Appendix B
Groundwater Impact Assessment

Australasian Groundwater & Environmental Consultants

Report on

Borumba Dam Exploratory Works EPBC Referral Groundwater Impact Assessment Amendment

Prepared for
Queensland Hydro Pty Ltd

Project No. BDP5001.004
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ageconsultants.com.au

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Document details and history

Document details

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Table of contents

Table of contents

List of figures

Table of contents

List of tables

Table of contents

List of appendices

Borumba Dam Exploratory Works EPBC Referral Groundwater Impact Assessment - Amendment

1 Introduction

The Borumba Pumped Hydro Energy Storage (PHES) Project being undertaken by Queensland Hydro (QH) requires the completion of exploratory works to confirm the suitability of the Borumba PHES Project location and design. The Borumba PHES Project—Exploratory Works (the 'Exploratory Works Project' or 'Project') includes the necessary geological investigations, supporting infrastructure, and activities to inform the development of the main works and related Borumba PHES Project.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has undertaken a preliminary groundwater impact assessment of the Exploratory Works Project in September 2023. This report is an amendment to the September 2023 report. The impact assessment will assist QH in responding to the request for information (RFI) from the Department of Climate Change, Energy, the Environment and Water (DCCEEW) in relation to the sought approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act, 1999) (EPBC 2023/09461).

As indicated above, a version of this document was submitted to QH in September 2023. In July 2024, QH provided additional design information to inform the impact assessment as follows and further discussed in Section 2:

- An alternate exploratory tunnel alignment (dual tunnels) may be constructed, with a decision to be made when reaching 600 metres (m), subject to the outcome of ongoing geotechnical investigations.
- The inclusion of two potential groundwater supply bores, to supply up to 140 mega litres per annum (ML/a) for construction purposes. These bores are intended to be used as a contingency shortfall supply in the event of reduced supply from surface water or groundwater ingress to the exploratory tunnel.

Since the Groundwater Impact Assessment (GIA) was submitted in September 2023, additional field investigations have been completed, and the conceptual understanding of the site has improved. The conceptual model has been updated to reflect these new findings.

1.1 Assessment framework and approach

A review of the RFI identified the following points (Table 1.1) that are considered to be relevant to groundwater and addressed within this report.

Table 1.1 DCCEEW RFI related to groundwater

RFI No.	Description	Relevant section
2.1 (b)	• a description of all components of the proposed action (pre-construction, construction, operational and decommissioning), including the anticipated start and completion dates, duration and maximum life. This should include a detailed outline of the expected timing of any staged clearing over the construction period. This description should include at a minimum: – iii. water infrastructure, <u>all new and existing groundwater bores</u>, stormwater infrastructure and drainage systems and transmission line trenching. – ix. other such actions, including, but not limited to, use of explosives, <u>changes to hydrological flow and groundwater</u>, concrete batching plant, material storage, construction facilities, fine particle and dust control management.	2.2 7

RFI No.	Description	Relevant section
2.1 (e)	• For all proposed tunnelling infrastructure, describe, map and illustrate: – i. Location in relation to **groundwater**.	2.3 Figure 6.1
4.3	• Confirm the area of habitat that will be directly and indirectly impacted by the proposed action, including but not limited to areas where – (a) Connectivity to surrounding habitat will be retained, removed or functionally lost. – (d) Habitat will be impacted due to changes in surface water, groundwater and leachate within the site and the area surrounding the site. – (e) Specifically, provide information on impacts to drainage, water quality and hydrology on Yabba Creek, the Mary River and onto the Great Sandy Strait Ramsar Wetland.	1.1.1 7 & 9.1
4.5	• Provide an assessment of the direct and indirect impacts that may occur during construction and post-construction phases, including: – (b) A local and regional scale analysis of likely impacts, with reference to the project's potential contribution to cumulative impacts in the context of development patterns in the locality and region. – (c) An assessment of the likely duration of impacts to MNES as a result of the proposed action. – (d) Discussion of the risk of potential impacts as a result of the proposed action, including but not limited to the following: o *vi. Impacts from the project at the local scale and regional context including changes to water flow regime and water quality (including runoff from spoil such as sedimentation and acid sulphate soils as well as other potential contaminants from explosives).* o *vii. Alterations to hydrology, surface water, groundwater and groundwater dependant flora and fauna.* o *ix. How tunnelling, drilling and blasting activities will impact the long term stability of the geology of the project area including:* ▪ *interactions with groundwater.*	9.1
5.1	• Provide a consolidated assessment of all proposed measures to avoid and mitigate impacts, including those provided in the referral and any additional to those described in the referral. This should include: – (m) A risk analysis of impacts to water quality. This includes: o *Risks associated with the action that could lead to water quality contamination or degradation. This includes but is not limited to runoff from spoil, contaminants from explosives used during the tunnelling process, increased erosion and sedimentation, introduced acid sulphate soils, changes to water flow, salinity, oxygenation and algal blooms.* o *An assessment of the likelihood of water quality impacts.* o *Proposed avoidance and mitigation measures to reduce the likelihood of impacts to water quality.* o *How any residual risks will be addressed upon finalisation of the action and will be managed ongoing into the Borumba Pumped Hydro Energy Scheme Project.*	8 & 10
5.3	• Provide management and mitigation measures relating to impacts of groundwater drawdown, groundwater contamination and surface water contamination on water resources. Specifically, the department requests the proponent include mitigation and/or management measures regarding the impacts on: – potential Groundwater Dependent Ecosystems; and – potential contaminants (such as those extracted as a part of the tunnelling and spoil storage actions).	10

1.1.1 Relevant MNES

A total of 56 hectares (ha) of native vegetation is proposed to be impacted by the Exploratory Works Footprint, including 2.5 ha that qualifies as a threatened ecological community (TEC) under the EPBC Act (Queensland Hydro, 2023b). With respect to impacts related to groundwater, the most at risk matters of national environment significance (MNES) are Threatened Ecological Communities listed in Table 1.2. These communities may depend on groundwater and are further discussed in Section 6.7.

Table 1.2 MNES description deemed relevant to groundwater

MNES	Description	Threatened Category
Listed Threatened Ecological Communities	Lowland Rainforest of Subtropical Australia	Critically Endangered
	Subtropical eucalypt floodplain forest and woodland of the New South Wales North Coast and Southeast Queensland bioregions	Endangered

2 Exploratory Works Project context

2.1 Exploratory Works Project location

The Exploratory Works Project is located within the Gympie Regional Council and Somerset Regional Council local government areas, approximately 13 km southwest of the township of Imbil, 48 km southwest of Gympie, and 180 km northwest of Brisbane (refer Figure 4.1). Constructed in 1963, Borumba Dam has a catchment area of 465 km^2 and was raised from 132.28 m AHD to 135.01 m AHD in 1997 bringing its full storage capacity to approximately 46 gigalitres (GL). The dam stores water for drinking as well as irrigation.

2.2 Proposed activities and project timeframes

The proposed activities for the exploratory works, including the size, layout and operational lifespan, are outlined in Table 2.1 and depicted on Figure 2.1. These activities largely support the development of the exploratory tunnel and, as such, will all have a similar lifespan of approximately 2 to 3 years.

2.3 Tunnel design and infrastructure

Conceptual design drawings of the exploratory tunnel and the alternate exploratory tunnel are provided in Table 2.1 and graphically presented in Figure 2.2 and Figure 2.3, respectively. The conceptual model designed by SMEC is based on inferred geological surface mapping, which still needs to be confirmed through future bore drilling. The tunnel portal will be located near Sandy Creek and the tunnel will extend approximately 2 km into the bedrock. The tunnel and supporting infrastructure are located on Queensland Hydro owned land.

Forward probing will be a critical input to the Permit to Tunnel (PTT) process. The process will include systematic probing of the rock conditions by drilling cored probe holes before advancing the tunnel excavation.

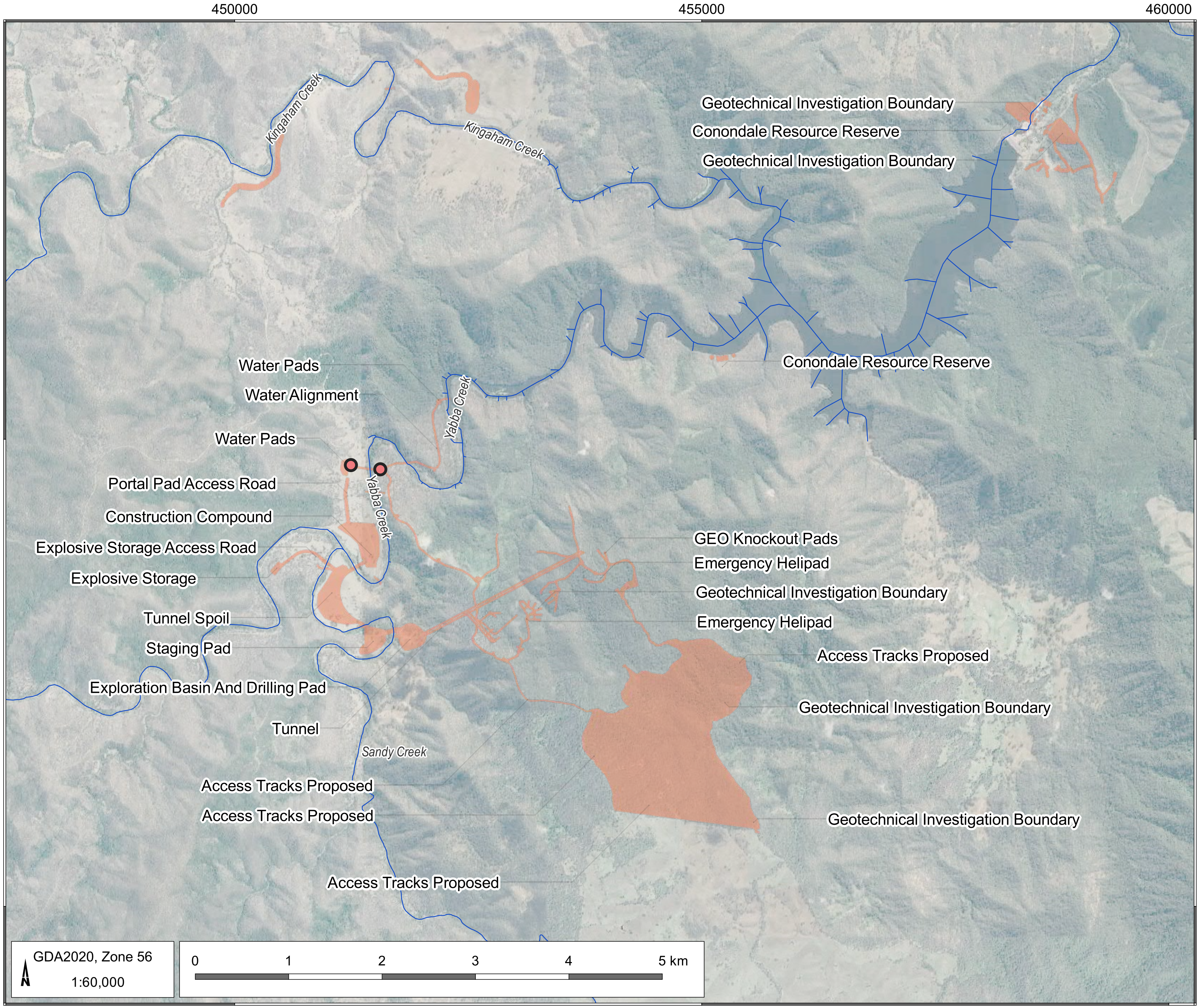
Potential impacts of the Exploratory Works underground infrastructure, including dewatering of the surrounding aquifer unit(s) and drawdown of the local groundwater levels as well as potential release of contaminants as a result of exposure of the bedrock to oxygen, are discussed in Section 8 and 9. The following excerpt is taken from Queensland Hydro (2024) on the strategies to control water inflow within the tunnel:

'The Contractor shall carry out pre-grouting ahead of tunnel excavation at locations indicated by the probe drilling and itemised by the Permit to Tunnel process.

- *During general excavation further pre-grouting may be required when one or a combination of the following criteria are measured as total combined water inflow from the excavation face and probe holes:*
  - *Combined flows recorded from probe holes and the tunnel face exceed 10 l/s and do not recede to at least 50 % of its initially measured rate within the first hour.*
  - *Water inflows remaining at more than 2 L/s after 24 hours since first observed, unless they are continuing to decline at a steady rate (i.e. rate is not slowing).*
  - *Unstable, saturated ground ahead of the face is indicated by probe holes or any ground investigation techniques ahead of the face, or by significant worsening of ground conditions.*
- *All probe holes shall be grouted.*
- *Groundwater inflow performance criteria are designed to limit tunnel inflows to a level which are likely to minimise environmental impacts. Additional benefits include lower water treatment and disposal costs and lower construction water management issues (pumping). For this purpose, water inflow into any section of the tunnel shall be limited to 2 L/s for any one-kilometre length of tunnel.*
- *Inflow measurements (post-excavation) are to be measured over any 1000 m section as a rolling measurement approximately 100 m behind the face.*
- *The performance criteria stipulated above shall be periodically reviewed and adjusted upwards or downwards, subject to agreement by the Principal, based on the review and assessment of data from groundwater monitoring, observations and monitoring of inflows in the tunnel and other additional information and experience during excavation.'*

2.4 Groundwater supply bores

As indicated in Table 2.1, and depicted on Figure 2.1, as part of the exploratory works, QH plan to construct two groundwater supply bores. As discussed in Section 8.2, the bores are planned to be drilled about 2 km north of the proposed tunnel portal area within the proposal construction laydown area and to supply 140 ML/a. Groundwater supply bores are intended to be used as shortfall, or contingency water supply in the event of reduced supply from surface water or ingress to the exploratory tunnel. The regulation of the proposed groundwater bore infrastructure is summarised in Section 4.



LEGEND

- Groundwater Supply Bores
- Watercourse/Drainage
- Exploratory Works Site Layout

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Exploratory Works Project site layout

AGE

DATE
30/08/2024

FIGURE No:
2.1

G:\Projects\BDP5001.004 Borumba PHES_EPBC Amendment Variation 4\3_GIS\Workspaces\002_Deliverable2\02.01_BDP5001_Exploratory Works Project site layout.qgz

Table 2.1 Site activities, extent and lifespan

Exploration Works Activity	Purpose	Size (ha)	Operational Lifespan*
Temporary Water Infrastructure	Pipeline, storage tanks and pump stations. To provide raw water to operate drilling rigs, facilitate dust suppression and moisture conditioning of materials associated with surface civil works construction. Approximate volume requirements are: Exploratory drilling ~55 kilolitres (kL)/day Geotechnical drilling ~60kL/day	~2.99	~2 years for exploratory works. Some equipment may be retained if the main work proceeds for duration of main works construction.
Yabba Creek Crossing	Installation of a Bailey bridge to enable heavy and long vehicle access to the exploratory drilling portal during high flow events	~0.78	~2 years Bridge to be removed once permanent access is established.
Sandy Creek Crossings	Installation of three bridges at both Sandy Creek crossings to enable heavy and long vehicle access to the exploratory drilling portal and the explosives store during high flow events	~1.6	~2 years Bridges for Yabba Creek and Sandy Creek will be removed at the completion of the exploratory works, if main works do not proceed, and after permanent access is established if main works do proceed.
Spoil Disposal Area	To store excess material (~395,000 cubic metres (m^3)) excavated from within the exploratory tunnel.	~8.72	Operation and Decommissioning **: Scenario 1 (if main works proceed): ~2 years Scenario 2 (if main works do not proceed): ~Life
Explosives Store	To store explosive materials used within the exploratory tunnel drill-and-blast operations.	~0.78	~2 years for exploratory works. Scenario 1: To be completely removed upon completion of exploratory tunnel if main works do not proceed. Scenario 2: Will retained if main work proceeds for duration of main works construction.
Portal Pad	To situate plant and equipment (water infiltration, ventilation, temporary excavated material, general with fuel storage, water treatment plant) that is required to be located at the entrance of the tunnel portal	~3.89	~2 years for exploratory works. Scenario 1: To be completely removed upon completion of exploratory tunnel if main works do not proceed. Scenario 2: Will retained if main work proceeds for duration of main works construction.

Exploration Works Activity	Purpose	Size (ha)	Operational Lifespan*
Support & Staging Area	To situate support facilities associated with the underground tunnelling operation, including • Plant & equipment maintenance facilities • Concrete batch plant • Raw materials stockpiles (for concrete production) • Potable water storage • Materials and consumables laydown and storage • Self-contained workforce amenities (office, crib sheds, ablutions) • Generator with fuel storage	~4.49	~2 years for exploratory works. Scenario 1: To be completely removed upon completion of exploratory tunnel if main works do not proceed. Scenario 2: Will retained if main work proceeds for duration of main works construction.
Exploratory Tunnel	To obtain geotechnical information on the conditions at the location of the proposed underground Powerhouse Cavern. Progression rate of about 3.7 m/day (AFRY, 2023a). **Two tunnel options are considered in this document:** Option 1: Exploratory tunnel – located west of Walkers Top Road and east of Sandy Creek, approximately 2 km long, orientation is north-east to south-west. Exploratory tunnel drilling would entail creating a sloping underground tunnel, approximately 8 m in diameter, that extends from the surface to a depth of approximately 450 m below the surface at the proposed powerhouse cavern. Option 2: Alternate exploratory tunnel alignment This includes a shorter tunnel of approximately 800 m in length. Exploratory tunnel construction will create dual sloping underground tunnels, approximately 5.5 m wide and 6 m high, that extend from the surface to a depth of approximately 450 m below the surface. The tunnels will be approximately 950 m long connecting to an alternative cavern location west of the proposed upper reservoir dam wall.	~1.98 (length in km) ~0.95 (length in km)	~2 years for active exploratory works. Scenario 1: Portal will be sealed with a concrete plug and tunnel will be permanent but sealed upon completion of exploratory tunnel if main works do not proceed. Scenario 2: Construction to continue if main work proceeds.
Geotechnical/groundwater monitoring bore activities, construction compound and drilling	Drilling pads will range in size with a typical footprint of approximately 200 m^2, where not on existing tracks. Some drill pads will utilise sleds or scaffolding. The purpose of drill pads will be for: • Information gathering for support of design planning or surface and subsurface infrastructure related to the exploratory works. • Installation of monitoring bores and vibrating wire piezometers at selected geotechnical locations for long term environmental monitoring.	~48.32	~18 months active drilling. Monitoring of bores to continue for duration of exploratory works. Monitoring activities to continue if main work proceeds.

