TERRA SANA CONSULTANTS

Water Monitoring and Management Plan 2025

MAHALO NORTH PL1128

PREPARED FOR COMET RIDGE

Water Monitoring and Management Plan, 2025

Comet Ridge Mahalo North, PL1128

Document Control

Revision History

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0	11/06/25	Dr Grazia Gargiulo	Jeremy Haynes Simon Garnett	Final
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Abbreviations

Abbreviation	Description
AEP	Annual Exceedance Probability
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ATP	Authority to Prospect
BAP	Baseline Assessment Plan
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CSG	Coal Seam Gas
DA	Development Application
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DEHP	Department of Environment and Heritage Protection (Queensland), now named DETSI
DETSI	Department of Environment, Tourism, Science and Innovation (Queensland)
DO	Dissolved Oxygen
EA	Environmental Authority
EC	Electrical Conductivity
EMR	Environmental Management Register
EP Act	Environmental Protection Act 1994 (Queensland)
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
EPP Water	Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Queensland)
ERA	Environmentally Relevant Activity
ESA	Environmentally Sensitive Area
EV	Environmental Value
GCF	Gas Compression Facility
GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse Gas
IESC	Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development
ML	Mega Litre
MODFLOW	Modular Finite-Difference Groundwater Flow Model
NDVI	Normalized Difference Vegetation Index
PAH	Polycyclic Aromatic Hydrocarbons
P&G Act	Petroleum and Gas (Production and Safety) Act 2004 (Queensland)
PLA	Petroleum Lease Application
PTDLs	Pressure Transducer Data Loggers
PWST	Produced Water Storage Tank
RE	Regional Ecosystem
RO	Reverse Osmosis
SCA	Strategic Cropping Area

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Abbreviation	Description
SMC	Streamlined Model Conditions
SSGVs	Site-Specific Guideline Values
SWL	Standing Water Level
TARP	Trigger Action Response Plan
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
VM Act	Vegetation Management Act 1999 (Queensland)
VWPs	Vibrating Wire Piezometers
WMMP	Water Monitoring and Management Plan
WQG	Water Quality Guidelines
WQO	Water Quality Objective

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1. Introduction

Comet Ridge Mahalo North Pty Ltd (Comet Ridge) is proposing to develop the Mahalo North Coal Seam Gas (CSG) Project (The Project), a greenfield gas development located in the northern section of the Bowen Basin, approximately 45 km north of Rolleston in Central Queensland.

The Project is situated within Authority to Prospect (ATP) 2048, which is transitioning to Petroleum Lease (PL) 1128.

1.1 Purpose and Scope

This Water Monitoring and Management Plan (WMMP) outlines the strategies, infrastructure, monitoring programs, assessment criteria and mitigation measures that will guide the responsible and scientifically robust management of water resources for the Project.

The WMMP has been developed in accordance with:

- Conditions of the Environmental Authority (EA) No. P-EA-100522021;
- Requirements of the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act); and
- Information Guidelines for Proponents Preparing Coal Seam Gas and Large Coal Mining Development Proposals (IESC, 2024).

The WMMP ensures that water-related Environmental Values (EVs)— associated with groundwater, surface water, and Groundwater-Dependent Ecosystems (GDEs)—are protected across all phases of project development and operation. Specifically, the WMMP is designed to collect multiple lines of evidence to support:

- The establishment of baseline datasets to inform the development of Site-Specific Guideline Values (SSGVs);
- The characterisation of aquifer interconnectivity;
- The identification of surface water–groundwater interactions; and
- The implementation of a transparent and risk-based monitoring and management framework.

This version of the WMMP supersedes the previous Groundwater Monitoring Program prepared by RDM Hydro (dated 14 November 2024). It incorporates detailed responses to feedback from the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and addresses key recommendations from the IESC, as outlined in Advice Reference IESC 2025-153.

2. Project Overview

In October 2019, Comet Ridge was appointed as the preferred tender for the gas acreage PLR 2019-1-2 by the Queensland Government, and the block has since been given the ATP 2048 for the project now referred to as the Mahalo North Coal Seam Gas (CSG) Project.

The Project represents a strategically significant resource development for Comet Ridge and the region. It targets the Bandanna Formation coal seams and has been designed to minimise surface disturbance while achieving commercial gas extraction through staged production.

The proposed development includes:

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- 34 vertical CSG production wells.
- 34 lateral wells, drilled directionally to intersect productive coal seams within the Bandanna Formation.
- Water and gas gathering infrastructure, including buried flowlines
- access tracks.
- A central Gas Compression Facility (GCF) to manage produced gas and associated water.
- Supporting facilities including produced water storage tanks, a Water Treatment Plant (WTP) for Reverse Osmosis (RO) treatment of brackish water, brine storage infrastructure, and stormwater containment measures.

Key project details are summarised in Table 1. Figure 1 shows the production well layout and the proposed drilling schedule.

Table 1 – Project Overview

Project Overview	
Project Name:	Mahalo North CSG Project
Location:	ATP2048, ~45 km north of Rolleston, Central Queensland
Lease area	PL1128 14,100 ha
Project Infrastructure:	● 34 vertical wells; ● 34 lateral wells (no hydraulic fracture stimulation); ● GCF; ● Water Treatment Plant (WTP) with RO; ● Produced Water Storage Tanks (PWSTs), brine storage tanks, and RO permeate tanks; and ● Gathering pipelines and associated access infrastructure.
Production Method:	Dewatering only (no hydraulic fracture stimulation)
Project duration	~ 30 years (staged approach)
Maximum disturbance:	180 ha (1.2% of entire PL area)

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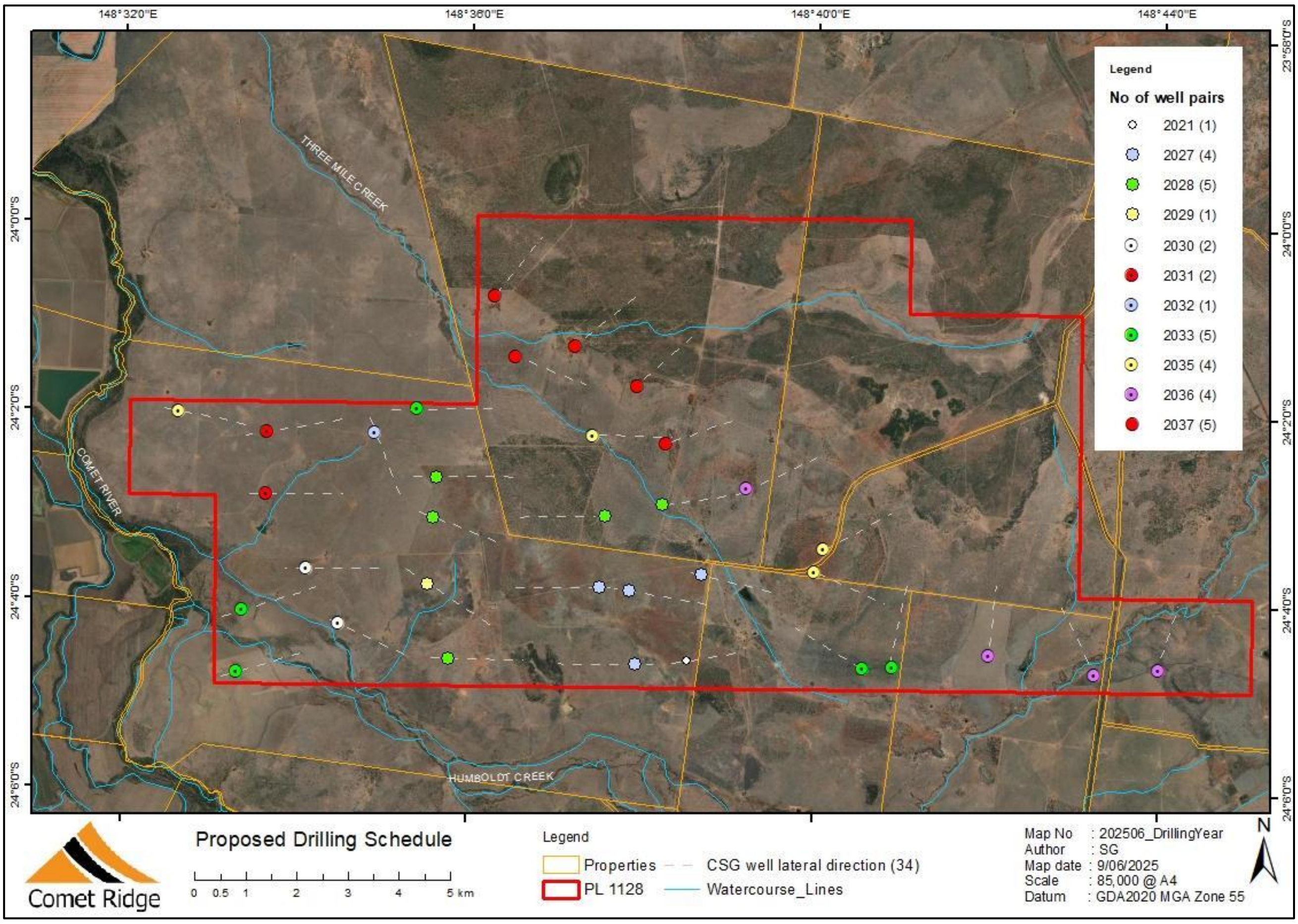

Figure 1 – Project Overview and Development Plan

3. Regulatory and Policy Context

To support the Project's planning and implementation, the applicable legislation, guidelines, and regulatory instruments have been summarised and aligned with key project activities, as presented in Tables 2 and 3 below.

Table 2 – Queensland State Legislation and Guidelines

Legislation / Policy	Context of Application
Environmental Protection Act 1994 (Qld)	Regulates environmental harm, outlines conditions in the Environmental Authority (EA) No. P-EA-100522021, conditions WS7 to WS9 including groundwater, surface water, waste, and land disturbance management.
Water Act 2000 (Qld)	Governs underground water rights, baseline assessments, and make-good obligations for affected landholders. Applies to groundwater take associated with CSG activities.
Vegetation Management Act 1999 (Qld)	Governs clearing of native vegetation, especially along drainage lines and in areas with potential GDEs.
Petroleum and Gas (Production and Safety) Act 2004 (Qld)	Authorises petroleum exploration and production; includes provisions for produced water management and safety of infrastructure (e.g., wells, pipelines).

Legislation / Policy	Context of Application
Environmental Protection Regulation 2019 (Qld)	Defines notifiable activities, Environmentally Relevant Activities (ERAs), water quality standards, and monitoring requirements under the EP Act.
Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (Qld)	Identifies EVs and Water Quality Objectives (WQOs) for Queensland waterways. The Comet River Sub-Basin WQOs apply to the Project.
Nature Conservation Act 1992 (Qld)	Applies to species and ecological communities of conservation significance that may rely on groundwater or be impacted by CSG operations.
Strategic Cropping Land Act 2011 / Planning Act 2016 (Qld)	Manages impacts on strategic cropping areas (SCA), with relevance to land access and project design (e.g., pipeline routes, infrastructure siting).
Contaminated Land Act (EMR/CLR)	Identifies land that may be listed on the Environmental Management Register (EMR) or Contaminated Land Register (CLR) due to CSG activities.
End of Waste Code: Associated Water (Irrigation) (DES, 2019)	Governs beneficial reuse of treated produced water under strict quality criteria, especially for irrigation or dust suppression.

Table 3 – Commonwealth Legislation and Guidelines

Legislation / Policy	Context of Application
Environment Protection and Biodiversity Conservation Act 1999 (Cth)	The project is subject to EPBC Act referral due to potential impacts on water resources and Matters of National Environmental Significance (MNES), including threatened species and ecological communities.
Water Trigger (EPBC Amendment)	Requires detailed groundwater modelling, impact assessments, and IESC advice where a CSG project may significantly affect water resources.
IESC Information Guidelines 2024	Sets technical standards for impact assessments, hydrogeological models, monitoring design, uncertainty analysis, and cumulative impact considerations.

4. Physical Setting

This section provides a summary of the physical setting of the Project area. A detailed description of the physiography, drainage patterns, geology, and hydrogeology is available in the supporting reports:

- Groundwater Monitoring Program 2024, prepared by RDM Hydro; and
- Mahalo North Project Site Specific Groundwater Modelling Report 2023, prepared by Terra Sana Consultants.

4.1 Climate

The Project is located in Central Queensland's semi-arid subtropical zone. The region experiences hot summers and mild, dry winters, with seasonal variability in rainfall. Long-term climate data from the Bureau of Meteorology (BOM) Rolleston (Station ID: 035096) indicate:

- Annual Rainfall: ~610 mm, with highest rainfall typically between December and February.
- Annual Evaporation: ~2,070 mm, indicating a strong net evaporative deficit.

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- Temperature Range: Summer maxima often exceed 35°C, while winter minima can fall below 5°C.
- Rainfall Intensity: Extreme daily rainfall events can exceed 50 mm.

The pronounced seasonal variability, particularly high summer rainfall and prolonged dry periods, plays a critical role in defining aquifer recharge rates, potential evapotranspiration losses, stormwater runoff dynamics and operational management of water storages.

4.2 Topography and Drainage

The project area lies across gently to moderately undulating terrain, characterised by a complex mosaic of ridgelines, shallow depressions, and ephemeral drainage features, which drain to the west and southwest, feeding into the Comet River, located >1,000m west of the PL.

Ground elevations range from approximately 180 mAHD in the southern floodplain areas to more than 245 mAHD along the northeastern and central highlands, as verified through 0.5 m interval LiDAR-based contour mapping, obtained in October 2023.

Key Terrain Characteristics:

- High Elevation Zones: Prominent ridgelines exceeding 235 mAHD are located in the northeast (Togara Station) and along the central uplands, forming natural drainage divides that influence surface flow direction and subsurface hydraulic gradients.
- Mid-Slope Catchments: Sloping lands (~200–230 mAHD) dominate much of the central project area, facilitating shallow overland flow during high-intensity storm events.
- Low-Lying Drainage Basins: Local depressions and swales, particularly toward the southwest near Struan and southern Meroo Downs, reach elevations as low as ~180 mAHD, corresponding with flood-prone areas and watercourse confluences.
- Surface Watercourses:
  - The southwest project area is traversed by Humboldt Creek, a seasonally flowing drainage line that integrates runoff from several ephemeral gullies originating from higher ridges.
  - The Comet River flows northward just west of the Project's western boundary. The Comet River generally flows year-round with varying degrees of flow. The Project is situated near the eastern edge of the Comet River's floodplain, which extends west approximately 6.5 km.
- Flood-Influenced Zones: Flood modelling indicates 1% Annual Exceedance Probability (AEP) flood extents are largely confined to the Humboldt Creek corridor and its alluvial fringes. These areas show potential for short-duration inundation but are limited in spatial extent.

Drainage Behaviour:

- Drainage Direction: Predominantly southwest oriented, aligning with regional topographic and hydraulic gradients.
- Drainage Density: Low to moderate, reflecting the low-relief nature of the terrain and the dominance of overland flow during convective summer storm events.
- Flood Mitigation Considerations: the GCF is sited outside the 1% AEP floodplain. However, site-specific hydrological modelling has identified the need for strategic infrastructure design to manage:
  - Sheet flow accumulation
  - Erosion and sediment transport
  - Potential overland ponding near infrastructure platforms

This refined understanding of the site's topographic setting underpins both the stormwater infrastructure design and the risk-based approach to surface water quality monitoring presented later in this plan.

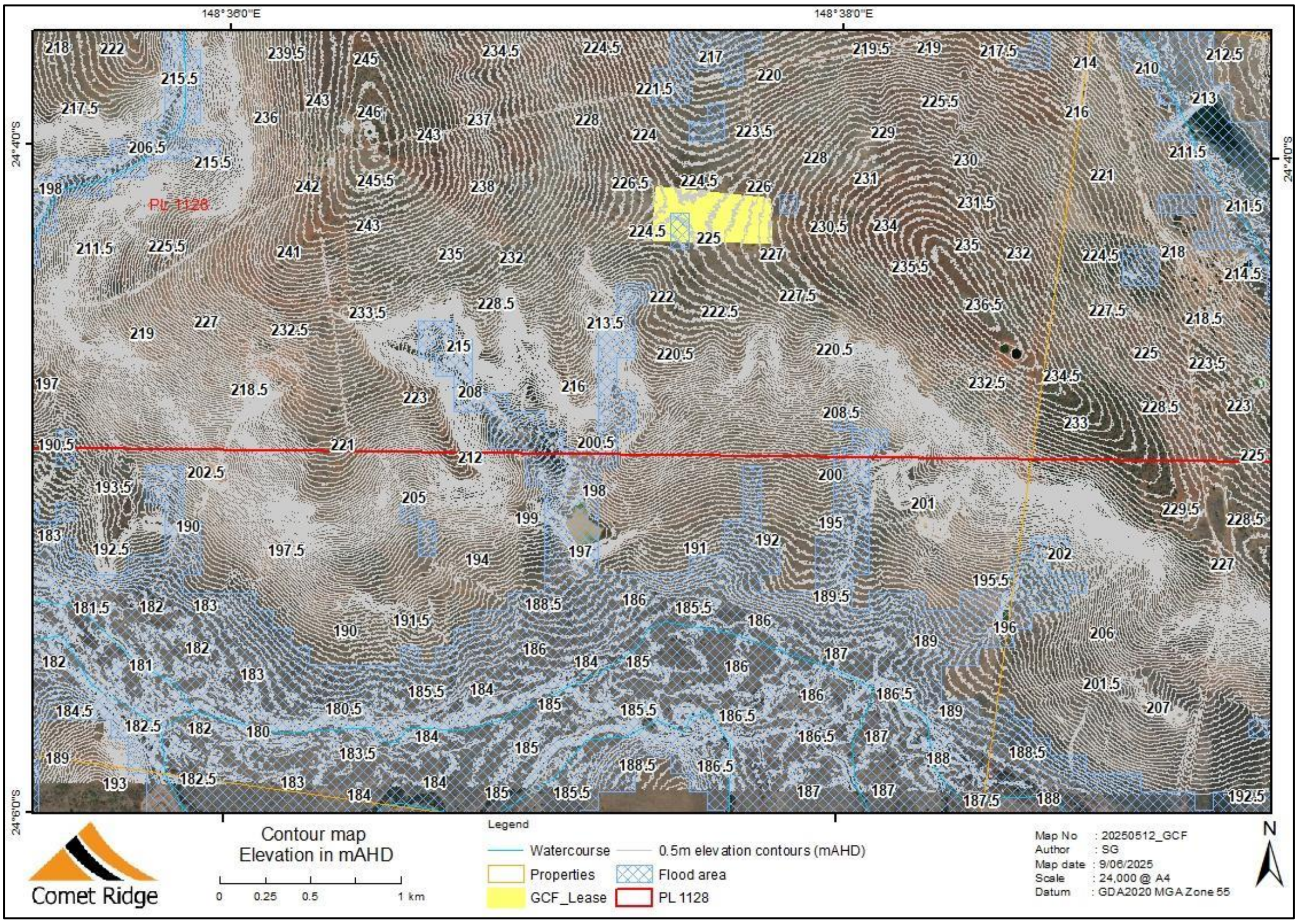

Figure 2 – Contours and Flood Map

4.3 Geology and Hydrogeology

The geological profile underlying the project area includes multiple hydrostratigraphic units relevant to groundwater flow and potential interconnectivity:

- **Bandanna Formation (Target Reservoir)**

The Bandanna Formation consists of interbedded coal seams, mudstone, and sandstone, encountered at ~330–380 m Below Ground Level (BGL). It is the primary reservoir for CSG production, with very low hydraulic conductivity ($<1\times10^{-7}$ m/s).

