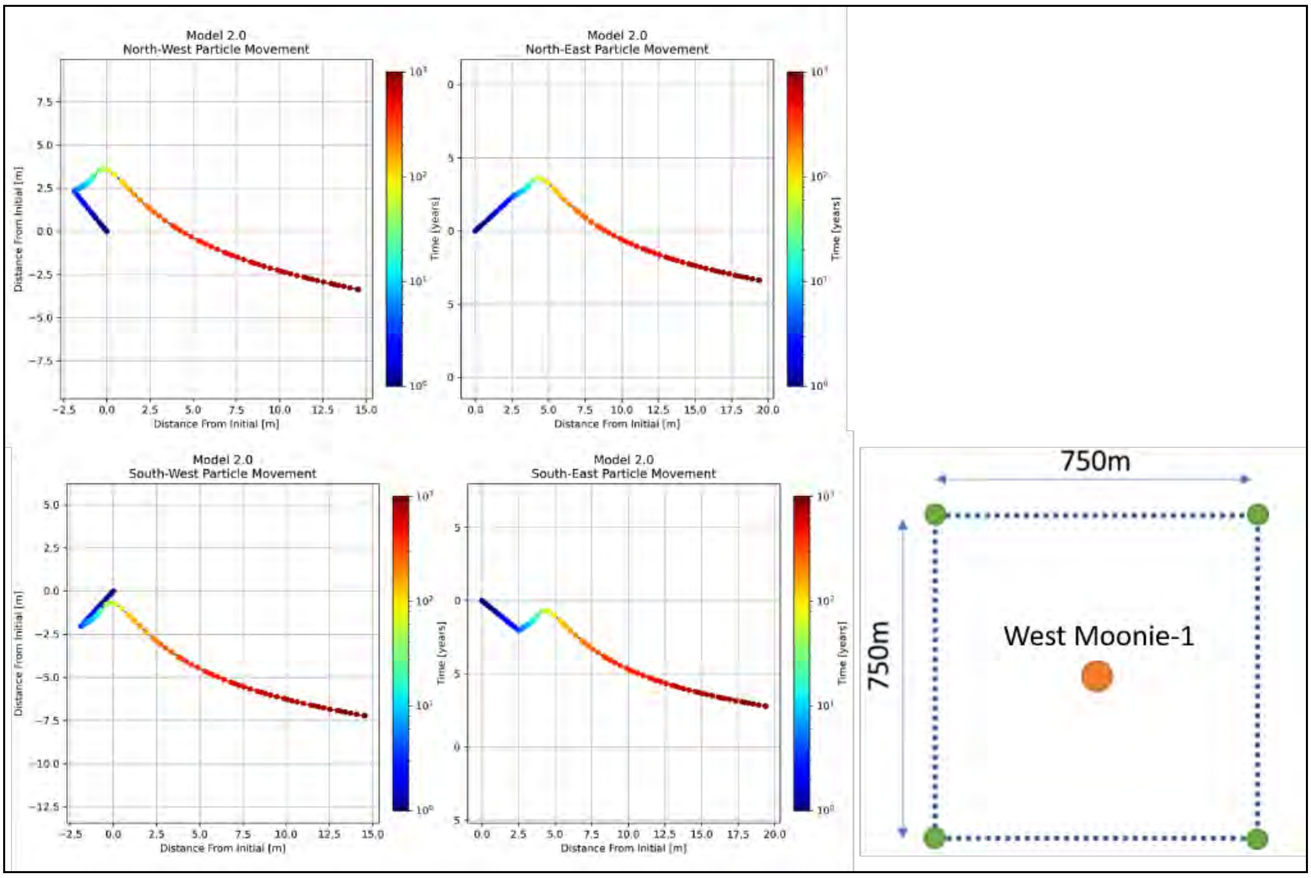


Figure 50: Particle paths relative to starting position for base case model (2.0). The particles are released on the corners of a 750 m x 750 m square with the well in the centre (figures provided by UQ)

5.1.2.2 Sensitivity analysis

As part of the sensitivity analysis, nine variations on the base case model where run, of which four simulations were defined to analyse the impact on hydraulic head, and five simulations to analyse the particle tracking results. The outcomes from the sensitivity analysis are included in Appendix A to Appendix D and summarised in this section.

The simulated pressure impact at the injection well location is shown in Figure 51. The hydraulic conductivity has the largest impact on pressure at the well location, as the hydraulic conductivity defines how fast the pressure can spread and dissipate.

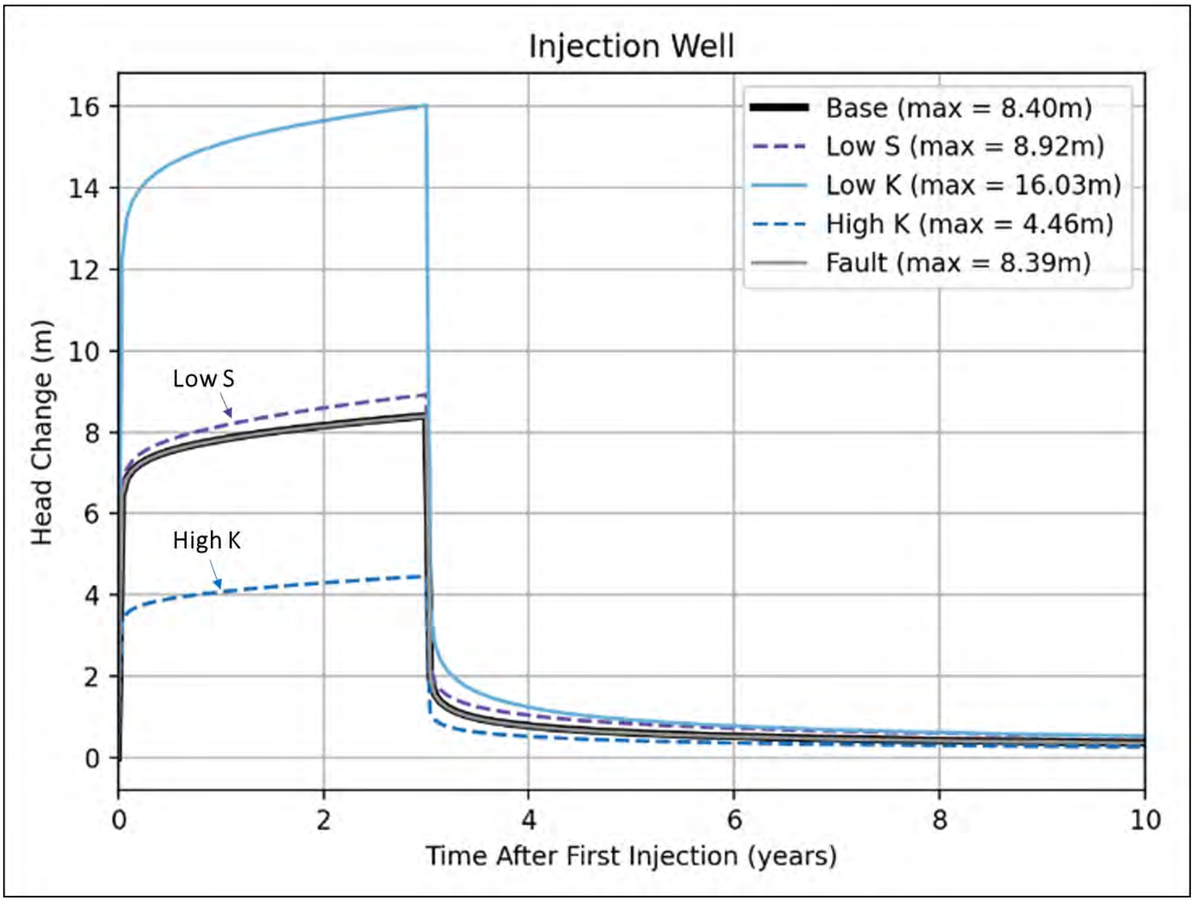
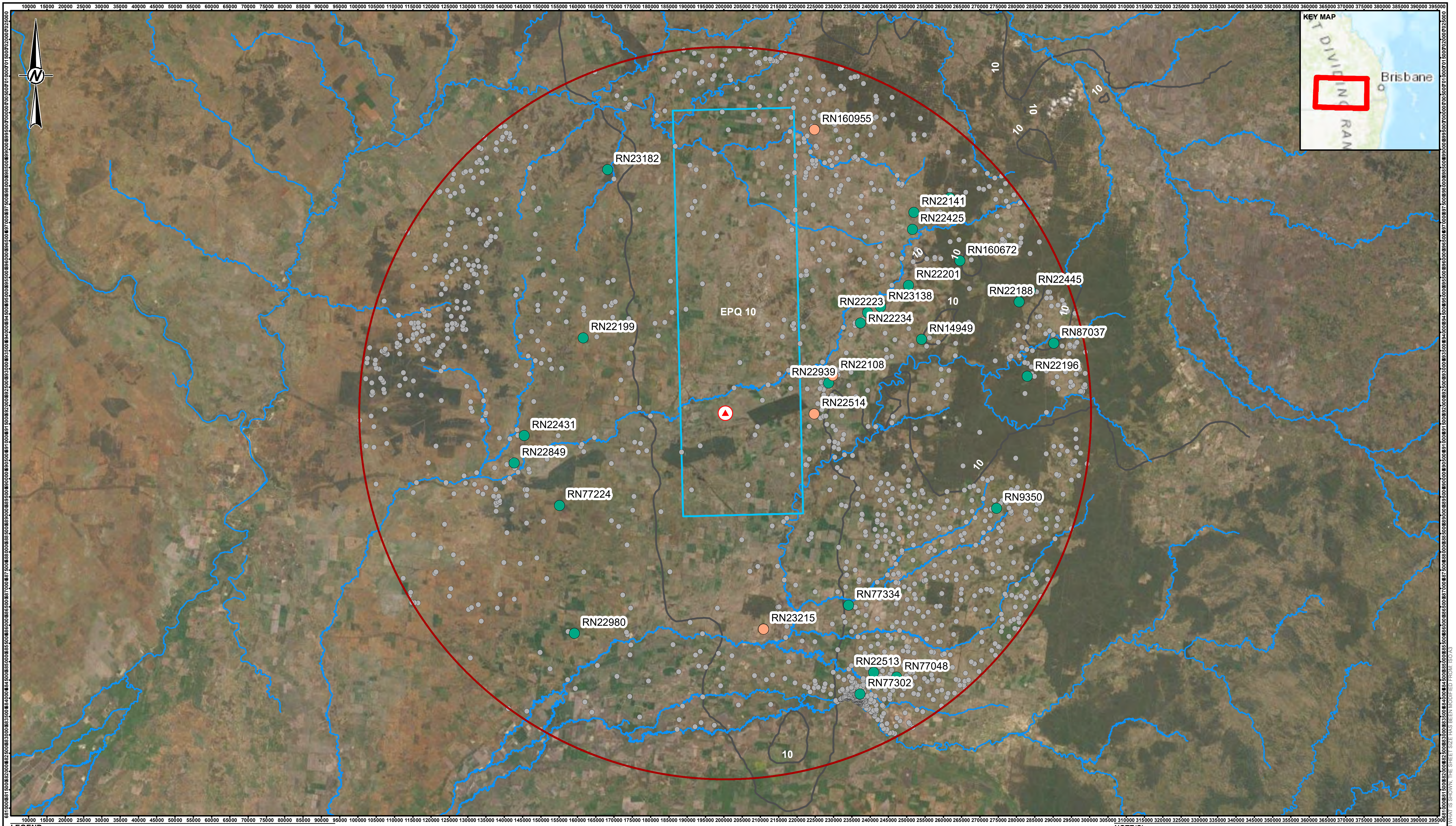


Figure 51: Impact on hydraulic head at West Moonie-1 Injection Well (figure provided by UQ)

The predicted pressure change over a 20-year period is extracted from the nearest 30 bores that have aquifer attribution assigned in the Precipice Sandstone and Hutton Sandstone, with locations shown in Figure 52. Hydrographs for four of these bores (indicated in orange in Figure 52) are shown in Figure 53. The Precipice Sandstone responds quickly to the pressure increase, while the pressure response of the Hutton Sandstone is limited to negligible.



LEGEND

- 🔺 West Moonie-1
- ● Hydrographs Precipice/ Hutton/ Evergreen
- ● Hydrographs Precipice/ Hutton/ Evergreen in Appendix
- ● Registered water bores 100km
- — Major watercourse
- — Precipice 10 m contour
- ▭ EPQ10
- ▭ West Moonie-1 100 km buffer zone

0 20 40
1:1,000,000 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES & GWDB: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. PRECIPICE CONTOUR: UQ
3. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO,

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION
(CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
NEAREST REGISTERED BORES FOR WHICH PRESSURE CHANGE HYDROGRAPHS ARE PREDICTED

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	052

PATH: V:\CTSCo\21456840 CTSC GW ESIA Moonie\GIS\99_PROJECTS\21456840-011-Rev2-F072-Bores with hydrographs.mxd PRINTED ON: 2022-06-16 AT: 11:57:41 AM

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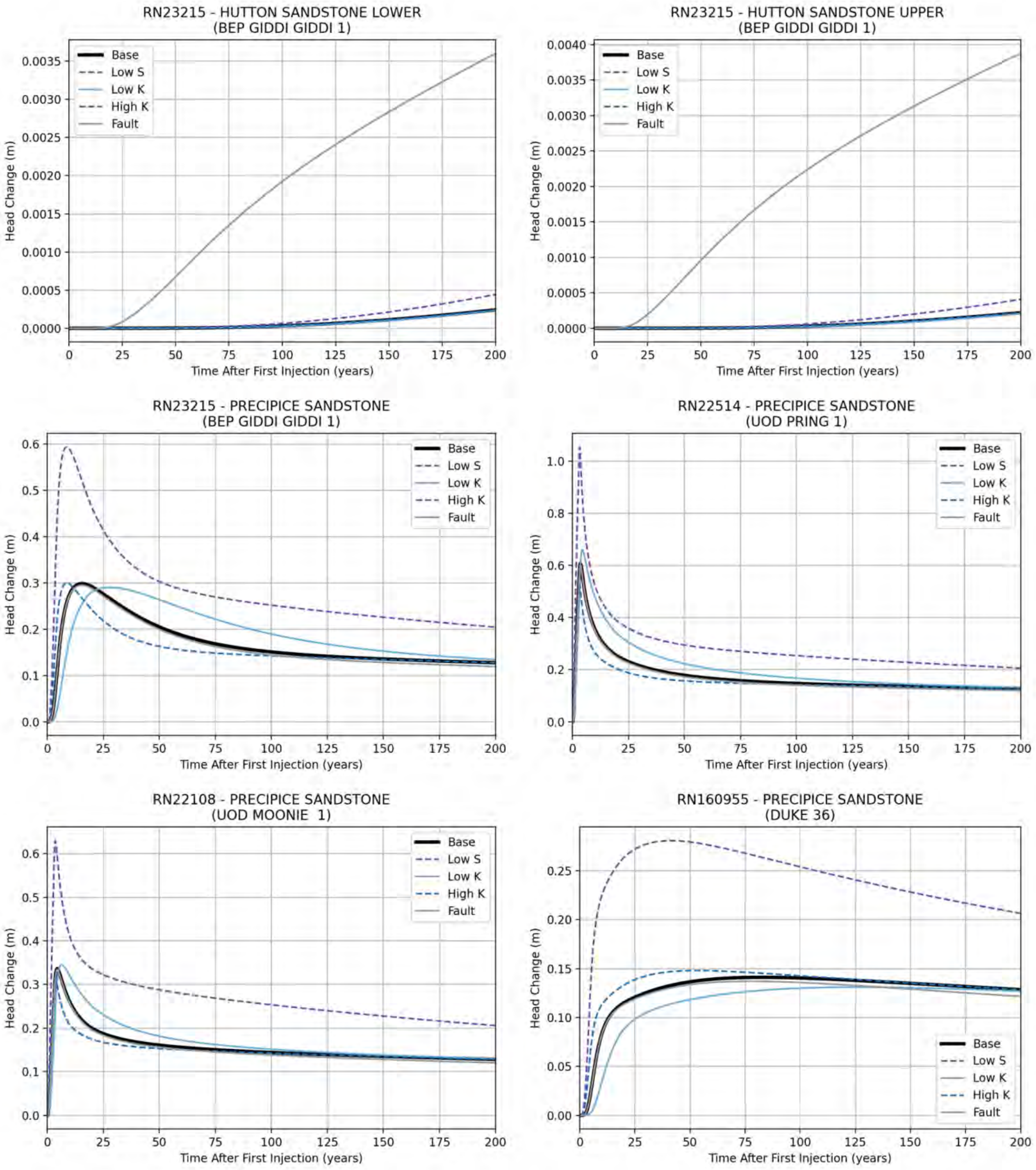


Figure 53: Pressure change hydrographs extracted from hydrodynamic model (locations indicated in orange in Figure 52). (Hydrographs provided by UQ)

In total 14 hydrographs were generated for the Precipice Sandstone, 5 for the Evergreen Formation and 20 for the Hutton Sandstone (9 for lower, 10 for upper, 1 unclassified), which are included in Appendix A. In the Evergreen Formation and the Hutton Sandstone the predicted pressure change after 200 years is below 0.2 m for all simulations. The model is most sensitive to the storage in the Precipice Sandstone.

The pressure change in the Precipice Sandstone exceeds 0.2 m in the entire model domain for the simulation with low storage (Case 1.4). For the other simulations the pressures exceedance drops below 0.2 m after 97 years of shut-in (Table 49 and Appendix B). The pressure change in the Hutton Sandstone is very low in all simulations and is most sensitive to the presence or absence of a fault (high K-zone) that improves the connectivity with the Precipice Sandstone (Figure 53). Despite the enhanced connectivity, the fault-induced pressure changes are still negligible where this might impact on the registered water user bore in the Hutton Sandstone.

Table 49: Simulated head change in the southern Surat Basin after 100 years (3 years of injection and 97 years shut-in)

Case	Name	Minimum head change (m)	Maximum head change (m)
1.0	Base case	0.14	0.15
1.1	Low storage	0.25	0.26
1.2	Low hydraulic conductivity	0.11	0.19
1.3	High hydraulic conductivity	0.14	0.14
1.4	Fault at 7 km from well	0.13	0.15

The particle tracking results are displayed in Appendix C and Appendix D. In most of the simulations the particle movement is less than 20 m in 1,000 years. The exceptions being Case 2.2 (with a low head and high Kv in the south) where particle movement is less than 100 m, and Case 2.4 (with a low porosity) where particle movement is less than 60 m in 1,000 years. All simulations show particle movement to the south-east or to south-south-east in alignment with the Mimosa Syncline, remaining within the operational lands and EPQ10 boundary.

5.1.3 Assumptions and limitations

The following assumptions are associated with the hydrodynamic model:

- The porosity is homogeneous for the entire model domain.
- Horizontal conductivity and vertical conductivity are constant in each formation.
- The Triassic Formations/ Basement underlying the Precipice Sandstone can be modelled as one layer with homogeneous properties.
- Kogan Creek Power Station and the Moonie Oil Field are the only regional groundwater users from the Precipice Sandstone and produce on a constant rate during a set time (Table 46).
- Head change can be predicted using closed boundary conditions.
- Old bore data is valid to determine boundary conditions for particle tracking.
- Faults do not impact the flow in the model domain.

Limitations of the hydrodynamic model include:

- The model is set up to make predictions on a regional scale and is therefore less accurate on a local scale.
- The model is based on available data. The density of data is limited in the deeper section of the Surat Basin.
- Faults are not included in the model domain, although a hypothetical fault was simulated during sensitivity analysis.
- The model does not consider current and future groundwater users other than Moonie Oil Field and Kogan Creek Power Station.
- The model does not consider past and future MAR projects.

5.2 Near-field dynamic reservoir modelling

In 2021, CTSCo developed a local scale dynamic reservoir model to predict the plume extent and formation pressure changes resulting from the injection of 55,000 and 110,000 t/year of GHG stream for 3 years.

Several different models were tested to investigate and assess how model design and input parameter ranges impact on injected plume movement. The investigations modelled a range of volumetric cell size resolutions, reservoir temperature conditions, rock property continuity and kv/kh anisotropy (vertical vs horizontal permeability). This work was informed by CTSCo's extensive reservoir modelling investigations in the Glenhaven area of EPQ7 between 2012 and 2016.

5.2.1 Model description

The static multiphase reservoir model was developed in Petrel^{TM}, with subsequent hydrodynamic modelling completed in tNavigator^{TM} software (Section 2.2.3.3). The dynamic reservoir model is limited to the vertical profile of the reservoir itself (lower Precipice Sandstone). Certain data and information obtained from CTSCo's 2016 Glenhaven reservoir models in EPQ7 were used in the West Moonie dynamic reservoir model build to supplement the modelling datasets.

The model properties include:

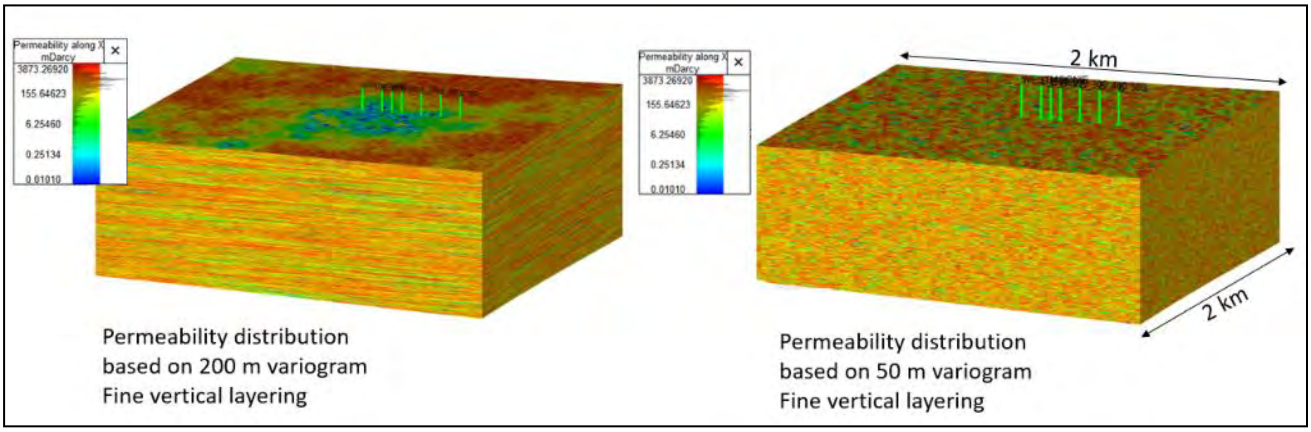
- 2 km by 2 km model domain centred around West Moonie-1 Injection Well
- Cell size: 25 m lateral, 1 m and 0.1524 m vertical (coarse and fine grid)
- Porosity and shale volume distribution based on West Moonie-1 Injection Well data (realisations shown in Figure 54):
  - Realisation 1: properties distributed using a 200 m horizontal variogram range
  - Realisation 2: properties distributed using a 50 m horizontal variogram range
- Permeability-porosity relationship based on hydraulic flow units (HFU), core data for the HFUs is based on West Wandoan-1 Well
- Relative permeability (relk) curve based on West Wandoan-1 Well digital core analysis (DCA)
- The base case kv/kh ratio is 0.01
- Three years of injection were simulated via a 2 m perforation interval towards the base of the lower Precipice Sandstone.

The GHG stream density was calculated using the Span Wagner equation of state, with a pressure of 220 bar and a temperature range between 65°C and 100°C. At 90°C in the base case scenario, the GHG stream density is 582 kg/m^3. Assuming a water density of 985 kg/m^3, the GHG stream density ratio is 0.6 and the viscosity ratio is 0.14. The West Moonie-2 Monitoring Well encountered a lower temperature in the Precipice Sandstone (approximately 75°C). The lower temperature implies a higher GHG stream density (approximately 672 kg/m^3), and therefore a higher GHG stream density ratio (approximately 0.7). Due to the decreased density difference between water and the GHG stream, the vertical migration upwards is slightly less than predicted by the base case, and the plume will spread further laterally. The total GHG stream volume in the reservoir will be lower as result of the higher density. Therefore, the lower temperature scenario result will overestimate the plume extent.

Sensitivity analysis was also conducted on the kv/kh ratio, the variogram range and the relative permeability curve. The impact of the vertical discretisation (1.0 m and 0.1524 m cell thickness) was also tested.

One of the objectives of the dynamic reservoir modelling was to determine the optimum spacing for the proposed monitoring bore from the injector. Figures throughout this section of the report show West Moonie-1 Injection Well and up to six additional ‘ghost’ wells, which were included for the purpose of identifying the optimum location for the West Moonie-2 Monitoring Well.

One of the locations was eventually selected as the bottom hole location for West Moonie-2 Monitoring Well and successfully drilled by CTSCo in 2021. The well results were in line with the pre-drill geological (static) model.



Permeability distribution based on 200 m variogram Fine vertical layering

Permeability distribution based on 50 m variogram Fine vertical layering

Figure 54: Permeability distribution based on property distribution using a 200 m variogram and a 50 m variogram

The relative permeability curves used in the hydrodynamic model are derived from West Wandoan-1 Well digital core analysis. West Wandoan-1 Well is located in EPQ7, in the north of the Surat Basin. It encountered 75 m of Precipice Sandstone at a depth of 1,162 to 1,237 m, with a slightly higher porosity than West Moonie-1 Injection Well. Nevertheless, the rock characteristics of the Precipice Sandstone at both locations are similar.

5.2.2 Local model results

Dynamic reservoir modelling for the base case scenario shows a maximum plume extent of approximately 500 m from the West Moonie-1 Injection Well at the end of the 3-year injection period at which point 330,000 t of GHG stream had been injected into the lower Precipice Sandstone. The plume is predicted to cease moving 2 years after injection and its maximum extent is approximately 525 m from the West Moonie-1 Injection Well. The model shows no significant movement of the plume between 5 years shut-in and 100 years shut-in, which is the end of the simulation.

At the end of injection, the maximum simulated pressure increase is 77 kPa (~11 psi), and after three years shut-in this maximum pressure reduces to 8.7 kPa (~1.3 psi). After 100 years the maximum simulated pressure increase is 5.4 kPa (~0.8 psi). At no point during the simulation, does the change in pressure exceed 14 kPa (~2 psi) at the interface of the upper and lower Precipice Sandstone indicating negligible pressure to instigate upwards migration of the plume to formations above the Precipice Sandstone or cause integrity issues associated with the Evergreen Formation seal.

Figure 55 shows the simulated gas saturation and gas solubility at the end of injection, after 5 years of shut-in, and after 100 years of shut-in, on a cross-section through the model. The modelling shows that initially the plume movement is upwards due to buoyancy. However, as more CO_2 dissolves into groundwater, the plume water density increases and the movement is downwards towards the base of the formation.

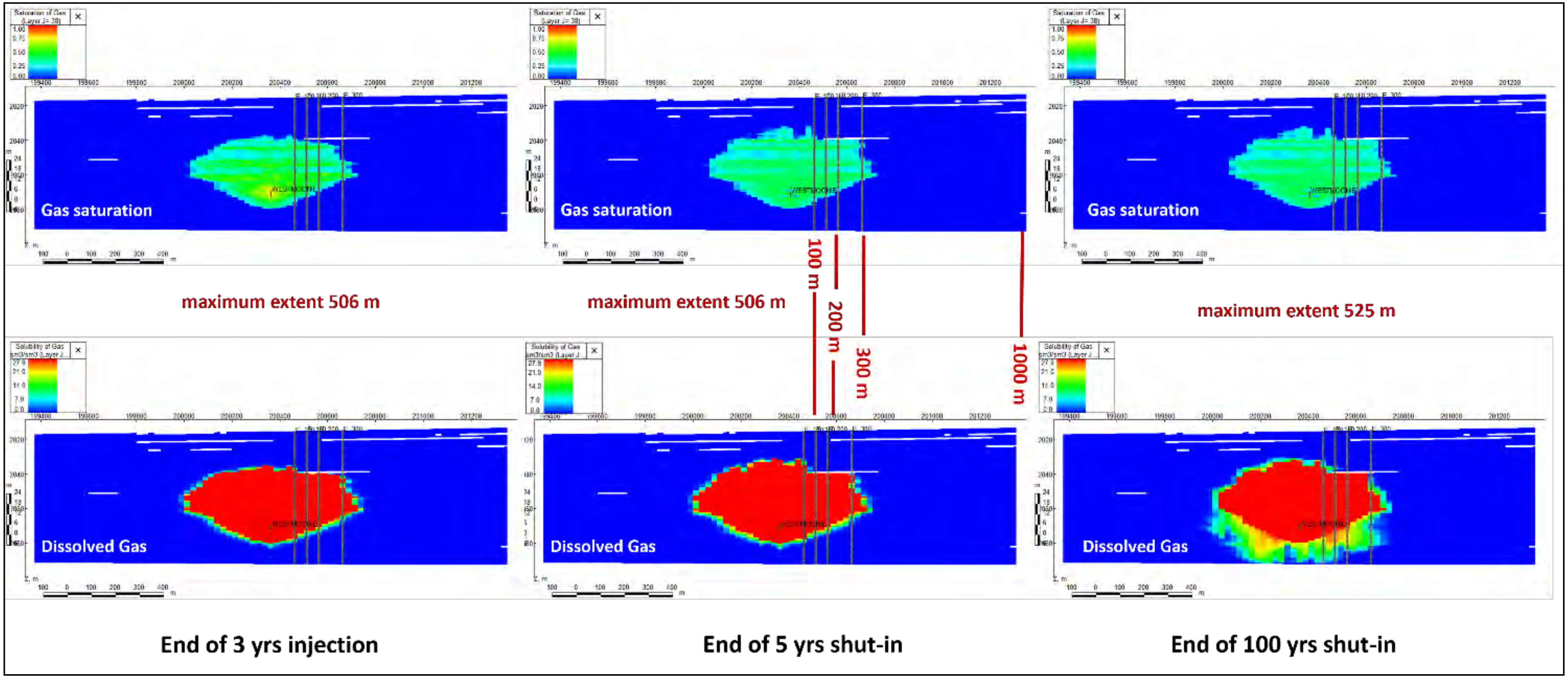


Figure 55: The simulated gas saturation (top row) and gas solubility (bottom row) at the end of injection, after 5 years shut-in and after 100 years shut-in (coarse model, 200 m variogram)

The reservoir (lower Precipice Sandstone) pressure impact of the GHG stream injection is low and diminishes rapidly, as shown on Figure 56:

- The maximum pressure increase at the end of injection in the target depth is 77 kPa (~11 psi).
- The maximum pressure increase after 3-years shut-in is 8.7 kPa (~1.3 psi).
- The maximum pressure increase after 100-years shut-in is 5.4 kPa (~0.8 psi).

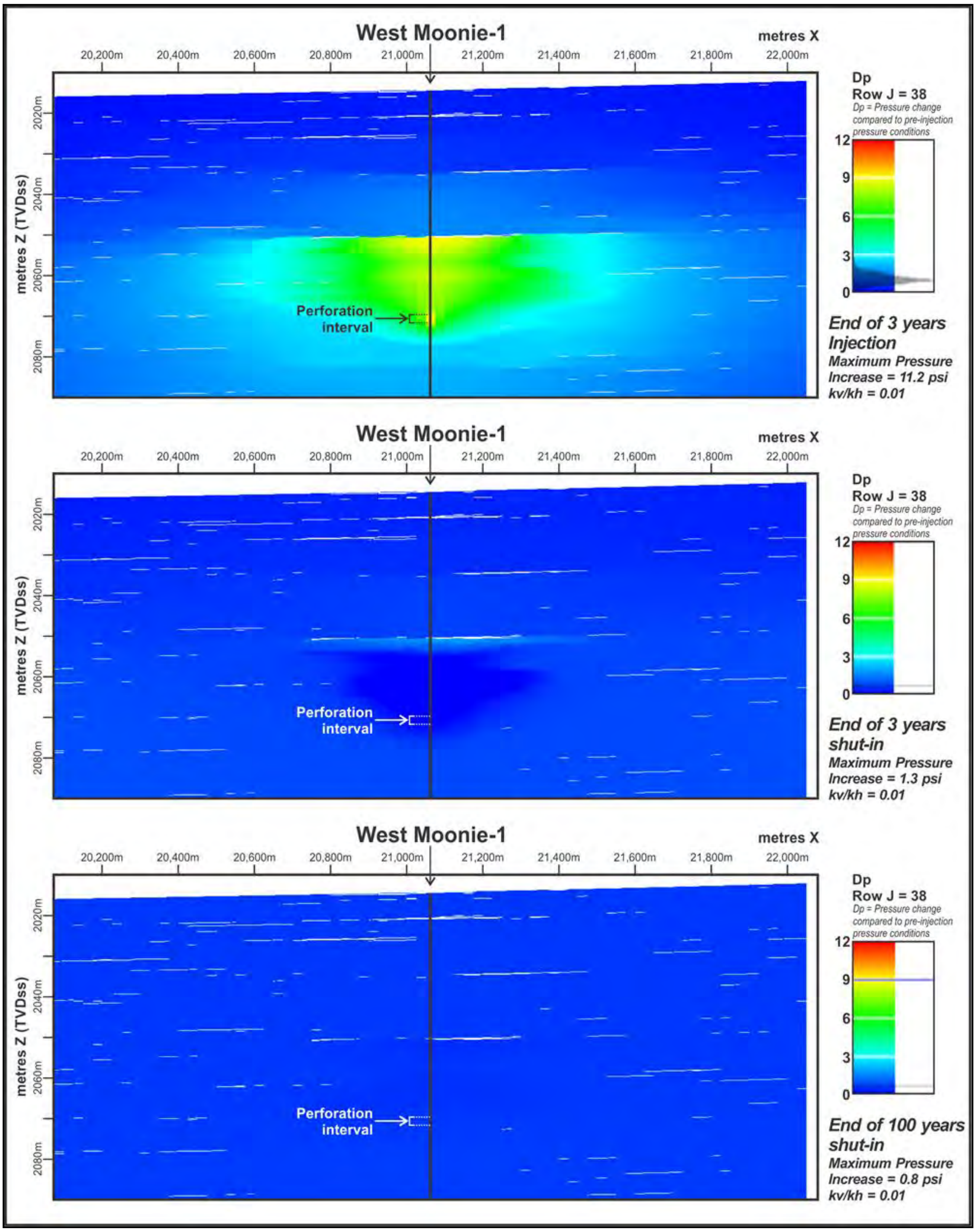


Figure 56: Pressure increase (psi) over time (fine model, 50 m variogram)

Figure 56 shows that pressures increase due to GHG stream injection at the end of Year 3 on a cross-section through the model that is centred on the West Moonie-1 Injection Well. This model simulation shows a distinct horizontal boundary in the pressure increase slightly shallower than 2,040 m True Vertical Depth Sub Sea (TVDSS). This is caused by a low permeability siltstone within the lower Precipice Sandstone, which creates a localised flow barrier. The interpreted permeability log for West Moonie-1 Injection Well shows several thin low permeability intervals (indicated with arrows in Figure 57).

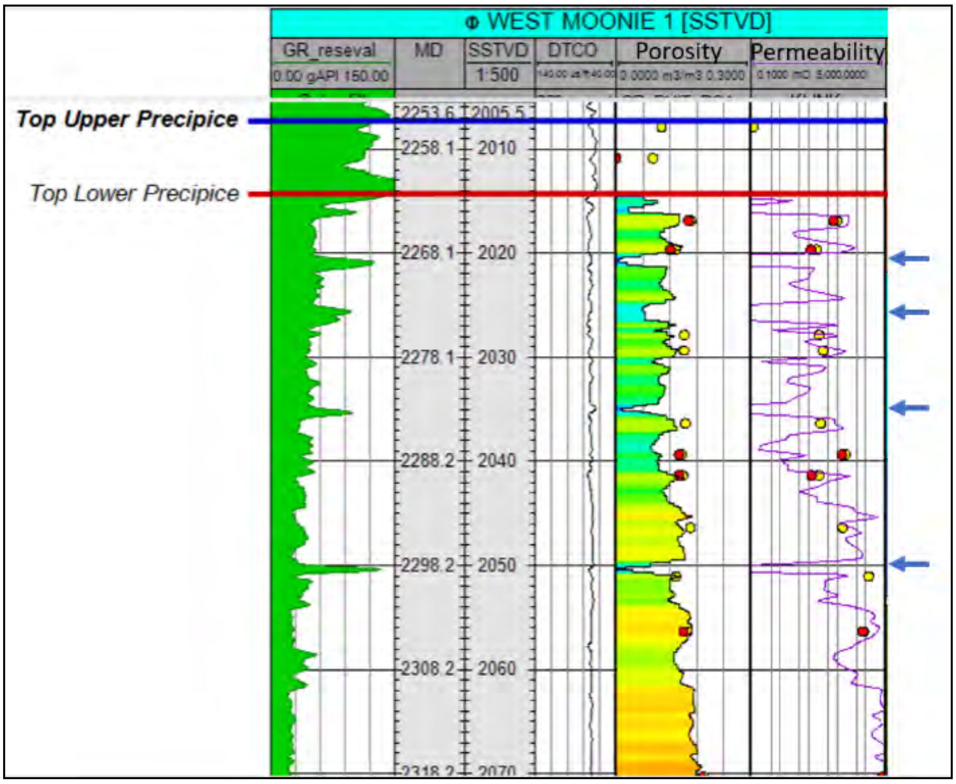


Figure 57: West Moonie-1 Injection Well log showing porosity and permeability calculated from wireline logs, with lower permeability layers indicated with arrows

5.2.3 Sensitivity analysis

In 2021, CTSCo created 'coarse' and 'fine' grid modes, with a vertical layering of 1.0 m and 0.1524 m, respectively, to investigate the impact of modelled vertical heterogeneity on plume movement. The vertical resolution of the fine model corresponds to the resolution of the wireline logs. Therefore, no upscaling or averaging of wireline log properties would be required as it can result in the loss of fidelity within the model. Although the finer scale model captures more permeability contrast, the Lorenz coefficient for both models show a similar heterogeneity, indicating that the increased vertical resolution has limited influence on the modelled outcome.

The variogram range used for property distribution does have an influence on the modelled plume geometry. A 200 m horizontal variogram range results in a more continuous rock property distribution compared to a 50 m variogram range. This is shown in Figure 54. The longer horizontal variogram model results in preferable pathways as well as more laterally extensive lower permeability zones. A smaller horizontal variogram range, results in less lateral continuity of properties, the distribution is more random, with a lower likelihood of laterally extensive barriers, or preferential pathways. Figure 58 and Figure 59 show the 200 m and 50 m variogram range used for property modelling (note that the modelled injection volume is 55,000 t/year for these simulation runs).

CTSCo conducted sensitivity analysis on the kv/kh ratio as this was found to have an influence on the plume geometry when tested in the Glenhaven injection models. The lower the kv/kh ratio the further the lateral movement of the GHG stream, while a higher kv/kh ratio results in more vertical movement as can be seen in Figure 58 and Figure 59.

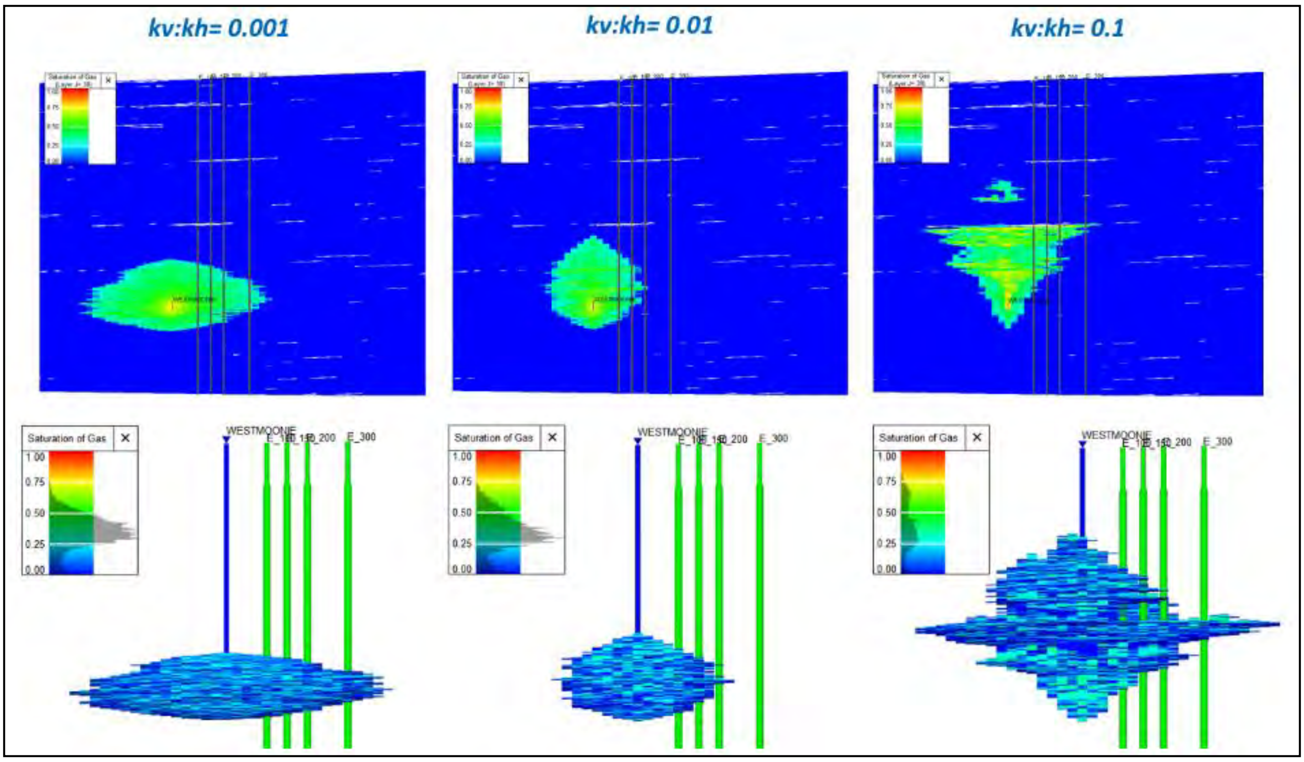


Figure 58: Simulated gas saturation after 100 years shut-in. Sensitivity analysis on kv/kh ratio using fine grid and a 200 m variogram length and 55,000 t/year GHG stream injection

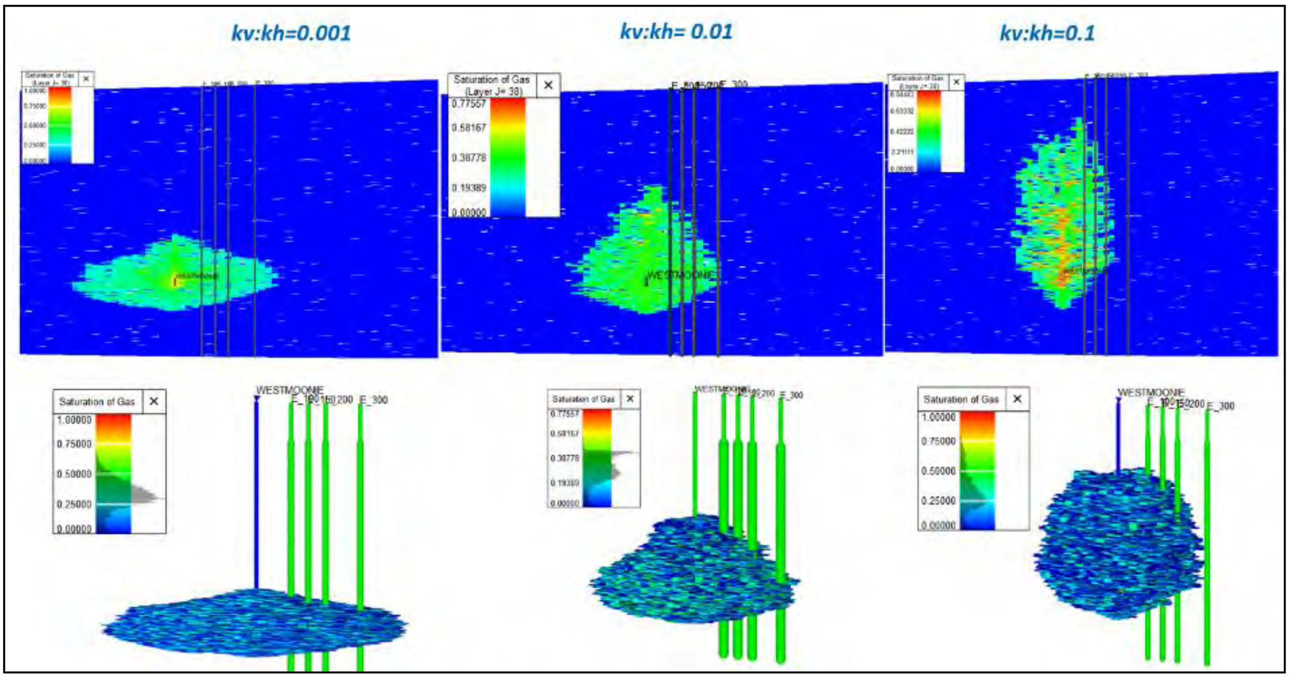


Figure 59: Simulated gas saturation after 100 years shut-in. Sensitivity analysis on kv/kh ratio using fine grid and a 50 m variogram range and 55,000 t/year GHG stream injection

The effect of the kv/kh ratio on the plume geometry at 55,000 t/year is similar for the higher injection volumes of 110,000 t/year GHG stream (CO_2). The plume only reaches the top of the reservoir with a kv/kh ratio of 0.1 (Figure 60). The maximum pressure at the end of the injection is shown in Figure 61 and does not exceed 110 kPa (approximately 11.9 m). The maximum pressure change at the lower Precipice Sandstone – upper Precipice Sandstone interface is 59 kPa (approximately 6.4 m) with a kv/kh ratio of 0.1.

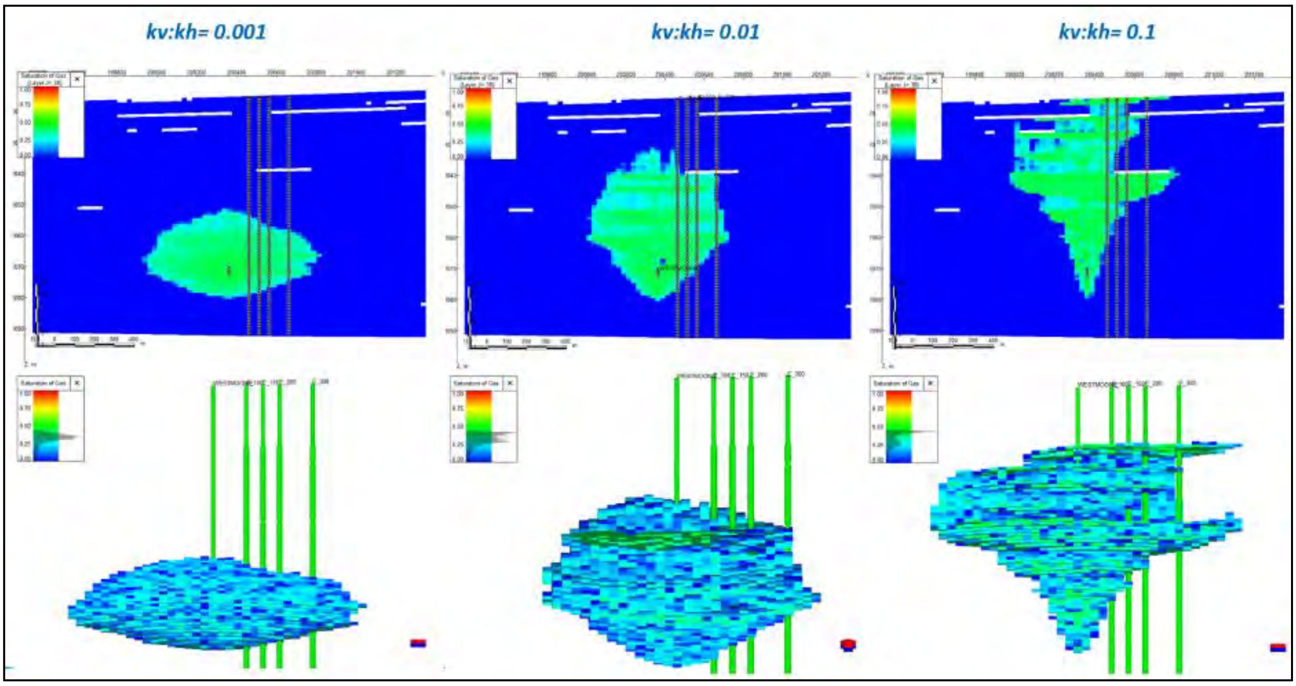


Figure 60: Simulated gas saturation after 100 years shut-in. Sensitivity analysis on kv/kh ratio using coarse grid and a 200 m variogram range and 110,000 t/year GHG stream injection

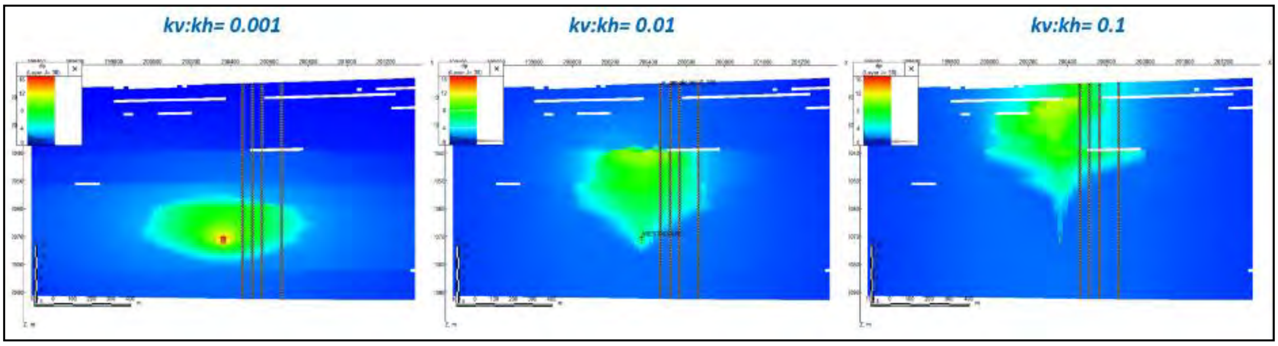


Figure 61: Simulated pressure change after 3 years injection. Sensitivity analysis on kv:kh ratio (Kv/Kh) using coarse grid and a 200 m variogram range and 110,000 t/year GHG stream injection

Using the linear relative permeability curve instead of the curve derived from West Wandoan-1 Well increases the GHG mobility in the initial plume migration phase (as the mobility of GHG stream is higher for GHG stream saturations below 0.34). This results in a more rapid vertical movement of the GHG stream and a larger lateral spread of the plume (Figure 62).

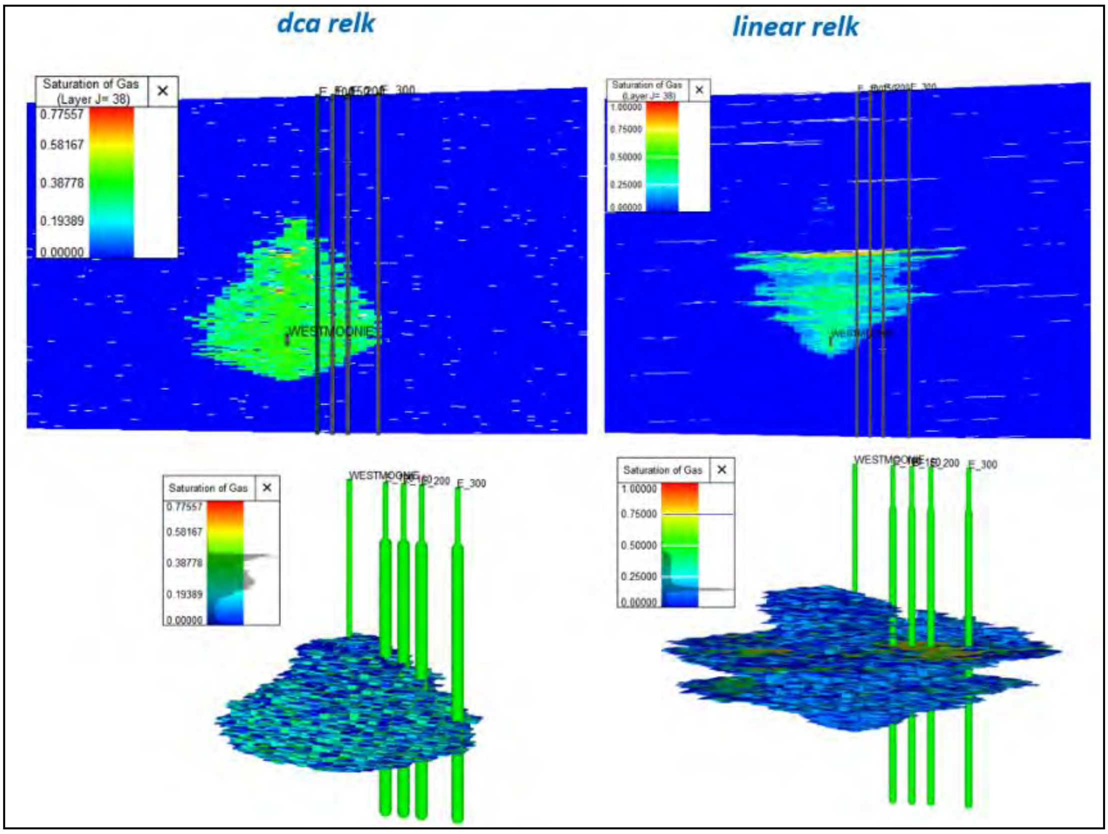


Figure 62: Sensitivity of plume extent on relative permeability curve

The porosity in the reservoir model is based on the porosity distribution as encountered at West Moonie-1 Injection Well. Having local data on porosity is important for the simulation as Rodger et al. (2019) previously indicated that porosity has the biggest impact on plume area. The thorough sensitivity analysis and consideration of the most influential parameters provides a high level of confidence that the maximum plume extent will be within 500 to 600 m from the West Moonie-1 Injection Well. This includes the 3-year injection and the monitoring period that will be required to show that the plume extent has stabilised once injection has ceased.

5.2.4 Assumptions and limitations

The following assumptions are associated with the dynamic reservoir model:

- The West Moonie-1 Injection Well derived porosity, permeability and shale content, are representative for the model domain.
- Properties do not evolve over time and are constant during the entire simulation.
- There are no faults encountered in the model domain.
- The density to water ratio and the viscosity to water ratio are based on pure CO_2.
- The West Wandoan-1 Well relative permeability curve is valid for West Moonie-1 Injection Well.
- The model domain is not impacted by other groundwater users.

Limitations of the dynamic reservoir model are:

- Limited data available:

  - Properties are based on West Moonie-1 Injection Well.
  - No seismic data covers the localised 2 km by 2 km model domain.
- The dip and azimuth of the Precipice Sandstone near West Moonie-1 Injection Well are based on regional data, although these have been locally confirmed Project FMI logs.
- Chemical processes are not considered in the dynamic reservoir modelling work, however these are modelled in the geochemical model described in section 5.3.
- Modelling work was focused on the plume extent/migration not the chemistry, including the time scale of CO_2 dissolving.
- Relative permeability curve is based on West Wandoan-1 Well digital core analysis.

5.3 Geochemical modelling

The evolution of water quality composition (i.e., major cations, anions and pH, etc.), and changes in aquifer mineralogical composition (mineral precipitation and dissolution) were assessed by reaction path modelling using the Geochemist's Workbench (GWB). The modelling assumes upon the injection CO_2 will dissolve in the formation water to form carbonic acid (Equation 3). Carbonic acid is a mild acid, and it will dissociate to proton (H^+) and carbonate ion (CO_3^{2-}). The formation of carbonic acid will decrease the pH of the groundwater from 8.35 to around 4 and result in the dissolution of some minerals (such as illite) and changes in the water chemistry (for example the mobilisation of metals).

The model also assumes that associated impurities (SO2, NO2 and O2) are highly soluble and will take part in several reactions to form sulfuric acid and nitric acid (Equation 4 to

Equation 6) as discussed in section 2.2.3.5. The injection of these gases will change the redox condition of the system and could lower the pH of the groundwater. These will potentially cause further mineral dissolution (such as the dissolution of siderite) and changes in the water composition. The modelling results are discussed in the following sections.

5.3.1 Evolution of mineralogical change within the GHG stream plume

The model predicted that, due to the injection of the GHG stream, over the 100-year simulation period, illite ($K_{0.6}Mg_{0.25}Al_{1.8}Al_{0.5}Si_{3.5}O_{10}(OH)_2$), siderite ($FeCO_3$) and quartz ($SiO_2$) would dissolve. This is illustrated in Figure 63, which shows the change in volume for each mineral phase over time. Correspondingly, kaolinite ($Al_2Si_2O_5(OH)_4$), nontronite-Ca ($Ca_{0.165}Fe_2Al_{0.33}Si_{3.67}H_2O_{12}$) and nontronite-Mg ($Mg_{0.165}Fe_2Al_{0.33}Si_{3.67}H_2O_{12}$) were simulated to precipitate (Figure 63). In addition, a small amount of ferrihydrite ($Fe(OH)_3$) was also predicted to form, but it dissolved gradually after dissolved oxygen was completely consumed (after about 0.5 year).

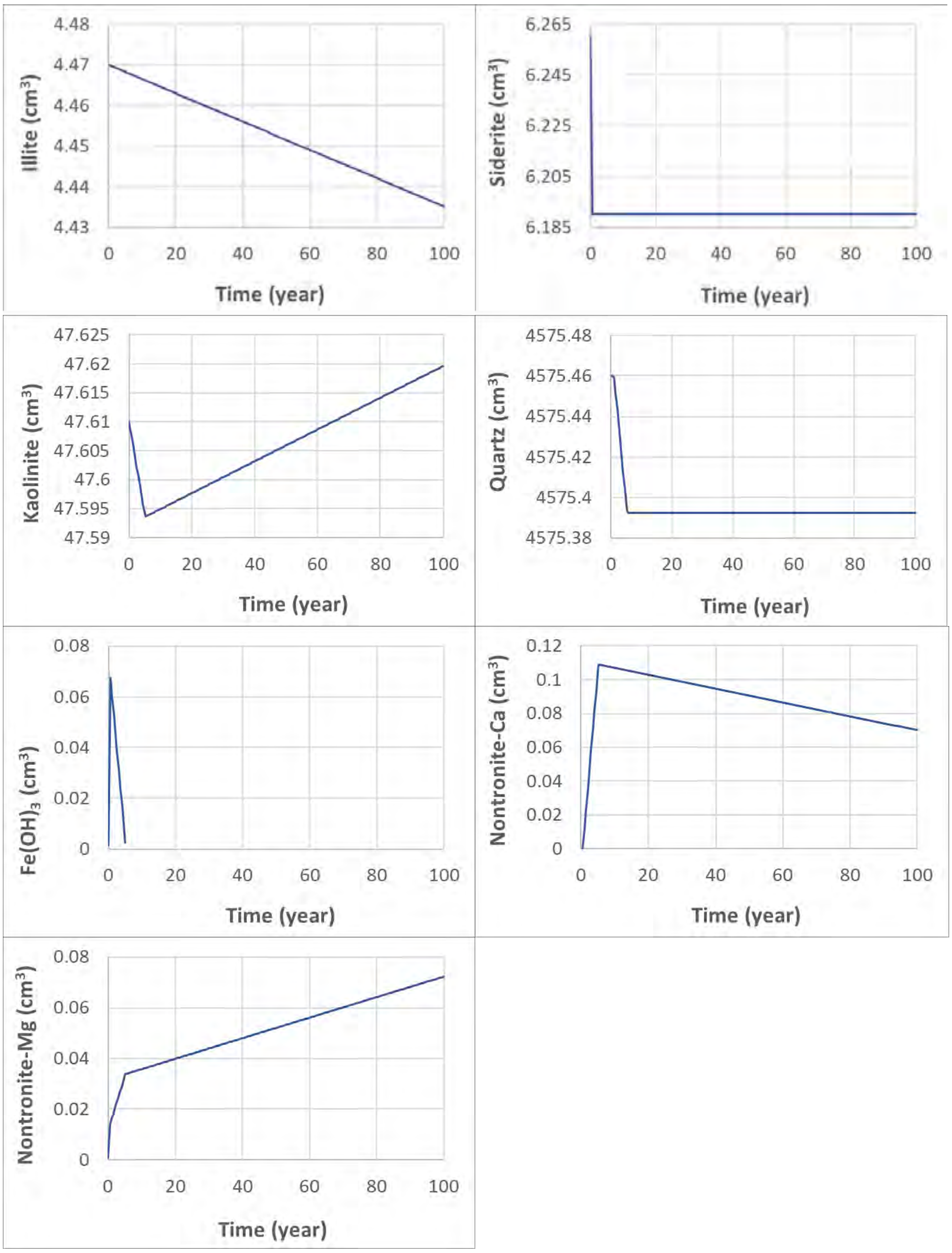


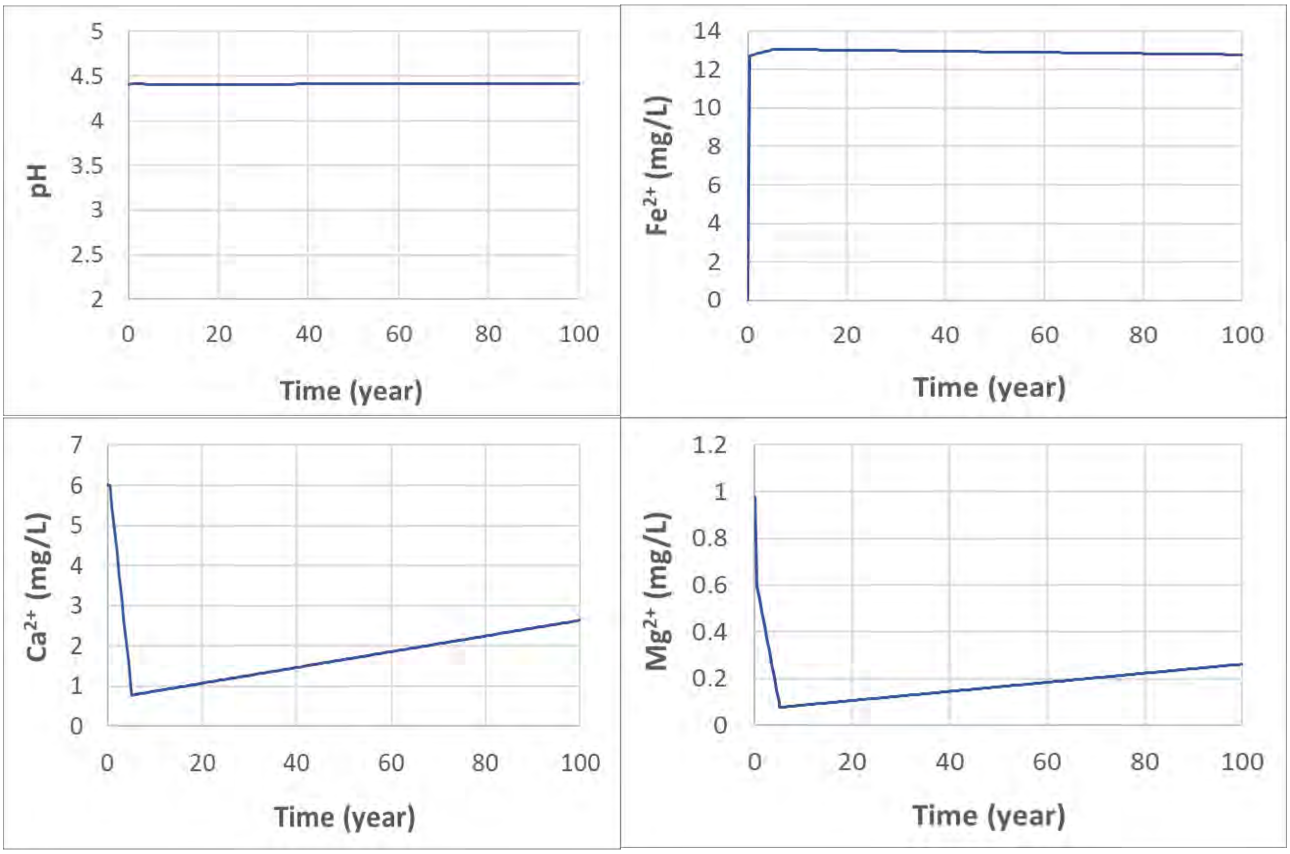
Figure 63: Modelled changes in mineral volumes (absolute cm^3 per L of formation water)

Over the 100-year period of modelling, the combined change in mineral volumes was predicted to result in no meaningful change in porosity with the porosity remaining at 17.75%.