Exploration Works Activity	Purpose	Size (ha)	Operational Lifespan*
Access tracks/ roads	Existing and proposed access roads to portal pad, explosives storage and geotechnical areas.	~48.73	~2 years Some roads will likely be maintained if main work proceeds, while others will be left to revegetate.
Groundwater supply bores	Inclusion of two potential groundwater supply bores, designed to supply to up 140 ML per year of raw water. Groundwater supply bores are intended to be used as shortfall, or contingency water supply in the event of reduced supply from surface water or ingress to the exploratory tunnel	0.0001	~2 years

Notes: * the time frames provided are based on indicative design, construction and operational time frames, some if the infrastructure will be retained. if main work proceeds for duration of main works construction.

** Queensland Hydro may remove the spoil from the spoil disposal area to an area outside of the floodplain, or potentially pursue commercial sale of the material. Alternatively, should the Borumba PHES Project proceed, the Project would seek to maximise beneficial reuse of the spoil. Any remaining spoil within the disposal area would be inundated by the reservoir after the Borumba dam wall is constructed.

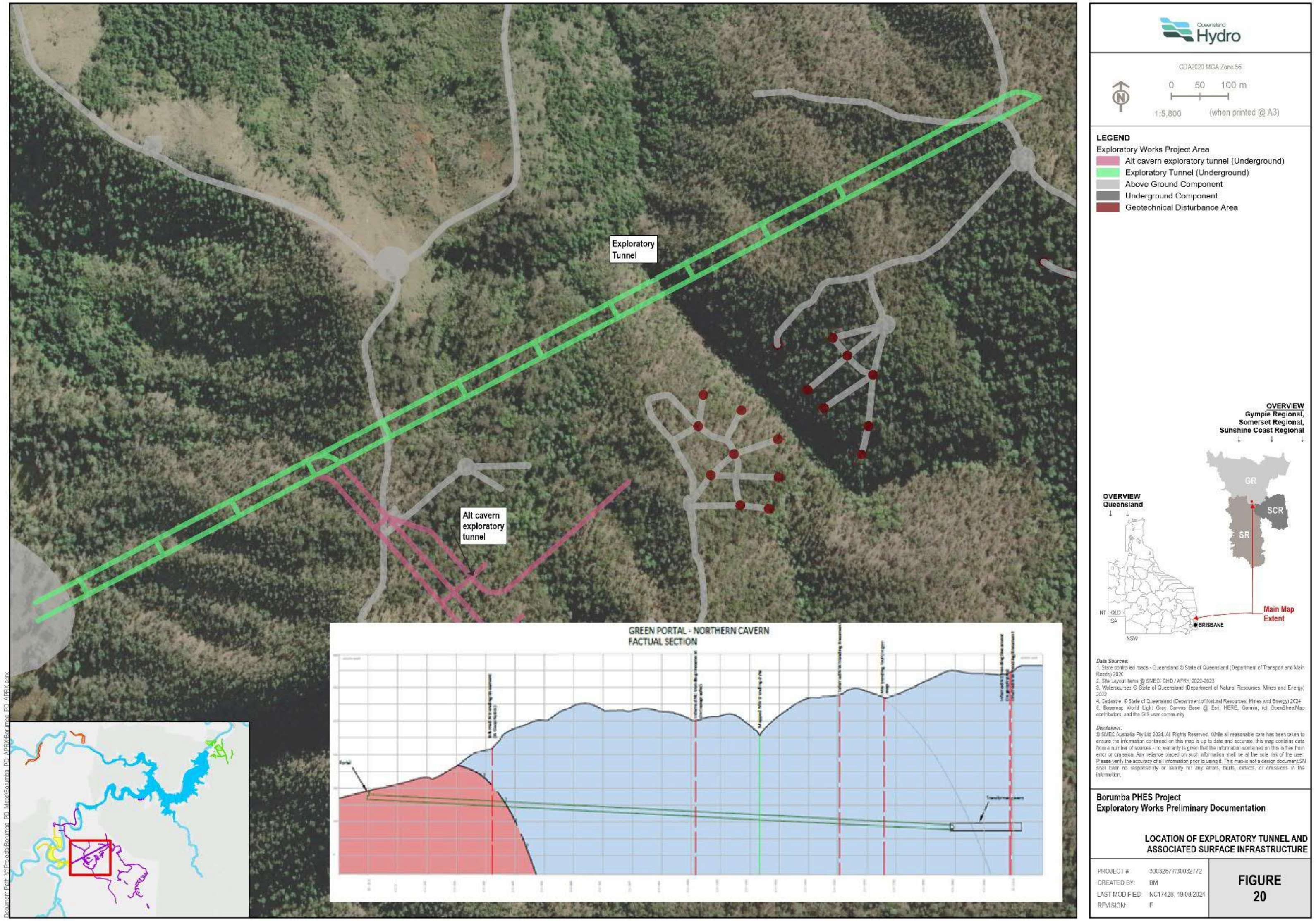
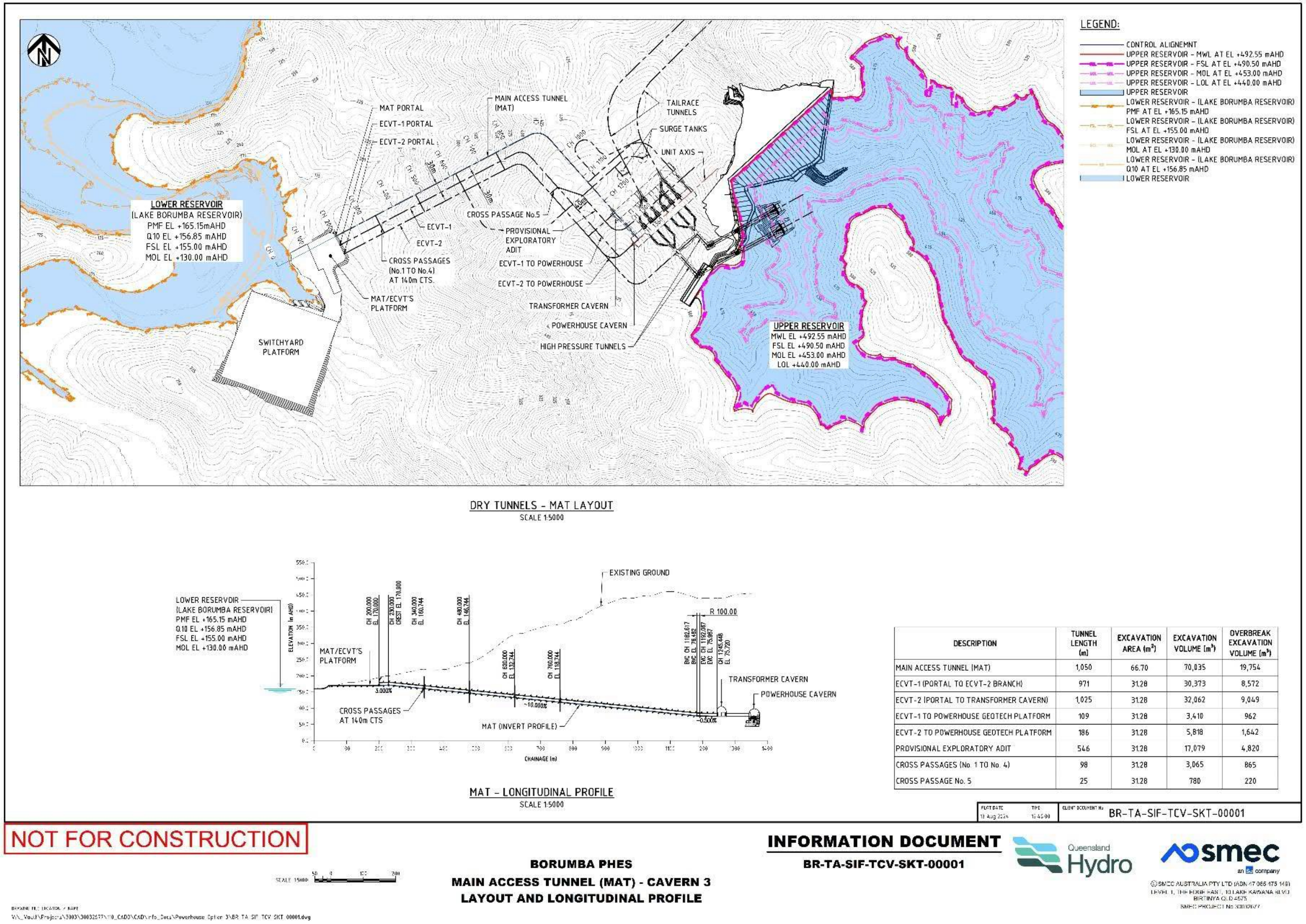


Figure 2.2 Exploratory tunnel conceptual design drawings



DESCRIPTION	TUNNEL LENGTH (m)	EXCAVATION AREA (m²)	EXCAVATION VOLUME (m³)	OVERBREAK EXCAVATION VOLUME (m³)
MAIN ACCESS TUNNEL (MAT)	1,050	66.70	70,035	19,754
ECVT-1 (PORTAL TO ECVT-2 BRANCH)	971	31.28	30,373	8,572
ECVT-2 (PORTAL TO TRANSFORMER CAVERN)	1,025	31.28	32,062	9,049
ECVT-1 TO POWERHOUSE GEOTECH PLATFORM	109	31.28	3,410	962
ECVT-2 TO POWERHOUSE GEOTECH PLATFORM	186	31.28	5,818	1,642
PROVISIONAL EXPLORATORY ADIT	546	31.28	17,079	4,820
CROSS PASSAGES (No. 1 TO No. 4)	98	31.28	3,065	865
CROSS PASSAGE No. 5	25	31.28	780	220

Figure 2.3 Alternate tunnel design and conceptual drawing

3 Methodology

The RFI items that are listed in Table 1.1 are addressed in the relevant sections of this document, The RFI will be discussed in the context of MNES, outlined in Table 1.2. The methodology to address the RFI is briefly described in the sections below.

3.1.1 Literature review

In addition to the desktop study completed by AGE (2022), the following additional information was used to supplement the overall understanding of the geology, hydrogeology, and the Exploratory Works Project:

- Alluvium (2022). Borumba Pumped Hydro Project – Fluvial Geomorphology Technical Report. A report for Queensland Hydro Pty Ltd.
- AFRY (2023a). Borumba Dam Pumped Hydro Feasibility Study – Borumba Pumped Storage (BPSP) Work Package Front End Engineering Design (FEED), FEED Report. 17 February 2023. Reference 115007213-001 - BPSP-ENG-REP-0009.
- AFRY (2023b). Front End Engineering Design (FEED) Geotechnical Report: Interpretive, Queensland Hydro Borumba Dam Pumped Hydro Feasibility Study – Borumba Pumped Storage (BPSP) Work Package, BPSP-ENG-REP-0007.
- Attexo, 2022. Borumba Pumped Hydro Project Soils Assessment Technical Report.
- ENGEO Australia Pty Ltd, (2022). Geotechnical Investigation – Borumba Pumped Hydro Energy Storage Project, Lake Borumba (Project Number #19754.000.000). DRAFT issue to SMEC.
- Epic Environmental, (2022). Desktop Assessment Contamination Technical Report.
- Powerlink. (2022). Preliminary Advice Statement. Borumba Pumped Hydro Energy Scheme 30032677-IAS-APRV-007 Rev A. 06/06/2022.
- Queensland Hydro (QH 2023). Borumba Pumped Hydro Energy Storage Project – Exploratory Works. Spoil Management Plan, QH.W17.1014.NS.ENV.RPT.0003.
- Queensland Hydro, 2023 (QH, 2023a). Borumba Pumped Hydro Energy Storage (PHES) Project – Exploratory Works EPBC Referral Report.
- Queensland Hydro, 2023 (QH, 2023b). Borumba Pumped Hydro Energy Storage Project – Exploratory Works Matters of National Environmental Significance Report. QH.W17.1014.NS.ENV.RPT.0007.
- Queensland Hydro, 2023 (QH, 2023c). Borumba Pumped Hydro Energy Storage (PHES) Project – PBC Referral Report for the Main Works, BOR-QHY-RPT-ENV-0003.
- Queensland Hydro, per email 28 July 2023 (QH, 2023d). Exploratory works amendments document – this is a summary document of the changes to the works since the referral.
- SMEC, February 2023 (SMEC, 2023a). Results of the Geotechnical Investigation along Borgan Road – DCPs and Test Pits for Exploratory Works Geotechnical Investigations - Borumba Pumped Hydro Energy Storage Project.
- SMEC, March 2023 (SMEC, 2023b). BPSP Exploratory tunnel, overview of design criteria and progress to date.
- SMEC, January 2024 (SMEC, 2024c). Preliminary Site (Contamination) Investigation, Borumba Pumped Hydro Energy Storage (BPHES) Project, 30032677-ENV-RPT-021 Rev B.
- Umwelt (2022). Borumba Dam Pumped Hydro Project Terrestrial Ecology Report. DRAFT, August 2022.
- Umwelt (2024). Threatened ecological communities, shapefile provided to AGE as a shapefile on 28/08/2024.

Other studies considered include:

- Gomes, A (SMEC) and Chapman, B (SMEC), May 2021. Development of the Geotechnical Baseline Report for the Snowy 2.0 pumped storage project. Conference: Australasian Tunnelling Conference, Melbourne, Victoria, Australia.
- SKM, (2007). Traveston Crossing Dam Environmental Impact Assessment, Volume 1, Chapter 6 – Hydrogeology (Groundwater).

3.1.2 Project key areas of discussion

The Project area is characterised by two distinctive zones, based on the significant change in topography across the site. For ease of discussing data gathering and hydrogeological conceptualisation, the Project area has been grouped into two distinct domains, as follows:

- the lower reservoir (LR) which constitutes the low-lying topography of the existing Lake Borumba; and
- the upper reservoir (UR) which defines the higher topographic area where the future upper reservoir would be located, should the main works proceed.

As shown in Figure 3.1, the grouping roughly uses the 300 m AHD topography split. The areas below 300 m AHD, north of the split forms part of the LR domain.

3.1.3 Field investigations

Field investigations were undertaken between 2022 and 2024. During that time, a total of twenty-seven standpipes were drilled and one Vibrating Wire Piezometer was installed. Currently, twenty-four of the standpipe bores comprise the site groundwater monitoring network and are monitored on a monthly basis.

The data for bores drilled in 2023 / 2024 are summarised in the factual report attached in Appendix D. This includes all borehole drilling information, bore logs, aquifer testing, telemetry installation information and water chemistry results. As shown in Figure 3.2 and listed in Table 3.1, ten locations are associated with the LR and specifically Yabba Creek, Kingaham Creek and Sandy Creek alluvium zones. The remaining monitoring sites are located across the UR area.

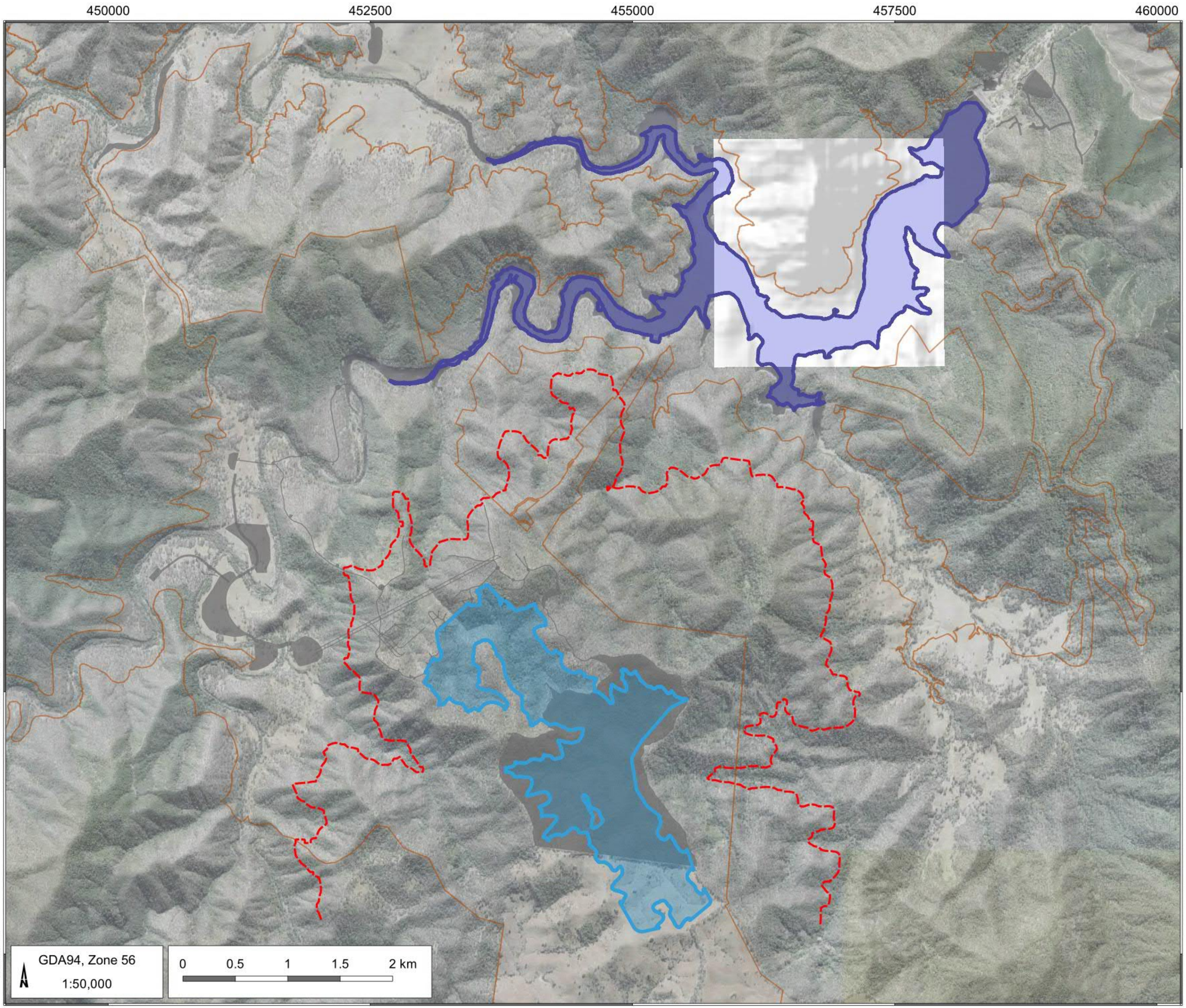
As described in the factual report in Appendix D, the data collected between August 2023 and June 2024 included:

- drilling and conversion of 22 groundwater monitoring sites, comprising 21 standpipe bores and one multilevel VWP. Monitoring sites target various groundwater units both spatially and at depth, including alluvium, weathered rock and fractured rock groundwater systems;
- recording hydrogeological information during drilling such as geology, water bearing zones, airlift yields, and water chemistry;
- evaluating the depth of alluvium and groundwater saturation adjacent to the Yabba and Kingaham Creeks;
- investigating the potential hydraulic connectivity between identified groundwater units;
- measuring static groundwater levels following bore completion and development;
- installing automatic water level loggers in the groundwater monitoring bores and automated pressure sensors in the VWP to collect information on hydrostratigraphic pressure (or water level) trends over time;
- conducting falling/rising head tests within monitoring bores to measure the hydraulic conductivity of the screened zone; and
- collecting water samples for baseline water quality assessment.