- **Rewan Formation (Overlying Aquitard)**

The Rewan Formation lies directly above the Bandanna Formation and serves as a regionally extensive confining aquitard. Composed predominantly of fine-grained mudstone and siltstone, this unit exhibits extremely low vertical permeability, effectively inhibiting hydraulic connectivity between the Bandanna coal seams and overlying aquifers such as the Tertiary Basalt and Quaternary Alluvium across much of the PL. However, where the Rewan Formation subcrops in the eastern portion of the PL, the unit thins and pinches out.

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In this area, the unit likely exhibits a weathered profile with a higher relative hydraulic conductivity relative to the unweathered Rewan Formation, which is greater than 200 m thick across the majority of the PLA.

As the principal confining unit in the hydrostratigraphic sequence, the Rewan Formation plays a critical role in limiting vertical fluid migration and maintaining the hydraulic separation between deep gas-bearing formations and shallow water resources.

- **Tertiary Basalt (Discontinuous Aquifer)**

Present in laterally discontinuous, isolated pockets, the Tertiary Basalt comprises weathered and fractured volcanic flows with moderate yields in areas of structural enhancement. The basalt is incised into a broad blanket of generally low permeability Tertiary sediments. The Tertiary sediments generally do not host groundwater. The basalt aquifer acts as the primary water source for stock and domestic supply across Meroo Downs, Togara Station, and Struan, with saturated thicknesses depending on local structural and weathering conditions.

- **Quaternary Alluvium (Shallow Aquifer)**

Alluvial sediments, comprised of lenticular deposits of sand, silt and clay are associated with the Comet River, Humboldt Creek and Rockland Creek. The Comet River floodplain does not extend within the PL boundary and the river is close to the channel boundary, with limited alluvial sediment present in the southwest at the confluence of the Comet River and Humboldt Creek. The extent of alluvium is limited to the stream channels in the ephemeral Humboldt and Rockland Creeks. Quaternary Alluvium is shown in Figure 5.

The alluvial sediments west of the Comet River are likely to host groundwater, which is exploited by local users as a water supply. The alluvial sediments of the ephemeral streams are unlikely to be permanently saturated and host groundwater for a brief period after significant rain events and stream flow. The streams are likely to be a recharge zone and do not receive groundwater discharge except
for periods of very high rainfall.

Table 4 – Summary of Hydrostratigraphic Units

Unit Name	Type	Lithology	Depth Range (m bgl)	Role / Function	Hydraulic Conductivity (m/s)
Bandanna Formation	Target Reservoir	Coal seams, carbonaceous mudstone	~330–380	CSG production zone	<1×10^{-7}
Rewan Formation	Regional Aquitard	Mudstone, siltstone	60–100 (thickness)	Confining layer, limits vertical flow	<1×10^{-8}
Tertiary Basalt	Discontinuous Aquifer	Fractured basalt flows	Variable	Primary aquifer for stock/domestic bores in project area	Variable (fracture-controlled)
Quaternary Alluvium	Shallow Aquifer	Sand, gravel, clay	2–8 (saturated)	Limited extent within the project area; not used for supply; environmental relevance	Moderate (~10^{-5} to 10^{-6} where present)

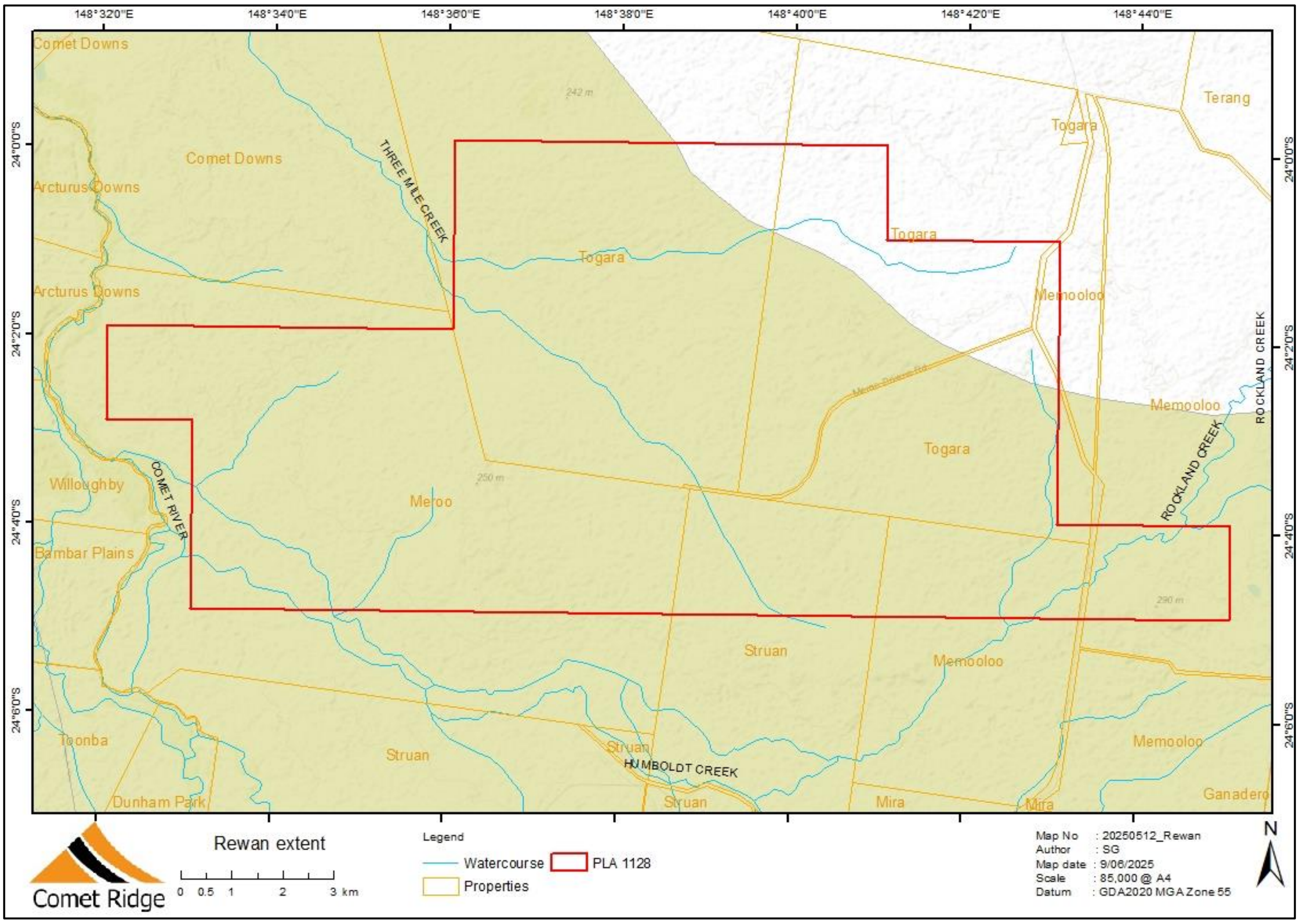

Figure 3 – Rewan Formation distribution within the Mahalo North project

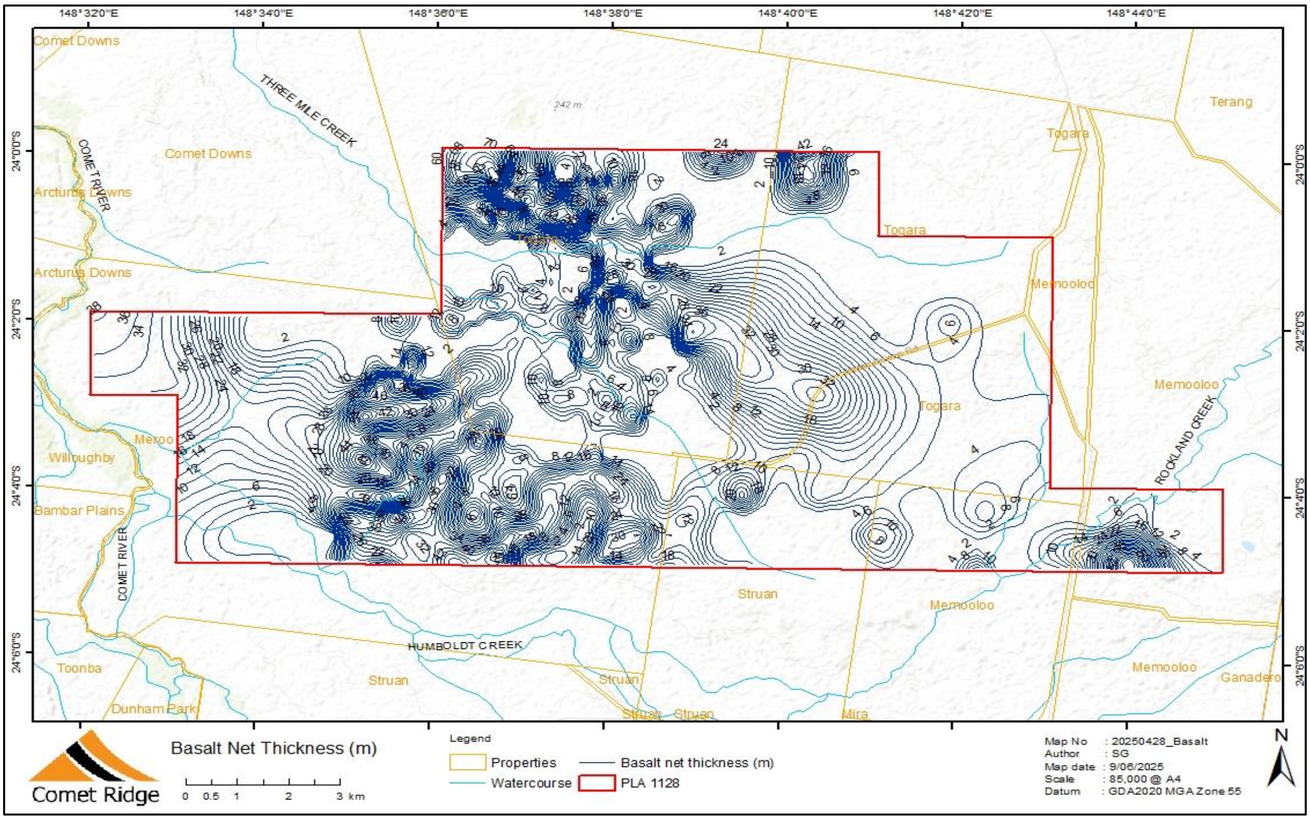

Figure 4 – Tertiary Basalt Distribution within the Mahalo North Project

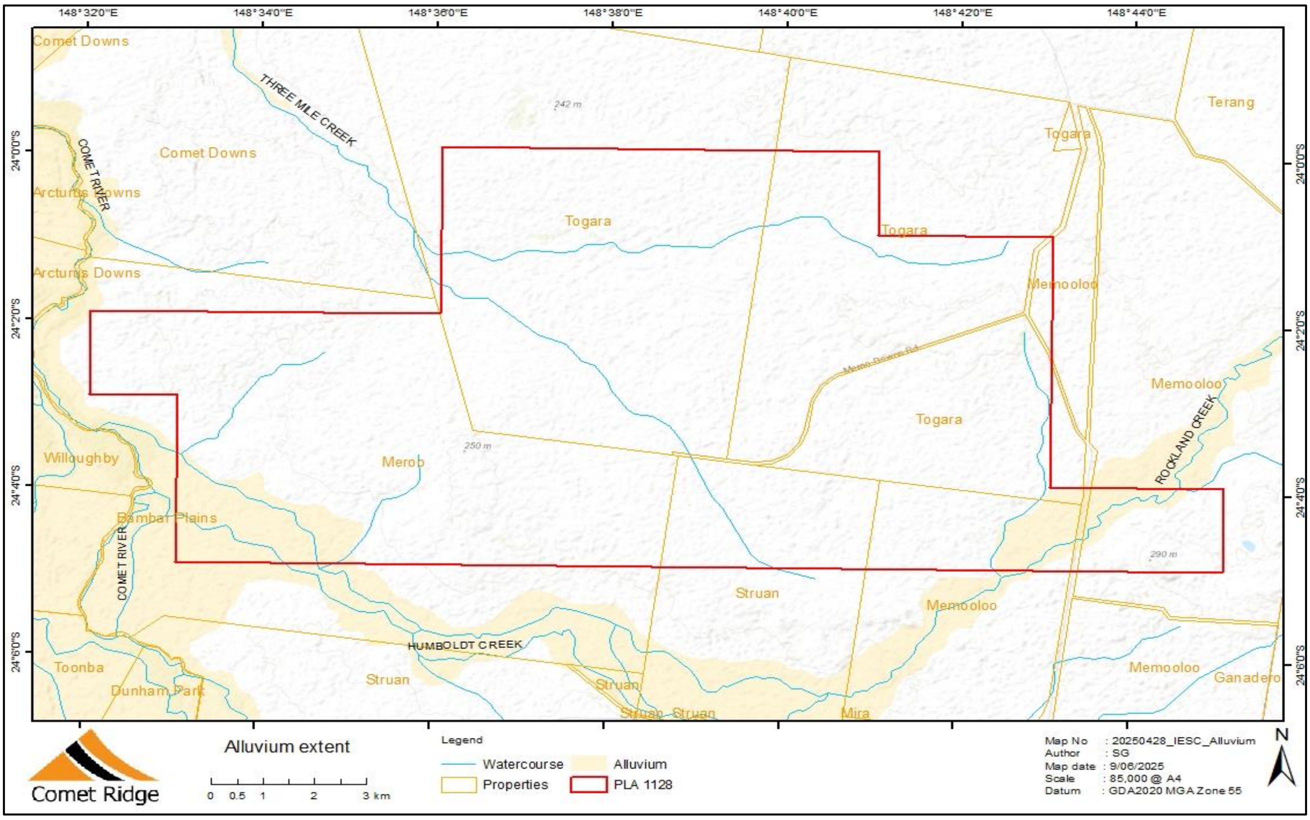

Figure 5 – Alluvium Distribution within the Mahalo North Project

4.4 Surrounding Land Use

The Project is situated within a region of Central Queensland characterised by diverse land uses, including extensive pastoral activities and a variety of industrial and resource development activities, summarised in Table 5 below.

Table 5 – Summary of Surrounding Land Use

Land Use/ Activity	Description	Reference Information
Coal Mining	The Project is located within the Bowen Basin, an active coal-producing region with nearby open-cut and underground coal operations.	QLD Department of Resources, Bowen Basin Geology and Mines Database (2024)
Other CSG Tenures	The Project is situated near several existing and proposed CSG tenures, including adjacent PLs that form part of a larger gas development hub in the region. Additional CSG tenures are located to the west of the Project area.	Queensland Petroleum Lease Register (Department of Resources, 2024)
Irrigated Agriculture	Downstream in the Comet River catchment, some irrigated cotton and forage cropping depend on surface water diversions.	Fitzroy Basin Water Resource Plan (Department of Regional Development, Manufacturing and Water, 2021); QLUMP (2023)
Dry Land Cropping	Broadacre cropping (e.g., sorghum, wheat, chickpeas) is practiced on suitable soils in the region, primarily reliant on seasonal rainfall.	ABARES Land Use Survey Data (2021); Queensland Land Use Mapping Program (QLUMP 2023)
Extensive Cattle Breeding and Grazing	Widespread across the region, using large landholdings for low-intensity grazing. Pasture condition varies with seasonal rainfall and land management.	Queensland Land Use Mapping Program (QLUMP 2023)
Linear Infrastructure	Includes Ergon powerlines and associated easements, coal train lines, rural roads.	Queensland Spatial Catalogue (QSpatial, 2024); Ergon Energy Network Plans; Aurizon Rail Corridor Data

4.5 Overlapping Tenure and Adjacent Projects

The Project overlaps with and is adjacent to several other resource tenures and mining leases shown in Figure 6, as of May 2025.

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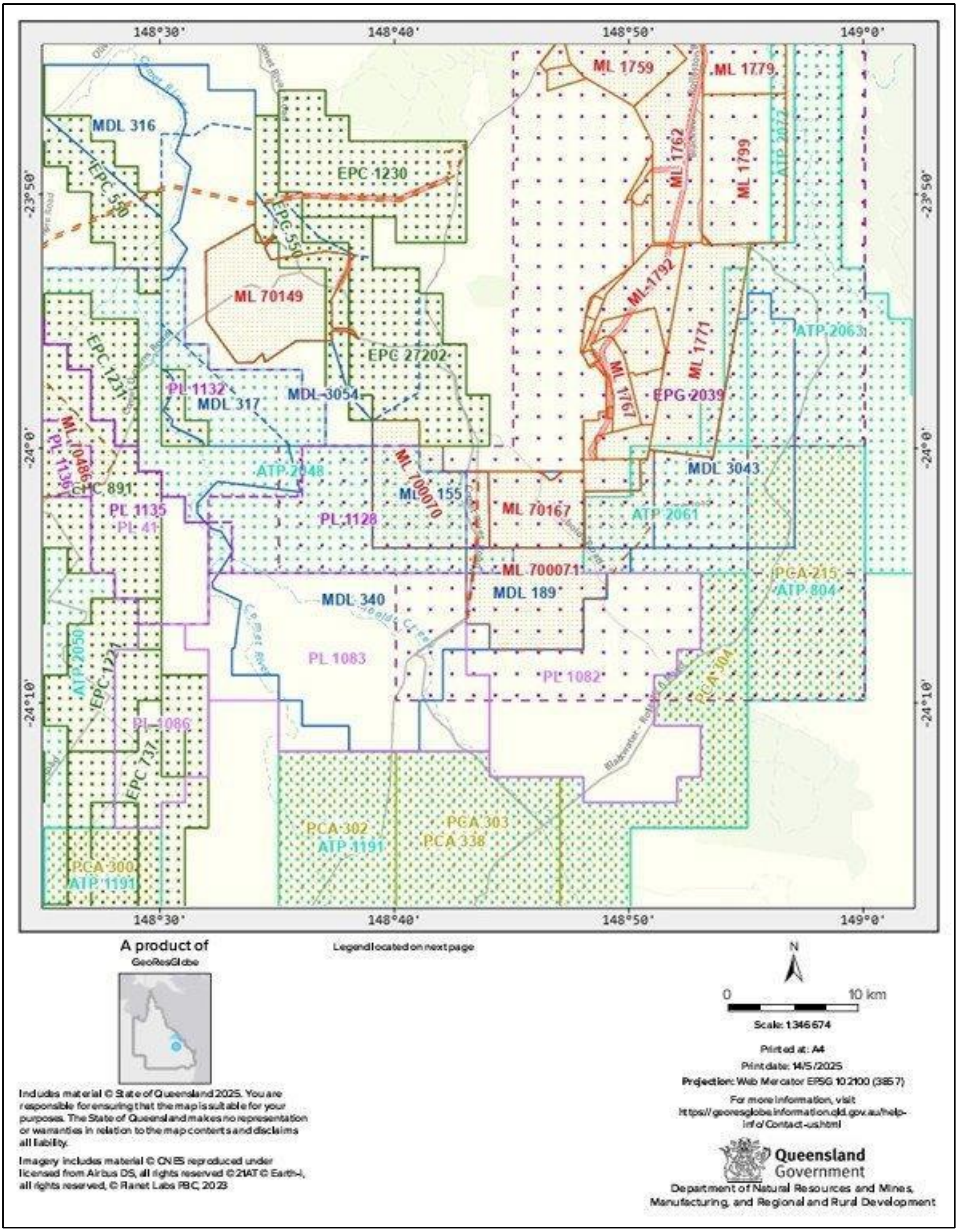

Figure 6 – Overlapping Tenures and Adjacent Projects

4.6 Pastoral Properties within PL1128

The Project encompasses four (4) large pastoral properties primarily used for extensive cattle grazing (refer to Table 6 below). These properties contribute to the regional beef industry and feature a mix of improved pasture, native vegetation, and ephemeral waterways.