5.3.2 Evolution of water composition change within the GHG stream plume

The predicted changes in water composition (due to GHG stream injection) reflect the modelled changes in mineralogical composition of the aquifer (Figure 64). Concentrations of Ca^{2+} and Mg^{2+} were controlled by illite dissolution and smectite (nontronites) precipitation. Concentrations of Ca^{2+} and Mg^{2+} decreased quickly from 6 mg/L and 1 mg/L within 5.7 years to approximately 0.79 mg/L Ca^{2+} and 0.08 mg/L Mg^{2+}, respectively, and then slightly increased to approximately 2.64 mg/L Ca^{2+} and 0.26 mg/L Mg^{2+}, respectively, at the end of the 100-year simulation. While the pH stayed constant at approximately 4.4, Fe^{2+} increased to about 13 mg/L (due to the oxidative dissolution of siderite) and remained relatively constant until the end of the modelling period.

Coincident with this was a sharp decline in the $SiO_{2(aq)}$ concentration due to the precipitation of the nontronites (an iron rich member of the smectite group of clay minerals), after which it recovered and slightly increased to 56.5 mg/L at 100 years. The concentration of K^+ moderately increased from approximately 150 to 155.3 mg/L after 100 years, corresponding to illite dissolution. In addition, the SO_4^{2-} concentration remained constant at about 10.3 mg/L, while the NO_3^{3-} concentration declined sharply after about 0.5 year (after dissolved oxygen was completely consumed).



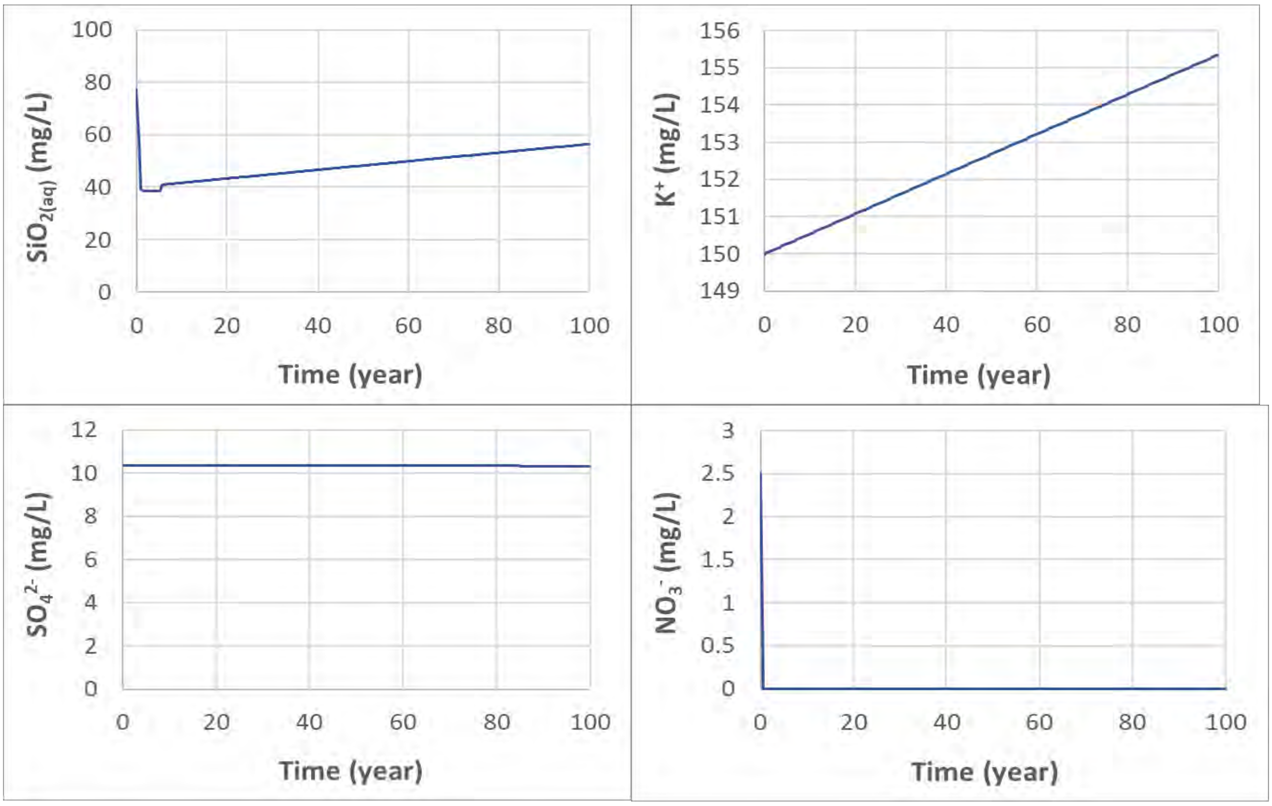


Figure 64: Predicted changes in formation water composition in the Precipice Sandstone

5.3.3 Summary of the geochemical modelling

In general, the injection of the GHG stream (CO_2 and associated impurities SO_2, NO_2, and O_2) would result in a substantial lowering of the pH of the Precipice Sandstone formation water within the plume, from 8.6 to 4.4. This results in predicted increases in K^+ and Fe^{2+} concentrations and in deceases in $SiO_{2(aq)}$, Ca^{2+} and Mg^{2+} concentrations. The modelling results also indicate that there would be no change in porosity, with porosity remaining at 17.75%. The predicted dissolution of minerals such as illite and siderite and the precipitation of secondary minerals such as kaolinite and smectites are consistent with results from previous field, laboratory and modelling studies (e.g., Kharaka et al. 2006; Kharaka et al. 2010; Xu et al. 2010; Fischer et al., 2011; Cantrell et al. 2012; Wilke et al. 2012; Chiquet et al. 2013; Corvisier et al. 2013; Jung et al. 2013; Bolourinejad et al. 2014; Renard et al. 2014; Erickson et al., 2015; Monne and Jammes, 2015; Pearce et al., 2015; Wei et al., 2015; de Dios et al., 2016; Waldmann and Rütters, 2016; Vu et al., 2017). The geochemical modelling also predicted that the impact of the impurities SO_2 and NO_2 would be negligible as their concentrations are relatively low. This is in contrast to previous work conducted for other reservoirs, which showed greater effects due to the significantly higher concentrations of impurities and the presence of other reactive minerals such as pyrite (e.g., Renard et al,. 2011; Wilke et al., 2012; Corvisier et al., 2013; Jung et al., 2013; Erickson et al., 2015; Pearce et al., 2015; Vu et al., 2017).

5.3.4 Mobilisation and fate of trace elements released in response to GHG stream injection

Reaction Path (RP) modelling of major elements was performed (Sections 2.2.3.5 and 5.3.3), to provide an overview of the water quality evolution as a result of GHG stream injection. The modelling code the Geochemist's Workbench (Bethke, 2021) was used for this purpose. However, the fate and transport of trace elements was not addressed by the RP modelling due to limitations associated with relevant thermodynamic data and a lack of data related to trace element content of minerals present in the reservoir. Instead, the release of trace elements and their potential impact on the groundwater quality within the reservoir due to the injection of the GHG stream was evaluated in a more qualitative manner by comparing the Project with an analogue project, EPQ7 (Pearce and Golding, 2021; Dawson et al., 2022).

Comparison of EPQ7 and EPQ10

EPQ10 (southern Surat basin) is located approximately 50 km from the EPQ7 project (northern Surat basin) and proposed injection zones (intervals) for EPQ7 and EPQ10 are within the lower Precipice Sandstone (Spycher et al., 2018; Hall 2021a, 2021c). The (Precipice Sandstone underlies the Boxvale Sandstone and Evergreen Formation, with the latter acting as a seal or caprock (Hall, 2021c). Due to the spatial heterogeneity and difference in depth, the chemical mineralogical composition, temperature, pressure, salinity (TDS) of the two reservoirs are different, as illustrated in Table 50. The proposed injection depths are included as well.

Table 50: Comparison between EPQ10 and EPQ7[11]

Minerals/Parameters	EPQ7	EPQ10
Quartz (wt%)	96	98.2
Illite (wt%)	-	0.1
Kaolinite (wt%)	3	1
Siderite (wt%)	0.5	0.2
K-feldspar (wt%)	0.5	-

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[11] CTSCo data; Spycher et al. 2018; Hall 2021a.

Minerals/Parameters	EPQ7	EPQ10
Temperature (°C)	65	90
Pressure (psi)	1800	3305
TDS (mg/L)	225	2850
Injection depth (TVDSS)	1000	2050

Note: TVDSS is True Vertical Depth Sub Sea. In general, the lower Precipice Sandstone is a clean sandstone. The injection depth in the EPQ10 reservoir is greater than in the EPQ7 reservoir, thus subject to higher temperature and pressure. In addition, the salinity of the groundwater at EPQ10 is higher than at EPQ7. Despite differences in salinity, temperature and pressure, it is assumed that injected CO_2 will eventually be dissolved in the formation water and the estimated solubility of CO_2 will be comparable (1.1 and 1.2 mol CO_2/kg water for EPQ7 and EPQ10, respectively). Formation water was predicted to be acidified to pH values of 4.1 and 4.4 for EPQ7 and EPQ10, respectively, as a result of the GHG stream injection.

The Precipice Sandstone from EPQ10, as observed at West Moonie-1 Injection Well, is quartz rich with minor kaolinite and illite and is generally consistent with the mineralogical composition of the EPQ7 reservoir (Pearce and Golding, 2021; Dawson et al., 2022). Trace amounts of siderite, rutile, monazite, and sylvite/KCl were also identified. Figure 65 and Figure 66 show the well core mineralogy for the reservoir at EPQ10 and EPQ7, respectively. These figures highlight the consistency in reservoir mineralogy between the two sites and allow for direct comparison of likely trace metal mobilisation as a result of injection.

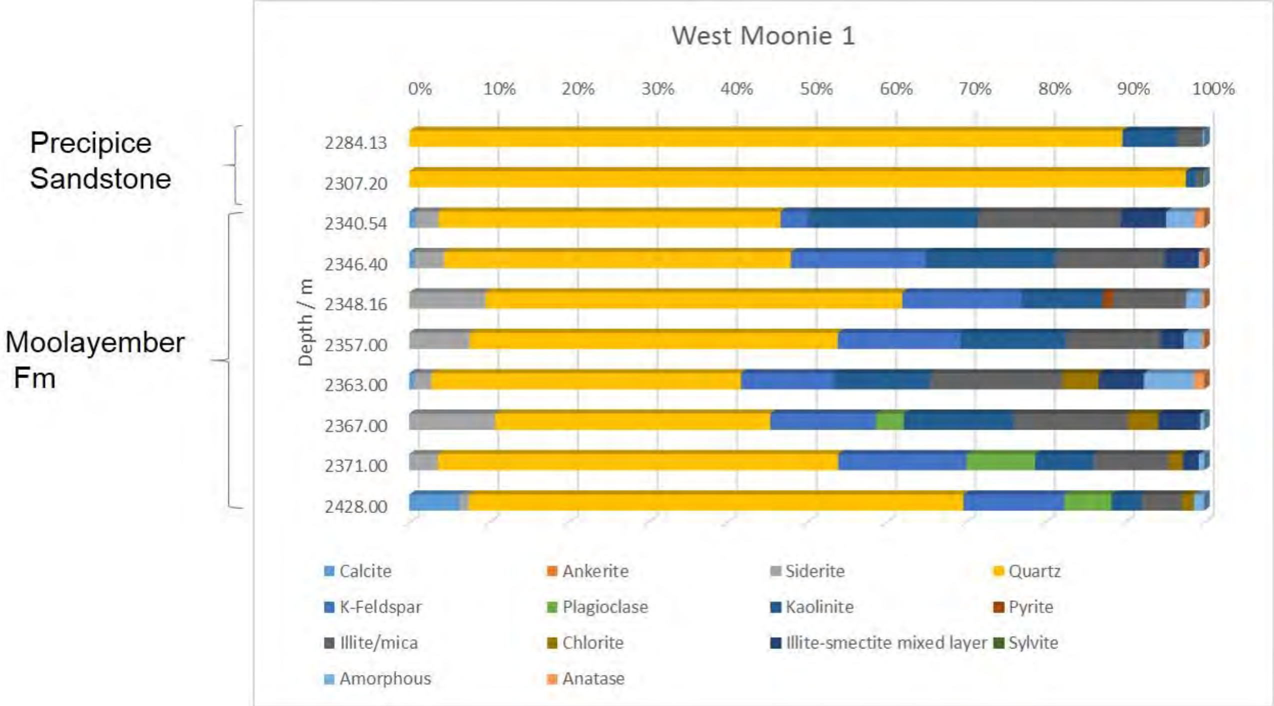

Figure 65: EPQ10 – West Moonie-1 Injection Well core mineral contents in the Precipice Sandstone and Moolayember Formation (Pearce and Golding, 2021)

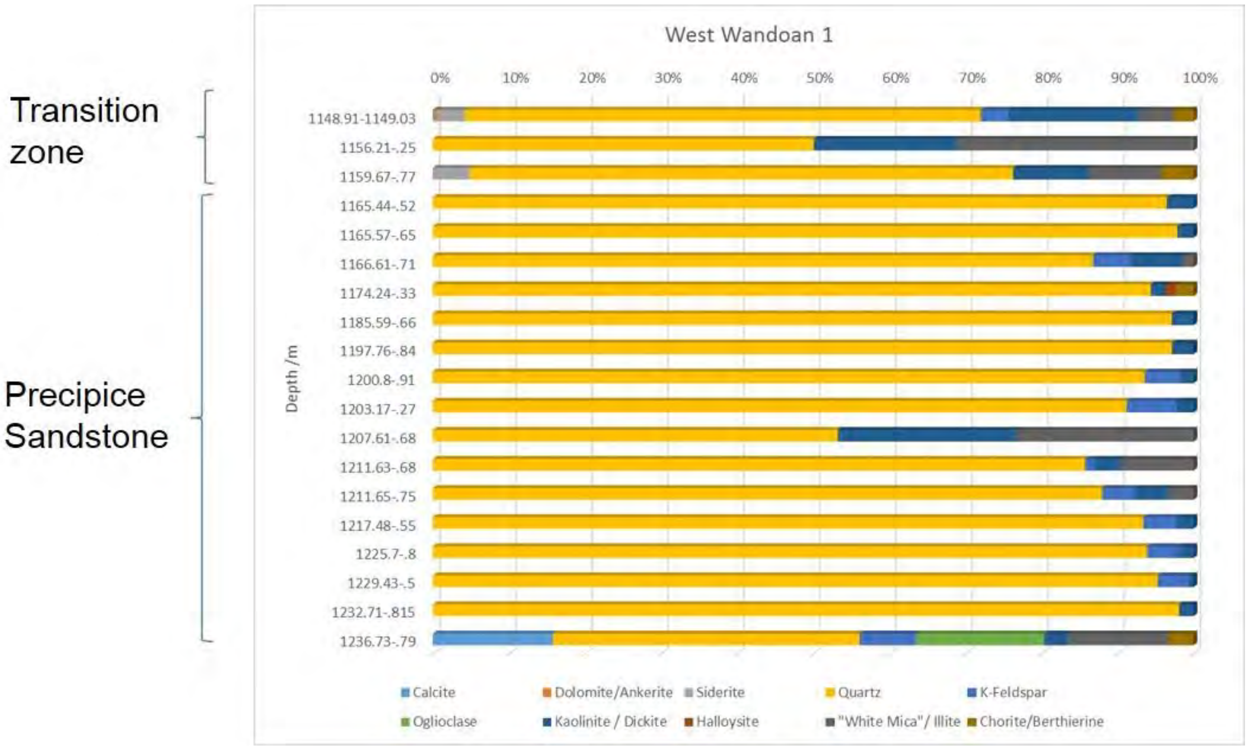

Figure 66: EPQ7 West Wandoan-1 Well core mineral contents in the Precipice Sandstone and lower Evergreen. From Pearce and Golding (2021)

Trace elements (such as arsenic, antimony, selenium and lead) have been reported from core samples in the Precipice Sandstone in EPQ10 (for example, Table 51). Based on similarities between the EPQ7 and EPQ10 areas as well as the results from batch reactor experiments for EPQ10 (Pearce and Golding 2021; Dawson et al. 2022 and Figure 67), it is expected that similar trace elements will be released from the aquifer solids in response to the lower pH caused by the injection of the GHG stream. It is further expected that the trace element concentrations will be elevated within the GHG stream plume, but their concentrations (e.g., Pb, Mo, Cd) will be lower or comparable with EPQ7, and controlled (i.e., lowered by orders of magnitude due to adsorption onto and or co-precipitation with secondary minerals such as iron (hydr)oxides, Dawson et al., 2022; Pearce and Golding, 2021).

Table 51: EPQ10 West Moonie-1 Injection Well core – summary of selected total element constituents in core of 3 lower Evergreen Formation samples and 13 Precipice Sandstone samples. From Pearce and Golding (2021)

mg element/kg rock	Mo	Mn	Fe	Co	Ni	Cu
lower Evergreen Formation (n=3)						
median	1.6	160	10,476	14	22	15
min	0.32	43	6,912	12	7.7	14
max	2	178	10,593	44	41	46
Precipice Sandstone (n=13)						
median	0.24	10	826	1.4	4.5	4.1
min	0.12	3.6	333	0.4	1.4	1.1
max	2.7	109	6,039	28	50	45

mg element/kg rock	Mo	Mn	Fe	Co	Ni	Cu
mg element/kg rock	**Zn**	**Cd**	**Pb**	**As**	**Se**	**Cr**
lower Evergreen Formation (n=3)						
median	119	0.33	28	7.1	0.71	53
min	77	0.16	16	5.3	0.49	19
max	124	0.6	39	9.9	0.9	153
Precipice Sandstone (n=13)						
median	14	0.05	6.7	1.2	0.37	11
min	4.3	0.03	3.3	0.45	0.32	2.3
max	169	0.55	40	6.9	0.88	149

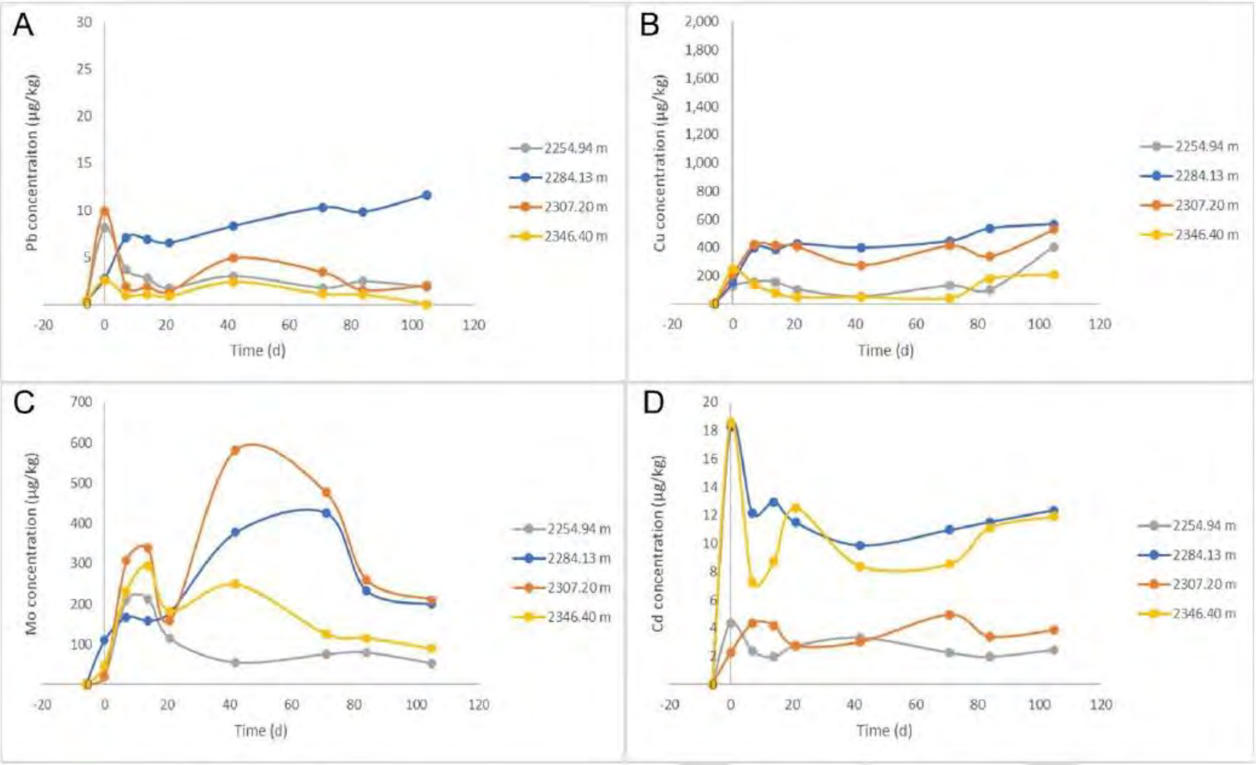

Figure 67: EPQ10 West Moonie-1 Injection Well core: a) Dissolved Pb, b) Cu, c) Mo, and d) Cd concentration (µg/kg) during batch reaction of Precipice Sandstone and Moolayember Formation with O_2-NO-SO_2-CO_2 (Dawson et al., 2022)

Elevated concentrations of trace metals will be restricted to the GHG stream plume, i.e., the mobile component of the GHG stream-impacted volume which is dominated by density-driven convection that is directed towards the bottom of the storage formation (Golding et al., 2019; Pearce and Golding, 2021). It is also expected that trace element concentrations will decrease as time progresses and the sources become depleted (Pearce and Golding, 2021).

6.0 POTENTIAL IMPACTS

This section of the report describes the outcome of the modelling methods described in Section 5.0, detailed in Appendix A to Appendix D, and used to predict the impacts of the groundwater systems at the West Moonie-1 Injection Well. This includes the modelling predictions of near-field plume extents and water quality changes (as described earlier in Section 5.2), as well as far-field pressure changes (as described in Section 5.1) to EVs associated with the Precipice Sandstone reservoir. Further, in Section 6.1 the risk of alternative exposure pathways for the plume are considered, including a risk assessment with consideration of potential mitigation measures.

One of the main purposes of an impact assessment is to provide answers to questions that various stakeholders may have about how the Project could impact EVs in local and regional areas. These are expressed as ‘key questions’, and they form the basis of the investigations of potential effects and impacts of the Project. Guidance on the key questions to be addressed/potential impacts to be considered for the Project are described in the technical guidelines published by the Qld Department of Environment and Science (DES 2021).

Key questions addressed in this GIA include what impact the Project could have on:

- Release of gases
- Groundwater pressure
- Groundwater quality
- Cumulative impacts

6.1 Exposure Pathway Assessment

The objective of the Exposure Pathway Assessment (EPA) is to build on the hydrogeological conceptualisation in the previous section and assess the potential pathways for migration of the GHG stream from the Precipice Sandstone to other regional aquifers in the Surat Basin. Migration of the plume into unintended aquifers would have implications for the groundwater quality and/or EVs for those aquifers. The potential pathways identified in this section are then considered in the GIA section (Section 6.1 and 6.3).

In this report a potential exposure pathway is defined as a pathway which connects the source (aquifer containing GHG stream) to the potential receptors. In contrast, incomplete exposure pathways do not reach potential receptors, as the pathway does not connect the source to the receptor.

The base case (most likely) exposure pathway scenario and less likely alternative exposure pathway scenarios are presented in the sub-sections below.

6.1.1 Base case exposure pathway scenario

The schematic representation of the base case exposure pathway scenario is shown in Figure 68. The main hydrogeological processes that are reflected in this scenario include:

- The bounding surfaces of the Precipice Sandstone (top and bottom) are very flat, with a very low formation dip to facilitate gas migration through buoyancy.

- The lateral hydraulic gradients in the Precipice Sandstone are relatively flat and the reservoir is therefore stagnant in comparison to the north of the basin where it is shallow and hydraulically dynamic.
- The sealing rock (the upper Evergreen Formation) forms a competent and effective tight aquitard (Section 4.3.2), with negligible hydraulic interaction between the Precipice Sandstone and the overlying geological formations over geological time scales.
- The injected GHG stream plume in supercritical state remains in place in the near-field environment around the well and does not migrate more than approximately 500 m away from the injection location, owing to a lack of driving pressure gradient.
- The broader aquifer remains in a stable state (chemically and hydraulically). The only changes occur within the actual plume, as expected.
- Hydraulic head is higher in the Hutton Sandstone than in the Precipice Sandstone, which suggests a downward vertical flow component over geological time scales, but not over Project time scales.
- Due to the isolated and deep nature of the injection site, there is no interaction with other human activities in the Surat Basin.
- The operational and monitoring phases are to be implemented in accordance with monitoring and management plans.

The base case scenario assumes natural conditions beyond 1 km from the West Moonie-1 Injection Well, with deviations from baseline conditions expected only within the GHG stream plume volume. The base case scenario reflects the local-scale and regional-scale datasets and is consistent with the HCM and the numerical modelling summarised in Section 5.0.

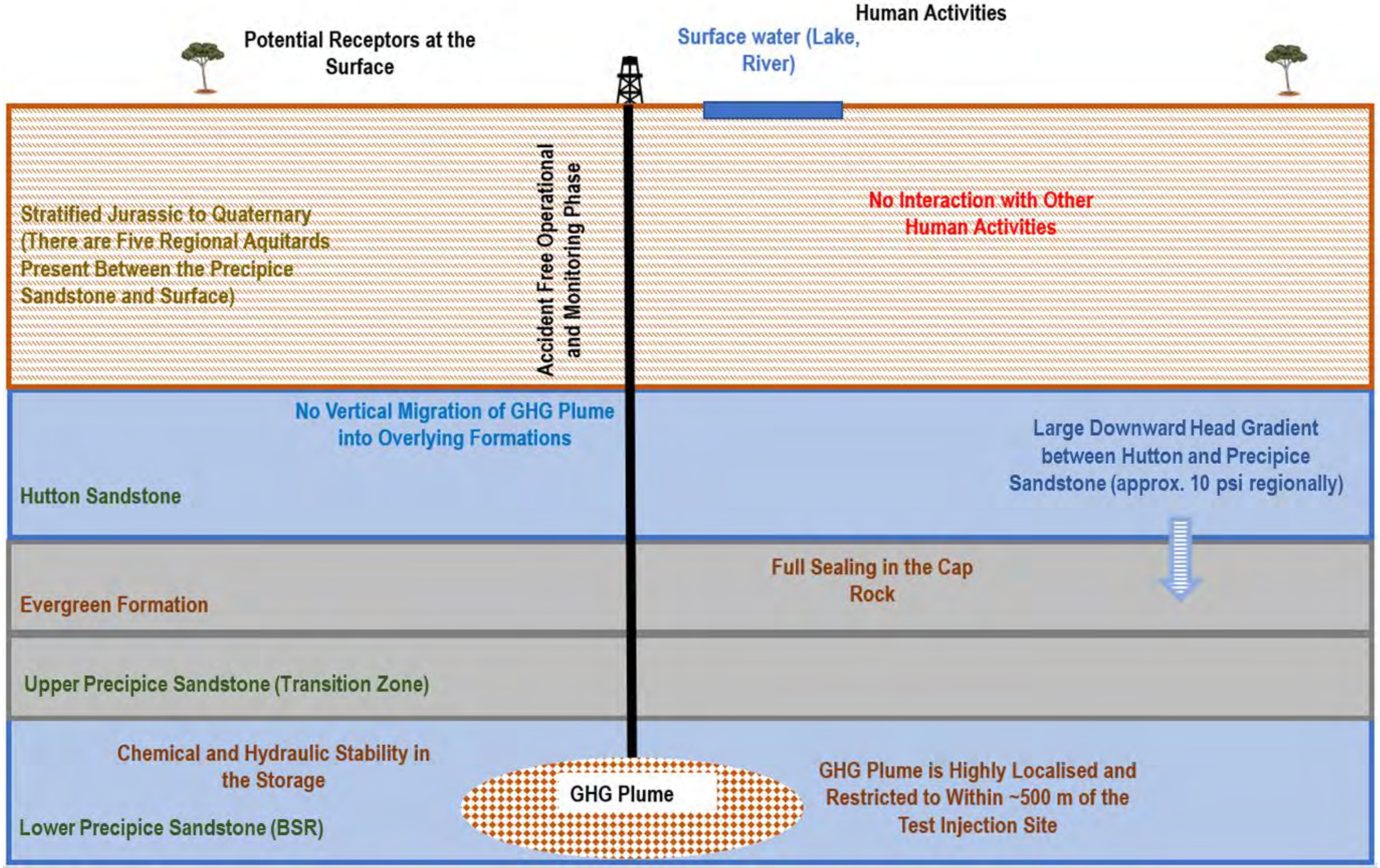

Figure 68: Qualitative hydrogeological conceptualisation of the base case exposure pathway scenario (schematic, not to scale)

6.1.2 Alternative exposure pathway scenarios

This section of the report describes four hypothetical alternative exposure pathway scenarios which deviate from the base case scenario. There are no current data or interpretations to support any of these scenarios occurring, and section 6.1.3 describes how implausible they are. In this regard, these alternative scenarios are highly improbable, and only consider hypothetical situations. These hypothetical alternative scenarios include:

- Caprock integrity
- Well integrity
- Mining and other underground activities
- Water management.

These alternative exposure pathways have been assessed in the impact assessment section (Section 6.1.3).

6.1.2.1 Caprock integrity scenario

The main assumption of this scenario is that the GHG stream injection initiates processes which may culminate in conditions where the caprock (Evergreen Formation) fails to act as a competent hydraulic barrier anymore. These processes may involve:

- Excessive formation pressures resulting in opening up of new fractures
- Excessive formation pressures resulting in reactivation of existing structures (faults) within the Precipice Sandstone and through the Evergreen Formation

It is assumed that the main driver of this scenario is the geomechanical (or hydraulic) response of the system to elevated pore pressure in the aquifer.

The schematic representation of the caprock integrity scenario is shown in Figure 69.

The likely main hydrogeological processes assumed in the near-field environment can be summarised as follows:

- GHG stream injection results in elevated pore pressure in the near-well area and reversed vertical flow direction.
- The GHG stream plume remains in place within the Precipice Sandstone in the near-field environment, and it does not migrate laterally away from the injection point beyond hundreds of metres.
- The enhanced hydraulic link through the Evergreen Formation may result in vertical GHG stream plume migration beyond the upper Precipice Sandstone.
- Lower pressures may initiate GHG stream changing state from supercritical fluid to gas if it moves vertically to shallower aquifers.
- The presence of the GHG stream plume in the cap rock and overlying aquifers may start the development of chemical and hydraulic alterations.
- No interaction with other human activities in the Surat Basin.

It is assumed that shallower barriers (aquitards) of the system in stratigraphical sequence remain intact, and no GHG stream migration is expected beyond the Hutton Sandstone.

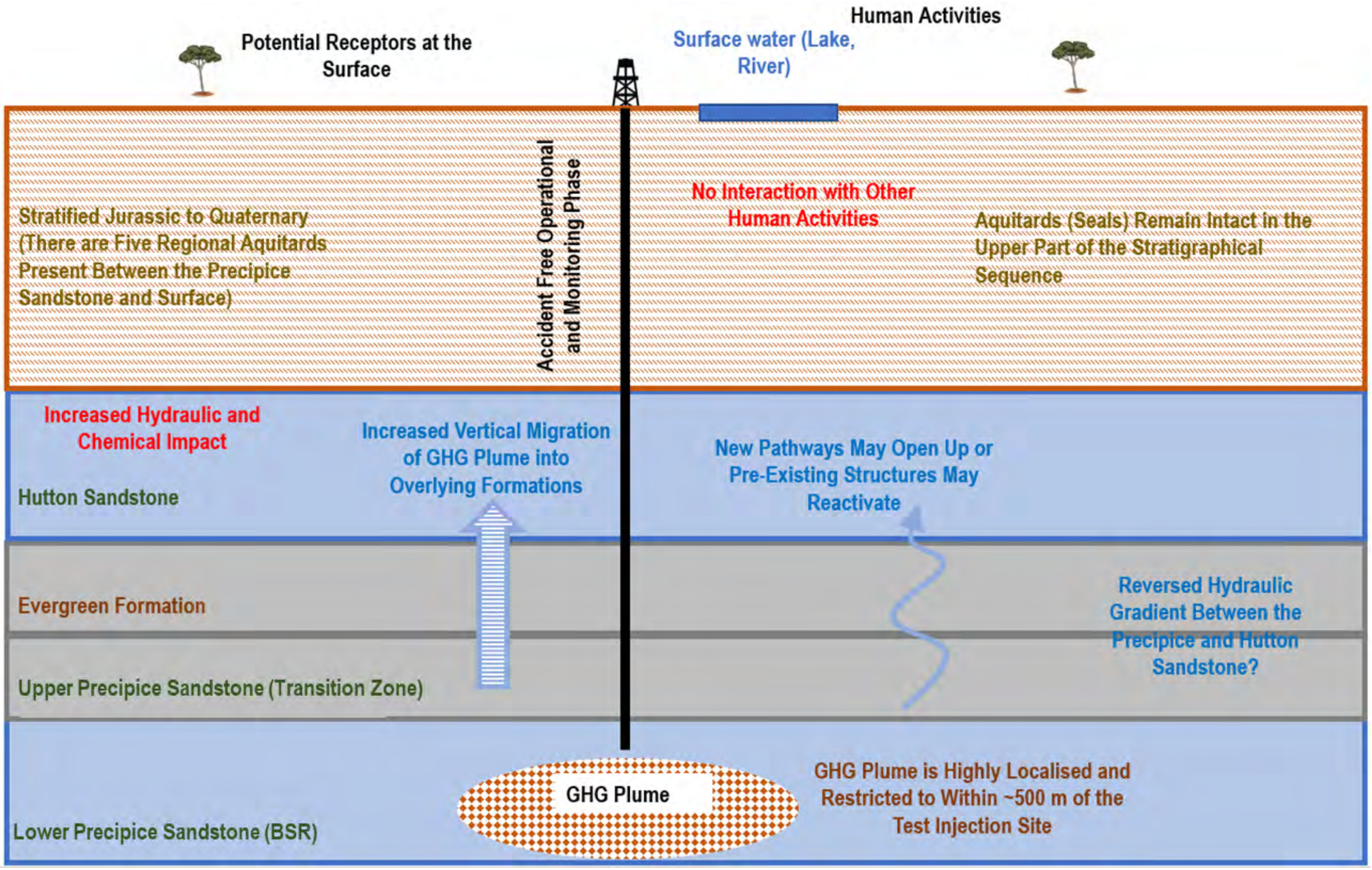

Figure 69: Qualitative hydrogeological conceptualisation of alternative caprock integrity exposure pathway scenario (schematic, not to scale)

6.1.2.2 *Well integrity scenario*

The main assumption of this scenario is that improperly constructed wells within the plume extents may act as conduits for gas or pressure to migrate towards the surface environment or shallower aquifers. This scenario can be initiated by the following causes:

- Inappropriate lining (casing, cementing and their degradation) and completion of injection and monitoring wells
- Inappropriate lining (casing, cementing and their degradation) and completion of existing domestic and industrial wells
- Incomplete or inappropriate abandonment of historical water and O&G wells within the Project site (there are none)
- Future drilling activities at the site.

The schematic representation of the well integrity scenario is shown in Figure 70.

The likely main hydrogeological processes assumed in the near-field environment can be summarised as follows:

- The GHG stream plume remains in place for a long period of time (geological time scales).
- There are stable hydraulic and chemical conditions within the Precipice Sandstone.
- Evergreen Formation acts as a highly effective hydraulic barrier.
- Wells may act as local conduits towards the surface allowing bypass of the hydraulic barrier of the Evergreen Formation aquitard.
- The primary migration pathway of the GHG stream is via existing well bores.
- GHG stream depressurisation may result in changing state from supercritical fluid to gas phase.
- Any overlying aquifer may be impacted hydraulically or chemically – leakage from well.

In a worst-case scenario, GHG stream might be released into the near-surface environment.

There is potential for complete migration pathways between source and receptors.

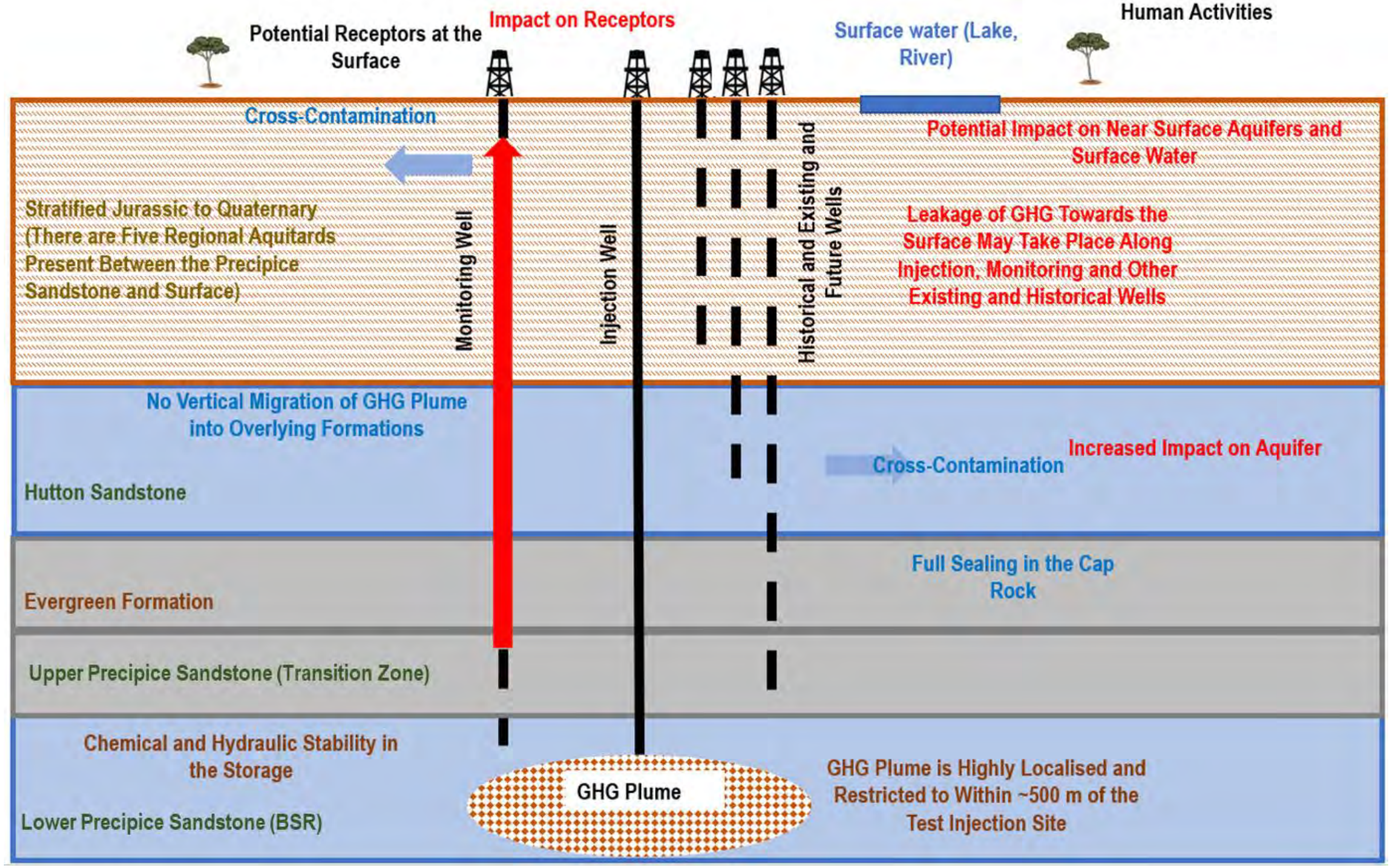

Figure 70: Qualitative hydrogeological conceptualisation of alternative well integrity exposure pathway scenario (schematic, not to scale)

The main assumption of this scenario is that human (mining, O&G or other underground) activities interact with the GHG storage system. This interaction may be intentional (resource mining, geothermal energy, injection of other waste, scientific investigation, etc.) or unintentional (not being aware of the extents of the GHG stream storage plume).

The relevance of this scenario has sub-regional context with the conventional O&G operation by Bridgeport Energy Pty Ltd at the Moonie Oil Field, where there are existing hydrocarbon resources which are actively extracted from the Precipice Sandstone.

The schematic representation of this scenario is shown in Figure 71.

The likely main hydrogeological processes assumed in the near-site environment can be summarised as follows:

- Evergreen Formation will act as a highly effective hydraulic barrier.
- Wells within the plume extents are properly designed and installed.
- Mining and other underground activities interact with the GHG stream storage system in a way that enhances the GHG stream plume migration towards or away from the activity (extraction vs. injection).
- This migration may be driven by an increased hydraulic gradient in the Precipice Sandstone aquifer.
- The chemical and hydraulic footprint of GHG stream in the aquifer will be extended across the migration pathway.
- GHG stream may be extracted at the point of mining and underground activity.
- Extracted GHG stream may have an economical and health impact on the surface.

Complete migration pathways between source and receptors may be formed under this scenario.

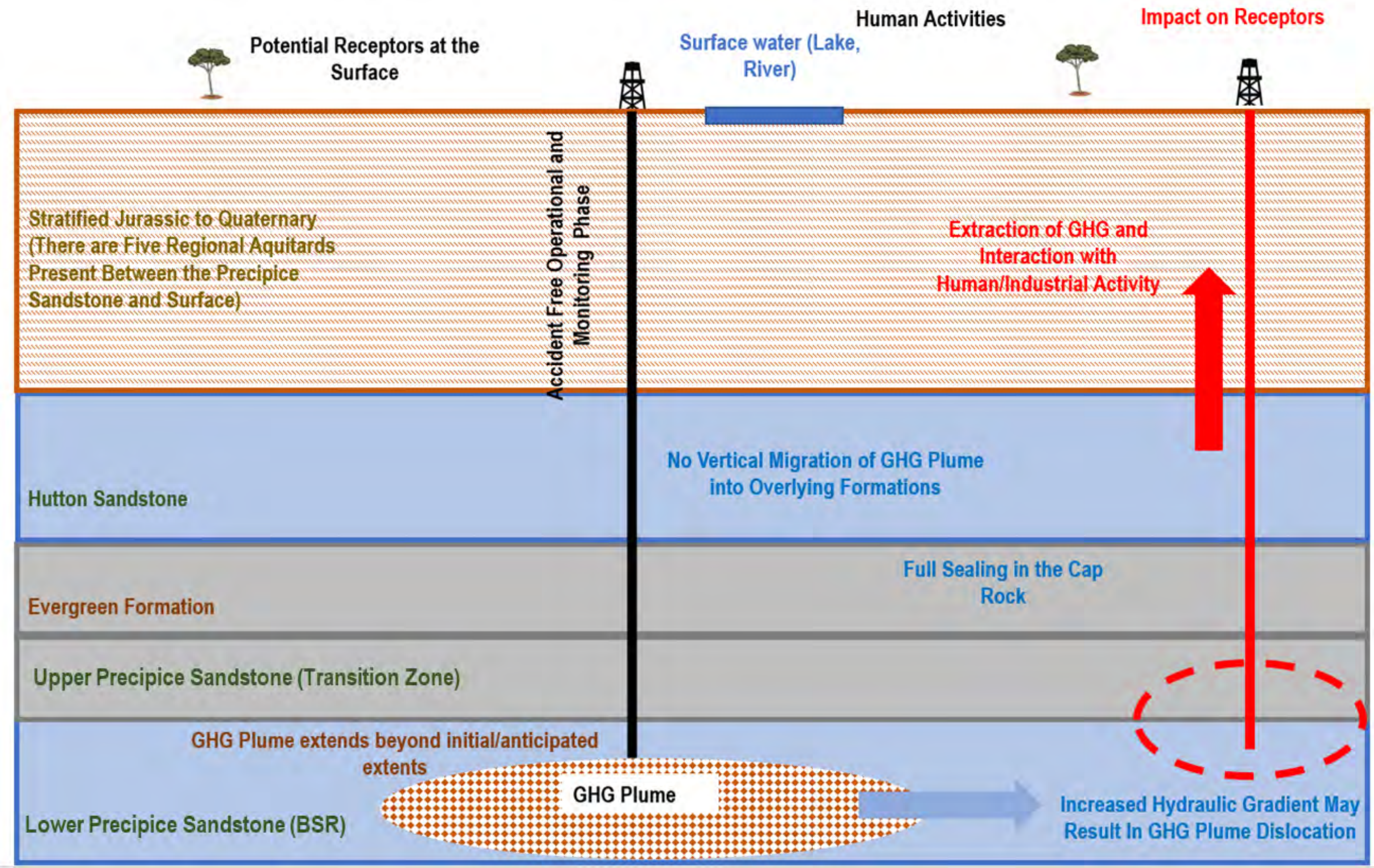

Figure 71: Qualitative hydrogeological conceptualisation of alternative exposure pathway scenario for mining and underground activities (schematic, not to scale)

6.1.2.3 Water management scenario

The main assumption of this scenario is that active or future aquifer management may interact with the aquifer in the vicinity of the GHG stream plume. This water management scenario may affect either the Precipice Sandstone or the overlying Hutton Sandstone. No other potential aquifers above the Hutton Sandstone were considered in this scenario as they are hydraulically separated by more than two recognised tight aquitards in the basin.

An analogue for this scenario is the ongoing artificial recharge of the Precipice Sandstone by two MAR schemes (Hayes et al., 2020). As an example, future MAR injection may occur deeper in the basin.

The schematic representation of this scenario is shown in Figure 72.

The likely main hydrogeological processes assumed in the near-site environment can be summarised as follows:

- Water injection may result in an enhanced hydraulic gradient within the Precipice Sandstone near EPQ10.
- As a result, the GHG stream plume migrates towards or away from the activity in an expedited manner.
- The chemical and hydraulic impact of GHG stream in the aquifer will be extended along the migration pathway.
- Eventually the GHG stream that has migrated may be extracted at the point of the water management activity.
- Also, near-field water extraction in the Hutton Sandstone may reverse the vertical hydraulic gradient and promote upwards flow from the Precipice Sandstone.
- Extracted GHG stream may have economical and/or health impact in the surface environment.

Complete migration pathways between source and receptors may be formed under this scenario.

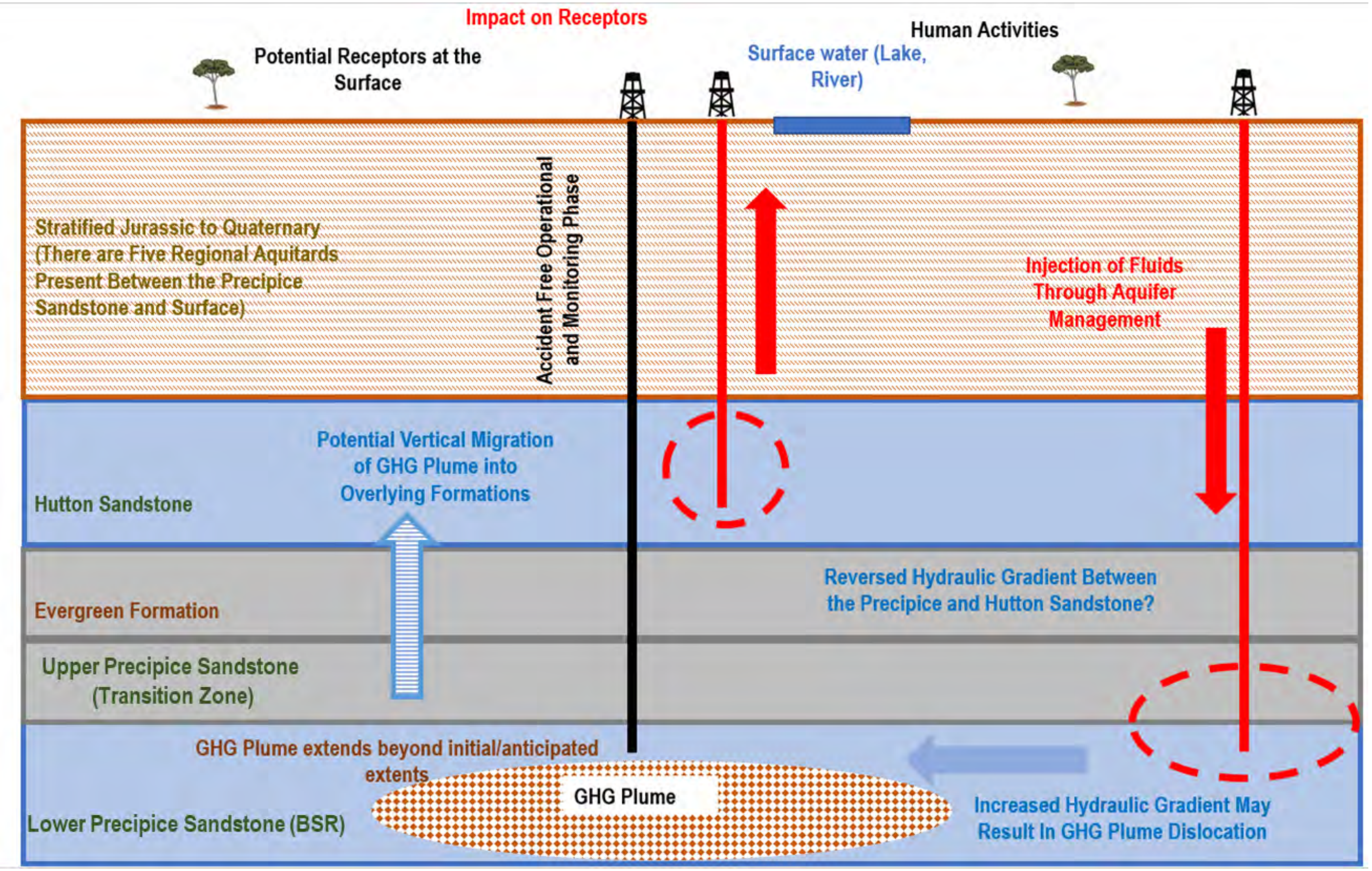

Figure 72: Qualitative hydrogeological conceptualisation of alternative exposure pathway scenario for water management (schematic, not to scale)

6.1.3 Risk of GHG stream plume migration through alternative pathways

Section 6.1.1 presented the most likely base case scenario for hydraulic and chemical containment of the GHG stream plume within the Precipice Sandstone reservoir. This base case scenario was formulated from the outcomes of the HCM presented in Section 4.5.9. The base case reservoir modelling presented in Section 5.2 was representative of this base case scenario and showed that there is no potential for vertical migration of the plume up through the Evergreen aquitard. This thick and competent hydraulic seal acts as it has over geological time: by isolating the Precipice Sandstone from the overlying Hutton Sandstone. This is best evidenced through incompatible water quality signatures (including isotopes) and very large head differences between these two formations prior to injection.

Section 6.1.2 presented four alternative exposure pathway scenarios that deviate from the base case, and potentially allow for migration of the plume beyond the local-scale extents described in Section 6.1.1. These alternative scenarios include:

- *Caprock integrity* – This scenario assumes the vertical migration of the GHG stream plume through the Evergreen Formation. However, current interpretations and data suggest that this scenario is highly unlikely.
- *Well integrity* – This scenario assumes migration pathways along existing, future or legacy wells. This scenario is possible, but relatively easy to control by meeting well design standards and implementing the MVP.
- *Mining and other underground operations* – This scenario assumes interaction between the Project and other future mining and underground activities, such as other GHG stream storage projects. Dynamic modelling demonstrated that this scenario is unlikely for the Project (Section 6.1.2).
- *Water management* – This highly unlikely scenario assumes interaction with current or future water management activities in the Precipice and Hutton sandstones. Interaction with future activities can be avoided with ongoing monitoring and the transfer of storage site knowledge to future generations.

Each of these alternative exposure pathways are described in more detail in Sections 6.1.3.1 to 6.1.3.4.

6.1.3.1 Caprock integrity

The Evergreen Formation is a complex arrangement of sandstone and mudstone layers and its general sealing capability appears to be proven and improving toward the syncline axis (Gonzalez, et al., 2013). However, the integrity of the sealing rock may be compromised by a variety of operational and natural factors, as summarised in Section 6.1.3.1.1.

This section of the report will evaluate the likelihood of these factors affecting caprock integrity during and post test injection. Based on the hydrogeology conceptualisation and consideration of the base case exposure pathway model (Section 6.1.1) no complete pathways were identified between the Precipice Sandstone and the surface environment (receptors). If the sealing potential of the Evergreen Formation fails, the GHG stream has potential to migrate upward to the next overlying aquifer in the GAB sequence (Hutton Sandstone). If this were to occur, the GHG stream may cause chemical, or hydraulic alterations to that aquifer. However, it is important to note that potential receptors at the surface are separated physically by at least four additional aquitards (Sections 2.3.2 and 4.0) from the storage formation (Precipice Sandstone). These additional aquitards, and intervening aquifers, act as extra hydraulic barriers to prevent vertical upward migration of GHG stream plume.

6.1.3.1.1 Mechanisms that may affect caprock integrity

Pre-existing faults and fractures in the caprock would be the first mechanism (referred to as 'localised pathways') that may provide a migration pathway of free phase GHG stream through the caprock. Such features may be transmissive prior to injection; however, it is also possible that previously sealing faults are reactivated or extended due to the increased pressures associated with injection (discussed below). Such 'fault valving' has the theoretical potential to create new pathways for fluid escape to the surface, or to enhance existing pathways (Zhu et al., 2020). The hydrodynamic simulations (for more details see Section 6.1.2.1) consider the presence of a hypothetical fault acting as a leakage window through the Evergreen aquitard in the near vicinity of the injection well. Model results from that fault scenario suggest that hydraulic head change in the Hutton Sandstone would be minimal.

A second mechanism that represents a potential exposure pathway via the caprock relates to over-pressuring of the host rock. When injection rates are higher than the host rock's capacity to dissipate pressure, a local build-up of pore pressure occurs, above and beyond the normal hydrostatic profile for the given depth. If the pore pressure in the host rock exceeds the caprock capillary entry pressure, the GHG stream plume will migrate upwards through the caprock itself. In this sense, the capillary entry pressure should be considered as the maximum permissible overpressure, so as not to risk compromising the sealing efficiency of the caprock. Note that the capillary entry pressure is a function of the brine/CO_2 interfacial tension, which is lower than that between brine and both oil and methane and water (Hildebrand et al, 2020). Accordingly, the sealing efficiency of a given caprock with regard to CO_2 is somewhat lower than that for hydrocarbons.

Over-pressuring of the host rock is also associated with other potential risks to caprock integrity. Swelling and expansion of the host rock caused by over-pressuring may lead to deformation of the caprock, and the resulting stresses may induce the creation of additional fracture- and fault-related flow paths (Wange et al., 2015). Furthermore, increased pore pressures in the host rock may lead to a reversal of the downwards hydraulic gradient in the caprock, which may aid the migration of GHG stream through the caprock, under over-pressured conditions.

Also, unforeseen over-pressuring of the host rock can occur when the formation is depressurised (i.e., through water production or GHG stream leakage) to a point where the formation pressure drops below the CO_2 critical pressure. This induces a phase change in the stored CO_2, such that the resulting expansion of the gas phase may lead to over-pressuring if the pressure does not dissipate. Generally, the risk is only significant for storage at depths near the critical pressure threshold for GHG stream, which is typically achieved at around 800 m below surface (Van de Meer et al., 2009) and/or in confined aquifers.

6.1.3.1.2 Over-pressuring mechanism

WSP Golder has carried out a high-level review of available geomechanical data associated with the West Moonie-1 Injection Well and Moonie-2 Monitoring Well. Further we have reviewed associated geomechanical studies as part of the overall risk assessment into GHG stream injection into the upper Precipice Sandstone. The key objectives are to collate information on the anticipated state of stress and geomechanical properties in the vicinity of West Moonie-1 Injection Well and Moonie-2 Monitoring Well and to identify the key risks associated with GHG stream injection, namely formation fracturing, possible cap breach and fault slip (reactivation).

Available data for this review was contained in primary references:

- *Precipice south Surat water chem JP.xlsx*, ANLEC-funded Southern Surat Hydrogeology project, unpublished spreadsheet (UQ, 2019)
- *West Moonie Geomechanics* (Tech Limit, 2020)

- *West Moonie-1 Update and Final Geomechanical Model* (Tech Limit, 2021).

Tech Limit (2020) provides a detailed review of available data, carrying out a pre-drill assessment of the likely stress conditions to be found at West Moonie-1 Injection Well and other available public information including stress orientation and stress gradient data. This pre-drill assessment defined four stress scenarios, namely a high-stress strike slip case and a low-stress isotropic case, and two horizontal stress (SH_{max}) orientations (Table 52).

Of these two stress scenarios, Stress Case 1 was considered the higher risk with lower fracture initiation pressures (Tech Limit, 2020). Based upon analysis of FMI data from West Moonie-1 Injection Well (1625-2688 m), eight breakout zones were identified, giving a mean direction for SH_{max} of 006°N. This is broadly consistent with data from the Ridgewood wells to the north-east of the Moonie Oil Field.

Table 52: Pre-drill stress states (Tech Limit, 2020)

Stress feature	Stress Case 1 (High)	Stress Case 2 (Low)
Major Horizontal Stress (SHmax) orientation[12]	008° N 136° N	008° N 136° N
SHmax Magnitude (MPa/km)	35	23
Minor Horizontal Stress (Shmin) Magnitude (MPa/km)	21	23
Vertical Stress (Sv) (MPa/km)	23	23
Pore Pressure (Pp) (MPa/km)	9.26	9.26

A mechanical stratigraphy of elastic and strength properties has been derived for the West Moonie-1 Injection Well and Moonie-2 Monitoring Well using wireline log measurements of density, sonic compressional wave and shear wave velocities. With the exception of Poisson’s ratio, the key strength and elastic properties are dynamic measurements and require calibration to static values using laboratory-derived measurements of rock properties. Tech Limit (2021) indicated the model calibration best reflected the confined triaxial results from West Moonie-1 Injection Well and Moonie-2 Monitoring Well and the confined parameters have been used for further model calibration in Tech Limit (2021) analysis.

Analysis of log-derived mechanical properties data, like the pre-drill stress analysis, gave two different stress models that both matched the horizontal stress calibrations and a leak off test from 1,625 m (West Moonie-1 Injection Well): Model 1 – high-stress case, and Model 2 – low-stress case. Comparison to the breakout data shows that the high-stress model over predicts breakout zones, whereas the low-stress model accurately predicts both breakout and non-breakout zones. Further calibration of the geomechanical model with West Moonie-2 Monitoring Well data indicates the low-stress model is considered the best candidate for describing the West Moonie-1 Injection Well and West Moonie-2 Monitoring Well stress conditions. Comparison between the low-stress case and the pre-drill low-stress case, shows a significant reduction in modelled stress gradients. Additionally, stress indicators (borehole breakouts) were identified within the Juandah Coal Measures and the Hutton Sandstone at West Moonie-2 Monitoring Well indicating a mean SH_{max} orientation approximately 112°N (compared to orientations provided in Table 52). This orientation is slightly rotated clockwise from east-west, as observed at West Moonie-1 Injection Well. However, east-west breakouts in West Moonie-2 Monitoring Well appear to be influenced by pre-existing discontinuities.

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[12] Note that borehole breakouts support SHmax 006° N

The results of this low-stress model suggest that with a fracture initiation pressure close to Sh_{min}, it would be relatively easy to propagate a hydraulic fracture beyond the wellbore. However, the stress conditions above and below the Precipice Sandstone suggest that any induced hydraulic fracture would be contained within the Precipice Sandstone. This is due in part to the values of SH_{max} and Sh_{min} within the Precipice Sandstone, which are lower than that of the above and below units.

Pressure tests (XLOT) conducted in the upper Evergreen at the West Moonie-2 Monitoring Well (Tech Limit, 2021) well demonstrated that a pressure increase of 7,000 psi (equivalent to 4,920 m of head) did not result in fracturing. The fracture pressure at this depth (2.2 km below the ground surface) is therefore higher than predicted by the pre-drill model and provides direct evidence that pressures associated with the proposed GHG stream injection will not compromise the integrity of the upper Evergreen Formation.

Shear failure may result in the generation of induced seismic events or the generation of conductive pathways upwards from the aquifer and the potential loss of containment. UQ conducted a Monte Carlo analysis of the pore pressure increase required to cause fault reactivation based on distributions of the required input parameters. There are some parameters from that study that could be modified without compromising the overall outcomes or conclusions. The friction angle was set at a high range of 40° to 50° when most work suggests an initial (unconstrained) value of 31° (Byerlee & Byerlee, 1978; Barton, Zoback & Moos, 1995). Similarly, the analysis considered both 'cohesionless' and 'with cohesion' scenarios. The cohesion values quoted are for intact material up to 11 MPa, whereas the Mohr-Coulomb criteria requires the fault cohesion value with typical values likely to be less than 100 kPa (i.e., 100 times lower). This has resulted in the average pressure increase to induce fault slip moving from approximately 34 MPa to 40 MPa. For the cohesionless case, the P90 (the value that is exceeded by 90% of estimates, equivalent to the 10th percentile) is 30.1 MPa. At a depth of 2,350 m, this results in a (P90) pressure to induce slip of 53.2 MPa. However, given a thermally adjusted bottomhole pressure (BHP) during injection of approximately 40 MPa (UQ, 2019), this is well below the reactivation pressure. However, the report does strongly recommend a campaign to locate faults through 3D seismic acquisition that CTSCo has planned for Q2 2023.

Summary of mechanism likelihood

The over-pressuring mechanism is assessed to be extremely unlikely to compromise caprock integrity. This is due largely to:

- The stress conditions above and below the Precipice Sandstone suggest that any induced hydraulic fracture would be contained within the Precipice Sandstone.
- Site-based pressure tests provide direct evidence that pressures associated with the proposed GHG stream injection will not compromise the integrity of the upper Evergreen Formation.
- The thermally adjusted BHP during injection is well below the pressure required to reactivate faults.

6.1.3.1.3 Localised pathways

Existing pathways through the caprock can be assessed by a combination of geological and hydrogeological observations. The Evergreen Formation displays a complex inter-layering of sandstone and mudstone (Hayes et al., 2020) deposited in a low energy, non-marine (meandering rivers, freshwater lakes), intracratonic setting (Cosgrove & Mogg, 1985). However, recent interpretations suggest substantial marine deposition (La Croix et al., 2019). It is assumed that sandstone encountered above the Precipice Sandstone (within the Evergreen Formation) may have limited extent, greater clay content and lower hydraulic conductivity (Hayes et al., 2020). The likelihood of existing interconnected hydraulic pathways through the Evergreen Formation needs to be considered with respect to the following site-specific conditions:

- The accumulation of hydrocarbon resources in the Precipice Sandstone east of the site indicate the effectiveness of the Evergreen as an effective seal on a geological time scale (‘geological trap’) and its negligible vertical permeability.
- The regional- and basin-scale hydraulic conductivity of the Evergreen Formation appears to be much lower than that of the Precipice and Hutton sandstones (OGIA, 2019a; Hayes et al., 2020).
- Basin-scale modelling of the Evergreen Formation indicates very low vertical hydraulic conductivity values that are in the order of $1x10^{-6}$ m/day or lower (OGIA, 2019a).
- Groundwater pressure differences between the Hutton Sandstone and Precipice Sandstone, based on the pressure gradient offsets between West Moonie-2 Monitoring Well (Precipice Sandstone) and West Wandoan-1 Well (Hutton Sandstone), further emphasise the excellent sealing potential of the Evergreen aquitard at the regional scale (Scorer, 1966; Rodger et al., 2020).