Table 3.1 Monitoring bore construction details

Bore ID	Easting[1]	Northing[1]	Ground level elevation (mAHD)	Drilled depth (mBGL)	Slotted interval (mBGL)	Filter pack interval (mBGL)	HSU	Screened geology
2023 / 2024 Monitoring bore installations								
BR-GW-KC01-MB001	451303	7068892	150.81	10	4 - 6	3.5 - 10	AA	Alluvium
BR-GW-KC01-MB002	451302	7068891	150.81	30	24 - 30	23 - 30	FRA	Serpentinite
BR-GW-YD01-MB001	459157	7068970	103.81	6	3 - 6	2.5 - 6	AA	Alluvium
BR-GW-YD01-MB002	459158	7068971	103.83	30	24 - 30	23 - 30	FRA	Phyllite
BR-GW-YU01-MB001	451420	7064452	140.95	6	3 - 6	2.5 - 6	AA	Serpentinite
BR-GW-YU01-MB002	451420	7064451	140.95	25	19 - 25	18 - 25	FRA	Serpentinite
BR-GW-YU01-MB003	451161	7063970	148.1	6	3 - 6	2.5 - 6	AA	Alluvium
BR-GW-YU01-MB004	451162	7063969	148.1	30	24 - 30	23 - 30	AA	Alluvium
BR-GW-UR01-MB001	454466	7062810	508.82	50	16 - 22	15 - 23	FRA	Metasediments
BR-GW-UR01-MB002	453924	7061450	477.79	25	13 - 19	12 - 20	FRA	Granodiorite
BR-GW-UR01-MB003	453735	7061735	466.9	28	22 - 28	21 - 28	FRA	Granodiorite
BR-GW-UR01-MB004	453924	7061450	485.48	50	10 - 16	9 - 17	WRA	Granodiorite
BR-GW-UR01-MB005	453735	7061735	481.51	30	12 - 18	11 - 19	FRA	Granodiorite
BR-GW-UR01-MB006	453924	7061450	490.64	35	29 - 35	28 - 35	FRA	Granodiorite
BR-GW-UR01-MB007	453735	7061735	494.64	35	18 - 24	17 - 25	FRA	Granodiorite
BR-GW-UR01-MB008	453924	7061450	486.06	30	8 - 14	6 - 15	WRA	Granodiorite
BR-GW-UR01-MB009	453735	7061735	506.85	50	37 - 43	36 - 44	FRA	Granodiorite
BR-GW-UR01-MB010	453924	7061450	506.23	50	11 - 20	10 - 21	FRA	Granodiorite
BR-GW-UR01-MB011	453735	7061735	500.55	50	36 - 42	35 - 43	FRA	Granodiorite
BR-GW-UR01-MB012	454387	7062091	503.07	50	36 - 42	35 - 43	FRA	Metasediments
BR-GW-UR01-MB013	452959	7062564	506.76	50	29 - 35	28 - 35	FRA	Metasediments
BR-GW-UR01-MB015	452576	7063254	430.07	50	39 - 45	38 - 46	FRA	Metasediments
2024 Vibrating wire piezometers (VWP)								
BR-GW-UR01-MB014	452561	7063248	430.07	310.98	VWP	-	-	Metasediments
MB014 VWP 1					87			Metasediments
MB014 VWP 2					200			Metasediments
MB014 VWP 3	-	-	-	-	250.5	-	FRA	Metasediments
MB014 VWP 4					281.5			Metasediments
MB014 VWP 5					309			Metasediments
2022 Geotechnical bores converted into standpipe monitoring bores								
NB-BH001	458744	7068317	144	45	40 - 46[2]	Unknown	WRA	Rhyolite
NB-BH003	458580	7068329	116	45	39 - 35[2]	Unknown	WRA	Meta volcanics
PW-BH001	454898	7060365	486	25	7 - 13[2]	Unknown	WRA	Granodiorite
SD-BH001	455240	7062082	478	20	14 - 20[2]	Unknown	WRA	Granodiorite
SD-BH003	455067	7061706	454	40	5 - 8[2]	Unknown	-	Granodiorite

Notes: [1] Surveyed co-ordinates in GDA2020 zone 56 (surveyed data provided by SMEC). [2] inferred from bore depth data
mBGL = metres below ground level.



Borumba Dam Exploratory Works
EPBC Referral – GIA – Amendment
(BDP5001.004)

Lower and UR areas as broad terms used for discussion purposes in this GA

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30/08/2024

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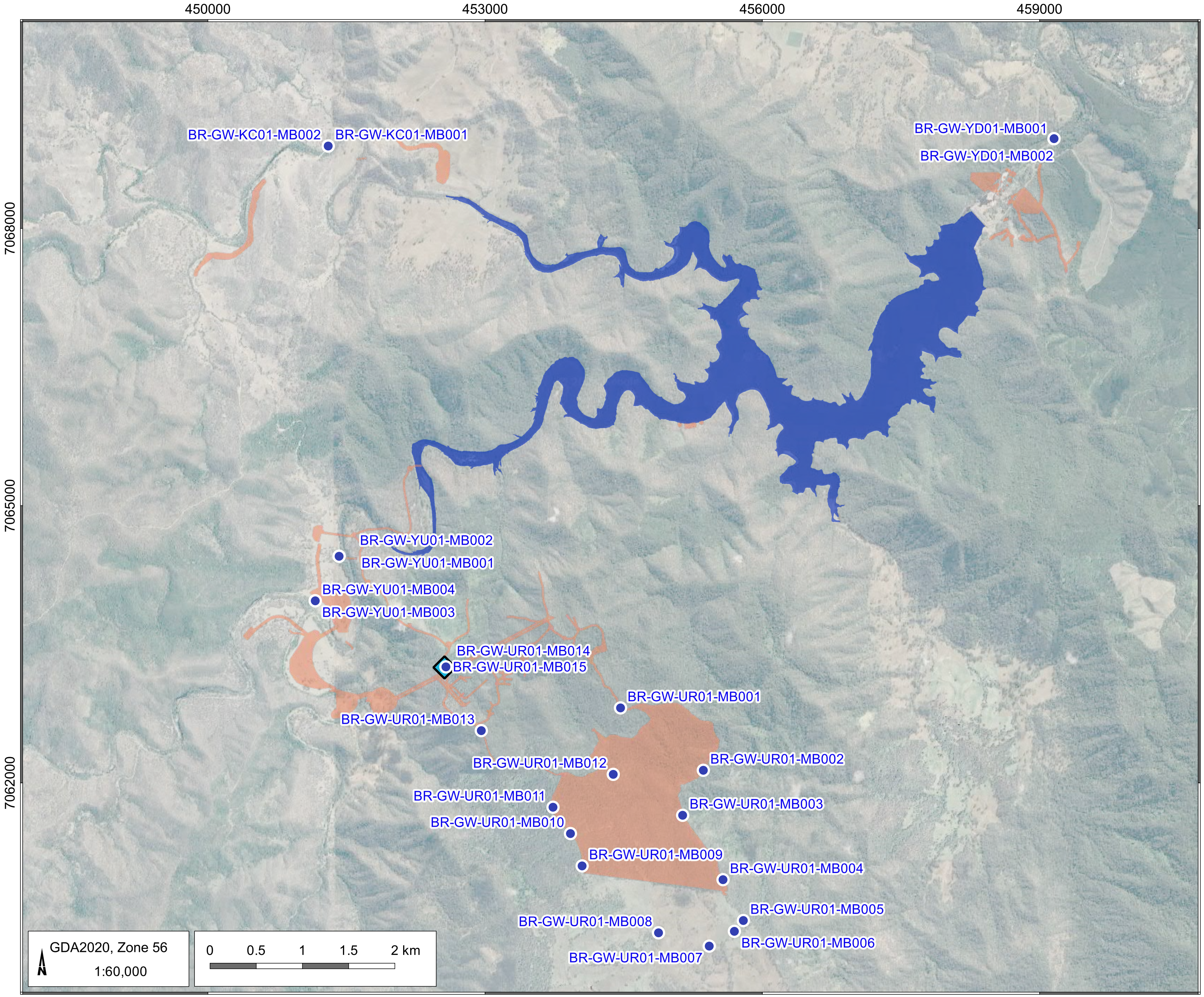

LEGEND

- Standpipe Monitoring Bore
- VWP
- Lower Reservoir (Current FSL 135.01 mAHD)
- Exploratory Works Site Layout

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Location of monitoring bores

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3.1.4 Hydrogeological Conceptual Model

Conceptual models are abstractions or simplifications of reality. They are intended to demonstrate how the key system components operate and interact. The Hydrogeological Conceptual Model (HCM) summarises the processes that control and influence the storage and movement of groundwater in the hydrogeological systems occurring in vicinity to the Project. AGE developed a site conceptual hydrogeological model in 2022 (AGE, 2022), in support of the Detailed Analytical Report. The HCM has been updated to inform this risk assessment, capturing the key findings of recent field investigations and an extended baseline monitoring dataset.

As discussed in Section 3.1.3, new data collected through the field investigation targeted key potential aquifer units to collect water level and water quality trend data, hydraulic property data, confirm the geological understanding of the site including depth of weathering and thickness of alluvium. This information will inform the HCM which is discussed further in Section 6.

3.1.5 Impact assessment

The impact assessment is based on the 2014 Commonwealth Environmental Management Plan Guidelines[1] which set out a qualitative approach to rating environmental risks. Each environmental risk is given a rating in terms of likelihood and consequence, as outlined in Table 3.2, which are then combined to determine the overall risk significance outlined in Table 3.3.

Table 3.2 Risk rating assessment criteria

Qualitative measure of likelihood **(how likely is it that this event/issue will occur after control strategies have been put in place)**	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances
Qualitative measure of consequences (what will be the consequence/result if this issue does occur rating)	
Minor	Minor incident of environmental damage that can be reversed
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts
High	Substantial instances of environmental damage that could be reversed with intensive efforts
Major	Major loss of environmental amenity and real danger of continuing
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage

Source: Australian Government, Department of the Environment, 2014.

[1] Environmental Management Plan Guidelines 2014 (dcceew.gov.au).

Table 3.3 Risk rating significance

	Consequence				
	Minor	Moderate	High	Major	Critical
Highly Likely	Medium	High	High	Severe	Severe
Likely	Low	Medium	High	High	Severe
Possible	Low	Medium	Medium	High	Severe
Unlikely	Low	Low	Medium	High	High
Rare	Low	Low	Low	Medium	High

3.1.6 Other guidelines

Additional consideration has been given to the groundwater impact assessment guidelines prepared by the Independent Expert Scientific Committee (IESC). The IESC provide advice to the Australian Government on impacts to water resources from coal seam gas and large coal mining activities. The guidelines are not applicable to this project, however, have been referenced as they contain useful guidance on the latest assessment techniques for potential water-related impacts, specifically:

- IESC (2019) Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems[2]
- IESC (2021) Information Guidelines Explanatory Note: Characterization and modelling of geological fault zones[3]
- IESC (2023) Information Guidelines Explanatory Note: Uncertainty analysis for groundwater modelling[4]

[2] https://iesc.environment.gov.au/system/files/resources/422b5f66-dfba-4e89-adda-b169fe408fe1/files/information-guidelines-explanatory-note-assessing-groundwater-dependent-ecosystems.pdf.

[3] https://www.iesc.gov.au/publications/information-guidelines-explanatory-note-characterisation-modelling-geological-fault-zones.

[4] https://www.iesc.gov.au/publications/information-guidelines-explanatory-note-uncertainty-analysis.

4 Relevant Queensland legislative framework

As this report mainly provides information in response to the RFI, discussed in Section 1.1, the local Queensland legislative framework is provided for context only.

4.1 Regulation of groundwater

A summary of groundwater specific legislation relevant for the Exploratory Works Project approvals is provided in Table 4.1.

Table 4.1 Preliminary list of key approvals required for the project in relation to groundwater

Legislation	Responsible Agency	Approval Trigger	Relevance to Exploratory Works Project
Environmental Protection Act 1994 (EP Act)	Queensland Department of Environment, Science and Innovation (DESI)	Material change of use for environmentally relevant activity	Within the EP Act the quality of Queensland waters is protected under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019. The Environmental Protection Act 1994 sets out the general environmental duty of all people to take reasonable and practicable measures to prevent or minimise the environmental harm resulting from their actions. This general environmental duty applies to all water bore drilling activities in addition to specific requirements, for example when drilling at a contaminated site.
Water Act 2000	Queensland Department of Regional Development, Manufacturing and Water (DRDMW)	Dewatering of sub surface infrastructure and foundations during construction. Changes to water balance in the Mary Basin. Potential changes in groundwater levels during construction due to tunnel dewatering. Reduced availability of water to groundwater users	Subsurface infrastructure constructed below the regional groundwater table and potentially dewatering of aquifers during construction. This include the use of two groundwater production bores during the exploratory works (i.e for about two years). Hardstand areas resulting in increased runoff and localised reduced rainfall recharge. The Project area is included within the Mary Basin Water Plan and is subject to the provisions of the Water Plan (Mary Basin) 2024 (refer to sections below). Chapter 3 of the Act provide a regulatory framework to

Legislation	Responsible Agency	Approval Trigger	Relevance to Exploratory Works Project
Water Regulation 2016	The Water Regulation (Qld) is subordinate to the Water Act (Qld)	A groundwater area is identified in the Water Regulation (Qld) as a Water Plan (WP) or a wild river declaration within which management requirements for groundwater exist. Groundwater areas are referred to in various ways under subordinate legislation; there are regulated areas (where management requirements for groundwater exist) and unregulated areas. The Project falls within an unregulated area.	Unregulated areas are known as unincorporated areas and they comprise all groundwater resources that are not part of regulated areas. Unincorporated areas have no requirements for allocations of groundwater abstraction for livestock, domestic, or construction use and, therefore, come under the relevant WP requirements. Under the Water Regulation the driller's licensing system comprises three classes of licence backed by drilling method endorsements. A class 1 and Class 2 driller required for the Project
Planning Act 2016	The State of Queensland, Department of Infrastructure, Local Government and Planning.	To drill a bore, a development approval under the Planning Act 2016 may be required.	The landholder is responsible for complying with the accepted development requirements and for employing a licensed driller with the correct class and endorsements on their licence for the type of activity being performed. It is recommended that the department be approached to confirm if any development approvals are required. It is our understanding that development approvals are only required for Cooloola Sandmass underground water management area (see sections below). All water bores drilled in Queensland must be constructed to meet the standards contained in the Minimum construction requirements for water bores in Australia available on the Australian Drilling Industry Association Drillers must supply the department with a completed drilling log on the approved form within 60 business days of commencing all water bore drilling activities.

4.1.1 Water Plan (Mary Basin) 2024

The Study area is located within the Water Plan (Mary Basin) 2024 area in the Yabba Creek sub catchment. Figure 4.1 shows the area extent covered by the water plan. Clause 2 states the purposes of the plan and provides some explanation to what the plan does, such as providing frameworks for the sustainable management of water in the plan area and providing access to water resources for Traditional Owners. These purposes reflect the requirements of section 43 of the Act.

Clause 5 states the types of water to which the plan applies under section 43 of the Act. This includes both surface water and underground water. Surface water is defined in section 4 of the plan, and includes all water in a watercourse, lake, or spring. Underground water in the plan is only managed in the Cooloola Sandmass underground water management area. Clause 18 states the cultural outcomes of the plan. The cultural outcomes aim to provide water for the cultural aspirations of traditional owners; to maintain flows of water to which the plan applies that support the cultural connection between the traditional owners of the plan area, and similarly to support cultural sites of significance, species of cultural significance, ecosystems, and waterways are preserved. The cultural outcomes also ensure that consultation and collaboration with traditional owner communities on the management of water is ongoing, to further incorporate cultural knowledge into water resource management and planning and continued acknowledgment of traditional owner connections to land and water.

Clause 19 states the environmental outcomes of the plan. The environmental outcomes encompass surface and underground water. These seek to maintain and if possible, improve flows that support aquatic ecosystems and ecological processes and minimise adverse impacts. The outcomes range from broad outcomes that seek to provide flows for native animals and plants and water quality, through to specific outcomes related to specific assets or locations. There are outcomes relating to maintaining groundwater levels and quality through to baseflows that these provide in ecosystems. The plan seeks to provide low flows for waterholes and riffles through to high flows that provide freshwater to estuaries and the Ramsar listed Great Sandy Strait wetland. The outcomes are defined in groups specific to flow regimes – low, medium, and high. This assists to develop measures and objectives for effective management and inform the development of a monitoring, evaluation, and reporting strategy.

Part 7 describes the limitation on taking or interfering with underground water in the Cooloola Sandmass underground water management area. Clause 34 relates to applications for a licence to interfere with the flow of surface, water in the plan area. The outcome of the detailed groundwater assessment for the main works EIS process will determine if any interference with groundwater may lead to interference with flow of surface water, directly or indirectly.

Clause 51 states the criteria for deciding applications for water licences to take or interfere with underground water under s43(2)(h) of the Act. The criteria that the decision maker must have regard to are - consideration of alternative supplies, the efficiency of proposed water use practices and impacts on water levels, associated ecosystems and surface water flows and the cumulative impact of the proposed taking or interfering with surface water flows and underground water flows. There is a note to also see s113 of the Act (criteria for deciding application for water licence).