Table 6 – Summary of Key Properties within PL1128

Property Name	General Location within PL1128	Primary Land Use	Notes
Togara Station	Northern sector	Extensive cattle grazing	Includes broadacre blade-ploughed paddocks, sown to buffel grass *(Cenchrus ciliaris)*
Meroo Downs	Southwestern lease area	Rotational grazing, pasture improvement, dryland cropping	Hosts Mahalo North pilot well (MN-1), Extensively cleared paddocks sown to buffel grass following blade ploughing.
Memooloo	East of Struan southeast of Togara	Livestock management across native and improved pasture	Mostly native pasture with improved pasture for grazing.
Struan	Southern Central area	High intensity cattle grazing and Droughtmaster bull stud	Extensively cleared and developed; buffel grass dominant.

5. Environmental Impact Assessment

This section provides an assessment of potential impacts from the Project on water-related EVs, consistent with the IESC Information Guidelines (2024), the EPBC Act 1999, and Queensland's Water Act 2000.

The assessment is underpinned by a site-specific conceptual model that incorporates geological, hydrogeological, and ecological processes, and their interrelationships.

A structured cause–effect pathway approach is used to evaluate the potential impacts associated with CSG development activities.

The impact assessment framework is structured to:

- Identify key EVs and sensitive receptors;
- Describe potential CSG-related impacts;
- Establish clear cause–effect pathways linking project activities to potential environmental impacts;
- Integrate site-specific geological and hydrogeological data with ecological indicators to develop a conceptual and predictive model of system interactions;
- Account for spatial and seasonal variability, including the role of faults, recharge zones, and climatic drivers in modulating aquifer connectivity and ecosystem resilience.

This structured approach ensures that impact predictions are scientifically robust, regulator-aligned, and responsive to dynamic environmental conditions throughout the life of the project.

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5.1 Sensitive Receptors

The key water-related receptors identified include:

Groundwater systems including Bandanna Formation (target formation), Rewan Formation (aquitard), Tertiary fractured rock aquifer, and Quaternary Alluvium.

- Quaternary Alluvium represents the shallowest aquifer in the area. It is unconfined and recharged primarily through rainfall and surface runoff. The aquifer is susceptible to surface-derived contaminants, including hydrocarbons, nutrients, or high-salinity water mobilised during CSG operations. As previously discussed, this aquifer is not used for stock water purposes.
- Beneath the alluvium lies the Tertiary Basalt, a semi-confined fractured rock aquifer. While its permeability is generally moderate, it is highly variable depending on the degree of fracturing and weathering.
- The Rewan Formation serves a critical role as a regional aquitard. It is characterised by low permeability and acts as the primary confining layer that separates shallow aquifers from the underlying Bandanna Formation

Third-party groundwater users

- Landholders' bores within the area are advanced in the tertiary basalt, particularly those located on Togara Station and Meroo Downs, drawn from these aquifers for stock use. They are legally protected under the *Water Act 2000*, and any observed changes in bore functionality or water quality must be assessed in accordance with make-good provisions.

Surface water features: Surface water systems in the Project area are considered sensitive environmental receptors include:

- The Comet River, a semi-permanent and regionally significant watercourse that serves as the primary downstream compliance receptor. It is listed under the Comet River Sub-basin WQOs (DEHP, 2011) and supports multiple EVs, including aquatic ecosystems, agriculture, and cultural values.
- Humboldt Creek is an ephemeral stream, its flow is highly seasonal and sensitive to changes in rainfall, runoff, and sediment load. It is particularly vulnerable to surface spills, stormwater discharges, and increased sedimentation during construction and operation.
- Rockland Creek, located in the southeast portion of the tenement, is a proposed monitoring site.

Groundwater-Dependent Ecosystems (GDEs): Riparian vegetation and potential refugial pools supporting *Elseya albagula* (white-throated snapping turtle), other EPBC-listed fauna, and potential subterranean GDEs (e.g., stygofauna in basalt and alluvial aquifers).

5.2 Potential Impacts

Potential project-induced impacts include:

- **Aquifer depressurisation**:
  - Pressure reduction in the Bandanna Formation may propagate through faults or discontinuous aquitards, affecting overlying aquifers.

- **Surface water changes**:
  - Altered baseflow regimes in ephemeral creeks due to drawdown-induced reduction in shallow aquifer discharge.

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- **GDEs stress**:
  - Reduction in water availability or quality may affect terrestrial and aquatic ecosystems reliant on shallow groundwater.

- **Water quality degradation**:
  - Mobilisation of contaminants from deep formations,
  - Changes in water quality through discharge, runoff, or inter-aquifer flows spills, seepage, or overtopping of storage infrastructure

5.2.1 Aquifer Depressurisation and Inter-Aquifer Connectivity

Depressurisation of the Bandanna Formation may inadvertently affect surrounding aquifers and ecological receptors through vertical or lateral hydraulic gradients.

Key risks associated with depressurisation include:

- Loss of Confinement and Vertical Leakage:
  - The low-permeability Rewan Formation acts as a barrier to upward or downward groundwater flow. However, depressurisation of the Bandanna coal seams could induce downward hydraulic gradients. In scenarios where the Rewan is faulted or thinned, this pressure differential could result in vertical leakage of groundwater, or the migration of deep formation water or gas into overlying aquifers.
- Changes to Inter-Aquifer Head Gradients:
  - Drawdown in the Bandanna Formation alters the natural hydraulic gradient across the stratigraphic column. This could induce reverse or enhanced flow directions in the Tertiary sediments and shallow alluvium, especially where inter-aquifer leakage is facilitated by structural discontinuities. This process not only affects the volumetric availability of groundwater in these units but also risks introducing saline or metal-rich water into otherwise fresh systems.
- Recharge–Discharge Balance Disruption:
  - The alluvium and fractured Basalt aquifers rely on episodic recharge from rainfall and surface water infiltration. Under prolonged drawdown conditions caused by Bandanna depressurisation, these shallow systems may lose water to the deeper strata, especially during dry periods when recharge is minimal. This may lead to cumulative depletion, altered aquifer chemistry, or loss of connectivity with surface water features such as Humboldt Creek and Rockland Creek.

5.2.2 Release of Contaminants and Risk of Impact to Shallow Groundwater and Surface Water

The Bandanna Formation—targeted for CSG extraction by the Project — contains groundwater with moderate to high salinity, typically ranging from 2,000 to 10,000 mg/L Total Dissolved Solids (TDS). This groundwater is characterised by a sodium-chloride (Na-Cl) hydrochemical signature and is generally near-neutral to slightly alkaline (average pH ~7.9).

These characteristics are supported by regional groundwater datasets from the University of Queensland's Centre for Coal Seam Gas (UQ-CCSG, 2017) and Geoscience Queensland hydrochemistry compilations (Geological Survey of Queensland, 2020).

Naturally occurring concentrations of trace elements are present in Bandanna Formation groundwater. Based on regional hydrogeochemical studies (UQ-CCSG, 2017; GISERA Report EP155808, 2015), the following elements are commonly detected and may pose a risk to EVs if mobilised to shallow aquifers or surface water bodies:

- Boron (B)-
- Barium (Ba)

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- Strontium (Sr)
- Manganese (Mn)
- Iron (Fe)
- Lithium (Li)
- Fluoride (F^-)

These analytes are considered critical for baseline and operational monitoring because they:

- Act as geochemical tracers of deep groundwater (e.g. from the Bandanna Formation);
- Indicate possible vertical leakage or inter-aquifer connectivity where they appear in overlying aquifers (UQ-CCSG, 2017);
- Support identification of infrastructure leakage or seepage (e.g. from produced water storage or pipelines) (APPEA, 2018);
- Aid in the source attribution of anomalous surface water chemistry (e.g. via aquifer interflow or stormwater mobilisation during rainfall events).

To support impact assessment and compliance monitoring, these elements are recommended for inclusion in baseline and operational water quality monitoring programs.

Table 7 – Release of Contaminants, Inorganic Elements

Metals/Anions	WQO (DEHP 2011)	NEPM 2013	CSG Indicator
Arsenic (As)	☑	☑	✗
Cadmium (Cd)	☑	☑	✗
Chromium (Cr VI)	☑	☑	✗
Copper (Cu)	☑	☑	✗
Lead (Pb)	☑	☑	✗
Nickel (Ni)	☑	☑	✗
Selenium (Se)	☑	☑	✗
Zinc (Zn)	☑	☑	✗
Cobalt (Co)	☑	☑	✗
Iron (Fe)	☑	✗	✗
Manganese (Mn)	☑	✗	✗
Boron (B)	✗	✗	☑
Barium (Ba)	✗	✗	☑
Strontium (Sr)	✗	✗	☑
Lithium (Li)	✗	✗	☑
Fluoride (F^-)	✗	✗	☑
Uranium (U)	✗ (ADWG/ANZG)	☑	✗

Studies including GISERA Report EP155808 (2015) and regional assessments by Geoscience Australia have documented the occasional presence of organic contaminants in coal seam formation water. Although typically at low concentrations, these compounds may be mobilised during gas extraction, produced water handling, or unintentional release, and pose risks to aquatic ecosystems and human health. Monitoring should include:

- BTEX compounds (Benzene, Toluene, Ethylbenzene, Xylenes);
- Polycyclic aromatic hydrocarbons (PAHs);
- Phenolic compounds.

Where these contaminants are of concern, monitoring should adopt a risk-based, site-specific approach consistent with ANZG (2018) water quality guidelines and the NEPM (2013) Schedule B framework.

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5.3 Pathways

These pathways serve as the foundation for the conceptual hydrogeological model and are used to design the monitoring network, set performance objectives, and identify contingency measures.

The release or upward migration of Bandanna Formation water may occur through a range of mechanisms, including:

- **Vertical hydraulic connectivity** due to geological features such as faults, poorly sealed wells, or compromised well integrity;
- **Subsurface leakage or seepage** from CSG infrastructure such as ponds, pipelines, or storage tanks;
- **Mobilisation via aquifer depressurisation** and changes to hydraulic gradients resulting from gas extraction;
- **Surface discharge or stormwater runoff**, where contaminants are transported to ephemeral streams or river systems (e.g., Humboldt Creek, Comet River).

5.3.1 Impact Pathway Identification

The Project involves several activities that could introduce pressures to the hydrogeological environment. These pressures may generate stressors that affect sensitive receptors—such as aquifers, surface water systems, soil, and ecosystems—through various impact mechanisms.

The impact pathway framework used in this plan applies the following structure:

Pressure (Activity) → Stressor/Change → Receptor → Potential Impact

Table 8 – Identified Impact Pathways

Pressure (Activity)	Stressor / Change	Receptor/s	Potential Impact/s
Operational dewatering	Depressurisation of Bandanna Formation	• Rewan Formation, • Tertiary Sediments and Basalt, • Quaternary Alluvium, • Comet River and streams, • aquatic ecosystems, • GDEs	• Groundwater drawdown; • Altered inter-aquifer pressure gradients; • Groundwater quality changes from aquifer interconnectivity; • Reduction in baseflow; • Potential vegetation stress.
Produced water extraction and handling	Produced water seepage or spill events	• Soil, • Shallow aquifer, • Surface water.	• Salt accumulation; • Reduced surface water and groundwater quality.
RO treatment and brine storage	Concentrated brine, elevated salts and metals	• Soil, • Shallow aquifers, • Root zones	• Salinisation; • Mobilisation of metals; • Long-term degradation of soil and water quality.
Stormwater runoff from CGP infrastructure	Increased sediment load, hydrocarbon/nutrient transport	• Humboldt Creek; and • Ephemeral gullies	• Water quality degradation; • Riparian habitat loss; • Sedimentation impacts; • Algal blooms

Pressure (Activity)	Stressor / Change	Receptor/s	Potential Impact/s
Site clearing and vehicle access	Soil compaction, loss of ground cover	• Overland flow paths; and • Ephemeral creeks	• Increased erosion and turbidity; • Altered drainage behaviour
Road and trench construction	Drainage redirection; potential flow obstruction	• Humboldt Creek; and • Floodplain hydrology	• Modified flow regime; • Flooding or drying of sensitive habitats

5.3.2 Integration of Geological and Hydrological Factors on Impacts

Faulting and Structural Controls

The geological framework of the Bowen Basin, including the Project area, features a network of faults, fractures, and stratigraphic variations that can act as either barriers or conduits to fluid movement. Of particular importance is the potential for structural discontinuities to compromise the integrity of the Rewan Formation—a key aquitard separating the target Bandanna Formation from overlying aquifers such as the Tertiary Basalt and Quaternary Alluvium. Faults may facilitate vertical connectivity if they are transmissive or poorly sealed, allowing for pressure transmission or migration of produced water, gas, or associated contaminants.

Recharge and Discharge Zones

Recharge and discharge zones regulate aquifer sustainability, water quality, and contaminant attenuation. The shallow alluvium within the Project area typically receives diffuse recharge during wet season rainfall events and may contribute to ephemeral stream flow (e.g., Humboldt Creek). In contrast, the Tertiary Basalt is variably recharged depending on surface exposure and fracture density, while deeper formations such as the Rewan and Bandanna are largely confined, with very limited natural recharge.
Recharge patterns are also influenced by climate variability, vegetation cover, and anthropogenic disturbances (e.g., vegetation clearing, road compaction).

Seasonal Variability

Hydrological and ecological processes in the region are strongly influenced by seasonal climate patterns, particularly the contrast between the wet and dry seasons. This variability affects:

- Surface-groundwater connectivity, with ephemeral streams such as Humboldt Creek more likely to recharge the alluvium or receive baseflow during the wet season; and
- Detection of contaminant pulses, which may only be observable during runoff or high-recharge events.

6. Assessment Criteria

To support impact assessment and environmental management, a suite of assessment criteria has been defined to guide monitoring, trigger investigations, and inform adaptive management responses. These criteria are directly linked to the EVs identified for the Project and are developed using a combination of baseline data, statutory water quality objectives, and national guideline values.

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6.1 Environmental Values

The EVs define both environmental and community's uses and values for local water resources. These underpin the monitoring and impact assessment framework and have been determined in accordance with:

- Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (EPP Water);
- Fitzroy Basin Environmental Values and Water Quality Objectives – Basin 130 (DEHP, 2011);
- EPBC Act 1999 – Significant Impact Guidelines;
- IESC Information Guidelines (2024), including Chapter 5 – Water Resources and the Explanatory Note on Site-specific Guideline Values (2023).

The key EVs relevant to The Project include:

- Aquatic ecosystem protection – Slightly to moderately disturbed systems that support biodiversity and ecological functions;
- Agricultural water use – Stock watering and limited irrigation;
- Recreational use – Primary and secondary contact activities (e.g. swimming, fishing);
- Cultural and spiritual values – Recognising Traditional Owner connection to land and water;
- Industrial use and visual amenity – Non-potable use and maintenance of aesthetic water quality.

6.2 Default Criteria for Water Quality

Where sufficient baseline data are not yet available, default criteria are adopted as interim thresholds, consistent with the following hierarchy:

1. WQOs for the Comet River Sub-basin (DEHP, 2011), as published in the Fitzroy Basin Environmental Values and Water Quality Objectives – Basin 130;
2. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) default guideline values (DGVs);
3. NEPM (2013) values and effect-based thresholds, where relevant.

These criteria are applied to both groundwater and surface water receptors and form the basis of event-based and trend-based monitoring evaluation.

Table 9 – WQOs for Groundwater (Comet River Sub-basin)

Category	Parameter	Proposed Limit	Source
Dissolved Gases	Methane	Baseline value	ANZG (2018) Site-specific
Field Parameters	pH	6.5 – 8.5	WQO (DEHP 2011)
Field Parameters	Dissolved Oxygen (DO)	>40% saturation	WQO (DEHP 2011)
Field Parameters	Electrical Conductivity (EC)	<1,000 µS/cm	WQO (DEHP 2011)
Field Parameters	Standing Water Level	Baseline value	CSG Risk Indicator
Major Ions	Calcium (Ca)	TBD	WQO (DEHP 2011)
Major Ions	Chloride (Cl)	TBD	WQO (DEHP 2011)
Major Ions	Magnesium (Mg)	TBD	WQO (DEHP 2011)
Major Ions	Sodium (Na)	TBD	WQO (DEHP 2011)

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Category	Parameter	Proposed Limit	Source
Major Ions	Sulfate (SO_4) Fluoride (F)	TBD	WQO (DEHP 2011)
Metals (Dissolved)	Arsenic (As III)	<24 µg/L	ANZG (2018)
Metals (Dissolved)	Barium (Ba)	TBD	CSG Risk Indicator
Metals (Dissolved)	Boron (B)	TBD	CSG Risk Indicator
Metals (Dissolved)	Cadmium (Cd)	<0.2 µg/L	ANZG (2018)
Metals (Dissolved)	Chromium (Cr III)	<3.3 µg/L	ANZG (2018)
Metals (Dissolved)	Cobalt (Co)	<1.4 µg/L	ANZG (2018)
Metals (Dissolved)	Copper (Cu)	<1.4 µg/L	ANZG (2018)
Metals (Dissolved)	Iron (Fe)	TBD	WQO (DEHP 2011)
Metals (Dissolved)	Lead (Pb)	<3.4 µg/L	ANZG (2018)
Metals (Dissolved)	Lithium (Li)	TBD	CSG Risk Indicator
Metals (Dissolved)	Manganese (Mn)	<1900 µg/L	WQO (DEHP 2011)
Metals (Dissolved)	Nickel (Ni)	<11 µg/L	ANZG (2018)
Metals (Dissolved)	Selenium (Se)	< 5 µg/L	ANZG (2018)
Metals (Dissolved)	Strontium (Sr)	TBD	CSG Risk Indicator
Metals (Dissolved)	Uranium (U)	<0.5 µg/L	ANZG (2018)
Metals (Dissolved)	Zinc (Zn)	<8 µg/L	ANZG (2018)
Nutrients	Ammonia	<20 µg/L	WQO (DEHP 2011)
Nutrients	Nitrate	<1.1 mg/L	WQO (DEHP 2011)
Nutrients	Total Nitrogen (TN)	<500 µg/L	WQO (DEHP 2011)
Nutrients	Total Phosphorus (TP)	<50 µg/L	WQO (DEHP 2011)
Organics	BTEX	TBD	ANZG (2018) Site-specific
Organics	PAHs	TBD	ANZG (2018) Site-specific
Organics	Phenolic compounds	TBD	ANZG (2018) Site-specific

The relevant surface WQOs for the Comet River sub-basin, including the project area, are found in the Queensland Department of Environment and Heritage Protection (DEHP) report titled Fitzroy Basin Environmental Values and Water Quality Objectives – Basin 130 (Comet River Sub-basin) (September 2011).