Although the overall sealing capability of the Evergreen Formation is well justified, there are a few local observations which may suggest historical leakage of the Evergreen Formation. In some parts of the basin, such as Eastern Surat (Suckow et al., 2018) found hydrochemical evidence of potential hydraulic connectivity between the Hutton and Precipice Sandstones along the northern Surat Hutton-Wallumbilla Fault and potentially along the Leichhardt-Burunga Fault. There have been some former interpretations that assumed that the Evergreen Formation can be a leaky aquitard (Commonwealth of Australia, 2014). Gonzalez et al (2013) reported the presence of oil and gas shows in the Hutton Sandstone, and the authors suggested that these shows are aligned with the fault systems on the margins of the syncline. Timing (episodic or continuous) of hydrocarbon migration (leakage) could not be determined. It is understood that the origin of reservoir oil is from Bowen Basin Permian rocks (Golding et al., 2016).

There is some evidence of potential fault-related interconnectivity between the Hutton Sandstone and the Precipice Sandstone over geological time. Avoiding faulted areas eliminates any risk and the results of the reservoir modelling and hydrodynamic modelling (Section 5.0) suggest that GHG stream plume migration will be limited, and it will not reach any faulted area in the next 100 years, with the nearest mapped fault being over 2 km from the West Moonie-1 Injection Well.

Formerly open fractures in the Evergreen Formation have been filled via previous natural CO_2 alteration (UQ, 2019). Siderite, calcite, Ti-oxides, apatite, pyrite, silica and barite cements have been observed to in-fill fractures in the Evergreen Formation. The implications of this natural CO_2-driven alteration include:

- CO_2 reacts with the mineralogy of the Evergreen Formation to precipitate minerals in any void space.
- This reaction likely results in reduced porosity throughout the Evergreen Formation.
- CO_2 alteration may improve the sealing capability of the Evergreen Formation.

Golding et al. (2016) concluded that “*precipitation of carbonate minerals within the pore space of the storage reservoir provides the greatest certainty of long-term storage and eliminates the risk of CO_2 leakage*”.

Summary of mechanism likelihood

The localised pathways mechanism is assessed to be extremely unlikely to compromise caprock integrity. This is due largely to:

- The bulk of hydrogeological conceptualisation and basin-scale modelling has demonstrated that the Evergreen Formation aquitard is an effective hydraulic seal and significantly limits hydraulic interaction between the basal Precipice Sandstone and overlying Surat Basin aquifers.

- There is some evidence that localised fault features may enhance connectivity across the Evergreen Formation over geological time scale. Avoiding these significant fault structures is the best form of mitigation. Modelling of the test injection shows that the plume will not migrate beyond approximately 500 m from West Moonie-1 Injection Well, and there are no mapped faults within 2 km of the site.
- If a localised pathway did exist, CO_2-driven precipitation of carbonate minerals in the Evergreen Formation will act to reduce porosity of that pathway and lead to self-healing.

6.1.3.2 Well integrity

The Surat Basin has a long history of hydrocarbon production, with over 100 accumulations having been discovered, but production only occurs from about 50% of these. Most of the accumulations are within the Precipice Sandstone, but there are also shallower accumulations that are mid- to early-Jurassic age. This means the caprock to the Precipice Sandstone (the Evergreen Formation) has been penetrated a number of times by wells which could have localised implications for well/caprock integrity.

The Surat Basin also has a number of coal mines, and more recently extensive CSG development targeting the Walloon Sub-Group. The Walloon coal measures are Middle Jurassic in age and are separated from the Precipice Sandstone by the Evergreen Formation and Durabilla/Eurombah Formation aquitards. EPQ10 is situated approximately 30 km to the west of Moonie, with the nearest CSG field being at least 70 km away from West Moonie-1 Injection Well. Therefore, CSG wells are not considered a risk to the Project.

Wells (existing and historical) are potential localised leakage pathways between the storage aquifer and the surface (or shallow aquifers). The primary way to control or to prevent gas migration along wells is to design and construct wells to appropriate standards. This has been achieved in West Moonie-1 Injection Well and West Moonie-2 Monitoring Well. The wells have been designed and constructed in accordance with appropriate standards for future, but some uncertainty is present for legacy historical wells. Further, wells may degrade chemically or mechanically over a long period of time resulting in decline in well integrity. Table 53 outlines the potential range of causes which may influence the integrity of wells.

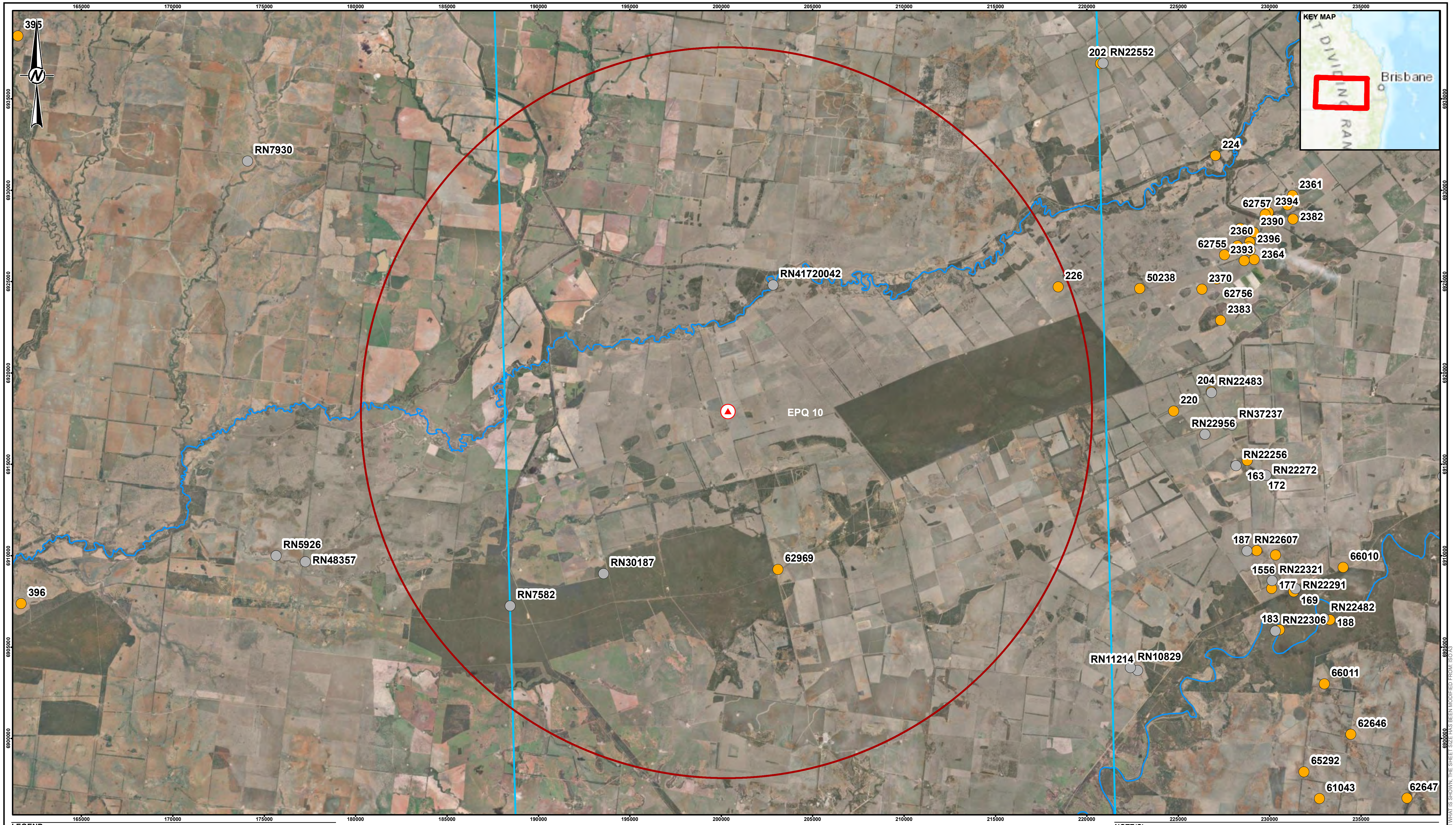
Table 53: Potential mechanisms that may influence well integrity

Mechanism for compromised well integrity	Assessment of failure mechanism
Operational failure of well (injection, monitoring, other industrial and commercial wells)	Well completion report, well decommissioning design
Compromised well integrity during well construction	QA/QC, accident response plan
Unexpected geological (e.g., earthquake), operational or monitoring events compromise well integrity	QA/QC, accident response plan
Poor well construction for historical wells	Well completion report

As described in Section 5.2, the test injection plume is unlikely to extend more than approximately 500 m from the West Moonie-1 Injection Well under a 110,000 t/year injection scenario for three years. Beyond the physical extents of the plume, a pressure wave will migrate tens of kilometres from the West Moonie-1 Injection Well, although that pressure head will tend to be around 0.2 m of head or less outside of EPQ10 (Section 6.1.2). Therefore, the potential chemical impacts to wells would be limited to within approximately 500 m of West Moonie-1 Injection Well and pressure impacts to wells (considering that less than 0.2 m of pressure head difference will not alter the well functionality) will mainly occur within EPQ10.

Five abandoned wells (from interrogation of both GWDB and QPED) were identified within a 20 km radius around West Moonie-1 Injection Well, but only one (Well 226) is deeper than the Precipice Sandstone (Figure 73). This well is located approximately 19 km east-north-east from West Moonie-1 Injection Well and is therefore very unlikely to induce connectivity (owing to 0.2 m pressure head increase versus the existing more than 50 m downward pressure gradient between the Hutton Sandstone and the Precipice Sandstone).

Bois et al. (2013) suggested that the chemical reaction between cement plug and CO_2 rich water can be very slow, but the chemical reaction in combination with mechanical failure can be a problem. Also, it is likely that the most important chemical reactions take place along pathways opened up by mechanical stresses (Carey, 2013) and Kelkar et al. (2014) found that 1 MPa (approximately 100 m of water head) overpressure in the aquifer may result in failure of weak cement-rock interface (no cohesion) and intensified flow in the annular space. In the case of strong cement-rock interface, no failure was simulated up to 5 MPa (approximately 500 m of water head). Note that the reservoir model simulation results indicate a maximum 77 kPa (approximately 7.9 m) pressure increase in the Precipice Sandstone at the end of injection, which suggests that well mechanical failure is extremely unlikely.



LEGEND

- 🔺 West Moonie-1
- ● Abandoned bores GWDB
- ● Abandoned or suspended bores QPED
- ▭ 20 km Radius
- ▭ EPQ10

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)
1. MAJOR WATERCOURSES & GWDB & QPED: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI

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1:200,000 @ A3 KILOMETRES

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT

wsp GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	JL
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
ABANDONED BORES AROUND THE STUDY AREA

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	073

PATH: V:\CTSCo\21456840 CTSC GW ESIA Moonie\GIS\99_PROJECTS\21456840-011-Rev2-F077-AbandonedBores.mxd PRINTED ON: 2022-06-16 AT: 12:11:22 PM

6.1.3.3 Mining and other underground operations

Further potential exposure pathways are associated with anthropogenic activities in the form of resource mining, hydrocarbon exploration or production, geothermal energy production and excavation or injection for storage, disposal or other industrial purposes. Such activities could potentially create exposure pathways by disturbing or altering hydraulic gradients in the reservoir and/or caprock. Groundwater abstraction, either for human domestic use or agricultural or industrial uses, are likely to induce similar effects. Indeed, direct abstraction of groundwater from the reservoir may lead to dislocation and migration of the GHG stream plume, or extraction of the stored GHG stream.

Table 54 lists the underground operations and activities that may enhance exposure pathways for the GHG stream.

Table 54: Mechanisms associated with underground operations mechanisms that may enhance exposure pathways

Mechanisms associated with underground operations that may enhance exposure pathways	Assessment of failure mechanism
Changes to the hydraulic and chemical conditions in the Precipice Sandstone	Knowledge transfer, monitoring GHG stream migration in the direction of extraction points, communication to potential stakeholders
Extraction of fluids with or without knowledge about the GHG stream storage with potential to influence near-field conditions at EPQ10	Knowledge transfer, monitoring GHG stream migration in the direction of extraction points, communication to potential stakeholders

This scenario may result in a complete pathway by extraction of fluids from the reservoir. Extraction processes have potential to increase the hydraulic gradient towards the extraction point, which may result in enhancing GHG stream plume migration towards the extraction well/s. Based on current knowledge, there are no Precipice wells within 30 km of the West Moonie-1 Injection Well, and the test injection plume is predicted to be contained to within approximately 500 m of West Moonie-1 Injection Well.

The rationale of this scenario is the presence of hydrocarbon accumulations in the Precipice Sandstone aquifer. The Moonie Oil Field, operated by Bridgeport Energy is located about 30 km east from the proposed West Moonie-1 Injection Well. The Moonie Oil Field is currently producing approximately 130 STB/day with over 99% water cut (UQ, 2019). The Moonie abstractions have been simulated as part of the hydrodynamic modelling described in Section 6.1.2. The result of the modelling suggests that the GHG stream plume from West Moonie-1 Injection Well has no potential to approach the Moonie Oil Field (approximately 30 km away) in the next 1,000 years under the current stress regimes active in the aquifer.

6.1.3.4 Water management

There are ongoing water management schemes, such as MAR, interfering with the Precipice Sandstone aquifer (Hayes et al., 2020). The existing MAR scheme operates at two sites (Reedy Creek and Spring Gully), although these sites are situated more than 170 km north-west of West Moonie-1 Injection Well. The injection schemes commenced operation in 2015 and by June 2018, 20.5 GL of water had been injected into the Precipice Sandstone. This injection resulted in a 2.5 m to 4 m increase in hydraulic head near Miles (CON-INJ002 and CON-INJ005), with these pressure increases being approximately 100 km from West Moonie-1 Injection Well (Hayes et al., 2020). Modelling of the MAR scheme (Hayes et al., 2020) is focused on the northern and central extents of the Precipice Sandstone where temporal pressure monitoring data was available. The model extent does not extend south towards the Moonie area. While the pressure in the

Precipice Sandstone at West Moonie-1 Injection Well may respond to the MAR, it would likely be a marginal increase in pressure on a sub-regional scale and would not significantly alter the flow field around West Moonie-1 Injection Well. It is highly unlikely to alter the migration pathway of the GHG stream plume.

The other mechanism which may affect the future evolution of the system studied is water extraction in the Hutton or Precipice Sandstones close to West Moonie-1 Injection Well. Complete migration pathways can be assumed if hydraulic head is reduced in the Hutton Sandstone due to future water management/usage. Currently no water abstraction takes place in the Hutton Sandstone or Precipice Sandstone close to operational lands which makes this scenario unlikely. This is due to the significant depth of these formations in this southern part of the Surat Basin (over 2 km deep), making them economically unviable for water supply.

6.2 Potential impacts in the injection phase

6.2.1 Geology

The modelling shows that the pressure increases by 77 kPa (approximately 11 psi) by the end of the 3-year injection period. The simulation indicates that the pressure increase never exceeds 14 kPa (approximately 2 psi) at the upper and lower Precipice Sandstone boundary. Therefore, pressure does not propagate upwards to any of the formations overlying the Precipice Sandstone.

Pressure testing done in the upper Evergreen Formation at West Moonie-2 Monitoring Well showed that the formation did not fracture at 48,265 kPa (7,000 psi). Therefore, the pressures induced during the GHG injection will not cause integrity issues with the Evergreen Formation which is the sealing unit.

6.2.2 Hydrogeology

6.2.2.1 Far-field groundwater pressure impacts

The hydrodynamic modelling predicts a very low regional impact on the pressure in the reservoir, with the high hydraulic conductivity and connectivity of the Precipice Sandstone allowing for effective pressure dissipation over a large area (Section 5.1).

Dynamic reservoir modelling (tNavigator modelling, Section 5.1) of the GHG injection predicts a maximum change in hydraulic head adjacent to the West Moonie-1 Injection Well of 8.4 m at the end of injection. Although this change in head quickly dissipates radially with generally less than 0.2 m head change outside of the EPQ10 boundary (see Figure 75). This maximum hydraulic head change is predicted to occur at the end of the test injection period. When injection ceases, the change in pressure recovers rapidly.

6.2.2.2 Local groundwater pressure impacts

The groundwater pressure impacts caused by GHG injection is limited to a very local scale. Dynamic reservoir modelling predicts that the GHG stream plume is expected to be limited laterally to within approximately 500 m of the West Moonie-1 Injection Well and vertically contained within the Precipice Sandstone reservoir itself (Section 5.2). The maximum pressure change at the end of injection is 77 kPa (approximately 7.9 m) with less than 1 m of pressure change outside of the immediate plume extents (Figure 56).

Dynamic reservoir modelling (Section 5.2) shows a maximum increase in pressure of 59 kPa (approximately 6.4 m) at the top of the Precipice Sandstone at the interface with the lower Precipice Sandstone. These local scale increases in pressure are an order of magnitude less than the existing more than 50 m head difference between the Precipice Sandstone and Hutton Sandstone formations. As such, the prevailing downward hydraulic gradient will remain during injection. There is no potential for upwards flow through the Evergreen Formation aquitard to the Hutton Sandstone as a result of the Project.

Pressure tests conducted in the upper Evergreen at the West Moonie-2 Monitoring Well demonstrated that a pressure increase of 7,000 psi (equivalent to 4,920 m of head) did not result in fracturing (refer TechLimit 2021 Report). The fracture pressure at this depth (2.2 km below the ground surface) provides direct evidence that pressures associated with the proposed GHG stream injection will not compromise the integrity of the upper Evergreen Formation.

6.2.3 Water quality

6.2.3.1 Far-field groundwater quality impacts

There will be no groundwater quality impacts outside of the GHG stream plume extents. This is consistent with operational monitoring of larger commercial-scale GHG stream injection fields in analogous reservoir settings internationally (see case studies summarised in Section 2.3).

6.2.4 Aquatic Ecosystems and Groundwater Dependent Ecosystems

Figure 74 shows the GHG stream plume extent with respect to mapped GDEs and within the Precipice Sandstone. There are no mapped GDEs within or near the plume extents. In addition, modelling results show that the upper Evergreen Formation will not crack due to the injection. Therefore, none of the GHG stream is released to impact surface water or GDEs during the Project.

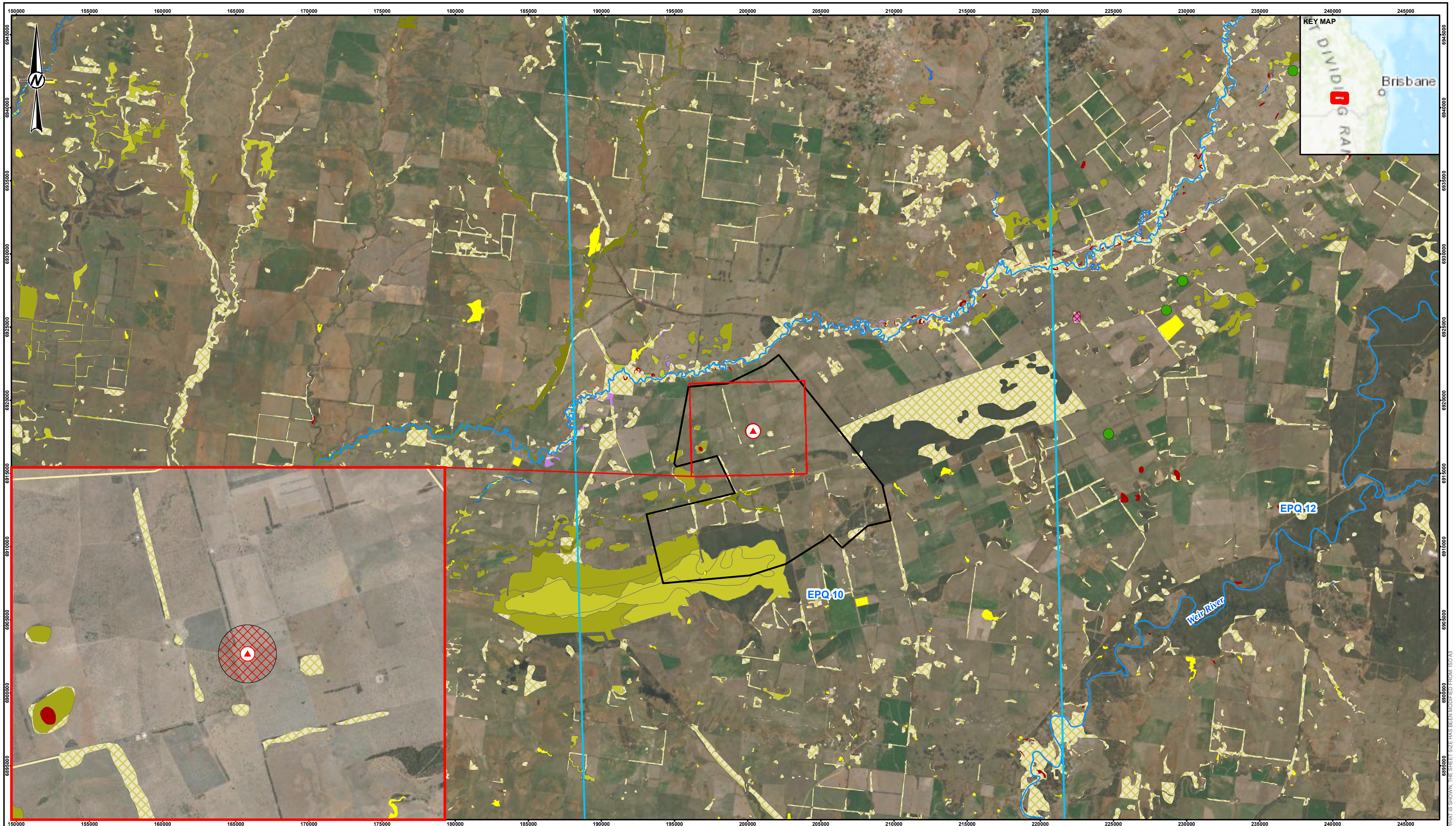
6.2.5 Groundwater water supply and users

Figure 75 presents the 0.2 m and 1.0 m pressure increase contours at the end of the injection trial (from the base case hydrodynamic model) compared with registered Precipice Sandstone bores within 50 km of West Moonie-1 Injection Well. This figure shows that there will be no impact to regional groundwater users as a result of the test injection.

Groundwater bore RN22514 (24 km east of West Moonie-1 Injection Well) is the only groundwater bore that encounters a change in head exceeding 1 m, based on the dynamic modelling work. The *Water Act 2000* defines a water level trigger threshold of a decline in water level of 5 m for a consolidated aquifer. The predicted impact of 1 m rise in water level at the closest registered water bore is well within the threshold of impact. It should also be noted that the bore is a petroleum well (UOD Pring 1) and according to its well completion report was plugged and abandoned to surface (Queensland Government, 2020).

As such, no regional groundwater bores are predicted to be impacted by pressure change as a result of the Project.

Figure 74 shows the GHG stream plume extent with respect to mapped GDEs and groundwater users within the Precipice Sandstone. There are no mapped groundwater users within or near the plume extents. As such, there is no potential for local-scale impacts to groundwater users.



LEGEND

- 🔺 West Moonie-1
- — Major watercourses
- ☐ Project Area Outline
- ☐ Exploration permits for greenhouse gas
- ▨ GHG Stream plume extent

Registered water bores

- ● PRECIPICE SANDSTONE

Wetland areas

- ■ M_WB
- ■ E_WB
- ■ R_WB
- ■ L_WB
- ■ P_WB
- ▨ M_RE
- ▨ E_RE
- ▨ R_RE
- ▨ L_RE
- ▨ P_RE
- ■ 51-80_RE
- ▨ 01-50_RE
- ■ MSES wetlands

Aquatic GDE from regional studies

- ■ Low potential GDE

Terrestrial GDE from regional studies

- ■ High potential GDE
- ■ Moderate potential GDE
- ■ Low potential GDE

0 5 10
1:250,000 @ A3 KILOMETRES

NOTE(S)

1. PROJECTION: GDA 1994 MGA ZONE 56.

REFERENCE(S)

1. MAJOR WATERCOURSES: © STATE OF QUEENSLAND (DEPARTMENT OF NATURAL RESOURCES, MINES AND ENERGY) 2020.
2. EXPLORATION PERMITS FOR GREENHOUSE GAS: © STATE OF QUEENSLAND (DEPARTMENT OF RESOURCES) 2021
3. PROJECT SHAPEFILES: CTSCO
4. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS,

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION
(CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	DW
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
GHG STREAM PLUME EXTENT BASED ON BASE CASE MULTI-PHASE RESERVOIR MODEL

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	074

PATH: V:\CTSCo\21456840 CTSC GW ESIA Moonie\GIS\99_PROJECTS\21456840-011-Rev2-F074-PlumeExtentGDE.mxd PRINTED ON: 2022-06-16 AT: 12:03:37 PM

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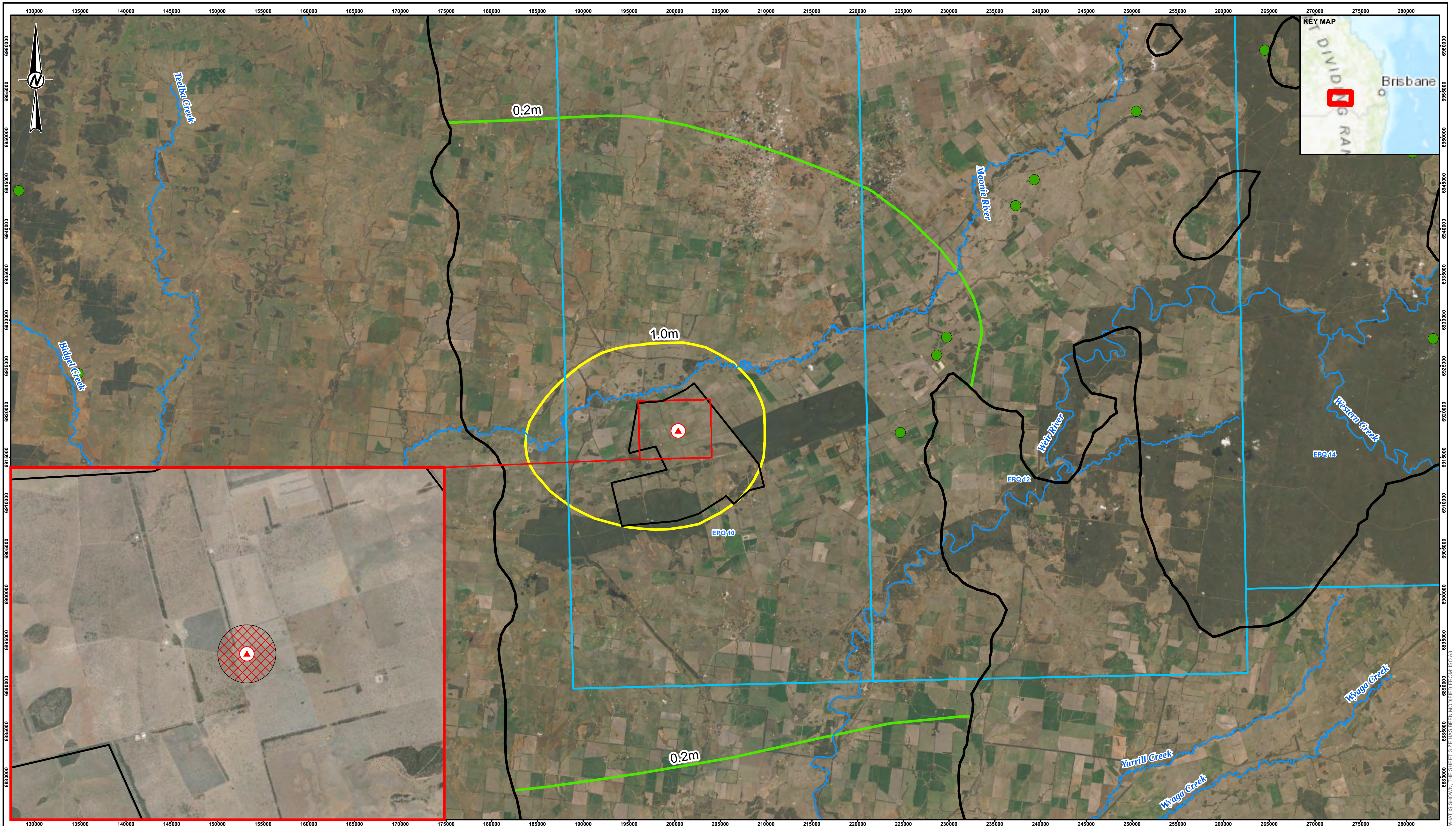

LEGEND

- 🔺 West Moonie-1
- ▬ Major watercourses
- ☐ Project Area Outline
- ☐ Exploration permits for greenhouse gas
- ▨ GHG Stream plume extent
- ▬ 1.0 m Modeled Precipice pressure increase
- ▬ 0.2 m Modeled Precipice pressure increase
- ▬ Precipice Extent

Registered water bores

- ● PRECIPICE SANDSTONE

0 5 10
1:400,000 @ A3 KILOMETRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 56.

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2. EXPLORATION PERMITS FOR GREENHOUSE GAS: © STATE OF QUEENSLAND (DEPARTMENT OF RESOURCES) 2021
3. PROJECT SHAPEFILES: CTSCO
4. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, GEOEYE, EARTHSTAR GEOGRAPHICS,

CLIENT
CARBON TRANSPORT AND STORAGE CORPORATION (CTSCO) PTY LIMITED

PROJECT
SURAT BASIN CARBON CAPTURE AND STORAGE PROJECT

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-09-02
DESIGNED	DW
PREPARED	MR
REVIEWED	ATD
APPROVED	RH

TITLE
REGIONAL PRESSURE IMPACTS IN THE PRECIPICE SANDSTONE BASED ON HYDRODYNAMIC MODELLING BASE CASE

PROJECT NO.	CONTROL	REV.	FIGURE
21456840	011	4	075

PATH: V:\CTSCo\21456840 CTSC GW ESIA Moonie\GIS\99_PROJECTS\21456840-011-Rev2-F075-RegionalPressureImpacts.mxd PRINTED ON: 2022-06-16 AT: 12:06:51 PM

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6.3 Potential impacts in the post-injection phase

6.3.1 Geology

Reservoir simulations indicate that pressure changes are minimal, and therefore, not enough to transfer pressures upwards or to cause integrity problems in the overlying seal (Evergreen Formation). Geochemical modelling predicts that during the 100-year simulation period some minerals will dissolve, whilst others will precipitate out. The overall change in mineral volumes is not predicted to cause any change in the average porosity.

6.3.2 Hydrogeology

Dynamic reservoir modelling shows that the pressure impact of the GHG stream injection is low and diminishes rapidly. The maximum pressure increase is 8.7 kPa (approximately 1.3 psi) after 3-years shut-in and 5.4 kPa (approximately 0.8 psi) after 100-years shut-in. Due to the low hydraulic gradient in the Precipice Sandstone in the deeper part of the southern Surat Basin, the pressure-impacted groundwater is restricted to less than 100 m away from the plume in 1,000 years (Section 5.1).

6.3.3 Water quality

6.3.3.1 Local groundwater quality impacts in the Precipice Sandstone

GHG injection into the Precipice Sandstone reduces the groundwater pH from 8.35 to approximately 4.4 within the plume. As a result of the lower pH, concentrations of potassium and iron are predicted to increase while the SiO_2, calcium and magnesium concentrations decrease over time (see Section 5.2.2). Trace element concentrations may also increase; however, these increases will also be limited to within the plume extent (approximately 500 m from West Moonie-1 Injection Well, as shown on Figure 74), but their concentrations (e.g., Pb, Mo, Cd) will be controlled (i.e., lowered by orders of magnitude) due to GHG storage (i.e., adsorption and co-precipitation) by secondary minerals such as iron (hydr)oxides, carbonates and clays. Hydrodynamic modelling (Section 5.1) and dynamic reservoir modelling (Section 5.2) shows that groundwater movement of less than approximately 500 m in 1,000 years. Therefore, the impact of GHG stream injection on groundwater quality occurs only on a local scale and there is no change in water chemistry of the groundwater outside of the plume.

Table 55: Local groundwater quality impacts in the Precipice Sandstone

Parameter	Existing aquifer water quality*e	Value after five years	Value after 100 years
pH	8.35	4.41	4.4
Iron (mg/L)	2.78	13.03	12.8
Potassium (mg/L)	150	150.3	155.4
SiO2 (mg/L)	78.113	38.5	56.5
Calcium (mg/L)	6	0.97	2.64
Magnesium (mg/L)	1	0.10	0.26

*Note: Formation water composition from West Moonie-1 Injection Well – specific parameters used in the model.

As described in Section 4.5, the groundwater quality, as encountered in West Moonie-1 Injection Well, does not meet the WQOs of the EVs for Aquatic Ecosystems, irrigation, stock water, and drinking water. Further, the extent of the impact on groundwater impact is highly localised (within approximately 500 m of West Moonie-1 Injection Well), and therefore, will not affect the nearest users of the Precipice Sandstone which are more than 30 km away.

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[13] Estimated using speciation model

Based on the (hydrodynamic, reservoir and geochemical) modelling and the poor existing water quality in the vicinity of the West Moonie-1 Injection Well which is unsuitable for the EVs which have been assigned to the Precipice Sandstone groundwater, it is concluded the test injection will have a highly localised (to within the GHG stream plume) and a negligible impact on the groundwater quality of the Precipice Sandstone regionally. Further, the test injection will not compromise the identified EVs in the shallow parts of the basin to the north.

6.3.3.2 Local groundwater quality impacts in overlying aquifers

The GHG stream plume will be contained within the Precipice Sandstone reservoir and will not migrate through the Evergreen Formation aquitard into overlying aquifers. GHG stream injection could only impact the water quality of the overlying aquifers if a vertical pathway is created via either of the following mechanisms:

- Failure of seal integrity (as discussed in Section 6.1.3 this is not possible as the injection pressures are much lower than the formation fracture pressure).
- Failure of well integrity (as discussed in Section 6.1.3.2, though this is not likely as the Project wells have been designed to achieve high integrity).

As discussed in Section 4.6.6, the vertical hydraulic gradient between the Hutton Sandstone and Precipice Sandstone is strongly downward in this part of the Surat Basin. West Moonie-1 Injection Well is drilled on the eastern flank of the Mimosa Syncline and there are no major faults and structures encountered within 2 km of the well. If the caprock was hydraulically compromised, there are more than five aquitards separating the Precipice Sandstone from the surface. Modelling shows that the GHG plume extent is approximately 500 m from West Moonie-1 Injection Well (Section 5.2) and impacted groundwater moves less than 100 m in 1,000 years (Section 5.1).

A failure of well integrity forms a higher risk than failure of the seal integrity of the caprock. West Moonie-1 Injection Well and the West Moonie-2 Monitoring Well are the only two bores penetrating the Precipice Sandstone reservoir within 1 km of the injection location. The risk of well failure (and control measures to mitigate this risk) are described in more detail in Section 6.1.3.2.

6.3.4 Aquatic Ecosystems and Groundwater Dependent Ecosystems

Figure 74 shows the GHG stream plume extent with respect to mapped GDEs and within the Precipice Sandstone. There are no mapped GDEs within or near the plume extents. In addition, modelling results indicated that fracturing will not be initiated in the upper Evergreen Formation as a result of the test injection. Therefore, none of the GHG stream is released to impact surface waters or GDEs during the post-injection period.

6.3.5 Groundwater water supply and users

Section 6.2.5 concludes that there are no forecasted impacts to regional groundwater bores due to injection testing. Pressures fall quickly at the end of the injection, and so, there are no predicted impacts to groundwater supply and users post-injection.

6.4 Cumulative impacts

6.4.1 Geology

Pressure changes caused by GHG stream injection are modelled to not cause any geological impacts and in fact (as discussed below), injection will offset pressure decreases caused by groundwater abstraction at the Moonie Oil Field.

In the southern Surat Basin, there are roughly 90 Precipice Sandstone bores. As illustrated in Figure 74, the nearest Precipice Sandstone groundwater extraction hole is 35 km east of the West Moonie-1 Injection Well. Natural springs are found at shallow depths at the outcrop edge, hence there are no Precipice Sandstone natural springs in the southern Surat Basin.

Some mineralogical changes will be caused by the injection of the GHG stream. However, as the injection plume is modelled to extend approximately 525 m from the West Moonie-1 Injection Well, there will be no cumulative impacts.

The Milgarra Bore is the closest groundwater abstraction bore to the Project area, located 17.3 km east-south-east of the West Moonie-1 Injection Well. As indicated in Figure 18, this bore draws water from the Gubberamunda Sandstone. The test injection into the lower Precipice Sandstone at West Moonie-1 Injection Well will have no effect on groundwater levels in the Gubberamunda Sandstone, and so the Project will have no cumulative effects.

6.4.2 Hydrogeology

OGIA (2021) created a regional groundwater model to predict the groundwater impact of existing extraction in the basin. Figure 76 shows the median, 95th, and 5th percentile modelling results of the predicted long-term impact on the Precipice Sandstone, which is associated with the past and ongoing extraction from the Moonie Oil Field (OGIA, 2021). West Moonie-1 Injection Well is located within the impacted area from the Moonie Oil Field. Due to the Moonie Oil Field extraction, there will likely be between 10 to 20 metres of predicted drawdown in the Precipice Sandstone aquifer based on 2021 OGIA’s regional groundwater model.

Hydrodynamic modelling (Section 5.1) shows the added pressure impact of GHG stream injection is negligible in contrast to the regional impacts from Moonie Oil Field extraction. Furthermore, the potential impact of the injection test is likely to slightly increase pressures, but is unlikely to be substantial enough to ameliorate the pressure declines caused by groundwater extraction at the Moonie Oil Field and elsewhere.

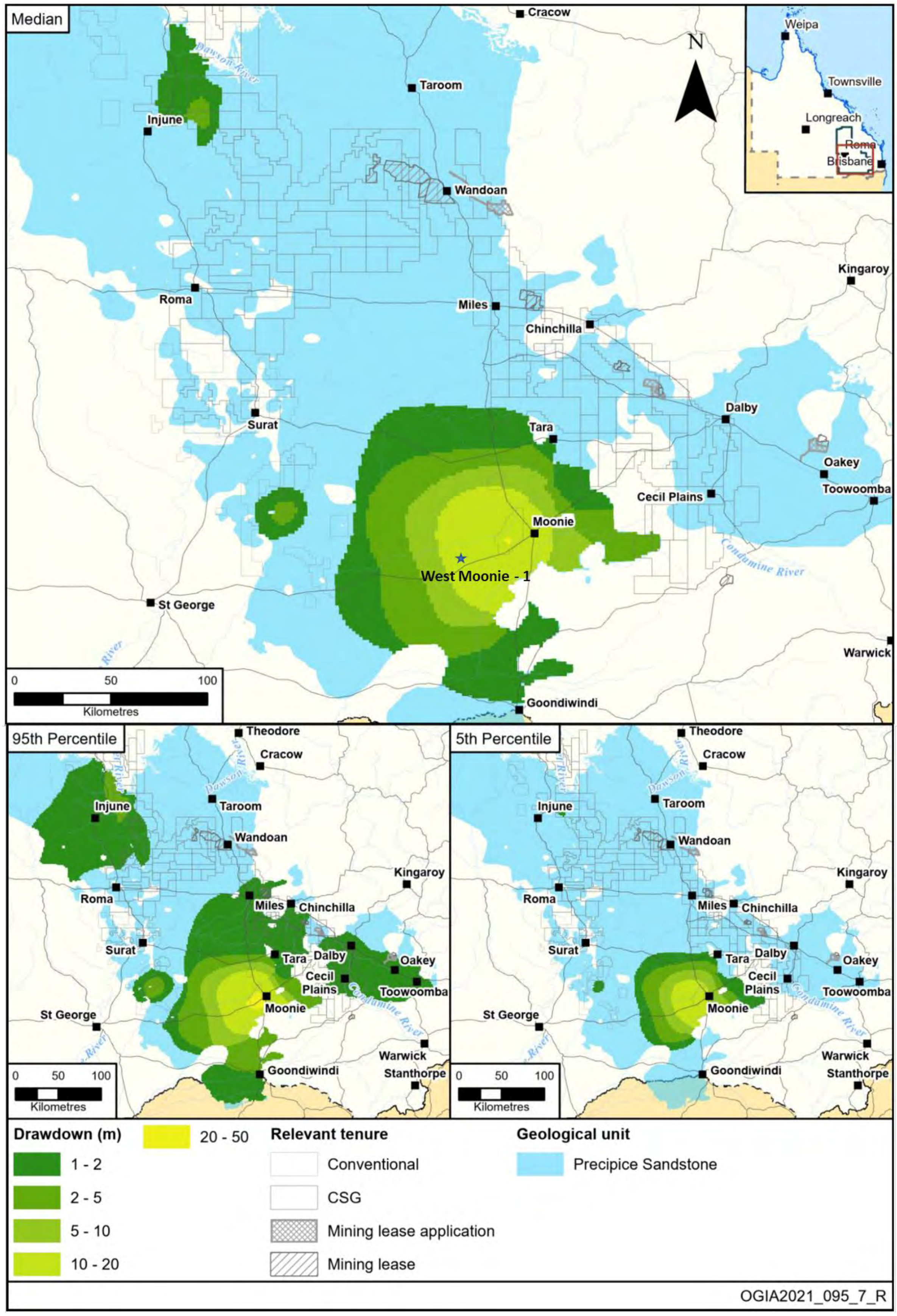

Figure 76: Extent of long-term affected areas from OGIA's model of existing groundwater extraction from the Precipice Sandstone aquifer (modified from OGIA, 2021)

6.4.3 Water quality

As discussed in Section 4.2, the Precipice Sandstone is a regional aquifer that is heavily used in the north of the basin, where its shallow depths and fresher water quality make it a viable regional aquifer. However, as discussed in Section 6.3.3.1, based on the (hydrodynamic, reservoir and geochemical) modelling and the poor existing water quality in the vicinity of the West Moonie-1 Injection Well which is unsuitable for the EVs which have been assigned to the Precipice Sandstone groundwater, it is concluded the test injection will have a highly localised (to within the GHG stream plume), negligible impact on the groundwater quality of the Precipice Sandstone regionally. Further, the test injection will not compromise the identified EVs in the shallow parts of the basin to the north.

The Precipice Sandstone is a regional aquifer that is heavily used in the north of the basin, where its shallow depths and fresher water quality make it a viable regional aquifer. Due to the high connectivity and hydraulic conductivity of the Precipice Sandstone, the aquifer reacts rapidly to pressure impacts and develops a new equilibrium, with inconsequential local impacts to water quality.

6.4.4 Aquatic Ecosystems and Groundwater Dependent Ecosystems

As discussed, GDEs and surface waters are not impacted by the GHG injection, either during or after. Therefore, there are no cumulative impacts to consider.

6.4.5 Groundwater water supply and users

As described in Section 6.2.5, groundwater supply and users are not affected as a result of the injection testing. The effect of the GHG stream pressurisation might minimally offset some of the groundwater pressure decrease caused by the Moonie Oil Field but this is unlikely to be meaningful.

6.5 Summary

The reservoir properties of the Precipice Sandstone are highly suited to GHG stream injection activities. Drilling and testing at West Moonie-1 Injection Well and West Moonie-2 Monitoring Well have demonstrated that the porosity and permeability of the reservoir allows for large volumes of GHG stream to be accommodated without compromising the integrity of the Precipice Sandstone aquifer or its sealing aquitards.

All of the evidence suggests that leaking from the Precipice Sandstone storage reservoir is very unlikely. The leakage risk assessment considered leakage paths via the top and/or bottom geological seals (Evergreen Formation and Moolayember Formation, respectively) and/or mechanical integrity issues in the West Moonie-1 Injection Well or West Moonie-2 Monitoring Well. This could include channels in the casing cement, or leaks in the production tubing, casing strings, and around production packers.

Modelling using regional data and specific data acquired from the West Moonie-1 Injection Well and the West Moonie-2 Monitoring Well demonstrates that the GHG stream can be safely contained within the Precipice Sandstone reservoir being:

- The Precipice Sandstone injection target is geologically isolated from other shallower aquifers by the Evergreen Formation which provides a regionally extensive caprock of at least 150 m thickness that regionally is a proven hydrocarbon seal over geological time, and during a period of extended production, at the nearby Moonie Oil Field.
- Comprehensive wireline pressure testing within the West Moonie-2 Monitoring Well has proven that the Precipice Sandstone and the Hutton Sandstone aquifer which overlies the Evergreen Formation are not in pressure communication at the proposed West Moonie-1 Injection Well site.
- Hydrogeological modelling indicates that all overlying aquifers are isolated from the Precipice Sandstone by many aquitards.

- No known faults have been identified within 2 km of the West Moonie site and no basin-scale faults exist within 20 km.
- Geomechanical modelling shows that natural fractures will not be initiated within the Evergreen Formation cap rock as a result of the proposed injection test, nor will any existing fractures (if present) be re-activated (opened) due to this activity.
- There are no legacy or abandoned wells within 15 km radius of the injection site that may pose a risk of providing a leakage pathway for injected GHG stream plume migration out of the Precipice Sandstone target aquifer.

Near-field dynamic reservoir modelling demonstrates that the GHG stream plume will be hydraulically contained within the Precipice Sandstone and will be laterally restricted to approximately 500 m from the West Moonie-1 Injection Well. The GHG stream will be injected into the well at a designed temperature and pressure. The GHG stream will take approximately 52 minutes to travel from the wellhead to the injection zone within the Precipice Sandstone. During this process the well is expected to act as an effective heat exchanger, warming the GHG stream as it travels between the surface and the injection depth. The relatively slow transport speed of the GHG stream within the well tubing results in the GHG stream being delivered to the injection zone at a temperature of about 80°C and a pressure of 3,270 psi.

As the GHG stream will enter the injection zone at the same temperature as the Precipice Sandstone there will be no thermally induced fracturing. Pressure tests conducted in the upper Evergreen at the West Moonie-2 Monitoring Well demonstrated that a pressure increase of 7,000 psi (equivalent to 4,920 m of head) did not result in fracturing. The calibrated geomechanical models using data acquired from the West Moonie-1 Injection Well and West Moonie-2 Monitoring Well show that the injection pressure of 3,270 psi would not cause any hydraulically induced fracturing within the Evergreen Formation caprock. The models also show that the injection pressure is insufficient to reactivate and open any pre-existing naturally occurring fractures or faults that could be present in the cap although none were identified from wellbore image logs that were acquired in the two West Moonie wells. Further, the maximum pressure change within the plume in the Precipice Sandstone is predicted to be 77 kPa (approximately 7.9 m), with that pressure dissipating rapidly away from the West Moonie-1 Injection Well and at the cessation of the test injection.

Reaction path geochemical modelling demonstrates that the injection of GHGs (with or without impurities) would result in a lowering of the pH of the Precipice Sandstone Formation water within the plume, from 8.35 to approximately 4.4. The lowering of the pH has the potential to mobilise trace elements (e.g., arsenic, cadmium, chromium, copper, nickel, lead and selenium) from the surrounding rock into the formation at concentrations which may initially exceed the Australian drinking water guidelines. However, subsequently it is expected that the trace element concentrations would reduce by several orders of magnitude within the plume due to adsorption and/or co-precipitation with secondary minerals such as iron oxides/hydroxides. No changes to water quality are predicted to occur beyond the boundary of the plume. Further, while the current Precipice Sandstone water quality at the injection location does not meet the WQOs for EVs, geochemical changes predict some localised deterioration to EVs within the plume. However, the effect of this on overall water quality in the Precipice Sandstone aquifer would be negligible.

Regional hydrodynamic modelling has shown that the GHG stream injection will result in a small increase in pressure head beyond the injection site. This pressure change is insufficient to influence any GDEs or springs, as the nearest springs that are sourced from the Precipice Sandstone are located approximately 235 km north in the Cockatoo Creek Complex which are separated from the Precipice Sandstone at the West Moonie-1 Injection Well by the groundwater divide that is situated to the south of the Great Dividing Range. The predicted pressure change would be expected to have a very minor positive impact on pressure within the Precipice Sandstone. Head changes of more than 0.2 m are predicted to be largely restricted to within the area of EPQ10 across all time periods. At the end of year 50 (after 47 years of shut-in) the models predict that the pressure change only exceeds 0.2 m in the southernmost section of the model, and after 100 years (97 years shut-in), the change in pressure is below 0.2 m in the entire model domain. No existing regional Precipice Sandstone bores will be impacted by the GHG stream injection.

7.0 AVOIDANCE AND MITIGATION MEASURES

Avoidance and mitigation measures to reduce the risk of unexpected plume containment breaches are discussed in the sections below. These measures have been selected based on efficiency and effectiveness and have been targeted to be proportional to the likelihood, magnitude and significance of the potential impact.

CTSCo will develop an Injection Test Plan (ITP) and a Monitoring and Verification Plan (MVP) as is required under the GHG Storage Act, and apply to amend the EA. Following provides a summary for consideration of monitoring data to be included in the plans and EA amendment application. Ongoing monitoring will allow for the effectiveness of measures to be identified and adapted in response to changes in circumstances and unexpected trends in collected data.

7.1 Implementation of lessons learned from global case studies

CTSCo has taken the learnings from the CCS global case studies and is applying them to the Project, including:

- Applying seismic processes to ensure the safe containment of GHGs and monitoring the plume location, but also identifying any induced seismic activity from the GHG injection process.
- Specific analyses such as for $\delta^{13}C$ of Dissolved inorganic carbon (DIC) and its stable isotope to allow different sources of CO_2 to be distinguishable and identifiable from groundwater sample analysis should leakage from the storage reservoir occur.
- The Fluid Recovery System to collect fluid from the storage reservoir and bring it to the surface under *in situ* conditions to provide useful monitoring information on CO_2-brine interactions.
- Communication strategy and proactive engagement with the local communities and decision makers to gain public acceptance.
- The Project data that can be useful to develop a reservoir scale model of long-term GHG containment in the Surat Basin.
- Community Advisory Panel of local leaders, regulatory agencies and members from the academic community as useful approach, particularly in terms of public acceptance.
- Comprehensive third-party expert audit of the Project storage development plan.

7.2 Avoidance and mitigation measures for the injection and post-injection phase

The assessment of the base case did not identify any significant potential groundwater impacts and hence there are no proposed avoidance and mitigation measures attached to the base case. It is noted that the potential for groundwater impacts is largely managed through the implementation of prevention, avoidance and mitigation measures brought forward into the Project design and construction as described in EIS. These measures are largely derived from regulatory requirements, guidance and standards and experience derived from other similar projects and case studies.

A suite of additional avoidance and mitigation measures have been proposed to manage risks arising from the alternative exposure pathway scenarios. These scenarios were assessed as being highly unlikely to occur provided that this suite of measures will be implemented. These measures have therefore been included for implementation as part of the Project to avoid, mitigate and detect the occurrence of these risks. These measures will be considered in the development and preparation of the water management plan to be prepared for the Project.

Caprock integrity

- Ongoing seismic surveys of 2D seismic lines that traverse the injection well and extend past the predicted boundary of the GHG plume
- Monitoring downhole pressure and temperature
- Defining maximum tolerable overpressure
- Water sampling for monitoring temporal changes in the reservoir water quality (CO_2 saturation, SOx, and NOx saturation, pH, tracers (inert and isotopic)
- Pulsed neutron and carbon/oxygen logging to measure changes and extent of the GHG stream plume within the reservoir.

Well integrity

- Annulus pressures and temperatures of Project wells to be measured and transmitted continuously
- Eddy current, magnetic and ultrasonic wireline logs used to determine the condition of casing and tubing and detect presence of corrosion or scale
- Use of corrosion resistant steel tubulars for the flow-wetted production casing and for any tubulars exposed to formation water combined with GHG stream
- Use of corrosion resistant cement
- Cement bond logs
- QA/QC and ongoing well maintenance of injection well and monitoring wells
- Appropriate decommissioning of wells to relevant GAB and Australian standards and guidelines (DNRME, 2019)
- Monitoring GHG stream plume movement
- Monitoring dedicated Gubberamunda Monitoring Well
- Atmospheric and soil gas monitoring.

Mining and other underground activities

- Monitoring downhole pressure and temperature
- Sharing knowledge with stakeholders
- Monitoring GHG stream plume movement.

Water management

- Monitoring downhole pressure and temperature
- Sharing knowledge with stakeholders
- Monitoring GHG stream plume movement.

A summary of the proposed monitoring activities during the injection phase is found in Table 56. The monitoring technologies are introduced in the following sub-sections. These measures will be considered in the development and preparation of the water management plan to be prepared for the Project.

Table 56: Summary of monitoring during injection phase

Monitoring Action	Frequency	Outcome
2D seismic monitoring from ground surface to Moolyamber Formation	6 monthly	Determine presence and extent of GHG plume, to compare to previous monitoring, across all formations
Pulsed neutron logging (or similar) down West Moonie-1 Injection Well and West Moonie-2 Monitoring Well	6 monthly	Determine presence of GHG plume across all formations immediately adjacent to well bore, to compare to previous monitoring
In situ pressure monitoring of Precipice Sandstone aquifer from West Moonie-2 Monitoring Well	continuous	Detect in situ changes in water pressure to compare to previous monitoring
Water quality monitoring of Precipice Sandstone aquifer from West Moonie-2 Monitoring Well	6 monthly	Obtain water samples for laboratory analysis by NATA certified lab to detect changes in water quality to compare to EA conditions and previous sampling results
In situ standing water level and water pressure of Gubbermunda aquifer from Gubberamunda Monitoring Bore	6 monthly	Detect in situ changes in standing water level and water pressure to compare to previous monitoring
Water quality monitoring of Gubbermunda aquifer from Gubberamunda Monitoring Bore	6 monthly	Obtain water samples for laboratory analysis by NATA certified lab to detect changes in water quality to compare to EA conditions and previous sampling results
In situ standing water level of Griman Creek Formation aquifer from the West Moonie Shallow Monitoring Bore	6 monthly	Detect in situ changes in standing water level to compare to previous monitoring
Water quality monitoring of Griman Creek Formation aquifer from the West Moonie Shallow Monitoring Bore	6 monthly	Obtain water samples for laboratory analysis by NATA-certified lab to detect changes in water quality to compare to EA conditions and previous sampling results
Atmospheric and soil CO_2 concentrations immediately adjacent to West Moonie-1 Injection Well	Continuous	Detect in situ changes in CO_2 to compare to EA conditions and previous monitoring

No registered groundwater user bores are predicted to be impacted by pressure changes as a result of the test injection. Additionally, the test injection will have a negligible impact on the regional groundwater quality of the Precipice Sandstone and will not compromise the realised EVs in the shallow parts of the basin to the north (Section 5). Therefore, no specific mitigation measures for potential impacts, or make good arrangements under the *Water Act 2000* are required. Risks of potential impacts and their assessment and control are discussed in Section 6.1.3.

7.2.1 Geological integrity management

The potential of gas releases through the injection or monitoring wells was mitigated by ensuring that well construction was undertaken in accordance with best practice well design standards including the *Code of Practice for the construction and abandonment of petroleum wells and associated bores in Queensland* (DNRME, 2019). The well design incorporated multiple barriers to isolate the wells and bores from the surrounding aquifers and prevent well corrosion or leakage, including:

- A solid steel surface casing – this is a large-diameter pipe with high structural strength. The surface casing is cemented into the shallow geology.
- A solid steel production casing – this is a medium-diameter pipe that is designed to withstand high pressure. The production casing is cemented into the aquifer seal to prevent any leakage from the aquifer to the overlying aquifers.
- A chrome steel production tubing – this is a smaller diameter tube within the production casing. The GHG stream will be delivered to the reservoir through the production tubing. The chrome steel construction will minimise the potential for well corrosion.
- Use of corrosion resistant cement across the Precipice Sandstone and Evergreen formations.

The construction of the West Moonie- and West Moonie-2 have met or exceeded the requirements of *Code of Practice for the construction and abandonment of petroleum wells and associated bores in Queensland* (DNRME, 2019), and the International Energy Agency *'Corrosion and Materials Selection in CCS Systems 2010'*, to ensure materials used to construct the wells were fit for purpose.

Monitoring of well condition during and following the test injection will further ensure the potential for GHG stream releases through the wells is adequately addressed including:

- Casing wall thickness loss
- Constant pressure and temperature monitoring at West Moonie-1 Injection Well and West Moonie-2 Monitoring Well
- Regular cement condition monitoring.

These measures will be included in the ITP and MVP to be approved under the GHG Act.

A 3D seismic survey will be carried out prior to the injection and the results will identify any potential leakage pathways such as geological seal faults.

A 2D seismic survey network will be installed. This involves the burial of fixed signal source units and array of geophones (also called seismic lines). The source units will emit ground penetrating low frequency waves generated by a vibrating pad. The seismic waves reflect off underlying geological rock layers and are detected at the surface by a grid of receivers, called geophones. Monitoring of the 2D seismic network will monitor the GHG plume movements. Baseline data will be acquired before injection begins.

7.2.2 Hydrogeological impact management

The hydrodynamic modelling should be updated on an annual basis to incorporate collected data and peer reviewed for accuracy. Multiple independent monitoring systems should be implemented on-site to validate the modelling predictions. For example, changes to and the extent of the plume will be determined utilising the following technologies:

- **Aquifer pressure monitoring**

  The movement of a plume of GHG stream will be accompanied by a propagating wave of pressure, the spatial footprint of which will far exceed the dimensions of the plume itself. Therefore, head pressure is a simple and effective monitoring parameter, and will be measured at West Moonie-2 Monitoring Well.

- **Wireline pulsed neutron and Carbon-Oxygen logging (C/O logging)**

  Pulsed neutron capture (PNC) logs measure changes in residual saturation (water saturation) as a consequence of the presence of CO_2. Data produced by PNC logging tools are used to establish quantitative interpretations for CO_2 gas saturation. This logging effort will include a comparison of baseline and repeat data to determine changes in gas and water saturations.

- **2D seismic monitoring network**

  The 2D seismic monitoring network will assess the GHG plume movement through the aquifer.

7.2.3 Management of water quality impacts

The predictive near-field chemical modelling indicates that the test injection will have a negligible impact on the regional groundwater quality of the Precipice Sandstone and will not compromise the realised EVs in the shallow parts of the Surat Basin to the north.

In order to demonstrate that regional groundwater quality within the target reservoir and overlying shallow aquifers has not been affected by the Project, there is a need to undertake groundwater quality monitoring every 6 months. Groundwater monitoring should be undertaken by suitably qualified persons in accordance with sampling procedures, which should be reviewed and updated as required, based on the following guidelines (or more recent where available):

- Queensland Government *Monitoring and Sampling Manual* (2018)
- AS/NZS 5667:11 1998 *Water Sampling Guidelines – Part 11 Guidance on groundwater*
- AS/NZS 5667:6 1998 *Water Quality Sampling – Guidance on sampling of rivers and streams*
- Australian Government *Groundwater Sampling and Analysis – A Field Guide* (2009:27).

The groundwater quality monitoring will be incorporated into the MVP.

Samples should be collected in accordance with the Queensland's *Monitoring and Sampling Manual* and stored in chilled eskies and transported to a NATA-accredited laboratory within the relevant holding times for all parameters. Other QA/QC measures should include the collection of field duplicates and the calculation of relative percentage differences between the primary and duplicate samples. Due to short holding times some parameters should be measured on-site using a calibrated water quality meter, as follows:

- Dissolved oxygen (DO)
- EC
- pH
- Temperature (°C)

- Redox Potential (ORP)
- Turbidity (NTU).

Groundwater samples will be analysed for the below list of parameters:

- Dissolved Metals: Al, As, B, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Li, Mn, Hg, Mo, Ni, Se, U, V, Zn
- Cations & Anions: Major (Ca, Mg, Na, K, Cl, SO_4, HCO_3, Alkalinity), Fluoride + Ionic Balance
- Physical parameters: TDS, hardness
- Silicon dioxide (SiO_2)
- TRH/TPH/BTEXN/PAH, including C1 to C4 fractions
- Nutrients: NO_3, NO_3-N, ammonia, phosphorous
- Total organic carbon (TOC)
- Dissolved Gases – Methane, Carbon Dioxide, Hydrogen Sulphide

Monitoring will also include the Gubberamunda Sandstone and the Griman Creek Formation as described in Table 56.

Following receipt of results for each sampling event, a report will be prepared to compare the monitoring results with the baseline water quality measurements and the Water Quality Objectives for the Precipice Sandstone Aquifer. Any exceedances will be identified and discussed in the report. The discussion may include identification of trends and comparison against model predictions.

All groundwater monitoring undertaken within the annual period should be included in an annual monitoring report and submitted to the relevant authority. This report should be prepared by a suitably qualified and experienced person. The report will identify:

- Sampling methodology, including any deviations of the method and any corrective actions required
- The date of sampling events
- The locations of all sampling points, and a rationale as to why a sampling location(s) were not included or sampled (dry, inaccessible due to weather, etc.)
- For monitoring wells – the standing water level
- Details of all exceedances of baseline values and relevant WQOs for the Precipice Sandstone aquifer.
- A discussion on the exceedances and potential influence from site activities and climate influences
- Comparison to previous monitoring data for the site
- The QA/QC of the sampling program, including:
    - Chain of Custody documentation
    - Calibration records for sampling and monitoring equipment
    - Field equipment inspections/ calibration/ testing logs (as required)
    - Field QA/QC – Blanks, Rinsate, Duplicate and Triplicate RPDs
    - Laboratory QA/QC.

The report will support the test injection completion assessment report and will be key to determining the success or otherwise of the test injection.

7.2.4 Aquatic Ecosystems and Groundwater Dependent Ecosystems

Modelling predictions indicate that no Aquatic Ecosystems or GDEs are predicted to be impacted during or after the Project.

An annual review of the GDE database should be undertaken. Should any be discovered within the zone of modelled impact, then a monitoring plan will be required.

7.2.5 Groundwater water supply and users

Modelling predictions indicate that no current groundwater user wells are predicted to be impacted by pressure changes as a result of the injection test. However, the registered bore database should be checked at least yearly to evaluate whether any new groundwater users are established in the area.

Future users should not be allowed to take groundwater supply from the zone impacted by the plume (Precipice Sandstone aquifer). This should include a zone around the impacted area from which water might be extracted by a well installed outside of the immediate residual impact zone. Although it is noted that the Precipice Sandstone is deep at this location and not likely to be used for water supply by regular users.

7.3 Avoidance and mitigation measures in the rehabilitation phase

The findings of the Project will determine whether or not the Project:

- is plugged and rehabilitated following completion of the 5-year period injection and monitoring period; or
- wells are suspended and shut-in for future development, subject to further approvals.

Final rehabilitation will be in accordance with EPQ10 conditions, EA conditions and legislative requirements, including the “*Code of Practice for the construction and abandonment of petroleum wells and associated bores in Queensland*” (DNRME, 2019) or later version thereof.

Pursuant to the GHG Act, s.31, given the temporary nature of all structures in the Transportation Facility, all structures will be removed from the area, with the operational lands rehabilitated to pasture consistent with the surrounding paddock.

Further details of the rehabilitation measures to be undertaken are provided in the EIS.

7.3.1 Geological and hydrogeological impact management

The two deep bores, West Moonie-1 Injection Well and West Moonie-2 Monitoring Well, should be plugged and decommissioned according to the *Code of Practice for the construction and abandonment of petroleum wells and associated bores in Queensland* (DNRME, 2019). However, the West Moonie Shallow Monitoring Bore can be decommissioned in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (NUDLC, 2020). Subject to agreement with the landowner, the Gubberamunda Monitoring Bore will be converted to a water supply bore and given to the landowner. Otherwise, the Gubberamunda Monitoring Bore will be plugged and decommissioned accordingly.

The hydrodynamic modelling and water quality monitoring program of the Precipice Sandstone should be updated at the closure of the Project using the most recent datasets.

7.3.2 Groundwater water supply and users

No current groundwater bores are predicted to be impacted by pressure changes as a result of the injection test. As discussed in Section 7.2.5, future users should not be allowed to take groundwater supply from the zone impacted by the plume. However, the registered bore database should be checked at least yearly to evaluate whether any new groundwater users are established in the area.

8.0 RESIDUAL IMPACTS

8.1 Geology

As mentioned in the impacts and avoidance sections, the induced pressures are not predicted to cause changes either in the Precipice Sandstone or overlying formations. Further, no residual geological disturbance or effect on the surface is anticipated.

Geochemical modelling indicates that whilst some minerals dissolve and others precipitate out, there is no overall change to the porosity. However, the permeability is modelled to be reduced due to the precipitation in the rock influenced by the GHG injection i.e., 525 m laterally from the injection well.