4.1.2 Licence and permitting

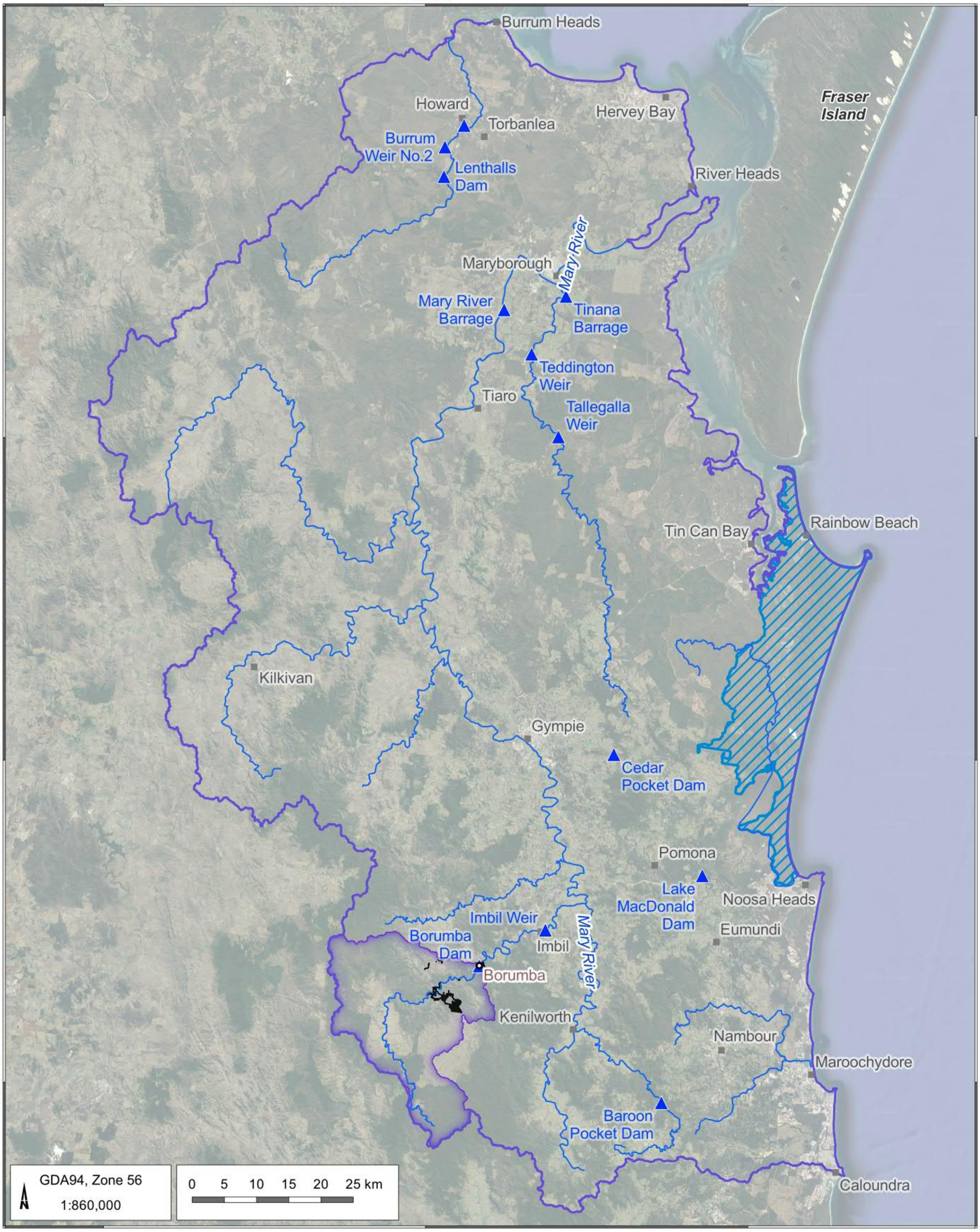
Surface water take in the Mary Basin is managed under the Water Plan, but there are no requirements to manage groundwater except in the Cooloola Sandmass area about 45 km east of the Exploratory Works Project. This managed groundwater area is far enough from the Exploratory Works Project that it is considered unconnected to the Exploratory Works Project from a groundwater perspective.

A licence to take groundwater (for use in construction for example) is therefore not required for the Exploratory Works Project but all relevant monitoring and reporting requirements will apply.

4.1.3 Exemption

In 2011 the Department of Regional Development, Manufacturing and Water (DRDMW) granted an exemption to constructing authorities regarding the take of water without a water entitlement (OSW/2020/5467). The exemption has undergone several reviews with the most recent, version 4.01, effective since February 2021. The exemption is authorised under Section 99 of the Water Act (Qld) and Sections 23 and 24 of the Water Regulation (Qld) with the purpose of providing protection for other water users and the environment.

The conditions outlined in the exemption (OSW/2020/5467) require the constructing authority to notify the Chief Executive 10 business days prior to the take of any water for purposes outlined in Section 99 of the Water Act. The constructing authority is also required to record details of the water taken (e.g. date, time, purpose, volume) and keep these records for a minimum of two years.



LEGEND

- Populated place
- Dams and Weirs
- Watercourse
- Water Plan (Mary Basin) 2006
- Cooloola Sandmass subartesian area
- Exploratory Works EPBC Site Layout
- Borumba dam catchment

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Water sharing plan

AGE

DATE 30/08/2024

FIGURE No: **4.1**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.; G:\Projects\BDP5001.004 Borumba PHES_EPBC Amendment Variation 4\3_GIS\Workspaces\002_Deliverable2\04.01_BDP5001_Water sharing plan.qgz

4.2 Environmental values

Environmental Protection Act 1994 (EP Act): This legislation protects environmental values and ensures sustainable management of an environmentally relevant activity. Within the EP Act, water quality of Queensland waters is managed under the Environmental Protection Policy 2019 (Water and Wetland Biodiversity) (EPP WWB). Based on the intent of the EP Act and Environmental Protection Regulation 2019, groundwater quality is to be protected. The groundwater 'performance outcomes' as stated in Schedule 8 of the Environmental Protection Regulation 2019 are:

- Both of the following apply:
  - there will be no direct or indirect release of contaminants to groundwater from the operation of the activity; and
  - there will be no actual or potential adverse effect on groundwater from the operation of the activity.
- The activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

4.2.1 Mary River Valley environmental values

The EPP was developed to protect Queensland's waters while supporting ecologically sustainable development. The Project and its surrounds occur within the Mary River catchment (Basin 138). The environmental values (EVs) and Water Quality Objectives (WQOs) for the Mary River are listed in Schedule 1 of the EPP WWB and include those specifically related to "Yabba Creek" and "wetlands, lakes and reservoirs" (e.g. Lake Borumba) and "Groundwater". The WQOs to protect human use EVs are the same for groundwater and surface water. While the aquatic ecosystem value is recognised for groundwater, no specific WQOs have been established due to a lack of information.

The EPP states that where groundwater interacts with surface water, groundwater quality should not compromise WQOs to protect the aquatic ecosystem EV for those bodies of water. Given the interconnected nature of the groundwater system with Lake Borumba and Yabba Creek, the following EVs are applicable to groundwaters for the Project:

- aquatic ecosystems;
- irrigation;
- farm supply/use;
- stock water;
- aquaculture;
- human consumer;
- primary recreation;
- secondary recreation;
- visual recreation;
- drinking water;
- industrial use; and
- cultural and spiritual values.

The Department of Environment and Resource Management (2010) does not provide clear guidance on cultural and spiritual values with some sections[5] suggesting that these values are not applicable for groundwater, but other sections[6] in the document suggests that it is applicable. This assessment adopts a conservative approach and assumes cultural and spiritual values are applicable to groundwaters.

WQOs guideline values for these uses are presented in Appendix A.

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[5] Section 2.2, page 12, table 1.

[6] Section 3.2, page 23, Table 3.

4.2.2 K'gari environmental values

The K'gari Basin (Queesland Basin 139) EVs are applicable to groundwaters that fall within, or adjoin, this basin. The Cooloola Sandmass adjoins the K'gari Basin, however as described above, the Cooloola Sandmass is not considered to be connected to the Project area. The K'gari Basin EVs for groundwater include aquatic ecosystems, irrigation, farm supply/use, stock water and drinking water. The applicable guidelines for comparison include the Australian and New Zealand Environment and Conservation Council (ANZECC) and the National Health and Medical Research Council (NHMRC) guidelines, which have been applied to this assessment and are included in Appendix A. The EVs for aquatic ecosystems require comparison to percentile thresholds (20^{th}, 50^{th} and 80^{th} percentiles), however insufficient baseline data is currently available for comparison.

5 Regional setting

This section describes the main processes and interactions in the Exploratory Works Project area that define how groundwater moves in the natural and modified groundwater system.

5.1 Terrain and drainage

The topography of the Study area, shown in Figure 5.1, varies greatly between the LR and UR. LiDAR data has been obtained for the area within and adjacent to the Project Footprint. The terrain is quite rugged and relatively inaccessible with the elevation ranging from about 120 m AHD to 550 m AHD. Much of the Project area is surrounded by the steep slopes of the Yabba Range, Conondale Range and Kandanga Range.

The proposed UR location is surrounded by steep slopes with deep incised drainage channels and is more than 330 m above the current Lake Borumba FSL. The incised drainage channels occasionally intersect the groundwater table, resulting in the emergence of contact springs across the escarpment between the proposed UR and Lake Borumba.

The existing Lake Borumba reservoir is situated within the Yabba Creek sub-catchment. Inflows into Lake Borumba is primarily by Yabba Creek, with subordinate drainage from Kingaham Creek, Borumba Creek and Sandy Creek. As shown in Figure 5.1, Sandy Creek, a tributary of Yabba Creek, drains the proposed drilling pad, staging pad and tunnel spoil area. Borumba Creek flows in a north-westerly direction into Lake Borumba and drains the area east of the UR escarpment within the Conondale National Park and Imbil State Forest areas. The UR is part of an unnamed drainage system ("Unnamed Creek") that drains into Lake Borumba. The topography below the existing dam wall transitions into a floodplain along Yabba Creek. This floodplain is also drained by Bella Creek, Derrier Creek and Casey Creek.

Source catchment modelling was undertaken by Alluvium (2022) to generate flow series data for the three main tributaries (Yabba Creek, Sandy Creek and Kingaham Creek) and releases into lower Yabba Creek. Yabba Creek joins the Mary River 31.1 km downstream from Borumba Dam. It is a further 238 km to the mouth of the Mary River and approximately 300 km to reach the boundary of the Great Sandy Straits Ramsar Wetland (Figure 4.1).

As shown on Figure 5.1, the Lake Borumba catchment is approximately 465 km^2 and is comprised primarily of vegetated and rural cleared land. As discussed in GHD, 2023, the Seqwater URBS model[7] extended to the Borumba Dam spillway location and was comprised of 35 sub-catchments. An additional 13 catchments were added for the adjacent Bella Creek catchment. The catchments generally have flat to moderate slopes, typically between 1% and 4% and feature an average sub-area of approximately 10 km^2, with the largest sub-area being 29 km^2 (GHD, 2023).

5.2 Land use

The Study area land uses consist of nature conservation, services, reservoir/dam, grazing native vegetation, production native forests, plantation forestry and residential (adjacent Borumba Dam). The areas immediately adjacent to Borumba Dam are primarily within the Conondale National Park and Imbil State Forest footprints. Upstream of Borumba Dam are Yabba State Forest and Wratten National Park. The areas along Bella Creek and Yabba Creek and downstream of Borumba Dam have largely been cleared for grazing and agriculture activities. The town of Imbil is located along Yabba Creek approximately 13 km northeast (downstream) of Borumba Dam.

The proposed UR located has two distinct zones: the northern portion is characterised as eucalyptus bushland, and the southern portion is cleared for cattle grazing.

[7] The Urban Runoff Branching Structure (URBS) runoff-routing model is based on a network of sub-catchments whose centroidal inflows are routed along a prescribed routing path to generate runoff.

Potential sources of contamination in the vicinity of the Project area include three livestock dips, seven areas of historic mine workings, two homesteads, a machinery shed and two potential fire brigade stations (Aurecon, 2024), shown on Figure 5.2. There is one active exploration permit (EPM26062) but no active mining leases and no petroleum tenures or leases within the Project area, although mining leases do exist in the broader region (Figure 5.2). A summary of the recorded mining activities is presented in Table 5.1 (Queensland Globe, 2024).

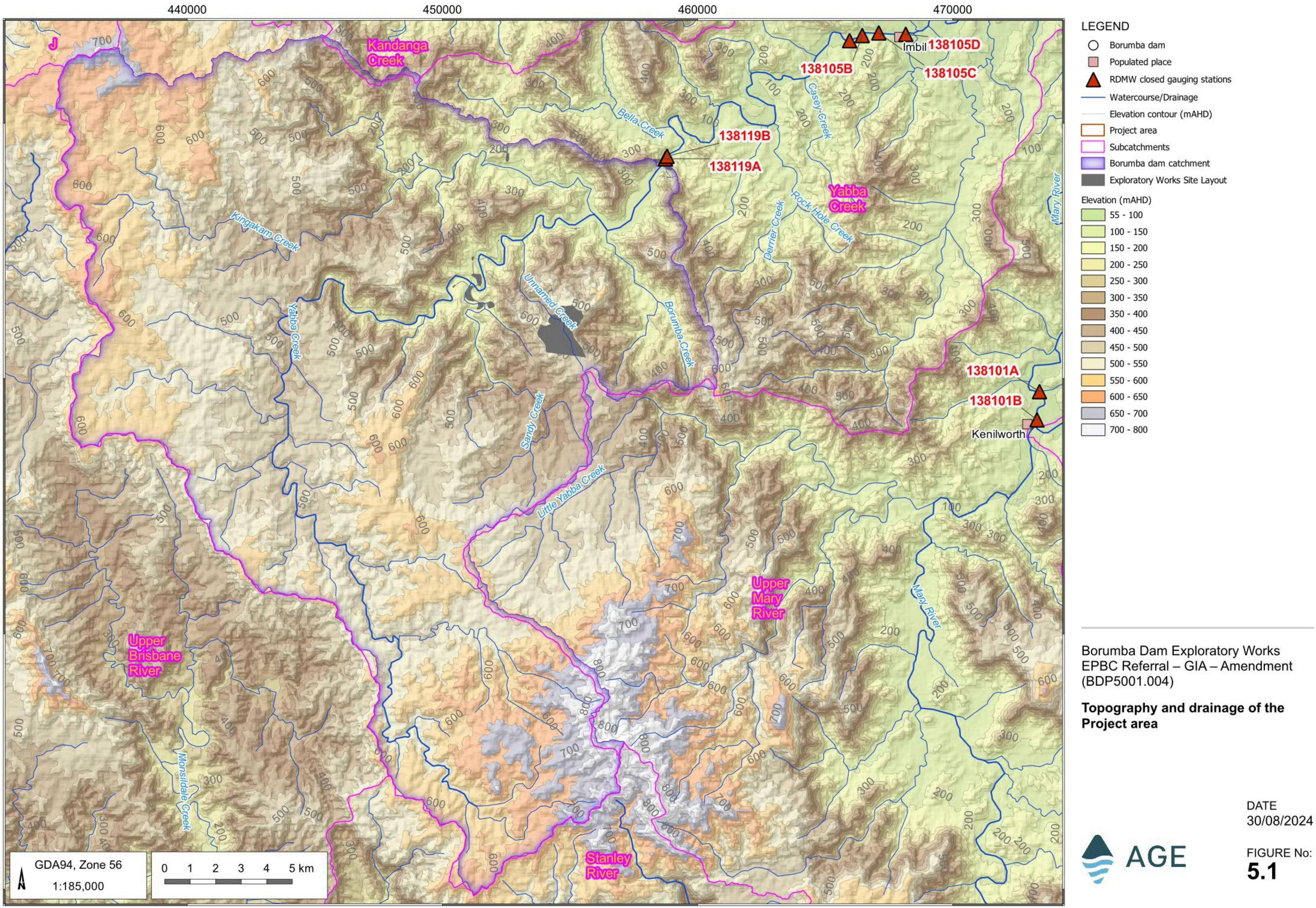
Table 5.1 Resource activities

Land parcel	Description	Status
Lot 3LX2754	Gold 1: Yours and Mine Workings (gold)	Abandoned
Lot 3LX2754	Gold 2: McAuliffe's Workings (gold)	Abandoned
Lot 1723L37994	Gold 10: Unnamed 516632 (gold)	Abandoned
Lot 20LX2359	MN 1: Craig's Lease (manganese)	Mineral occurrence with outcrop exposure
Lot 20LX2359	MN 2: Yabba Creek ML (manganese)	Abandoned
Lot 4AP23628	Nic 1: Sandy Creek Nickel Occurrence (nickel)	Mineral occurrence with outcrop exposure

While works will occur on lots listed on the environmental management register, the actual source of contamination are discrete areas that are easily identified and avoided. All mining activity is historical (generally several decades). Epic Environmental (2022) reviewed abandoned historical workings present in the area, the working dimensions are noted to be relatively small, the largest approximately 250 × 50 m.

Aurecon (2024) completed site inspections at Gold 1, Gold 2, MN 1 and MN 2. Sites Gold 3 and Gold 10 were not accessible due to steep terrain and dense vegetation, while Nic 1 was partly visible from Borgan Road. No evidence of gold mining activity or ground disturbance was identified in the Gold 1 and Gold 2 areas. The areas were densely vegetated with tall grass and mature trees on steep hills (Aurecon, 2024). No evidence of manganese mining activity or ground disturbance was identified in the MN 1 and MN 2 areas. The areas were densely vegetated with vines, lantana and mature trees on gentle slopes.

It is uncertain if any acid mine drainage could be released from these historical mine workings and sites. According to the recent Aurecon site visit data and site photos (Aurecon, 204, Appendix F), no signs of the workings or evidence of any historical mining could be observed. It will, therefore, be difficult to assess groundwater at the sites as no site-specific information on the dimensions and extent of historical mining (if any) exists. No further intrusive work was undertaken (i.e. auger drilling, soil sampling or installation of monitoring bores).