Table 10 – WQOs for Surface Water (Comet River Sub-basin)

Category	Analyte	Limit	Guideline Source
Field Parameters	Dissolved Oxygen (DO)	>85 % and <110 % saturation	WQO (DEHP 2011)
Field Parameters	Electrical Conductivity (EC)	<375 µS/cm (base flow) <210 µS/cm (high flow)	WQO (DEHP 2011)
Field Parameters	Turbidity	<50 NTU	WQO (DEHP 2011)
Field Parameters	pH	6.5 – 8.5	WQO (DEHP 2011)
Major Ions	Calcium (Ca)	TBD	WQO (DEHP 2011)
Major Ions	Chloride (Cl)	TBD	WQO (DEHP 2011)
Major Ions	Magnesium (Mg)	TBD	WQO (DEHP 2011)
Major Ions	Sodium (Na)	TBD	WQO (DEHP 2011)

Category	Analyte	Limit	Guideline Source
Major Ions	Sulfate (SO_4) Fluoride (F)	TBD	WQO (DEHP 2011)
Metals (Dissolved)	Barium (Ba)	TBD	CSG Risk Indicator
Metals (Dissolved)	Boron (B)	TBD	CSG Risk Indicator
Metals (Dissolved)	Copper (Cu)	<1.4 µg/L	ANZG (2018)
Metals (Dissolved)	Iron (Fe)	TBD	WQO (DEHP 2011)
Metals (Dissolved)	Lead (Pb)	<3.4 µg/L	ANZG (2018)
Metals (Dissolved)	Lithium (Li)	TBD	CSG Risk Indicator
Metals (Dissolved)	Manganese (Mn)	<1900 µg/L	ANZG (2018)
Metals (Dissolved)	Strontium (Sr)	TBD	CSG Risk Indicator
Metals (Dissolved)	Uranium (U)	<0.5 µg/L	ANZG (2018)
Metals (Dissolved)	Zinc (Zn)	<8 µg/L	ANZG (2018)
Nutrients	Ammonia	<20 µg/L	WQO (DEHP 2011)
Nutrients	Total Nitrogen (TN)	<500 µg/L	WQO (DEHP 2011)
Nutrients	Total Phosphorus (TP)	<50 µg/L	WQO (DEHP 2011)
Organics	BTEX	TBD	ANZG (2018) Site-specific
Organics	PAHs	TBD	ANZG (2018) Site-specific
Organics	Phenolic compounds	TBD	ANZG (2018) Site-specific

6.3 Site-Specific Guideline Values (SSGVs) Development Framework

SSGVs are being progressively developed for The Project, following the IESC Explanatory Note on SSGVs (2023). The process adopts a tiered approach:

1. Measured Baseline Data
    - Further data collection is ongoing to improve statistical confidence.
2. Published WQOs:
    - Where baseline data are incomplete, applicable WQOs for the Comet River sub-basin are adopted to ensure EV protection.
3. ANZG (2018) Default Guideline Values (DGVs):
    - In the absence of WQOs, DGVs are applied, with local adjustment where necessary, based on hydrogeological context and known natural background levels.
4. Effect-Based Criteria:
    - For analytes not covered by the above, conservative toxicological or ecological effect levels are adopted (e.g., NEPM 2013 health-based limits or literature-derived thresholds).

These thresholds are subject to annual review. As further baseline data are collected, particularly in dry and wet seasons, SSGVs will be refined to improve statistical confidence and site relevance.
All SSGVs will be embedded within the project's Trigger–Action–Response Plan (TARP) and reviewed periodically in line with risk-based monitoring outcomes and evolving baseline understanding.

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7. Contingency Plan

The Contingency Plan outlines a structured, risk-based framework to respond proactively to potential water-related impacts associated with the Project. It integrates adaptive management principles and reflects site-specific hydrogeological, geochemical, and ecological conditions.

It supports the overarching WMMP by defining clear trigger levels, response actions, and mitigation measures to safeguard the identified EVs identified for the Project area.

The contingency plan has been developed in alignment with the requirements of the EA, the EPBC Act 1999, and the IESC Information Guidelines (2024).

7.1 Trigger–Action–Response Plan (TARP)

The TARP sets out a proactive framework for identifying and responding to deviations from baseline or expected environmental performance. It supports early detection of potential environmental impacts, particularly in groundwater and surface water systems, associated with CSG activities.

Trigger values serve as early warning thresholds within the monitoring framework. While not compliance limits, they are designed to initiate further assessment, validation, or management action when exceeded. Their purpose is to detect deviations from baseline or expected conditions before significant environmental harm occurs.

7.2 Water Quality Trigger Values

Monitoring results will initially be assessed against interim trigger limits following each monitoring round. These interim thresholds remain in place until sufficient temporal data are available to establish statistically robust Site-Specific Trigger Levels (SSTLs). Once SSTLs are defined, review frequency will shift to a quarterly basis.

To support trend identification and decision-making, monitoring data will be plotted using control charts. These charts enable visualisation of parameter variation over time and provide a quantitative basis for determining when management responses are required. The trigger values and corresponding response thresholds are defined according to the Department of Environment and Science (DES, 2021) methodology:

- **Limit A**: Exceedance of the 80th percentile for five consecutive monitoring rounds;
- **Limit B**: Exceedance of the 95th percentile for three consecutive monitoring rounds;
- **Trend-Based Trigger**: Five or more consecutive data points with an increasing trend gradient exceeding 0.25.

These control charts are parameter- and location-specific, ensuring targeted and responsive management of emerging trends.

The control chart to be used based on the example chart in Figure 7. The chart plots parameter concentration over time, trigger (Limits A and B) and response zones (normal, control and critical).

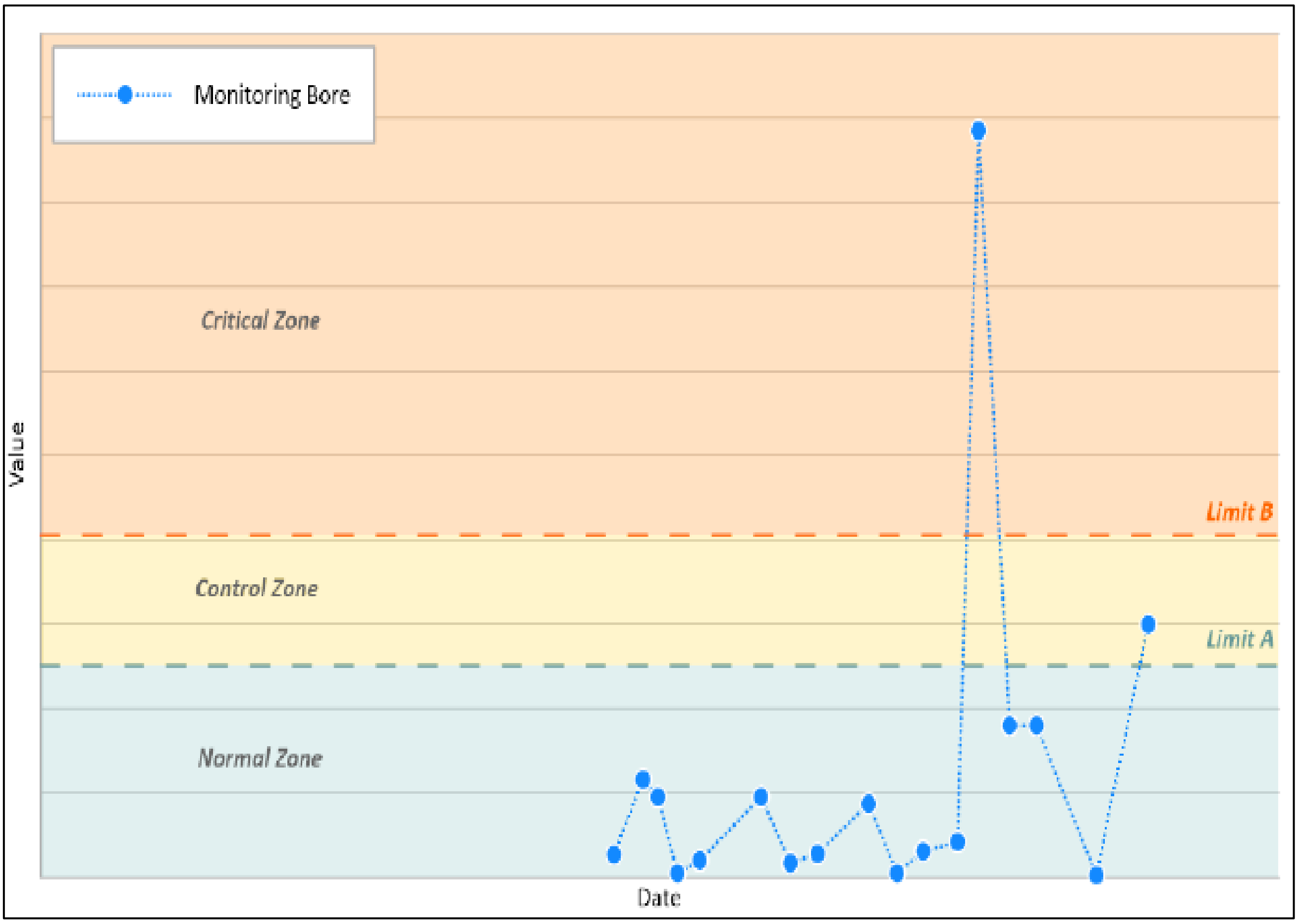

Figure 7 – Example Control Chart

7.3 Mitigation Response

Table 11 – Landholder's Bore Contingency Plan

Monitoring Component	Trigger Level	Action	Response Mitigation	Reporting
Standing Water Level (SWL)	±20% deviation from baseline or exceedance of modelled drawdown threshold	Field validation and resampling	Investigate cause (e.g., production drawdown, climatic variation). Adjust CSG extraction rates if necessary	Log in TARP register; notification as per EA and DCCEEW conditional approval if sustained deviation persists
pH, EC, DO (Field Parameters)	±20% deviation from baseline	Resample and confirm using field probes and lab data	Investigate source. Assess well condition and adjacent infrastructure	Include in quarterly monitoring report
Major Ions, Metals, Nutrients (Lab Parameters)	Exceedance of site-specific baseline range or WQO	Initiate full contaminant profile analysis	Source identification (e.g., seepage, spills); implement	Notify regulator as per the EA, if persistent exceedance;

Monitoring Component	Trigger Level	Action	Response Mitigation	Reporting
			containment or treatment	document in EA Annual Return
BTEX, PAHs, Hydrocarbons	Detected above laboratory detection limits	Immediate resampling and risk assessment	Isolate potential source (e.g., produced water management system); implement remediation	Notification to DETSI and DCCEEW as per EA/EPBC conditions.
Dissolved Gases (CH_4, CO_2)	Notable increase relative to baseline	Isotopic fingerprinting; pressure testing of casing/seals	Investigate potential gas migration pathway	Include in groundwater impact assessment reporting
Stable Isotopes	Shift outside baseline variability	Re-sampling and hydrochemical modelling	Evaluate for mixing zones or leakage from deeper units	Document in technical addendum to WMMP
Well Infrastructure (Integrity)	Visible damage, poor recovery, or failed purging	Immediate inspection	Repair or replace bore if impairment related to CSG activities; Reassess bore utility	Include in infrastructure inspection log
Landholder Bore Complaint or Bore Failure	Formal complaint or verified bore failure	Independent third-party assessment	Make-good agreement as per Water Act 2000 (s.406); bore rehabilitation or replacement	Notification to Regulator as per the EA conditions and Water Act 2000 (Qld) conditions; include in EA return and landholder consultation record

Table 12 – Surface Water Contingency Plan

Trigger Event	Action	Response / Mitigation	Reporting Requirement
Exceedance of WQO or baseline trigger	Confirm exceedance with resampling	Investigate potential source (e.g. bunding breach)	Include in EA Annual Monitoring report.
Visible change (sheen, turbidity, algal bloom)	Field inspection, deploy spill response if needed	Isolate source, assess infrastructure integrity	As per notification requirements in the EA
Fish kill or ecological impact observed	Emergency response and environmental harm assessment	Full incident investigation and impact mitigation	As per notification requirements in the EA
Unauthorised discharge suspected	Validate through rainfall, flow, and infrastructure inspection	Update TARP; implement controls	Trigger incident report as per EA and EPBC conditions

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Table 13 – Stormwater Contingency Plan

Monitoring Component	Trigger Level	Action	Response / Mitigation	Reporting
Brine/CSG Produced Water Storage Capacity	Tank level >90% or forecast rainfall exceeds freeboard limit	Activate alarms and inspect system	Recirculate brine between tanks or initiate inter-tank transfer to manage volume or initiate trucking of brine to offsite disposal with licensed waste contractor.	• Internal incident register; • Include in quarterly SWMP
RO Plant Operation	Forecast high rainfall event or loss of containment capacity	Pre-emptive system checks and standby	Temporarily shut down RO plant to prevent overflow or process disruptions	Log in operational records
Basin Freeboard or Overflow	Freeboard <0.3 m or discharge observed beyond design limits	Site inspection; confirm rainfall data	Implement containment; assess infrastructure for maintenance or upgrade needs	Notify as per EA requirements
Contaminated Stormwater Detection	• Presence of water in seepage bores, and lab exceedance; • Visual evidence of contamination in the dam (e.g. sheen, odour, turbidity), and lab exceedance.	• Initiate investigation to found the cause (spill, leak, overflow) • Collect a sample from the bore advance in the basalt	Implement remediation as required	As per EA reporting requirements
Unauthorised Discharge Event	Any flow outside containment system or bund	Site inspection; check control system	Identify failure point (e.g. overtopping, valve release); rectify cause; conduct site clean-up	Trigger incident report as per EA and EPBC conditions

8. Monitoring and Management

This section outlines the groundwater and surface water monitoring and management strategy for the Project. The strategy has been developed to be scientifically robust, risk-responsive, and adaptive to changing conditions over the life of the project.

The monitoring program is designed to protect water-related EVs by achieving the following:

- Establish robust baseline conditions for surface water and groundwater systems;
- Identify long-term trends and capture seasonal and spatial variability;
- Enable early detection of exceedances against assessment criteria or thresholds;
- Support event-based responses, particularly during high-risk periods such as extreme rainfall events or operational upscaling.

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A central component of the strategy involves the identification of hydraulic head and geochemical indicators characteristic of deep formation water (e.g., Bandanna Formation) and hydraulic head within each hydrostratigraphic unit (between shallow alluvium and deeper confined units). These indicators will support the assessment of potential vertical connectivity or contaminant migration pathways.

8.1 Monitoring Network Overview and Sampling Program Summary

The monitoring network consists of several strategically located monitoring points across the PL, designed to provide representative coverage of key receptors and flow paths. It includes:

- Landholder bores – for receptor-level monitoring and stakeholder assurance;
- Groundwater monitoring bores – including existing and planned installations across different hydrostratigraphic units;
- GDE monitoring bores – to assess groundwater availability and ecological dependencies in riparian or sensitive areas;
- Surface water monitoring points – focusing on ephemeral creeks and drainage lines near the GCF, particularly Humboldt Creek.

Each location has been selected based on hydrogeological mapping, groundwater flow modelling, receptor sensitivity, and proximity to CSG infrastructure. Together, the network captures both natural environmental variability and project-induced pressures, supporting a holistic water monitoring and management framework. The spatial layout of the existing and proposed monitoring locations is shown in Figure 8.

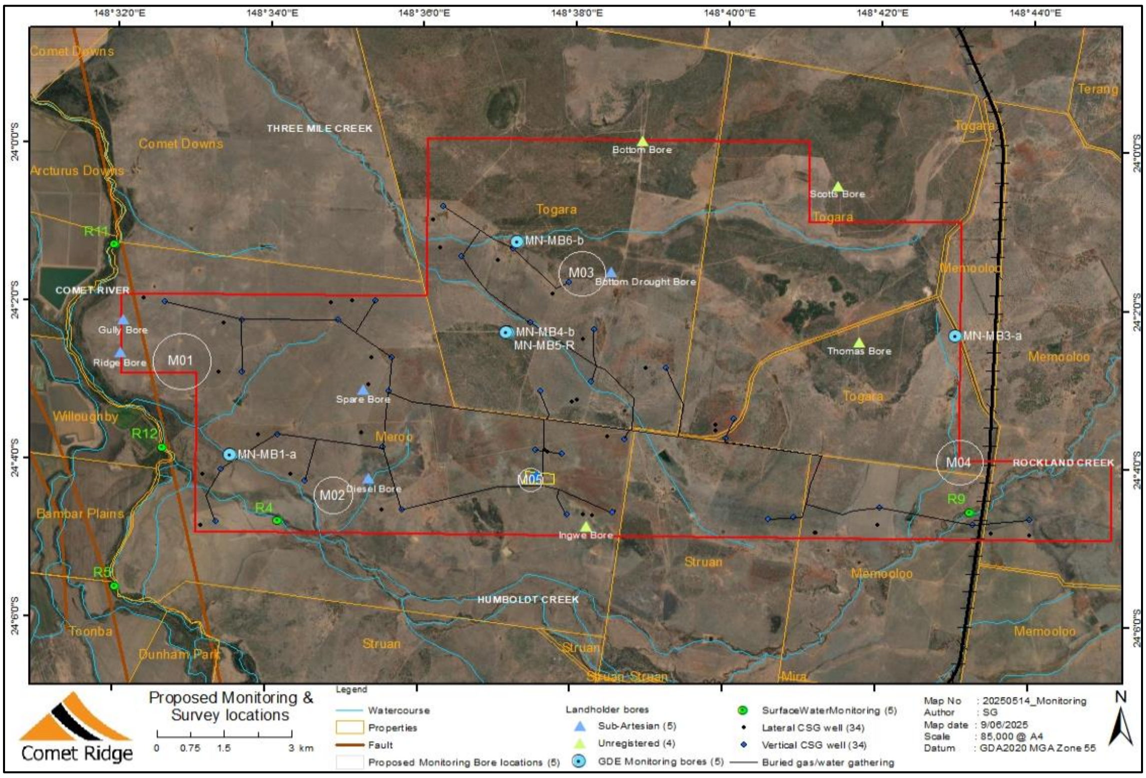

Figure 8 – Existing and Proposed Water Monitoring Locations

Table 14 – Monitoring Program Summary

Monitoring	Number	Description Monitoring Locations	Baseline Sampling Frequency	Operations Sampling Frequency
Landholder bores	9	All the bores are installed in the tertiary basalt and used for stock watering	Annually	Annually
GDEs monitoring bores	5	Bores installed in the alluvium and nearby the location of potential terrestrial GDEs	Monthly	-
Aquifer interconnectivity assessment	14	Clustered bores Installed to target each hydrogeological feature of the site	Quarterly	Biannually *
Groundwater/ surface water interaction evaluation	4	Part of the clustered bores, installed close to ephemeral waterways to target alluvium.	Quarterly	Biannually *
Surface water	3	• R11 • R4 • R9	Quarterly	Biannually *

Stormwater	3	• 3 groundwater monitoring bores:
		  ○ 2 seepage bores; and
		  ○ 1 bore advanced in the Basalt
		• Surface Water Catchment Dam
			-	• Event-based (post-rainfall >25 mm over 24 hours);
				• Quarterly check for presence of seepage water and sampling Surface Water Catchment Dam.

Riparian vegetation/ permanent pools	5	• R5, • R12, • R11, • R4, and • R9.	Annually	Annually, using remotely sensed satellite imagery, and utilising NDVI to compare potential changes over time.

*April (end of wet season), and September (end of dry season)

8.2 Adaptive Management Approach

While this WMMP reflects the current best understanding of the site's hydrogeological setting and regulatory context, it is designed as a dynamic tool. Updates may occur throughout the operational lifecycle to reflect:

- Improved site-specific hydrochemical and pressure data;
- Changes in regulatory expectations;
- Observations from baseline or operational monitoring; and
- Technological advancements in sampling or analysis.

Potential refinements may include adjustments to monitoring frequency, scope of analytes, or threshold values. However, the core principles of the plan remain constant: early risk identification, environmental protection, transparent reporting, and compliance with legal and approval conditions.
This adaptive but accountable structure supports responsiveness without compromising rigour. It ensures scientific integrity across the life of the project while maintaining alignment with community expectations and regulatory best practices.

8.3 Landholder Bores

8.3.1 Rationale

Landholder bores are routinely monitored to assess potential groundwater impacts associated with petroleum activities within the tenure area. These assessments form the foundation of compliance with Queensland's underground water management framework:

- Baseline Assessments are undertaken prior to gas production to establish a benchmark dataset for each registered bore, including water quality, standing water level (SWL), and bore construction details. These data are critical for predictive groundwater modelling, impact attribution, and compliance with make-good obligations under Chapter 3 of the *Water Act 2000* (Qld).
- Bore Condition Assessments, conducted during and after operations, re-evaluate the structural integrity, yield, and performance of landholder bores. These assessments ensure that monitoring results remain reliable and that any degradation in bore condition is identified and addressed early.

Together, these assessments:

- Provide the evidence base for potential "make good" agreements under the *Water Act 2000*;
- Support early detection of project-related drawdown or contamination; and
- Inform updates to hydrogeological models and risk assessments.

8.3.2 Relevant Legislation

Under the Petroleum and Gas (Production and Safety) Act 2004 and the Petroleum Act 1923 (collectively referred to as the P&G Acts), tenure holders are granted an "underground water right", which permits unavoidable interference with groundwater during petroleum resource activities, including gas production.