8.2 Hydrogeological impact management

The modelling indicates that the GHG injection increases pressures within the aquifer in the short-term and somewhat offsets the pressure decreases caused by groundwater abstraction at the Moonie Oil Field site. However, these pressures fall quickly post-injection and are not expected to cause residual impacts.

As discussed in Section 8.1 above, geochemical changes are expected not to cause changes to porosity, but it is thought that permeability will be reduced in the zone immediately affected by the injection.

8.3 Water quality

Water quality change is expected to be within approximately 500 m of West Moonie-1 Injection Well. Whilst this residual impact is expected to remain in the long-term, it is highly localised.

8.4 Aquatic ecosystems and Groundwater Dependent Ecosystems

Modelling indicates that there are no aquatic ecosystems or GDEs that will be impacted by the GHG injection, and so, no residual impacts are expected.

8.5 Groundwater water supply and users

There are no current groundwater users that are predicted to be impacted by the Project. Future users should not be allowed to take groundwater supply from the zone impacted by the plume.

8.6 Summary of Residual Impacts with reference to the *Environmental Protection Regulations 2019*

Under Section 35 (1) (a) of the EP Reg, the administering authority must, for making an environmental management decision relating to an ERA, (other than a prescribed ERA) carry out an environmental objective assessment against the environmental objective and performance outcomes mentioned in Schedule 8, Part 3, Divisions 1 and 2.

Under Schedule 8, the Project should achieve item 1 or item of the relevant environmental objective to meet the requirements of Schedule 8.

Table 57 and Table 58 presents a summary of the residual impacts of relevance to the requirements of Schedule 8 and section 41 of the EP Reg.

Table 57: *Environmental Protection Regulation 2019*, Schedule 8, groundwater environmental objectives and performance outcomes summary

ID	Objectives and performance outcomes	Project detail
Groundwater		
Objective	The activity will be operated in a way that protects the EVs of groundwater and any associated surface ecological systems.	The Project has been designed, constructed and operated in a way that protects the EVs of aquifers, outside of the target aquifer and outside of the GHG stream plume. The design of the Project seeks to target a deep, low quality, and confined aquifer to avoid and minimise impacts to higher value and more frequently used aquifers in the area. An assessment of the residual impacts of the Project on EVs and WQOs within the plume within the targeted area of the target Precipice Sandstone aquifer, is presented in Section 8.7.
Performance outcomes		
1	Each of the following apply —	
(a)	There will be no direct or indirect release of contaminants to groundwater from the operation of the activity.	The Project is to directly inject the GHG stream to the Precipice Sandstone aquifer. The purpose of the Project is to intentionally target a confined, low quality and deep aquifer for the purpose of testing the injection and storage of a GHG stream. Hence, the Project will not meet this performance outcome.
(b)	There will be no actual or potential adverse effect on groundwater from the operation of the activity.	The groundwater is not predicted to have a significant change in pressure. The test injection of the GHG stream will have a negligible impact on the regional groundwater quality of the Precipice Sandstone and will not compromise the fresher water quality groundwater. The groundwater EVs and WQOs of the vast majority of the Precipice Sandstone aquifer will remain unaffected by the Project, with the exception of changes to pressure and water quality within the plume from the injection of the GHG stream. The modelled projected changes to the EVs and WQOs from the Project, within the GHG stream injection plume, are presented in Table 59,Table 60, Table 61 and Table 62.
2	The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.	The Project will be designed, constructed and operated in a way that will prevent the potential for adverse effects to higher value aquifers, and minimise the extent of adverse impacts to a GHG stream plume that will affect the EVs and WQOs of a negligible proportion of the Precipice Sandstone aquifer. Multiple independent monitoring systems will be implemented on-site to measure actual changes to allow comparison with the projected modelling outcomes.

ID	Objectives and performance outcomes	Project detail
		Ongoing monitoring of groundwater quality and a seismic survey network will also be used to detect any unexpected adverse impacts. Corrective actions, such as cessation of the injection of the GHG stream, will be implemented to precent or minimise the occurrence of unexpected adverse effects on groundwater or any associated surface ecological systems. In summary, the Project will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.
	Note — Some activities involving direct releases to groundwater are prohibited under section 41 of this regulation.	

Table 58: *Environmental Protection Regulation 2019*, section 41

ID	Activity involving direct release of waste to groundwater	Project detail
1	This section applies to the administering authority for making an environmental management decision relating to an activity that involves, or may involve, the release of waste directly to groundwater (the ***receiving groundwater***). *Example of direct release of waste to groundwater –* *an activity involving the release of contaminated water to groundwater through a well, deep-well injection or a bore*	The Project involves the injection of a GHG stream into the Precipice Sandstone aquifer. Hence s41 of the EP Reg applies.
2	The administering authority must refuse to grant the application if the authority considers:	
a	for an application other than one relating to an EA for a petroleum activity – the waste is not being, or may not be, released entirely within a confined aquifer; or	The characteristics of the target aquifer are described in Section 4, and specifically with regard to whether it is confined or not, in Section 4.3.1 of this report. In summary, the Precipice Sandstone injection target is geologically isolated from other shallower aquifers by the lower Evergreen Formation, which provides a regionally extensive caprock at least 150 m thick. The Precipice Sandstone and lower Evergreen Formation onlap the underlying basement along the western and eastern margins of the Surat Basin. This means the Precipice Sandstone is confined to the central part of the Surat Basin. The closest mapped contiguous outcrop of the Precipice Sandstone is approximately 235 km north of the proposed injection location. Hence, the targeted area of the Precipice Sandstone aquifer meets the definition of a confined aquifer – as defined in Section 41(3). The design, construction, operation and closure of the injection well will be to ensure that the GHG stream is

ID	Activity involving direct release of waste to groundwater	Project detail
		injected into the confined Precipice Sandstone aquifer.
b	the release of the waste is affecting adversely, or may affect adversely, a surface ecological system; or	The potential for the release of waste to adversely affect a surface ecological system is discussed in Section 6.1 of this report. In summary, the exposure pathway assessment shows that no complete pathways have been identified between the surface ecological systems and the target formation. In addition, the surface ecological systems are separated physically by at least four additional aquitards from the storage formation. These additional aquitards act as extra hydraulic barriers to prevent vertical upward migration of a GHG stream plume. Thus, the test injection of the GHG stream is extremely unlikely to impact on the surface ecological system.
c	the waste is likely to result in a deterioration in the EVs of the receiving groundwater.	The EVs and WQOs of the target aquifer are defined in Section 4.5 of this report. The existing groundwater is not consistent with the WQOs for the identified EVs. An assessment of the potential impacts of the Project on EVs are set out in Section 6 of this report. A summary of the anticipated residual impacts of the Project on the groundwater EVs are set out in Section 8.1.7 of this report. In summary, the GHG stream test injection will be hydraulically contained within the Precipice Sandstone and has modelled as likely to extend a distance of approximately 500 m from the West Moonie-1 Injection Well. No changes to water quality are predicted to occur beyond the boundary of the plume. The modelled projected changes to water quality within the plume are set out in Section 8.1.7 of this report. The GHG stream injection will result in a small increase in head beyond the injection site. This pressure change is insufficient to influence any EVs including GDEs or springs. The GHG stream has been modelled to result in a change in water quality within the plume around the injection well, including altering some water quality parameters from within to outside of the 20th and 80th percentile WQOs (see Table 59). These changes to water quality within the plume could be interpreted as a highly localised deterioration of the WQOs and EVs. However, the changes to the overall water quality in the entirety of the Precipice Sandstone aquifer would

ID	Activity involving direct release of waste to groundwater	Project detail
		be negligible, and immeasurable outside of the plume. Strictly speaking, some of the WQOs and EVs within the plume do not strictly comply with s.41(c) of the Environmental Protection Regulation 2019 (as shown in Tables 59, 60, 61, 62). However, this is a localised measurement only. To put this in context, the approximate extent of the plume from the West Moonie-1 Injection Well is 525 m. For comparison, the approximate extent of the Precipice Sandstone aquifer is 450 km in the east–west direction
3	In this section – ***confined aquifer*** means an aquifer is contained entirely within impermeable strata.	

8.7 Summary of residual impacts with reference to Environmental Values and Water Quality Objectives

This section presents a summary of the modelled projected changes across a suite of water quality parameters at the West Moonie-1 Injection Well. The changes in water quality are within the plume only.

The changes are presented at three points in time, to show short-term and long-term concentrations:

- Year 3 – at the end of the GHG stream injection test.
- Year 5 – two years after the end of the GHG stream injection test.
- Year 100 – 97 years after the end of the GHG stream injection test.

The modelled projected water quality concentrations are shown in comparison with the WQOs of the EVs that have been attributed to the Precipice Sandstone aquifer.

There are no numerical WQO values for the industrial and cultural and spiritual EVs.

8.7.1 Water Quality Objectives for Aquatic Ecosystems

The modelled projected water quality parameters for years 3, 5 and 100, are presented with comparison to the WQOs for Aquatic Ecosystems, in Table 59. Exceedances are highlighted in orange.

Table 59: Comparison of Aquatic Ecosystem WQOs and groundwater quality within Precipice Sandstone Aquifer at West Moonie-1

Parameter	Units	WQO – (80th percentile, except where indicated)	Existing water quality of the Precipice Sandstone aquifer	Projected Water Quality of the Precipice Sandstone aquifer within the GHG stream plume		
			West Moonie 1 Injection Well - Sample 3 value	Year 3	Year 5	Year 100
Sodium (Na)	mg/L	342	611	611.01	610.99	611.00
Calcium (Ca)	mg/L	8.0	6	3.20	0.97	2.64
Magnesium (Mg)	mg/L	1.0 – 50th %ile 5.0 – 80th %ile	1	0.32	0.10	0.26
Bicarbonate Alkalinity (HCO_3)	mg/L	673	1,060	875.50	869.99	880.32
Chloride (Cl)	mg/L	163	318	459.52	459.51	459.51
Sulphate (SO_4)	mg/L	28	8	10.34	10.34	10.34
Nitrate (NO_3)	mg/L	1	<0.01	<0.001	<0.001	<0.001
EC	µS/cm	1,484	2,920	2,966.33	2,958.50	2,975.99
pH	pH units	7.5: 20th %ile 8.2: 50th %ile 8.6: 80th %ile	8.35	4.41	4.41	4.41
Total Alkalinity	mg/L	568	1,080	876.56	871.04	881.39

Orange shading indicates exceedance for the 80th Percentile.

8.7.2 Water Quality Objectives for Irrigation

The modelled projected water quality parameters for years 3, 5 and 100, are presented with comparison to the WQOs for Irrigation, in Table 60. Exceedances of long-term triggers are highlighted in lighter orange, AND exceedances of short-term triggers are highlighted in darker orange.

Table 60: Comparison of irrigation WQOs and groundwater quality from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	Units	WQO long-term trigger value	WQO short-term trigger value	Existing water quality of the Precipice Sandstone aquifer	Projected Water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
				West Moonie 1 Injection Well - Sample 3 value	Year 3	Year 5	Year 100
pH	pH units	6 to 8.5	6 to 8.5	8.35	4.41	4.41	4.41
Sodium	mg/L	115		611	611.01	610.99	611.00
Chloride	mg/L	40		318	459.52	459.51	459.51
Fluoride	mg/L	1	2	6.3	6.30	6.30	6.30
Aluminium	mg/L	5	20	0.05	0.00	0.00	0.00
Arsenic	mg/L	0.1	2	<0.001	NA	NA	NA
Beryllium	mg/L	0.1	0.5	<0.001	NA	NA	NA
Boron	mg/L	0.5		0.73	0.73	0.73	0.73
Cadmium	mg/L	0.01	0.05	<0.0001	NA	NA	NA
Chromium	mg/L	0.1	1	<0.001	NA	NA	NA
Cobalt	mg/L	0.05	0.1	<0.016	NA	NA	NA
Copper	mg/L	0.2	5	<0.001	0.0005	0.0005	0.0005
Iron	mg/L	0.2	10	2.78	12.90[14]	13.03[15]	12.77[16]
Lead	mg/L	2	5	<0.001	0.0005[17]	0.0005[18]	0.0005[19]
Manganese	mg/L	0.2	10	0.049	0.05	0.05	0.05
Mercury	mg/L	0.002	0.002	<0.0001	<0.0001[20]	<0.0001	<0.0001
Nickel	mg/L	0.2	2	0.001	0.001	0.001	0.001
Selenium	mg/L	0.02	0.05	<0.01	NA	NA	NA
Uranium	mg/L	0.01	0.1	<0.001	NA	NA	NA
Vanadium	mg/L	0.1	0.5	<0.01	NA	NA	NA
Zinc	mg/L	2	5	<0.005	0.0025	0.0025	0.0025

Note: Orange shading indicates exceedance of the short-term trigger value, while yellow shading indicates exceedance of the long-term trigger value.

Release of trace elements from minerals not predicted by the geochemical model (for example Pb, Hg, As and Ni).

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[14] Reported as Fe (2+)

[15] Reported as Fe (2+)

[16] Reported as Fe (2+)

[17] The model did not predict the release of Pb from minerals such as sulfides.

[18] The model did not predict the release of Pb from minerals such as sulfides.

[19] The model did not predict the release of Pb from minerals such as sulfides.

[20] The model did not predict the release of Hg from minerals.

8.7.3 Water Quality Objectives for Stock Water

The modelled projected water quality parameters for years 3, 5 and 100, are presented with comparison to the WQOs for Stock Water, in Table 61. Exceedances are highlighted in orange.

Table 61: Exceedances of stock water WQOs from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	WQO	Existing water quality of the Precipice Sandstone aquifer	Projected water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
		West Moonie 1 Injection Well - Sample 3 value	Year 3	Year 5	Year 100
TDS (No adverse effects threshold)	5,000 mg/L for sheep 4,000 for beef cattle, horses and pigs 2,500 mg/L for dairy cattle 2,000 mg/L for poultry	1,850	1987.44[21]	1982.19	1993.91
Fluoride	2 mg/L	6.30	6.30	6.30	6.30

Orange shading indicates exceedance.

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[21] Converted from EC using a factor of 0.67.

8.7.4 Water Quality Objectives for Drinking Water

The modelled projected water quality parameters for years 3, 5 and 100, are presented with comparison to the WQOs for Drinking Water, in Table 62. Exceedances are highlighted in orange.

Table 62: Comparison of drinking water WQOs and groundwater quality from the Precipice Sandstone aquifer at West Moonie-1 Injection Well

Parameter	WQO	Existing water quality of the Precipice Sandstone aquifer	Projected Water quality of the Precipice Sandstone aquifer at West Moonie-1 Injection Well		
		West Moonie 1 Injection Well - Sample 3 value	Year 3	Year 5	Year 100
pH	6.5-8.5	8.35	4.41	4.41	4.41
TDS	600 mg/L (post treatment)	1850	1987.44[22]	1982.19	1993.91
Sodium	180 mg/L (and 20 mg/L for at risk groups)	611	611.01	610.99	611.00
Sulphate	250 mg/L	8	10.34	10.34	10.34

Orange shading indicates exceedance.

8.8 Cumulative impacts

The operation of the Moonie Oil Field and its impacts on the Precipice Sandstone aquifer have been considered as part of the definition of baseline conditions and as part of the impact assessment. Therefore, the cumulative impacts of the operation of the Moonie Oil Fields and the Project are considered in the results of this assessment.

The Project has specifically targeted an aquifer and an injection location that is isolated and remote from existing uses and users, and is highly unlikely to be used by others in the foreseeable future. The potential for other projects to use this aquifer is very limited, and accordingly, the potential for cumulative residual impacts is very limited.

9.0 SUMMARY OF COMMITMENTS

Commitments related to impact mitigation are identified as part of the GIA and are summarised below. The majority of these commitments will be included in either CTSCo's ITP or MVP.

- Maintain the quality control program that was implemented for the design and construction of well infrastructure including corrosion studies.
- Undertake well condition monitoring (as discussed in Section 4.4.1).
- Undertake peer reviewed annual modelling update.
- Install and operate the Seismic Survey Network.

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[22] Converted from EC using a factor of 0.67.

- 2024: drill and complete a Gubberamunda Sandstone aquifer monitoring bore within the operational lands, and analyse water quality samples taken from this bore at 6-month intervals; and
- Undertake ongoing aquifer pressure monitoring.
- Conduct routine groundwater quality sampling during and post test injection to monitor potential impacts, including reporting.
- Check the registered bore database at least yearly to evaluate whether any new groundwater users are established in the area.
- Undertake an annual monitoring review.

10.0 CONCLUSIONS

The top of the lower Precipice Sandstone reservoir is at a depth of 2,258 m bgl at the West Moonie-1 Injection Well in EPQ10. At these significant depths, the reservoir temperature is in excess of 75°C and has a brackish water quality with high concentrations of fluoride and other analytes that render the groundwater unsuitable for a range of groundwater uses and EVs (Section 4.0). Despite not being suitable to support EVs, the reservoir properties are highly suited to injection activities (Section 4.4.2). Drilling and testing at West Moonie-1 Injection Well and West Moonie-2 Monitoring Well have demonstrated that the porosity and permeability of the reservoir will allow for large volumes of GHG stream to be accommodated without compromising the integrity of the reservoir to contain that GHG stream at depth (Section 4.4.2).

There are no springs or GDEs associated with the Precipice Sandstone in the vicinity of West Moonie-1 Injection Well. The springs that are sourced by the Precipice Sandstone are significantly removed (235 km) in the northern part of the Surat Basin, as shown in Figure 3.

Hydrogeological conceptual modelling (Section 4.4.2) has demonstrated that the GHG stream can be safely contained within the Precipice Sandstone reservoir at the West Moonie-1 Injection Well site. There are several key reasons for this conclusion:

- The Evergreen Formation provides a regionally extensive caprock.
- There is little in the way of faulting in the nearby area (no known faults within 2 km and no basin-scale faults within 20 km).
- Current hydrogeological interpretation indicates that overlying aquifers are isolated from the Precipice Sandstone by many tight aquitards (see Figure 13).
- Regional pressure data confirm that there is a lack of hydraulic connection between the reservoir and the overlying aquifer, i.e., the Hutton Sandstone (Section 4.4.2).
- There are no legacy or abandoned wells within 15 km of West Moonie-1 Injection Well that may pose a risk of providing a pathway for plume migration out of the target aquifer.
- The geology, pressures and temperatures are well understood, and can be used to ensure injection pressures are maintained below fracture pressure.
- No issues were identified when considering the geochemical interactions of the GHG stream-Precipice Sandstone-groundwater.

Near-field dynamic reservoir modelling (Section 5.2) has demonstrated that the GHG stream plume will be hydraulically contained within the Precipice Sandstone and will be laterally restricted to approximately 500 m of West Moonie-1 Injection Well. Further, the maximum pressure change within the plume is predicted to be

77 kPa (approximately 7.9 m), with that pressure dissipating rapidly away from the West Moonie-1 Injection Well and at the cessation of the Project.

Geochemical modelling (RP, Section 5.3) has demonstrated that the injection of GHGs (with or without impurities) would result in a lowering of the pH of the Precipice Sandstone Formation water within the plume, from 8.35 to approximately 4.4. The impact of the impurities SO_2 and NO_2 would be negligible as their concentrations are negligible.

Trace elements (such as arsenic, antimony, selenium and lead) will be mobilised in response to acidification caused by the injection of the GHG stream, but their concentrations (e.g., Pb, Mo, Cd) will be lower or comparable with EPQ7, and controlled (i.e., lowered by orders of magnitude due to adsorption onto and or co-precipitation with secondary minerals such as iron (hydr)oxides). Elevated concentrations of trace metals will be restricted to within the GHG stream plume. It is also expected that trace element concentrations will decrease as time progresses and the sources become depleted.

Regional dynamic modelling (Section 5.1) has shown that head changes of more than 0.2 m are largely restricted to within the EPQ10 boundary across all time periods. Long-term (after 97 years shut-in), the change in pressure is below 0.2 m in the entire model domain. No regional Precipice Sandstone water bores will be impacted at any point in the life cycle of the Project.

In terms of near-field impacts:

- There is no potential for local-scale pressure impacts to GDEs or groundwater users under the base case scenario.
- Trace metal mobilisation will likely occur as a result of the low pH conditions. However, these trace metals will be contained within the plume, i.e., within approximately 500 m of the West Moonie-1 Injection Well.
- Under the base case scenario, there will be no contamination of overlying aquifers as the GHG stream plume will be contained within the Precipice Sandstone reservoir.

In terms of far-field impacts:

- No regional groundwater bores are predicted to be impacted by pressure change as a result of the test injection.
- There will be no impact on the groundwater quality of the Precipice Sandstone regionally. Further, under the base case scenario the test injection will not compromise the fresher water quality and associated identified EVs in the shallow parts of the basin to the north.
- The added pressure impact of the test GHG stream injection is negligible in contrast to the regional impacts from Moonie Oil Field extraction, and as such there is no potential for cumulative impacts.

11.0 PROPOSED AMENDMENTS TO ENVIRONMENTAL AUTHORITY CONDITIONS

This section sets out the existing EA conditions relevant to groundwater, with proposed amendments shown in ***Bold, Italics***. Deletions are shown as ~~***Strikethrough, Bold, and Italics***~~.

Condition 41 Groundwater

If the holder of this EA becomes aware that environmental harm is caused or threatened to be caused, as a result of injection activities, injection must cease immediately.

Condition 42

A ***GHG stream*** ~~***Water***~~ Management Plan addressing the following matters must be developed and submitted to DES prior to commencement of any GHG storage exploration activities involving ~~***water***~~ ***GHG stream*** injection ***testing***:

- Estimated volumes and rates of ~~***water***~~ ***the GHG stream*** to be produced and injected;
- A description of the physical, chemical and biological components and their concentrations of the ~~***water***~~ ***GHG stream*** to be ***injected***;
- How and where the ~~***water***~~ ***GHG stream*** will be produced, aggregated, stored and ~~***kept separate from other waters until it Is, treated***~~ ~~***to the quality of the receiving aquifer and re***~~ injected into the ~~***source***~~ aquifer;
- ~~***Where water is proposed to be treated, describe the treatment process and demonstrate that the injection fluid has inconsequential reactivity with the target formation and native groundwater it will come into contact with;***~~
- The characteristics of the receiving environment;
- Identify the ***impacts to water quality and pressure due to GHG stream injection testing***; ~~***water quality impact zone and the hydraulic impact zone[1];***~~
- Identify any injection wells, all existing bores, springs, environmental assets and watercourses connected to groundwater, faults and other geologic features that ***may incur impacts to water quality and pressure due to GHG stream injection testing*** ~~***occur within the water quality impact zone and the hydraulic impact zone;***~~
- Identify the EVs and WQOs of the potential water quality impact~~***s zone***~~ of the target formation in accordance with the ~~***Environmental Protection (Water) Policy 1997***~~ ***Environmental Protection (Water and Wetland Biodiversity) Policy 2019*** ~~***and the Queensland Water Quality Guidelines 2006***~~;
- Assess the potential for migration of ***the GHG stream*** ~~***injection fluid***~~ or native groundwater out of the target formation through wells, bores, springs, connected watercourses, faults or other geologic features likely to impact on other aquifers;
- A risk assessment identifying potential hazards, their inherent risk, preventative measures for the management of potential hazards and after consideration of the preventative measures, the residual risk of the potential hazards. Potential hazards include but are not limited to:
  a) Impacts on water quality within the ~~***water quality impact zone***~~ ***GHG plume*** within the target formation and surrounding aquifers;
  b) impact on physical integrity of the aquifer or geological formation due to reactions between ***GHG stream,*** ~~***injection fluid***~~, aquifer material and native groundwater;
  c) the potential for migration of ***the injected GHG stream*** ~~***injected fluid***~~ or native groundwater out of the target formation during the injection operations;
  d) over-pressurisation of target formation and its impact on surrounding aquifers;
  e) impacts on users or resources;

f) impacts on other aquifers of environmental, economic or social importance; and

g) impacts on groundwater-dependent ecosystems.

- A groundwater monitoring program that is sufficient for the prediction and early detection of any detrimental impacts on the receiving environment from the injection activity. The program must include but not be limited to:

  a) Operational monitoring to manage potential hazards identified in the risk assessment (including details on sampling and analysis methods (including frequency and locations) and quality assurance and control).

  b) Verification to assess performance of the injection activities, preventative measures and compliance.

- Control measures that will be implemented for each ~~**water**~~ ***GHG stream*** management option (storage, treatment and reinjection) to prevent or control the release of a contaminant or waste to the environment;
- The indicators or other criteria against which the performance of the ***GHG stream*** ~~**water**~~ management practices will be assessed;
- Procedures that will be adopted to regularly review the monitoring program and to report to management and the administering authority should unforeseen or non-compliant monitoring results be recorded;
- Procedures that will be implemented to prevent unauthorised environmental harm from unforeseen or non-compliant monitoring results; and
- Procedures for dealing with accidents, spills, failure of containment structures, and other incidents that may arise in the course of the ~~***produced water***~~ ***GHG stream*** management practices and result in the unexpected release of contaminants or waste to the environment.

Condition 43 ~~*Water*~~ *GHG Stream Year 3* Injection Cessation Report *and Year 5 Monitoring Report*

The holder of this environmental authority must, within 60 business days of the completion of injection activities, submit an injection cessation report to the administering authority that includes but is not limited to:

a) volumes of fluid injected at each well;

b) a risk assessment statement providing details on identified hazards including their inherent risk, summary of the results from the verification monitoring, preventative measures and the residual risk; and

c) a monitoring report outlining the methods and results of verification monitoring undertaken to assess the performance of the injection activities and preventative measures for identified hazards.

The holder of this environmental authority must, within 60 business days of the two-year anniversary of the cessation of GHG stream injection activities, submit a monitoring report to the administering authority that sets out the results of groundwater monitoring program under Condition 42.

Condition 56— Monitoring

The holder of this environmental authority must:

a) develop a monitoring program that will demonstrate compliance with the conditions of the environmental authority;

b) document monitoring and inspections carried out under the monitoring program and any actions taken; and

c) record, compile and keep for a minimum of seven (7) years all monitoring results and data.

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13.0 GLOSSARY

ACROSS	accurately controlled routinely operated signal system
ANLEC R&D	Australia National Low Emissions Coal Research and Development
APLNG	Australia Pacific Liquified Natural Gas
Bbls	barrels
BHCM	baseline hydrogeological conceptual model
BHP	bottomhole pressure
BSR	Blocky Sandstone Reservoir
CAS	Chemically Abstract Services
CCS	Carbon Capture and Storage
CESM	Controlled Source Electromagnetic
CMA	Cumulative Management Area
CO_2	carbon dioxide
CSG	coal seam gas
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CTSCo	Carbon Transport and Storage Corporation (CTSCo) Pty Limited
DAS	distributed acoustic system
DAFF	Department of Agriculture, Fisheries and Forestry
DAWE	Department of Agriculture, Water and the Environment
DCA	digital core analysis
DES	Department of Environment and Science
DHPT	Downhole Pressure & Temperature
DO	dissolved oxygen
DST	Drill Stem Test
DTS	distributed temperature system
EA	Environmental Authority
EC	electrical conductivity
EIS	Environmental Impact Statement
EOR	Engineered Oil Recovery
EPM	Equivalent Porous Media
ERA	Environmentally Relevant Activity
EV	Environmental Value
FEP	Feature Event Process
FRS	Fluid Recovery System
FTE	full-time equivalent

GAB	Great Artesian Basin
GABORA	Great Artesian Basin and Other Regional Aquifers
GABWRA	Great Artesian Basin Water Resource Assessment
GIA	Groundwater Impact Assessment
GDE	Groundwater Dependent Ecosystem
GHG	greenhouse gas
GMWL	global meteoritic water line
GWDB	Groundwater Database
HCM	hydrogeological conceptual model
HFU	hydraulic flow unit
HSA	hydrogeology study area
HST	High Stand Systems Tract
HSU	hydrostratigraphic unit
IAS	Initial Advice Statement
ITP	Injection Test Plan
K	hydraulic conductivity
kh	horizontal permeability
kv	vertical permeability
kv/kh	vertical to horizontal permeability ratio
L	litre
LST	Low Stand Systems Tract
LMWL	local meteoritic water line
m bgl	metres below ground level
MAR	Managed Aquifer Recharge
mD	millidarcys (unit of measurement of intrinsic permeability)
m/d	metres per day (unit of measurement of hydraulic conductivity)
MDT	Modular Formation Dynamic Tester
MMV	measurement, monitoring and verification
MNES	Matters of National Environmental Significance
MPS	Millmerran Power Station
mRT	metres below rotary table
$MtCO_2$	million tonnes of CO_2
MVP	monitoring and verification plan
MVR	monitoring, verification and reporting
NDVI	normalised difference vegetation index

NER	National Electricity Rules
NTU	turbidity
O&G	oil and gas
OGIA	Office of Groundwater Impact Assessment
ORP	redox potential
P&G	petroleum and gas
PCC	post combustion capture
PNC	pulsed neutron capture
PIT	pressure integrity test
Pp	pore pressure
ppmV	parts per million by volume
psi	pressure increase
PTA	pressure transient analysis
QPED	Queensland petroleum exploration data
RCA	routine core analysis
relk	relative permeability
RP	reaction path
SH_{max}	Major Horizontal Stress
SH_{min}	Minor Horizontal Stress
S_v	Vertical Stress
t	tonne
t/year	tonnes per year
TDS	total dissolved solids
TOC	total organic carbon
ToR	Terms of Reference
TRH	Total Recoverable Hydrocarbons
TST	Transgressive Systems Tract
TVDSS	true vertical depth sub sea
TVT	true vertical thickness
TZ	Transition Zone
UQ	The University of Queensland
UQ-SDAAP	The University of Queensland Surat Deep Aquifer Appraisal Project
US	Ultimate Seal
USDW	Underground Source of Drinking Water
UWIR	underground water impact report

WQO	Water Quality Objective
Vcl	clay volume
VSP	Vertical Seismic Profiling

Signature Page

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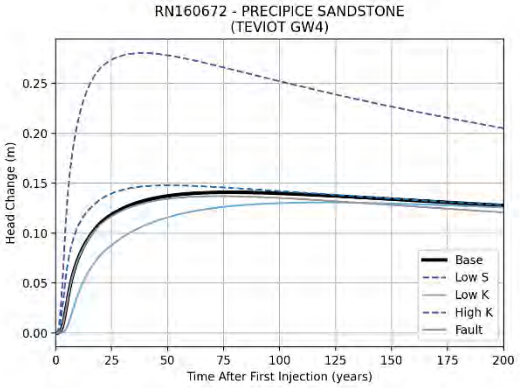
APPENDIX A

Hydrographs Hydrodynamic Modelling



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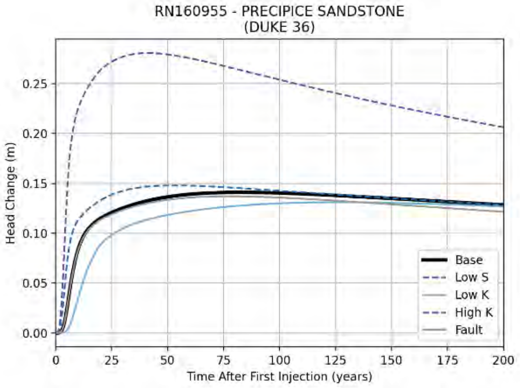

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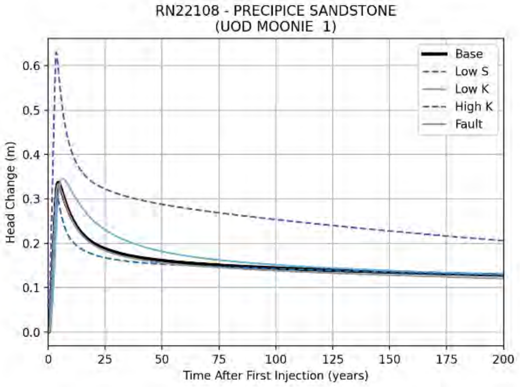
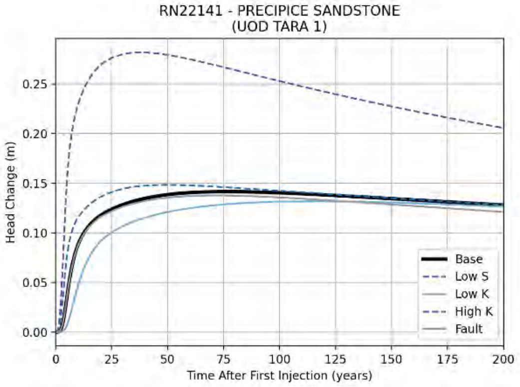
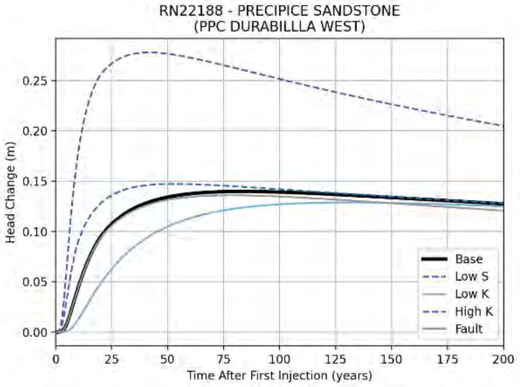