Borumba Dam Exploratory Works
EPBC Referral – GIA – Amendment
(BDP5001.004)

Topography and drainage of the Project area

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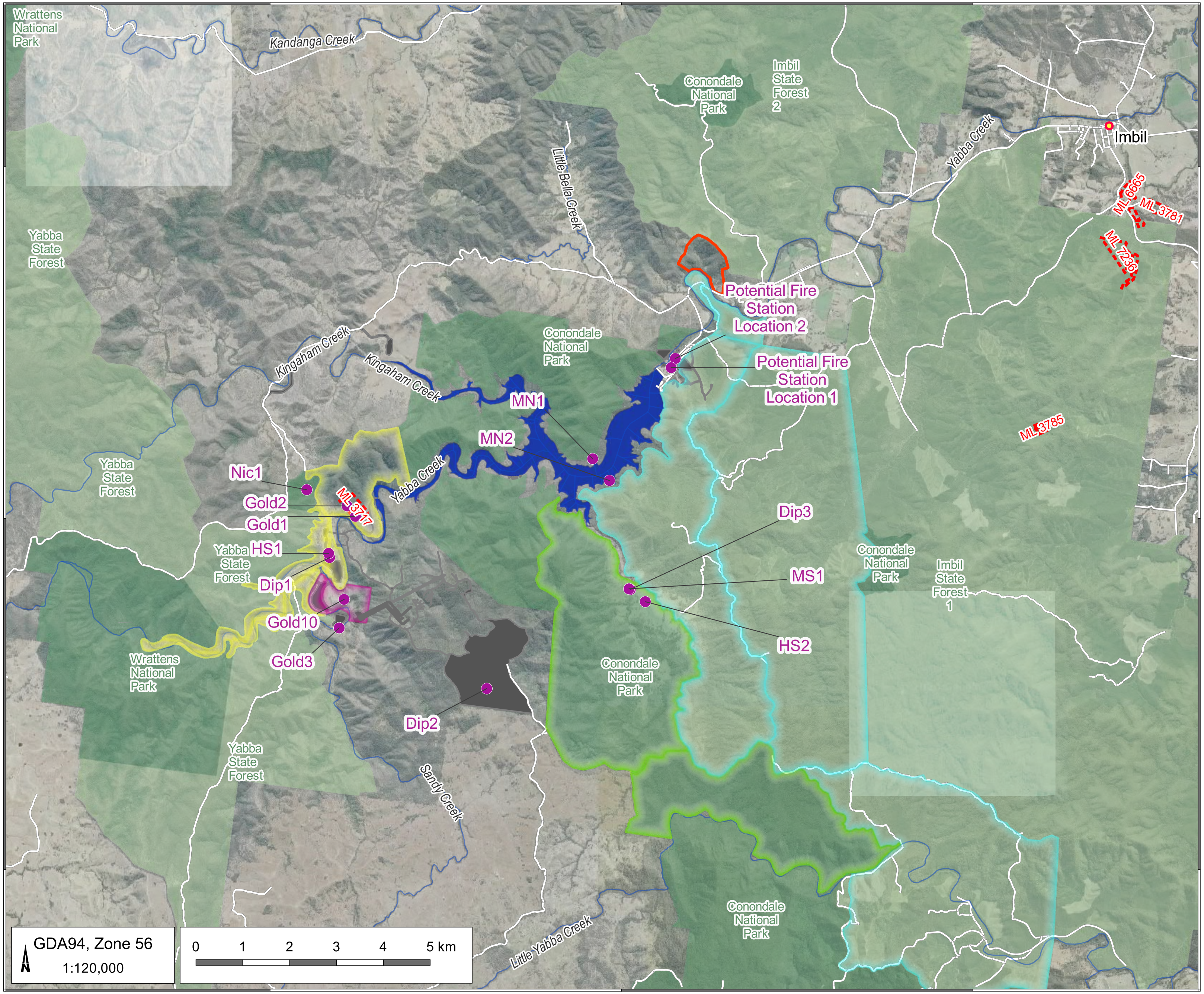

LEGEND

- Populated place
- Borumba dam
- Historical land use activities
- Road
- Watercourse
- National Park
- State Forest
- Project area
- Historical ML extent
- ML permit granted
- Lower Reservoir
- Exploratory Works Site Layout

Environmental Management Register (EMR)

- Lot135FTY1911
- Lot135NPW746
- Lot1723L37994
- Lot3LX2754

Source area	Current or historic land use
Gold 1 (Yours and Mine Workings)	
Gold 2 (McAuliffe's Workings)	
Gold 3 (Sandy Creek Gold Workings)	
NIC 1 (Sandy Creek Nickel Occurrence)	Mineral Processing
Gold 10 (Unnamed 516632)	
MN 1 (Craig's Lease)	
MN 2 (Yabba Creek ML 158)	
Dip 1	Livestock dip or spray race
Dip 2	
Dip 3	
HS 1	Homestead
HS 2	
MS 1	Machinery shed
Potential Fire Station 1	Rural fire brigade building
Potential Fire Station 2	

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Land use

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5.3 Climate

The climate in the region is classified as humid subtropical as per the Köppen climate classification. Climate data was obtained from the Scientific Information for Land Owners (SILO[8]) (DESI, 2023) database of historical climate and meteorological records for Australia. The summarised rainfall and evaporation data from January 1970 to June 2024 for the Project location (-26.53, 152.56) is provided in Table 5.2. The SILO database incorporates climate data from surrounding weather stations and interpolates climate statistics such as rainfall and evaporation on an Australia-wide grid. The closest Bureau of Meteorology (BOM) stations recording evapotranspiration (ET) data are at Gympie (040093) and Nambour Daff (040988); climate data from the Gympie station is also shown in Table 5.2. Within 15 km of the Project area there are three stations recording daily rainfall data: Oakwood TM (040889), Yabba Station (040486), and Imbil Post Office (040099).

Table 5.2 SILO and Gympie BOM climate statistics

Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Rainfall (mm)													
BOM Station 040093	160.1	168.9	143.9	81.5	71.8	59.6	51.5	39.3	44.7	72.3	87.4	135.7	1118.2
SILO (-26.53, 152.56)	169.7	155.1	135.2	75.6	71.2	58.2	55.0	35.5	44.7	88.5	87.9	132.0	1108.6
Areal Potential ET (mm)													
BOM Station 040093	190.3	158.7	157.9	126.9	101.6	80.9	87.2	106.7	130.4	156.0	171.0	190.6	1658.2
SILO (-26.53, 152.56)	164.9	132.3	126.2	98.3	75.8	61.3	70.0	92.8	122.2	152.2	159.4	170.3	1425.5

Note: millimetre (mm).

In order to place recent rainfall years into a historical context, the cumulative rainfall departure (CRD) (also referred to as the residual rainfall mass) was calculated for the Project area. The CRD is calculated by subtracting the long-term average monthly rainfall from the actual recorded monthly rainfall, providing a monthly departure from average conditions. A rising slope in the CRD plot indicates periods of above-average rainfall, while a falling slope indicates below-average rainfall. A standard technique for assessing groundwater level trends is to compare the water level hydrographs with the CRD. The CRD can be used to assess if changes in groundwater levels are correlated with climatic conditions or other factors such as resource extraction, mining, irrigation etc.

Figure 5.3 shows the Cumulative Rainfall Departure (CRD) over the period 1970 to 2024. The data shows an overall declining CRD trend since the mid-1970s. The distinct decline observed between 2000 and 2008 is representative of the Millennium drought which was characterized by below-average rainfall and El Niño events. The region was also declared drought affected between 2017 to late 2021 as a result of below average rainfall. Multiple flood events in early 2022 resulted in an increasing trend in the CRD, but recent data indicates a subsequent decreasing trend.

Groundwater levels within water table (unconfined) groundwater systems would be expected to decline naturally during drier periods, such as 2000 to 2008 and 2017 to 2021, due to ongoing drainage from the aquifers exceeding the replenishment rate from rainfall recharge. Typically, it is expected that groundwater levels will recover during wet periods, as observed from 2021 to 2022, especially in the shallow, unconfined (primary) aquifer systems and decrease during declining CRD trends, as observed between 2022 and 2024.

[8] This service interpolates climate records from available BoM weather stations with data gaps addressed by interpolation to produce a complete climate dataset. SILO data was downloaded for a point within the Project boundary (152.580, -26.50).

Data source: SILO (accessed 17/06/2024).

Figure 5.3 Cumulative rainfall departure

5.4 Soils

The Initial Advice Statement for the Project (prepared by Queensland Hydro, 2023c) included an assessment of soils across the entire Project footprint. Soils were identified as ranging from sandy loams to light, medium clays. Sodic subsoils were stated as having the potential to exist across the entire Project footprint, which was stated as being highly erodible if exposed.

The Initial Advice Statement indicated that gully erosion exists in the slopes of channels in Kingaham Creek and Borumba Creek situated above Lake Borumba. The presence of this erosion was attributed to soils in these areas having a high dispersiveness and extreme erosion risk when disturbed. Sandy soils within granodiorite areas were additionally identified as having an erosion risk, given their low coherence.

Salinity was identified as generally low across the Project footprint, with the exception of a few areas with moderate levels. These include quaternary alluvium surrounding the lower dam wall and construction activities, and subsoils in the UR areas.

As described in Attexo (2022) and for the benefit of this groundwater assessment, acid sulfate soils (ASS) risk mapping indicates that the proposed construction area for the dam and associated laydown areas that surround it are not located in, or in proximity to, areas mapped with ASS risk classes (1-4) (Queensland Globe, 2024).

5.5 Geology

The Lake Borumba region is located geologically within the North D'Aguilar Block, which contains a large variety of diverse geological units and structures. An extract of the published geology for the Project area is shown in Figure 5.4. The dominant geological structure of the block is represented by several north and northwest trending faults, which contribute to typical thrust fault terrain, that forms the mountain ranges prevalent throughout the region.

Rock formations shown within proximity of the Exploratory Works in the 1:100,000 published geology (Donchak *et al*, 1995) is summarised in Table 5.3. These geological units mainly comprise Late Devonian to Early Carboniferous aged rock formations belonging to the Amamoor and Marumba Beds, which have been intruded by younger Permian aged granitoids.

Table 5.3 Published Regional Geology of the Study area

Formation	Map Symbol	Age	Description
Flood plain alluvium	Qa	Quaternary	Clay, silt, sand, and gravel; flood-plain alluvium
Colluvial deposits	TQr	Late Tertiary - Quaternary	Clay, silt, sand, gravel and soil; colluvial and residual deposits (generally an older land surface)
Sandy claystone	TS	Tertiary	Clayey sublabile to quartzose sandstone, sandy claystone, laminated siltstone, and local conglomerate
Tungi Creek (Ck) Granodiorite	Rgt	Late Triassic	Biotite-hornblende granodiorite, hornblende-biotite granite
Rg/d-SEQ	Rg/d	Middle Triassic - Late Triassic	Equigranular to porphyritic microdiorite; porphyritic microdiorite, biotite-hornblende diorite
PRg/g-SEQ	PRg/g	Middle Triassic - Late Triassic	Hornblende-biotite granodiorite
Marumba Beds	Pm	Late Permian	Mudstone, sandstone, conglomerate, rhyolite
Jimna Phyllite	DCj	Late Permian	Polydeformed slate, phyllite, metachert and mafic greenschist
Gallangowan Granodiorite	Cgg	Late Carboniferous	Foliated to strongly foliated granodiorite with mica and quartz/feldspar rich domains with chloritisation and biotite in earliest phases
Amamoor Beds	DCa- DCa/2	Late Devonian - Early Carboniferous	Mudstone, Buff shale, slate, basic metavolcanics, basalt, chert, schist, jasper, greywacke
Mt Mia Serpentinite-matrix melange	DCs	Early to Middle Carboniferous	Assemblage of serpentinite, mafic schist, quartz mica schist, metachert, metagabbro, marble and limestone, relict peridotite, garnet amphibolite and anti gorite-tremolite-magnetite

The major geological formations occurring near the Exploratory Works Project area are the Marumba beds, and various volcanic intrusions (Rg/g-SEQ).

The Marumba beds are Early Permian aged and comprise mudstone, sandstone, conglomerate, and rhyolite (GSQ, 2018). This unit accumulated in grabens and half basins within the back-arc basin to the west of the subduction zone and accretionary wedge deposits to the east. This unit is described by Donchak et al (1995) as being dominated by either ‘thick monotonous successions of lithic sandstone/greywacke’ or ‘matrix supported polymictic [volcanic, quartzite, granodiorite] conglomerate, with clasts to 900 mm, with thinly bedded siltstone/sandstone’. Occasional rhyolites and andesitic flows also occur within the sequence. Being a back-arc basin infill sequence, apparently dominated by debris flow materials (i.e. matrix supported conglomerates and wackes), the presence of basin stage and tectonic structures, both compressional and extensional, should be expected within this unit.

A Middle Triassic aged intrusion lies to the west of the upper reservoir consists of biotite-hornblende granodiorite (GSQ, 2018). This unit is truncated to the south by the younger Tungi Creek Granodiorite. There is little to no published information relating to this unit.

The proposed new Borumba Dam (NB) is located within the Amamoor Beds (DCa), described as comprising mudstone, slate, metavolcanics, chert, schist, jasper, greywacke. Alluvial flood plains follow the Yabba creek to the northeast of the dam wall and may overlie the basement rock materials to varying extents in some locations.

5.5.1 Weathering and regolith

To assess weathering profiles in the Project area, three sets of data have been considered. These include the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Wilford *et al*, 2016) depth to regolith dataset, the Seismic Refraction Test (SRT) data collected by Scurbàt Geophysics & Projects (2022) and drilling logs of monitoring bores drilled by Engeo and AGE in 2023. A review of the Geological Survey of Queensland (GSQ, 2024) open data portal showed no historical geophysical data for the Kilcoy- Imbil Study area.

Regolith, which is not typically shown on geological maps, is the weathered in-situ and transported unconsolidated material overlying unweathered bedrock. Figure 5.5 shows the CSIRO (Wilford *et al*, 2016) depth to regolith dataset. The definition of regolith is largely adopted to be in line with Wilford *et al* (2016):

- transported regolith material – alluvium, colluvium; and
- in-situ regolith – residual soil to highly weathered (HW) material.

The CSIRO dataset shows an average depth of regolith of 3 m across the proposed UR location and 6 m in the Lower Reservoir but can be as deep as 20 m along valleys and creek lines. A comparison of the CSIRO estimated regolith depth and the observed weathered depth spatially shown in Figure 5.5. The data from all boreholes drilled between 2022 and 2023 shows an average highly weathered to extremely weathered depth of 17 m in the LR and 7 m in the proposed UR location.

5.5.2 Upper Reservoir

Diamond core drilling around the UR offered higher resolution of the complex structural history suggested by fractures, shear zones, dykes and veining influenced by both tectonic and magmatic processes. One deep bore was drilled to 300 m over the exploratory tunnel alignment.

Four of the boreholes located in the UR were drilled into metamorphosed sediments of the Marumba Beds where the rest were drilled into granodiorite indicating a lithological spatial heterogeneity. This heterogeneity coincided with a higher fracture concentration at the contact between the granodiorite and phyllite.

Fracturing within the phyllite was observed to be more significant, due to the internal structure of the rock with fractures frequently occurring along its foliations. By comparison, the massive structure of the granodiorite resulted in fewer fractures observed along the core. This indicates that fracturing around the underground workings, during drill and blast, may be more pronounced within the phyllite. Further, the alignment of mineral grains along the foliation planes provides pathways for water infiltration, facilitating weathering processes and potential for aquifer recharge.

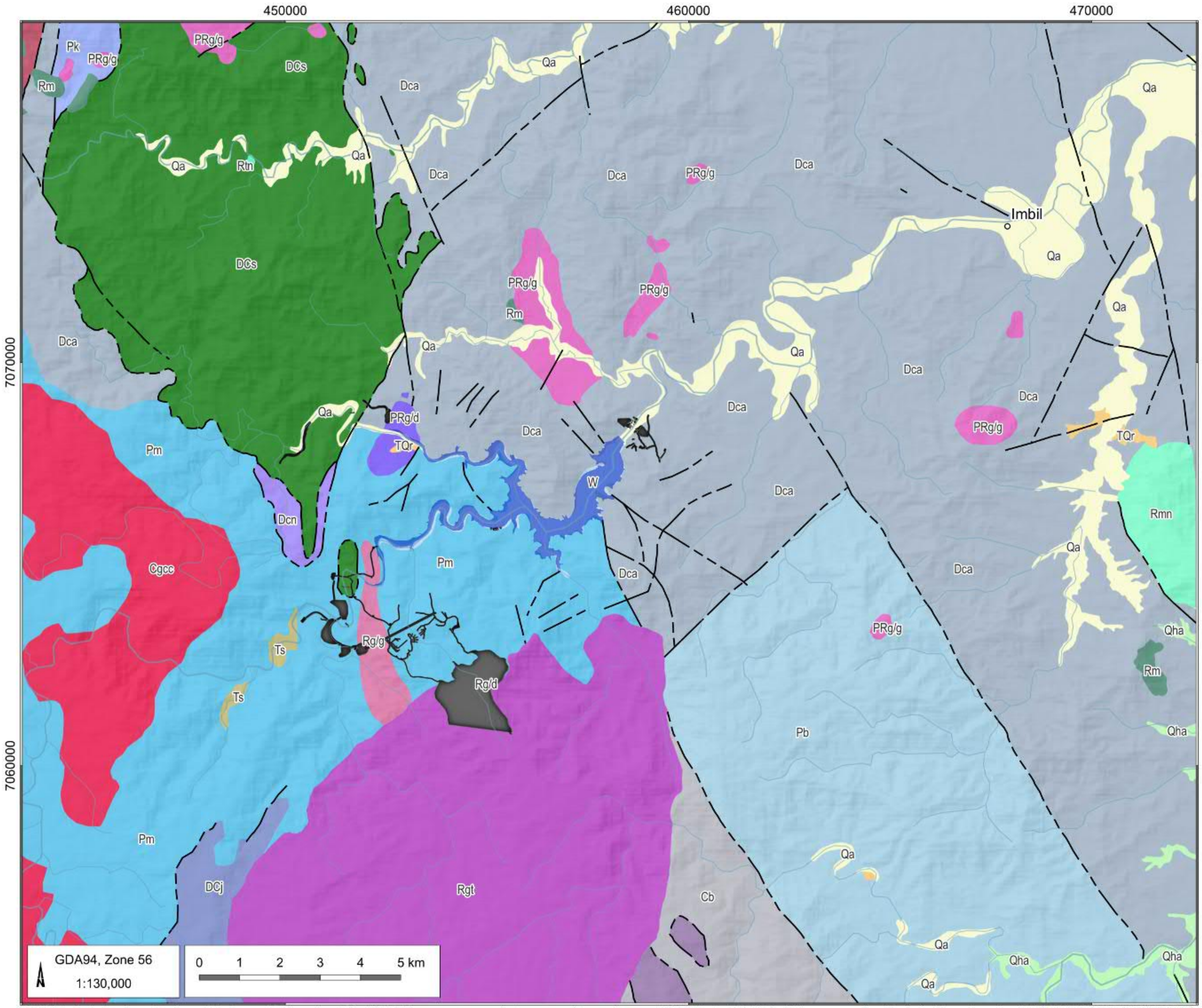
5.5.3 Lower Reservoir

Quaternary sediments in the Project area comprise clays, silts, sands, and gravel and occur along Yabba Creek, Sandy Creek and Bella Creek. This distribution can be attributed to the established watercourses promoting enhanced sediment accumulation. Moreover, the depositional processes accentuated by the lower elevation of these areas within the valley catchment contribute to a higher level of erosional input originating from the surrounding mountains.