However, this right is conditional and governed by the Water Act 2000 (Qld), which establishes the "Underground Water Management Framework". This framework mandates proactive and ongoing obligations to assess, monitor, and manage the impacts of resource activities on groundwater systems and landholder bores.

The Underground Water Management Framework obliges tenure holders to:

- Submit a BAP (Section 396), detailing bore locations, assessment timeframes, and sampling methodology;
- Conduct baseline assessments of all bores that may be affected by petroleum activities (Section 395), to establish pre-development water quality and level benchmarks;
- Monitor groundwater condition during operations (Section 376) and enter into *make-good agreements* with landholders if a bore is materially impacted by resource activity (Section 407).

These requirements are operationalised through:

- Baseline Assessment Guideline (ESR/2016/1999, Version 3.04); and
- BAP Guideline (ESR/2016/2004).
- Bore Assessments Guideline (ESR/2016/2005)

8.3.3. Alignment with IESC Recommendations

The landholder bore monitoring program is aligned with the IESC Information Guidelines (2024) for coal seam gas developments, which emphasise the early characterisation and ongoing protection of groundwater receptors.

Key areas of alignment include:

- Baseline and Operational Monitoring: The program includes both pre-development (2021) and operational (2023 onward) bore assessments, consistent with IESC expectations for identifying pre-disturbance conditions and detecting long-term impacts.
- Receptor-Specific Approach: The selection of landholder bores as monitoring locations reflects IESC guidance to focus on sensitive receptors (e.g. stock watering bores in Tertiary Basalt aquifers) that are potentially at risk from project-related drawdown or water quality changes.
- Comprehensive Analytical Suite: The analytical plan incorporates all key parameter groups identified in the IESC guidelines, including field parameters, major ions, nutrients, dissolved metals, hydrocarbons, and gases, supporting risk detection and source attribution.
- Use of Guideline Values: Monitoring results are compared against site-specific or default guideline values as outlined in the ANZG (2018) and the Baseline Assessment Guideline (ESR/2016/1999), ensuring alignment with IESC-recommended evaluation methods.
- Risk-Based Monitoring and Compliance: The monitoring supports the Water Act 2000 (Qld) obligations under the Underground Water Management Framework, including make-good provisions. This risk-based and legally compliant framework is consistent with IESC expectations for adaptive management.

This dual-layered approach—integrating both *baseline assessments* and ongoing *bore assessments*—ensures that groundwater impacts are identified early, managed appropriately, and remain scientifically defensible and regulatory compliant throughout the life of the project.

8.3.4 Monitoring Locations

All landholder bores included in the monitoring network were identified in the Baseline Assessment Plan (BAP) prepared by Comet Ridge 2021.

These bores are used for stock watering purposes and are screened within the Tertiary Basalt aquifer. The bore locations are shown on Figure 9 with construction details provided in Table 15.

Table 15 – Landholder Bore Monitoring Network

Property	Bore Name	Registered No.	Bore Depth (m)	Screened Interval (m bgl)	Aquifer(s) Intersected
Togara Station	Bottom Drought Bore	RN132658	90	60–90	Tertiary Basalt, potentially Rewan interface
Togara Station	Bottom Bore	-	60	35–60	Tertiary Basalt
Togara Station	Thomas Bore	-	72	45–72	Tertiary Basalt, near Rewan interface
Togara Station	Scotts Bore	-	60	30–60	Tertiary Basalt
Meroo Downs	Diesel Bore	RN103517	84	48–84	Tertiary Basalt, possibly touching Rewan
Meroo Downs	Spare Bore	RN165210	72	40–72	Tertiary Basalt, approaching Rewan
Meroo Downs	Ingwe Bore	-	68	35–68	Tertiary Basalt
Meroo Downs	Gully Bore	RN62040	60	30–60	Tertiary Basalt
Meroo Downs	Ridge Bore	RN62041	58	28–58	Tertiary Basalt

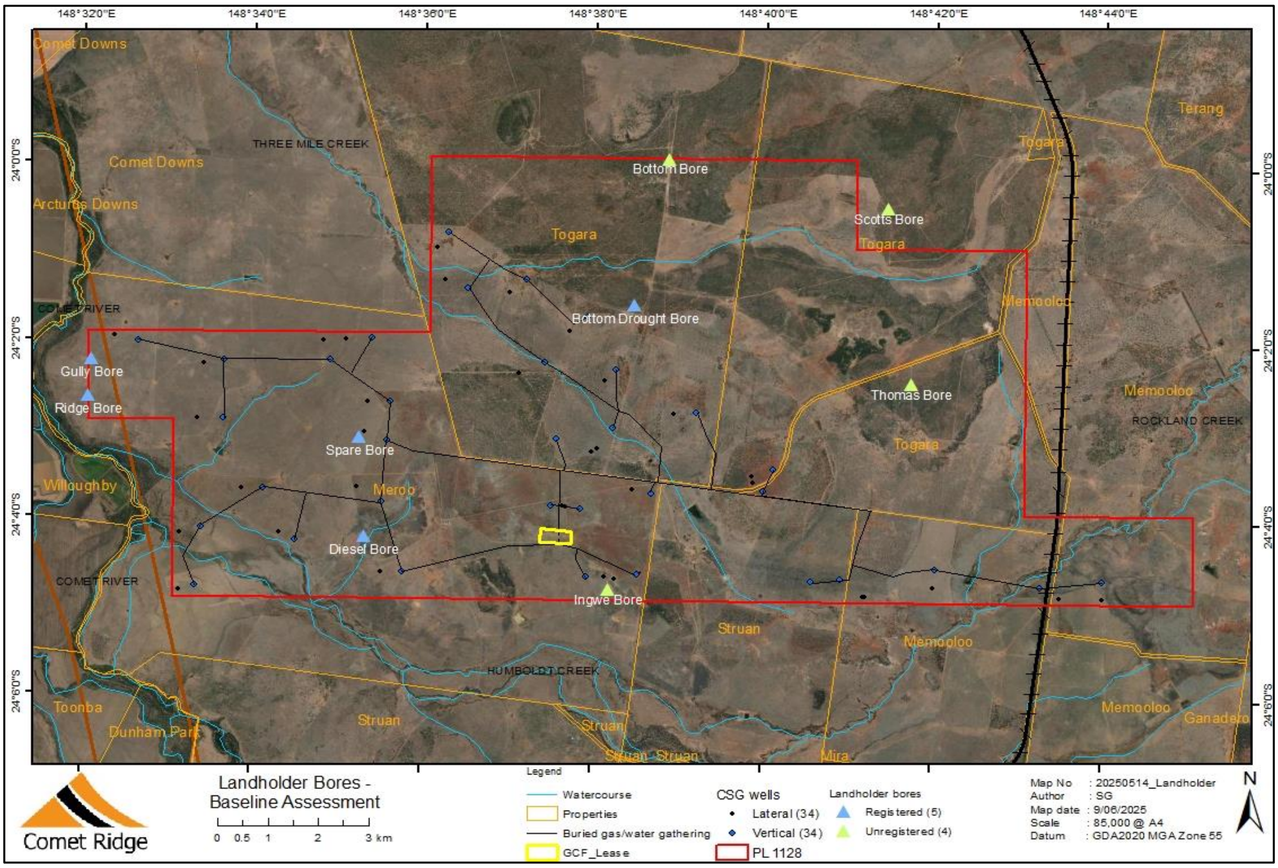

Figure 9 – Landholder Bores on Togara Station and Meroo Downs

8.3.4 Baseline Monitoring

Baseline assessments were conducted at landholder bores on Togara Station and Meroo Downs, in 2021. An additional bore assessment of all landholder bores was conducted in 2023, following the operation of Mahalo North Pilot 1 in 2022.

8.3.5 Operations Monitoring

In addition to pre-development baseline assessments, subsequent bore assessments will be undertaken annually during the operational life of the project. These assessments are aimed to:

- Re-evaluate the condition and functionality of landholder bores over time;
- Identify potential deterioration in bore performance, water quality, or standing water level;
- Help verify whether observed impacts can be reasonably attributed to resource activities; and
- Support compliance with make-good obligations under the Water Act 2000.

Bore assessments typically include structural inspections, repeat groundwater sampling and water level measurements, if the bore headworks access allows.

8.3.6 Landholder's Analytical Plan

The analytical plan used in the baseline assessment included the minimum water quality analytes for baseline assessments (refer to Section 3.6.4 The Baseline Assessment Guideline ESR/2016/1999, Version 3.04, 2022) and the elements detected in CSG produced water for Bandanna Formation.

Table 16 – Landholder's Bore Analytical Plan

Parameter Group	Analytes	Reference
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL)	Baseline Assessment Guideline
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-)	Baseline Assessment Guideline
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)	Baseline Assessment Guideline
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)	Baseline Assessment Guideline
Total and Dissolved Metals	Lithium (Li), Strontium (Sr)	Key Trace Elements in CSG Water
Hydrocarbons	BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAHs)	Baseline Assessment Guideline
Dissolved Gases	Methane (CH_4), Carbon Dioxide (CO_2),	Baseline Assessment Guideline

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8.4 Groundwater Dependent Ecosystems

8.4.1 Rationale

GDEs are ecological communities that require access to groundwater to sustain key ecological functions, particularly during dry periods. Their accurate identification and assessment are essential for ensuring protection under both Queensland and Commonwealth environmental frameworks, including the Environmental Protection Act 1994 (Qld) and the Environment Protection and Biodiversity Conservation Act 1999 (Cth).

A preliminary desktop assessment was undertaken using the Queensland GDE Atlas and the EPBC Act Protected Matters Search Tool (PMST, 2024). This review did not identify any mapped GDEs within the Project area. However, due to recognised limitations in the spatial resolution and completeness of regional GDE mapping in regional Queensland, the desktop findings were not considered sufficient to rule out the presence of unmapped or diffuse GDE systems.

To address this data gap, a GDE field verification program was undertaken in August 2024 in the locations presented in Figure 10 (Refer to Groundwater Dependent Ecosystem Assessment, Mahalo North CSG Development, December 2024, prepared by Watermark Eco).

The field verification program comprised:

- Targeted field inspections of riparian zones and alluvial settings with elevated GDE potential;
- Vegetation surveys to identify phreatophytic species indicative of groundwater access;
- Soil investigations to detect saturation indicators or rooting depth profiles suggestive of groundwater use;
- Surface expression surveys for springs, baseflow segments, and damp depressions; and
- Shallow groundwater monitoring through installation of piezometers and observation bores to record depth to water, groundwater chemistry, and seasonal variability.

No formally listed or high-value GDEs were confirmed within the Project boundary.

Following consultation with DCCEEW under the EPBC Act process, five (5) shallow monitoring bores were installed in August 2024 across Meroo Downs and Togara Station (refer to Table 17). These bores were strategically positioned based on remote sensing and a multi-criteria analysis (RDM Hydro, 2024) to target areas with elevated potential for GDEs. The objective was to monitor depth to water and support ongoing GDE risk screening. This initiative aimed to respond to regulator feedback highlighting the need for enhanced hydrogeological data coverage in environmentally sensitive areas.

In line with subsequent advice from the IESC, a follow-up GDE field assessment has been scheduled for August 2025—timed to coincide with the end of the dry season and to align seasonally with the 2024 baseline survey. The follow-up aims to incorporate seasonal variation and strengthen the evidence base for the absence or presence of GDEs within the project area.

8.4.2 Relevant Legislation

The assessment and protection of GDEs aligns with obligations under the Environmental Protection Act 1994 (Qld), the Environmental Protection (Water and Wetland Biodiversity) Policy 2019, and national frameworks such as the EPBC Act 1999 (Cth).

8.4.3 Alignment with IESC Requirements

The GDE assessment program aligns with the IESC Information Guidelines (2024), which recommend early identification of water-dependent ecosystems and site-specific investigations to confirm risk potential.

Key areas of alignment include:

- Multi-Stage Assessment: The program integrates a desktop review, field-based validation (2024), and a planned seasonal reassessment (2025), as recommended by IESC for robust characterisation of GDE presence and function.
- Site-Specific Monitoring: Installation of five shallow bores in potential GDE zones supports IESC guidance to ground-truth modelled risks and improve understanding of local hydrogeological conditions.
- Hydroecological Indicators: The monitoring incorporates vegetation, soil, and groundwater data to distinguish between opportunistic and obligate groundwater use, in line with IESC expectations for defensible GDE classification.
- Adaptive Monitoring Approach: The follow-up assessment in August 2025 reflects IESC advice to capture seasonal variability and provides a pathway for scaling monitoring intensity based on verified risk.

8.4.4 GDE Monitoring Network

The bore locations are shown on Figure 10 with coordinates and construction details provided in Table 17.

Table 17 – GDE Groundwater Monitoring Network

Property	Bore ID	Easting	Northing	Depth (m)	Screened Interval (m bgl)
Meroo Downs	MN-MB1-A	658464.7	7337611.6	17.0	10.1 – 16.1
Togara Station	MN-MB3-A	674586.1	7340392.6	25.1	18.3 – 24.3
Togara Station	MN-MB4-B	664644.0	7340479.9	20.0	16.0 – 19.0
Togara Station	MN-MB5-R	664636.8	7340479.7	34.1	27.1 – 33.1
Togara Station	MN-MB6-B	664873.2	7342602.8	30.0	23.0 – 29.0

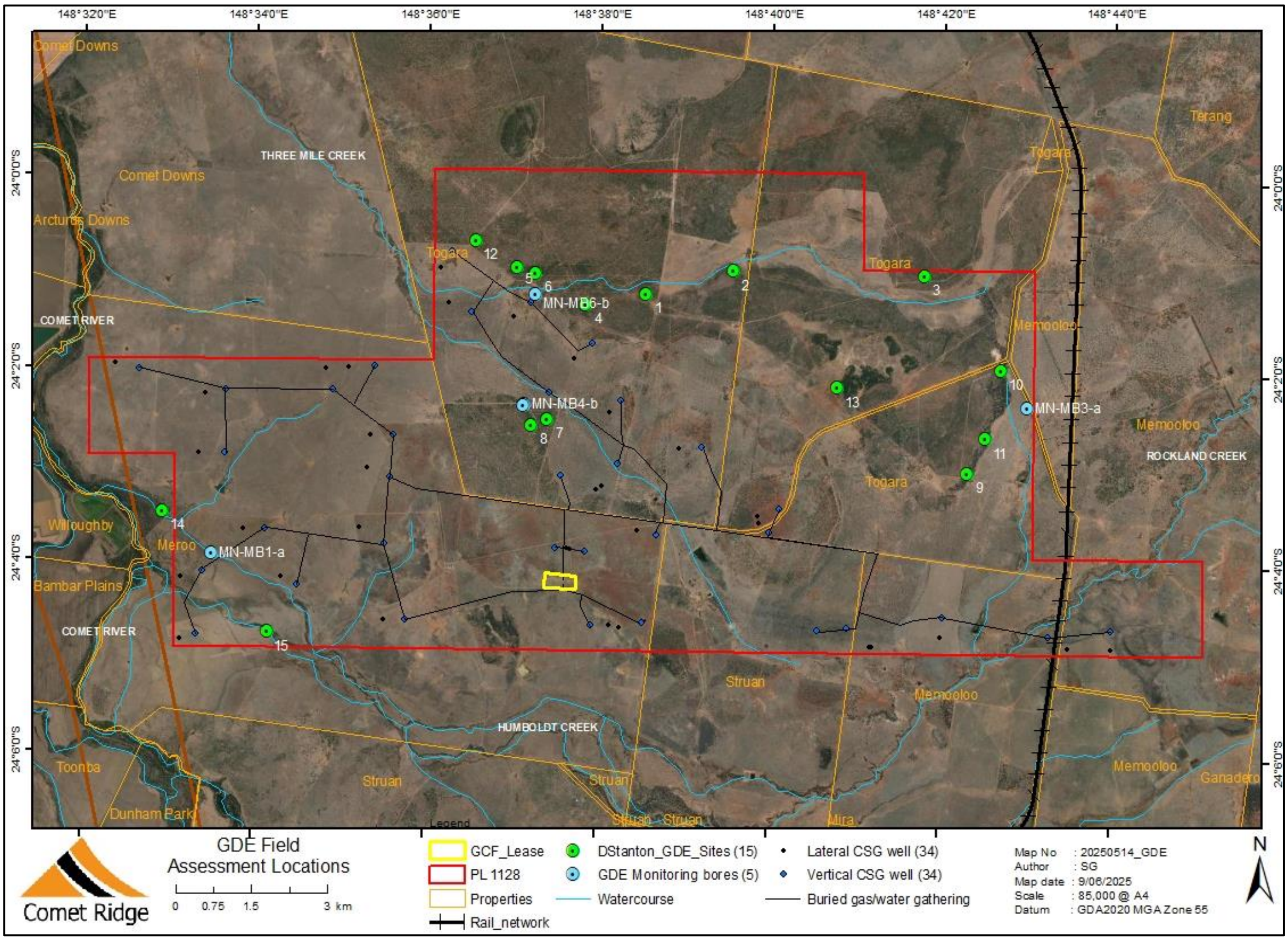

Figure 10 – GDEs Monitoring Locations

8.4.5 Baseline Assessments

Groundwater samples were collected monthly (approximately every four weeks) since August 2024. Data collected from field validation and bore monitoring confirmed:

- No sustained surface expression of groundwater at the identified sites;
- Vegetation and soil characteristics consistent with opportunistic use of shallow water during wet periods rather than obligate groundwater dependency;
- Depth to water tables inconsistent with the persistence of obligate GDEs; and
- Water quality parameters (e.g., salinity, nutrient levels) outside the optimal range for GDEs health.

8.4.6 Operations Monitoring

Following advice from the IESC, an additional field assessment targeting GDEs is scheduled for August 2025. This assessment will evaluate seasonal variability in vegetation condition, surface expression, and shallow groundwater interactions within previously assessed priority areas.

The August 2025 program will complement the initial assessment and support the finalisation of the Project's groundwater and ecosystem impact risk evaluation under the EPBC Act framework.

Following completion of the August 2025 assessment, it is proposed that monthly groundwater monitoring of the five shallow GDEs observation bores will cease after September 2025, subject to confirmation that no GDEs-related risks remain and pending agreement from relevant regulatory authorities. The data collected to date will be used to confirm groundwater stability and inform any future contingency planning, should risk profiles change during operations.

8.4.7 Analytical Plan

The analytical plan for GDEs monitoring covered a comprehensive suite of physical and chemical parameters to assess groundwater quality and chemistry. The parameters are grouped and summarised below.

Table 18 – GDEs Baseline Analytical Plan

Parameter Group	Analytes
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL)
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-)
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)
Total and Dissolved Metals	Lithium (Li), Strontium (Sr)
Hydrocarbons	BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAHs)
Dissolved Gases	Methane (CH_4)

8.5 Aquifer Interconnectivity Assessment

8.5.1 Rationale

The hydrogeological assessment for the Project suggests limited vertical hydraulic connectivity between the Bandanna Formation (the target coal seam gas reservoir) and the overlying aquifers, including the Tertiary Basalt and Quaternary Alluvium. The intervening Rewan Formation is interpreted as a regionally extensive aquitard with low permeability, functioning as a primary confining unit that restricts vertical groundwater flow between deeper and shallower systems.

The current evidence and sensitivity modelling presented in the site-specific MODFLOW-USG model supports the assumption of low to negligible vertical flux between the coal seams and shallow aquifers. However, data collected during baseline monitoring and early production phases will be critical to verifying this assumption and managing regulatory risk.

8.5.2 Monitoring Bore Design and Strategy

To directly assess potential vertical leakage associated with CSG production-induced pressure gradients, a series of four (4) nested bore clusters (M1 to M4) will be installed at strategically selected locations. Each cluster will monitor hydraulic conditions across the following hydrostratigraphic units:

- Bandanna Formation – target coal seam for CSG production
- Rewan Formation – confining aquitard

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- Tertiary Basalt/Sediments – potentially semi-confined, fractured aquifer
- Quaternary Alluvium – shallow unconfined aquifer associated with stream valleys

Each bore within a cluster will be screened in a specific unit to enable depth-discrete monitoring of pressure and water quality, reducing the risk of cross-contamination and enabling clear interpretation of vertical gradients.