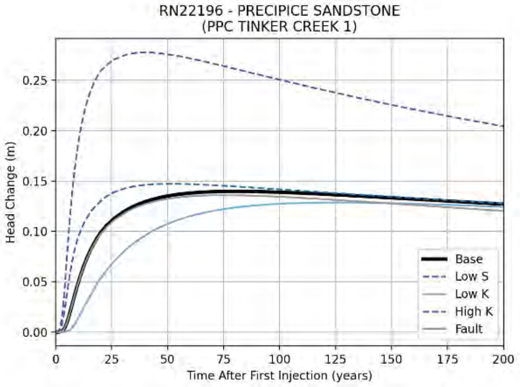
RN22108 - PRECIPICE SANDSTONE



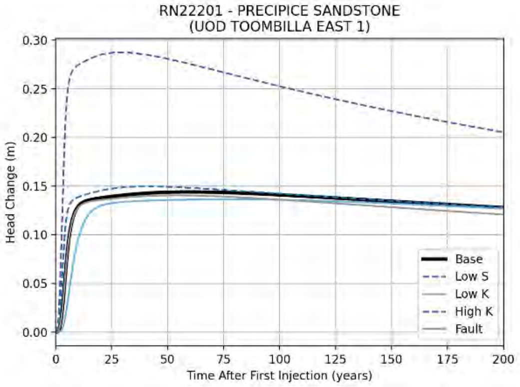
RN22141 - PRECIPICE SANDSTONE



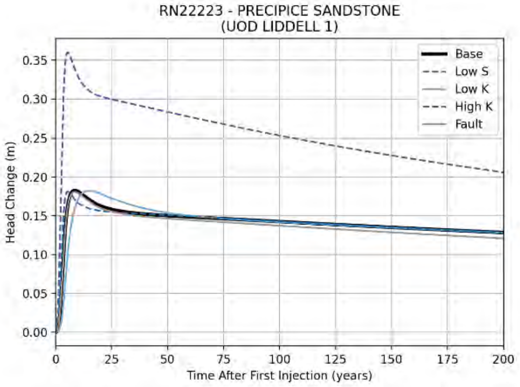
RN22188 - PRECIPICE SANDSTONE



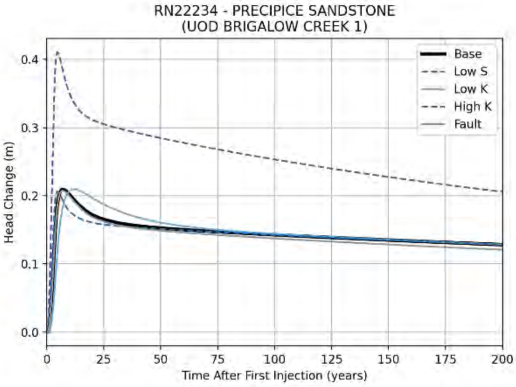
RN22196 - PRECIPICE SANDSTONE



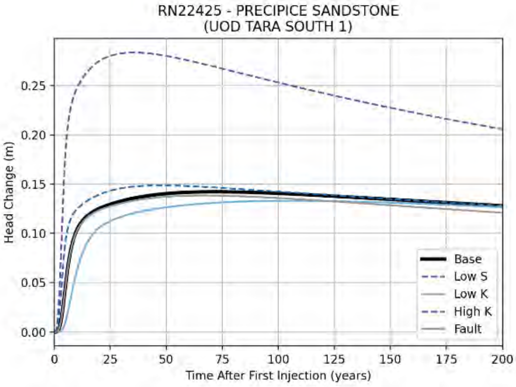
RN22201 - PRECIPICE SANDSTONE



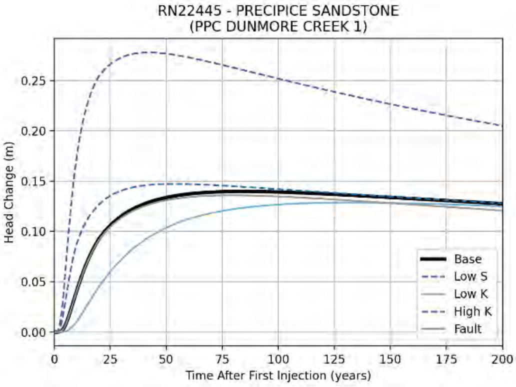
RN22223 - PRECIPICE SANDSTONE



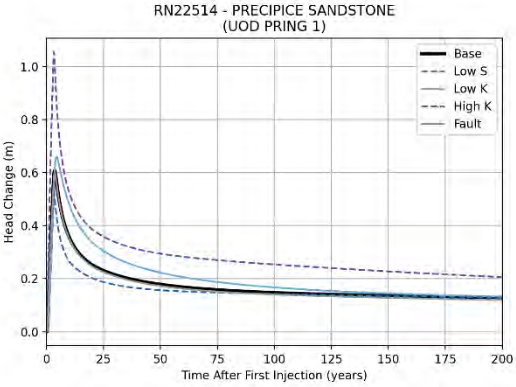
RN22234 - PRECIPICE SANDSTONE



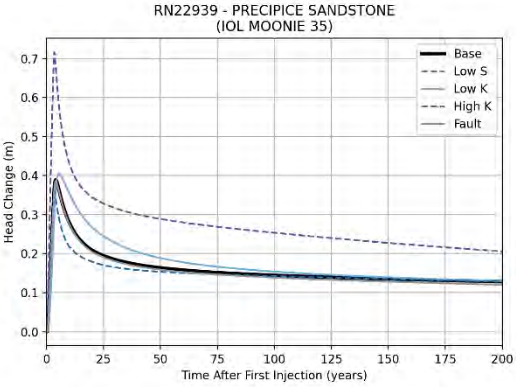
RN22425 - PRECIPICE SANDSTONE



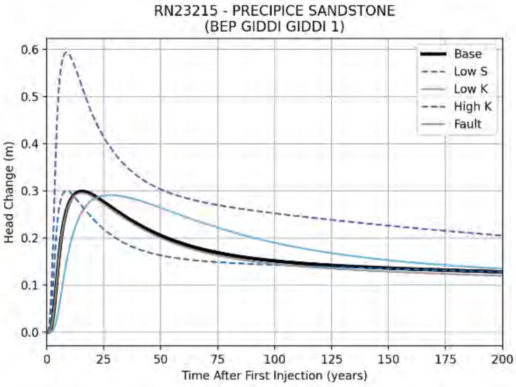
RN22445 - PRECIPICE SANDSTONE



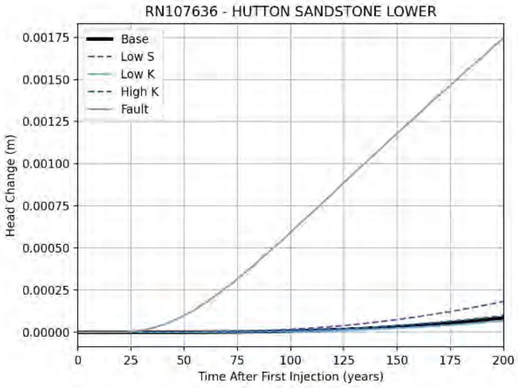
RN22514 - PRECIPICE SANDSTONE



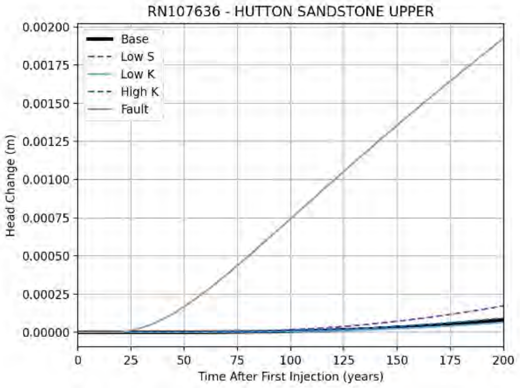
RN22939 - PRECIPICE SANDSTONE



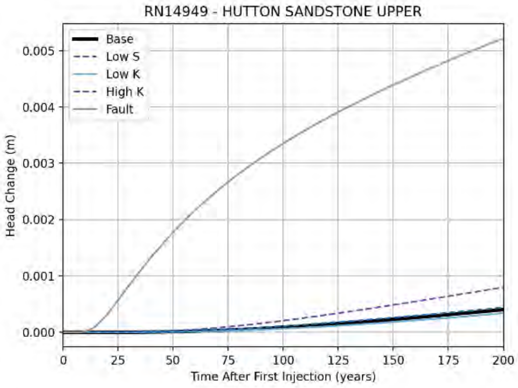
RN23215 - PRECIPICE SANDSTONE



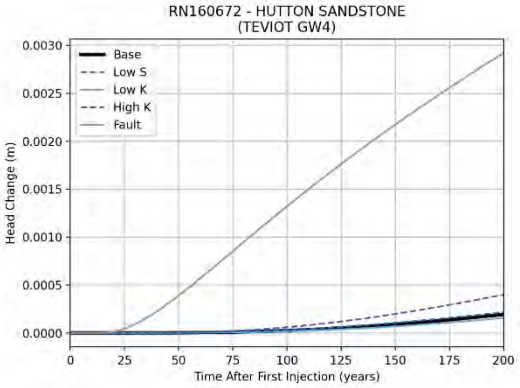
RN107636 - HUTTON SANDSTONE LOWER



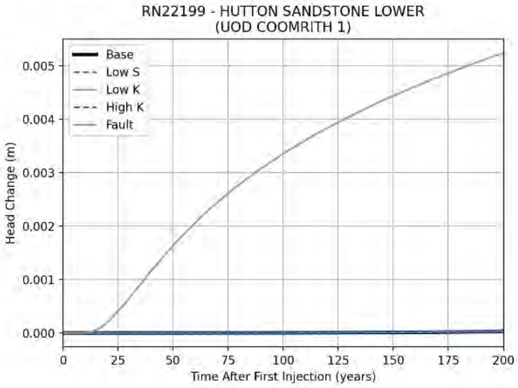
RN107636 - HUTTON SANDSTONE UPPER



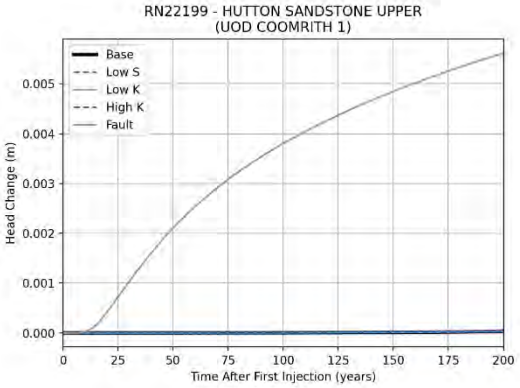
RN14949 - HUTTON SANDSTONE UPPER



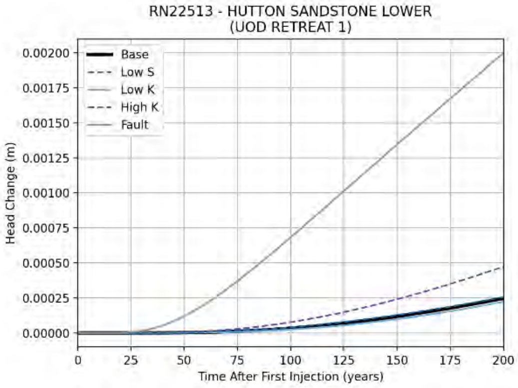
RN160672 - HUTTON SANDSTONE



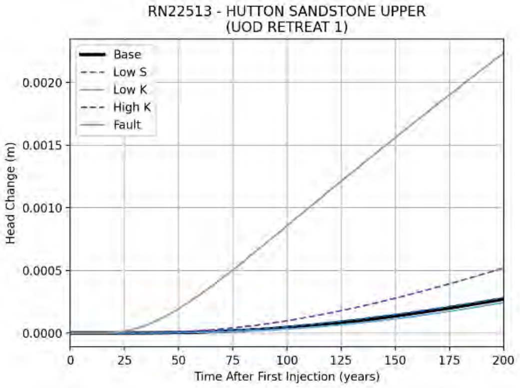
RN22199 - HUTTON SANDSTONE LOWER



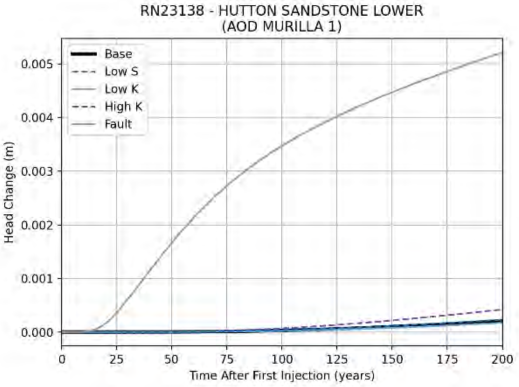
RN22199 - HUTTON SANDSTONE UPPER



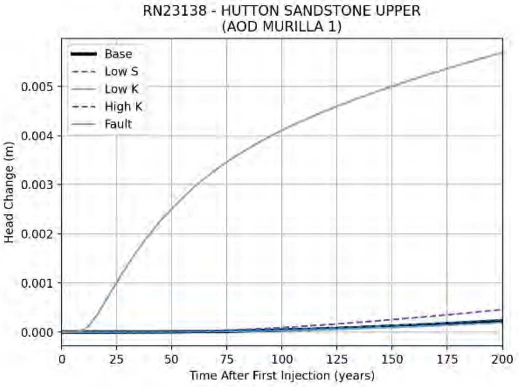
RN22513 - HUTTON SANDSTONE LOWER



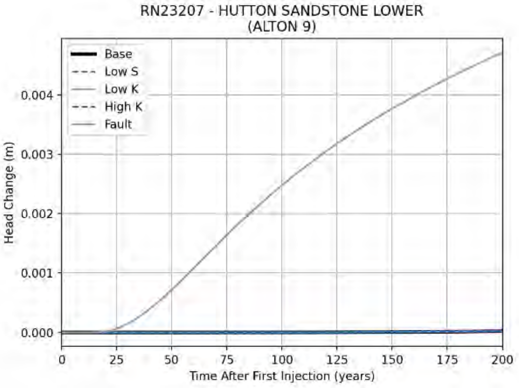
RN22513 - HUTTON SANDSTONE UPPER



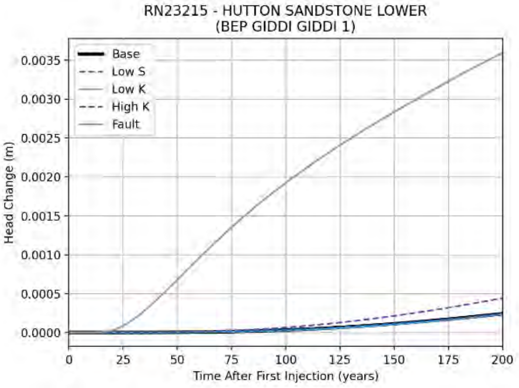
RN23138 - HUTTON SANDSTONE LOWER



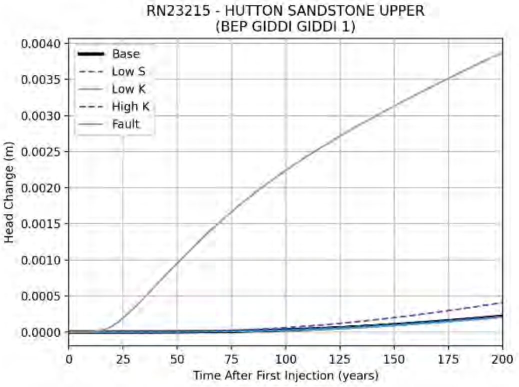
RN23138 - HUTTON SANDSTONE UPPER



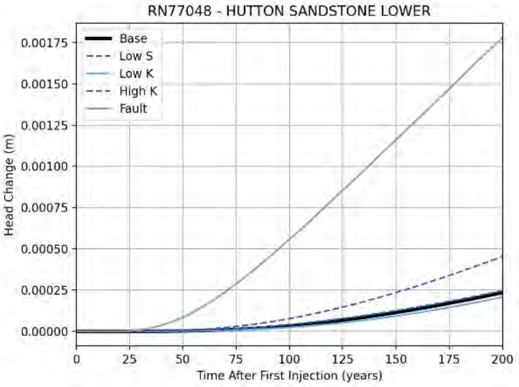
RN23207 - HUTTON SANDSTONE LOWER



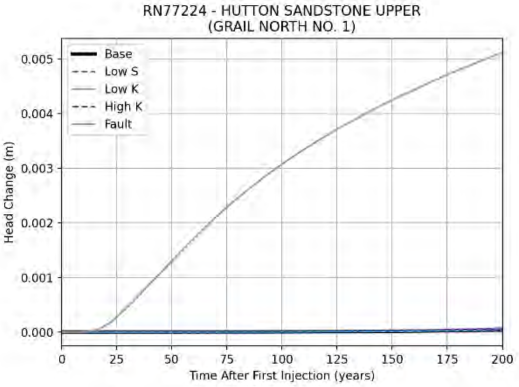
RN23215 - HUTTON SANDSTONE LOWER



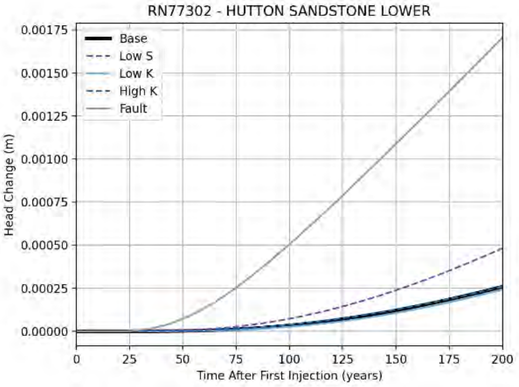
RN23215 - HUTTON SANDSTONE UPPER



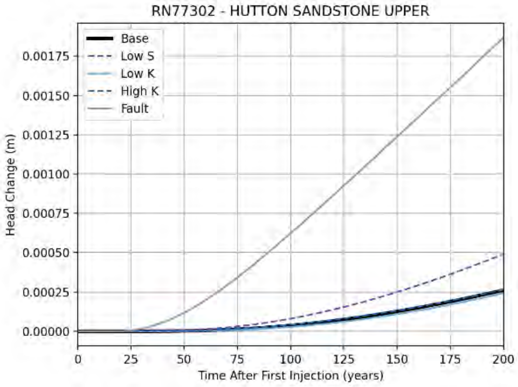
RN77048 - HUTTON SANDSTONE LOWER



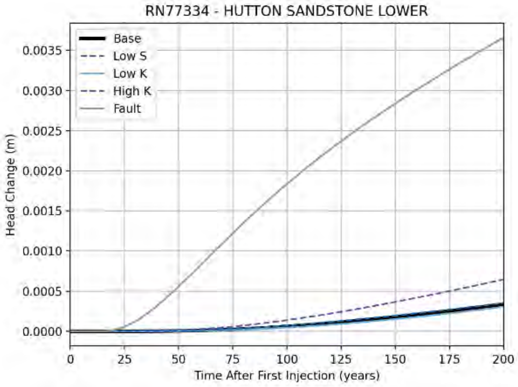
RN77224 - HUTTON SANDSTONE UPPER



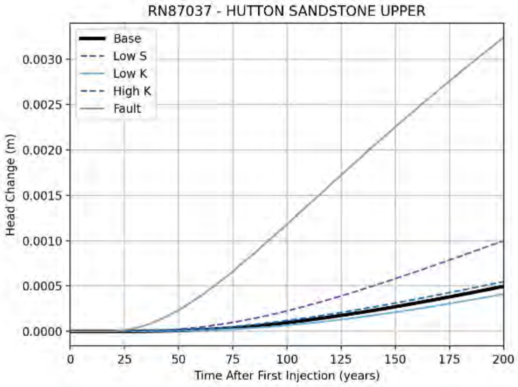
RN77302 - HUTTON SANDSTONE LOWER



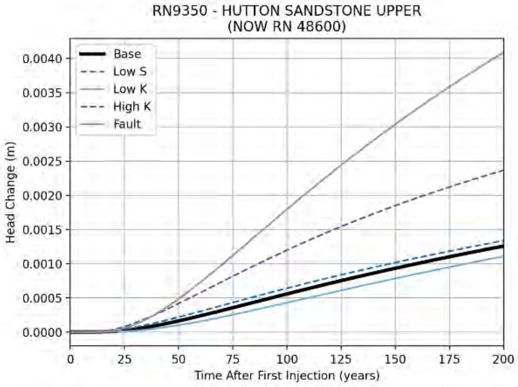
RN77302 - HUTTON SANDSTONE UPPER



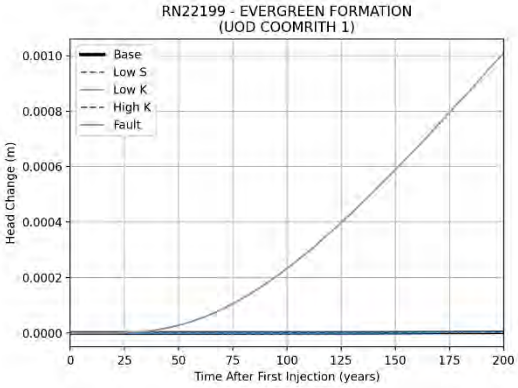
RN77334 - HUTTON SANDSTONE LOWER



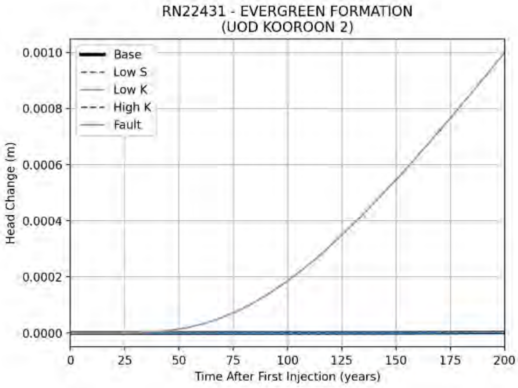
RN87037 - HUTTON SANDSTONE UPPER



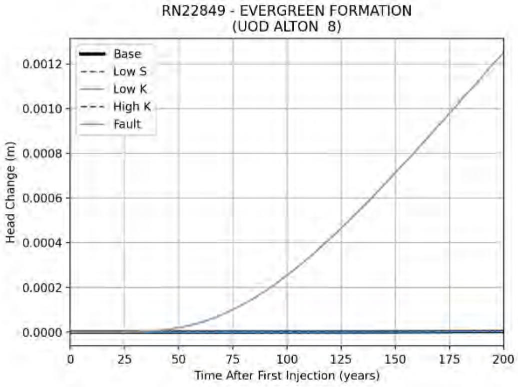
RN9350 - HUTTON SANDSTONE UPPER



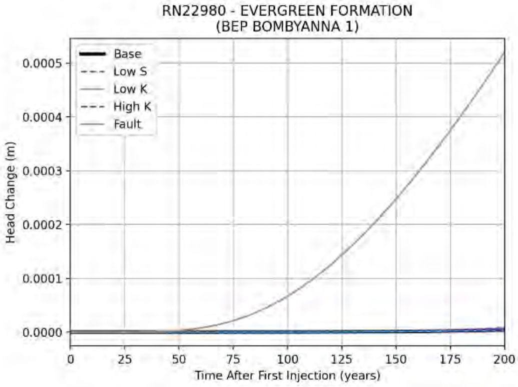
RN22199 - EVERGREEN FORMATION



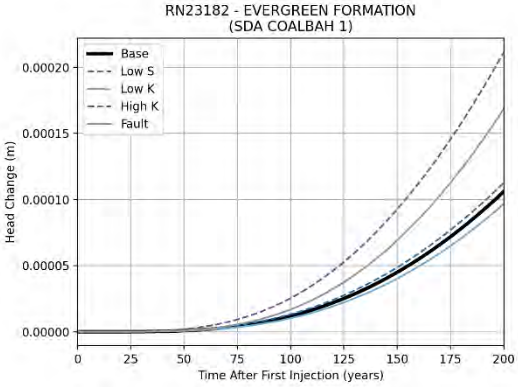
RN22431 - EVERGREEN FORMATION



RN22849 - EVERGREEN FORMATION



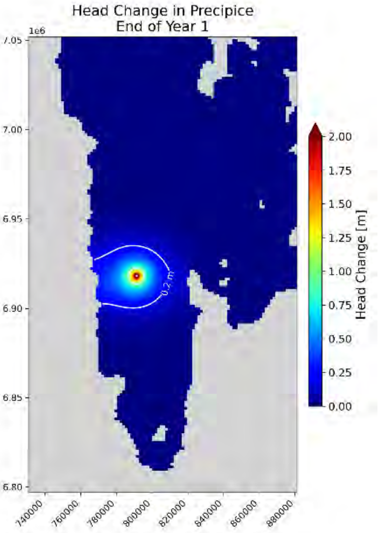
RN22980 - EVERGREEN FORMATION



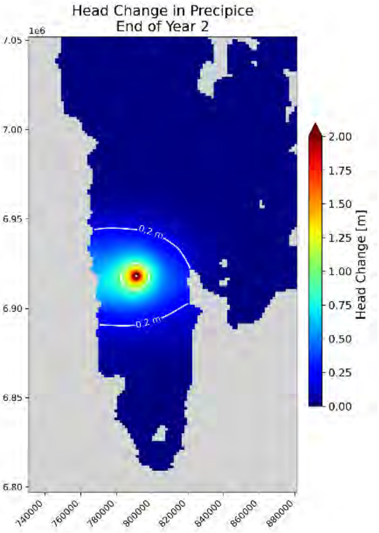
RN23182 - EVERGREEN FORMATION

APPENDIX B

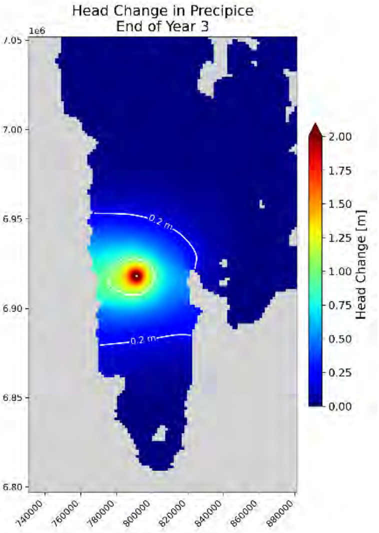
Head Change Hydrodynamic Modelling



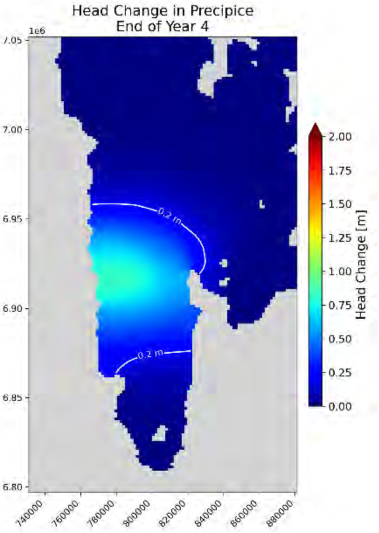
Scenario 1.0: Base Case



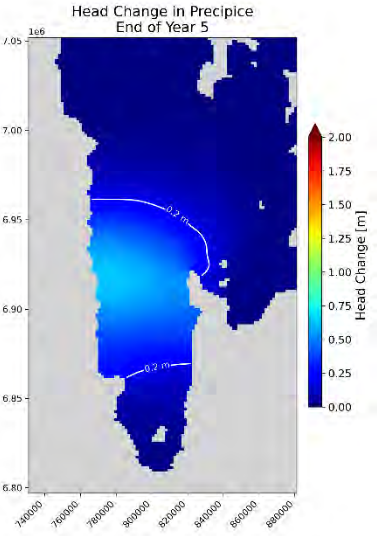
Scenario 1.0: Base Case



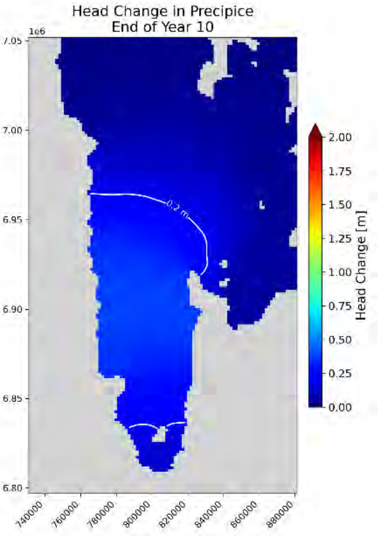
Scenario 1.0: Base Case



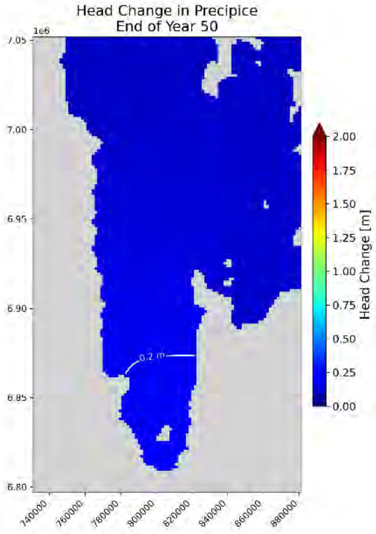
Scenario 1.0: Base Case



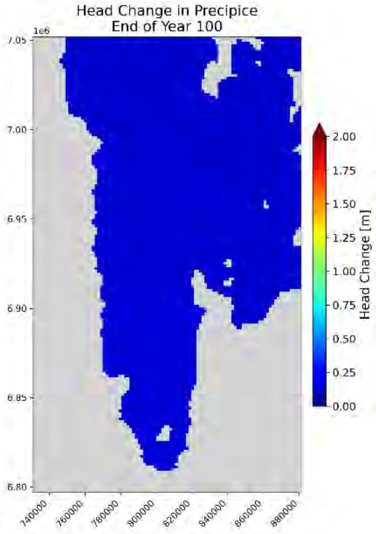
Scenario 1.0: Base Case



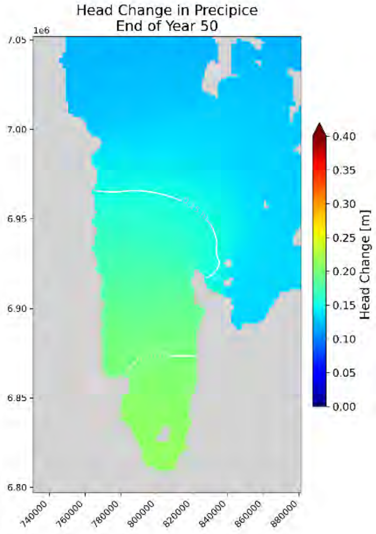
Scenario 1.0: Base Case



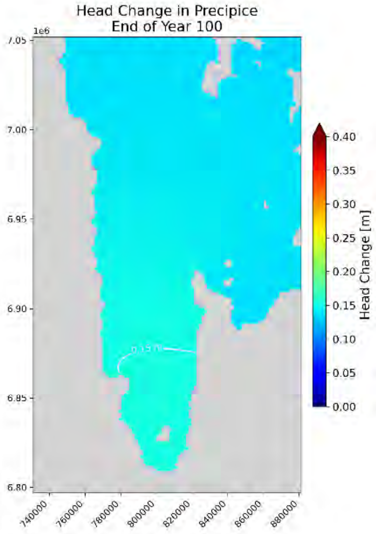
Scenario 1.0: Base Case



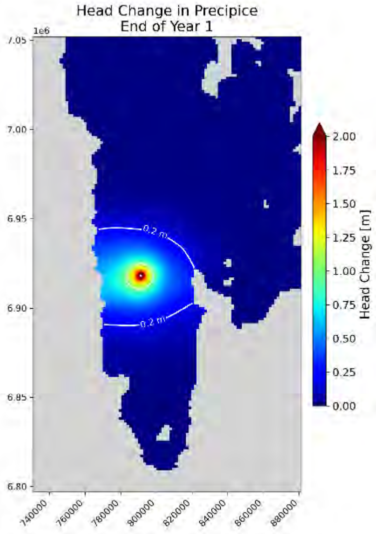
Scenario 1.0: Base Case



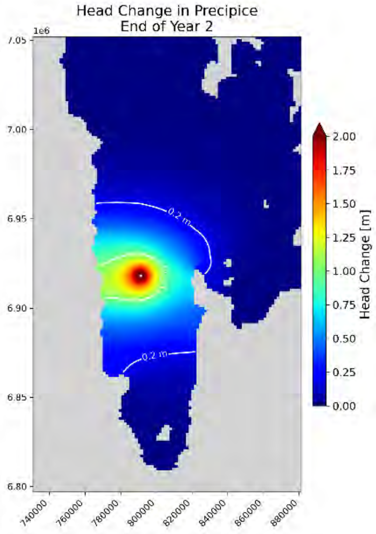
Scenario 1.0: Base Case



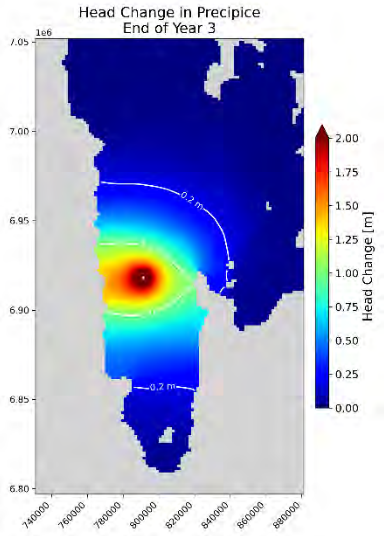
Scenario 1.0: Base Case



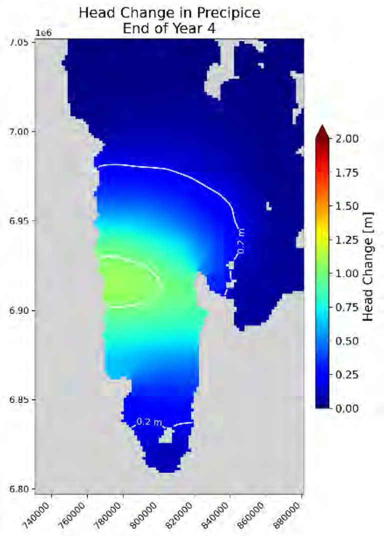
Scenario 1.1: Low storage



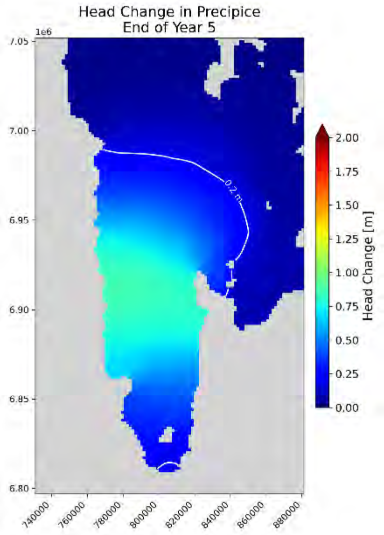
Scenario 1.1: Low storage



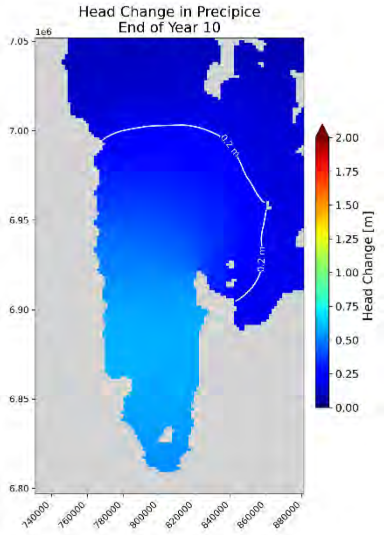
Scenario 1.1: Low storage



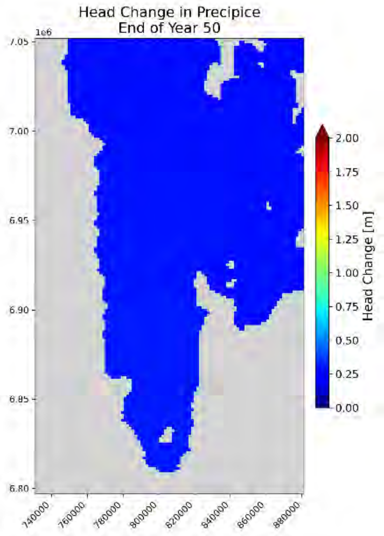
Scenario 1.1: Low storage



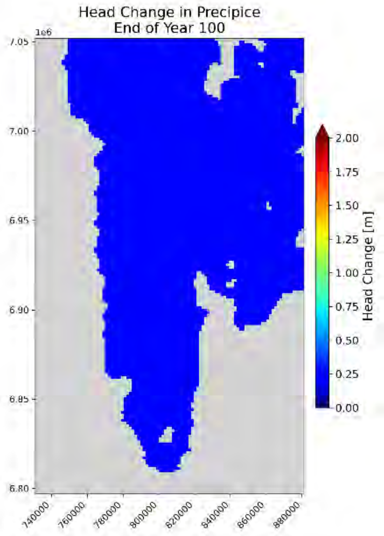
Scenario 1.1: Low storage



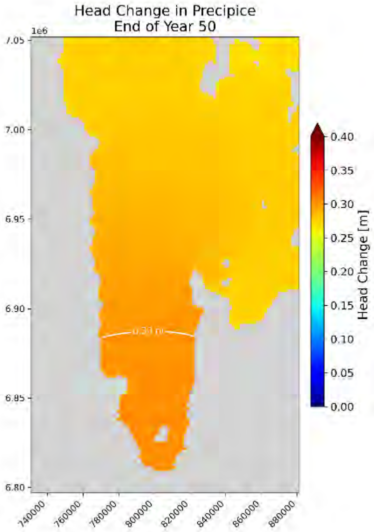
Scenario 1.1: Low storage



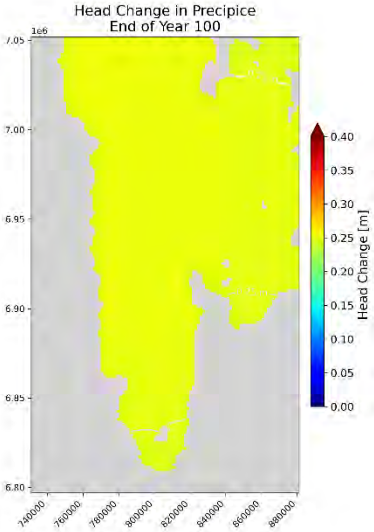
Scenario 1.1: Low storage



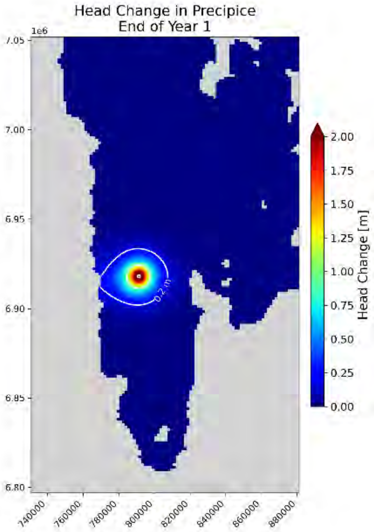
Scenario 1.1: Low storage



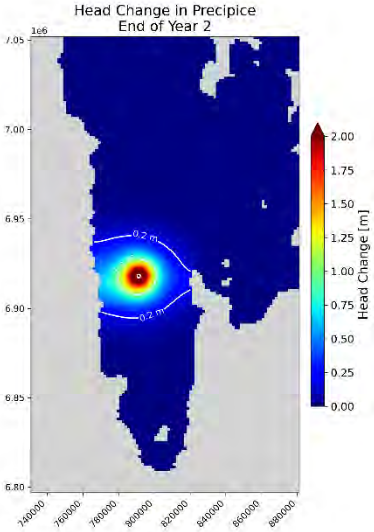
Scenario 1.1: Low storage



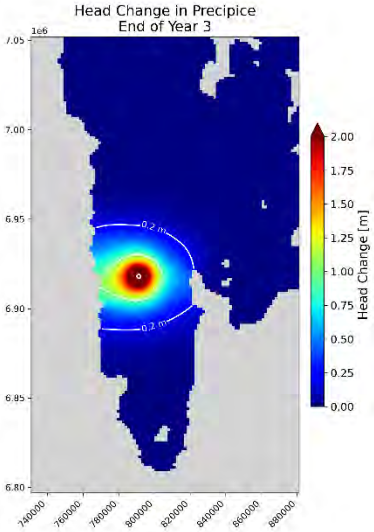
Scenario 1.1: Low storage



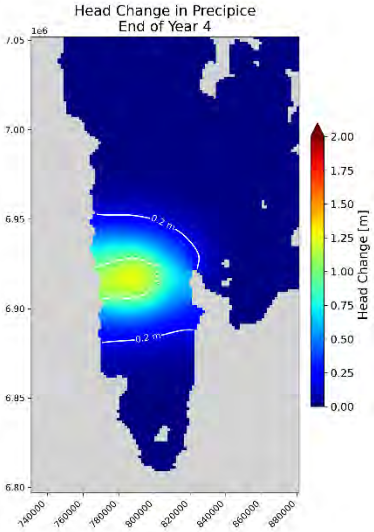
Scenario 1.2: Low hydraulic conductivity



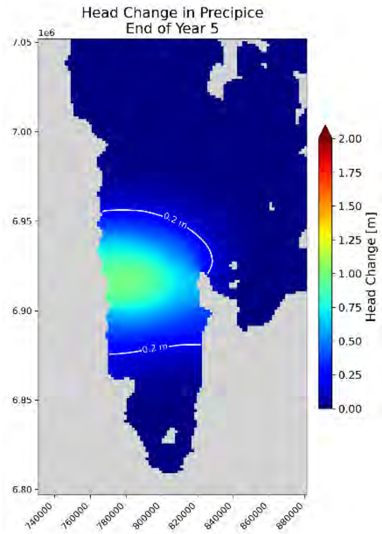
Scenario 1.2: Low hydraulic conductivity



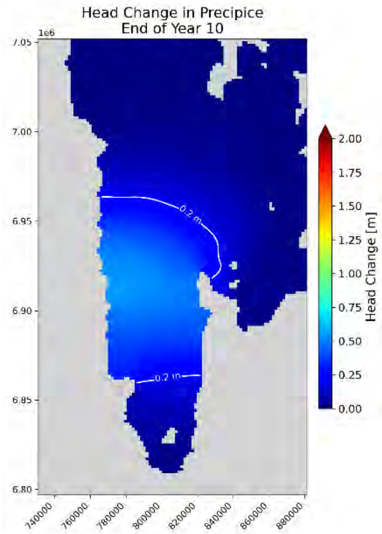
Scenario 1.2: Low hydraulic conductivity



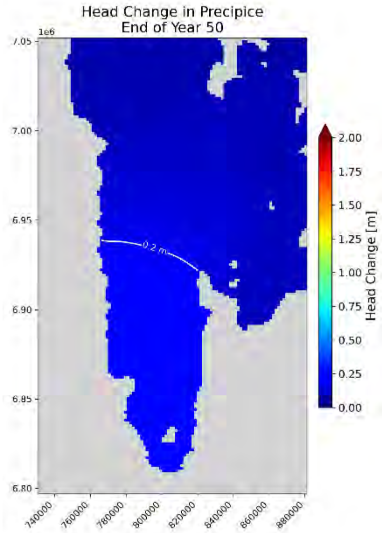
Scenario 1.2: Low hydraulic conductivity



Scenario 1.2: Low hydraulic conductivity



Scenario 1.2: Low hydraulic conductivity



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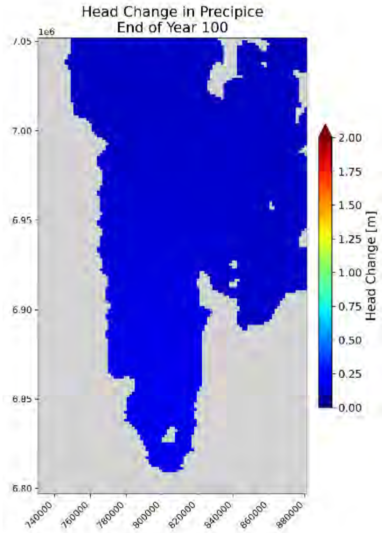

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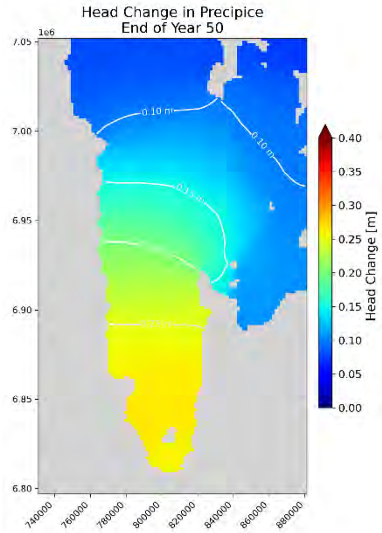
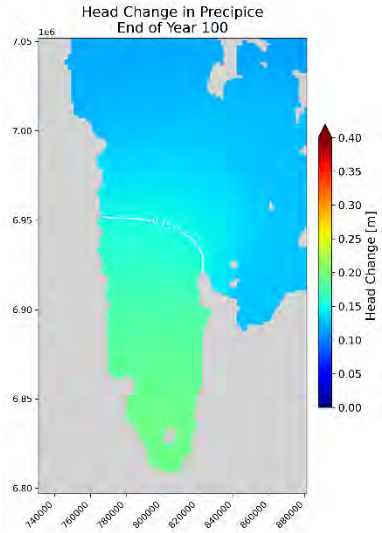
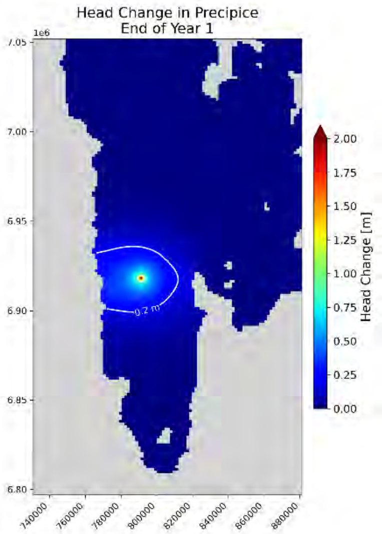


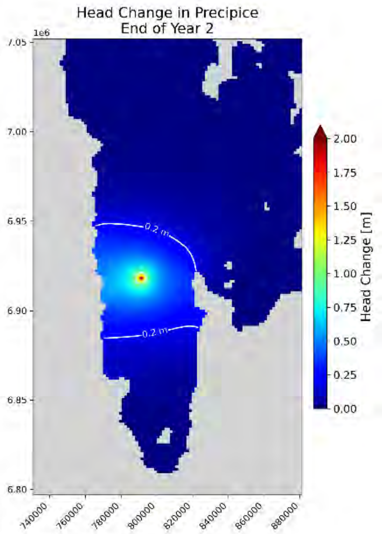
Scenario 1.2: Low hydraulic conductivity



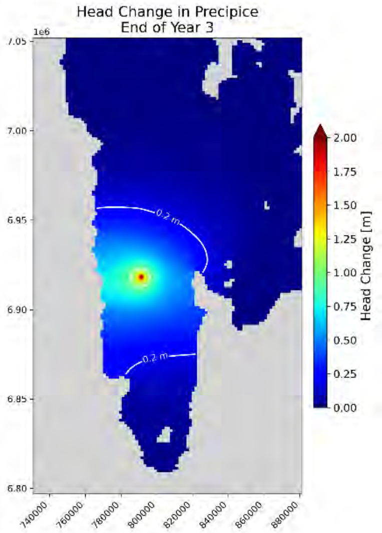
Scenario 1.2: Low hydraulic conductivity



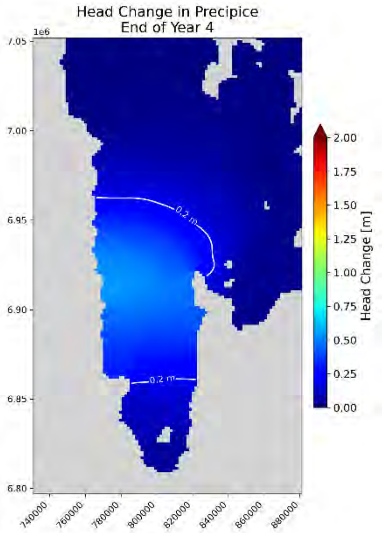
Scenario 1.3: High hydraulic conductivity



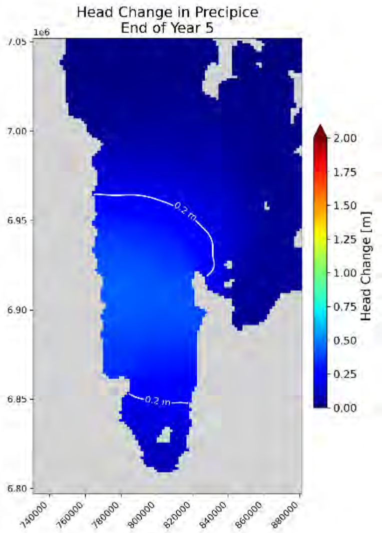
Scenario 1.3: High hydraulic conductivity



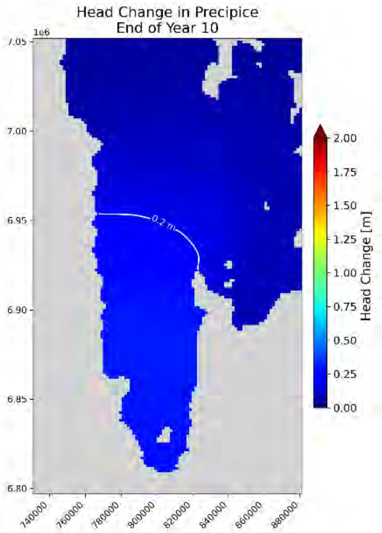
Scenario 1.3: High hydraulic conductivity



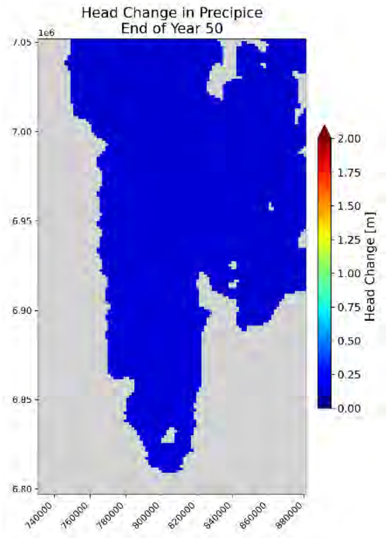
Scenario 1.3: High hydraulic conductivity



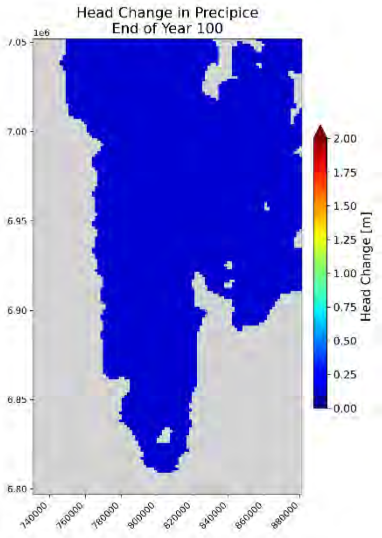
Scenario 1.3: High hydraulic conductivity



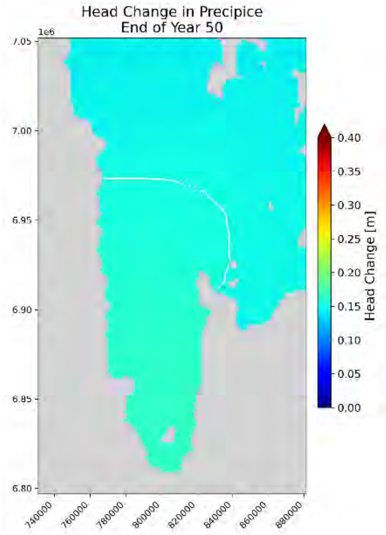
Scenario 1.3: High hydraulic conductivity



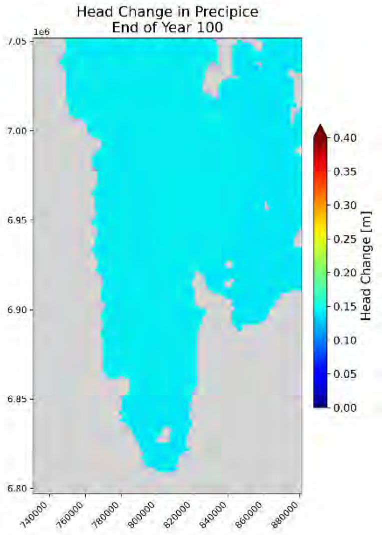
Scenario 1.3: High hydraulic conductivity



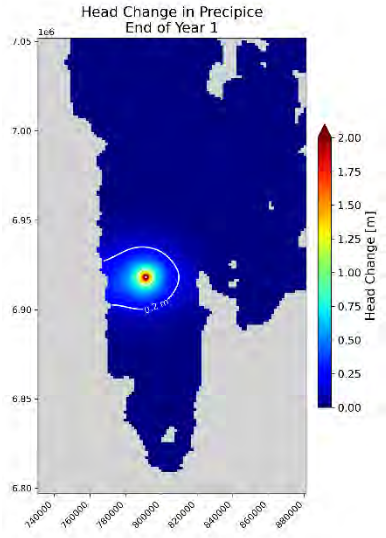
Scenario 1.3: High hydraulic conductivity



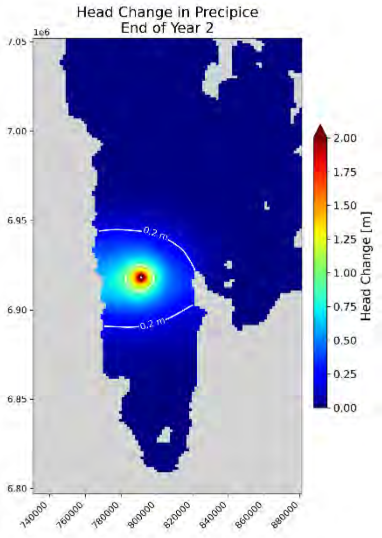
Scenario 1.3: High hydraulic conductivity



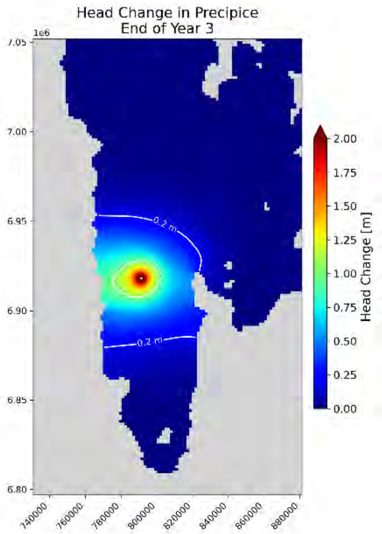
Scenario 1.3: High hydraulic conductivity



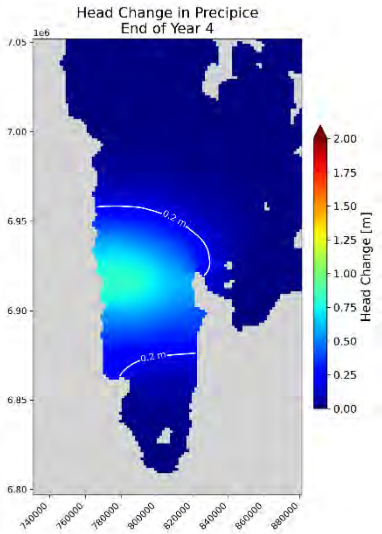
Scenario 1.4: Fault at 7 km



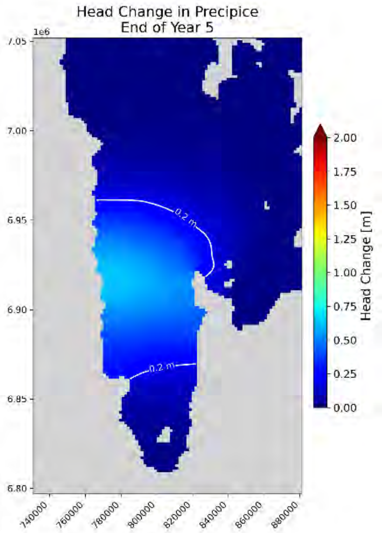
Scenario 1.4: Fault at 7 km



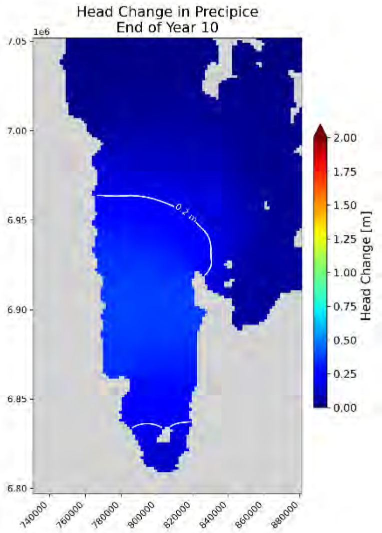
Scenario 1.4: Fault at 7 km



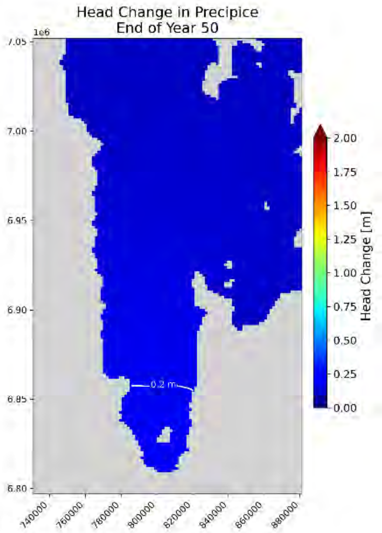
Scenario 1.4: Fault at 7 km



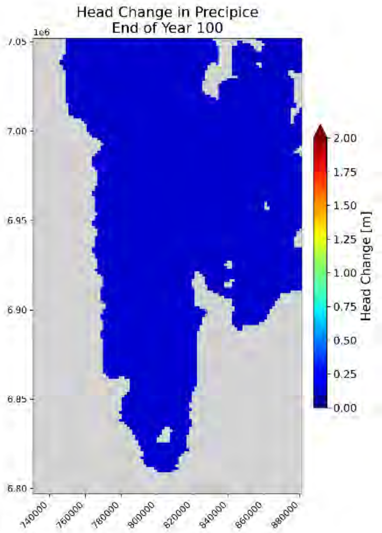
Scenario 1.4: Fault at 7 km



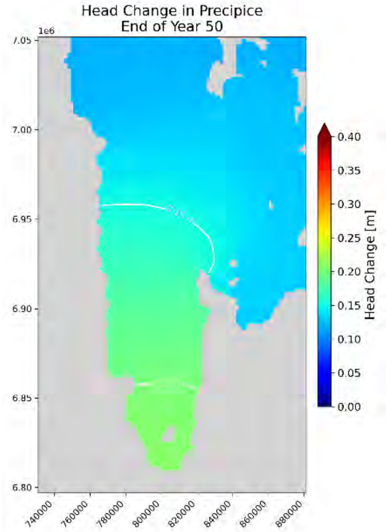
Scenario 1.4: Fault at 7 km



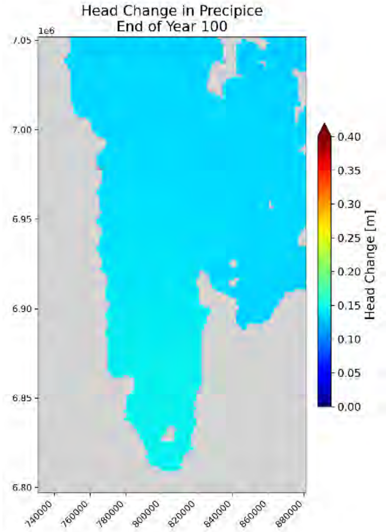
Scenario 1.4: Fault at 7 km



Scenario 1.4: Fault at 7 km



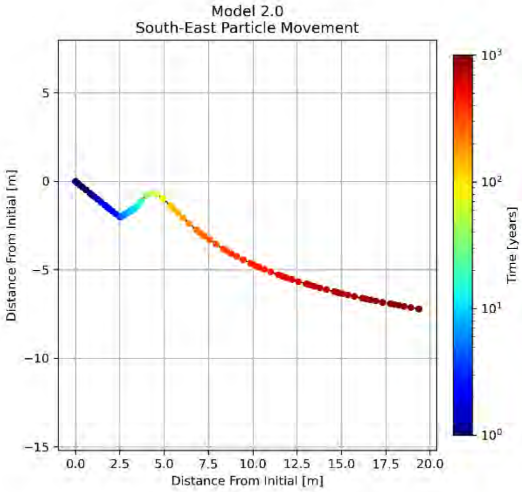
Scenario 1.4: Fault at 7 km



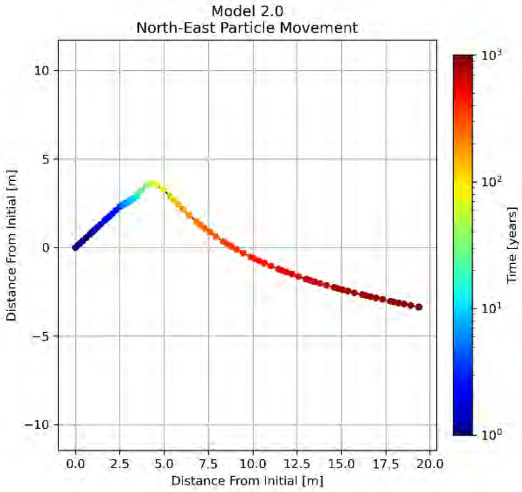
Scenario 1.4: Fault at 7 km

APPENDIX C

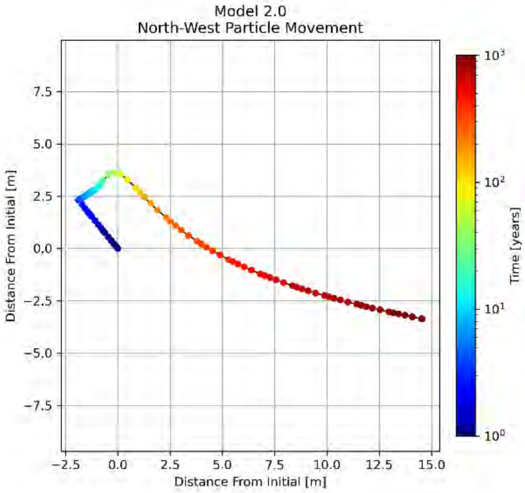
Particle Tracking Hydrodynamic Modelling - Particles



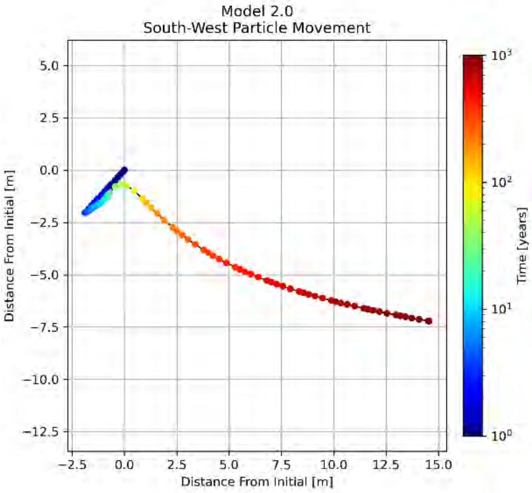
Scenario 2.0: Base Case



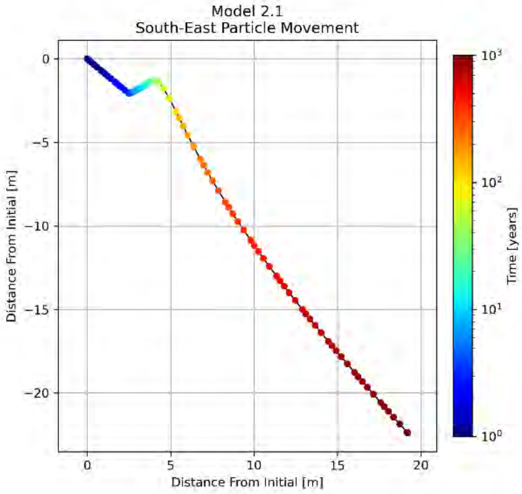
Scenario 2.0: Base Case



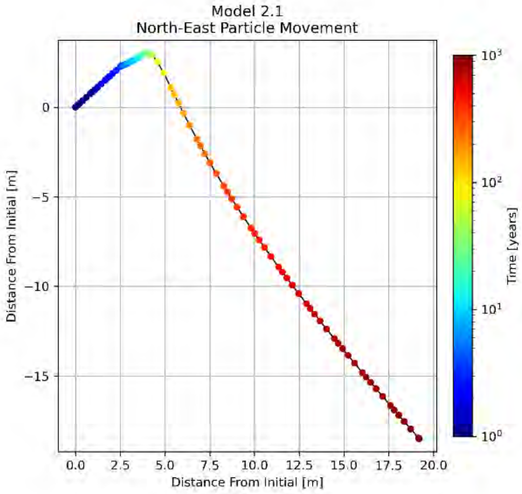
Scenario 2.0: Base Case



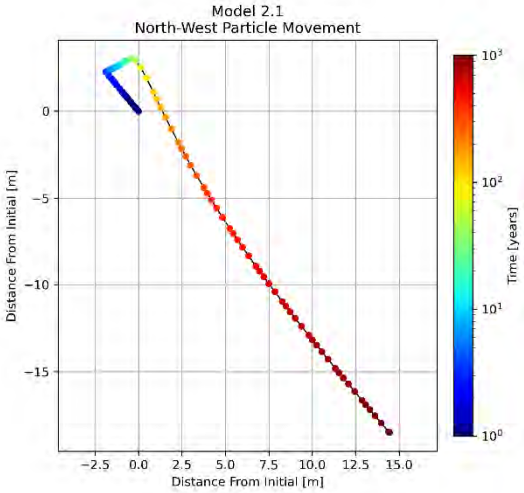
Scenario 2.0: Base Case



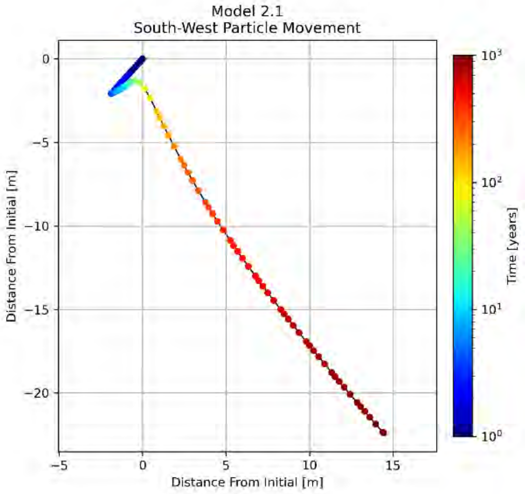
Scenario 2.1: Low Southern Head



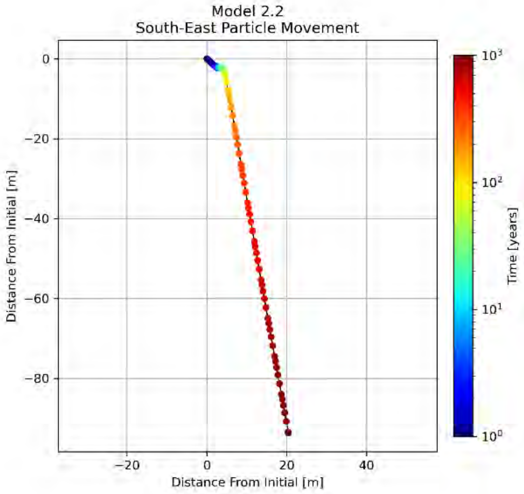
Scenario 2.1: Low Southern Head



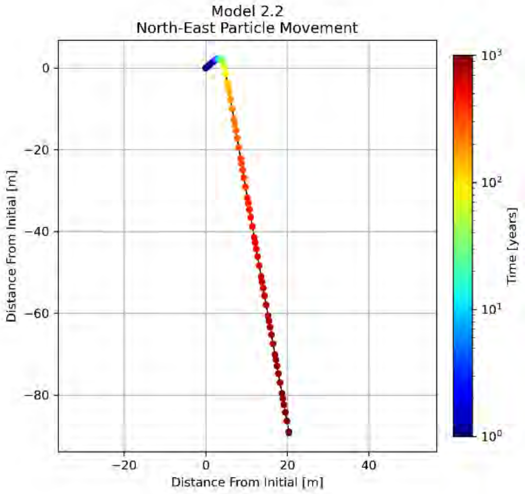
Scenario 2.1: Low Southern Head



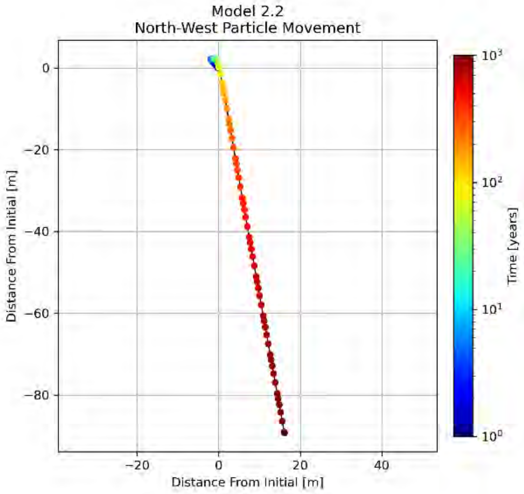
Scenario 2.1: Low Southern Head



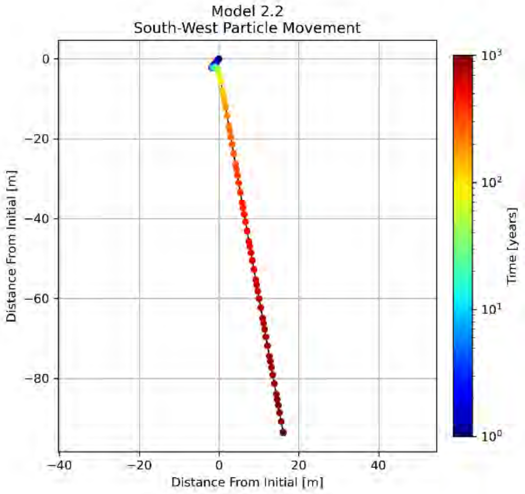
Scenario 2.2: Low Southern Head & high Kv in S



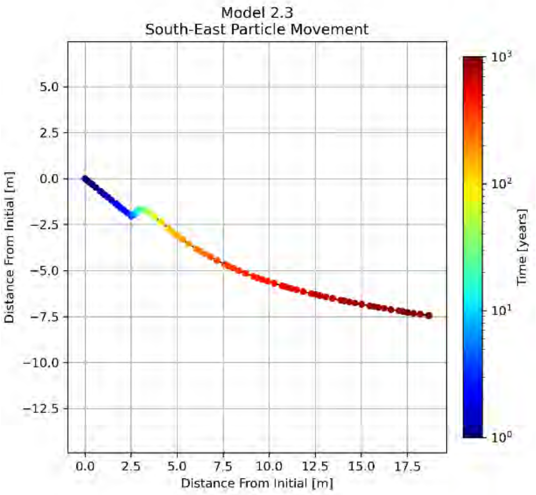
Scenario 2.2: Low Southern Head & high Kv in S



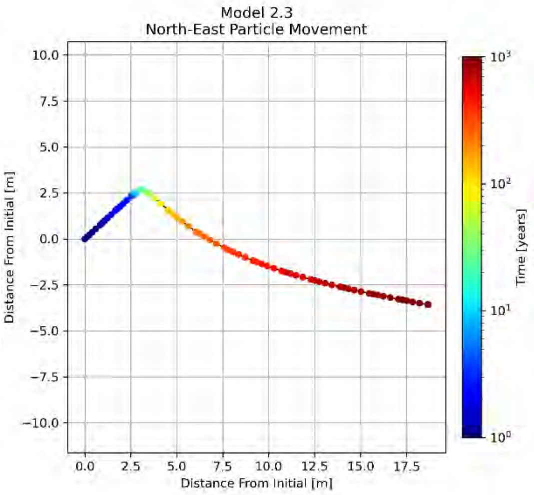
Scenario 2.2: Low Southern Head & high Kv in S



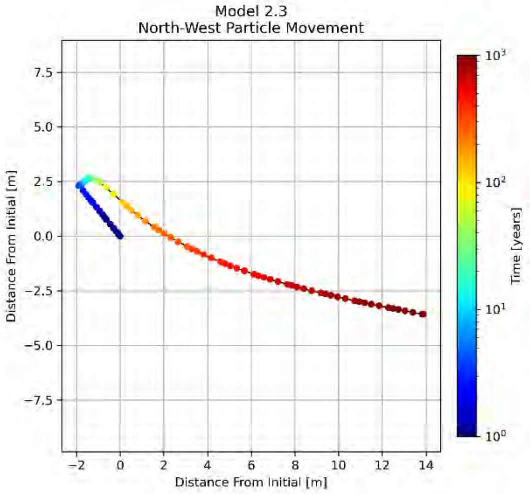
Scenario 2.2: Low Southern Head & high Kv in S



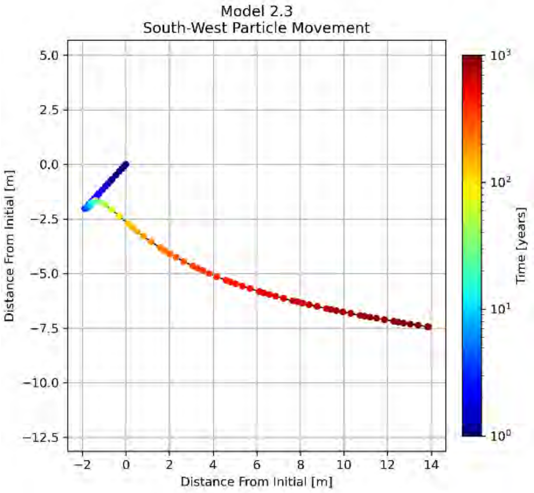
Scenario 2.3: Early Moonie/ Kogan Creek



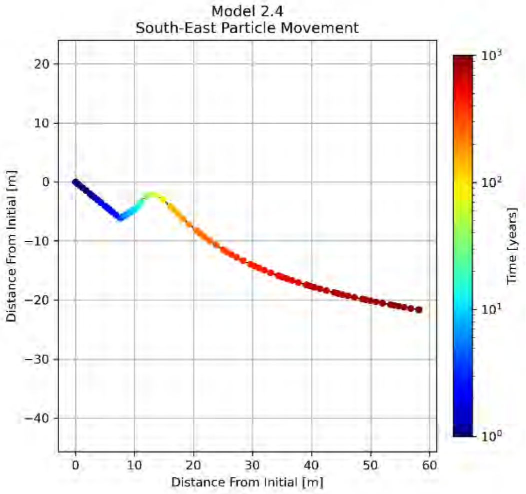
Scenario 2.3: Early Moonie/ Kogan Creek



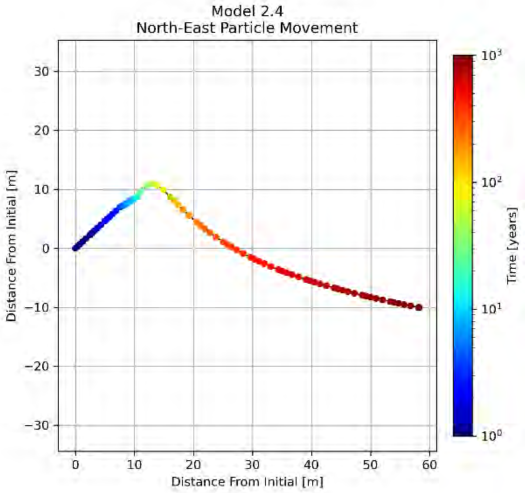
Scenario 2.3: Early Moonie/ Kogan Creek



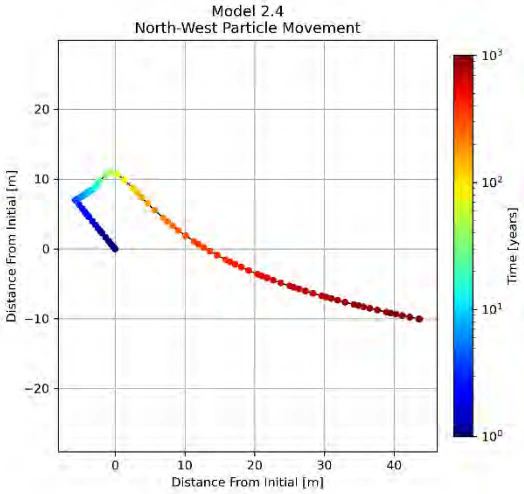
Scenario 2.3: Early Moonie/ Kogan Creek



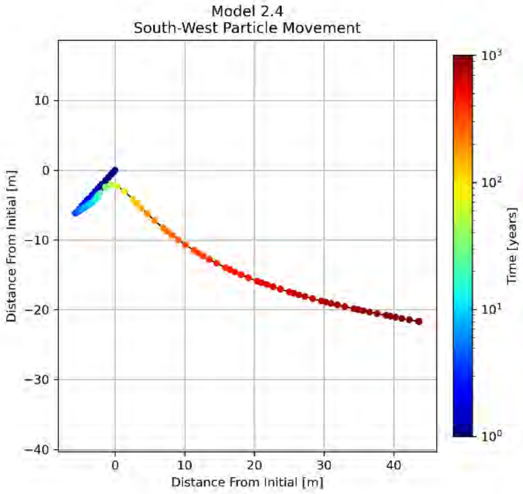
Scenario 2.4: Low porosity



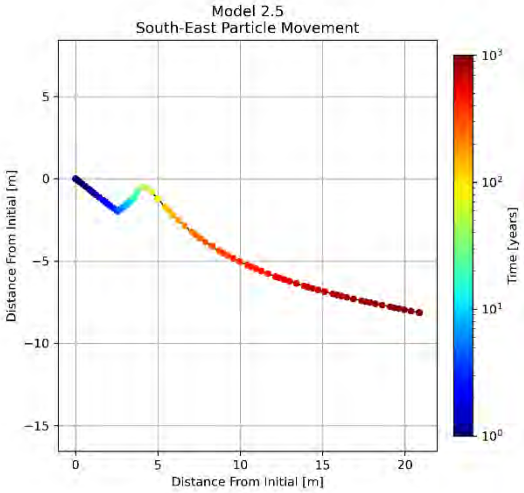
Scenario 2.4: Low porosity



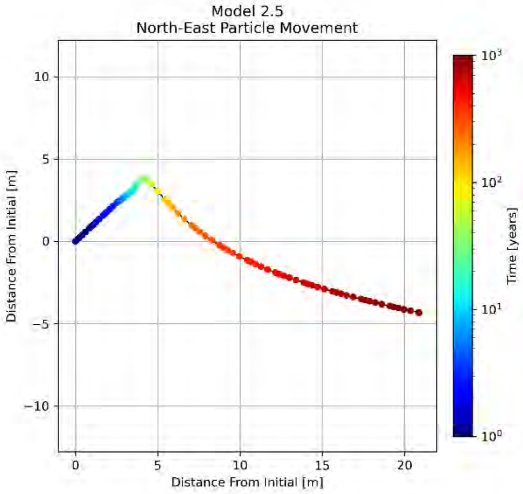
Scenario 2.4: Low porosity



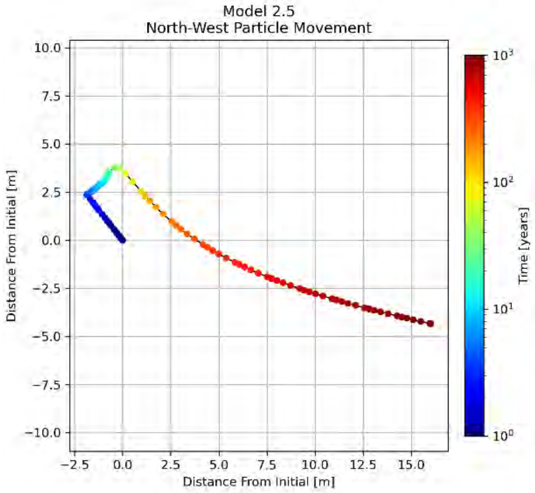
Scenario 2.4: Low porosity



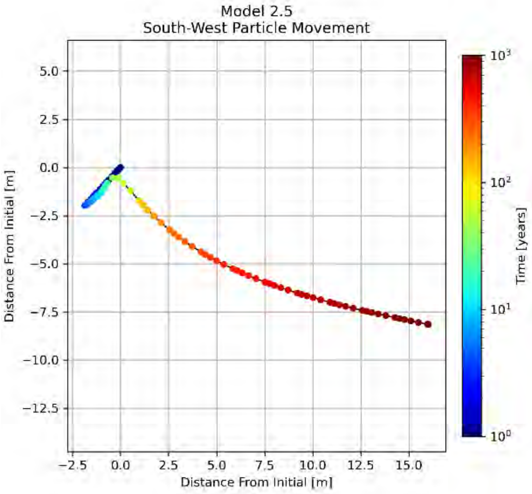
Scenario 2.5: High hydraulic conductivity



Scenario 2.5: High hydraulic conductivity



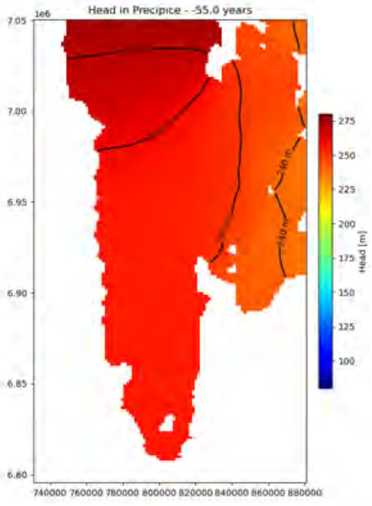
Scenario 2.5: High hydraulic conductivity



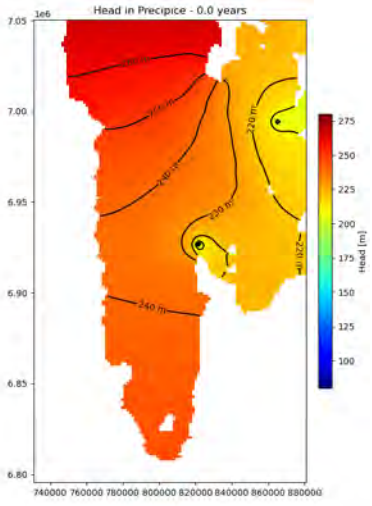
Scenario 2.5: High hydraulic conductivity

APPENDIX D

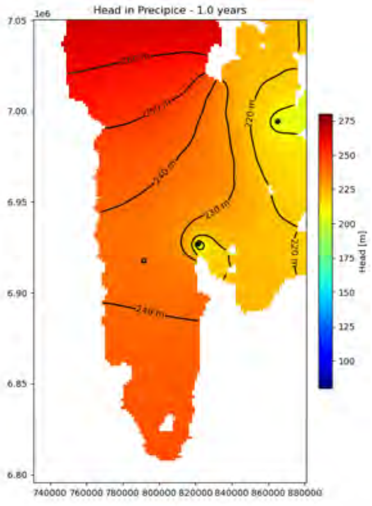
Particle Tracking Hydrodynamic Modelling - Heads



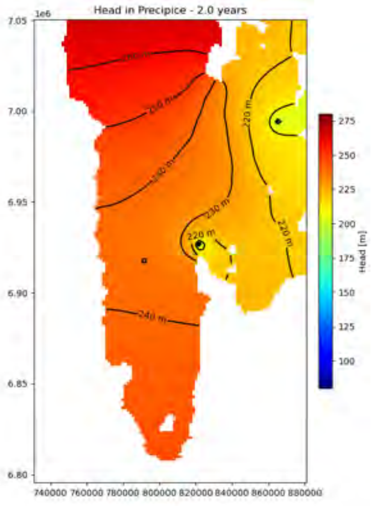
Scenario 2.0: Base Case



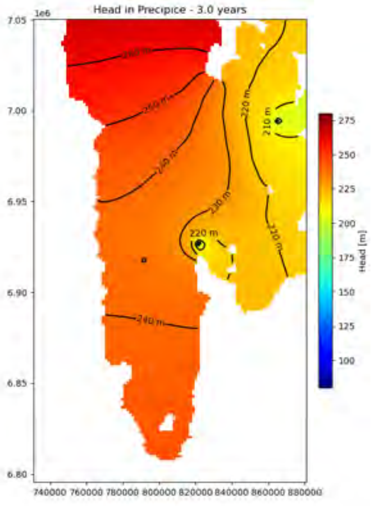
Scenario 2.0: Base Case



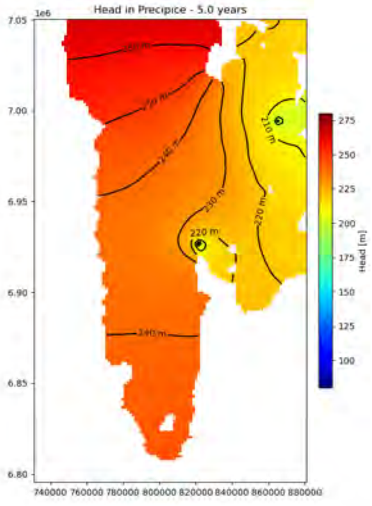
Scenario 2.0: Base Case



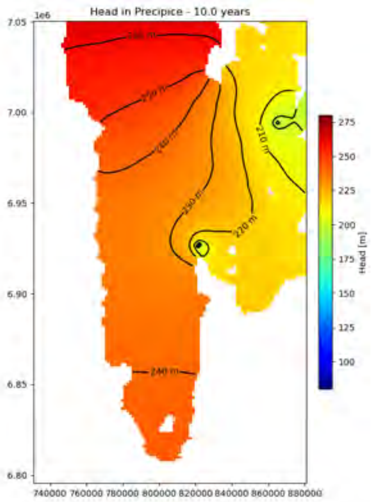
Scenario 2.0: Base Case



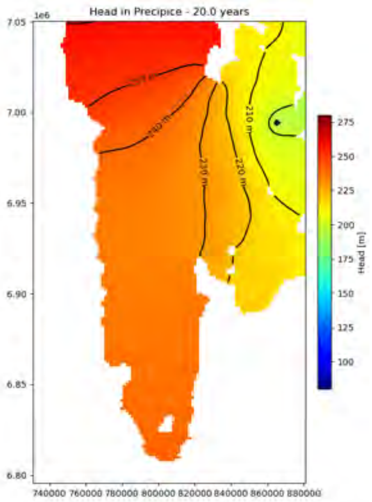
Scenario 2.0: Base Case



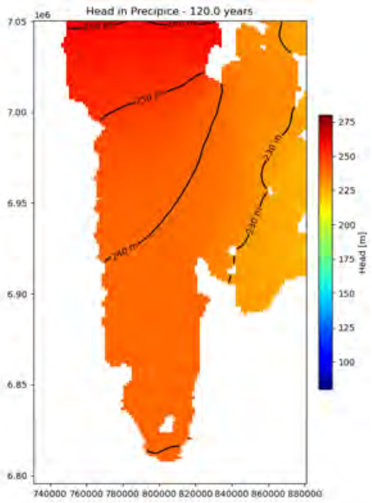
Scenario 2.0: Base Case



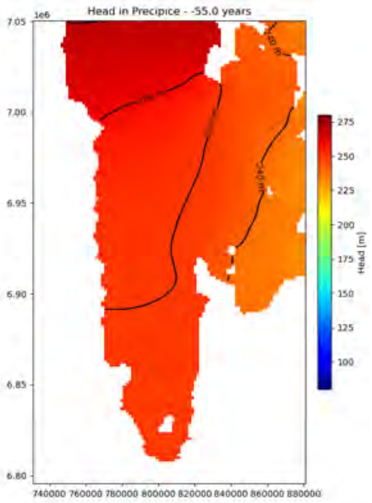
Scenario 2.0: Base Case



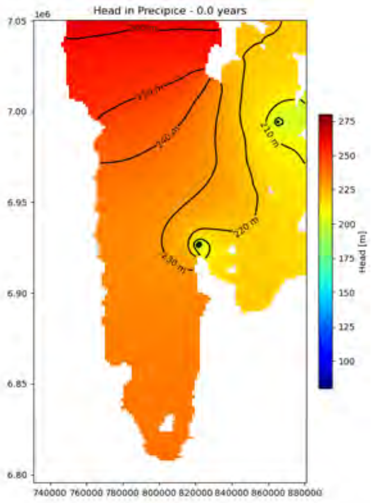
Scenario 2.0: Base Case



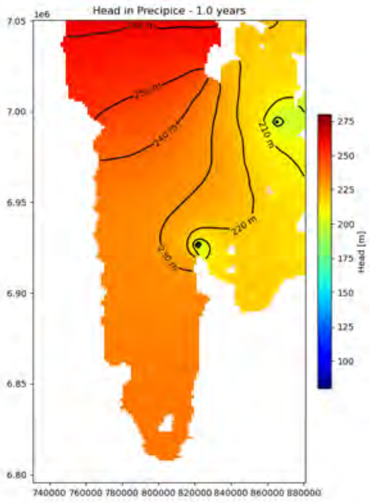
Scenario 2.0: Base Case



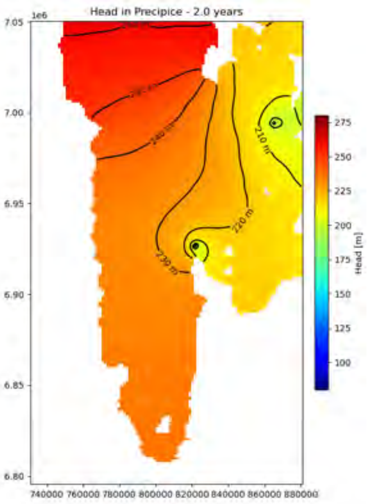
Scenario 2.1: Low Southern Head



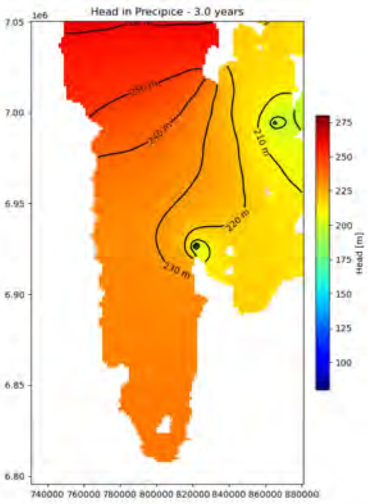
Scenario 2.1: Low Southern Head



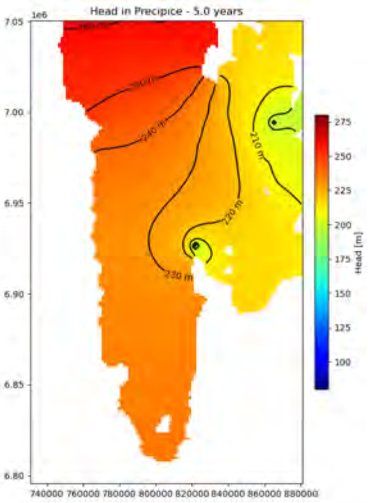
Scenario 2.1: Low Southern Head



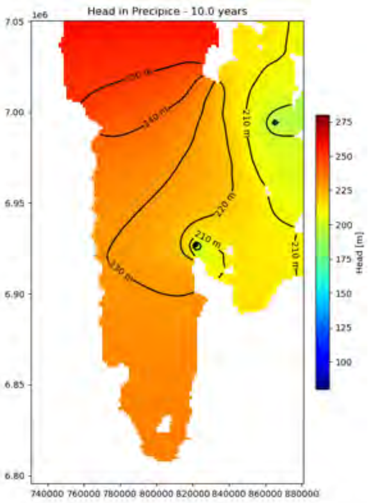
Scenario 2.1: Low Southern Head



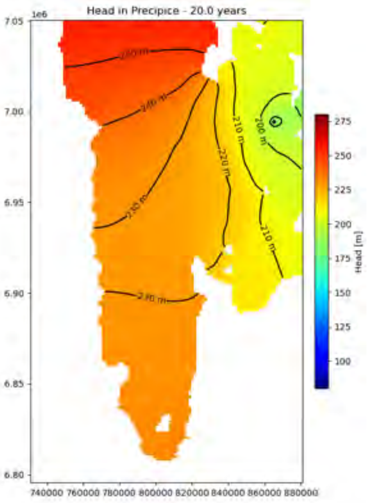
Scenario 2.1: Low Southern Head



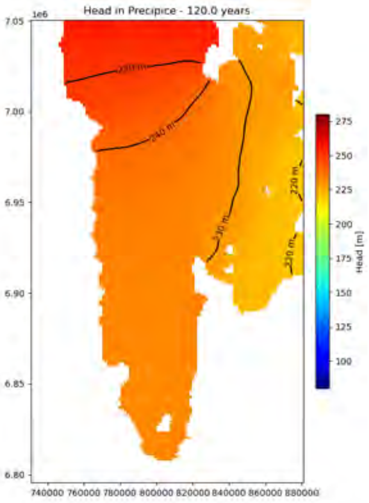
Scenario 2.1: Low Southern Head



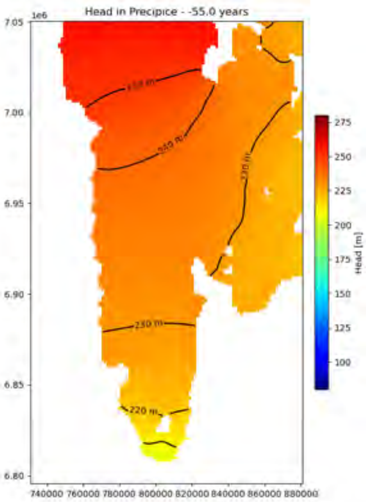
Scenario 2.1: Low Southern Head



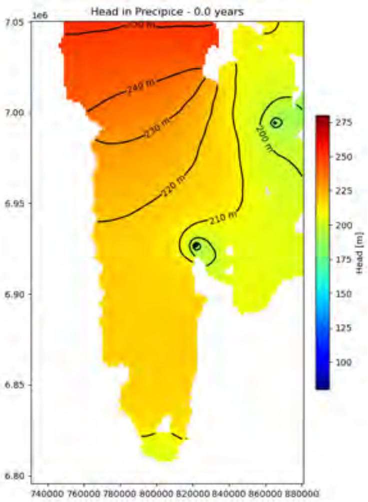
Scenario 2.1: Low Southern Head



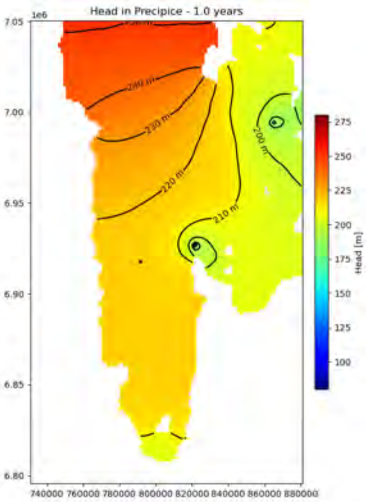
Scenario 2.1: Low Southern Head



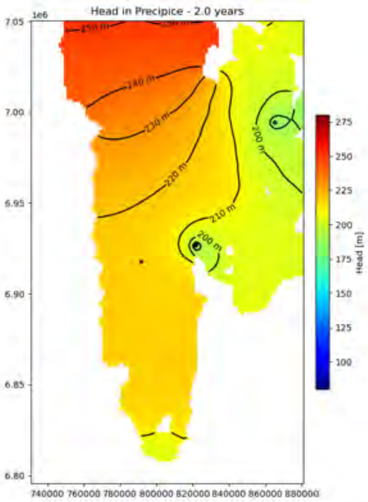
Scenario 2.2: Low Southern Head & high Kv in S