Where the alluvium was observed adjacent to creek beds, it overlaid a range of lithologies at varying depths. Alluvium was observed overlying the Marumba Beds in the confluence of Yabba and Sandy Creek, Mt Mia Serpentinite adjacent to Yabba Creek, and at lower depths at Kingaham Creek, and Amamoor Beds metasediments near Yabba Creek at the Borumba Dam campgrounds. From the September to October 2023 drilling operations, the average alluvium thickness was in the order of 10 m ranging between 3 to 28 m thick and was intercepted between 1 to 7 m below the residual/top soil. The boreholes drilled at the confluence of Yabba and Sandy Creeks had the most extensive alluvium deposition between 1 and 30 m thick (maximum drill depth).

As described in Alluvium, 2022b, the geology of Kingaham Creek differs from Sandy Creek and Yabba Creek, lying predominantly over Mount Mia Serpentinite, an igneous ultramafic rock that has very low silica content. The two main differences are the silica content and rate of weathering of the Kingaham Creek igneous Mount Mia Serpentinite ultramafic rock compared to the sedimentary Marumba beds sandstone found in Yabba Creek/Sandy Creek. The silica content influences the amount of sand these tributaries supply to the system and the rate of weathering influences the volume of sediment to the system. Igneous rocks are usually more resistant to weathering than sedimentary rocks, meaning that the Yabba Creek/Sandy Creek tributaries can be expected to supply more sediment to the system than Kingaham Creek. The higher silica content of the Marumba beds sandstone in Yabba Creek/Sandy Creek also means the sand content in those tributaries is likely to be higher than in Kingaham Creek.

The geology of Yabba Creek catchment downstream of Borumba Dam consists almost entirely of Amamoor beds, which are a Late Devonian to Early Carboniferous sedimentary formation. Yabba Creek flows over Quaternary alluvium. The upper reaches below the dam generally have red friable earths transitioning into dark friable earths near the confluence of the Mary River, with brown friable earths on the broad middle terrace.



LEGEND

- Drainage
- Fault
- Exploratory Works Site Layout
- Project area
- Lower Reservoir (Current FSL 135.01 m AHD)

Surface geology (100k)

- Water body (unspecified) (W)
- Gravel, sand, silt, clay (Qha)
- Flood-plain alluvium (Qa)
- Colluvial and residual deposits (TQr)
- Sandy claystone (Ts)
- Mount Mia Serpentinite (DCs)
- North Arm Volcanic Group (Rm)
- Kulangoor Member/a (Rmk/a)
- Kenilworth Bluff Rhyolite (Rmn)
- Porphyritic microdiorite (Rg/d)
- Biotite-hornblende granodiorite (Rg/g)
- Tungi Creek Granodiorite (Rgt)
- Neara Volcanics (Rtn)
- Pyroxene-biotite-hornblende diorite (PRg/d)
- Hornblende-biotite granodiorite PRg/g
- Marumba beds (Pm)
- Kandanga Creek Megabreccia (Pk)
- Cambroon beds (Pb)
- Gallangowan Granodiorite (Cgg)
- Capsize Creek Complex (Cgcc)
- Booloumba beds (Cb)
- Amamoor beds (DCa)
- Talamy Schist (DCt)
- Peters Creek Greenstone (DCp)
- Jimna Phyllite (DCj)
- Anderson Creek Phyllite (DCn)

Source: Downloaded through the Queensland Spatial Catalogue available as ESRI SHP

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Geology of the Project area

DATE
30/08/2024

AGE

FIGURE No:
5.4

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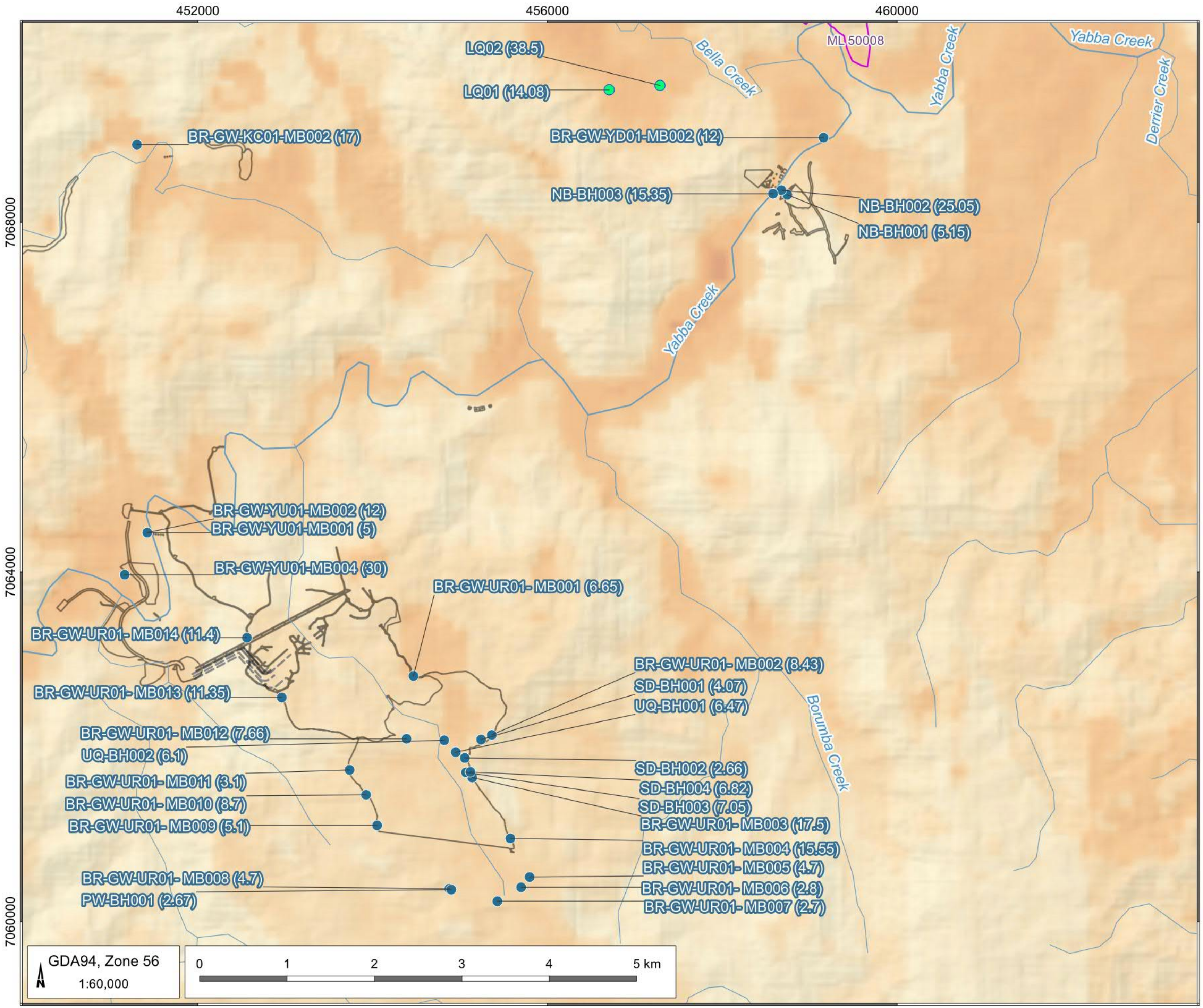

Borumba Dam Exploratory Works
EPBC Referral – GIA – Amendment
(BDP5001.004)

Depth to regolith

DATE
30/08/2024

AGE

FIGURE No:
5.5

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6 Hydrogeological Conceptual Model

The HCM is a description of how the groundwater system operates given the available data and is an idealised and simplified representation of the natural system. The HCM has been updated with a summary of the key findings of the 2023 / 2024 field investigations.

6.1 Hydrostratigraphic units

The key hydrostratigraphic units (HSU) controlling the transmission of impacts from the proposed Project activities to other surrounding units and which may be impacted by the development are outlined in Table 6.1. The HSU presented are based on the screened lithology of the monitoring bores.

Table 6.1 Hydrogeologic units

Rock Stratigraphic Unit	Hydro Stratigraphic Unit (HSU)	HSU ID	Type	Description (screened lithology)	Occurrence at Project
Quaternary Alluvium	Alluvial aquifer	AA	Unconfined, high permeability	Gravel sands	LR area
Amamoor Beds	Weathered Rock Aquifer	WRA - AB	Unconfined, low to moderate permeability	Rhyolite and metavolcanics	LR area
	Fractured Rock	FRA - AB	Unconfined, low permeability	Phyllite	LR area
Marumba Beds	Fractured Rock Aquifer	FRA - MB	Unconfined, generally low permeability	Phyllite	LR and UR areas
Mt Mia Serpentinite	Fractured Rock Aquifer	FRA - MMS	Unconfined, generally low permeability	Serpentinite	LR area
Tungi Creek Granodiorite	Weathered Rock Aquifer	WRA - TCGD	Unconfined, low to moderate permeability	Granodiorite	UR area
	Fractured Rock Aquifer	FRA - TCGD	Unconfined, generally very low permeability	Granodiorite	UR area

Figure 5.4 show the fault structures mapped within and around the Exploratory Works Project area. Fault zones with increased permeability can provide a pathway for leakage under a dam or a conduit which can propagate any groundwater drawdown where abstraction occurs. Conversely, fault zones could also be a barrier for groundwater flow if associated with lower hydraulic properties than the nearby geology.

The hydraulic testing results to date described in Section 6.2 do not show a discrete high permeability zone in the Exploratory Works Project, and as a result distinct hydrogeologic unit representing a faulted geological unit has not been conceptualised here. The proposed exploratory geotechnical holes will further investigate the occurrence of faulting at the Exploratory Works Project area.

6.2 Hydraulic properties

The numerical measure of a rock unit’s ability to store and transmit water is described as its hydraulic properties. The most common measure of hydraulic properties is hydraulic conductivity, measured in metres per day (m/d). Hydraulic conductivity values were calculated from the testing completed during the field investigations (as discussed in Section 3.1.3).

A summary of the range of the hydraulic conductivity values derived for each HSU is shown in Table 6.2. The wide range of measured hydraulic conductivity values reflects the heterogeneous nature of fractured rock groundwater systems, which is typical of fractured rock environments. Figure 6.1 shows a scatter plot of the hydraulic conductivity values plotted against depth of investigation.

The distribution of hydraulic conductivity values by HSU indicates:

- the data typically shows low hydraulic conductivity values for the Fractured Rock Aquifer, which is expected as groundwater occurrence is limited to secondary porosity, i.e. open fractures;
- the effect of weathering on these rocks is apparent, with average hydraulic conductivity values increasing in the Weathered Rock Aquifer; and
- overall higher average hydraulic conductivity values are observed in the shallow Alluvial Aquifer when compared with the often deeper and more competent Fractured Rock Aquifer.

Table 6.2 Hydraulic conductivity data for different hydrogeological units

Geology	HSU	Hydraulic conductivity (m/d)		
		min	max	average
Alluvium	AA	6.20×10^{-2}	1.18	4.74×10^{-1}
Amamoor Beds	WRA – AB	5.89×10^{-2}	-	5.89×10^{-2}
Amamoor Beds	FRA – AB	3.98×10^{-3}	-	3.98×10^{-3}
Granodiorite	WRA – TCGD	0.00×10^{00}	2.5×10^{-01}	2.11×10^{-02}
Granodiorite	FRA – TCGD	0.00×10^{00}	8.81×10^{-02}	6.73×10^{-03}
Phyllite	WRA - MB	6.37×10^{-03}	5.14×10^{-01}	1.04×10^{-01}
Phyllite	FRA – MB	4.17×10^{-03}	4.41×10^{-02}	1.32×10^{-02}
Serpentinite	FRA – MMS	2.57×10^{-2}	3.80×10^{-2}	3.19×10^{-2}

Note: metres per day (m/d).

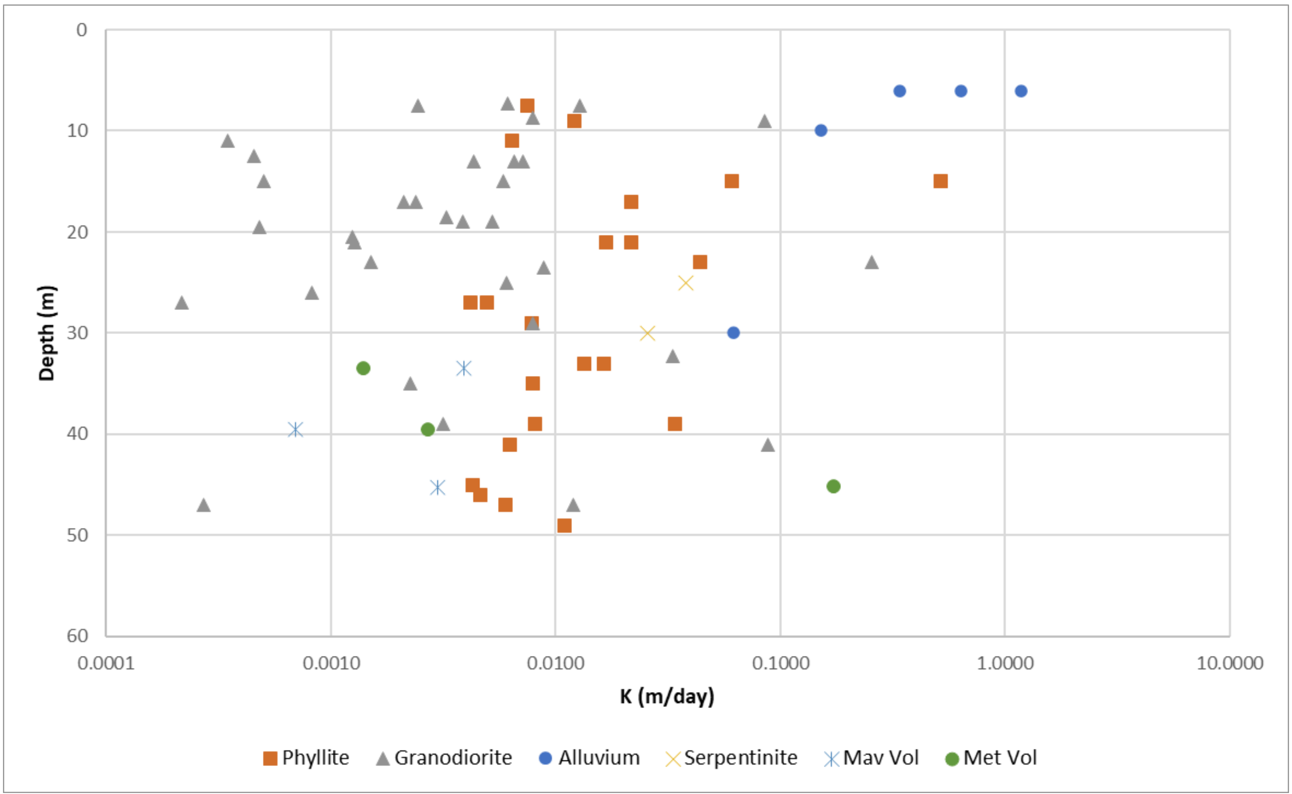

Figure 6.1 Scatter plot of hydraulic conductivity with depth

Specific storage (m^{-1}) measurement parameters can be estimated through laboratory core measurements or field pump testing, but actual values can be different by an order or magnitude or more. Rau, et.al, (2018) concluded that when a more complete consideration of poroelastic theory is considered the specific storage is limited to the range of 2.3×10^{-7} $m^{-1} \leq Ss \leq 1.3 \times 10^{-5}$ m^{-1}. The lower limit is derived from the poroelastic parameters of marble and the upper limit from materials where the grain size is smaller than that of fine sands, but where the adsorbed water fraction is small compared to the total water content.

This degree of uncertainty was addressed using uncertainty analysis during the numerical modelling assessment conducted by AGE in 2022. Furthermore, it is evident from the available data that hydraulic conductivity across the tested strata is relatively low and suggest overall low groundwater flow properties.

6.3 Groundwater recharge and discharge

Recharge was estimated using two different methods. The soil moisture balance method calculates the timing and magnitude of recharge events for the Exploratory Works Project area. This showed that diffuse recharge from rainfall to the alluvium in the Project area was estimated at an average rate of 138 millimetres per year (mm/y), or 12.2% of the annual rainfall (1,112 mm) (AGE, 2022). Recharge into the less permeable, clay dominant regolith is lower and is typically between 1 and 5% of annual rainfall and depends on the thickness and hydraulic properties.

The chloride mass balance (CMB) recharge method assumes that chloride is a conservative tracer that can derive the relationship between groundwater and precipitation. The site groundwater monitoring data and chloride rainfall observation data from regional datasets[9] was used in the CMB equation developed by Wood (1999) to determine the potential recharge rates within the Project area. The data indicates higher recharge rates in the LR area with a geometric mean of 3.00%, in comparison to the UR area with a geometric mean of 0.93% of average annual rainfall

Groundwater is primarily discharged to ground surface through evapotranspiration from vegetation, through localised springs and as baseflow seepage into the drainage lines around Borumba Dam. No known active groundwater abstraction currently occurs within the Project area.

6.4 Groundwater levels and flow

As discussed earlier in Section 3.1.3 several groundwater monitoring bores were installed between 2022 and 2024, and water level monitoring data became available during this period. Ongoing groundwater level monitoring is in progress.

The minimum, maximum and average water levels measured per HSU are summarised in Table 6.3. Daily[10] water level trend data for the proposed UR and LR locations are shown in Figure 6.2 and Figure 6.3, respectively. Graphs of the recorded manual dips per bore are provided in Appendix C.

[9] After Crosbie (2012) and Biggs (2004).
[10] Data provided for the period October 2023 to April 2024. More recent trend data will be provided in the Main Works EIS GIA report.