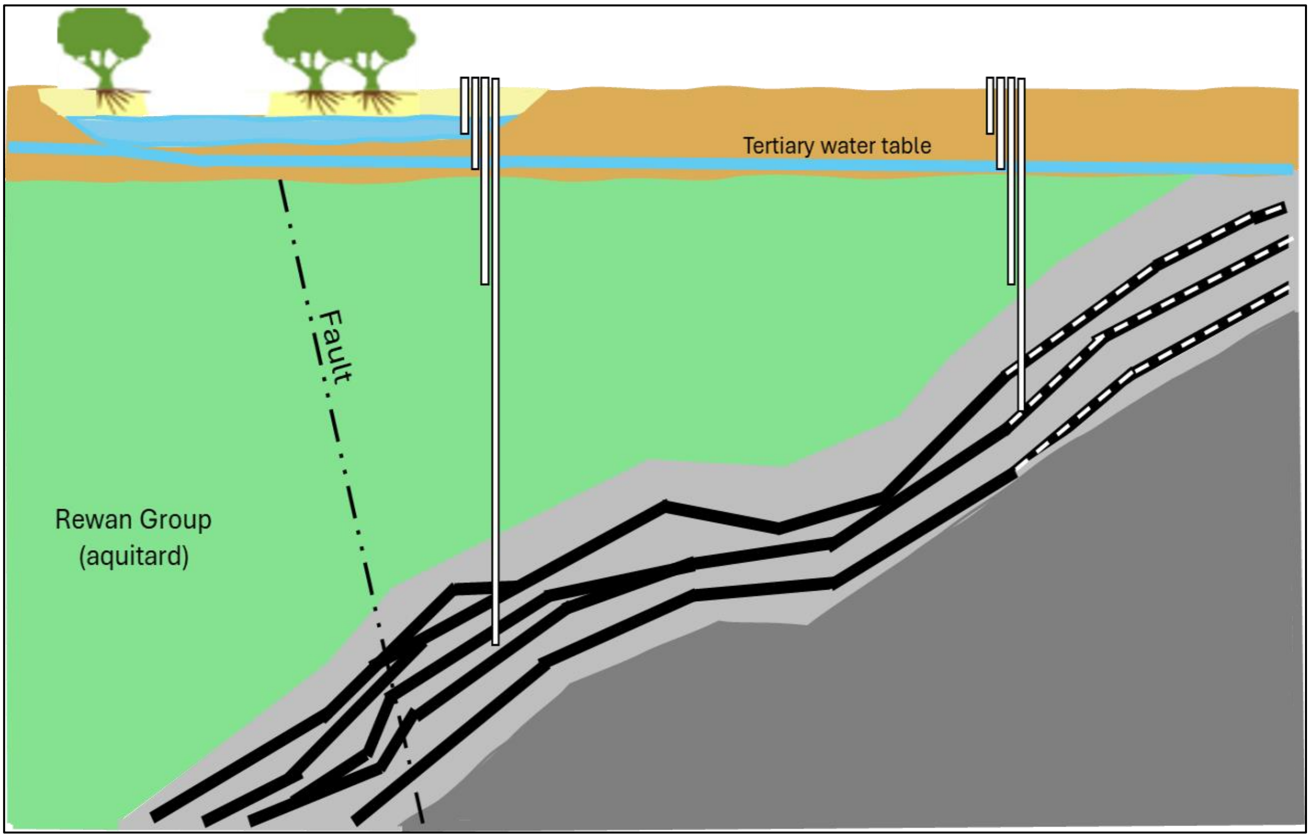

Figure 11 – Nested Bores Design and Strategy

8.5.3 Well Construction and Risk Mitigation

To mitigate cross-aquifer flow and potential gas migration risks:

- Grouted completions will be implemented for the Rewan and Bandanna bores using VWPs;
- Bore designs will comply with "Minimum Construction Requirements for Water Bores in Australia (2020)".
- All installations will follow strict drilling and well integrity protocols to prevent unintended connectivity.

8.5.4 Bore Siting and Geophysical Support

Monitoring bore locations will be refined and confirmed using Electrical Resistivity Tomography (ERT) to improve the confidence in intersecting the intended hydrostratigraphic units. This geophysical data will guide precise siting of the bore clusters to ensure that each unit—Alluvium, Tertiary Basalt/sediments, Rewan Formation, and Bandanna Formation—is appropriately monitored for hydrogeological and geochemical assessments. By integrating ERT prior to drilling, the program aims to reduce uncertainty in bore stratigraphy and ensure alignment with the project's aquifer interconnectivity and impact assessment objectives.

8.5.5 Lines of Evidence for Interconnectivity Assessment

A multiple-lines-of-evidence approach will be employed, including:

- Hydraulic Head Monitoring
    1. Bores will be equipped with Pressure Transducer Data Loggers (PTDLs) or Vibrating Wire Piezometers (VWPs) to record continuous groundwater pressure data.
    2. Focus will be placed on identifying pressure differentials between units and assessing temporal drawdown responses during CSG production.
- Isotopic Tracing
    1. Environmental isotopes will be used to identify recharge sources, residence times, and potential inter-aquifer mixing.
- Hydrogeochemistry
    1. Groundwater samples will be analysed for major ions, trace metals, and geochemical indicators.
    2. The goal is to establish baseline water chemistry for each hydrostratigraphic unit and identify any shifts that might indicate vertical mixing or leakage.

8.5.6 Relevant Legislation

This monitoring program is developed under the Water Act 2000 (Qld) and aligns with:

- IESC Information Guidelines (2024);
- Water Monitoring and Management Plans (WMMP) requirements.
- Environmental Protection (Water and Wetland Biodiversity) Policy 2019;
- EPBC Act 1999 (Cth) significant impact considerations.

8.5.7 Alignment with IESC Recommendations

The IESC has specifically recommended that multi-level nested monitoring bores be used to evaluate the vertical hydraulic gradient across the Bandanna, Rewan, and shallow formations to detect potential leakage.

8.5.8 Proposed Monitoring Locations

The four bore clusters (M1 to M4) are sited to intercept varying geological conditions across the Project area.

Table 19 – Bore Clusters Locations

Monitoring Cluster	Strategic Location Context	Targeted Formations	Geological Considerations	Purpose/ Monitoring Objective
M01	Western edge near Comet River and Arcturus Fault; Near landholder bores for data integration	Rewan Bandanna	Downgradient of fault zone	Baseline monitoring, Rewan connectivity and fault-related connectivity.
M02	Southern margin near Humboldt Creek; recharge zone. Near the Mahalo North Pilot is positioned to capture any potential early-stage pressure	Alluvium, Tertiary deposits, Rewan Bandanna	Transition zone; fault-crossing with potential vertical leakage.	Surface water/groundwater interaction, early-stage pressure responses from production.

Monitoring Cluster	Strategic Location Context	Targeted Formations	Geological Considerations	Purpose/ Monitoring Objective
	responses from production.			
M03	Central-north, higher elevation area with thin, weathered Rewan near the formation subcrop; positioned near proposed CSG wells and surface drainage.	Alluvium, Basalt Rewan, Bandanna	Presence of saturated alluvium subcrop and weathering of Rewan; production drawdown influence	Interconnectivity between aquifers through the thinner, weathered Rewan formation; sensitive receptor check; verify predicted drawdown propagation.
M04	Eastern zone near Rockland Creek; targets preserved stratigraphy and wider basalt extent; away from identified faults.	Alluvium, Tertiary sediments or basalt (if present), Rewan, Bandanna	subcrop and weathering of Rewan; end of hydraulic gradient; intersects floodplain.	Surface water/groundwater interactions, long-term impact tracking near ecologically sensitive areas.