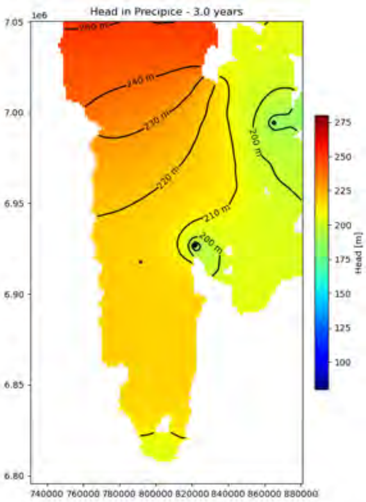
Scenario 2.2: Low Southern Head & high Kv in S



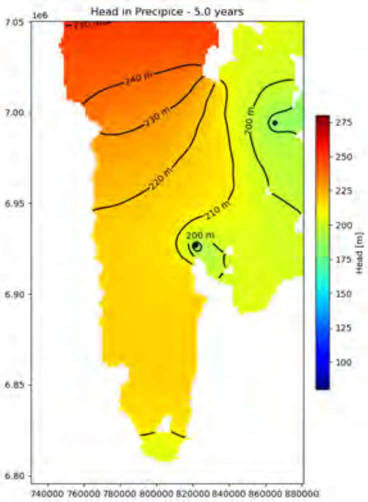
Scenario 2.2: Low Southern Head & high Kv in S



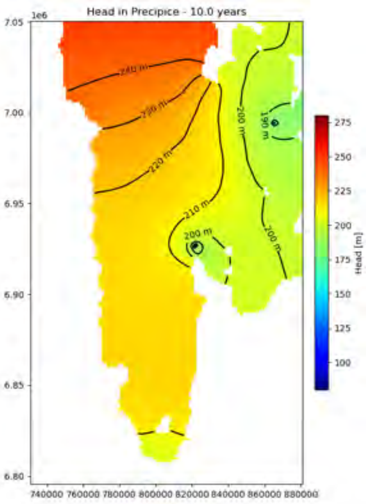
Scenario 2.2: Low Southern Head & high Kv in S



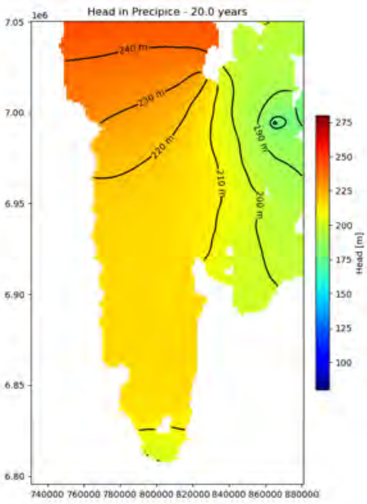
Scenario 2.2: Low Southern Head & high Kv in S



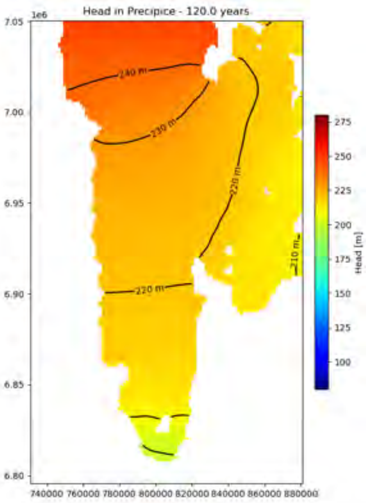
Scenario 2.2: Low Southern Head & high Kv in S



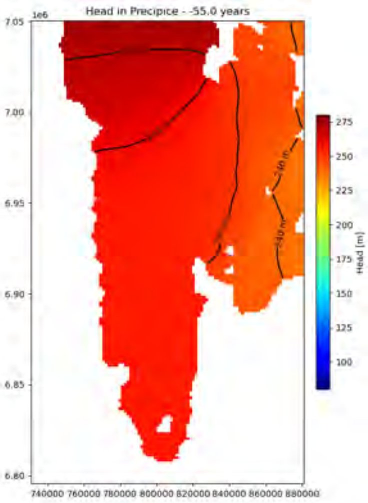
Scenario 2.2: Low Southern Head & high Kv in S



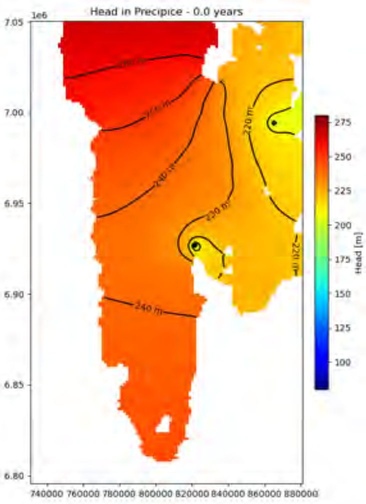
Scenario 2.2: Low Southern Head & high Kv in S



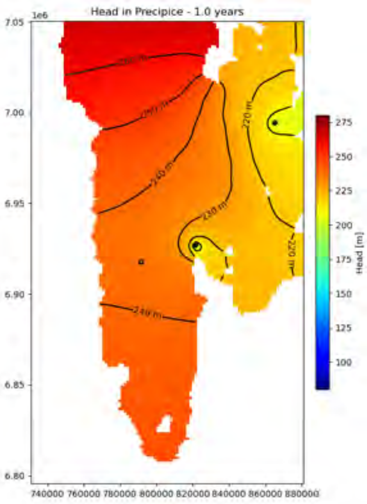
Scenario 2.2: Low Southern Head & high Kv in S



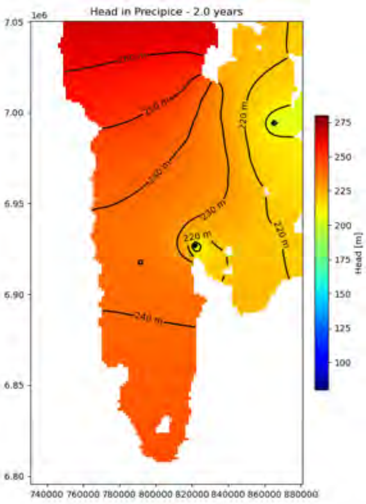
Scenario 2.3: Early Moonie/ Kogan Creek



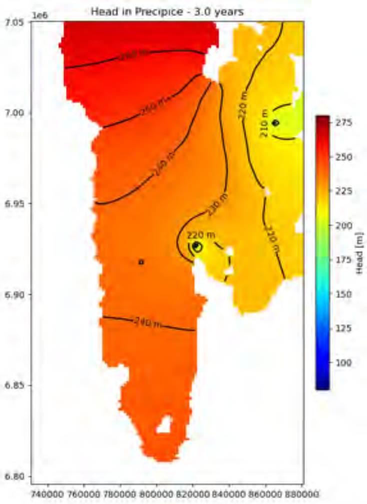
Scenario 2.3: Early Moonie/ Kogan Creek



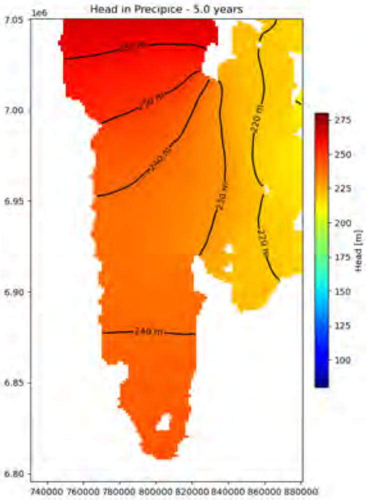
Scenario 2.3: Early Moonie/ Kogan Creek



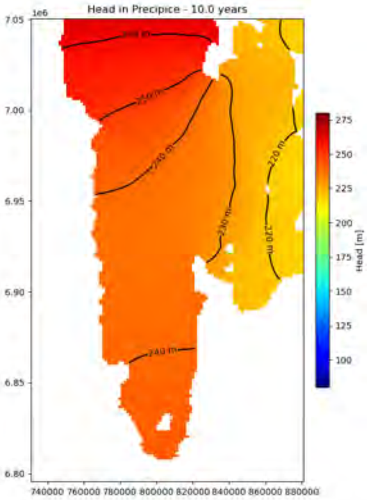
Scenario 2.3: Early Moonie/ Kogan Creek



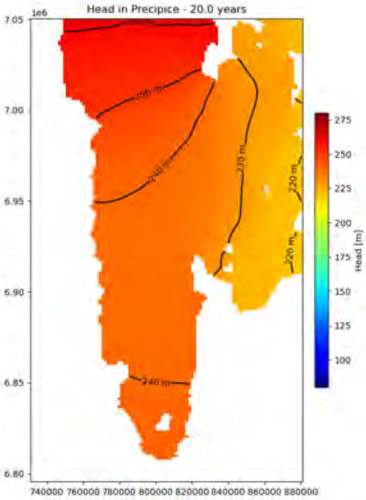
Scenario 2.3: Early Moonie/ Kogan Creek



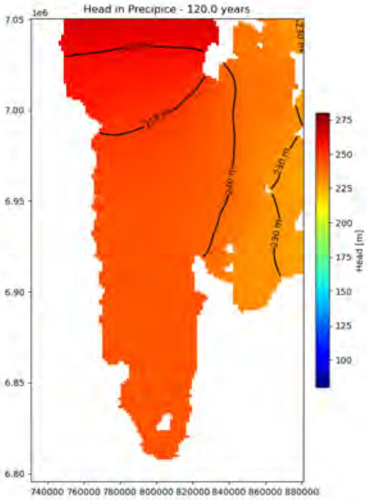
Scenario 2.3: Early Moonie/ Kogan Creek



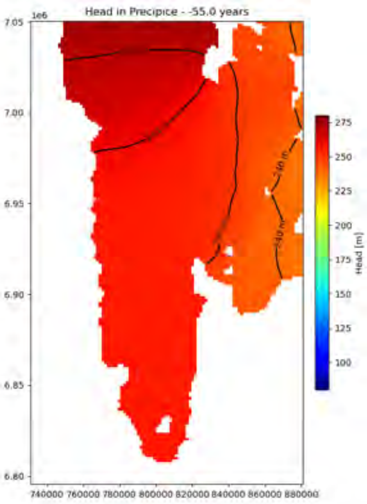
Scenario 2.3: Early Moonie/ Kogan Creek



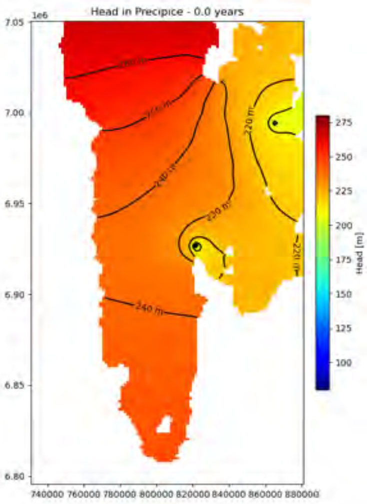
Scenario 2.3: Early Moonie/ Kogan Creek



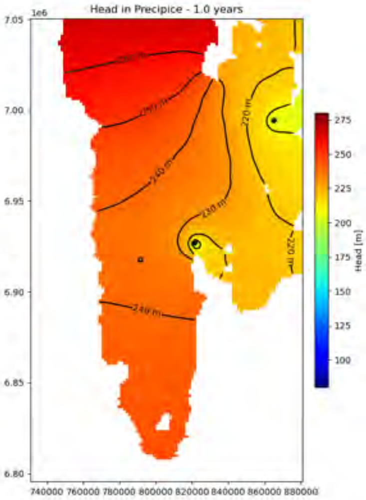
Scenario 2.3: Early Moonie/ Kogan Creek



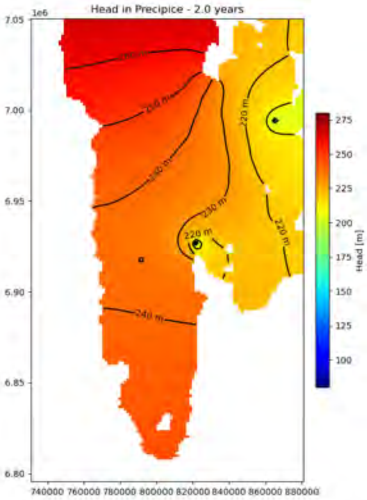
Scenario 2.4: Low porosity



Scenario 2.4: Low porosity



Scenario 2.4: Low porosity



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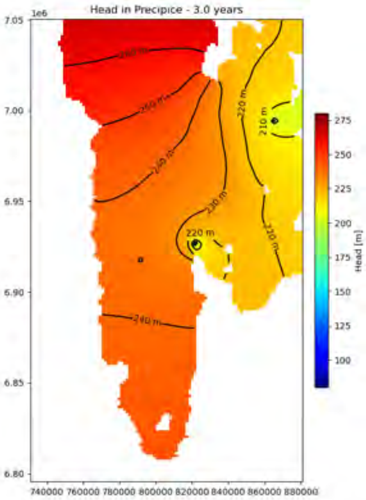

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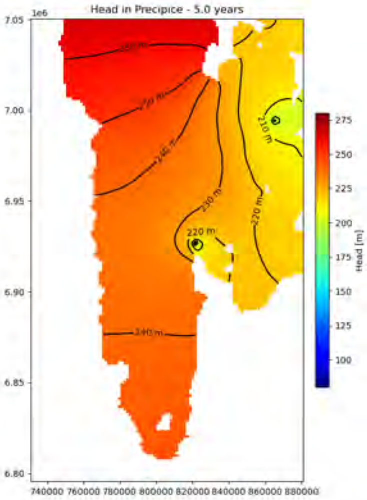

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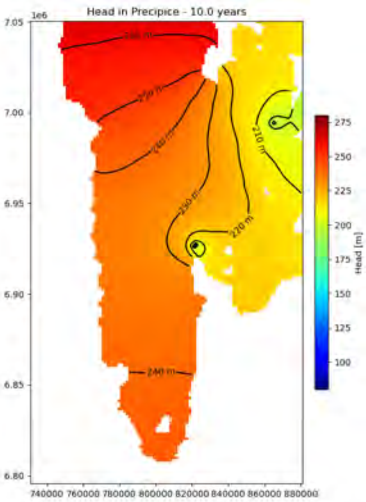

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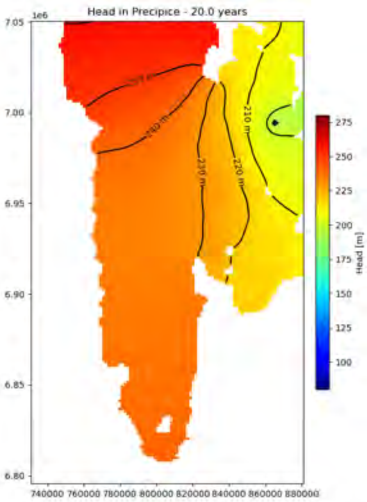

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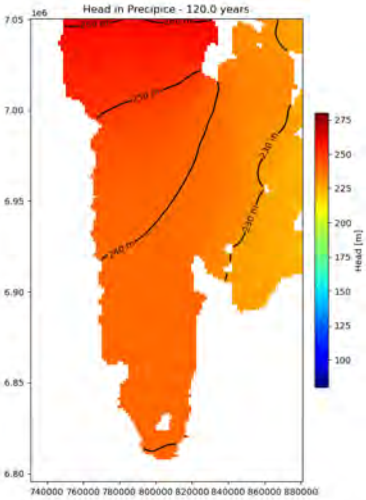

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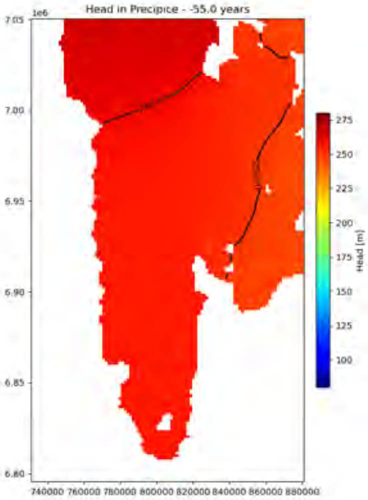
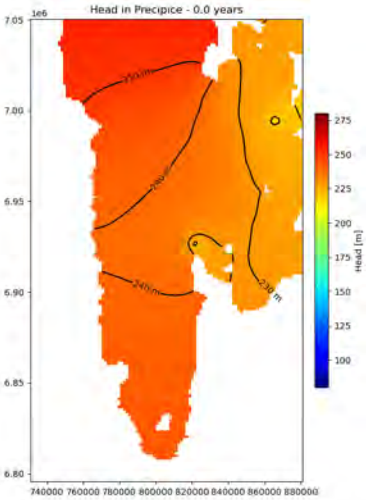
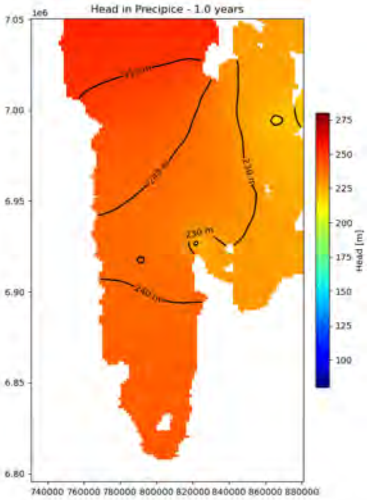


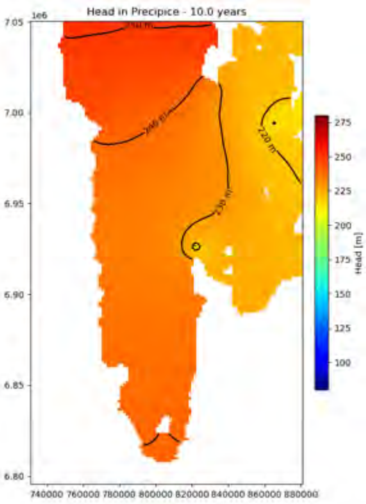
Scenario 2.5: High hydraulic conductivity



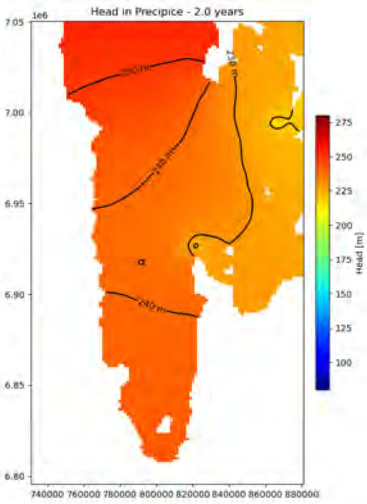
Scenario 2.5: High hydraulic conductivity



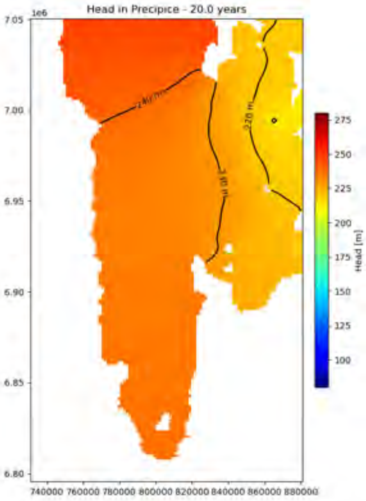
Scenario 2.5: High hydraulic conductivity



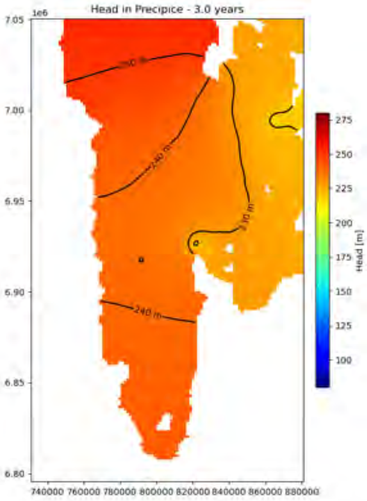
Scenario 2.5: High hydraulic conductivity



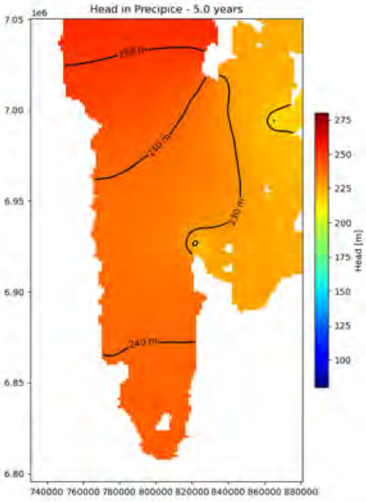
Scenario 2.5: High hydraulic conductivity



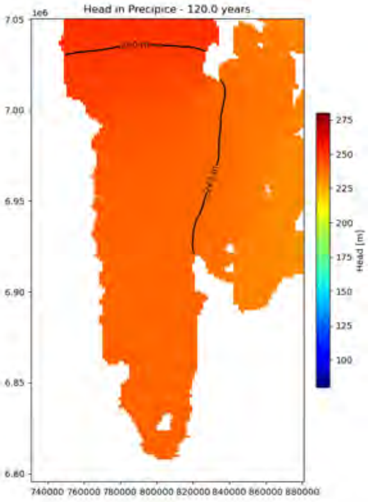
Scenario 2.5: High hydraulic conductivity



Scenario 2.5: High hydraulic conductivity



Scenario 2.5: High hydraulic conductivity



Scenario 2.5: High hydraulic conductivity

APPENDIX E

ALS Laboratory Certificates

Australian Laboratory Services Pty. Ltd.

32 Shand Street
Stafford
Brisbane QLD 4053
Phone: +61 7 3243 7222 Fax: +61 7 3243 7218
www.alsglobal.com/geochemistry

ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation No: 825, Corporate Site No: 818.

To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

CERTIFICATE BR21092657

Project: West Moonie 1

P.O. No.: 6000452

This report is for 98 samples of Drill Core submitted to our lab in Brisbane, QLD, Australia on 16-APR-2021.

The following have access to data associated with this certificate:

NICK HALL	ROB HEATH	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LEV-01	Waste Disposal Levy
TRA-21	Transfer sample
LOG-22	Sample login - Rcd w/o BarCode
PUL-31m	Metallurgy Sample
WSH-22	"Wash" pulverizers

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-MS61	48 element four acid ICP-MS	

This is the Final Report and supersedes any preliminary report with this certificate number.Results apply to samples as submitted.All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager

Sample Description	Method Analyte Units LOD	WEI-21 Recvd Wt. kg 0.02	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01
West Moonie 1 2234.4		<0.02	0.03	2.09	2.7	90	0.56	0.15	0.02	0.04	22.1	11.5	36	0.94	13.1	2.95
West Moonie 1 2237		<0.02	0.04	8.44	2.9	290	2.71	0.22	0.03	0.07	39.7	6.8	63	4.81	34.1	2.72
West Moonie 1 2241		0.03	0.05	4.55	6.1	230	1.19	0.15	0.04	0.05	69.1	10.1	55	4.18	10.3	1.61
West Moonie 1 2243		<0.02	0.09	9.59	4.2	340	2.92	0.59	0.04	0.14	70.2	12.1	73	13.25	29.0	2.43
West Moonie 1 2247.4		<0.02	0.07	8.15	8.5	410	2.97	0.72	0.03	0.10	109.0	13.1	82	14.60	38.4	1.40
West Moonie 1 2250		<0.02	0.09	7.55	13.2	460	2.51	0.40	0.15	0.40	74.2	183.5	57	1.92	33.0	2.24
West Moonie 1 2253.7		<0.02	0.03	5.95	4.5	440	1.26	0.08	0.10	0.06	73.7	11.9	31	1.38	6.3	2.28
West Moonie 1 2257.3		<0.02	0.05	8.05	5.0	480	2.36	0.17	0.09	0.11	86.0	31.7	46	2.51	12.8	0.97
West Moonie 1 2260.8		<0.02	0.08	9.37	9.8	440	3.51	0.37	0.10	0.17	140.0	33.9	51	3.54	21.8	0.93
West Moonie 1 2263.75		0.03	0.03	1.91	2.8	140	0.29	0.04	0.01	<0.02	10.75	3.7	11	1.36	2.5	0.69
West Moonie 1 2267.2		0.02	0.12	3.29	10.6	220	1.08	0.71	0.07	0.11	80.3	17.0	39	3.38	31.9	3.70
West Moonie 1 2270		0.02	0.03	2.76	1.6	180	0.61	0.07	0.01	0.02	12.25	2.1	20	1.90	5.9	1.26
West Moonie 1 2273.18		0.07	0.03	3.77	1.4	190	0.76	0.06	0.01	0.08	22.8	1.6	17	2.09	3.8	0.50
West Moonie 1 2275		0.03	0.03	1.13	1.7	70	0.39	0.04	0.01	<0.02	23.3	1.9	33	0.79	4.7	1.19
West Moonie 1 2276.84		0.02	0.04	2.83	3.0	160	1.06	0.12	0.02	0.02	37.4	4.0	44	2.51	8.5	1.60
West Moonie 1 2279.97		0.04	0.02	2.07	1.8	100	0.53	0.08	0.01	0.06	22.6	4.5	19	1.27	9.4	0.89
West Moonie 1 2283.18		0.03	0.03	2.18	2.4	40	0.44	0.05	0.01	0.02	12.95	5.9	13	0.57	3.6	0.79
West Moonie 1 2286.1		0.05	0.03	1.83	0.9	60	0.49	0.08	0.01	0.02	19.55	3.3	20	1.09	4.6	0.59
West Moonie 1 2287.95		0.02	0.02	1.98	1.0	30	0.33	0.07	0.03	0.02	11.20	1.7	21	0.54	6.2	1.84
West Moonie 1 2289.91		0.06	0.03	2.43	0.8	50	0.60	0.10	0.01	0.02	24.5	2.6	22	0.89	5.7	0.63
West Moonie 1 2293		0.03	0.03	0.96	1.9	40	0.19	0.08	0.01	<0.02	17.45	3.6	14	0.34	6.8	1.19
West Moonie 1 2295		0.03	0.02	0.44	0.7	40	0.16	0.04	0.01	<0.02	13.05	0.8	13	0.19	4.1	0.99
West Moonie 1 2298.1		0.08	0.02	1.13	0.6	50	0.30	0.06	0.01	<0.02	19.60	1.0	12	0.75	4.0	0.71
West Moonie 1 2300.45		0.06	0.04	2.86	1.6	90	1.01	0.26	0.01	0.16	95.8	3.8	18	1.66	14.0	0.65
West Moonie 1 2302.8		<0.02	0.01	0.76	0.7	40	0.17	0.03	0.01	<0.02	11.45	1.1	21	0.23	6.3	2.22
West Moonie 1 2305.4		0.03	0.02	1.05	0.7	70	0.32	0.05	0.01	<0.02	32.5	1.4	17	0.62	3.9	0.83
West Moonie 1 2308.2		0.02	0.01	0.83	0.8	40	0.17	0.03	0.01	<0.02	10.70	1.3	20	0.27	6.5	2.20
West Moonie 1 2311.7		0.03	0.01	0.49	0.6	40	0.13	0.03	0.01	<0.02	12.85	1.0	14	0.19	4.0	1.25
West Moonie 1 2314.8		0.03	0.02	0.52	1.0	40	0.15	0.04	0.01	<0.02	15.70	2.4	14	0.21	2.9	1.09
West Moonie 1 2317.7		0.04	0.01	0.28	0.6	30	0.10	0.05	0.01	<0.02	8.93	0.7	8	0.14	7.7	0.70
West Moonie 1 2320.55		0.03	0.01	0.61	0.5	60	0.15	0.03	0.01	<0.02	11.20	0.7	12	0.37	3.3	1.02
West Moonie 1 2324.5		0.03	0.01	0.34	0.5	50	0.11	0.03	0.01	<0.02	9.78	0.7	13	0.17	3.7	1.04
West Moonie 1 2326.95		<0.02	0.01	0.38	0.6	50	0.11	0.02	0.01	<0.02	8.48	0.9	18	0.21	5.0	1.94
West Moonie 1 2330.6		Not Recvd														
West Moonie 1 2333.3		0.02	0.01	0.45	0.6	60	0.13	0.03	0.01	<0.02	15.40	0.9	20	0.26	4.3	1.17
West Moonie 1 2334.9		0.05	0.01	1.00	0.6	70	0.23	0.06	0.01	<0.02	17.95	1.2	17	0.65	3.3	0.69
West Moonie 1 2337.2		0.06	0.04	1.57	0.8	80	0.34	0.04	0.01	<0.02	16.50	1.5	12	0.89	4.0	0.66
West Moonie 1 2339.6		Not Recvd														
West Moonie 1 2343.5		0.04	0.06	5.95	2.8	410	2.07	0.31	0.21	0.07	53.7	9.7	36	6.07	16.9	10.20
West Moonie 1 2345.5		0.03	0.07	6.21	3.7	510	1.52	0.18	0.13	0.05	43.8	7.1	22	4.10	10.4	2.42

Australian Laboratory Services Pty. Ltd.

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To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
LOD	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5
West Moonie 1 2234.4	5.52	0.07	1.2	0.021	0.56	10.4	12.4	0.05	363	1.68	0.04	5.1	23.9	50	6.5
West Moonie 1 2237	20.8	0.11	3.2	0.083	1.49	18.7	64.5	0.12	267	1.76	0.12	12.6	20.4	90	17.7
West Moonie 1 2241	10.90	0.14	4.6	0.038	1.25	33.6	19.6	0.15	123	0.85	0.09	9.7	30.9	90	11.5
West Moonie 1 2243	26.1	0.16	5.2	0.107	1.73	32.2	70.8	0.20	216	2.27	0.14	15.7	30.7	140	28.3
West Moonie 1 2247.4	25.5	0.20	6.3	0.143	2.24	49.7	40.7	0.16	127	2.35	0.13	23.4	21.1	160	35.8
West Moonie 1 2250	20.6	0.15	4.7	0.183	2.16	30.9	24.5	0.13	276	11.05	0.15	10.7	179.5	350	44.0
West Moonie 1 2253.7	13.40	0.15	2.6	0.047	2.18	33.1	15.9	0.14	348	0.64	0.12	5.4	10.8	290	14.2
West Moonie 1 2257.3	21.6	0.17	4.1	0.086	2.27	38.6	30.8	0.11	109	1.76	0.15	12.0	28.1	340	21.7
West Moonie 1 2260.8	26.5	0.24	7.5	0.083	2.11	59.9	37.2	0.11	82	2.12	0.14	16.1	34.6	460	32.2
West Moonie 1 2263.75	3.81	0.05	0.8	0.012	1.06	5.0	5.9	0.02	76	0.44	0.06	1.6	5.9	40	6.5
West Moonie 1 2267.2	8.47	0.17	3.6	0.205	1.38	40.7	8.0	0.14	785	1.86	0.08	11.3	33.6	160	23.6
West Moonie 1 2270	5.90	0.06	1.1	0.017	1.33	5.8	8.3	0.03	151	0.66	0.07	2.7	6.4	50	8.5
West Moonie 1 2273.18	7.17	0.06	1.0	0.020	1.36	10.3	10.2	0.03	49	0.29	0.08	2.9	5.7	60	8.0
West Moonie 1 2275	3.09	0.06	1.8	0.010	0.56	11.7	3.2	0.02	137	0.61	0.03	5.4	6.5	50	7.4
West Moonie 1 2276.84	9.27	0.09	2.9	0.028	1.20	18.7	6.3	0.07	186	0.78	0.07	9.4	11.4	80	22.6
West Moonie 1 2279.97	4.91	0.05	1.1	0.020	0.80	8.8	6.1	0.03	125	0.44	0.05	3.6	10.0	40	9.3
West Moonie 1 2283.18	4.36	0.05	0.8	0.019	0.18	6.2	7.7	0.01	83	0.68	0.02	1.5	11.0	40	9.5
West Moonie 1 2286.1	5.02	0.05	1.5	0.026	0.30	10.5	6.3	0.03	61	0.49	0.03	4.4	9.7	40	8.4
West Moonie 1 2287.95	4.18	<0.05	0.7	0.016	0.39	5.3	6.7	0.02	192	0.98	0.04	1.7	8.0	30	5.4
West Moonie 1 2289.91	5.79	0.05	1.4	0.020	0.32	11.3	8.3	0.03	63	0.49	0.03	5.7	10.5	50	10.0
West Moonie 1 2293	2.21	<0.05	1.6	0.010	0.18	9.7	3.2	0.01	126	0.91	0.02	3.3	10.2	40	6.1
West Moonie 1 2295	1.23	<0.05	0.9	0.005	0.21	7.4	2.5	0.01	106	0.84	0.03	2.5	4.0	30	4.8
West Moonie 1 2298.1	3.46	<0.05	1.3	0.011	0.29	10.6	4.1	0.01	75	0.53	0.03	3.8	3.9	40	7.7
West Moonie 1 2300.45	9.17	0.10	2.6	0.038	0.34	52.7	9.9	0.03	63	0.55	0.03	5.8	9.4	180	25.3
West Moonie 1 2302.8	2.00	<0.05	0.8	0.006	0.19	6.5	3.0	0.01	252	1.14	0.03	1.4	6.4	30	4.5
West Moonie 1 2305.4	3.31	<0.05	2.1	0.014	0.25	16.8	3.6	0.02	110	0.67	0.03	6.2	5.0	50	7.9
West Moonie 1 2308.2	2.24	<0.05	0.6	0.005	0.19	5.9	3.7	0.01	257	1.31	0.03	1.4	6.8	30	4.4
West Moonie 1 2311.7	1.37	<0.05	0.7	0.005	0.19	6.5	2.5	0.01	158	0.70	0.03	1.6	3.8	30	4.2
West Moonie 1 2314.8	1.47	<0.05	1.0	<0.005	0.15	7.8	2.5	0.01	117	0.83	0.02	3.0	6.8	30	7.5
West Moonie 1 2317.7	0.82	<0.05	0.5	0.006	0.22	4.8	2.0	<0.01	78	0.45	0.03	0.6	2.5	20	3.3
West Moonie 1 2320.55	1.95	<0.05	0.7	0.006	0.20	6.0	2.8	0.01	112	0.57	0.03	2.0	6.1	20	4.7
West Moonie 1 2324.5	1.03	<0.05	0.7	<0.005	0.18	5.5	2.4	0.01	114	0.89	0.03	1.8	4.7	20	4.4
West Moonie 1 2326.95	1.20	<0.05	0.6	0.005	0.20	4.8	2.5	<0.01	206	1.03	0.03	0.9	5.6	20	3.6
West Moonie 1 2330.6															
West Moonie 1 2333.3	1.29	<0.05	1.1	<0.005	0.20	8.1	2.7	0.01	123	0.66	0.03	3.5	3.6	20	3.9
West Moonie 1 2334.9	2.99	<0.05	1.5	0.008	0.28	9.3	4.0	0.01	73	0.43	0.03	4.0	4.9	30	5.8
West Moonie 1 2337.2	4.23	<0.05	1.1	0.010	0.26	8.4	6.2	0.02	68	0.46	0.03	3.0	5.8	30	6.2
West Moonie 1 2339.6															
West Moonie 1 2343.5	15.15	0.19	3.8	0.053	2.30	27.1	25.9	0.51	1900	1.15	0.13	8.1	16.4	210	17.8
West Moonie 1 2345.5	15.10	0.10	3.0	0.047	2.74	23.4	22.7	0.32	364	1.14	0.15	6.2	10.5	230	17.1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
	Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
	Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
	LOD	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1
West Moonie 1 2234.4		24.6	<0.002	0.01	0.30	3.1	<1	1.2	16.5	0.42	<0.05	3.45	0.169	0.15	0.8	24
West Moonie 1 2237		81.1	<0.002	0.01	0.47	11.2	<1	3.0	51.5	0.93	0.05	8.20	0.475	0.36	2.0	86
West Moonie 1 2241		68.4	<0.002	0.13	0.76	6.4	<1	3.4	40.4	0.74	<0.05	14.65	0.424	1.17	2.0	58
West Moonie 1 2243		108.5	<0.002	0.04	0.73	16.0	1	4.4	69.0	1.10	0.09	13.75	0.590	0.52	2.9	103
West Moonie 1 2247.4		130.0	<0.002	0.06	0.81	21.3	<1	5.2	78.3	1.75	0.09	20.2	0.884	0.80	4.7	120
West Moonie 1 2250		85.4	0.004	0.22	1.18	15.5	1	3.1	91.3	0.72	0.16	11.65	0.524	1.57	2.8	106
West Moonie 1 2253.7		80.5	<0.002	0.03	0.37	11.4	<1	1.2	77.6	0.37	<0.05	9.32	0.231	0.45	1.6	57
West Moonie 1 2257.3		94.5	<0.002	0.04	0.48	12.4	<1	2.5	87.5	0.80	0.05	12.20	0.489	0.58	2.4	99
West Moonie 1 2260.8		98.7	<0.002	0.15	0.87	14.2	1	4.1	97.8	1.16	0.07	22.7	0.612	0.76	4.6	115
West Moonie 1 2263.75		49.5	<0.002	0.02	0.36	1.4	<1	1.1	19.9	0.17	<0.05	2.03	0.049	0.26	0.5	9
West Moonie 1 2267.2		69.6	<0.002	0.05	0.89	8.0	<1	4.0	85.4	0.91	0.08	11.70	0.383	0.51	2.9	39
West Moonie 1 2270		64.0	<0.002	0.01	0.36	1.9	<1	1.6	25.8	0.25	<0.05	2.68	0.081	0.31	0.7	16
West Moonie 1 2273.18		67.9	<0.002	0.03	0.34	2.3	<1	1.3	37.3	0.23	<0.05	3.07	0.079	0.33	0.7	25
West Moonie 1 2275		24.0	<0.002	0.02	0.37	1.7	<1	1.6	18.2	0.47	<0.05	4.42	0.237	0.13	0.8	14
West Moonie 1 2276.84		62.9	<0.002	0.03	0.47	5.7	<1	3.4	43.3	0.74	<0.05	6.66	0.322	0.30	1.9	38
West Moonie 1 2279.97		36.6	<0.002	0.02	0.32	2.6	<1	1.1	25.0	0.31	<0.05	2.97	0.123	0.18	0.8	20
West Moonie 1 2283.18		9.8	<0.002	0.02	0.38	1.4	<1	1.1	23.7	0.16	<0.05	2.71	0.040	0.08	0.6	12
West Moonie 1 2286.1		17.0	<0.002	0.02	0.30	2.5	<1	1.9	19.5	0.40	<0.05	3.77	0.170	0.10	1.0	20
West Moonie 1 2287.95		9.7	<0.002	0.01	0.26	1.5	<1	0.9	15.9	0.16	<0.05	2.00	0.053	0.06	0.5	13
West Moonie 1 2289.91		17.4	<0.002	0.01	0.28	2.3	<1	1.5	28.2	0.46	<0.05	4.56	0.199	0.08	1.1	17
West Moonie 1 2293		4.5	<0.002	0.01	0.31	0.9	<1	1.2	16.9	0.31	<0.05	4.07	0.102	0.05	0.8	7
West Moonie 1 2295		2.5	<0.002	0.01	0.16	0.6	<1	0.7	13.1	0.23	<0.05	2.77	0.083	0.04	0.6	4
West Moonie 1 2298.1		9.8	<0.002	0.01	0.21	1.4	<1	1.2	19.4	0.34	<0.05	3.71	0.109	0.07	0.9	10
West Moonie 1 2300.45		18.2	<0.002	0.03	0.36	2.9	<1	2.1	88.2	0.57	<0.05	10.65	0.167	0.17	2.2	24
West Moonie 1 2302.8		3.4	<0.002	0.01	0.18	0.7	<1	0.7	12.1	0.14	<0.05	2.08	0.042	0.03	0.5	6
West Moonie 1 2305.4		9.5	<0.002	0.01	0.24	1.7	<1	2.1	26.6	0.53	<0.05	7.47	0.215	0.07	1.3	12
West Moonie 1 2308.2		3.9	<0.002	0.01	0.19	0.6	<1	0.7	12.0	0.14	<0.05	1.81	0.043	0.03	0.4	6
West Moonie 1 2311.7		2.1	<0.002	0.01	0.16	0.6	<1	0.6	13.3	0.15	<0.05	2.22	0.056	<0.02	0.5	4
West Moonie 1 2314.8		2.4	<0.002	0.02	0.21	0.6	<1	0.9	14.8	0.29	<0.05	2.75	0.087	0.03	0.7	5
West Moonie 1 2317.7		1.5	<0.002	0.01	0.18	0.3	<1	0.3	9.9	0.07	<0.05	1.41	0.017	0.02	0.4	2
West Moonie 1 2320.55		4.8	<0.002	0.01	0.16	0.7	<1	0.7	12.1	0.18	<0.05	2.16	0.064	0.04	0.5	6
West Moonie 1 2324.5		2.0	<0.002	0.01	0.14	0.5	<1	0.6	10.0	0.17	<0.05	1.99	0.063	0.02	0.5	4
West Moonie 1 2326.95		2.4	<0.002	0.01	0.16	0.4	<1	0.6	10.1	0.10	<0.05	1.79	0.029	0.02	0.5	4
West Moonie 1 2330.6																
West Moonie 1 2333.3		2.7	<0.002	0.01	0.19	0.8	<1	1.6	10.2	0.36	<0.05	4.08	0.135	0.02	0.6	7
West Moonie 1 2334.9		7.4	<0.002	0.01	0.22	1.5	<1	1.3	15.8	0.37	<0.05	4.20	0.154	0.06	0.9	11
West Moonie 1 2337.2		9.7	<0.002	0.01	0.26	1.7	<1	1.2	17.5	0.29	<0.05	3.25	0.102	0.07	0.8	12
West Moonie 1 2339.6																
West Moonie 1 2343.5		109.5	<0.002	0.02	0.86	11.9	<1	3.7	76.3	0.68	<0.05	12.15	0.340	0.61	3.5	73
West Moonie 1 2345.5		123.0	<0.002	0.01	1.07	8.2	<1	3.6	80.2	0.57	<0.05	10.80	0.252	0.73	2.6	56

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description / Method / Analyte / Units / LOD	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
West Moonie 1 2234.4	0.9	6.3	29	44.9
West Moonie 1 2237	2.2	11.8	82	118.5
West Moonie 1 2241	1.5	17.7	83	193.5
West Moonie 1 2243	2.8	25.1	139	196.5
West Moonie 1 2247.4	4.0	36.2	90	243
West Moonie 1 2250	1.8	35.4	323	230
West Moonie 1 2253.7	1.0	18.2	54	95.1
West Moonie 1 2257.3	1.8	28.6	86	149.5
West Moonie 1 2260.8	2.6	37.9	89	254
West Moonie 1 2263.75	0.5	4.2	15	23.2
West Moonie 1 2267.2	2.6	20.8	99	135.5
West Moonie 1 2270	0.8	5.9	20	35.2
West Moonie 1 2273.18	0.6	6.5	33	30.1
West Moonie 1 2275	1.0	6.7	12	59.9
West Moonie 1 2276.84	2.0	15.8	19	106.5
West Moonie 1 2279.97	0.8	8.0	23	35.8
West Moonie 1 2283.18	0.3	6.1	20	23.8
West Moonie 1 2286.1	1.0	6.4	14	49.3
West Moonie 1 2287.95	0.5	3.6	16	23.3
West Moonie 1 2289.91	1.1	5.4	12	43.6
West Moonie 1 2293	0.7	4.1	7	45.0
West Moonie 1 2295	1.5	3.1	5	30.0
West Moonie 1 2298.1	0.9	4.3	10	39.3
West Moonie 1 2300.45	1.0	8.4	29	69.0
West Moonie 1 2302.8	0.4	2.2	8	25.9
West Moonie 1 2305.4	1.4	5.5	9	73.5
West Moonie 1 2308.2	0.4	2.0	6	18.4
West Moonie 1 2311.7	0.5	1.7	5	20.8
West Moonie 1 2314.8	0.5	2.9	4	31.6
West Moonie 1 2317.7	0.3	1.6	5	18.0
West Moonie 1 2320.55	0.4	2.1	5	22.0
West Moonie 1 2324.5	0.5	2.1	5	24.6
West Moonie 1 2326.95	0.3	1.9	5	20.3
West Moonie 1 2330.6				
West Moonie 1 2333.3	0.9	3.1	4	36.9
West Moonie 1 2334.9	1.0	4.0	8	48.3
West Moonie 1 2337.2	0.9	4.2	10	35.2
West Moonie 1 2339.6				
West Moonie 1 2343.5	2.4	24.8	60	106.0
West Moonie 1 2345.5	1.8	18.2	55	84.8

Sample Description	Method Analyte Units LOD	WEI-21 Recvd Wt. kg 0.02	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01
West Moonie 1 2348.75		0.02	0.05	4.98	2.4	460	1.25	0.13	0.16	0.04	37.3	5.2	20	3.05	8.3	2.67
West Moonie 1 2351.05		0.02	0.06	4.81	2.6	470	1.25	0.13	0.17	0.05	38.6	5.6	21	3.01	11.0	1.94
West Moonie 1 2354		0.04	0.05	4.84	2.8	460	1.17	0.11	0.31	0.03	41.4	5.8	17	2.73	7.7	1.83
West Moonie 1 2356.95		0.05	0.08	6.61	2.8	540	1.94	0.22	0.15	0.06	41.5	6.6	27	4.51	13.9	2.53
West Moonie 1 2361		0.03	0.05	6.15	3.2	570	1.58	0.17	0.27	0.04	43.9	7.0	25	4.00	11.8	3.07
West Moonie 1 2368.97		<0.02	0.04	5.35	2.7	490	1.26	0.15	0.49	0.05	32.4	6.2	30	3.42	11.0	2.37
West Moonie 1 2557.5		0.03	0.04	4.52	3.5	390	1.16	0.10	0.52	0.02	34.6	5.2	17	2.95	5.5	1.48
West Moonie 1 2560.45		0.02	0.05	5.89	4.5	490	1.66	0.13	0.10	0.03	34.4	7.0	19	4.07	7.7	2.12
West Moonie 1 2563.55		0.05	0.05	4.04	3.3	350	1.13	0.11	2.70	0.04	67.0	4.8	25	2.68	5.0	1.58
West Moonie 1 2619.35		0.03	0.04	4.41	2.2	420	1.04	0.10	0.08	0.02	28.7	3.6	13	2.58	6.8	1.52
West Moonie 1 2234.4 QF																
West Moonie 1 2237 QF																
West Moonie 1 2241 QF																
West Moonie 1 2243 QF																
West Moonie 1 2247.4 QF																
West Moonie 1 2250 QF																
West Moonie 1 2253.7 QF																
West Moonie 1 2257.3 QF																
West Moonie 1 2260.8 QF																
West Moonie 1 2263.75 Q/F																
West Moonie 1 2267.2 QF																
West Moonie 1 2270 QF																
West Moonie 1 2273.18 Q/F																
West Moonie 1 2275 QF																
West Moonie 1 2276.84 QF																
West Moonie 1 2279.97 QF																
West Moonie 1 2283.18 QF																
West Moonie 1 2286.1 QF																
West Moonie 1 2287.95 QF																
West Moonie 1 2289.91 QF																
West Moonie 1 2293 QF																
West Moonie 1 2295 QF																
West Moonie 1 2298.1 QF																
West Moonie 1 2300.45 QF																
West Moonie 1 2302.8 QF																
West Moonie 1 2305.4 QF																
West Moonie 1 2308.2 QF																
West Moonie 1 2311.7 QF																
West Moonie 1 2314.8 QF																
West Moonie 1 2317.7 QF																

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
	Analyte	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
	Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
	LOD	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5
West Moonie 1 2348.75		12.75	0.10	2.8	0.038	2.43	20.0	19.4	0.29	420	2.18	0.13	5.3	8.1	260	13.7
West Moonie 1 2351.05		13.05	0.10	2.7	0.036	2.43	20.9	20.3	0.26	238	1.11	0.13	4.7	8.7	250	13.0
West Moonie 1 2354		12.40	0.10	2.5	0.032	2.41	21.3	19.5	0.33	277	0.72	0.13	4.5	8.8	290	17.5
West Moonie 1 2356.95		16.45	0.11	3.3	0.052	2.87	22.0	31.8	0.44	312	0.56	0.17	7.1	10.6	290	17.6
West Moonie 1 2361		15.00	0.12	3.0	0.046	3.13	22.2	26.2	0.53	394	0.56	0.17	6.6	11.0	230	17.3
West Moonie 1 2368.97		13.40	0.10	3.0	0.033	2.67	17.1	21.8	0.42	299	0.97	0.64	5.8	9.6	170	14.0
West Moonie 1 2557.5		11.15	0.10	2.4	0.030	1.89	17.9	13.0	0.24	277	0.55	1.03	4.5	7.3	80	13.8
West Moonie 1 2560.45		14.20	0.10	2.7	0.032	2.39	18.1	17.6	0.37	207	0.69	1.26	5.2	10.3	100	17.5
West Moonie 1 2563.55		11.10	0.14	2.6	0.035	1.74	33.7	12.2	0.27	956	0.48	1.00	5.3	7.7	100	13.9
West Moonie 1 2619.35		10.55	0.09	2.3	0.026	1.91	15.0	11.0	0.21	149	0.74	0.69	4.0	6.1	50	10.6
West Moonie 1 2234.4 QF																
West Moonie 1 2237 QF																
West Moonie 1 2241 QF																
West Moonie 1 2243 QF																
West Moonie 1 2247.4 QF																
West Moonie 1 2250 QF																
West Moonie 1 2253.7 QF																
West Moonie 1 2257.3 QF																
West Moonie 1 2260.8 QF																
West Moonie 1 2263.75 Q/F																
West Moonie 1 2267.2 QF																
West Moonie 1 2270 QF																
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West Moonie 1 2279.97 QF																
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West Moonie 1 2286.1 QF																
West Moonie 1 2287.95 QF																
West Moonie 1 2289.91 QF																
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West Moonie 1 2298.1 QF																
West Moonie 1 2300.45 QF																
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West Moonie 1 2317.7 QF																

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Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description / Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
LOD	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1
West Moonie 1 2348.75	109.0	<0.002	0.02	0.95	6.6	<1	2.4	74.8	0.48	<0.05	9.90	0.215	0.65	2.3	42
West Moonie 1 2351.05	104.5	<0.002	0.01	0.84	6.3	<1	2.1	73.9	0.45	<0.05	8.98	0.192	0.62	2.1	44
West Moonie 1 2354	108.5	<0.002	0.01	0.75	6.4	<1	2.2	86.1	0.42	<0.05	8.78	0.177	0.63	2.0	38
West Moonie 1 2356.95	137.5	<0.002	0.02	0.93	9.2	<1	3.4	82.2	0.64	<0.05	11.85	0.284	0.79	2.9	61
West Moonie 1 2361	146.5	<0.002	0.01	0.67	8.8	<1	2.8	74.0	0.57	<0.05	10.45	0.249	0.80	2.6	55
West Moonie 1 2368.97	121.0	<0.002	0.01	0.79	6.7	<1	2.6	68.6	0.53	<0.05	8.69	0.244	0.70	2.0	43
West Moonie 1 2557.5	92.2	<0.002	0.01	0.80	5.0	<1	2.0	119.5	0.42	<0.05	7.96	0.163	0.53	1.8	33
West Moonie 1 2560.45	118.0	<0.002	0.01	0.80	6.2	<1	2.2	92.6	0.46	<0.05	8.79	0.177	0.67	2.2	43
West Moonie 1 2563.55	83.5	<0.002	<0.01	0.60	5.2	<1	1.8	307	0.53	<0.05	11.70	0.219	0.49	1.9	36
West Moonie 1 2619.35	84.8	<0.002	0.01	0.67	4.3	<1	1.6	64.8	0.36	<0.05	6.61	0.123	0.46	1.6	28
West Moonie 1 2234.4 QF															
West Moonie 1 2237 QF															
West Moonie 1 2241 QF															
West Moonie 1 2243 QF															
West Moonie 1 2247.4 QF															
West Moonie 1 2250 QF															
West Moonie 1 2253.7 QF															
West Moonie 1 2257.3 QF															
West Moonie 1 2260.8 QF															
West Moonie 1 2263.75 Q/F															
West Moonie 1 2267.2 QF															
West Moonie 1 2270 QF															
West Moonie 1 2273.18 Q/F															
West Moonie 1 2275 QF															
West Moonie 1 2276.84 QF															
West Moonie 1 2279.97 QF															
West Moonie 1 2283.18 QF															
West Moonie 1 2286.1 QF															
West Moonie 1 2287.95 QF															
West Moonie 1 2289.91 QF															
West Moonie 1 2293 QF															
West Moonie 1 2295 QF															
West Moonie 1 2298.1 QF															
West Moonie 1 2300.45 QF															
West Moonie 1 2302.8 QF															
West Moonie 1 2305.4 QF															
West Moonie 1 2308.2 QF															
West Moonie 1 2311.7 QF															
West Moonie 1 2314.8 QF															
West Moonie 1 2317.7 QF															

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method Analyte Units LOD	ME-MS61 W ppm 0.1	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
West Moonie 1 2348.75		1.5	16.3	41	78.5
West Moonie 1 2351.05		1.8	16.2	46	75.5
West Moonie 1 2354		1.1	16.1	39	72.8
West Moonie 1 2356.95		1.7	19.6	61	94.8
West Moonie 1 2361		1.4	19.6	54	85.5
West Moonie 1 2368.97		1.8	15.7	45	82.8
West Moonie 1 2557.5		1.0	13.6	32	69.0
West Moonie 1 2560.45		1.1	15.2	43	80.8
West Moonie 1 2563.55		1.1	20.0	36	70.8
West Moonie 1 2619.35		0.9	12.8	31	70.1
West Moonie 1 2234.4 QF					
West Moonie 1 2237 QF					
West Moonie 1 2241 QF					
West Moonie 1 2243 QF					
West Moonie 1 2247.4 QF					
West Moonie 1 2250 QF					
West Moonie 1 2253.7 QF					
West Moonie 1 2257.3 QF					
West Moonie 1 2260.8 QF					
West Moonie 1 2263.75 Q/F					
West Moonie 1 2267.2 QF					
West Moonie 1 2270 QF					
West Moonie 1 2273.18 Q/F					
West Moonie 1 2275 QF					
West Moonie 1 2276.84 QF					
West Moonie 1 2279.97 QF					
West Moonie 1 2283.18 QF					
West Moonie 1 2286.1 QF					
West Moonie 1 2287.95 QF					
West Moonie 1 2289.91 QF					
West Moonie 1 2293 QF					
West Moonie 1 2295 QF					
West Moonie 1 2298.1 QF					
West Moonie 1 2300.45 QF					
West Moonie 1 2302.8 QF					
West Moonie 1 2305.4 QF					
West Moonie 1 2308.2 QF					
West Moonie 1 2311.7 QF					
West Moonie 1 2314.8 QF					
West Moonie 1 2317.7 QF					

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Sample Description Method	WEI-21	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Recvd Wt.	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe
Units	kg	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%
LOD	0.02	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01
West Moonie 1 2320.55 QF															
West Moonie 1 2324.5 QF															
West Moonie 1 2326.95 QF															
West Moonie 1 2334.9 QF															
West Moonie 1 2337.2 QF															
West Moonie 1 2343.5 QF															
West Moonie 1 2348.75 QF															
West Moonie 1 2351.05 QF															
West Moonie 1 2354 QF															
West Moonie 1 2356.95 QF															
West Moonie 1 2361 QF															
West Moonie 1 2368.97 QF															
West Moonie 1 2557.5 QF															
West Moonie 1 2560.45 QF															
West Moonie 1 2563.55 QF															
West Moonie 1 2619.35 QF															

***** See Appendix Page for comments regarding this certificate *****

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
Units	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm
Sample Description LOD	0.05	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5
West Moonie 1 2320.55 QF															
West Moonie 1 2324.5 QF															
West Moonie 1 2326.95 QF															
West Moonie 1 2334.9 QF															
West Moonie 1 2337.2 QF															
West Moonie 1 2343.5 QF															
West Moonie 1 2348.75 QF															
West Moonie 1 2351.05 QF															
West Moonie 1 2354 QF															
West Moonie 1 2356.95 QF															
West Moonie 1 2361 QF															
West Moonie 1 2368.97 QF															
West Moonie 1 2557.5 QF															
West Moonie 1 2560.45 QF															
West Moonie 1 2563.55 QF															
West Moonie 1 2619.35 QF															

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To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V
Units	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm
LOD	0.1	0.002	0.01	0.05	0.1	1	0.2	0.2	0.05	0.05	0.01	0.005	0.02	0.1	1
Sample Description															
West Moonie 1 2320.55 QF															
West Moonie 1 2324.5 QF															
West Moonie 1 2326.95 QF															
West Moonie 1 2334.9 QF															
West Moonie 1 2337.2 QF															
West Moonie 1 2343.5 QF															
West Moonie 1 2348.75 QF															
West Moonie 1 2351.05 QF															
West Moonie 1 2354 QF															
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West Moonie 1 2361 QF															
West Moonie 1 2368.97 QF															
West Moonie 1 2557.5 QF															
West Moonie 1 2560.45 QF															
West Moonie 1 2563.55 QF															
West Moonie 1 2619.35 QF															

***** See Appendix Page for comments regarding this certificate *****

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	W	Y	Zn	Zr
Units	ppm	ppm	ppm	ppm
Sample Description / LOD	0.1	0.1	2	0.5
West Moonie 1 2320.55 QF				
West Moonie 1 2324.5 QF				
West Moonie 1 2326.95 QF				
West Moonie 1 2334.9 QF				
West Moonie 1 2337.2 QF				
West Moonie 1 2343.5 QF				
West Moonie 1 2348.75 QF				
West Moonie 1 2351.05 QF				
West Moonie 1 2354 QF				
West Moonie 1 2356.95 QF				
West Moonie 1 2361 QF				
West Moonie 1 2368.97 QF				
West Moonie 1 2557.5 QF				
West Moonie 1 2560.45 QF				
West Moonie 1 2563.55 QF				
West Moonie 1 2619.35 QF				

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BRISBANE QLD 4000

Page: Appendix 1
Total # Appendix Pages: 1
Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

CERTIFICATE OF ANALYSIS BR21092657

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REEs may not be totally soluble in this method.

Applies to Method: ME-MS61

ACCREDITATION COMMENTS

NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones,ICPMS Supervising Chemist

Applies to Method: ME-MS61

LABORATORY ADDRESSES

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23 Pineapple Street, Zillmere, QLD, 4034, Australia

Applies to Method:

LEV-01
TRA-21
LOG-22
WEI-21
ME-MS61
WSH-22
PUL-31m

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To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

QC CERTIFICATE BR21092657

Project: West Moonie 1

P.O. No.: 6000452

This report is for 98 samples of Drill Core submitted to our lab in Brisbane, QLD, Australia on 16-APR-2021.

The following have access to data associated with this certificate:

NICK HALL	ROB HEATH	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LEV-01	Waste Disposal Levy
TRA-21	Transfer sample
LOG-22	Sample login - Rcd w/o BarCode
PUL-31m	Metallurgy Sample
WSH-22	"Wash" pulverizers

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-MS61	48 element four acid ICP-MS	

This is the Final Report and supersedes any preliminary report with this certificate number.Results apply to samples as submitted.All pages of this report have been checked and approved for release.

***** See Appendix Page for comments regarding this certificate *****

Signature:

Shaun Kenny, Brisbane Laboratory Manager

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BRISBANE QLD 4000

Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Sample Description															
Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga
Units	ppm	%	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm
LOD	0.01	0.01	0.2	10	0.05	0.01	0.01	0.02	0.01	0.1	1	0.05	0.2	0.01	0.05
STANDARDS															
EMOG-17	66.6	4.47	570	410	1.90	5.29	1.91	19.70	46.0	722	53	7.56	8370	4.73	11.90
Target Range - Lower Bound	60.9	4.18	522	310	1.60	5.31	1.72	18.15	42.9	686	49	6.56	7750	4.42	10.75
Upper Bound	74.5	5.13	638	440	2.06	6.51	2.12	22.2	52.5	838	62	8.12	8910	5.42	13.25
GBM908-10	2.64	6.13	58.1	1010	1.42	1.44	3.57	1.77	100.0	26.2	130	3.88	3430	5.13	20.4
Target Range - Lower Bound	2.60	6.40	50.2	930	1.27	1.12	3.33	1.53	99.0	24.0	125	3.44	3350	4.98	18.65
Upper Bound	3.20	7.84	61.8	1280	1.66	1.39	4.10	1.91	121.0	29.6	155	4.32	3850	6.10	22.9
MRGeo08	4.26	7.19	34.8	1040	3.60	0.73	2.58	2.22	71.4	19.6	84	11.55	621	3.77	19.35
Target Range - Lower Bound	3.93	6.64	29.5	920	2.98	0.58	2.35	2.00	66.2	17.7	81	11.20	587	3.55	17.50
Upper Bound	4.83	8.14	36.5	1270	3.76	0.73	2.90	2.48	81.0	21.9	102	13.80	675	4.37	21.5
OREAS 152a	0.63	7.62	33.6	80	0.41	0.12	1.52	0.23	10.40	10.8	17	0.63	3730	3.52	16.75
Target Range - Lower Bound	0.59	7.20	31.0	50	0.33	0.12	1.42	0.16	8.58	10.8	15	0.58	3610	3.37	16.45
Upper Bound	0.75	8.83	38.3	110	0.58	0.17	1.75	0.27	10.50	13.5	21	0.85	4150	4.14	20.2
BLANKS															
BLANK	<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	1	<0.05	0.3	<0.01	<0.05
BLANK	<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	1	<0.05	0.3	<0.01	<0.05
BLANK	<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	1	<0.05	<0.2	<0.01	<0.05
BLANK	<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	1	<0.05	<0.2	<0.01	<0.05
Target Range - Lower Bound	<0.01	<0.01	<0.2	<10	<0.05	<0.01	<0.01	<0.02	<0.01	<0.1	<1	<0.05	<0.2	<0.01	<0.05
Upper Bound	0.02	0.02	0.4	20	0.10	0.02	0.02	0.04	0.02	0.2	2	0.10	0.4	0.02	0.10
DUPLICATES															
West Moonie 1 2267.2	0.12	3.29	10.6	220	1.08	0.71	0.07	0.11	80.3	17.0	39	3.38	31.9	3.70	8.47
DUP	0.10	3.16	10.7	210	1.14	0.72	0.07	0.11	79.7	17.3	37	3.25	32.2	3.54	8.30
Target Range - Lower Bound	0.09	3.05	9.9	190	1.00	0.67	0.06	0.08	76.0	16.2	35	3.10	30.7	3.43	7.92
Upper Bound	0.13	3.40	11.4	240	1.22	0.76	0.08	0.14	84.0	18.1	41	3.53	33.4	3.81	8.85
West Moonie 1 2317.7	0.01	0.28	0.6	30	0.10	0.05	0.01	<0.02	8.93	0.7	8	0.14	7.7	0.70	0.82
DUP	0.02	0.30	0.5	40	0.09	0.05	0.02	<0.02	9.36	0.6	7	0.15	7.7	0.65	0.82
Target Range - Lower Bound	<0.01	0.27	0.3	20	<0.05	0.04	<0.01	<0.02	8.68	0.5	6	0.09	7.2	0.63	0.73
Upper Bound	0.02	0.31	0.8	50	0.10	0.06	0.02	0.04	9.61	0.8	9	0.20	8.2	0.72	0.91

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
Analyte	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
Units	ppm	ppm	ppm	%	ppm	ppm	%	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
Sample Description LOD	0.05	0.1	0.005	0.01	0.5	0.2	0.01	5	0.05	0.01	0.1	0.2	10	0.5	0.1
STANDARDS															
EMOG-17	0.18	1.9	0.928	1.64	22.8	26.7	0.93	736	1110	1.11	14.1	7630	770	7210	111.5
Target Range - Lower Bound	0.07	1.6	0.823	1.49	20.7	23.9	0.86	670	997	0.99	12.7	6820	700	6570	98.9
Upper Bound	0.29	2.2	1.015	1.85	26.4	29.7	1.08	830	1220	1.23	15.7	8330	880	8030	121.0
GBM908-10	0.17	4.1	0.076	1.94	50.9	9.2	1.63	745	62.5	2.10	10.4	2180	910	1910	119.0
Target Range - Lower Bound	0.13	3.3	0.064	1.87	49.0	9.8	1.61	715	57.9	1.93	9.5	2020	880	1845	153.0
Upper Bound	0.35	4.3	0.092	2.31	61.0	12.4	1.99	885	70.9	2.38	11.9	2470	1100	2250	187.0
MRGeo08	0.17	3.5	0.179	3.06	34.9	32.5	1.30	542	16.25	2.01	21.5	699	990	1050	188.0
Target Range - Lower Bound	<0.05	2.8	0.155	2.79	31.1	29.5	1.17	497	13.65	1.76	19.0	622	930	971	173.5
Upper Bound	0.27	3.6	0.201	3.43	39.1	36.5	1.45	619	16.75	2.18	23.4	760	1160	1185	212
OREAS 152a	0.10	0.1	0.029	1.34	3.8	5.3	2.01	280	80.0	2.17	1.0	10.9	570	5.2	27.1
Target Range - Lower Bound	<0.05	<0.1	0.018	1.31	2.7	5.5	1.89	258	72.2	2.06	0.7	10.3	550	5.0	19.7
Upper Bound	0.27	0.3	0.040	1.62	5.1	7.2	2.33	326	88.3	2.54	1.2	13.1	690	7.7	24.2
BLANKS															
BLANK	<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
BLANK	<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
BLANK	<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
BLANK	<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
Target Range - Lower Bound	<0.05	<0.1	<0.005	<0.01	<0.5	<0.2	<0.01	<5	<0.05	<0.01	<0.1	<0.2	<10	<0.5	<0.1
Upper Bound	0.10	0.2	0.010	0.02	1.0	0.4	0.02	10	0.10	0.02	0.2	0.4	20	1.0	0.2
DUPLICATES															
West Moonie 1 2267.2	0.17	3.6	0.205	1.38	40.7	8.0	0.14	785	1.86	0.08	11.3	33.6	160	23.6	69.6
DUP	0.16	3.5	0.206	1.31	39.9	8.9	0.13	751	1.81	0.07	11.0	34.1	160	23.8	67.9
Target Range - Lower Bound	0.11	3.3	0.190	1.27	37.8	7.8	0.12	725	1.69	0.06	10.5	32.0	140	22.0	65.2
Upper Bound	0.22	3.8	0.221	1.42	42.8	9.1	0.15	811	1.98	0.09	11.8	35.7	180	25.4	72.3
West Moonie 1 2317.7	<0.05	0.5	0.006	0.22	4.8	2.0	<0.01	78	0.45	0.03	0.6	2.5	20	3.3	1.5
DUP	<0.05	0.6	0.006	0.23	5.1	2.2	0.01	73	0.43	0.03	0.6	2.5	20	3.7	1.4
Target Range - Lower Bound	<0.05	0.4	<0.005	0.20	4.2	1.8	<0.01	67	0.37	0.02	0.5	2.2	<10	2.8	1.3
Upper Bound	0.10	0.7	0.010	0.25	5.7	2.4	0.02	84	0.51	0.04	0.7	2.8	30	4.2	1.6

***** See Appendix Page for comments regarding this certificate *****

Australian Laboratory Services Pty. Ltd.