The following summarises the key findings:

- As shown in Figure 6.2 most boreholes in the proposed UR location area show consistently stable trends, with no significant response to rainfall, with the exception of bores UR01-MB007 and UR01-MB011. The lack of observed connection between rainfall and measured groundwater levels in some of the bores indicates that the deeper fractured rock aquifer is not vertically connected with the overlying weathered aquifer. Limited responses could also be attributed to rainfall does not infiltrate (e.g. canopy interception, sealed ground surface or steep slopes) or that the piezometer used to measure pressure response is not or only poorly hydraulically connected to the groundwater body. =
- Groundwater monitoring bores around the LR area are predominantly located along creek floodplains and observed groundwater levels range between 2.3 and 8.5 m BGL along Yabba Creek, Kingaham Creek and Sandy Creek. Deeper groundwater levels are measured within the Weathered Rock Aquifer and Fractured Rock Aquifer underlying the Alluvial Aquifer. Groundwater flow is controlled by topography, vegetation and weathering depths. A shown in Figure 6.3 the bores within the LR area indicate a strong response to rainfall, reflecting the shallow, unconfined environment. The trend data shows stable water levels in the drier months (October to mid-December 2023) and then a general increase in water levels with increasing volume and frequency of rainfall from mid-December 2023.

Table 6.3 Summary of groundwater level measurements per HSU

Geology	HSU	WL Depth (m BGL)		
		min	max	average
Alluvium	AA	2.3	8.5	4.3
Amamoor Beds	WRA – AB	8.0	36.9	22.7
Amamoor Beds	FRA – AB	2.6	3.6	3.0
Granodiorite	WRA – TCGD	3.3	15.0	9.8
Granodiorite	FRA – TCGD	0.8	27.2	14.2
Phyllite	WRA - MB	14.1	32.3	25.0
Phyllite	FRA – MB	2.1	8.3	4.9
Serpentinite	FRA - MMS	2.3	8.5	4.3

Notes: mBGL = metres below ground level.
HSU = hydrostratigraphic unit.
WL Depth = depth to water from ground surface.
FRA = fractured rock aquifer.
WRA = weathered rock aquifer.
MS = metasediments, GD = granodiorite.

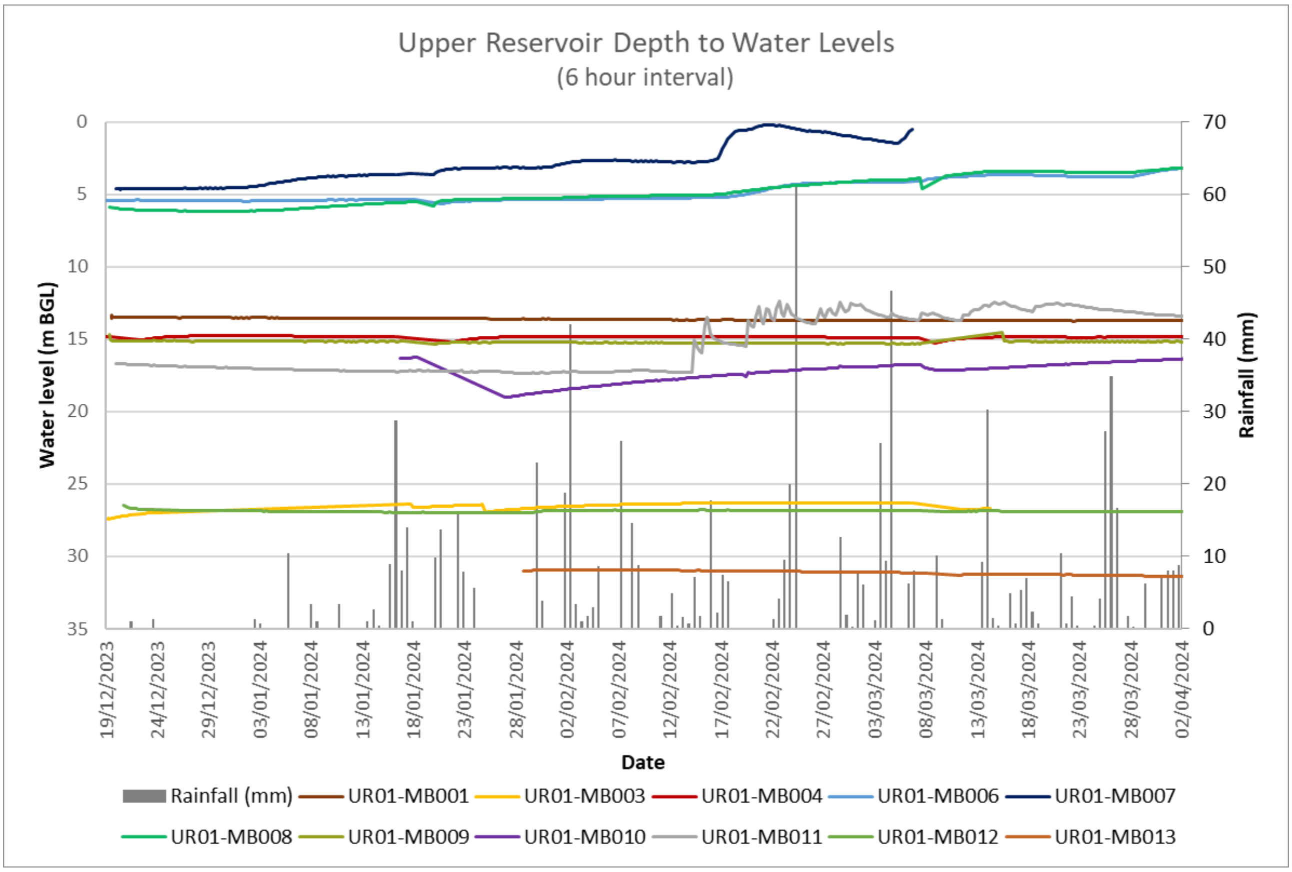

Figure 6.2 Daily groundwater hydrographs for the UR boreholes

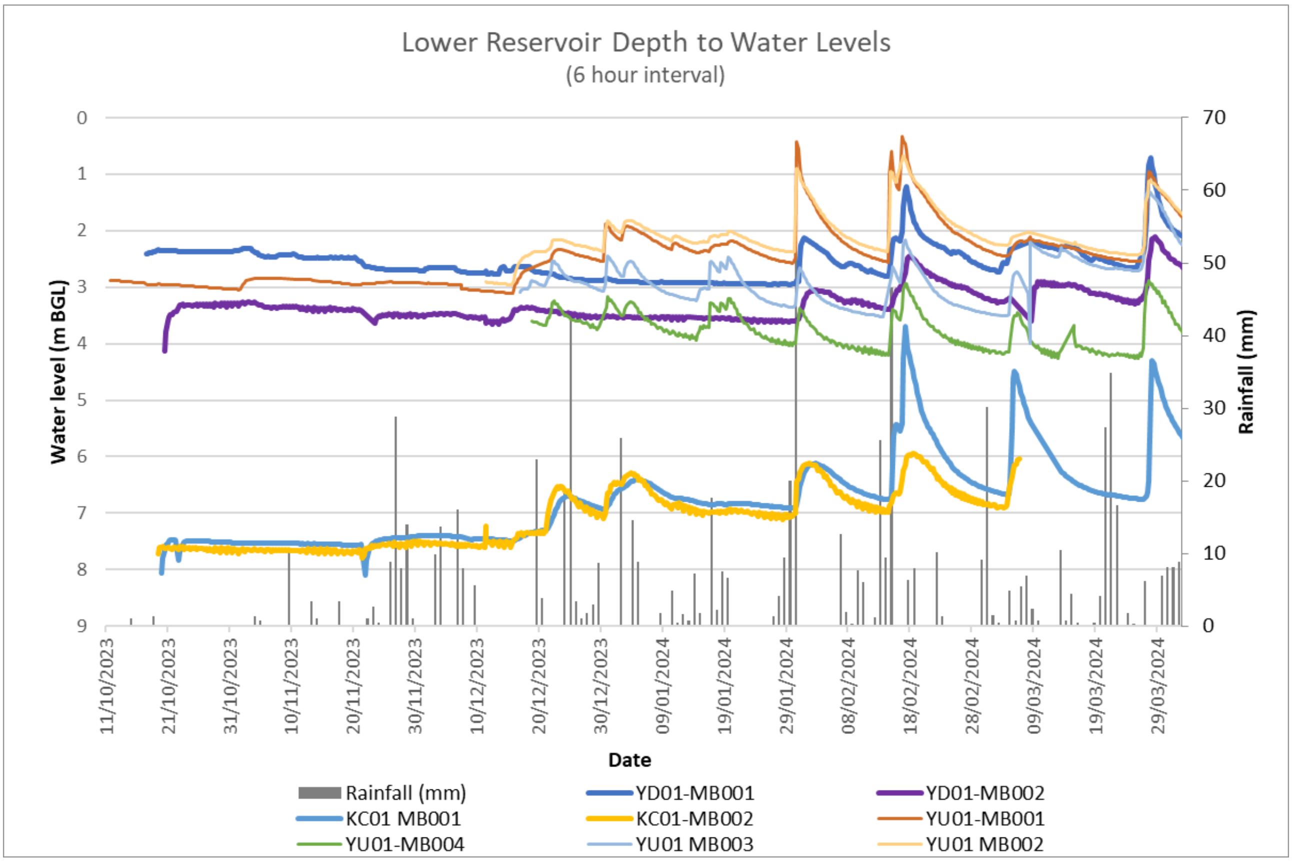

Figure 6.3 Daily groundwater hydrographs for the LR boreholes

6.4.1 Flow direction and movement

Based on the current available baseline monitoring dataset and noting the limitations of the spatial extent of monitoring, GW flow direction is interpreted to follow the general topography. It is likely, however, that movement will also occur along structural features with continuity of flow determined by fracture frequency, connectivity and orientation.

6.5 Groundwater quality

The land use in the surrounding areas is primarily forestry and recreation and Borumba Lake supplies drinking water and irrigation water as part of the Mary Valley irrigation scheme. As such the results were compared to the Mary River Valley Environmental Values, the ANZECC and the NHMRC guidelines, refer to Table B 1., Appendix B. Water quality trend graphs for each bore are provided in Appendix C. The following sections discuss these exceedances and their outcomes on functional use of the groundwater quality.

6.5.1 Monitoring data summary

Table 6.4 summarises the range of results observed across the site monitoring dataset that exceeded the guidelines listed above. The percentage of exceedances of the dataset are also provided in Table 6.4, to highlight parameters that have shown repetitive exceedances. Parameters that have exceeded the above guidelines in more than 50% of the dataset include TDS, chloride, ammonia, total nitrogen, total phosphorous, organic nitrogen, aluminium, iron, manganese and zinc.

Table 6.4 Water quality analysis summary

Parameter	Water quality data (Oct 2023 – July 2024)									
	Exceedance Range (mg/L)					Total exceedances (% of dataset)				
	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River
Physical Parameters										
pH	8.53 - 9.19	8.53 - 9.19	-	8.53 - 9.19	-	2	2	-	2	-
Total Dissolved Solids	-	-	-	617 - 2020	-	-	-	-	55	-
Major Ions										
Sulfate as SO_4	-	-	-	372	-	-	-	-	1	-
Chloride	-	44 - 810	-	252 - 810	-	-	86	-	35	-
Fluoride	-	1.1 - 84	2.5 - 84	1.8 - 84	-	-	15	7	10	-
Calcium	-	-	-	-	-	-	-	-	-	-
Sodium	-	-	-	197 - 477	-	-	-	-	27	-
Nutrients										
Nitrate as N	0.84 - 8.52	-	-	-	-	3	-	-	-	-
Ammonia as N	6 - 136	-	-	-	0.02 - 136	9	-	-	-	80
Total Nitrogen as N	-	-	-	-	0.4 - 69.2	-	-	-	-	83

Parameter	Water quality data (Oct 2023 – July 2024)									
	Exceedance Range (mg/L)					Total exceedances (% of dataset)				
	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River
Total Phosphorus as P	-	-	-	-	0.02 - 2.15	-	-	-	-	83
Organic Nitrogen	-	-	-	-	0.4 - 58.4	-	-	-	-	69
Reactive Phosphorus as P	-	-	-	-	0.01 - 0.22	-	-	-	-	21
Dissolved Metals										
Aluminium	-	-	-	-	-	-	-	-	-	-
Arsenic	-	-	-	0.012 - 0.082	-	-	-	-	14	-
Barium	-	-	-	-	-	-	-	-	-	-
Beryllium	-	-	-	-	-	-	-	-	-	-
Boron	-	-	-	-	-	-	-	-	-	-
Cadmium	-	-	-	-	-	-	-	-	-	-
Chromium	-	-	-	-	-	-	-	-	-	-
Cobalt	-	-	-	-	-	-	-	-	-	-
Copper	-	-	-	-	-	-	-	-	-	-
Iron	-	-	-	-	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-	-	-
Manganese	-	-	-	0.51 - 4.16	-	-	-	-	34	-
Mercury	-	-	-	-	-	-	-	-	-	-
Molybdenum	-	-	-	-	-	-	-	-	-	-
Nickel	-	-	-	0.021 - 0.122	-	-	-	-	6	-
Selenium	-	-	-	-	-	-	-	-	-	-
Strontium	-	-	-	-	-	-	-	-	-	-
Vanadium	-	-	-	-	-	-	-	-	-	-
Zinc	-	-	-	-	-	-	-	-	-	-
Total Metals										
Aluminium	0.06 - 306	-	5.73 - 306	0.22 - 306	-	77	-	16	51	-
Arsenic	0.014 - 0.26	0.261	-	0.014 - 0.261	-	16	1	-	16	-
Barium	-	-	-	-	-	-	-	-	-	-
Beryllium	-	-	-	-	-	-	-	-	-	-

Parameter	Water quality data (Oct 2023 – July 2024)									
	Exceedance Range (mg/L)					Total exceedances (% of dataset)				
	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River	Fresh Water Aquatic	Long Term Irrigation	Stock Water	Drinking Water	Mary River
Boron	0.38 - 0.41	-	-	-	-	3	-	-	-	-
Cadmium	0.0011	-	-	-	-	1	-	-	-	-
Chromium	-	0.107 - 0.973	-	0.051 - 0.973	-	-	5	-	12	-
Cobalt	-	0.133	-	-	-	-	1	-	-	-
Copper	0.016 - 1.1	0.237 - 1.1	1.1	1.1	-	15	2	1	1	-
Iron	-	0.22 - 332	-	0.34 - 332	-	-	83	-	70	-
Lead	0.004 - 0.22	-	-	0.068	-	17	-	-	1	-
Lithium	-	-	-	-	-	-	-	-	-	-
Manganese	1.93 - 18.4	0.208 - 18.4	-	0.105 - 18.4	-	9	60	-	86	-
Mercury	0.0012	-	-	-	-	1	-	-	-	-
Molybdenum	-	0.011 - 4.68	4.68	0.025 - 4.68	-		33	5	11	-
Nickel	0.012 - 0.84	0.248 - 0.84	-	0.021 - 0.84	-	35	2	-	27	-
Selenium	-	-	-	-	-	-	-	-	-	-
Strontium		-	-	-						
Uranium		0.013 - 0.03	-	0.019 - 0.03			5		4	
Vanadium		0.18 - 1.66	-	-			3			
Zinc	0.009 - 6.48	6.48	-	6.48		68	1		1	

6.5.2 Salinity, major cations and anions

To provide an overview of the typical salinity characteristics of the groundwater, the available data was compared to the Queensland Government released science notes about salinity classification ranges for water (Queensland Government, 2018).

6.5.2.1 Salinity

Salinity can be described by total dissolved solid (TDS) concentrations or electrical conductivity (EC[11]). TDS concentrations are commonly classified on a scale ranging from fresh to extremely saline.

- The water quality of the LR area monitoring bores is classified as freshwater, with TDS concentrations consistently smaller than 800 milligrams per litre (mg/L) (Queensland Government, 2018). However, based on the general limits for irrigation, some samples would have an impact on salt sensitive crops. This correlates with elevated chloride concentrations exceeding the long-term irrigation ANZECC guidelines.
- The quality of the UR area monitoring bores varies between freshwater and brackish water (Queensland Government, 2018). Most samples would have an impact on salt sensitive crops and several samples would impact moderately salt sensitive crops. This correlates with elevated chloride concentrations exceeding the ANZECC long term irrigation guidelines in all samples, and intermittently exceeding the NHMRC drinking water guidelines. Elevated sodium concentrations are also observed in several of these samples.
  - A comparison of the water quality of the UR and LR shows that the UR is characterised by more saline conditions with brackish water as a result of consistently higher TDS, chloride and sodium.
- None of the results indicate an impact to livestock.

6.5.2.2 Nutrients

In terms of nutrients, most samples showed low concentrations, with some exceptions observed.

- Ammonia, organic nitrogen, total nitrogen and total phosphorus concentrations typically exceeded the Mary River Valley guidelines, with a 69 to 83% exceedance rate. Total nitrogen and total phosphorus were only tested in samples taken from the LR. Reactive phosphorus exceeded the Mary River Valley guidelines in only 21% of samples. The majority of these exceedances were observed in samples taken from the UR bores.
- Water samples obtained from UR01-MB011 and UR01-MB013 have consistently elevated ammonia concentrations, ranging between 6 and 136 mg/L, exceeding the NHMRC drinking water and ANZECC fresh water aquatic guidelines.
- Nitrate as N was elevated in approximately 3% of samples in both the LR and proposed UR area.

6.5.2.3 Metals

Several metals were elevated above the ANZECC and NHMRC guidelines in most samples.

- Elevated concentrations of total aluminium, arsenic, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel and vanadium were observed in several groundwater samples obtained from monitoring bores in both the UR and LR areas. Elevated uranium was also observed in some groundwater samples obtained from monitoring bores located in the UR area.
  - Aluminium, iron and manganese were typically elevated at most sites, this is usually related to suspended material in the sample, particularly clay fines. All other metals were intermittently elevated.
  - Elevated arsenic was detected in several samples, in both the total and dissolved fraction. A recent contamination study undertaken by Aurecon (2024) looked at potential sources of contamination within the Project area. This study identified historical activities such as cattle dips, fire stations and mining through past aerial photography. Soil samples were collected around each of these areas and analysed for a range of contaminants including heavy metals and pesticides. Most sites did not return any evidence of contamination, however soil samples collected near one of the old cattle dips (present on site in 1951) indicated high levels of arsenic (up to 2300 mg/kg at 0.5 m depth) and zinc (up to 1400 mg/kg at 0.2 m depth). The pesticide DDT was also present, although this has not been included in any groundwater quality testing. Arsenic and DDT have historically been used at cattle dips as a tickicide.