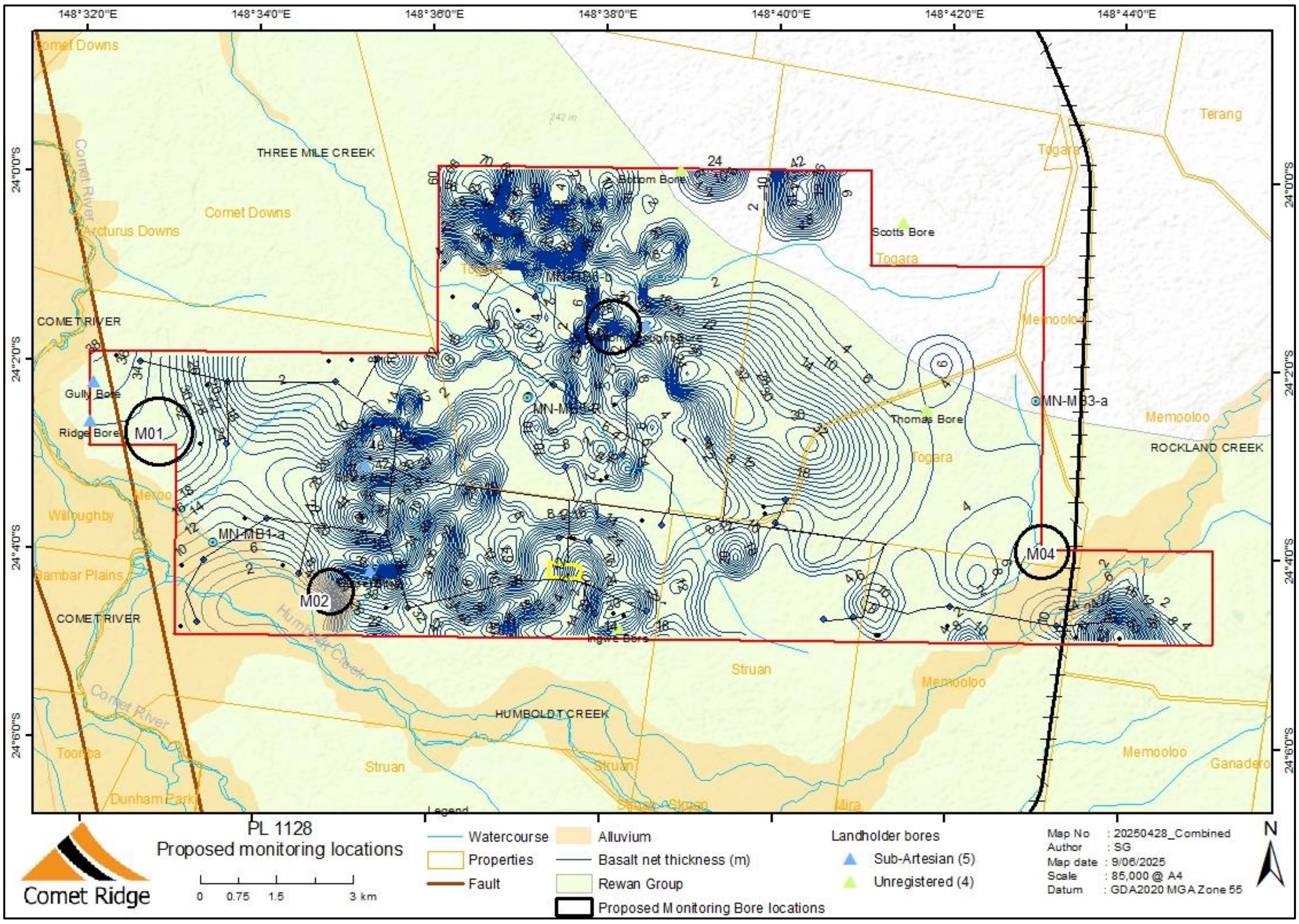

Figure 12 – Aquifer Interconnectivity Monitoring Locations

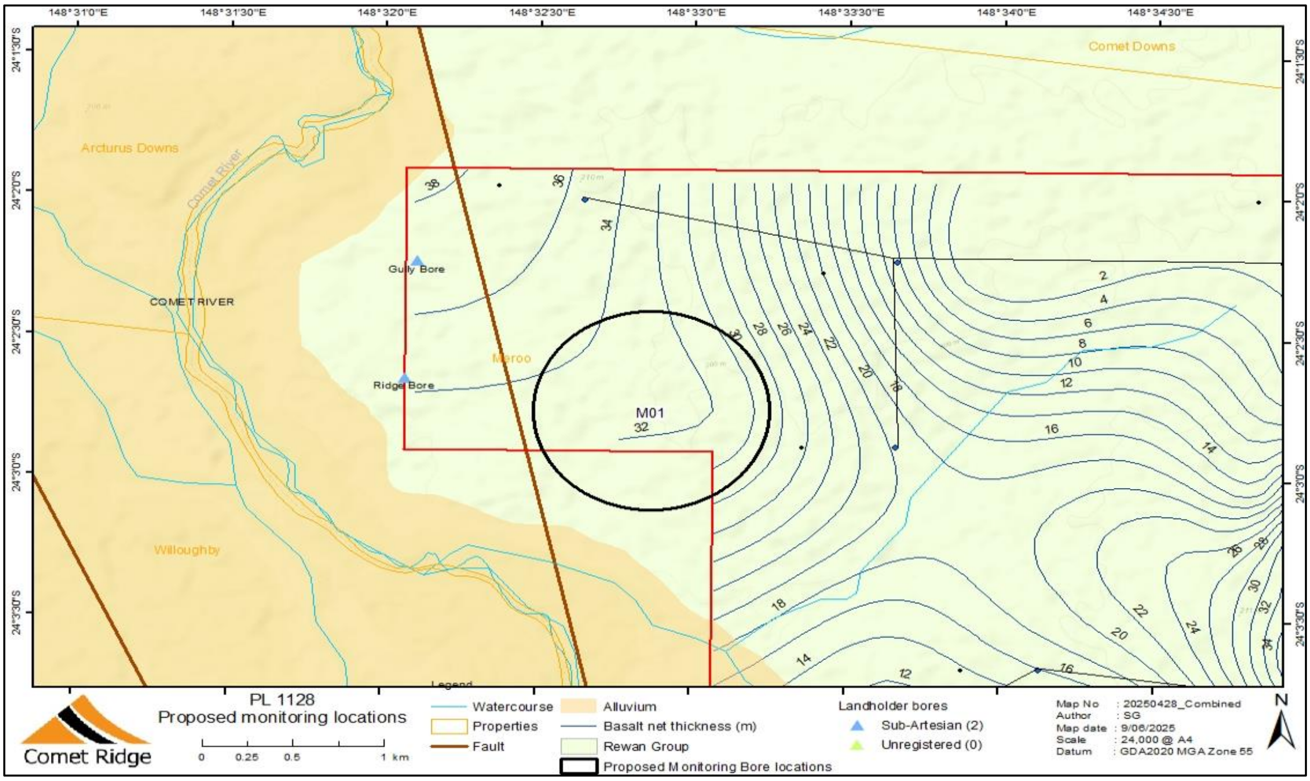

Figure 13 – Aquifer Interconnectivity Cluster M1

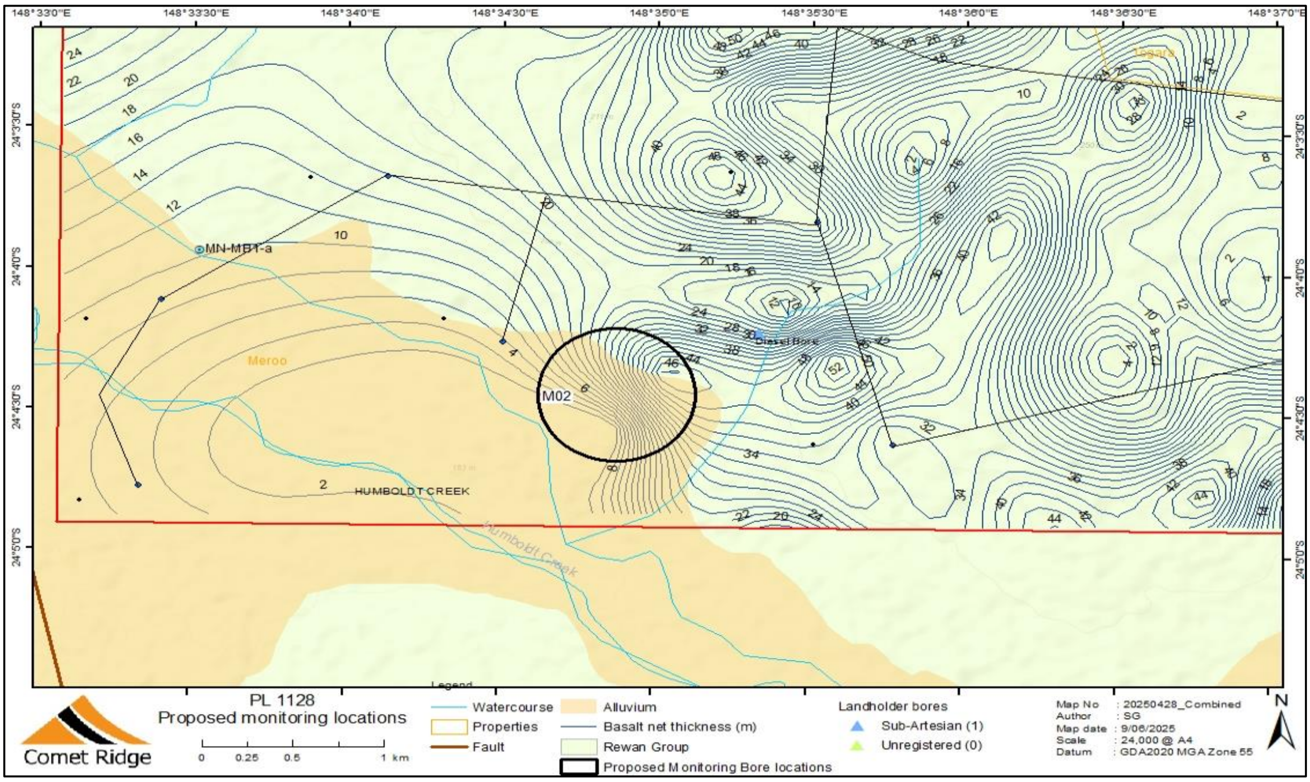

Figure 14 – Aquifer Interconnectivity Cluster M2

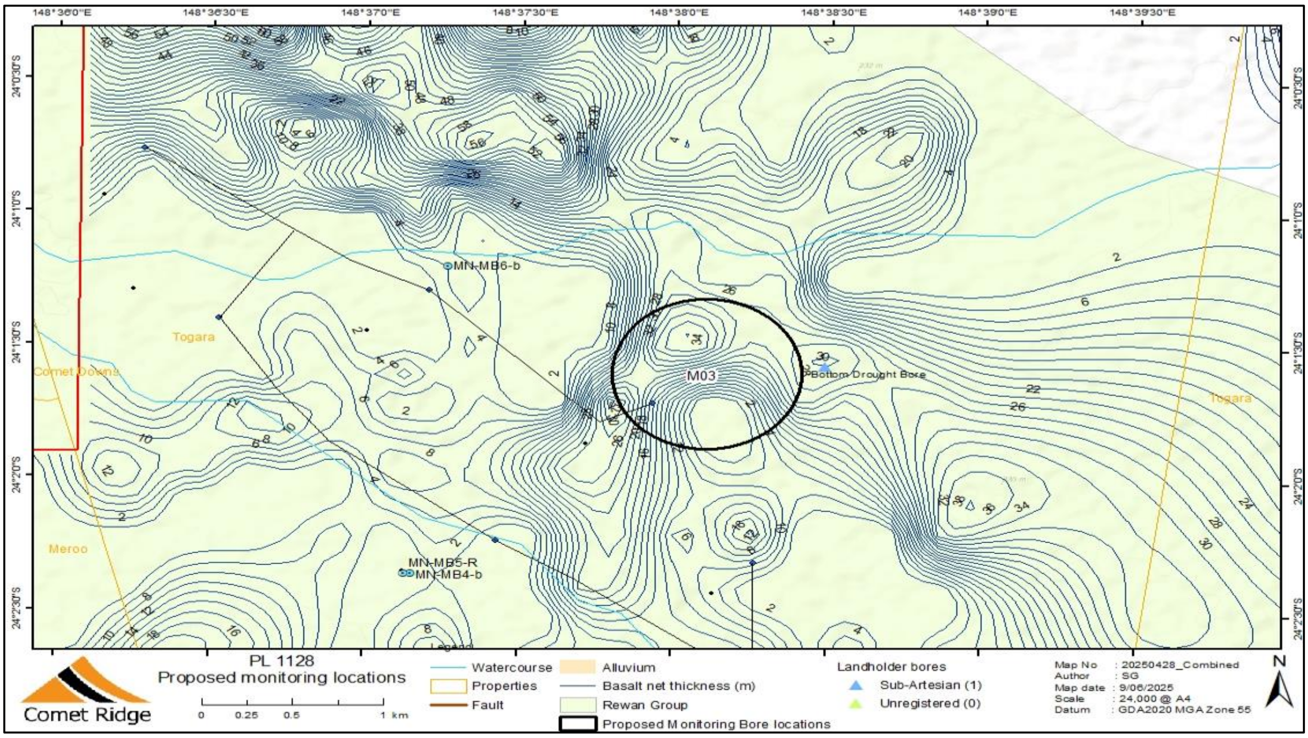

Figure 15 – Aquifer Interconnectivity Cluster M3

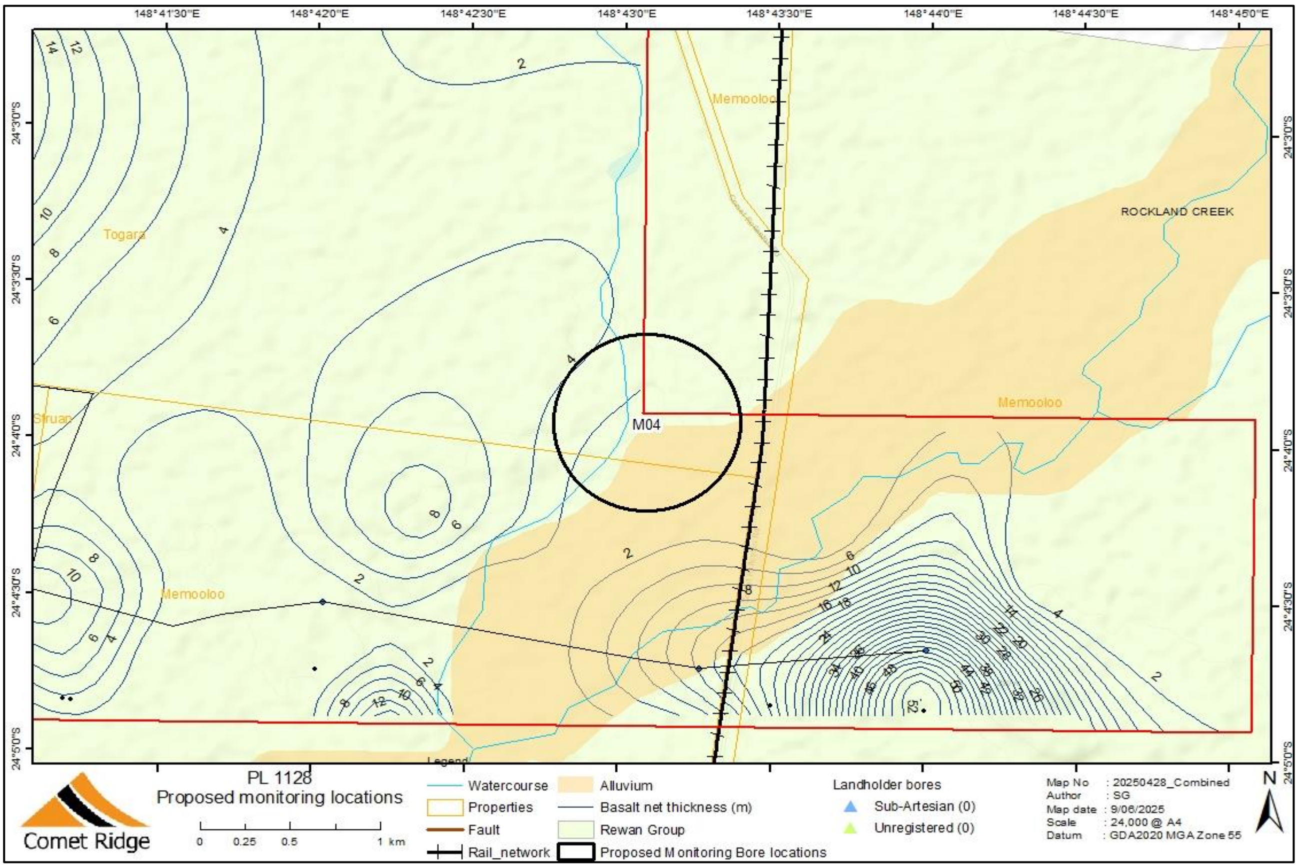

Figure 16 – Aquifer Interconnectivity Cluster M4

8.5.9 Operational Integration and Sampling

Water quality samples to characterise the Rewan and Bandanna will be collected during bore installation. Samples from the Bandanna will be collected periodically during the operational phase from nearby gas production wells, where feasible.

8.5.10 Analytical Plan

To evaluate connectivity between coal seams and overlying aquifers the 4 multi-level nested monitoring bore clusters (Bandanna, Rewan, Tertiary, Alluvium) will be analysed for the parameters outlined in Table 20 below.

Table 20 – Aquifer Interconnectivity Analytical Plan

Parameter Group	Analytes
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL)
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO_4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-)
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)
Total and Dissolved Metals	Lithium (Li), Strontium (Sr)
Organics	BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAHs) Phenolic compounds
Dissolved Gases	Methane (CH_4), Carbon Dioxide (CO_2),
Isotopes	Stable isotopes and isotopic tracers (as needed for source identification)

8.5.11 Assessment Criteria

Monitoring data will be evaluated against baseline conditions, model predictions, and expected pressure responses. Triggers for review include:

- Increased head gradient from Bandanna to overlying units;
- Unexpected isotopic signatures suggesting vertical migration; and
- Anomalous changes in water chemistry inconsistent with natural variability.

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8.6 Surface Water/Groundwater (SW/GW) Interaction Evaluation

8.6.1 Rationale

The Project area includes several ephemeral surface water systems—namely the Comet River, Humboldt Creek, and Rockland Creek—which only flow in response to substantial or prolonged rainfall.

These watercourses are not perennial and, due to their intermittent nature, are more likely to recharge underlying aquifers than to receive sustained baseflow contributions. However, in areas where hydraulically connected shallow alluvial aquifers are present, localised discharge to these streams may occur.

Understanding the direction and magnitude of flow between surface water and shallow groundwater systems is essential for identifying potential impacts from CSG operations, particularly where depressurisation of the Bandanna Formation may propagate through hydraulically connected shallow groundwater systems. The aquifer interconnectivity study will determine the likelihood of this connectivity.
The objective of this monitoring program is to develop an evidence-based understanding of:

- The direction and magnitude of hydraulic gradients between surface water and shallow groundwater;
- The extent to which surface flows recharge groundwater systems (losing streams), (gaining streams) or have bidirectional flow dynamics under varying seasonal and hydraulic conditions; and
- The influence of seasonal variability and project-related drawdown on SW/GW dynamics.

Data collection and analysis focuses on measurement of hydraulic head gradients between the monitored watercourses and alluvial groundwater (where and if present) and to a lesser degree the hydrogeochemistry of the alluvial system(s). Differences in hydraulic head and hydrogeochemistry will inform if groundwater is discharging into the watercourse, or vice versa. Recharge estimates will also inform the SW/GW dynamics.

To meet these objectives, the program incorporates:

- Installation of multi-level nested monitoring bores to be used to evaluate the vertical hydraulic gradient across the Bandanna, Rewan, and shallow formations to detect potential leakage;
- Correlation of monitoring data from shallow groundwater monitoring bores near existing surface water monitoring sites to identify and characterise the hydraulic relationship
- Measurement of groundwater levels and comparison to surface water elevation at each site to assess potential flow direction;
- Routine major ion analyses and one-off stable isotope sampling to characterise hydrochemical differences between surface and groundwater;
- Estimation of recharge volumes based on water balance and hydraulic data.

The ephemeral Humboldt Creek and Rockland Creek do not have flow gauging stations. Because of this, monitoring will comprise shallow current surface water monitoring locations and groundwater monitoring in the bore nests. The hydraulic head of groundwater will be compared to the elevation of water in the creek to ascertain if groundwater is discharging to the creek or vice versa.
Groundwater monitoring data will also be compared to the Comet River stage height, but this comparison will be semiquantitative, given the distance of the upstream gauging station (>20 km) and the lack of alluvial deposits present in the PL boundaries.

Geochemical analyses will comprise major ions on a routine basis with stable isotopes analysed during the first monitoring event only. Stable isotopes will not be sampled routinely because groundwater flow paths are likely to be very short due to the limited extent of alluvial sediments and the depth of the Tertiary water table. However, if monitoring data suggest that groundwater from multiple sources is mixed with the stream water, then additional analyses would be implemented as part of the investigation and assessment process.

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8.6.2 Lines of Evidence

Hydraulic Head Monitoring:

- Continuous logging of shallow and intermediate aquifer pressure using VWPs and PTDLs.
- Correlation with creek stage height and rainfall events to detect lagged recharge/discharge responses.

Water Chemistry and Isotope Analysis:

- Major ions, stable isotopes, and trace elements will be assessed to delineate mixing zones, recharge sources, and identify any anomalous chemistry indicative of connectivity to deeper formation water.

8.6.3 Relevant Legislation

This evaluation is designed to address obligations under the following regulatory frameworks:

- Environmental Protection Act 1994 (QLD) and the Environmental Protection (Water) Policy 2019, including compliance with WQOs for the Comet River sub-basin (DEHP, 2011);
- Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999), including identification of Matters of National Environmental Significance (MNES) such as GDEs and listed threatened ecological communities;
- Queensland Environmental Authority (EA) Conditions, including requirements for baseline and operational water monitoring, assessment of hydraulic connectivity, and TARP.

8.6.4 Alignment with IESC (2024) Recommendations

This surface water–groundwater (SW–GW) monitoring program has been developed in accordance with the IESC Information Guidelines (2024). It is designed to inform the project's conceptual hydrogeological model and provide the evidence base necessary to assess and manage potential impacts on sensitive receptors.

Specifically, the program aligns with the IESC's recommended principles by:

- Applying a multiple-lines-of-evidence approach to evaluate hydraulic connectivity between surface water features and shallow aquifers;
- Characterising seasonal variability in recharge–discharge dynamics and surface water features – aquifer interactions;
- Assessing changes in flow regimes associated with potential depressurisation of the Bandanna Formation;
- Quantifying baseflow contributions and recharge pathways, particularly for ephemeral systems such as Humboldt and Rockland Creeks;
- Utilising isotopic tracers and geochemical signatures (e.g., major ions, stable isotopes) to distinguish between formation water, alluvial groundwater, and surface water sources;
- Incorporating field-derived monitoring data into the site's conceptual hydrogeological models to evaluate potential impact scenarios under both baseline and operational conditions.

8.6.5 Monitoring Locations

SW/GW interaction will be monitored in the following bore nests:

- M01 – nested bores with VWPs in the Rewan Formation and Bandanna Formation.
- M02 – nested bores targeting Alluvium and Tertiary sediments/basalt with VWPs in the Rewan Formation and Bandanna Formation.
- M03 – nested bores targeting Alluvium with VWPs in all formations.

- M04 – nested bores targeting Alluvium (Basalts if present), with VWPs in the Rewan Formation and Bandanna Formation.

8.6.6 Analytical Plan

Table 21 – GW/SW Interaction Analytical Plan

Parameter Group	Analytes
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL)
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO_4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-)
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)
Total and Dissolved Metals	Lithium (Li), Strontium (Sr)
Organics	BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAHs) Phenolic compounds
Isotopes	Stable isotopes and isotopic tracers (as needed for source identification)

8.6.7 Assessment Criteria

Monitoring data will be evaluated against baseline conditions, model predictions, and expected pressure responses.

Triggers for review include:

- Declining water table head in shallow aquifers;
- Decreased vertical head gradient between Bandanna Formation and overlying units;
- Unexpected isotopic signatures suggesting vertical migration; and
- Anomalous changes in water chemistry inconsistent with natural variability.

8.7 Surface Water Monitoring

8.7.1 Rationale

Surface water monitoring is a critical component ensuring early identification of water quality risks from resource activities.

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The Project tenement encompasses several surface water features that differ in hydrology, ecological value, and sensitivity to potential impacts from coal seam gas (CSG) activities, key surface water receptors, includes:

- Comet River,
- Humboldt Creek, and
- Rockland Creek.

These watercourses act as receptors for potential surface runoff, sediment transport, and contaminant mobilisation, particularly during the construction and production phases. Monitoring is necessary to track any degradation in water quality related to stormwater flows, chemical storage, or CSG water handling.

These systems support aquatic ecosystems and are particularly vulnerable to increases in sediment, nutrient, and hydrocarbon loads during high-flow events.

Table 22 – Summary of Key Surface Water Monitoring Receptors

Receptor	Hydrological Type	Key Characteristics
Comet River	Permanent stream	Regionally significant watercourse along the western boundary of PL1128; primary downstream receptor for surface discharges; covered by Comet River WQOs; long-term baseline monitoring confirms flow reliability.
Humboldt Creek	Ephemeral stream	Located in the northwest of the project area. Important for assessing event-based mobilization of contaminants.
Rockland Creek	Ephemeral Stream	Located in the southeastern portion of PL1128. May interact with basalt and alluvial systems.

8.7.2 Relevant Legislation

The monitoring program supports compliance with Environmental Authority (EA) conditions and EPBC Act 1999 requirements including:

- Environmental Protection Act 1994 (Qld);
- Water Act 2000 (Qld);
- Environmental Protection (Water and Wetland Biodiversity) Policy 2019;
- Comet River Sub-Basin WQOs (DEHP, 2011);and
- ANZG (2018) Water Quality Guidelines for Ecosystem Protection.

8.7.3 Alignment with IESC Recommendations

The surface water monitoring program has been developed in alignment with the IESC Information Guidelines (2024) for coal seam gas (CSG) developments, ensuring scientific robustness and regulatory compliance.

Key elements of alignment include:

- Receptor-Based Network: Monitoring locations target key hydrological receptors (Comet River, Humboldt Creek, Rockland Creek) based on ecological value, flow regime, and proximity to infrastructure—consistent with IESC recommendations.
- Use of Baseline Data: Historical data informs site-specific WQOs and supports defensible impact assessments, as required by the IESC.
- Hydrological Variability: Inclusion of both permanent and ephemeral systems addresses IESC guidance on flow regime sensitivity and episodic contaminant transport.

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- Comprehensive Analytical Suite: The monitoring includes field parameters, nutrients, major ions, metals (total and dissolved), CSG indicator elements (e.g., Li, Sr, F^-), and organics (BTEX, PAHs), supporting early detection and source attribution.
- Guideline Consistency: The program is aligned with ANZG (2018), Comet River WQOs (DEHP 2011), the EPBC Act 1999, EP Act, and EA conditions.
- Adaptive Design: Provision for future expansion (e.g., Rockland Creek) enables adaptive management in response to new data or IESC feedback.

8.7.4 Baseline Surface Water Monitoring Locations

Historical surface water quality monitoring has been undertaken since early project scoping phases, encompassing multiple sites across the Comet River and ephemeral streams within or near PL1128. This data establishes the pre-development condition of aquatic environments and supports the derivation of site-specific WQOs.

Table 23 – Baseline Surface Water Monitoring Locations

Site ID	Watercourse	Rationale
R1	Comet River	Established for upstream background quality; outside western PL boundary.
R2	Comet River	Used in early baseline characterisation; outside northern boundary.
R3	Comet River	Historical site now removed due to duplication with downstream accessible points.
R4	Humboldt Creek	Retained for sensitivity to infrastructure runoff; shallow alluvial connection noted.
R5	Unnamed stream	Intermittently monitored; identified via GIS as potential runoff conduit.
R6–R9	Drainage lines and Rockland Creek	Mapped minor ephemeral flows; not retained due to lack of persistent flow, R9 located in a permanent water hole on Rockland Creek
R10	Comet River	Historical downstream compliance site; outside PL1128.
R11	Comet River	Primary downstream receptor outside of tenure; aligned with WQOs.

8.7.5 Operation Surface Water Monitoring Locations

The monitoring network targets key hydrological receptors, including the Comet River (R11) and Humboldt Creek (R4), with future expansion proposed to include Rockland Creek (R9).

Table 24 – Summary of Surface Water Monitoring Locations

Site ID	Watercourse	Hydrological Type	Monitoring Status
R11	Comet River	Permanent	Active – downstream compliance point with good access
R4	Humboldt Creek	Ephemeral	Active – sensitive receptor near infrastructure
R9	Rockland Creek	Ephemeral	Active – located in a permanent water hole on Rockland Creek

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Figure 8 shows the locations of the surface water monitoring locations in relation to the development area, drainage lines, and surrounding infrastructure.

8.7.6 Analytical Plan

Table 25 – Analytical Plan Surface Water Monitoring

Parameter Group	Analytes
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL)
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-)
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)
CSG Indicator Metals	Lithium (Li), Strontium (Sr)
Organics	TPHs/TRHs, BTEX, PAHs, Phenolic compounds

8.8 Stormwater Management Program

8.8.1 Rationale

The Mahalo North GCF will manage produced CSG water extracted from surrounding wells and conveyed to the site via underground pipelines. Produced water will be temporarily stored and treated on-site before reuse or disposal.

The Key Infrastructure present within the GCF footprint includes:

- Above-Ground Storage Tanks (AGSTs) for:
    - Produced Water (raw);
    - RO Permeate (treated water for potential reuse); and
    - Brine Concentrate.
- RO Treatment Plant to separate the brine and permeate from CSG produced water

Given the site's location in the Comet River sub-basin, where ephemeral streams and overland flow pathways intersect with project infrastructure, robust stormwater management is essential to:

- Prevent uncontrolled discharges during rainfall events;
- Protect sensitive receptors such as Humboldt Creek, the Comet River, and surrounding GDEs;
- Mitigate contaminant mobilisation and sediment runoff; and
- Ensure compliance with Environmental Authority (EA) conditions and national environmental guidelines.

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8.8.2 Design Measures

A suite of engineered controls and operational safeguards have been integrated into the facility design to manage stormwater, prevent environmental harm, and ensure regulatory compliance. These measures are informed by hydrological modelling, industry best practices, and relevant guidelines (e.g., QLD State Planning Policy, ANZG 2018, and IESC Information Guidelines 2024).

1. Capture Basin and Hydrological Control
   - A capture basin with an approximate capacity of 325m³ to 495m³ has been designed to manage runoff from rainfall events up to 25mm in 24-hours. Noting that this threshold captures approximately 95% of daily rainfall events based on the historical 125 years dataset. It is also consistent with the proposed water quality monitoring trigger. The basin provides temporary containment of site runoff.
   - The basin includes a low flow piped outlet and emergency spillway, ensuring resilience under high rainfall conditions. The piped outlet from the capture basin would have a valve to enable water to be held within the basin for treatment or redirection (e.g. to produced water tank for treatment using RO plant) in the case of a contaminated discharge event.

2. Clean and Dirty Water Separation
   - Swales and diversion bunds are installed to direct uncontaminated overland flow away from operational areas and direct potentially contaminated water toward the capture basin. This separation reduces the volume of water being directed to the capture basin and therefore lowers the risk of cross-contamination.
   - The operational phase has site grading and bunds and swales to ensure that all runoff from the tanks and RO plant and associated infrastructure would be directed to the capture basin.
   - All drainage infrastructure is graded to promote positive flow, preventing ponding and minimising mosquito breeding or standing water hazards.