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Stafford
Brisbane QLD 4053
Phone: +61 7 3243 7222 Fax: +61 7 3243 7218
www.alsglobal.com/geochemistry

ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation No: 825, Corporate Site No: 818.

To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Sample Description / Method / Analyte / Units / LOD	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
STANDARDS															
EMOG-17	0.310	3.15	783	8.4	7	2.4	200	0.87	1.39	9.54	0.314	1.98	2.9	70	3.7
Target Range - Lower Bound	0.286	2.91	643	7.2	4	2.2	184.5	0.78	1.10	10.35	0.294	1.89	2.8	67	3.3
Upper Bound	0.354	3.57	869	9.0	9	3.2	226	1.08	1.46	12.65	0.370	2.61	3.7	84	4.7
GBM908-10	<0.002	0.32	1.84	16.2	<1	3.5	262	0.80	0.05	16.20	0.615	1.39	2.4	131	3.7
Target Range - Lower Bound	<0.002	0.33	1.40	17.0	<1	2.7	258	0.64	<0.05	16.55	0.591	1.00	2.0	123	2.9
Upper Bound	0.005	0.43	2.01	21.0	2	3.9	316	0.92	0.15	20.3	0.733	1.40	2.6	153	4.1
MRGeo08	0.008	0.29	4.84	11.4	1	4.3	292	1.66	<0.05	20.5	0.482	1.22	6.2	104	5.2
Target Range - Lower Bound	0.004	0.27	3.89	11.1	<1	3.5	277	1.39	<0.05	17.90	0.443	0.86	4.9	97	4.1
Upper Bound	0.013	0.35	5.39	13.7	4	4.7	339	1.81	0.12	21.9	0.553	1.21	6.2	121	5.8
OREAS 152a	0.281	0.86	1.35	21.2	8	1.4	114.0	0.07	0.16	0.26	0.335	0.18	0.1	279	3.9
Target Range - Lower Bound	0.264	0.80	1.28	19.4	6	1.1	107.0	<0.05	0.07	0.24	0.278	0.15	<0.1	269	3.4
Upper Bound	0.327	1.00	1.85	23.9	10	2.1	131.0	0.17	0.28	0.32	0.351	0.28	0.3	331	4.8
BLANKS															
BLANK	<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
BLANK	<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
BLANK	<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
BLANK	<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Target Range - Lower Bound	<0.002	<0.01	<0.05	<0.1	<1	<0.2	<0.2	<0.05	<0.05	<0.01	<0.005	<0.02	<0.1	<1	<0.1
Upper Bound	0.004	0.02	0.10	0.2	2	0.4	0.4	0.10	0.10	0.02	0.010	0.04	0.2	2	0.2
DUPLICATES															
West Moonie 1 2267.2	<0.002	0.05	0.89	8.0	<1	4.0	85.4	0.91	0.08	11.70	0.383	0.51	2.9	39	2.6
DUP	<0.002	0.05	0.85	8.4	<1	3.8	82.2	0.88	0.10	11.30	0.367	0.52	2.9	37	2.5
Target Range - Lower Bound	<0.002	0.04	0.75	7.7	<1	3.5	79.4	0.80	<0.05	10.90	0.351	0.46	2.7	35	2.3
Upper Bound	0.004	0.06	0.99	8.7	2	4.3	88.2	0.99	0.10	12.10	0.399	0.57	3.1	41	2.8
West Moonie 1 2317.7	<0.002	0.01	0.18	0.3	<1	0.3	9.9	0.07	<0.05	1.41	0.017	0.02	0.4	2	0.3
DUP	<0.002	0.01	0.20	0.3	<1	0.4	9.9	0.07	<0.05	1.49	0.018	0.02	0.3	2	0.4
Target Range - Lower Bound	<0.002	<0.01	0.13	0.2	<1	<0.2	9.2	<0.05	<0.05	1.37	0.012	<0.02	0.2	<1	0.2
Upper Bound	0.004	0.02	0.25	0.4	2	0.4	10.6	0.10	0.10	1.53	0.023	0.04	0.5	3	0.5

***** See Appendix Page for comments regarding this certificate *****

QC CERTIFICATE OF ANALYSIS BR21092657

Method	ME-MS61	ME-MS61	ME-MS61
Analyte	Y	Zn	Zr
Units	ppm	ppm	ppm
Sample Description LOD	0.1	2	0.5
STANDARDS			
EMOG-17	16.4	7430	65.3
Target Range - Lower Bound	14.3	6800	55.6
Upper Bound	17.7	8320	76.4
GBM908-10	37.3	1030	134.5
Target Range - Lower Bound	35.2	961	117.5
Upper Bound	43.2	1180	160.5
MRGeo08	28.1	810	106.0
Target Range - Lower Bound	23.8	722	92.2
Upper Bound	29.3	886	126.0
OREAS 152a	11.3	85	1.6
Target Range - Lower Bound	9.7	76	0.8
Upper Bound	12.1	98	3.2
BLANKS			
BLANK	<0.1	<2	<0.5
BLANK	<0.1	<2	<0.5
BLANK	<0.1	<2	<0.5
BLANK	<0.1	<2	<0.5
Target Range - Lower Bound	<0.1	<2	<0.5
Upper Bound	0.2	4	1.0
DUPLICATES			
West Moonie 1 2267.2	20.8	99	135.5
DUP	20.9	96	131.0
Target Range - Lower Bound	19.7	91	123.0
Upper Bound	22.0	104	143.5
West Moonie 1 2317.7	1.6	5	18.0
DUP	1.6	5	15.5
Target Range - Lower Bound	1.4	3	15.0
Upper Bound	1.8	7	18.5

***** See Appendix Page for comments regarding this certificate *****

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method Analyte Units LOD	ME-MS61 Ag ppm 0.01	ME-MS61 Al % 0.01	ME-MS61 As ppm 0.2	ME-MS61 Ba ppm 10	ME-MS61 Be ppm 0.05	ME-MS61 Bi ppm 0.01	ME-MS61 Ca % 0.01	ME-MS61 Cd ppm 0.02	ME-MS61 Ce ppm 0.01	ME-MS61 Co ppm 0.1	ME-MS61 Cr ppm 1	ME-MS61 Cs ppm 0.05	ME-MS61 Cu ppm 0.2	ME-MS61 Fe % 0.01	ME-MS61 Ga ppm 0.05
									DUPLICATES							
West Moonie 1 2557.5		0.04	4.52	3.5	390	1.16	0.10	0.52	0.02	34.6	5.2	17	2.95	5.5	1.48	11.15
DUP		0.04	4.44	3.5	390	1.00	0.11	0.51	0.03	35.7	5.0	17	2.92	5.7	1.51	10.35
Target Range - Lower Bound		0.03	4.25	3.1	350	0.98	0.09	0.48	<0.02	33.4	4.7	15	2.74	5.2	1.41	10.15
Upper Bound		0.05	4.71	3.9	430	1.18	0.12	0.55	0.04	36.9	5.5	19	3.13	6.0	1.58	11.35
ORIGINAL		0.67	6.63	6.3	760	2.00	0.09	5.38	0.49	24.3	36.6	219	4.41	1940	5.49	14.20
DUP		0.55	6.65	5.7	770	1.55	0.09	5.36	0.56	23.9	33.3	226	4.27	1930	5.50	13.80
Target Range - Lower Bound		0.57	6.30	5.5	700	1.64	0.08	5.09	0.48	22.9	33.1	210	4.07	1865	5.21	13.25
Upper Bound		0.65	6.98	6.5	830	1.91	0.10	5.65	0.57	25.3	36.8	235	4.61	2000	5.78	14.75

Sample Description	Method Analyte Units LOD	ME-MS61 Ge ppm 0.05	ME-MS61 Hf ppm 0.1	ME-MS61 In ppm 0.005	ME-MS61 K % 0.01	ME-MS61 La ppm 0.5	ME-MS61 Li ppm 0.2	ME-MS61 Mg % 0.01	ME-MS61 Mn ppm 5	ME-MS61 Mo ppm 0.05	ME-MS61 Na % 0.01	ME-MS61 Nb ppm 0.1	ME-MS61 Ni ppm 0.2	ME-MS61 P ppm 10	ME-MS61 Pb ppm 0.5	ME-MS61 Rb ppm 0.1
		DUPLICATES														
West Moonie 1 2557.5		0.10	2.4	0.030	1.89	17.9	13.0	0.24	277	0.55	1.03	4.5	7.3	80	13.8	92.2
DUP		0.12	2.5	0.029	1.85	17.9	10.2	0.24	273	0.59	1.02	4.2	7.3	80	14.0	85.5
Target Range - Lower Bound		<0.05	2.2	0.023	1.77	16.5	10.8	0.22	256	0.49	0.96	4.0	6.7	70	12.7	84.3
Upper Bound		0.17	2.7	0.036	1.97	19.3	12.4	0.26	294	0.65	1.09	4.7	7.9	90	15.1	93.4
ORIGINAL		0.14	1.4	0.134	2.90	11.5	44.3	3.83	1140	8.23	2.47	5.8	126.5	1330	8.1	106.5
DUP		0.15	1.3	0.136	2.91	11.3	34.1	3.83	1110	7.42	2.48	5.7	122.0	1320	8.0	101.0
Target Range - Lower Bound		0.09	1.2	0.123	2.75	10.3	37.0	3.63	1065	7.38	2.34	5.4	118.0	1250	7.1	98.5
Upper Bound		0.20	1.5	0.147	3.06	12.5	41.4	4.03	1185	8.27	2.61	6.1	130.5	1400	9.0	109.0

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method Analyte Units LOD	ME-MS61 Re ppm 0.002	ME-MS61 S % 0.01	ME-MS61 Sb ppm 0.05	ME-MS61 Sc ppm 0.1	ME-MS61 Se ppm 1	ME-MS61 Sn ppm 0.2	ME-MS61 Sr ppm 0.2	ME-MS61 Ta ppm 0.05	ME-MS61 Te ppm 0.05	ME-MS61 Th ppm 0.01	ME-MS61 Ti % 0.005	ME-MS61 Tl ppm 0.02	ME-MS61 U ppm 0.1	ME-MS61 V ppm 1	ME-MS61 W ppm 0.1
							DUPLICATES									
West Moonie 1 2557.5		<0.002	0.01	0.80	5.0	<1	2.0	119.5	0.42	<0.05	7.96	0.163	0.53	1.8	33	1.0
DUP		<0.002	0.01	0.81	4.5	<1	2.1	112.5	0.43	<0.05	8.07	0.158	0.52	1.9	32	1.0
Target Range - Lower Bound		<0.002	<0.01	0.69	4.4	<1	1.7	110.0	0.35	<0.05	7.60	0.147	0.47	1.7	30	0.8
Upper Bound		0.004	0.02	0.92	5.1	2	2.4	122.0	0.50	0.10	8.43	0.174	0.58	2.0	35	1.2
ORIGINAL		0.072	0.19	0.88	26.7	2	2.3	598	0.32	0.11	1.25	0.429	0.30	1.4	192	1.2
DUP		0.066	0.19	0.86	24.7	2	2.2	603	0.31	0.11	1.18	0.431	0.29	1.4	190	1.2
Target Range - Lower Bound		0.064	0.17	0.75	24.3	<1	1.9	570	0.25	<0.05	1.14	0.404	0.25	1.2	180	1.0
Upper Bound		0.074	0.21	0.99	27.1	3	2.6	631	0.38	0.17	1.29	0.457	0.34	1.6	202	1.4

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ALS Brisbane is a NATA Accredited Testing Laboratory. Corporate Accreditation No: 825, Corporate Site No: 818.

To: CARBON TRANSPORT & STORAGE CORPORATION
SUITE 3/LEVEL 3 320 ADELAIDE STREET
BRISBANE QLD 4000

Finalized Date: 4-MAY-2021
Account: CTSCOR

Project: West Moonie 1

QC CERTIFICATE OF ANALYSIS BR21092657

Sample Description	Method Analyte Units LOD	ME-MS61 Y ppm 0.1	ME-MS61 Zn ppm 2	ME-MS61 Zr ppm 0.5
DUPLICATES				
West Moonie 1 2557.5		13.6	32	69.0
DUP		12.7	32	64.3
Target Range - Lower Bound		12.4	28	61.2
Upper Bound		13.9	36	72.1
ORIGINAL		17.5	107	53.1
DUP		17.1	107	52.6
Target Range - Lower Bound		16.3	100	48.4
Upper Bound		18.3	114	57.3

***** See Appendix Page for comments regarding this certificate *****

CERTIFICATE COMMENTS

ANALYTICAL COMMENTS

REEs may not be totally soluble in this method.

Applies to Method: ME-MS61

ACCREDITATION COMMENTS

NATA Accreditation covers the performance of this service but does not cover the performance of ALS Brisbane Sample Preparation. Corporate Accreditation No: 825, Corporate Site No: 818. The Technical Signatory is David Jones,ICPMS Supervising Chemist

Applies to Method: ME-MS61

LABORATORY ADDRESSES

Processed at ALS Brisbane located at 32 Shand Street, Stafford, Brisbane, QLD, Australia. Processed at ALS Brisbane Sample Preparation at 23 Pineapple Street, Zillmere, QLD, 4034, Australia

Applies to Method:
LEV-01
LOG-22
ME-MS61
PUL-31m
TRA-21
WEI-21
WSH-22

CERTIFICATE OF ANALYSIS

Work Order : **EB2031718**
Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : UNIT 2 - 209 LEITCHS ROAD
BRENDALE QLD 4500
Telephone : ----
Project : AB-106884
Order number : 20000053
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : EN/333
No. of samples received : 5
No. of samples analysed : 5

Page : 1 of 3
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 01-Dec-2020 17:25
Date Analysis Commenced : 02-Dec-2020
Issue Date : 08-Dec-2020 16:09

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**WM1_Water01 at 450 bbls**	**WM1_Water02 at 500 bbls**	**WM1_Water03 at 520 bbls**	**WM1_Water04 at 540 bbls**	**WM1_Water05 at 560 bbls**
			Sampling date / time	30-Nov-2020 09:08	30-Nov-2020 09:40	30-Nov-2020 09:50	30-Nov-2020 10:00	30-Nov-2020 10:10
Compound	*CAS Number*	*LOR*	*Unit*	**EB2031718-001**	**EB2031718-002**	**EB2031718-003**	**EB2031718-004**	**EB2031718-005**
				Result	Result	Result	Result	Result
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.52**	**8.57**	**8.57**	**8.59**	**8.59**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	<1	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**63**	**75**	**72**	**85**	**78**
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**1120**	**1120**	**1120**	**1090**	**1110**
Total Alkalinity as CaCO3	----	1	mg/L	**1180**	**1190**	**1200**	**1180**	**1190**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**18**	**14**	**14**	**13**	**14**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**834**	**709**	**749**	**734**	**719**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**12**	**10**	**12**	**10**	**11**
Magnesium	7439-95-4	1	mg/L	**2**	**2**	**2**	**2**	**2**
Sodium	7440-23-5	1	mg/L	**644**	**605**	**660**	**633**	**632**
Potassium	7440-09-7	1	mg/L	**548**	**431**	**487**	**463**	**446**
EG020T: Total Metals by ICP-MS								
Iron	7439-89-6	0.05	mg/L	**16.1**	**8.52**	**8.38**	**7.98**	**7.65**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**6.6**	**6.9**	**6.9**	**7.0**	**7.0**
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	**0.01**	<0.01	<0.01	<0.01	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	**0.02**	**0.02**	**0.01**	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.02**	**0.02**	**0.02**	**0.01**	**0.02**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.01**	**0.03**	**0.02**	**0.02**	**0.02**
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**47.5**	**44.1**	**45.4**	**44.6**	**44.3**
ø Total Cations	----	0.01	meq/L	**42.8**	**38.0**	**41.9**	**40.0**	**39.6**
ø Ionic Balance	----	0.01	%	**5.19**	**7.39**	**3.97**	**5.34**	**5.64**

Environmental

QUALITY CONTROL REPORT

Work Order : **EB2031718**

Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : UNIT 2 - 209 LEITCHS ROAD
BRENDALE QLD 4500
Telephone : ----
Project : AB-106884
Order number : 20000053
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : EN/333
No. of samples received : 5
No. of samples analysed : 5

Page : 1 of 5

Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 01-Dec-2020
Date Analysis Commenced : 02-Dec-2020
Issue Date : 08-Dec-2020

ilac-MRA

NATA

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high

Key :
Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EA005P: pH by PC Titrator (QC Lot: 3399955)									
EB2031718-005	WM1_Water05 at 560 bbls	EA005-P: pH Value	----	0.01	pH Unit	8.59	8.60	0.116	0% - 20%
EB2031757-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	8.65	8.67	0.231	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 3399956)									
EB2031718-005	WM1_Water05 at 560 bbls	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.00	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	78	88	12.9	0% - 20%
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	1110	1120	0.616	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	1190	1200	1.47	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3397937)									
EB2031718-003	WM1_Water03 at 520 bbls	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	14	14	0.00	0% - 50%
EB2031718-001	WM1_Water01 at 450 bbls	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	18	18	0.00	0% - 50%
ED045G: Chloride by Discrete Analyser (QC Lot: 3397935)									
EB2031718-003	WM1_Water03 at 520 bbls	ED045G: Chloride	16887-00-6	1	mg/L	749	753	0.460	0% - 20%
EB2031718-001	WM1_Water01 at 450 bbls	ED045G: Chloride	16887-00-6	1	mg/L	834	835	0.144	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 3395962)									
EB2031718-001	WM1_Water01 at 450 bbls	ED093F: Calcium	7440-70-2	1	mg/L	12	13	10.7	0% - 50%
		ED093F: Magnesium	7439-95-4	1	mg/L	2	3	0.00	No Limit
		ED093F: Sodium	7440-23-5	1	mg/L	644	664	3.09	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	548	563	2.56	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 3396153)									
EB2031653-001	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	7.31	7.21	1.44	0% - 20%
EB2031653-010	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	2.70	2.70	0.00	0% - 20%
EG020T: Total Metals by ICP-MS (QC Lot: 3396154)									
EB2031718-004	WM1_Water04 at 540 bbls	EG020A-T: Iron	7439-89-6	0.05	mg/L	7.98	7.94	0.535	0% - 20%
ET2004705-007	Anonymous	EG020A-T: Iron	7439-89-6	0.05	mg/L	1.47	1.44	1.59	0% - 20%

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Recovery Limits (%)*
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 3396155)									
EB2031653-001	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.00	No Limit
EB2031690-003	Anonymous	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.1 µg/L	<0.0001	0.00	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 3399952)									
EB2031503-002	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	33.0	37.0	11.4	0% - 20%
EB2031602-003	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	<0.1	0.00	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 3397936)									
EB2031718-003	WM1_Water03 at 520 bbls	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EB2031718-001	WM1_Water01 at 450 bbls	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	0.01	<0.01	0.00	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 3399873)									
EB2031777-004	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.05	138	No Limit
EB2031602-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	0.00	No Limit
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 3397938)									
EB2031718-001	WM1_Water01 at 450 bbls	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.01	0.01	0.00	No Limit

Method Blank (MB) and Laboratory Control Spike (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Spike (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Recovery Limits (%)*	
Method: Compound	*CAS Number*	*LOR*	*Unit*	*Result*	*Concentration*	*LCS*	*Low*	*High*
EA005P: pH by PC Titrator (QCLot: 3399955)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	100	98.0	102
				----	7 pH Unit	100	98.0	102
ED037P: Alkalinity by PC Titrator (QCLot: 3399956)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	104	80.0	120
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3397937)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	105	85.0	118
				<1	100 mg/L	93.3	85.0	118
ED045G: Chloride by Discrete Analyser (QCLot: 3397935)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	102	90.0	115
				<1	1000 mg/L	105	90.0	115
ED093F: Dissolved Major Cations (QCLot: 3395962)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	104	70.0	130
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	104	70.0	130
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	101	70.0	130
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	99.4	70.0	130
EG020T: Total Metals by ICP-MS (QCLot: 3396153)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	104	82.0	118
EG020T: Total Metals by ICP-MS (QCLot: 3396154)								
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	103	82.0	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 3396155)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	103	84.0	118
EK040P: Fluoride by PC Titrator (QCLot: 3399952)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	5 mg/L	109	80.0	117
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3397936)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	96.8	90.0	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3399873)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	94.8	85.7	111
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 3397938)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	95.1	81.7	117

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	*SpikeRecovery(%)*	*Recovery Limits (%)*	
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*Concentration*	*MS*	*Low*	*High*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3397937)							
EB2031718-002	WM1_Water02 at 500 bbls	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	20 mg/L	108	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 3397935)							
EB2031718-002	WM1_Water02 at 500 bbls	ED045G: Chloride	16887-00-6	400 mg/L	87.9	70.0	130
EG035T: Total Recoverable Mercury by FIMS (QCLot: 3396155)							
EB2031653-002	Anonymous	EG035T: Mercury	7439-97-6	0.01 mg/L	97.9	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 3399952)							
EB2029996-002	Anonymous	EK040P: Fluoride	16984-48-8	10 mg/L	83.0	70.0	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3397936)							
EB2031718-002	WM1_Water02 at 500 bbls	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	111	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3399873)							
EB2031602-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	90.7	70.0	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 3397938)							
EB2031718-002	WM1_Water02 at 500 bbls	EK071G: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	122	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB2031718**	Page	: 1 of 8
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 01-Dec-2020
Site	: ----	Issue Date	: 08-Dec-2020
Sampler	: ----	No. of samples received	: 5
Order number	: 20000053	No. of samples analysed	: 5

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **NO Matrix Spike outliers occur.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method **Container** / Client Sample ID(s)		*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	**Days overdue**	*Date analysed*	*Due for analysis*	**Days overdue**
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural WM1_Water01 at 450 bbls, WM1_Water03 at 520 bbls, WM1_Water05 at 560 bbls	WM1_Water02 at 500 bbls, WM1_Water04 at 540 bbls,	----	----	----	03-Dec-2020	30-Nov-2020	**3**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Natural WM1_Water01 at 450 bbls, WM1_Water03 at 520 bbls, WM1_Water05 at 560 bbls	WM1_Water02 at 500 bbls, WM1_Water04 at 540 bbls,	----	----	----	03-Dec-2020	02-Dec-2020	**1**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)					
Total Metals by ICP-MS - Suite A	0	22	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*		**Sample Date**	*Extraction / Preparation*			*Analysis*		
			Date extracted	*Due for extraction*	*Evaluation*	**Date analysed**	*Due for analysis*	*Evaluation*
EA005P: pH by PC Titrator								
Clear Plastic Bottle - Natural (EA005-P) WM1_Water01 at 450 bbls, WM1_Water03 at 520 bbls, WM1_Water05 at 560 bbls	WM1_Water02 at 500 bbls, WM1_Water04 at 540 bbls,	**30-Nov-2020**	**----**	----	----	**03-Dec-2020**	30-Nov-2020	×
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P) WM1_Water01 at 450 bbls, WM1_Water03 at 520 bbls, WM1_Water05 at 560 bbls	WM1_Water02 at 500 bbls, WM1_Water04 at 540 bbls,	**30-Nov-2020**	**----**	----	----	**03-Dec-2020**	14-Dec-2020	✓

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**02-Dec-2020**	28-Dec-2020	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**02-Dec-2020**	28-Dec-2020	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**03-Dec-2020**	07-Dec-2020	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG020A-T) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**04-Dec-2020**	29-May-2021	✓	**04-Dec-2020**	29-May-2021	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG035T) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**04-Dec-2020**	28-Dec-2020	✓
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**03-Dec-2020**	28-Dec-2020	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural (EK057G) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**02-Dec-2020**	02-Dec-2020	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Natural (EK059G) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**03-Dec-2020**	02-Dec-2020	✗

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method ***Container*** */ Client Sample ID(s)*	***Sample Date***	*Extraction / Preparation*			*Analysis*		
		Date extracted	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural (EK071G) WM1_Water01 at 450 bbls, WM1_Water02 at 500 bbls, WM1_Water03 at 520 bbls, WM1_Water04 at 540 bbls, WM1_Water05 at 560 bbls	**30-Nov-2020**	**----**	----	----	**02-Dec-2020**	02-Dec-2020	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	1	9	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	9	**11.11**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	4	22	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	14	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	2	22	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	0	22	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA seal method 2 017-1-L
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM Schedule B(3)

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	* EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM Schedule B(3)

8/12

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph: 07 7471 5600 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 024423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsgl

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
ental@alsglobal.com
llongong NSW 2500
bal.com

Environmental Division
Brisbane
Work Order Reference
EB2031718

Telephone : + 61-7-3243 7222

CLIENT: Stratum Reservoir (Australia) Pty Ltd	TURNAROUND REQUIREMENTS : ☒ Standard TAT (List due date):
OFFICE: Unit 2 205 Leitchs Road Brendale	(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics) ☐ Non Standard or urgent TAT (List due date):
PROJECT: AB-106884	ALS QUOTE NO.: EN/333
ORDER NUMBER: 20000053	
PROJECT MANAGER: Keith Window	CONTACT PH: 0400 934 304
SAMPLER:	SAMPLER MOBILE:
COC emailed to ALS? (YES / NO)	EDD FORMAT (or default):

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6
OF: 1 2 3 4 5 6

No N/A
No N/A
°C

Email Reports to (will default to PM if no other addresses are listed): : keith.window@stratumreservoir.com

Email Invoice to (will default to PM if no other addresses are listed): : keith.window@stratumreservoir.com

RELINQUISHED BY:	RECEIVED BY:	BY:
	CHRIS PENNY	
DATE/TIME:	DATE/TIME: 1/12/2020 1725	

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	NT-1 & NT-2	NT-3	EA005P	EG020T	EG035T				Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	WM1_Water01 at 450 bbls	30/11 9:08	W	P N	2	X	X	X	X	X				
2	WM1_Water02 at 500 bbls	30/11 9:40	W	P N	2	X	X	X	X	X				
3	WM1_Water03 at 520 bbls	30/11 9:50	W	P N	2	X	X	X	X	X				
4	WM1_Water04 at 540 bbls	30/11 10:00	W	P N	2	X	X	X	X	X				
5	WM1_Water05 at 560 bbls	30/11 10:10	W	P N	2	X	X	X	X	X				
				TOTAL										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

ALS Environmental

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB2031757**

Client	: **CARBON TRANSPORT & STORAGE CORP PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: LOCHLAN GIBSON	Contact	: Customer Services EB
Address	: LEVEL 10, 320 ADELAIDE STREET BRISBANE	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: lochlan.gibson@ctsco.com.au	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: ----	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: AB-106884	Page	: 1 of 3
Order number	: 60005055523	Quote number	: EB2020CTSCOR0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: KIERAN MACKELLAR		

Dates

Date Samples Received	: 01-Dec-2020 17:25	Issue Date	: 07-Dec-2020
Client Requested Due Date	: 08-Dec-2020	Scheduled Reporting Date	: **08-Dec-2020**

Delivery Details

Mode of Delivery	: Client Drop Off	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 12.9°C
Receipt Detail	: SMALL ESKY	No. of samples received / analysed	: 1 / 1

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- Please note sampling ID & date assigned has been taken from sample containers provided
- Please be advised that a split turn around time for results has been assigned to this work order. All ALS Brisbane analysis shall have an expected reporting date of 08/12/2020 with all other analysis to follow on 23/12/2020
- **Please note where you have requested 'Dissolved' metals and an unspecified sample container was received, the laboratory will filter an aliquot from the non-preserved plastic (ALS Green label) container for this analysis, however this is a non-compliant container/process and should be taken into consideration when reviewing the metals data. The laboratory is not able to filter from a preserved container. Additional charges will be incurred for laboratory filtration.**
- **Strontium Isotope analysis has been subcontracted to University of Melbourne**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- **Arsenic Speciation analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- **Radiological analysis will be undertaken by ALS WRG Canberra, NATA accreditation no. 992, site no. 1531.**
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Sample(s) requiring volatile organic compound analysis received in airtight containers (ZHE).**
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

Method *Sample ID*	**Sample Container Received**	**Preferred Sample Container for Analysis**
Dissolved Mercury by FIMS : EG035F		
1	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite A : EG020A-F		
1	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered
Dissolved Metals by ICP-MS - Suite B : EG020B-F		
1	- Clear Plastic Bottle - Natural	- Clear Plastic Bottle - Nitric Acid; Filtered

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA005P pH (PCT)	WATER - EA010P Electrical Conductivity (PCT)	WATER - EA015H Total Dissolved Solids - Standard Level	WATER - EG020F Dissolved Metals by ICP/MS	WATER - EG032SL Arsenic Speciation by LC-ICPMS (Marine)	WATER - EG053FG-MS Dissolved Ferric Iron by ICPMS/DA	WATER - W-03 15 Metals (NEPM Suite)
EB2031757-001	30-Nov-2020 00:00	1	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA250-LSC (CA) Gross Alpha and Beta Activity	WATER - ED009-X Standard Anions (Extended method	WATER - NT-01 & 02A Ca, Mg, Na, K, Cl, SO4, Alkalinity & Fluoride	WATER - Sr_ISOTOPE Strontium ration 87Sr/86Sr analysis	WATER - W-24 TRH/BTEXN/PAH/Phenols
EB2031757-001	30-Nov-2020 00:00	1	✓	✓	✓	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method Client Sample ID(s)	Container	Due for extraction	Due for analysis	Samples Received		Instructions Received	
				Date	Evaluation	Date	Evaluation
EA005-P: pH by PC Titrator							
1	Clear Plastic Bottle - Natural	----	30-Nov-2020	01-Dec-2020	✘	----	----

Requested Deliverables

LOCHLAN GIBSON

- *AU Certificate of Analysis - NATA (COA)	Email	lochlan.gibson@ctsco.com.au
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	lochlan.gibson@ctsco.com.au
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	lochlan.gibson@ctsco.com.au
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	lochlan.gibson@ctsco.com.au
- A4 - AU Tax Invoice (INV)	Email	lochlan.gibson@ctsco.com.au
- Attachment - Report (SUBCO)	Email	lochlan.gibson@ctsco.com.au
- Chain of Custody (CoC) (COC)	Email	lochlan.gibson@ctsco.com.au
- EDI Format - XTab (XTAB)	Email	lochlan.gibson@ctsco.com.au

8/12

ALS Environmental

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Laboratory:
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☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com

☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph: 07 7471 5600 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com

☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com

☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com

☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 024423 2063 E: nowra@alsglobal.com

☐PERTH 10 Hod Way Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsglobal.com

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Carbon Transport and Storage Company Pty Ltd

OFFICE: Level 10, 320 Adelaide Street, Brisbane

PROJECT: AB-106884

ORDER NUMBER: 60005055523

PROJECT MANAGER: Lochlan Gibson **CONTACT PH:** 0400 025 339

SAMPLER: Kieran MacKeller **SAMPLER MOBILE:** 0476 256 618

COC emailed to ALS? (YES) **EDD FORMAT (or default):**

Email Reports to (will default to PM if no other addresses are listed): **lochlan.gibson@ctsco.com.au**

Email Invoice to (will default to PM if no other addresses are listed): : **lochlan.gibson@ctsco.com.au**

TURNAROUND REQUIREMENTS : ☒ Standard TAT **(List due date):**

(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics) ☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EN/333

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	**RECEIVED BY:** CHRIS PERRY	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME:	DATE/TIME: 1/12/2020 1725	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	See attached quote details													
				TOTAL										

Environmental Division
Brisbane
Work Order Reference
EB2031757

Telephone : + 61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

QUOTE - EN/333

MATRIX	TEST PARAMETER	ALS Code	TECHNIQUE / METHOD REFERENCE	LIMIT OF REPORTING	NUMBER OF SAMPLES	PRICE PER SAMPLE ($) Ex. GST	TOTAL COST ($) Ex. GST
WATER	15 Dissolved Metals (NEPM Suite) (As, B, Ba, Be, Cd, Cr, Co, Cu, Mn, Ni, Pb, Se, V, Zn, Hg)	**W-3**	ICP/MS, CV/FIMS	0.0001-0.05 mg/L	1	36.3	36.3
WATER	TRH(C6-C40)/BTEXN/PAH/Phenols	**W-24**	See W-4 & W-14A	See W-4 & W-14A	1	110	110
WATER	Cations: Major (Ca, Mg, Na, K)	**NT-1**	Various	Various	1	13.2	13.2
WATER	Anions: Major (Cl, SO4, F, Alkalinity)	**NT-2A**	Various	Various	1	30.8	30.8
WATER	Bromide - Standard	ED009X	APHA 4110B	0.01 mg/L	1	55	55
WATER	Conductivity (EC)	EA010P	APHA 2510 B	1 µS/cm	1	5.5	5.5
WATER	pH (pH units)	EA005P	APHA 4500 H+ - B	0.01 pH units	1	5.5	5.5
WATER	Total Dissolved Solids (TDS) - Standard Level	EA015H	APHA 2540 C	10 mg/L	1	11	11
WATER	ICP/MS: Additional Dissolved Metals – Al, Fe, Sr, U	EG020F	USEPA 6020 ICP/MS	0.0001-0.05 mg/L	1	8.8 (4 x 2.20)	8.8
WATER	Ferrous Iron	EG051G	APHA3500 Fe-B	0.05 mg/L	1	13.2	13.2
WATER	Ferric Iron **(must be requested with Ferrous Iron and Dissolved Iron)**	EG053F	Calc from dissolved and ferrous.	0.05 mg/L	1	No charge	No charge
WATER	Gross alpha + Gross beta with K40 correction in clean matrices (TDS < 400 mg/L (EC ~600µS/cm)). Samples with TDS 400-2000mg/L (EC~3,000µS/cm) will have LORs raised to 0.25 or 0.5Bq/L(E)	EA250-LSC	ASTM D7283-06	Alpha (0.05) Beta (0.1) Bq/L	1	148.5	148.5
WATER	Arsenic Speciation (III) and (V)	EG032SL	HPLC/ORC/ICP/MS	4 µg/L	1	308	308
WATER	Strontium Isotopes (87Sr / 86 Sr)*	MSC-WAT	Subcontracted to University of Melbourne	-	1	260	260
WATER	**TOTAL PROJECT COST FOR WATER SAMPLES – STD TAT (EX GST):**						1,008.80
	ADMINISTRATION FEES:				1	40	40
	TOTAL PROJECT COST FOR WORK ORDER INCLUDING ANY ADDITIONAL DISCOUNTS, FEES OR SURCHARGES (EX GST):						1,048.80

CERTIFICATE OF ANALYSIS

Work Order	: **EB2031757**	Page	: 1 of 7
Amendment	: **(Preliminary Report)**		
Client	: **CARBON TRANSPORT & STORAGE CORP PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: LOCHLAN GIBSON	Contact	: Customer Services EB
Address	: LEVEL 10, 320 ADELAIDE STREET BRISBANE	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 01-Dec-2020 17:25
Order number	: 60005055523	Date Analysis Commenced	: 03-Dec-2020
C-O-C number	: ----	Issue Date	: 08-Dec-2020 16:30
Sampler	: KIERAN MACKELLAR		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	WB Water Lab Brisbane, Stafford, QLD
Thomas Donovan		Brisbane Organics, Stafford, QLD

(Preliminary Report)

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

This report contains preliminary authorised results. The report may contain semi-quantitative results. Any result presented in this preliminary report may be subject to change in the final report.

- EP075 (SIM): Where reported, Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP075(SIM): Where reported, Total Cresol is the sum of the reported concentrations of 2-Methylphenol and 3- & 4-Methylphenol at or above the LOR.
- Strontium isotope analysis has been performed by the University of Melbourne who do not hold NATA accreditation for this analysis.
- **Arsenic Speciation analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Sample ID	1	----	----	----	----
			Sampling date / time	30-Nov-2020 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2031757-001**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.65**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**4610**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**2850**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**106**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**1070**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**1170**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**14**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**806**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**11**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**2**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**673**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**564**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.58**	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.280**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.005**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.168**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.004**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	1	----	----	----	----
			Sampling date / time	30-Nov-2020 00:00	----	----	----	----
				EB2031757-001	--------	--------	--------	--------
				Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.610**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**5.04**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG051G: Ferrous Iron by Discrete Analyser								
Ferrous Iron	----	0.05	mg/L	**2.69**	----	----	----	----
EG053FG-MS: Dissolved Ferric Iron by ICPMS and DA								
Ferric Iron	----	0.05	mg/L	**2.35**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**6.8**	----	----	----	----
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**46.4**	----	----	----	----
ø **Total Cations**	----	0.01	meq/L	**44.4**	----	----	----	----
ø **Ionic Balance**	----	0.01	%	**2.19**	----	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	----	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L	<1.0	----	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L	<1.0	----	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L	<2.0	----	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L	<1.0	----	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L	<1.0	----	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L	<1.0	----	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L	<1.0	----	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L	<1.0	----	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L	<1.0	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L	<1.0	----	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L	<2.0	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**1**	----	----	----	----
			Sampling date / time	30-Nov-2020 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2031757-001**	--------	--------	--------	--------
				Result	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued								
Phenanthrene	85-01-8	1.0	µg/L	<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	----	----	----	----
^ **Sum of polycyclic aromatic hydrocarbons**	----	0.5	µg/L	<0.5	----	----	----	----
^ **Benzo(a)pyrene TEQ (zero)**	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	**340**	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	**340**	----	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L	**680**	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	**620**	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	**120**	----	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L	**740**	----	----	----	----
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**1**	**----**	**----**	**----**	**----**
			Sampling date / time	30-Nov-2020 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EB2031757-001**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EP080: BTEXN - Continued								
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ **Total Xylenes**	----	2	µg/L	<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
ED009: Anions								
Bromide	24959-67-9	0.010	mg/L	**1.26**	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	**20.1**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	**47.5**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	**26.4**	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	**61.4**	----	----	----	----
Anthracene-d10	1719-06-8	1.0	%	**62.5**	----	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	**75.6**	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**96.0**	----	----	----	----
Toluene-D8	2037-26-5	2	%	**101**	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	**107**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	*CAS Number*	*Recovery Limits (%)* Low	*Recovery Limits (%)* High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	72
2-Chlorophenol-D4	93951-73-6	27	130
2.4.6-Tribromophenol	118-79-6	19	181
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	14	146
Anthracene-d10	1719-06-8	35	137
4-Terphenyl-d14	1718-51-0	36	154
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EB2118210**
Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : 8 COX ROAD
WINDSOR QLD, AUSTRALIA 4030
Telephone : ----
Project : AB-108643
Order number : 20000105
C-O-C number : ----
Sampler : ----
Site : ----
Quote number : EN/333
No. of samples received : 1
No. of samples analysed : 1

Page : 1 of 7
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 29-Jun-2021 17:00
Date Analysis Commenced : 30-Jun-2021
Issue Date : 07-Jul-2021 14:49

ilac-MRA
NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

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Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Hannah Beazley	Phycologist.	Brisbane Microbiological, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Thomas Donovan		Brisbane Organics, Stafford, QLD

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LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- Results apply to sample(s) as submitted.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- KEY: PTP=Potential Toxin Producers
  ; ND=Not Detected; NS=Not Specified
  ; cf. = comparable form
- Samples were preserved with Lugols Iodine solution.
- Algal enumeration values of <5 cells/mL will not be reported.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**Milgarra Bore**	----	----	----	----
			Sampling date / time	14-Jun-2021 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2118210-001**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.74**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1240**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**826**	----	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.5**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	<1	----	----	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**2**	----	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**486**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**59**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**521**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**581**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**24.9**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**7**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**69**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**330**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**Milgarra Bore**	**----**	**----**	**----**	**----**
			Sampling date / time	14-Jun-2021 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2118210-001**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.011**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.002**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.13**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.06**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG049T: Total Trivalent Chromium								
Trivalent Chromium	16065-83-1	0.01	mg/L	<0.01	----	----	----	----
EG050T: Total Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Silver	7440-22-4	0.01	µg/L	<0.01	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.33**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**Milgarra Bore**	----	----	----	----
			Sampling date / time	14-Jun-2021 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2118210-001**	--------	--------	--------	--------
				Result	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser - Continued								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**13.7**	----	----	----	----
ø **Total Cations**	----	0.01	meq/L	**14.4**	----	----	----	----
ø **Ionic Balance**	----	0.01	%	**2.51**	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**5**	----	----	----	----
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**7.9**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ **Total Xylenes**	----	2	µg/L	<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**Milgarra Bore**	**----**	**----**	**----**	**----**
			Sampling date / time	14-Jun-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EB2118210-001**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
MW024PTP:Total Potentially Toxic Cyanophytes								
Total Potentially Toxic Cyanophytes	----	5	cells/ml	<5	**----**	**----**	**----**	**----**
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**96.0**	**----**	**----**	**----**	**----**
Toluene-D8	2037-26-5	2	%	**99.1**	**----**	**----**	**----**	**----**
4-Bromofluorobenzene	460-00-4	2	%	**99.4**	**----**	**----**	**----**	**----**

Surrogate Control Limits

Sub-Matrix: **WATER**

		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory:
please tick →

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Ph: 08 8359 0890 E: adelaide@alsglobal.com

☐BRISBANE 32 Shand Street Stafford QLD 4053
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sydney@alsglobal.com

Environmental Division
Brisbane
Work Order Reference
EB2118210

elephone : + 61-7-3243 7222

CLIENT: Stratum Reservoir

OFFICE:

PROJECT: AB-108643

ORDER NUMBER:

PROJECT MANAGER: Keith Window **CONTACT PH:** 0400 934 034

SAMPLER: **SAMPLER MOBILE:**

COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to keith.window@stratumreservoir.com

Email Invoice to (will default to PM if no other addresses are listed):

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: Attached

COC SEQUENCE NUMBER (Circle)

COC:	1	2	3	4	5	6	7
OF:	1	2	3	4	5	6	7

FOR LABORAT
Custody Seal Inta
Free ice / frozen i
receipt?
Random Sample
Other comment

RELINQUISHED BY:
DATE/TIME:

RECEIVED BY: Martin
DATE/TIME: 29/6/21 17:00

RELINQUISHED BY
DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS									Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	Milgarra Bore	14-06-21				Attached								
					TOTAL									

HT

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Keith Window

Subject: FW: [EXTERNAL] - RE: ALS Environmental - analysis price request

Keith Window
Data Analyst and SCA Specialist
STRATUM
2/209 Leitchs Road Brendale
Queensland, Australia 4500
Reception: +61 (0)4 0735 4748
Email: keith.window@stratumreservoir.com

Visit our New Website: www.stratumreservoir.com
For sale quotes and enquiries - Contact: customerservice.au@stratumreservoir.com

From: ALSEnviro Brisbane <ALSEnviro.Brisbane@alsglobal.com>
Sent: Tuesday, 29 June, 2021 12:57 PM
To: Keith Window <keith.window@stratumreservoir.com>
Subject: FW: [EXTERNAL] - RE: ALS Environmental - analysis price request

Hi Keith,

Well, as discussed there is very little left from your list that I would proceed with analysis for. All that you have left is EC and Fluoride (both have a 28 day holding time from an unpreserved container.

You may potentially elect to analyse for metals but these could bias low?

This would not include any of the speciated arsenic or chromium.

Below the pricing table is the recommended containers (per sample). I have also provided prices on a per sample basis to allow you to mix and match moving forward and calculate accordingly. Just remember to add your $40.00 admin fee and GST.

Tailored Analytical Services & Charges: Test

Parameter	ALS Code	Technique/ Method Reference	Limit Of Reporting (LOR)	No.	Price per Sample ($)
pH (PCT)	EA005P	APHA 4500-H+ B	0.01 pH Unit	1	5.50
Electrical Conductivity (PCT)	EA010P	APHA 2510 B	1 µS/cm	1	5.50
Turbidity	EA045	APHA 2130 B	0.1 NTU	1	5.50
CO2 - Free and Total	EA165	APHA 4500-CO2 D	1 mg/L	1	15.40
Dissolved Oxygen (DO)	EP025	APHA 4500-O G	0.1 mg/L	1	7.70
Dissolved Major Anions Silica as Si02	ED040F	APHA 3120	0.1 mg/L	1	11.00
Major Cations (Ca, Mg, Na, K) + Hardness	NT-01D	USEPA 6010	1 mg/L	1	15.40

Received
29/6/21
17:00 Martin

Parameter	ALS Code	Technique/ Method Reference	Limit Of Reporting (LOR)	No.	Price per Sample ($)
Minor Anions (Nitrite, Nitrate, Fluoride, Reactive-P)	NT-03	APHA 4500-F C, APHA 4500-NO3 F, APHA 4500-NO2 B, APHA 4500-P F	0.01 - 0.1 mg/L	1	38.50
Total Dissolved Solids - Standard Level	EA015H	APHA 2540C	10 mg/L	1	11.00
Major Anions (Chloride, Sulphate, Alkalinity)	NT-02	APHA 2320 B, APHA 4500-Cl G, APHA 4500-SO4	1 mg/L	1	22.00
Methane in Water	EP033 - Methane	In house HS/GC/FID	10 µg/L	1	82.50
Total Organic Carbon (TOC)	EP005	APHA 5310 B	1 mg/L	1	26.40
Arsenic Speciation by LC-ICPMS	EG032	In house	0.5 - 1 µg/L	1	308.00
Ammonia as N By Discrete Analyser	EK055G	APHA 4500-NH3 G	0.01 mg/L	1	15.40
8 metals (Total) As, Cd, Cr, Cu, Ni, Pb, Zn, Hg	W-02T	USEPA 6020, APHA 3112- Hg B	0.0001 - 0.005 mg/L	1	31.90
Additional total Metals by ICP/MS (including digestion) Al, Be, B, Co, Fe, Li, Mn, Mo, Ni, Se, U,V	EG020T	USEPA 6020	0.001 - 0.05 mg/L	1	24.00 (2.00 per additional metal)
Trivalent Chromium - Total	EG049G-T	USEPA 6020, APHA 3500-Cr B, APHA 3500-Cr B / USEPA 6020	0.001 - 0.01 mg/L	1	26.40
Total Hexavalent Chromium	EG050G-T	APHA 3500-Cr B	0.01 mg/L	1	11.00
Ultra trace Total Silver to meet ANZECC 99% protection	EG094-AgT	APHA 3125; USEPA SW846 - 6020	0.01 µg/L	1	44.00
Un-ionised Hydrogen Sulfide	EK084	APHA 4500-S2 H	0.1 mg/L	1	22.00
TRH/BTEXN	W-04	USEPA 8015, USEPA 8260	1 - 100 µg/L	1	46.20
Total Potentially Toxic Cyanophytes	MW024_PTOX	Hotzel & Croome	5 cells/ml, 5 cells/mL	1	60.50
Total cost per sample (Excluding GST)					$835.80

To order containers for pick up please email bottles.brisbane@alsglobal.com

Just copy the below table and then say how many samples you are taking. Be sure to specify when you would like to pick these up. Alternatively order these in advance and we can have these couriered free to you.

Sample Containers for: Test

No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Purple	2 x 40mL Amber VOC Vial - Sulfuric Acid	Methane in Water, TRH - volatile /BTEXN
	Green	1 x 500mL Clear Plastic Bottle - Natural	CO2 - Free and Total, Dissolved Major Anions, Dissolved Oxygen (DO), Electrical Conductivity (PCT), Major Anions (Chloride, Sulphate, Alkalinity), Nitrite, Nitrate, Fluoride, Reactive-P, pH (PCT), Total Dissolved Solids, Turbidity
	Purple	1 x 40mL Amber TOC Vial - Sulfuric Acid	Total Organic Carbon (TOC)
	Purple	1 x 60mL Clear Plastic Bottle - Sulfuric Acid	Ammonia as N By Discrete Analyser
	Red	1 x 60mL Clear Plastic Bottle - Nitric Acid; Unfiltered	Total Metals by ICP/MS (including digestion)
	Blue	1 x 60mL Clear Plastic Bottle - NaOH	Total Hexavalent Chromium, Trivalent Chromium - Total

29/6/21
17:00
Martin

No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Fluorescent Yellow	1 x 125mL Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED	Un-ionised Hydrogen Sulfide
	Red	1 x 60mL Clear Plastic Bottle - Nitric Acid; Filtered	Major Cations (Ca, Mg, Na, K) + Hardness
	Green	1 x 250mL Plastic Bottle - Lugols Iodine	Total Potentially Toxic Cyanophytes
	Orange	1 x 100mL Amber Glass Bottle - Unpreserved	TRH
	Maroon	1 x 60mL Clear Plastic Bottle - HCl - Filtered	Speciated Arsenic

Additional bottles are required on water samples for semi-volatile organics and PFAS analysis for laboratory QA/QC purposes. For further information, click here

EA005-P pH by PC Titrator (6 hours)
EP030 Biochemical Oxygen Demand (BOD) (2 days)
EA045 Turbidity (2 days)
EA165 Free and Total CO2 (6 hours)
EK057G Nitrite as N by Discrete Analyser (2 days)
EK058G Nitrate as N by Discrete Analyser (2 days)
EK071G Reactive Phosphorus as P-By Discrete Analyser (2 days)
EP025 Oxygen - Dissolved (6 hours)
EK084 - Unionised Hydrogen Sulfide(1 day unpreserved)
EA015H - Total Dissolved Soilds(7 days)
Methane - inappropriate container for analysis
BTEXN - inappropriate container for analysis
MW024_PTOX - 2 days unpreserved
Semi-Vol TRH - 7 days
Volatile TRH - inappropriate container for analysis
Speciated Arsenic - inapproriate container for analysis
TOC - inappropriate container for analysis

Kind regards,

Jenny Bevan
Business Development Officer- Environmental
Brisbane

ALS
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jenny.bevan@alsglobal.com
2 Byth Street (cnr Shand & Byth Street)
Stafford QLD 4053 AUSTRALIA

EnviroMail™ 00 – All EnviroMails™ in one convenient library.
EnviroMail™ 123 Re-Release – Leaching Environmental Assessment Framework
EnviroMail™ 125 – ALS Now NATA Accredited for Total Organic Fluorine (TOF)
EnviroMail™ 126 – TOF for Compliance with Guideline ERA 60 Now NATA Accredited

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www.alsglobal.com

29/6/21
17:00
Martin

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order : **EB2120349**
Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : UNIT 2 - 209 LEITCHS ROAD
BRENDALE QLD 4500
Telephone : ----
Project : ANLEC South Surat
Order number : 20000109
C-O-C number : ----
Sampler : JULIE PEARCE
Site : ----
Quote number : EN/333
No. of samples received : 2
No. of samples analysed : 2

Page : 1 of 4
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 20-Jul-2021 17:17
Date Analysis Commenced : 22-Jul-2021
Issue Date : 29-Jul-2021 10:15

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Thomas Donovan		Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- **C1-C4 Gases analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- It is recognised that EP005 (Total Organic Carbon) is less than EP002 (Dissolved Organic Carbon) for sample 'West moonie 1'. However, the difference is within experimental variation of the methods.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**West moonie 1**	**W moonie Shallow**	----	----	----
			Sampling date / time	19-Jul-2021 15:00	19-Jul-2021 16:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2120349-001**	**EB2120349-002**	--------	--------	--------
				Result	Result	----	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**20**	**71**	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**944**	**81**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**1050**	**11**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**1050**	**11**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**4**	**1250**	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**291**	**17700**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**5**	**1320**	----	----	----
Magnesium	7439-95-4	1	mg/L	**1**	**1150**	----	----	----
Sodium	7440-23-5	1	mg/L	**588**	**10600**	----	----	----
Potassium	7440-09-7	1	mg/L	**126**	**65**	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Manganese	7439-96-5	0.001	mg/L	**0.050**	**3.75**	----	----	----
Rubidium	7440-17-7	0.001	mg/L	**0.070**	**0.057**	----	----	----
Strontium	7440-24-6	0.001	mg/L	**0.310**	**37.1**	----	----	----
Iron	7439-89-6	0.05	mg/L	**2.44**	**7.19**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.00004	mg/L	<0.00004	<0.00004	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**6.4**	<0.1	----	----	----
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**29.3**	**526**	----	----	----
ø **Total Cations**	----	0.01	meq/L	**29.1**	**623**	----	----	----
ø **Ionic Balance**	----	0.01	%	**0.24**	**8.50**	----	----	----
EP002: Dissolved Organic Carbon (DOC)								
Dissolved Organic Carbon	----	1	mg/L	**6**	**6**	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**3**	**6**	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**West moonie 1**	**W moonie Shallow**	**----**	**----**	**----**
			Sampling date / time	19-Jul-2021 15:00	19-Jul-2021 16:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2120349-001**	**EB2120349-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	1	µg/L	**8060**	**2**	----	----	----
Ethene	74-85-1	1	µg/L	<1	<1	----	----	----
Ethane	74-84-0	1	µg/L	**113**	<1	----	----	----
Propene	115-07-1	1	µg/L	<1	<1	----	----	----
Propane	74-98-6	1	µg/L	**14**	<1	----	----	----
Butene	25167-67-3	1	µg/L	<1	<1	----	----	----
Butane	106-97-8	1	µg/L	**1**	<1	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EP033: C1 - C4 Hydrocarbon Gases

Jetcourier # 3474

CHAIN OF CUSTODY

ALS Environmental

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com
☒BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
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☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
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☐NOWRA 4/13 Geary Place North Nowra NSW 2541
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☐PERTH 10 Hod Way Malaga WA 6090
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☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: University of Queensland
OFFICE: [illegible]
Project: ANLEC South Surat
ORDER NUMBER:
PROJECT MANAGER: Julie Pearce **CONTACT PH:** 0435848879
SAMPLER: Julie pearce **SAMPLER MOBILE:** 0435848879
COC emailed to ALS? ([✓ YES] / NO) **EDD FORMAT (or default):**
Email Reports to (will default to PM if no other addresses are listed): j.pearce2@uq.edu.au
Email Invoice to (will default to PM if no other addresses are listed): j.pearce2@uq.edu.au, invoices@uq.edu.au

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g., Ultra Trace Organics)
☒ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.: EN/222/20
UQ BLANKET QUOTE

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: [✓ 1] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
J Pearce	CHRIS PERRY		
DATE/TIME: 20/7/21 1.30pm	DATE/TIME: 20/7/21 17.17	DATE/TIME:	DATE/TIME:

COMMENTS email Julie Pearce j.pearce2@uq.edu.au with preliminary invoice for PO no.

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	EP033 LL	EG005F dissolved Fe,Mn, Sr; EG020F Rb dissolved	NT-1	EG035F LL dissolved	NT-2A	EA165	EP002	EP005	Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	West moonie 1	19/7/21 3pm	W	V,V, N, P,V,v	6	x	x	x	x	x	x	x	x	
2	W moonie Shallow	19/7/21 4pm	W	V,V, N, P,V,v	6	x	x	x	x	x	x	x	x	
				TOTAL	12	2	2	2	2	2	2	2	2	

Environmental Division
Brisbane
Work Order Reference
EB2120349
Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

~~07 3365 6455~~

Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB2120461**	Page	: 1 of 6
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 21-Jul-2021 16:54
Order number	: 20000110	Date Analysis Commenced	: 27-Jul-2021
C-O-C number	: ----	Issue Date	: 04-Aug-2021 16:02
Sampler	: ----		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 3		
No. of samples analysed	: 3		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Edwandy Fadjar	Organic Coordinator	Sydney Organics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP080: Result for West Moonie 1 Flow back water 2 has been confirmed.
- **Methane, BTEXN and TOC analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**West Moonie 1 Flow back water 1**	**West Moonie 1 Flow back water 2**	**West Moonie 1 Flow back water 3**	----	----
			Sampling date / time	16-Jul-2021 00:00	16-Jul-2021 00:00	16-Jul-2021 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2120461-001**	**EB2120461-002**	**EB2120461-003**	--------	--------
				Result	Result	Result	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.12**	**8.16**	**8.35**	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**2930**	**2910**	**2920**	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**1880**	**1850**	**1850**	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**8.2**	**6.8**	**7.4**	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**17**	**19**	**19**	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**16**	**15**	**9**	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**967**	**947**	**951**	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	**19**	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**1080**	**1060**	**1060**	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**1080**	**1060**	**1080**	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**38.6**	**38.6**	**38.8**	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**8**	**8**	**8**	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**328**	**319**	**318**	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**5**	**6**	**6**	----	----
Magnesium	7439-95-4	1	mg/L	**1**	**1**	**1**	----	----
Sodium	7440-23-5	1	mg/L	**518**	**598**	**611**	----	----
Potassium	7440-09-7	1	mg/L	**139**	**155**	**150**	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.14**	**0.03**	**0.05**	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**West Moonie 1 Flow back water 1**	**West Moonie 1 Flow back water 2**	**West Moonie 1 Flow back water 3**	**----**	**----**
			Sampling date / time	16-Jul-2021 00:00	16-Jul-2021 00:00	16-Jul-2021 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2120461-001**	**EB2120461-002**	**EB2120461-003**	**--------**	**--------**
				Result	Result	Result	----	----
EG020T: Total Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	**0.003**	<0.001	<0.001	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Cobalt	7440-48-4	0.001	mg/L	**0.003**	**0.002**	**0.016**	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.001**	**0.001**	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	<0.005	----	----
Lithium	7439-93-2	0.001	mg/L	**0.126**	**0.157**	**0.138**	----	----
Manganese	7439-96-5	0.001	mg/L	**0.048**	**0.047**	**0.049**	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.003**	**0.003**	**0.003**	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	----	----
Boron	7440-42-8	0.05	mg/L	**0.68**	**0.83**	**0.73**	----	----
Iron	7439-89-6	0.05	mg/L	**3.12**	**2.84**	**2.78**	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	----
EG049T: Total Trivalent Chromium								
Trivalent Chromium	16065-83-1	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EG050T: Total Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Silver	7440-22-4	0.01	µg/L	**0.34**	**0.24**	**0.07**	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**5.7**	**6.0**	**6.3**	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.92**	**0.84**	**0.70**	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	<0.01	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**West Moonie 1 Flow back water 1**	**West Moonie 1 Flow back water 2**	**West Moonie 1 Flow back water 3**	----	----
			Sampling date / time	16-Jul-2021 00:00	16-Jul-2021 00:00	16-Jul-2021 00:00	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2120461-001**	**EB2120461-002**	**EB2120461-003**	--------	--------
				Result	Result	Result	----	----
EK071G: Reactive Phosphorus as P by discrete analyser - Continued								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.01**	**0.01**	**0.01**	----	----
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**31.0**	**30.3**	**30.7**	----	----
ø **Total Cations**	----	0.01	meq/L	**26.4**	**30.4**	**30.8**	----	----
ø **Ionic Balance**	----	0.01	%	**7.98**	**0.02**	**0.13**	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**6**	----	**8**	----	----
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**1.1**	**5.1**	**2.1**	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**1640**	**1420**	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	----	<20	<20	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	----	<20	<20	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	----	<20	<20	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	----	<1	<1	----	----
Toluene	108-88-3	2	µg/L	----	**3**	<2	----	----
Ethylbenzene	100-41-4	2	µg/L	----	<2	<2	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	----	**2**	<2	----	----
ortho-Xylene	95-47-6	2	µg/L	----	<2	<2	----	----
^ **Total Xylenes**	----	2	µg/L	----	**2**	<2	----	----
^ **Sum of BTEX**	----	1	µg/L	----	**5**	<1	----	----
Naphthalene	91-20-3	5	µg/L	----	<5	<5	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	----	**116**	**122**	----	----
Toluene-D8	2037-26-5	2	%	----	**111**	**118**	----	----
4-Bromofluorobenzene	460-00-4	2	%	----	**110**	**120**	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	*CAS Number*	*Recovery Limits (%)* Low	*Recovery Limits (%)* High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EP005: Total Organic Carbon (TOC)

(WATER) EP033: C1 - C4 Hydrocarbon Gases

(WATER) EP080/071: Total Petroleum Hydrocarbons

(WATER) EP080: BTEXN

(WATER) EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions

(WATER) EP080S: TPH(V)/BTEX Surrogates

Environmental Division
Brisbane
Work Order Reference
EB2120461

Telephone : + 61-7-3243 7222

CHAIN OF CUSTODY

ALS Laboratory: please tick →

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Ph: 08 8359 0890 E: adelaide@alsglobal.com
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Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 024423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsglobal.com

CLIENT: Stratum Reservoir (Australia) Pty Ltd
OFFICE:
PROJECT: AB-106884
ORDER NUMBER: To be advised
PROJECT MANAGER: Keith Window **CONTACT PH:** 0400 934 304
SAMPLER: **SAMPLER MOBILE:**
COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**
Email Reports to keith.window@stratumreservoir.com
Email Invoice to keith.window@stratumreservoir.com

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☒ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORA
Custody Seal Int
Free ice / frozen receipt?
Random Sample
Other comment

RELINQUISHED BY:	**RECEIVED BY:** Toichs	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME:	DATE/TIME: 21/7/21 1654	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	EA005P Analysis as per attached quote.								Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	West Moonie 1 Flow back water 1	16-07-21				X								
2	West Moonie 1 Flow back water 2	16-07-21				X								
3	West Moonie 1 Flow back water 3	16-07-21				X								
														HT
				TOTAL										

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

Keith Window

Subject: FW: [EXTERNAL] - RE: ALS Environmental - analysis price request

Hi Keith,

Well, as discussed there is very little left from your list that I would proceed with analysis for. All that you have left is EC and Fluoride (both have a 28 day holding time from an unpreserved container.

You may potentially elect to analyse for metals but these could bias low?

This would not include any of the speciated arsenic or chromium.

Below the pricing table is the recommended containers (per sample). I have also provided prices on a per sample basis to allow you to mix and match moving forward and calculate accordingly. Just remember to add your $40.00 admin fee and GST.

Tailored Analytical Services & Charges: Test

Parameter	ALS Code	Technique/ Method Reference	Limit Of Reporting (LOR)	No.	Price per Sample ($)
pH (PCT)	EA005P	APHA 4500-H+ B	0.01 pH Unit	1	5.50
Electrical Conductivity (PCT)	EA010P	APHA 2510 B	1 µS/cm	1	5.50
Turbidity	EA045	APHA 2130 B	0.1 NTU	1	5.50
CO2 - Free and Total	EA165	APHA 4500-CO2 D	1 mg/L	1	15.40
Dissolved Oxygen (DO)	EP025	APHA 4500-O G	0.1 mg/L	1	7.70
Dissolved Major Anions Silica as Si02	ED040F	APHA 3120	0.1 mg/L	1	11.00
Major Cations (Ca, Mg, Na, K) + Hardness	NT-01D	USEPA 6010	1 mg/L	1	15.40
Minor Anions (Nitrite, Nitrate, Fluoride, Reactive-P)	NT-03	APHA 4500-F C, APHA 4500-NO3 F, APHA 4500-NO2 B, APHA 4500-P F	0.01 - 0.1 mg/L	1	38.50
Total Dissolved Solids - Standard Level	EA015H	APHA 2540C	10 mg/L	1	11.00
Major Anions (Chloride, Sulphate, Alkalinity)	NT-02	APHA 2320 B, APHA 4500-Cl G, APHA 4500-SO4	1 mg/L	1	22.00
Methane in Water	EP033 - Methane	In house HS/GC/FID	10 µg/L	1	82.50
Total Organic Carbon (TOC)	EP005	APHA 5310 B	1 mg/L	1	26.40
Arsenic Speciation by LC-ICPMS	EG032	In house	0.5 - 1 µg/L	1	308.00
Ammonia as N By Discrete Analyser	EK055G	APHA 4500-NH3 G	0.01 mg/L	1	15.40
8 metals (Total) As, Cd, Cr, Cu, Ni, Pb, Zn, Hg	W-02T	USEPA 6020, APHA 3112- Hg B	0.0001 - 0.005 mg/L	1	31.90
Additional total Metals by ICP/MS (including digestion) Al, Be, B, Co, Fe, Li, Mn, Mo, Ni, Se, U,V	EG020T	USEPA 6020	0.001 - 0.05 mg/L	1	24.00 (2.00 per additional metal)
Trivalent Chromium - Total	EG049G-T	USEPA 6020, APHA 3500-Cr B,	0.001 - 0.01 mg/L	1	26.40

Parameter	ALS Code	Technique/ Method Reference	Limit Of Reporting (LOR)	No.	Price per Sample ($)
		APHA 3500-Cr B / USEPA 6020			
Total Hexavalent Chromium	EG050G-T	APHA 3500-Cr B	0.01 mg/L	1	11.00
Ultra trace Total Silver to meet ANZECC 99% protection	EG094-AgT	APHA 3125; USEPA SW846 - 6020	0.01 µg/L	1	44.00
Un-ionised Hydrogen Sulfide	EK084	APHA 4500-S2 H	0.1 mg/L	1	22.00
TRH/BTEXN	W-04	USEPA 8015, USEPA 8260	1 - 100 µg/L	1	46.20
Total Potentially Toxic Cyanophytes	MW024_PTOX	Hotzel & Croome	5 cells/ml, 5 cells/mL	1	60.50
Total cost per sample (Excluding GST)					**$835.80**

To order containers for pick up please email bottles.brisbane@alsglobal.com

Just copy the below table and then say how many samples you are taking. Be sure to specify when you would like to pick these up. Alternatively order these in advance and we can have these couriered free to you.

Sample Containers for: Test

No.	Label Colour	Container Type (Preservation noted if required)	Test Parameter(s)
	Purple	2 x 40mL Amber VOC Vial - Sulfuric Acid	Methane in Water, TRH – volatile /BTEXN
	Green	1 x 500mL Clear Plastic Bottle - Natural	CO2 - Free and Total, Dissolved Major Anions, Dissolved Oxygen (DO), Electrical Conductivity (PCT), Major Anions (Chloride, Sulphate, Alkalinity), Nitrite, Nitrate, Fluoride, Reactive-P, pH (PCT), Total Dissolved Solids, Turbidity
	Purple	1 x 40mL Amber TOC Vial - Sulfuric Acid	Total Organic Carbon (TOC)
	Purple	1 x 60mL Clear Plastic Bottle - Sulfuric Acid	Ammonia as N By Discrete Analyser
	Red	1 x 60mL Clear Plastic Bottle - Nitric Acid; Unfiltered	Total Metals by ICP/MS (including digestion)
	Blue	1 x 60mL Clear Plastic Bottle - NaOH	Total Hexavalent Chromium, Trivalent Chromium - Total
	Fluorescent Yellow	1 x 125mL Clear Plastic Bottle - Zn Acetate/NaOH-FLOCCULATED	Un-ionised Hydrogen Sulfide
	Red	1 x 60mL Clear Plastic Bottle - Nitric Acid; Filtered	Major Cations (Ca, Mg, Na, K) + Hardness
	Green	1 x 250mL Plastic Bottle - Lugols Iodine	Total Potentially Toxic Cyanophytes
	Orange	1 x 100mL Amber Glass Bottle - Unpreserved	TRH
	Maroon	1 x 60mL Clear Plastic Bottle - HCl - Filtered	Speciated Arsenic

Additional bottles are required on water samples for semi-volatile organics and PFAS analysis for laboratory QA/QC purposes. For further information, click **here**

EA005-P pH by PC Titrator (6 hours)
EP030 Biochemical Oxygen Demand (BOD) (2 days)
EA045 Turbidity (2 days)
EA165 Free and Total CO2 (6 hours)
EK057G Nitrite as N by Discrete Analyser (2 days)
EK058G Nitrate as N by Discrete Analyser (2 days)
EK071G Reactive Phosphorus as P-By Discrete Analyser (2 days)
EP025 Oxygen - Dissolved (6 hours)
EK084 – Unionised Hydrogen Sulfide(1 day unpreserved)
EA015H – Total Dissolved Soilds(7 days)
Methane – inappropriate container for analysis
BTEXN - inappropriate container for analysis
MW024_PTOX – 2 days unpreserved
Semi-Vol TRH – 7 days
Volatile TRH - inappropriate container for analysis
Speciated Arsenic – inapproriate container for analysis
TOC - inappropriate container for analysis

Kind regards,

Jenny Bevan
Business Development Officer- Environmental
Brisbane

T +61 7 3243 7222 D +61 7 3552 8657
jenny.bevan@alsglobal.com
2 Byth Street (cnr Shand & Byth Street)
Stafford QLD 4053 AUSTRALIA

EnviroMail™ 00 – All EnviroMails™ in one convenient library.
EnviroMail™ 123 Re-Release – Leaching Environmental Assessment Framework
EnviroMail™ 125 – ALS Now NATA Accredited for Total Organic Fluorine (TOF)
EnviroMail™ 126 – TOF for Compliance with Guideline ERA 60 Now NATA Accredited

CERTIFICATE OF ANALYSIS

Work Order	: **EB2122434**	Page	: 1 of 2
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: West Moonie 2	Date Samples Received	: 10-Aug-2021 16:53
Order number	: 20000110	Date Analysis Commenced	: 13-Aug-2021
C-O-C number	: ----	Issue Date	: 23-Aug-2021 15:35
Sampler	: JULIE PEARCE		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 2		
No. of samples analysed	: 2		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG032: LOR's have been raised due to matrix interference. (High Total Dissolved Solids)
- **Arsenic Speciation analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913). The estimated reporting date for this analysis is 02/09/2021.**

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Sample ID	**WEST Moonie 1**	**W.Moonie Shallow**	**----**	**----**	**----**
			Sampling date / time	19-Jul-2021 15:00	19-Jul-2021 16:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2122434-001**	**EB2122434-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EG032: Arsenic Speciation by LC-ICPMS								
Arsenobetaine (ASB)	----	1	µg/L	<1	<10	----	----	----
Arsenious Acid (As (III))	----	0.5	µg/L	<0.5	<5.0	----	----	----
Dimethylarsenic Acid (DMA)	----	1	µg/L	<1	<10	----	----	----
Monomethylarsonic Acid (MMA)	----	1	µg/L	<1	<10	----	----	----
Arsenic Acid (As (V))	----	0.5	µg/L	<0.5	<5.0	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.91**	**1.75**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	<0.01	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EG032: Arsenic Speciation by LC-ICPMS

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory:
please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com

☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph. 07 3243 7222 E: samples.brisbane@alsglobal.com

☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph: 07 7471 5600 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com

☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com

☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com

☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 024423 2063 E: nowra@alsglobal.com

☐PERTH 10 Hod Way Malaga WA 6090
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☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Stratum Reservoir

OFFICE: [illegible]

PROJECT: West Moonie 2

ORDER NUMBER: 20000110

PROJECT MANAGER: Keith Window **CONTACT PH:** 0400 934 304

SAMPLER: **SAMPLER MOBILE:**

COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to : keith.window@stratumreservoir.com

Email Invoice to Thanawat Khumtong <thanawat.khumtong@stratumreservoir.com>

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT **(List due date):**
☐ Non Standard or urgent TAT **(List due date):**

ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY:	**RECEIVED BY:** Daren	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME:	DATE/TIME: 1653 10/8/21	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	EG0332	EK055	EK059	EP035					Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1		19/7/21 3pm				✓	✓	PENDING						
2		19/7/21 4pm				✓	✓							
				TOTAL										

Can someone please confirm price for these 2 tests. Thanks

Environmental Division
Brisbane
Work Order Reference
EB2122434

Telephone : + 61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CERTIFICATE OF ANALYSIS

Work Order : **EB2123041**
Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : UNIT 2 - 209 LEITCHS ROAD
BRENDALE QLD 4500
Telephone : ----
Project : CTSCO
Order number : ----
C-O-C number : ----
Sampler : JULIE PEARCE
Site : ----
Quote number : EN/333
No. of samples received : 2
No. of samples analysed : 2

Page : 1 of 3
Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 16-Aug-2021 14:15
Date Analysis Commenced : 19-Aug-2021
Issue Date : 23-Aug-2021 11:32

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

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When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG020T (Total Metals by ICP-MS): Limit of reporting raised for sample W MOONIE SHALLOW (EB2123041-002) due to matrix interference.
- EG093: Samples containing high levels of sulfate may precipitate barium under the acidic conditions of this method and may therefore bias results low.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**WEST MOONIE 1**	**W MOONIE SHALLOW**	**----**	**----**	**----**
			Sampling date / time	19-Jul-2021 03:00	19-Jul-2021 16:00	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2123041-001**	**EB2123041-002**	**--------**	**--------**	**--------**
				Result	Result	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	**0.15**	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.005	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.005	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	**0.0008**	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.005	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	**0.128**	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.005	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.138**	**0.120**	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.043**	**3.37**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.004**	<0.005	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	**0.077**	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.05	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.005	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.05	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	**0.075**	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.65**	**0.51**	----	----	----
Iron	7439-89-6	0.05	mg/L	**2.03**	**4.76**	----	----	----
EG093T: Total Metals in Saline Water by ORC-ICPMS								
Silver	7440-22-4	0.1	µg/L	----	**0.6**	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Silver	7440-22-4	0.01	µg/L	<0.01	----	----	----	----

JET COURIER 2166

* and thanawat.khumtong@stratumreservoir.com

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 3/1 Burma Road Pooraka SA 5095
Ph: 08 8162 5130 E: adelaide@alsglobal.com

☒BRISBANE 2 Byth Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

☐GLADSTONE 46 Callemondah Drive Gladstone QLD 4680
Ph: 07 4978 7944 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
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☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
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☐MUDGEE 1/29 Sydney Road Mudgee NSW 2850
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☐NEWCASTLE 5/585 Maitland Road Mayfield West NSW 2304
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☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 02 4423 2063 E: nowra@alsglobal.com

☐PERTH 10 Hod Way Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsglobal.com

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐WOLLONGONG 1/19-21 Ralph Black Drive, Nth Wollongong NSW 2500
Ph: 02 4225 3125 E: wollongong@alsglobal.com

CLIENT: STRATUM (UQ)

OFFICE: RESERVOIR

PROJECT: CTSCO **PROJECT NO.:**

ORDER NUMBER: **PURCHASE ORDER NO.:**

PROJECT MANAGER: KEITH WINDOW **CONTACT PH:** 0407354748

SAMPLER: JULIE PEARCE (UQ) **SAMPLER MOBILE:** 0435848879

COC Emailed to ALS? ([✓ YES] / NO) **EDD FORMAT (or default):** + ESDAT

Email Reports to (will default to PM if no other addresses are listed): J.PEARCE2@UQ.EDU.AU

Email Invoice to (will default to PM if no other addresses are listed): KEITH.WINDOW@STRATUMRESERVOIR.COM

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: // EMAIL KEITH.WINDOW@STRATUMRESERVOIR.COM FOR PO *

TURNAROUND REQUIREMENTS : (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☑ Standard TAT (List due date):

☐ Non Standard or urgent TAT (List due date):

ALS QUOTE NO.: EN222/21

COUNTRY OF ORIGIN: AUSTRALIA

COC SEQUENCE NUMBER (Circle)

COC: [✓ 1] 2 3 4 5 6 7

OF: [✓ 1] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? Yes No N/A

Free ice / frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RELINQUISHED BY: J PEARCE	**RECEIVED BY:** Martin	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME: 16/8/21 9:45 am	DATE/TIME: 16/8/21 14:15	DATE/TIME:	DATE/TIME:

ALS USE ONLY	SAMPLE DETAILS MATRIX: Solid(S) Water(W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL BOTTLES	Ag EG094T	EG020T	Al, As, Be	Cd, Cr, Co	Pb, Li, Mn, Mo	Ni, Se, U, V, Zn	B, Fe		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
	WESTMOONIE 1	19/7/21 3pm	W	N	1	✓	✓	✓	✓	✓	✓	✓		TOTAL METALS
	W MOONIE SHALLOW	19/7/21 4pm	W	N	1	✓	✓	✓	✓	✓	✓	✓		TOTAL METALS
														ICP·MS + Ag
				TOTAL	[✓ 2]	2	2	2	2	2	2	2		

Environmental Division
Brisbane
Work Order Reference
EB2123041

Telephone : + 61-7-3243 7222

2166

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag; LI = Lugols Iodine Preserved Bottles; STT = Sterile Sodium Thiosulfate Preserved Bottles.

ENFM (20/4/13)

CERTIFICATE OF ANALYSIS

Work Order	: **EB2124168**	Page	: 1 of 7
Amendment	: **(Preliminary Report)**		
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 26-Aug-2021 10:00
Order number	: 20000110	Date Analysis Commenced	: 27-Aug-2021
C-O-C number	: ----	Issue Date	: 02-Sep-2021 13:19
Sampler	: D GREER		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key :
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

This report contains preliminary authorised results. The report may contain semi-quantitative results. Any result presented in this preliminary report may be subject to change in the final report.

- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- **Methane analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (*Matrix*: **WATER**)			*Sample ID*	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.66**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1280**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**814**	----	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.3**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**2**	----	----	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**2**	----	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**454**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**44**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**492**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**536**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**24.1**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**6**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**68**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**1**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**331**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.011**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.014**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.13**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.13**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG049T: Total Trivalent Chromium								
Trivalent Chromium	16065-83-1	0.01	mg/L	<0.01	----	----	----	----
EG050T: Total Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Silver	7440-22-4	0.1	µg/L	**0.5**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.54**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.07**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.07**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser - Continued								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.02**	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**3**	----	----	----	----
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**9.9**	----	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**Not Authorised**	----	----	----	----
Ethene	74-85-1	10	µg/L	**Not Authorised**	----	----	----	----
Ethane	74-84-0	10	µg/L	**Not Authorised**	----	----	----	----
Propene	115-07-1	10	µg/L	**Not Authorised**	----	----	----	----
Propane	74-98-6	10	µg/L	**Not Authorised**	----	----	----	----
Butene	25167-67-3	10	µg/L	**Not Authorised**	----	----	----	----
Butane	106-97-8	10	µg/L	**Not Authorised**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**MILGARRA BORE**	**----**	**----**	**----**	**----**
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2124168-001**	**--------**	**--------**	**--------**	**--------**
				Result	----	----	----	----
EP080: BTEXN - Continued								
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ **Total Xylenes**	----	2	µg/L	<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**93.5**	----	----	----	----
Toluene-D8	2037-26-5	2	%	**101**	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	**111**	----	----	----	----

Surrogate Control Limits

Sub-Matrix**: WATER**

		Recovery Limits (%)	
Compound	*CAS Number*	***Low***	***High***
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EP033: C1 - C4 Hydrocarbon Gases

Environmental

QUALITY CONTROL REPORT

Work Order : **EB2124168**
Amendment : **(Preliminary Report)**

Page : 1 of 10

Client : **STRATUM RESERVOIR**
Contact : KEITH WINDOW
Address : UNIT 2 - 209 LEITCHS ROAD
BRENDALE QLD 4500
Telephone : ----
Project : AB-106884
Order number : 20000110
C-O-C number : ----
Sampler : D GREER
Site : ----
Quote number : EN/333
No. of samples received : 1
No. of samples analysed : 1

Laboratory : Environmental Division Brisbane
Contact : Customer Services EB
Address : 2 Byth Street Stafford QLD Australia 4053
Telephone : +61-7-3243 7222
Date Samples Received : 26-Aug-2021
Date Analysis Commenced : 27-Aug-2021
Issue Date : 02-Sep-2021

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
\# = Indicates failed QC

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EA005P: pH by PC Titrator (QC Lot: 3871238)									
EB2123960-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	7.41	7.34	0.9	0% - 20%
EB2123880-001	Anonymous	EA005-P: pH Value	----	0.01	pH Unit	9.04	9.06	0.2	0% - 20%
EA010P: Conductivity by PC Titrator (QC Lot: 3871237)									
EB2123960-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	2630	2610	0.8	0% - 20%
EB2123880-001	Anonymous	EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	12200	12200	0.7	0% - 20%
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 3869400)									
EB2123388-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	4500	4480	0.5	0% - 20%
EB2123777-002	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	210	207	1.4	0% - 20%
EA045: Turbidity (QC Lot: 3870719)									
EB2123934-001	Anonymous	EA045: Turbidity	----	0.1	NTU	1.5	1.5	0.0	0% - 50%
EB2124173-003	Anonymous	EA045: Turbidity	----	0.1	NTU	27.3	27.2	0.4	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 3871239)									
EB2123960-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	78	70	9.8	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	78	70	9.8	0% - 20%
EB2123880-001	Anonymous	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	215	205	5.1	0% - 20%
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	543	560	3.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	758	764	0.8	0% - 20%
ED040F: Dissolved Major Anions (QC Lot: 3870782)									
EB2124104-001	Anonymous	ED040F: Silicon as SiO2	14464-46-1	0.1	mg/L	52.3	53.2	1.6	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3870779)									

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 3870779) - continued									
EB2124168-001	MILGARRA BORE	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	6	6	0.0	No Limit
EB2124104-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	11	11	0.0	0% - 50%
ED045G: Chloride by Discrete Analyser (QC Lot: 3870780)									
EB2124104-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	95	95	0.0	0% - 20%
ED093F: Dissolved Major Cations (QC Lot: 3869118)									
EB2123935-001	Anonymous	ED093F: Calcium	7440-70-2	1	mg/L	235	224	4.7	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	267	255	4.8	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	1300	1240	5.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	6	6	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 3869544)									
EB2124168-001	MILGARRA BORE	EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
EG020T: Total Metals by ICP-MS (QC Lot: 3869545)									
EB2124168-001	MILGARRA BORE	EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Lithium	7439-93-2	0.001	mg/L	0.011	0.012	0.0	0% - 50%
		EG020A-T: Manganese	7439-96-5	0.001	mg/L	0.014	0.014	0.0	0% - 50%
		EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	0.005	0.005	0.0	No Limit
		EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	0.0	No Limit
		EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	<0.005	0.0	No Limit
		EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	0.0	No Limit
		EG020A-T: Boron	7440-42-8	0.05	mg/L	0.13	0.14	0.0	No Limit
		EG020A-T: Iron	7439-89-6	0.05	mg/L	0.13	0.14	0.0	No Limit
EG035T: Total Recoverable Mercury by FIMS (QC Lot: 3869542)									
EB2124168-001	MILGARRA BORE	EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG050T: Total Hexavalent Chromium (QC Lot: 3872898)									
EB2123771-001	Anonymous	EG050G-T: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EG094T: Total metals in Fresh water by ORC-ICPMS (QC Lot: 3869543)									
EB2124168-001	MILGARRA BORE	EG094A-T: Silver	7440-22-4	0.1	µg/L	0.5	0.6	17.8	No Limit
EK040P: Fluoride by PC Titrator (QC Lot: 3871240)									
EB2123960-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	0.7	0.8	0.0	No Limit
EB2123880-001	Anonymous	EK040P: Fluoride	16984-48-8	0.1	mg/L	1.5	1.5	0.0	0% - 50%

Sub-Matrix: **WATER**				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 3870832)									
EB2123565-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 3870778)									
EB2124168-001	MILGARRA BORE	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EB2124104-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 3870833)									
EB2124168-001	MILGARRA BORE	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.07	0.07	0.0	No Limit
EB2123565-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	1.59	1.62	1.7	0% - 50%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 3870783)									
EB2124168-001	MILGARRA BORE	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.02	0.02	0.0	No Limit
EP005: Total Organic Carbon (TOC) (QC Lot: 3869873)									
EB2123416-001	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	40	40	0.0	0% - 50%
EB2123416-010	Anonymous	EP005: Total Organic Carbon	----	1	mg/L	40	36	11.2	0% - 50%
EP033: C1 - C4 Hydrocarbon Gases (QC Lot: 3878292)									
EB2124187-001	Anonymous	EP033: Methane	74-82-8	10	µg/L	22200	22000	0.9	0% - 20%
		EP033: Ethene	74-85-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Ethane	74-84-0	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propene	115-07-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propane	74-98-6	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butene	25167-67-3	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butane	106-97-8	10	µg/L	<10	<10	0.0	No Limit
EB2124351-001	Anonymous	EP033: Methane	74-82-8	10	µg/L	10700	10700	0.4	0% - 20%
		EP033: Ethene	74-85-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Ethane	74-84-0	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propene	115-07-1	10	µg/L	<10	<10	0.0	No Limit
		EP033: Propane	74-98-6	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butene	25167-67-3	10	µg/L	<10	<10	0.0	No Limit
		EP033: Butane	106-97-8	10	µg/L	<10	<10	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 3869627)									
EB2124168-001	MILGARRA BORE	EP071: C15 - C28 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: C10 - C14 Fraction	----	50	µg/L	<50	<50	0.0	No Limit
		EP071: C29 - C36 Fraction	----	50	µg/L	<50	<50	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 3869683)									
EB2123296-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<0.02 mg/L	<20	0.0	No Limit
EB2123416-009	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 3869627)									
EB2124168-001	MILGARRA BORE	EP071: >C10 - C16 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: >C16 - C34 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
		EP071: >C34 - C40 Fraction	----	100	µg/L	<100	<100	0.0	No Limit

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD (%)*	*Acceptable RPD (%)*
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 3869683)									
EB2123296-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<0.02 mg/L	<20	0.0	No Limit
EB2123416-009	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.0	No Limit
EP080: BTEXN (QC Lot: 3869683)									
EB2123296-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<0.001 mg/L	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<0.002 mg/L	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<0.002 mg/L	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<0.002 mg/L	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<0.002 mg/L	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<0.005 mg/L	<5	0.0	No Limit
EB2123416-009	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA005P: pH by PC Titrator (QCLot: 3871238)								
EA005-P: pH Value	----	----	pH Unit	----	4 pH Unit	99.8	98.0	102
				----	7 pH Unit	100	98.0	102
EA010P: Conductivity by PC Titrator (QCLot: 3871237)								
EA010-P: Electrical Conductivity @ 25°C	----	1	µS/cm	<1	220 µS/cm	102	91.0	107
				<1	12890 µS/cm	96.1	91.0	107
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 3869400)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2460 mg/L	102	88.0	112
				<10	293 mg/L	107	88.0	112
				<10	2000 mg/L	99.3	80.9	118
EA045: Turbidity (QCLot: 3870719)								
EA045: Turbidity	----	0.1	NTU	<0.1	4 NTU	100	90.0	110
				<0.1	40 NTU	100	90.0	110
				<0.1	400 NTU	98.8	90.0	110
ED037P: Alkalinity by PC Titrator (QCLot: 3871239)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	50 mg/L	103	80.0	120
ED040F: Dissolved Major Anions (QCLot: 3870782)								
ED040F: Silicon as SiO2	14464-46-1	0.1	mg/L	<0.1	10.7 mg/L	94.4	70.0	130
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3870779)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	25 mg/L	102	85.0	118
				<1	100 mg/L	101	85.0	118
ED045G: Chloride by Discrete Analyser (QCLot: 3870780)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	10 mg/L	93.1	90.0	115
				<1	1000 mg/L	102	90.0	115
ED093F: Dissolved Major Cations (QCLot: 3869118)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	115	70.0	130
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	107	70.0	130
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	104	70.0	130
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	108	70.0	130
EG020T: Total Metals by ICP-MS (QCLot: 3869544)								
EG020B-T: Uranium	7440-61-1	0.001	mg/L	<0.001	0.1 mg/L	103	70.0	130
EG020T: Total Metals by ICP-MS (QCLot: 3869545)								
EG020A-T: Aluminium	7429-90-5	0.01	mg/L	<0.01	0.5 mg/L	98.5	80.0	114
EG020A-T: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	100	88.0	112

Sub-Matrix: **WATER**

Method: Compound	*CAS Number*	*LOR*	*Unit*	*Method Blank (MB) Report*	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Acceptable Limits (%)*	
				Result	*Concentration*	*LCS*	*Low*	*High*
EG020T: Total Metals by ICP-MS (QCLot: 3869545) - continued								
EG020A-T: Beryllium	7440-41-7	0.001	mg/L	<0.001	0.1 mg/L	100	81.0	119
EG020A-T: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	103	88.0	111
EG020A-T: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	98.2	89.0	115
EG020A-T: Cobalt	7440-48-4	0.001	mg/L	<0.001	0.1 mg/L	98.5	89.0	115
EG020A-T: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	108	88.0	116
EG020A-T: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	100	89.0	112
EG020A-T: Lithium	7439-93-2	0.001	mg/L	<0.001	0.1 mg/L	114	70.0	130
EG020A-T: Manganese	7439-96-5	0.001	mg/L	<0.001	0.1 mg/L	102	88.0	114
EG020A-T: Molybdenum	7439-98-7	0.001	mg/L	<0.001	0.1 mg/L	105	90.0	114
EG020A-T: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	101	88.0	116
EG020A-T: Selenium	7782-49-2	0.01	mg/L	<0.01	0.1 mg/L	98.4	79.0	111
EG020A-T: Vanadium	7440-62-2	0.01	mg/L	<0.01	0.1 mg/L	101	87.0	114
EG020A-T: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	101	84.0	114
EG020A-T: Boron	7440-42-8	0.05	mg/L	<0.05	0.5 mg/L	92.8	82.0	128
EG020A-T: Iron	7439-89-6	0.05	mg/L	<0.05	0.5 mg/L	105	82.0	118
EG035T: Total Recoverable Mercury by FIMS (QCLot: 3869542)								
EG035T: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	94.3	84.0	118
EG050T: Total Hexavalent Chromium (QCLot: 3872898)								
EG050G-T: Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	0.5 mg/L	99.9	86.0	120
EG094T: Total metals in Fresh water by ORC-ICPMS (QCLot: 3869543)								
EG094A-T: Silver	7440-22-4	0.1	µg/L	<0.1	10 µg/L	100	80.0	120
EK040P: Fluoride by PC Titrator (QCLot: 3871240)								
EK040P: Fluoride	16984-48-8	0.1	mg/L	<0.1	0.5 mg/L	96.0	80.0	117
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3870832)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	0.5 mg/L	97.4	83.5	114
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3870778)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	98.4	90.0	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3870833)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	90.0	85.7	111
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 3870783)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	95.4	81.7	117
EP005: Total Organic Carbon (TOC) (QCLot: 3869873)								
EP005: Total Organic Carbon	----	1	mg/L	<1	10 mg/L	94.9	79.0	113
				<1	100 mg/L	96.2	79.0	113
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 3878292)								
EP033: Methane	74-82-8	10	µg/L	Not Authorised	----	# Not Authorised	86.0	114
EP033: Ethene	74-85-1	10	µg/L	Not Authorised	----	# Not Authorised	87.0	111

Sub-Matrix: **WATER**

Method: Compound	*CAS Number*	*LOR*	*Unit*	*Method Blank (MB) Report*	*Laboratory Control Spike (LCS) Report*			
					Spike	*Spike Recovery (%)*	*Acceptable Limits (%)*	
				Result	*Concentration*	*LCS*	*Low*	*High*
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 3878292) - continued								
EP033: Ethane	74-84-0	10	µg/L	Not Authorised	----	# Not Authorised	87.0	111
EP033: Propene	115-07-1	10	µg/L	Not Authorised	----	# Not Authorised	85.0	113
EP033: Propane	74-98-6	10	µg/L	Not Authorised	----	# Not Authorised	84.0	112
EP033: Butene	25167-67-3	10	µg/L	Not Authorised	----	# Not Authorised	83.0	115
EP033: Butane	106-97-8	10	µg/L	Not Authorised	----	# Not Authorised	85.0	115
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3869627)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	1070 µg/L	120	51.9	126
EP071: C15 - C28 Fraction	----	100	µg/L	<100	1770 µg/L	109	51.4	124
EP071: C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3869683)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	180 µg/L	98.5	66.8	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3869627)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	1560 µg/L	115	53.2	125
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	1190 µg/L	109	49.5	123
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3869683)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	225 µg/L	101	65.1	123
EP080: C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
EP080: BTEXN (QCLot: 3869683)								
EP080: Benzene	71-43-2	1	µg/L	<1	10 µg/L	95.6	79.8	115
EP080: Toluene	108-88-3	2	µg/L	<2	10 µg/L	104	78.6	116
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	10 µg/L	107	77.3	115
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	20 µg/L	106	75.8	120
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	10 µg/L	107	80.9	115
EP080: Total Xylenes	----	2	µg/L	<2	----	----	----	----
EP080: Sum of BTEX	----	1	µg/L	<1	----	----	----	----
EP080: Naphthalene	91-20-3	5	µg/L	<5	10 µg/L	96.9	77.8	116

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

Laboratory sample ID	*Sample ID*	*Method: Compound*	*CAS Number*	*Matrix Spike (MS) Report*			
				Spike	*SpikeRecovery(%)*	*Acceptable Limits (%)*	
				Concentration	*MS*	*Low*	*High*
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3870779)							

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 3870779) - continued							
EB2124153-002	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	100 mg/L	105	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 3870780)							
EB2124153-002	Anonymous	ED045G: Chloride	16887-00-6	400 mg/L	107	70.0	130
EG050T: Total Hexavalent Chromium (QCLot: 3872898)							
EB2123771-002	Anonymous	EG050G-T: Hexavalent Chromium	18540-29-9	20 mg/L	87.7	70.0	130
EK040P: Fluoride by PC Titrator (QCLot: 3871240)							
EB2123880-002	Anonymous	EK040P: Fluoride	16984-48-8	5 mg/L	81.4	70.0	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 3870832)							
EB2123565-002	Anonymous	EK055G: Ammonia as N	7664-41-7	0.4 mg/L	89.9	70.0	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 3870778)							
EB2124153-002	Anonymous	EK057G: Nitrite as N	14797-65-0	0.4 mg/L	93.6	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 3870833)							
EB2123565-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.4 mg/L	# Not Determined	70.0	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 3870783)							
EB2124153-002	Anonymous	EK071G: Reactive Phosphorus as P	14265-44-2	0.4 mg/L	94.8	70.0	130
EP005: Total Organic Carbon (TOC) (QCLot: 3869873)							
EB2123416-002	Anonymous	EP005: Total Organic Carbon	----	100 mg/L	97.7	70.0	130
EP033: C1 - C4 Hydrocarbon Gases (QCLot: 3878292)							
EB2124188-001	Anonymous	EP033: Methane	74-82-8	----	# Not Authorised	70.0	130
		EP033: Ethene	74-85-1	----	# Not Authorised	70.0	130
		EP033: Ethane	74-84-0	----	# Not Authorised	70.0	130
		EP033: Propene	115-07-1	----	# Not Authorised	70.0	130
		EP033: Propane	74-98-6	----	# Not Authorised	70.0	130
		EP033: Butene	25167-67-3	----	# Not Authorised	70.0	130
		EP033: Butane	106-97-8	----	# Not Authorised	70.0	130
EP080/071: Total Petroleum Hydrocarbons (QCLot: 3869683)							
EB2123296-002	Anonymous	EP080: C6 - C9 Fraction	----	40 µg/L	71.6	70.0	130

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report Spike Concentration	SpikeRecovery(%) MS	Acceptable Limits (%) Low	High
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 3869683)							
EB2123296-002	Anonymous	EP080: C6 - C10 Fraction	C6_C10	40 µg/L	76.3	70.0	130
EP080: BTEXN (QCLot: 3869683)							
EB2123296-002	Anonymous	EP080: Benzene	71-43-2	10 µg/L	93.3	70.0	130
		EP080: Toluene	108-88-3	10 µg/L	98.8	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EB2124168**	Page	: 1 of 10
Amendment	: **(Preliminary Report)**		
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 26-Aug-2021
Site	: ----	Issue Date	: 02-Sep-2021
Sampler	: D GREER	No. of samples received	: 1
Order number	: 20000110	No. of samples analysed	: 1

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	**Analyte**	CAS Number	Data	Limits	**Comment**
Matrix Spike (MS) Recoveries							
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Ar	EB2123565--002	Anonymous	**Nitrite + Nitrate as N**	----	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)	*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EA005P: pH by PC Titrator						
Clear Plastic Bottle - Natural MILGARRA BORE	----	----	----	27-Aug-2021	25-Aug-2021	**2**
EP025: Oxygen - Dissolved (DO)						
Clear Plastic Bottle - Natural MILGARRA BORE	----	----	----	27-Aug-2021	25-Aug-2021	**2**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type	Count		Rate (%)		Quality Control Specification
Method	QC	Regular	Actual	Expected	
Laboratory Duplicates (DUP)					
TRH - Semivolatile Fraction	1	20	5.00	10.00	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)					
Total Mercury by FIMS	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	0	1	0.00	5.00	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	0	20	0.00	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	***Sample Date***	*Extraction / Preparation*			*Analysis*		
***Container** / Client Sample ID(s)*		***Date extracted***	*Due for extraction*	*Evaluation*	***Date analysed***	*Due for analysis*	*Evaluation*

Matrix: **WATER**

Evaluation: ✘ = Holding time breach ; ✓ = Within holding time.

Method *Container / Client Sample ID(s)*	*Sample Date*	*Extraction / Preparation* *Date extracted*	 *Due for extraction*	 *Evaluation*	*Analysis* *Date analysed*	 *Due for analysis*	 *Evaluation*
EA005P: pH by PC Titrator							
Clear Plastic Bottle - Natural (EA005-P) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	25-Aug-2021	✘
EA010P: Conductivity by PC Titrator							
Clear Plastic Bottle - Natural (EA010-P) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EA015: Total Dissolved Solids dried at 180 ± 5 °C							
Clear Plastic Bottle - Natural (EA015H) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	01-Sep-2021	✓
EA045: Turbidity							
Clear Plastic Bottle - Natural (EA045) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	27-Aug-2021	✓
ED037P: Alkalinity by PC Titrator							
Clear Plastic Bottle - Natural (ED037-P) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	08-Sep-2021	✓
ED040F: Dissolved Major Anions							
Clear Plastic Bottle - Natural (ED040F) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA							
Clear Plastic Bottle - Natural (ED041G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
ED045G: Chloride by Discrete Analyser							
Clear Plastic Bottle - Natural (ED045G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
ED093F: Dissolved Major Cations							
Clear Plastic Bottle - Natural (ED093F) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	01-Sep-2021	✓
EG020T: Total Metals by ICP-MS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG020B-T) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	21-Feb-2022	✓	**27-Aug-2021**	21-Feb-2022	✓
EG035T: Total Recoverable Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG035T) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EG050T: Total Hexavalent Chromium							
Clear Plastic Bottle - NaOH (EG050G-T) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**30-Aug-2021**	22-Sep-2021	✓
EG094T: Total metals in Fresh water by ORC-ICPMS							
Clear Plastic Bottle - Nitric Acid; Unfiltered (EG094A-T) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	21-Feb-2022	✓	**27-Aug-2021**	21-Feb-2022	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method	*Sample Date*	*Extraction / Preparation*			*Analysis*		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	*Evaluation*	*Date analysed*	*Due for analysis*	*Evaluation*
EK040P: Fluoride by PC Titrator							
Clear Plastic Bottle - Natural (EK040P) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural (EK057G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	27-Aug-2021	✓
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK059G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural (EK071G) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	27-Aug-2021	✓
EP005: Total Organic Carbon (TOC)							
Amber TOC Vial - Sulfuric Acid (EP005) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	22-Sep-2021	✓
EP025: Oxygen - Dissolved (DO)							
Clear Plastic Bottle - Natural (EP025) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**27-Aug-2021**	25-Aug-2021	×
EP033: C1 - C4 Hydrocarbon Gases							
Amber VOC Vial - Sulfuric Acid (EP033) MILGARRA BORE	**25-Aug-2021**	**----**	----	----	**Not Authorised**	08-Sep-2021	✓
EP080/071: Total Petroleum Hydrocarbons							
Amber Glass Bottle - Unpreserved (EP071) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	01-Sep-2021	✓	**27-Aug-2021**	06-Oct-2021	✓
Amber VOC Vial - Sulfuric Acid (EP080) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	08-Sep-2021	✓	**27-Aug-2021**	08-Sep-2021	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions							
Amber Glass Bottle - Unpreserved (EP071) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	01-Sep-2021	✓	**27-Aug-2021**	06-Oct-2021	✓
Amber VOC Vial - Sulfuric Acid (EP080) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	08-Sep-2021	✓	**27-Aug-2021**	08-Sep-2021	✓
EP080: BTEXN							
Amber VOC Vial - Sulfuric Acid (EP080) MILGARRA BORE	**25-Aug-2021**	**27-Aug-2021**	08-Sep-2021	✓	**27-Aug-2021**	08-Sep-2021	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by PC Titrator	ED037-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	10	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Total	EG050G-T	1	3	**33.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	4	**25.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	11	**18.18**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	2	15	**13.33**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	**100.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	20	**5.00**	**10.00**	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	19	**10.53**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by PC Titrator	ED037-P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	10	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Total	EG050G-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
pH by PC Titrator	EA005-P	2	17	**11.76**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Control Samples (LCS) - Continued							
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	9	**22.22**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	3	15	**20.00**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	3	20	**15.00**	**15.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							
Ammonia as N by Discrete analyser	EK055G	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Conductivity by PC Titrator	EA010-P	1	17	**5.88**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Total	EG050G-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Anions - Dissolved	ED040F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	1	15	**6.67**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite B	EG020B-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	1	1	**100.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Turbidity	EA045	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	1	4	**25.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
C1 - C4 Gases	EP033	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	10	**10.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Fluoride by PC Titrator	EK040P	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Hexavalent Chromium by Discrete Analyser - Total	EG050G-T	1	3	**33.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	1	11	**9.09**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Matrix: **WATER**

Evaluation: ✗ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Matrix Spikes (MS) - Continued							
Nitrite as N by Discrete Analyser	EK057G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	7	**14.29**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	9	**11.11**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Mercury by FIMS	EG035T	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Metals by ICP-MS - Suite A	EG020A-T	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	0	1	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
Total Organic Carbon	EP005	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	0	20	**0.00**	**5.00**	✗	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	19	**5.26**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
pH by PC Titrator	EA005-P	WATER	In house: Referenced to APHA 4500 H+ B. This procedure determines pH of water samples by automated ISE. This method is compliant with NEPM Schedule B(3)
Conductivity by PC Titrator	EA010-P	WATER	In house: Referenced to APHA 2510 B. This procedure determines conductivity by automated ISE. This method is compliant with NEPM Schedule B(3)
Total Dissolved Solids (High Level)	EA015H	WATER	In house: Referenced to APHA 2540C. A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM Schedule B(3)
Turbidity	EA045	WATER	In house: Referenced to APHA 2130 B. This method is compliant with NEPM Schedule B(3)
Hardness as CaCO3	EA065	WATER	In house: Referenced to APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Free and Total CO2	EA165-P	WATER	In house: Referenced to APHA 4500-CO2 D. This method is compliant with NEPM Schedule B(3)
Alkalinity by PC Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Major Anions - Dissolved	ED040F	WATER	In house: Referenced to APHA 3120. The 0.45µm filtered samples are determined by ICP/AES for Sulfur and/or Silcon content and reported as Sulfate and/or Silica after conversion by gravimetric factor.
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride.in the presence of ferric ions the librated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm APHA seal method 2 017-1-L
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Total Metals by ICP-MS - Suite A	EG020A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Total Metals by ICP-MS - Suite B	EG020B-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
Total Mercury by FIMS	EG035T	WATER	In house: Referenced to AS 3550, APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the unfiltered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Trivalent Chromium - Total	EG049G-T	WATER	In house: Referenced to APHA 3500 Cr-B & 3120/3125. Trivalent Chromium is the difference between total dissolved and dissolved hexavalent chromium.
Hexavalent Chromium by Discrete Analyser - Total	EG050G-T	WATER	In house: Referenced to APHA 3500 Cr-A & B. Hexavalent chromium is determined directly on water sample by Descrete Analyser as received by pH adjustment and colour development using dephenylcarbazide. Each run of samples is measured against a five-point calibration curve. This method is compliant with NEPM Schedule B(3).
Total Metals in Fresh Water -Suite A by ORC-ICPMS	EG094A-T	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020. The ORC-ICPMS technique removes interfering species through a series of chemical reactions prior to ion detection. Ions are passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to measurement by a discrete dynode ion detector. This method is compliant with NEPM Schedule B(3).
Fluoride by PC Titrator	EK040P	WATER	In house: Referenced to APHA 4500-F C: CDTA is added to the sample to provide a uniform ionic strength background, adjust pH, and break up complexes. Fluoride concentration is determined by either manual or automatic ISE measurement. This method is compliant with NEPM Schedule B(3)
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM Schedule B(3)
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Total Organic Carbon	EP005	WATER	In house: Referenced to APHA 5310 B, The automated TOC analyzer determines Total and Inorganic Carbon by IR cell. TOC is calculated as the difference. This method is compliant with NEPM Schedule B(3)
Oxygen - Dissolved	EP025	WATER	In house: Referenced to APHA 4500-O G. Dissolved Oxygen Probe. This method is compliant with NEPM Schedule B(3)
C1 - C4 Gases	EP033	WATER	Technical Guidance for the Natural Attenuation Indicators: Methane, Ethane, and Ethene, US EPA - Region 1, EPA New England, July 2001. Automated static headspace, dual column GC/FID. A 12 mL sample is pipetted into a 20 mL headspace vial containing 3g of sodium chloride and sealed. Each sample is equilibrated with shaking at 40 degrees C for 10 minutes prior to analysis by GC/FID using a pair of PLOT columns of different polarity.

Analytical Methods	*Method*	*Matrix*	*Method Descriptions*
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015 The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260 Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Digestion for Total Recoverable Metals	EN25	WATER	In house: Referenced to USEPA SW846-3005. Method 3005 is a Nitric/Hydrochloric acid digestion procedure used to prepare surface and ground water samples for analysis by ICPAES or ICPMS. This method is compliant with NEPM Schedule B(3)
Digestion for Total Recoverable Metals - ORC	EN25-ORC	WATER	In house: Referenced to USEPA SW846-3005. This is an Ultrapure Nitric acid digestion procedure used to prepare surface and ground water samples for analysis by ORC- ICPMS. This method is compliant with NEPM Schedule B(3)
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for purging.

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB2124168**

Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: keith.window@stratumreservoir.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: ----	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: AB-106884	Page	: 1 of 3
Order number	: ----	Quote number	: EB2018ACSLAB0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: D GREER		

Dates

Date Samples Received	: 26-Aug-2021 10:00	Issue Date	: 26-Aug-2021
Client Requested Due Date	: 31-Aug-2021	Scheduled Reporting Date	: **31-Aug-2021**

Delivery Details

Mode of Delivery	: Client Drop Off	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 10.9°C - Ice present
Receipt Detail	: MEDIUM HARD ESKY	No. of samples received / analysed	: 1 / 1

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please be advised, Methane analysis will be conducted by ALS Sydney and as a result the TAT of 3 Days may not be possible. All ALS Brisbane analysis has been allocated a 3 Day TAT(31/08/21) and the TAT for Methane will be advised at a later date.**
- ***A 10% surcharge applies for results returned within 3 days.***
- **Please be advised that the analysis for this work order has been assigned as per EB2120461, as requested. For further information, please contact client services at ALSEnviro.Brisbane@alsglobal.com**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- **Methane analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- **Volatile organic compound analysis may be compromised as sample containers contained headspace.**
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The laboratory will process these samples unless instructions are received from you indicating you do not wish to proceed. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.
If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA045 Turbidity	WATER - EA065 Total Hardness as CaCO3	WATER - ED037-P Alkalinity as CaCO3 (PCT)	WATER - ED093F Dissolved Major Cations	WATER - EG035T Total Mercury	WATER - EK040-P Fluoride (PCT)	WATER - EP025 Dissolved Oxygen (DO)
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA005P pH (PCT)	WATER - EA010P Electrical Conductivity (PCT)	WATER - ED040F Dissolved Major Anions	WATER - ED045G Chloride by Discrete Analyser	WATER - EG094-T Total Metals by ORC - Ultra Trace in Fresh Water	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP033 C1 - C4 Gases in Water
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA165-PH CO2 - Free and Total (Default)	WATER - ED041G Sulfate (Turbidimetric) as SO4 2 by Discrete	WATER - EG020T Total Metals by ICP/MS (including digestion)	WATER - EG049G-T Trivalent Chromium - Total	WATER - EK055G Ammonia as N By Discrete Analyser	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA015H Total Dissolved Solids - Standard Level	WATER - W-04 TRH/BTEXN
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method **Client Sample ID(s)**	**Container**	**Due for extraction**	**Due for analysis**	**Samples Received**		**Instructions Received**	
				Date	**Evaluation**	**Date**	**Evaluation**
EA005-P: pH by PC Titrator							
MILGARRA BORE	Clear Plastic Bottle - Natural	----	25-Aug-2021	26-Aug-2021	×	----	----
EP025: Oxygen - Dissolved							
MILGARRA BORE	Clear Plastic Bottle - Natural	----	25-Aug-2021	26-Aug-2021	×	----	----

Requested Deliverables

KEITH WINDOW

- *AU Certificate of Analysis - NATA (COA)	Email	keith.window@stratumreservoir.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	keith.window@stratumreservoir.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	keith.window@stratumreservoir.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	keith.window@stratumreservoir.com
- A4 - AU Tax Invoice (INV)	Email	keith.window@stratumreservoir.com
- Chain of Custody (CoC) (COC)	Email	keith.window@stratumreservoir.com
- EDI Format - XTab (XTAB)	Email	keith.window@stratumreservoir.com

THANAWAT (ARTHUR) KHUMTONG

- A4 - AU Tax Invoice (INV)	Email	thanawat.khumtong@stratumreservoir.com

~~MILGA~~RRA BORE WATER ANALYSIS

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541
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☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Stratum Reservoir

OFFICE: Brendale

PROJECT: AB-106884

ORDER NUMBER:

PROJECT MANAGER: Keith Window **CONTACT PH:** 0400 934 304

SAMPLER: D GREER **SAMPLER MOBILE:**

COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to: Keith Window <keith.window@stratumreservoir.com>

Email Invoice to: Keith Window <keith.window@stratumreservoir.com>

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)

☑ Standard TAT **(List due date):**

☑ Non Standard or urgent TAT **(List due date):** 3 DAY TAT

ALS QUOTE NO.: Attached quote

COC SEQUENCE NUMBER (Circle)

COC: [✓ 1] 2 3 4 5 6 7

OF: [✓ 1] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact? Yes No N/A

Free ice / frozen ice bricks present upon receipt? Yes No N/A

Random Sample Temperature on Receipt: °C

Other comment:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
NICK HALL	TJicks		
DATE/TIME:	DATE/TIME: 26/8/21 1000	DATE/TIME:	DATE/TIME:

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	Analysis as per attached	EB2120961							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	MILGARRA BORE	25/6/21 / NOON	W				✓							1 SAMPLE ONLY (DUPLICATE / EXTRA BOTTLES SUPPLIED)
					TOTAL									

LH

URGENT

Environmental Division
Brisbane
Work Order Reference
EB2124168

Telephone : + 61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

CERTIFICATE OF ANALYSIS

Work Order	: **EB2124168**	Page	: 1 of 7
Amendment	: **(Preliminary Report)**		
Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61-7-3243 7222
Project	: AB-106884	Date Samples Received	: 26-Aug-2021 10:00
Order number	: 20000110	Date Analysis Commenced	: 27-Aug-2021
C-O-C number	: ----	Issue Date	: 01-Sep-2021 17:04
Sampler	: D GREER		
Site	: ----		
Quote number	: EN/333		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Mark Hallas	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Matt Frost	Assistant Laboratory Manager	Brisbane Organics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

This report contains preliminary authorised results. The report may contain semi-quantitative results. Any result presented in this preliminary report may be subject to change in the final report.

- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- **Methane analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			*Sample ID*	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.66**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**1280**	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**814**	----	----	----	----
EA045: Turbidity								
Turbidity	----	0.1	NTU	**0.3**	----	----	----	----
EA065: Total Hardness as CaCO3								
Total Hardness as CaCO3	----	1	mg/L	**2**	----	----	----	----
EA165: CO2 - Free and Total								
Free Carbon Dioxide as CO2	85540-96-1	1	mg/L	**2**	----	----	----	----
Total Carbon Dioxide as CO2	85540-96-1	1	mg/L	**454**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**44**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**492**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**536**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**24.1**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**6**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**68**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**1**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	----	----	----	----
Sodium	7440-23-5	1	mg/L	**331**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	----	----	----	----
EG020T: Total Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	<0.01	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	<0.001	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**
(Matrix: **WATER**)

			Sample ID	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EG020T: Total Metals by ICP-MS - Continued								
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.011**	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.014**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.005**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	<0.005	----	----	----	----
Boron	7440-42-8	0.05	mg/L	**0.13**	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.13**	----	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EG049T: Total Trivalent Chromium								
Trivalent Chromium	16065-83-1	0.01	mg/L	<0.01	----	----	----	----
EG050T: Total Hexavalent Chromium								
Hexavalent Chromium	18540-29-9	0.01	mg/L	<0.01	----	----	----	----
EG094T: Total metals in Fresh water by ORC-ICPMS								
Silver	7440-22-4	0.1	µg/L	**0.5**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.5**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.54**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.07**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.07**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser - Continued								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.02**	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**3**	----	----	----	----
EP025: Oxygen - Dissolved (DO)								
Dissolved Oxygen	----	0.1	mg/L	**9.9**	----	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	-	µg/L	**Not Authorised**	----	----	----	----
Ethene	74-85-1	-	µg/L	**Not Authorised**	----	----	----	----
Ethane	74-84-0	-	µg/L	**Not Authorised**	----	----	----	----
Propene	115-07-1	-	µg/L	**Not Authorised**	----	----	----	----
Propane	74-98-6	-	µg/L	**Not Authorised**	----	----	----	----
Butene	25167-67-3	-	µg/L	**Not Authorised**	----	----	----	----
Butane	106-97-8	-	µg/L	**Not Authorised**	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)			Sample ID	**MILGARRA BORE**	----	----	----	----
			Sampling date / time	25-Aug-2021 12:00	----	----	----	----
Compound	CAS Number	LOR	Unit	**EB2124168-001**	--------	--------	--------	--------
				Result	----	----	----	----
EP080: BTEXN - Continued								
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ **Total Xylenes**	----	2	µg/L	<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	**93.5**	----	----	----	----
Toluene-D8	2037-26-5	2	%	**101**	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	**111**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	Recovery Limits (%) High
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	66	138
Toluene-D8	2037-26-5	79	120
4-Bromofluorobenzene	460-00-4	74	118

Inter-Laboratory Testing

Analysis conducted by ALS Sydney, NATA accreditation no. 825, site no. 10911 (Chemistry) 14913 (Biology).

(WATER) EP033: C1 - C4 Hydrocarbon Gases

SAMPLE RECEIPT NOTIFICATION (SRN)

Work Order : **EB2124168**

Client	: **STRATUM RESERVOIR**	Laboratory	: Environmental Division Brisbane
Contact	: KEITH WINDOW	Contact	: Customer Services EB
Address	: UNIT 2 - 209 LEITCHS ROAD BRENDALE QLD 4500	Address	: 2 Byth Street Stafford QLD Australia 4053
E-mail	: keith.window@stratumreservoir.com	E-mail	: ALSEnviro.Brisbane@alsglobal.com
Telephone	: ----	Telephone	: +61-7-3243 7222
Facsimile	: ----	Facsimile	: +61-7-3243 7218
Project	: AB-106884	Page	: 1 of 3
Order number	: ----	Quote number	: EB2018ACSLAB0001 (EN/333)
C-O-C number	: ----	QC Level	: NEPM 2013 B3 & ALS QC Standard
Site	: ----		
Sampler	: D GREER		

Dates

Date Samples Received	: 26-Aug-2021 10:00	Issue Date	: 26-Aug-2021
Client Requested Due Date	: 31-Aug-2021	Scheduled Reporting Date	: **31-Aug-2021**

Delivery Details

Mode of Delivery	: Client Drop Off	Security Seal	: Not Available
No. of coolers/boxes	: 1	Temperature	: 10.9°C - Ice present
Receipt Detail	: MEDIUM HARD ESKY	No. of samples received / analysed	: 1 / 1

General Comments

- This report contains the following information:
  - Sample Container(s)/Preservation Non-Compliances
  - Summary of Sample(s) and Requested Analysis
  - Proactive Holding Time Report
  - Requested Deliverables
- **Please be advised, Methane analysis will be conducted by ALS Sydney and as a result the TAT of 3 Days may not be possible. All ALS Brisbane analysis has been allocated a 3 Day TAT(31/08/21) and the TAT for Methane will be advised at a later date.**
- ***A 10% surcharge applies for results returned within 3 days.***
- **Please be advised that the analysis for this work order has been assigned as per EB2120461, as requested. For further information, please contact client services at ALSEnviro.Brisbane@alsglobal.com**
- Discounted Package Prices apply only when specific ALS Group Codes ('W', 'S', 'NT' suites) are referenced on COCs.
- **Methane analysis is conducted by ALS Environmental, Sydney, NATA accreditation no. 825, Site No. 10911 (Micro site no. 14913).**
- Please direct any turn around / technical queries to the laboratory contact designated above.
- Sample Disposal - Aqueous (3 weeks), Solid (2 months ± 1 week) from receipt of samples.
- **Volatile organic compound analysis may be compromised as sample containers contained headspace.**
- Analysis will be conducted by ALS Environmental, Brisbane, NATA accreditation no. 825, Site No. 818 (Micro site no. 18958).
- **Breaches in recommended extraction / analysis holding times (if any) are displayed overleaf in the Proactive Holding Time Report table.**
- Please be aware that APHA/NEPM recommends water and soil samples be chilled to less than or equal to 6°C for chemical analysis, and less than or equal to 10°C but unfrozen for Microbiological analysis. Where samples are received above this temperature, it should be taken into consideration when interpreting results. Refer to ALS EnviroMail 85 for ALS recommendations of the best practice for chilling samples after sampling and for maintaining a cool temperature during transit.
- **Please refer to the Proactive Holding Time Report table below which summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory. The laboratory will process these samples unless instructions are received from you indicating you do not wish to proceed. The absence of this summary table indicates that all samples have been received within the recommended holding times for the analysis requested.**

Sample Container(s)/Preservation Non-Compliances

All comparisons are made against pretreatment/preservation AS, APHA, USEPA standards.

- **No sample container / preservation non-compliance exists.**

Summary of Sample(s) and Requested Analysis

Some items described below may be part of a laboratory process necessary for the execution of client requested tasks. Packages may contain additional analyses, such as the determination of moisture content and preparation tasks, that are included in the package.

If no sampling time is provided, the sampling time will default 00:00 on the date of sampling. If no sampling date is provided, the sampling date will be assumed by the laboratory and displayed in brackets without a time component

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA045 Turbidity	WATER - EA065 Total Hardness as CaCO3	WATER - ED037-P Alkalinity as CaCO3 (PCT)	WATER - ED093F Dissolved Major Cations	WATER - EG035T Total Mercury	WATER - EK040-P Fluoride (PCT)	WATER - EP025 Dissolved Oxygen (DO)
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA005P pH (PCT)	WATER - EA010P Electrical Conductivity (PCT)	WATER - ED040F Dissolved Major Anions	WATER - ED045G Chloride by Discrete Analyser	WATER - EG094-T Total Metals by ORC - Ultra Trace in Fresh Water	WATER - EP005 Total Organic Carbon (TOC)	WATER - EP033 C1 - C4 Gases in Water
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA165-PH CO2 - Free and Total (Default)	WATER - ED041G Sulfate (Turbidimetric) as SO4 2 by Discrete	WATER - EG020T Total Metals by ICP/MS (including digestion)	WATER - EG049G-T Trivalent Chromium - Total	WATER - EK055G Ammonia as N By Discrete Analyser	WATER - EK058G Nitrate as N by Discrete Analyser	WATER - EK071G Reactive Phosphorus by Discrete analyser
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓	✓	✓	✓	✓	✓

Matrix: **WATER**

Laboratory sample ID	*Sampling date / time*	*Sample ID*	WATER - EA015H Total Dissolved Solids - Standard Level	WATER - W-04 TRH/BTEXN
EB2124168-001	25-Aug-2021 12:00	MILGARRA BORE	✓	✓

Proactive Holding Time Report

The following table summarises breaches of recommended holding times that have occurred prior to samples/instructions being received at the laboratory.

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method **Client Sample ID(s)**	**Container**	**Due for extraction**	**Due for analysis**	**Samples Received**		**Instructions Received**	
				Date	**Evaluation**	**Date**	**Evaluation**
EA005-P: pH by PC Titrator							
MILGARRA BORE	Clear Plastic Bottle - Natural	----	25-Aug-2021	26-Aug-2021	✗	----	----
EP025: Oxygen - Dissolved							
MILGARRA BORE	Clear Plastic Bottle - Natural	----	25-Aug-2021	26-Aug-2021	✗	----	----

Requested Deliverables

KEITH WINDOW

- *AU Certificate of Analysis - NATA (COA)	Email	keith.window@stratumreservoir.com
- *AU Interpretive QC Report - DEFAULT (Anon QCI Rep) (QCI)	Email	keith.window@stratumreservoir.com
- *AU QC Report - DEFAULT (Anon QC Rep) - NATA (QC)	Email	keith.window@stratumreservoir.com
- A4 - AU Sample Receipt Notification - Environmental HT (SRN)	Email	keith.window@stratumreservoir.com
- A4 - AU Tax Invoice (INV)	Email	keith.window@stratumreservoir.com
- Chain of Custody (CoC) (COC)	Email	keith.window@stratumreservoir.com
- EDI Format - XTab (XTAB)	Email	keith.window@stratumreservoir.com

THANAWAT (ARTHUR) KHUMTONG

- A4 - AU Tax Invoice (INV)	Email	thanawat.khumtong@stratumreservoir.com

~~MILGA~~RRA BORE WATER ANALYSIS

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095
Ph: 08 8359 0890 E: adelaide@alsglobal.com

☐BRISBANE 32 Shand Street Stafford QLD 4053
Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com

☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680
Ph. 07 7471 5600 E: gladstone@alsglobal.com

☐MACKAY 78 Harbour Road Mackay QLD 4740
Ph: 07 4944 0177 E: mackay@alsglobal.com

☐MELBOURNE 2-4 Westall Road Springvale VIC 3171
Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com

☐MUDGEE 27 Sydney Road Mudgee NSW 2850
Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com

☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304
Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com

☐NOWRA 4/13 Geary Place North Nowra NSW 2541
Ph: 024423 2063 E: nowra@alsglobal.com

☐PERTH 10 Hod Way Malaga WA 6090
Ph: 08 9209 7655 E: samples.perth@alsglobal.com

☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164
Ph: 02 8784 8555 E: samples.sydney@alsglobal.com

☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818
Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com

☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500
Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Stratum Reservoir

OFFICE: Brendale

PROJECT: AB-106884

ORDER NUMBER:

PROJECT MANAGER: Keith Window **CONTACT PH:** 0400 934 304

SAMPLER: D GREER **SAMPLER MOBILE:**

COC emailed to ALS? (YES / NO) **EDD FORMAT (or default):**

Email Reports to: Keith Window <keith.window@stratumreservoir.com>

Email Invoice to: Keith Window <keith.window@stratumreservoir.com>

TURNAROUND REQUIREMENTS :
(Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☑ Standard TAT **(List due date):**
☑ Non Standard or urgent TAT **(List due date):** 3 DAY TAT

ALS QUOTE NO.: Attached quote

COC SEQUENCE NUMBER (Circle)
COC: [✓ 1] 2 3 4 5 6 7
OF: [✓ 1] 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY: NICK HALL	**RECEIVED BY:** TJicks 26/8/21	**RELINQUISHED BY:**	**RECEIVED BY:**
DATE/TIME:	**DATE/TIME:** 1000	**DATE/TIME:**	**DATE/TIME:**

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL:

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required).								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	Analysis as per attached	EB2120461							Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	MILGARRA BORE	25/6/21 / NOON	W				✓							1 SAMPLE ONLY (DUPLICATE / EXTRA BOTTLES SUPPLIED)
					TOTAL									

LH

URGENT

Environmental Division
Brisbane
Work Order Reference
EB2124168

Telephone : +61-7-3243 7222

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserved ORC; SH = Sodium Hydroxide/Cd Preserved; S = Sodium Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Preserved; AV = Airfreight Unpreserved Vial SG = Sulfuric Preserved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag for Acid Sulphate Soils; B = Unpreserved Bag.

APPENDIX F

Limitations Relating to This Report

The document ("Report") to which this page is attached and which this page forms a part of, has been issued by Golder Associates Pty Ltd ("Golder") subject to the important limitations and other qualifications set out below.

This Report constitutes or is part of services ("Services") provided by Golder to its client ("Client") under and subject to a contract between Golder and its Client ("Contract"). The contents of this page are not intended to and do not alter Golder's obligations (including any limits on those obligations) to its Client under the Contract.

This Report is provided for use solely by Golder's Client and persons acting on the Client's behalf, such as its professional advisers. Golder is responsible only to its Client for this Report. Golder has no responsibility to any other person who relies or makes decisions based upon this Report or who makes any other use of this Report. Golder accepts no responsibility for any loss or damage suffered by any person other than its Client as a result of any reliance upon any part of this Report, decisions made based upon this Report or any other use of it.

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Having regard to the matters referred to in the previous paragraphs on this page in particular, carrying out the Services has allowed Golder to form no more than an opinion as to the actual conditions at any relevant location. That opinion is necessarily constrained by the extent of the information collected by Golder or otherwise made available to Golder. Further, the passage of time may affect the accuracy, applicability or usefulness of the opinions, assessments or other information in this Report. This Report is based upon the information and other circumstances that existed and were known to Golder when the Services were performed and this Report was prepared. Golder has not considered the effect of any possible future developments including physical changes to any relevant location or changes to any laws or regulations relevant to such location.

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Any uncertainty as to the extent to which this Report can be used or relied upon in any respect should be referred to Golder for clarification.

WSP GOLDER

golder.com

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Carbon Transport & Storage

A GLENCORE Company

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Carbon Transport and Storage Corporation (CTSCo) Pty Limited ABN 12 143 012 971