3. Tank Design and Secondary Containment
   - All above-ground storage (produced water, permeate and brine) tanks are constructed with corrosion-resistant materials and All tanks are to have two liners (primary and secondary) with interstitial leak detection. Each tank has a minimum 0.3 m freeboard above its maximum operating volume to accommodate rainfall inputs and provide 2–3 days' operational buffer, allowing for reactive management under abnormal operating or weather conditions.
   - The system will enable recirculation between tanks to manage inflow surges and maintain operational levels.
   - Suffice space is provided to install additional tanks if volumes exceed expected rates.
   - In the unlikely event that onsite containment is exceeded, tankering of excess water offsite is available as a contingency.
   - Production processes can be paused during high rainfall events or when tank storage capacity is nearing its limit. This safeguard prevents excess inflow to the water management system and reduces the risk of containment system exceedance. Production restart is only permitted once sufficient storage capacity is restored.

4. Instrumentation, Monitoring and Alarms
   - Tanks are equipped with digital level sensors and telemetry-connected alarms to provide real-time alerts for rising water levels, potential overflows, or equipment failures.
   - The telemetry system is integrated into the site's Supervisory Control and Data Acquisition (SCADA) network, ensuring remote monitoring and rapid response capability by operators. The alarms would be set with multiple levels (i.e.. 1m to overtopping 0.5m to overtopping and maximum operational level being 0.3m till overtopping) to ensure that personnel are aware as the levels within the tanks are reaching capacity.

5. Emergency Spill Management and Isolation
   - The site includes spill containment kits and shutoff valves at key transfer points to isolate infrastructure and contain any accidental releases.

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- A stormwater isolation valve on the capture held within the basin for treatment or redirection (eg. to produced water tank for treatment using RO plant) in the case of a contaminated discharge event, thus preventing discharge of contaminated water offsite.

6. Erosion and Sediment Control
- Exposed soil areas are stabilised using temporary erosion controls (e.g., geotextiles, mulch) and permanent vegetation cover where feasible.
- Sediment fences, check dams, and sediment traps are installed during construction and maintained during operations to reduce turbidity and total suspended solids (TSS) in runoff.
- The capture basin is to be installed as a sediment dam during the construction phase.

7. Operational Readiness and Maintenance
- Standard operating procedures (SOPs) outline inspection, maintenance, and emergency response protocols for all stormwater infrastructure.
- Routine inspections are conducted before and after rainfall events to verify infrastructure integrity, sediment build-up, and bund condition.

8.8.3 Relevant Legislation

Stormwater controls have been designed in accordance with:

- *Environmental Protection Act 1994 (Qld)*
- *Environmental Protection (Water) Policy 2019*
- *EPBC Act 1999* (if discharge risks to aquatic ecosystems are triggered)
- *ANZG (2018) Water Quality Guidelines*
- *Queensland Urban Drainage Manual (QUDM, 2017)*
- *CSG Water Management Policy (DES, 2012; revised 2021)*
- *Comet River Sub-basin WQOs (DEHP, 2011)*
- *IESC Information Guidelines (2024)*

8.8.4 Alignment with IESC (2024) Recommendations

The stormwater management strategy addresses IESC Advice (2025-153), which identified overtopping, spills, and seepage from water storages as key risks to EPBC Act–listed species and surface water quality.

The Project's approach includes:
- Bunded and engineered storages with high freeboard thresholds and level alarms to mitigate overtopping risk.
- Event-based contingency actions triggered by rainfall forecasts, tank levels, or observed overflows .
- Dedicated seepage monitoring bores to detect early signs of leakage or mobilisation of contaminants.
- Siting of key infrastructure outside the 1% AEP floodplain based on flood modelling and topographic analysis.
- Adaptive design and response measures including RO plant shutdown, inter-tank transfer, and offsite disposal where required.
- Compliance with EA and EPBC Act notification and reporting requirements for any exceedance or discharge events.

8.8.5 Proposed Monitoring Infrastructure

- Surface Water Catchment Dam (SWCD):
  - Positioned strategically to intercept runoff from GCF infrastructure.
  - Monitored during both baseline and operational phases to assess overflow water quality.

- Seepage Monitoring Bores (2):
    - Located adjacent to tanks to detect infiltration or leakage into shallow soils and groundwater.

- Basalt Monitoring Bore (1):
    - Positioned east of the facility to detect any downstream groundwater quality impacts in the Tertiary Basalt aquifer.

8.8.6 Analytical Plan

Table 26 – Analytical Plan for Stormwater Monitoring

Parameter Group	Analytes
Field Parameters	pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Oxidation-Reduction Potential (Redox), Temperature, Standing Water Level (SWL), Turbidity, Total Dissolved Solids.
Major Ions	Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Chloride (Cl), Sulfate (SO_4), Bicarbonate (HCO_3), Carbonate (CO_3), Fluoride (F^-).
Nutrients	Total Nitrogen (TN), Nitrate (NO_3), Nitrite (NO_2), Ammonia (NH_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP)
Total and Dissolved Metals	Aluminium (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Copper (Cu), Iron (Fe), Lead (Pb), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Selenium (Se), Silver (Ag), Uranium (U), Vanadium (V), Zinc (Zn)
Total and Dissolved Metals	Lithium (Li), Strontium (Sr)
Organics	TRHs, BTEX (Benzene, Toluene, Ethylbenzene, Xylene), Polycyclic Aromatic Hydrocarbons (PAHs) Phenolic compounds
Isotopes	Stable isotopes and isotopic tracers (as needed for source identification)

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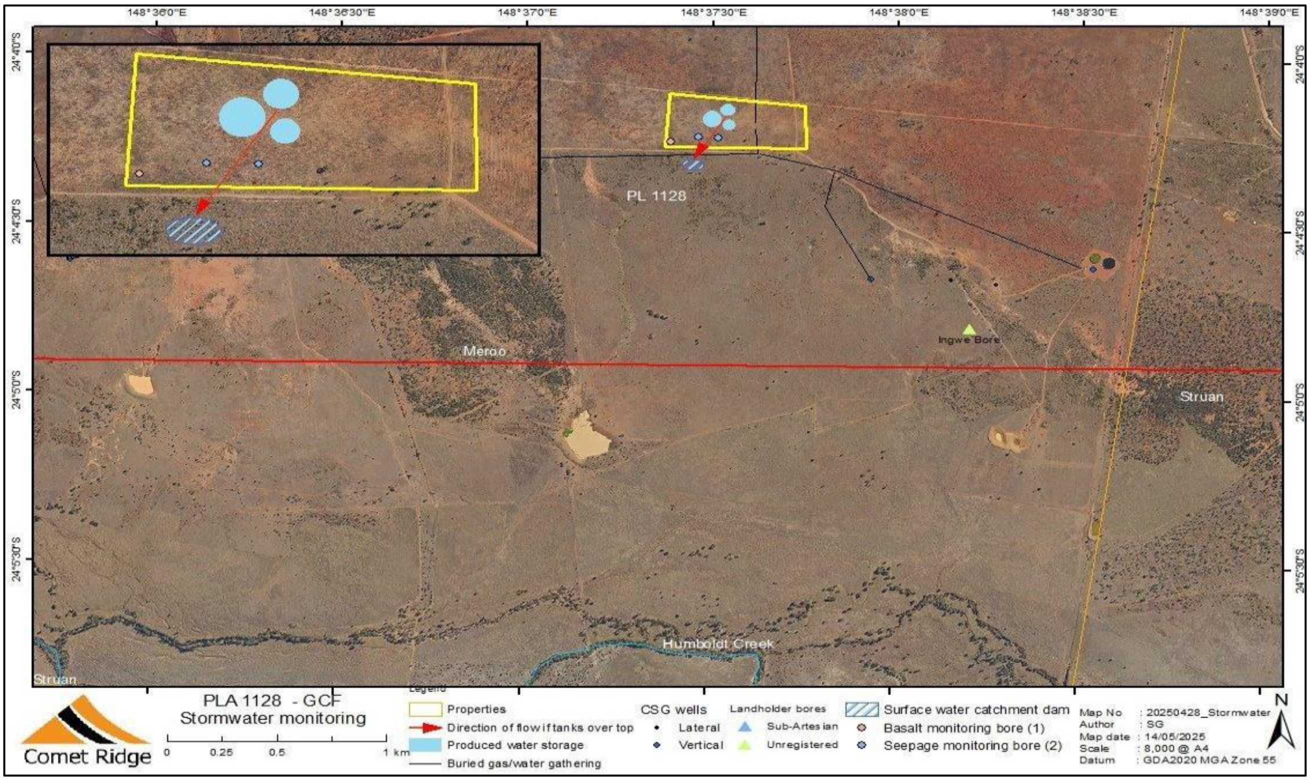

Figure 17 – Stormwater Monitoring Locations

9. Cumulative Impact Assessment

The Project is located within the Bowen Basin, a region subject to intensive and overlapping resource development activities. These include coal mining, coal seam gas (CSG) production, irrigated agriculture, and associated infrastructure development. Individually and collectively, these activities have the potential to affect surface water and groundwater systems through additive, synergistic, or antagonistic interactions—impacts that may not be apparent when assessed in isolation.

9.1 Assessment Framework and Methodology

This assessment follows the principles outlined in Chapter 5 of the IESC Information Guidelines (2024) and adopts a precautionary, risk-based approach to identifying and managing cumulative water-related impacts. Key elements include:

- Comprehensive Scope – All past, present, and reasonably foreseeable developments within and adjacent to the project area have been considered.
- Defined Spatial and Temporal Boundaries – The assessment includes a 20 km radius from the Project area (PL1128), encompassing adjacent and overlapping tenures, and considers impacts from pre-construction through to post-closure.
- Integrated Data Sources – Regional datasets were drawn from the Office of Groundwater Impact Assessment (OGIA), Queensland Globe, land use planning tools, and industry forecasts to support the assessment of broader-scale effects.

- Precautionary Assumptions – Where data gaps exist, conservative assumptions have been applied and all uncertainties are clearly documented.

9.2 Spatial and Temporal Boundaries

The cumulative impact zone encompasses:

- The Project area (PL1128);
- All adjacent or overlapping resource tenures within a 20 km buffer;
- The full vertical hydrostratigraphy from Bandanna Formation to Quaternary Alluvium;
- Surface water systems, particularly Humboldt Creek and the Comet River catchment.

Temporally, the assessment includes exploration, construction, production, decommissioning, and post-closure stages.

9.3 Regional Activities

Key developments across the region that may influence water resources includes:

- Nearby coal mining operations;
- Adjacent and overlapping CSG development;
- Agricultural activities such as cotton and forage cropping near the Comet River;
- Grazing on nearby properties (e.g., Togara, Meroo Downs, Memooloo);
- Land clearing and vegetation loss from infrastructure corridors; and
- Potential impacts from climate change (e.g., increased evapotranspiration, reduced recharge).

9.4 Focus Areas of Cumulative Impact

The key themes assessed in the context of potential cumulative impacts include:

- Drawdown in shared aquifers (Bandanna Formation, Rewan, Basalt and other Tertiary water-bearing sediments, Alluvium) from overlapping depressurisation.
- Surface water degradation due to increased salinity and nutrient loads from mining, agriculture, and vegetation clearing.
- Impacts to GDEs due to changes in flow regimes, water quality, and vegetation clearance.
- Exceedance of hydrological or ecological thresholds, with the potential to trigger tipping points or long-term ecosystem degradation.

Table 27 – Regional Activities and Interacting Pathways

Land Use/Activity	Cumulative Risk Pathways	Water Receptors Affected
Coal mining	Groundwater depressurisation, aquifer interference, spoil runoff, seepage to groundwater from mine waste storage	Bandanna, Basalt, Alluvium
Other CSG	Groundwater depressurisation, field-scale aquifer drawdown, seepage from produced water and/or brine storage infrastructure	Bandanna, Alluvium

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Land Use/Activity	Cumulative Risk Pathways	Water Receptors Affected
Mineral Development	Shared infrastructure, potential future extraction	Bandanna, Basalt, Alluvium
Irrigated agriculture	Surface water extraction, reduced stream baseflow and alluvial aquifer drawdown, runoff of nutrients and salts	Comet River, aquatic ecosystems, GDEs, alluvial aquifers
Grazing (extensive)	Groundwater abstraction, land access, runoff of nutrients, salts and animal waste, degradation of stream banks from cattle access	Aquatic ecosystems, GDEs, Shallow aquifers (Basalt/Alluvium)
Infrastructure corridors	Soil compaction, sediment transport, drainage alteration	Ephemeral surface water & floodplains

Integration of results with OGIA's regional groundwater models to assess spatial and temporal trends. Implementation of TARP that describe investigation and mitigation actions in the event of threshold exceedance.

9.5 Cumulative Impact Triggers

The following thresholds are applied to manage cumulative environmental impacts from regional CSG activities:

- Adoption of Comet River WQOs (DEHP, 2011) as baseline reference values;
- 10% deviation in SWL from baseline triggers investigation and potential make-good response under the Water Act 2000;
- Exceedance of salinity or contaminant tolerance thresholds for aquatic and riparian species;
- Overlap of drawdown zones assessed via OGIA modelling.

9.6 Ongoing Review and Modelling

- The site-specific numerical groundwater model will be recalibrated within two years using new monitoring data;
- The model will be benchmarked against the OGIA regional cumulative impact model to distinguish site-specific from broader regional effects;
- The monitoring network includes:
    - Cross-tenure bores across hydrostratigraphic units;
    - Isotopic and gas tracer sampling to attribute sources of water quality or level changes.

9.7 Mitigation Response for Cumulative Impact

To address potential cumulative impacts arising from regional CSG activities—particularly those affecting groundwater levels, quality, and dependent ecosystems—Comet Ridge will implement the following tiered mitigation measures in line with EA conditions, the EPBC Act, and the IESC Information Guidelines (2024):

1. Adaptive Groundwater Management

- Drawdown Management: Where cumulative drawdown exceeds >20% deviation from baseline or modelled predictions, groundwater extraction rates will be reduced or reallocated to lower-risk zones.
- Make-Good Obligations: If landholder bores are affected beyond agreed thresholds, Comet Ridge will implement make-good measures in accordance with the *Water Act 2000*, including bore deepening, refurbishment, or replacement.

2. Enhanced Monitoring and Analysis
   - Increased Monitoring Frequency: Sites showing signs of pressure decline or water quality deterioration linked to broader regional trends will shift to monthly monitoring.
   - Trend Evaluation: Time-series data will be analysed for persistent declines or step-changes, and model predictions will be adjusted accordingly.

3. Groundwater Model Recalibration
   - Biennial Updates: The site-specific numerical groundwater model will be updated every two years to incorporate monitoring results, compare with OGIA's cumulative regional model, and refine drawdown predictions.
   - Scenario Testing: Simulations will evaluate stress responses under different operational scenarios to pre-emptively mitigate risks.

4. Source Attribution
   - Use of Environmental Tracers: Isotopic ($\delta^{18}O$, $\delta^{2}H$), hydrocarbon (BTEX), and gas tracers (CH_4, CO_2) will be used to distinguish localised effects from broader cumulative signals.
   - Cross-Tenure Data Sharing: Collaborations with adjacent tenure holders will support data integration and a regionally coherent mitigation approach.

5. Ecosystem Safeguards
   - GDEs Protection Measures: If signs of stress (e.g., vegetation dieback, spring flow reduction) are detected in groundwater-dependent ecosystems, targeted ecological assessments will be initiated, and water extraction regimes adjusted.
   - Surface Water Integration: Surface–groundwater interaction monitoring will help differentiate climatic variability from cumulative anthropogenic influence.

6. Regulatory Engagement and Transparency
   - Early Regulator Notification: Where cumulative impact indicators exceed internal thresholds, Comet Ridge will engage proactively with DES and DCCEEW to review management measures.
   - Public Disclosure: Summary results, trends, and responses will be incorporated into the WMMP Annual Report to maintain transparency with stakeholders and regulators.

10. WMMP Review and Update

This plan is a living document designed to accommodate evolving site conditions, operational changes, monitoring results, and regulatory requirements.
By embedding adaptive management principles, the plan ensures that Comet Ridge remains responsive to environmental risks, regulatory expectations, and stakeholder concerns. Continuous improvement, data integration, and scientific defensibility underpin the long-term protection of water resources.

In line with best-practice environmental management and the principles outlined in the IESC Information Guidelines (2024), this section outlines the procedures for periodic review, update triggers, and plan revision responsibilities.

10.1 Review Frequency

Formal reviews of the WMMP will be undertaken at the following intervals:

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- Annually – as part of the Annual Environmental Report (AER) submitted to the Department of Environment and Science (DES);
- Biannually – for cumulative impact review in alignment with OGIA model updates and site-specific MODFLOW model recalibrations;
- Trigger-Based Reviews – initiated if monitoring data, regulatory feedback, or operational changes indicate that current monitoring or mitigation measures may no longer be adequate.

10.2 Review Triggers

Updates to the WMMP may be required if any of the following occur:

- Exceedance of trigger thresholds (e.g., >20% deviation from baseline SWL, WQO exceedance, detection of hydrocarbons or CSG indicator elements);
- Detection of aquifer interconnectivity inconsistent with the conceptual model;
- Changes to project infrastructure or operational scope (e.g., new production areas, expanded water treatment capacity);
- Significant stakeholder or landholder feedback (e.g., bore complaints or make-good claims);
- Amendments to regulatory conditions, including EA revisions, EPBC approval modifications, or updates to applicable guidelines (e.g., ANZG, IESC);
- Emergence of new data or EVs, such as confirmed GDEs or revised water quality objectives.

10.3 Update Procedure

Plan updates will follow a structured and auditable process:

- Data Review – Evaluate monitoring results against baseline conditions, model predictions, and trigger values.
- Gap Analysis – Identify inconsistencies, risks, or emerging trends that warrant management response or plan modification.
- Stakeholder Engagement – Where appropriate, consult with regulatory agencies (e.g., DES, DCCEEW), landholders, or technical specialists.
- Plan Revision – Update relevant sections (e.g., analytical plans, TARP tables, bore networks) and document rationale for changes.
- Version Control – Apply a new revision number and maintain a detailed change history in the document control register.
- Re-Submission – Provide the revised WMMP to DES and/or DCCEEW where updates are material or required under the EA or EPBC Act.

10.4 Version Management and Responsibilities

Comet Ridge will assign responsibility for WMMP management to the Project Environmental Manager (or equivalent delegate), who will:

- Coordinate internal and external technical reviews;
- Ensure alignment with groundwater modelling and other environmental management plans (e.g., Biodiversity Management Plan, Stormwater Plan);
- Maintain version control and register of changes;

- Ensure all staff and contractors are aware of any changes relevant to their roles.

The updated WMMP and associated monitoring datasets will be made available upon request to regulators and affected stakeholders, consistent with transparency principles.

10.5 Integration with Broader Environmental Management

Revisions to this WMMP will be coordinated with updates to other environmental plans and approvals to ensure consistency across the broader Environmental Management System (EMS). This includes:

- Stormwater and Erosion Control Plans;
- GDEs and Biodiversity Monitoring Programs; and
- Annual Environmental Return (EA Condition compliance).

11. Limitation

Terra Sana Consultants Pty Ltd (TSC) has prepared this report for the sole use of the Client. The report has been prepared in accordance to the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. The methodology adopted to sources of information used by TSC includes interview(s), review of documentation, inspection, sampling or other means of investigation. TSC has made no independent verification of the information supplied by the representative of Client's representative and assumes no responsibility for any inaccuracies or omissions. This report is based on the conditions encountered and information reviewed at the time of preparations. TSC disclaims responsibility for any changes that may have occurred after this time. This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Any changes in regulations or scientific understanding could impact on our conclusions and recommendations. TSC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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