[11] Electrical conductivity is a measure of the saltiness of the water and is measured on a scale from 0 to 50,000 µS/cm. Electrical conductivity is measured in micro siemens per centimetre (µS/cm).

  - This cattle dip is located near two sets of shallow and deep monitoring bores along Yabba Creek, namely YU01 MB001, YU01 MB002, YU01 MB003 and YU01 MB004. The data does not indicate contamination of the groundwater at these bores near the cattle dip (~220 to ~320 m from the source), however there may be localised contamination closer to the source.
  - Historical agricultural practices, such as use of pesticides, may influence the presence of metals in the LR area. However, given the distribution of contaminants of concern at the site with regards to known potential sources of contamination, it is more likely that these metals are a result of natural water-rock interaction. Especially given the consistency in elevated parameters between the upper and LR.
- A comparison of total and dissolved metal results show that most concentrations decrease significantly in the dissolved fraction. This confirms that the majority of total metals reported are attached to suspended materials in the water. However, elevated concentrations of dissolved arsenic, total chromium, manganese, and nickel were observed in some samples.

6.5.3 Groundwater type

Figure 6.5 displays the distribution and hydrogeochemical signature (type) of groundwater from the shallow aquifer and fractured rock aquifer derived from monitoring bores established at the LR. Similarly, Figure 6.7 display the distribution and hydrogeochemical signature of the granodiorite and metasediment WRA and FRA at the UR bores. The piper diagram determines the water type of each point by calculating the percentage dominance of cations and anions in each sample.

The following is observed:

- Most boreholes located around the LR area, representing both the Alluvial Aquifer and Fractured Rock Aquifer, indicate calcium-magnesium-bicarbonate type water. This typically indicates recently recharged groundwater.
  - There is a good correlation between the water type of the shallow and deeper groundwater, indicating similar processes influencing the water quality and suggesting a connection between the aquifers.
- Most of the monitoring bores with the UR area (screened in both Weathered Rock Aquifer and Fractured Rock Aquifer units) are classified as sodium-potassium-chloride type. This typically indicates changed rainfall recharge or reduced recharge properties.
  - Several monitoring bores within the UR area (screened in both Weathered and Fractured Rock Aquifer units) are classified as mixed type. This is a combination of the two types mentioned above.
  - The monitoring bores within the metasediments (Fractured Rock Aquifer) tend to show a more dominant sodium type, whereas the boreholes in the granodiorite (screened in both Weathered and Fractured Rock Aquifer units) range between mixed and sodium.

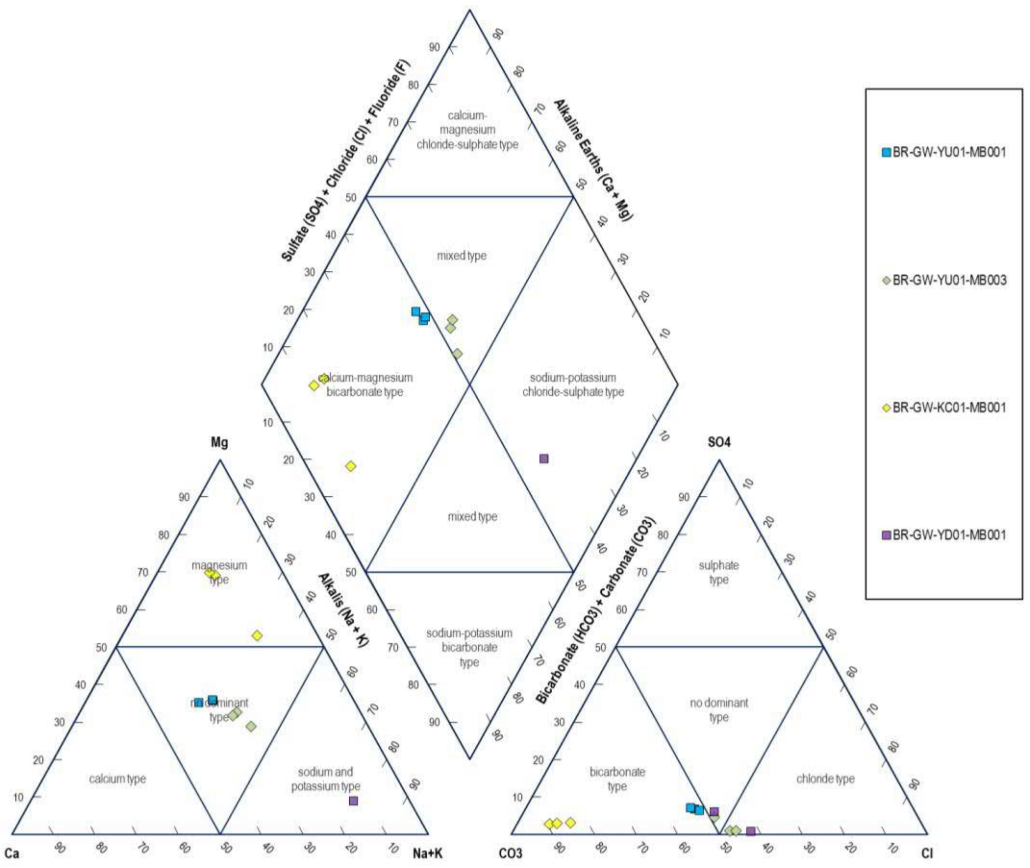

Figure 6.4 Piper diagrams for LR boreholes in the shallow aquifer (AA)

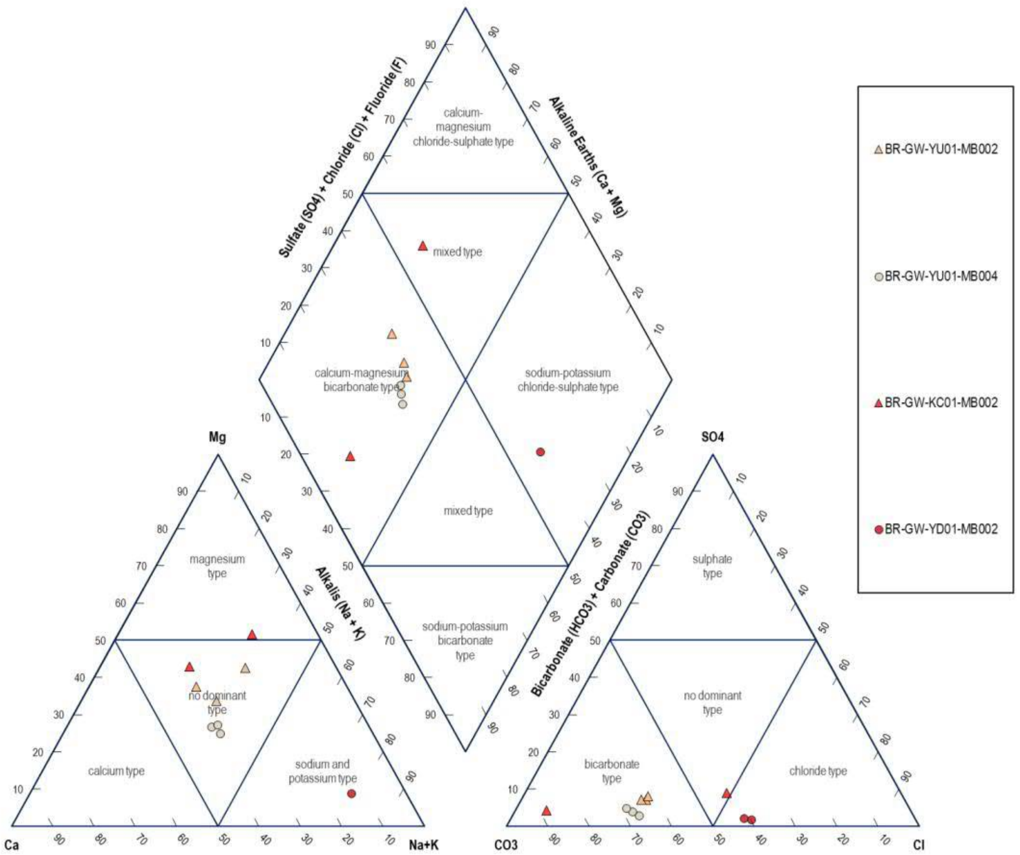

Figure 6.5 Piper diagrams for LR boreholes in the FRA

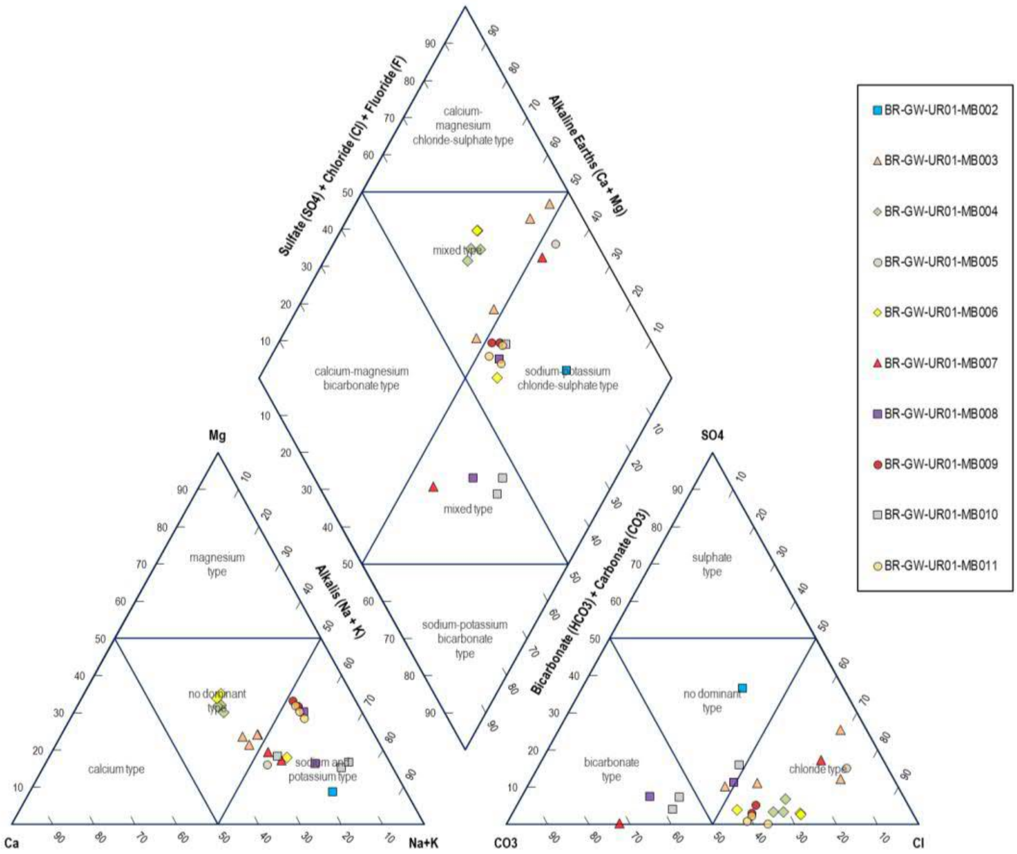

Figure 6.6 Piper diagrams for UR boreholes in the granodiorite (WRA/FRA – TCGD)

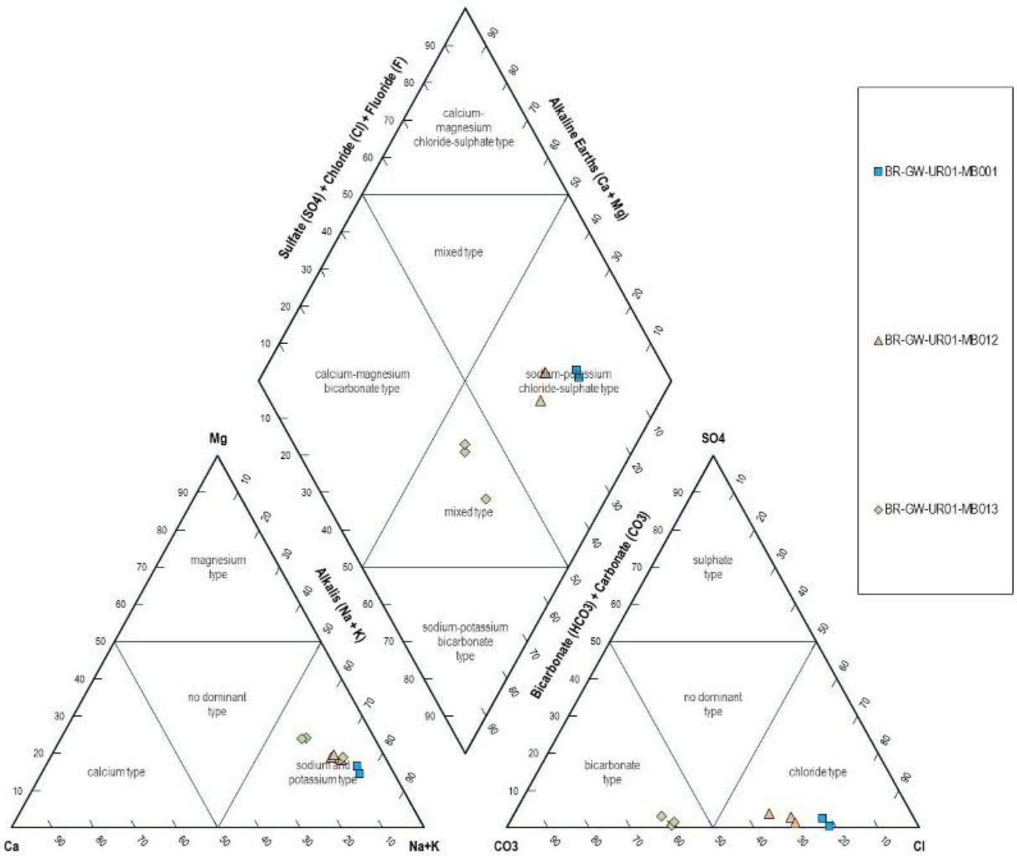

Figure 6.7 Piper diagram for UR bores in the phyllite (FRA-MB)

6.6 Geochemistry

Soil and rock samples were tested during the previous geotechnical assessment to assess the potential for acid mine drainage (Queensland Hydro, 2023). A total of 20 samples, collected from nine locations, were analysed for net acid generation (NAG) potential and net acid production potential (NAPP). Results were compared with the Commonwealth of Australia (2016) screening criteria.

The results showed a low acid forming potential with negative NAPP results and NAG results with a pH above 4.5 in all samples.

6.7 Groundwater Use

6.7.1 Bore census

A search of the Queensland Groundwater database[12] was conducted to identify the locations of any registered bores within the Project catchment. The search showed that there are no private registered bores in the Lake Borumba catchment. A total of 38 registered bores were recorded in the groundwater database in the downstream sub catchment between Lake Borumba and Imbil, shown on Figure 6.8. Of these bores, 26 are existing sub artesian wells and 12 are listed as abandoned and destroyed. The majority of the existing bores are located in the Imbil area or northeast of Imbil, approximately 10 km north east of the Project area.

6.7.1.1 Field verified bores in the Project area

The field bore census targeted private properties within the Project area. As shown on Figure 6.8, 25 locations or properties were identified by Queensland Hydro within this target area for further investigation. These properties were primarily located along Bella Creek Road and Yabba Creek Road. These landowners were contacted by QLD Hydro in February 2024, the following summarises the outcome of that survey:

- 12 landowners confirmed that there are no bores on their property.
- six properties could not be accessed, either due to no response from the landowner or restricted access. Three of the registered bores that are listed as existing 'sub artesian facilities' are located on these properties. As such, the specific groundwater use of the existing bores (e.g. stock, irrigation, domestic) and demand volumes remain unknown.

One landowner confirmed that two bores had been drilled on his property by Queensland Hydro, however these have since been decommissioned. A conversation with the landowner confirmed that locals in the area typically rely on surface water (from dams or creeks) for stock watering or irrigation needs.

6.7.2 Environmental use

6.7.2.1 Springs

A review of the QLD Open Data Portal Springs Database[13] and the QLD Wetlands Information website showed no springs mapped within the Project area.

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[12] https://qldglobe.information.qld.gov.au/ AND https://water-monitoring.information.qld.gov.au/

[13] https://www.data.qld.gov.au/dataset/springs.

AGE were engaged to undertake a spring survey as part of the EIS investigation. Site visits were undertaken between 31 October and nine November 2023 and between four to eight March 2024. The survey mostly covered areas within and surrounding the proposed UR area and a few areas along Bella Creek Road on private land north of the Borumba Lake (LR). Springs visited in 2023 / 2024, shown on Figure 6.9, have been provisionally characterised based on several descriptors including a) geomorphology, b) structural settings, c) source aquifer, d) landform location and e) spring flow. These has allowed the identification of four spring types including:

- The rheocrene springs on the upper plateau of the Upper Reservoir, on the valley floor and along hillslopes, are most likely recharged ephemerally during periods of higher rainfall. These springs seep due to the low permeability from open fissures of rock outcrops in joints or fractures, at lower elevations of the recharge point originating from the crystalline bedrock or at contacts with saprolite and bedrock.
- The hillslope depression springs on the upper plateau of the Upper Reservoir featuring most predominantly down gullies and drainage lines which are potentially sourced from unconfined groundwater in scoured colluvium or alluvium re-entrants along the escarpment towards the Lower Reservoir at gradients 15º to 60º.
- The helocrene springs in the Upper Reservoir which occur within depressions between interfluves in the valley floor as well contact between colluvium or alluvium aquifers, most notably in the southern end of the proposed Upper Reservoir adjacent to Yielo Road towards the Queensland Hydro entrance as well as along low gradient sections of hillslopes and escarpments, primarily on the valley floor in the Lower Reservoir. Flow can emanate from low permeability fissures from outcropping crystalline bedrock or from stratigraphic contacts in valley floors. These springs predominantly appear as seeps with persistent saturated fine sediment or soil post-rainfall. With subaerial or diffuse emergence, lentic flow conditions predominate.
- Limnocrene springs were observed exclusively near Bella Creek adjacent to the Lower Reservoir where the emergence of discharged water is collected in artificial basins forming lentic ponds and are positioned at higher elevations in association with Groundwater Dependent Ecosytems. Discussions with local landowners indicate a reliance on spring fed dams in the LR locality.

6.7.2.2 Aquatic, terrestrial and aquatic GDEs

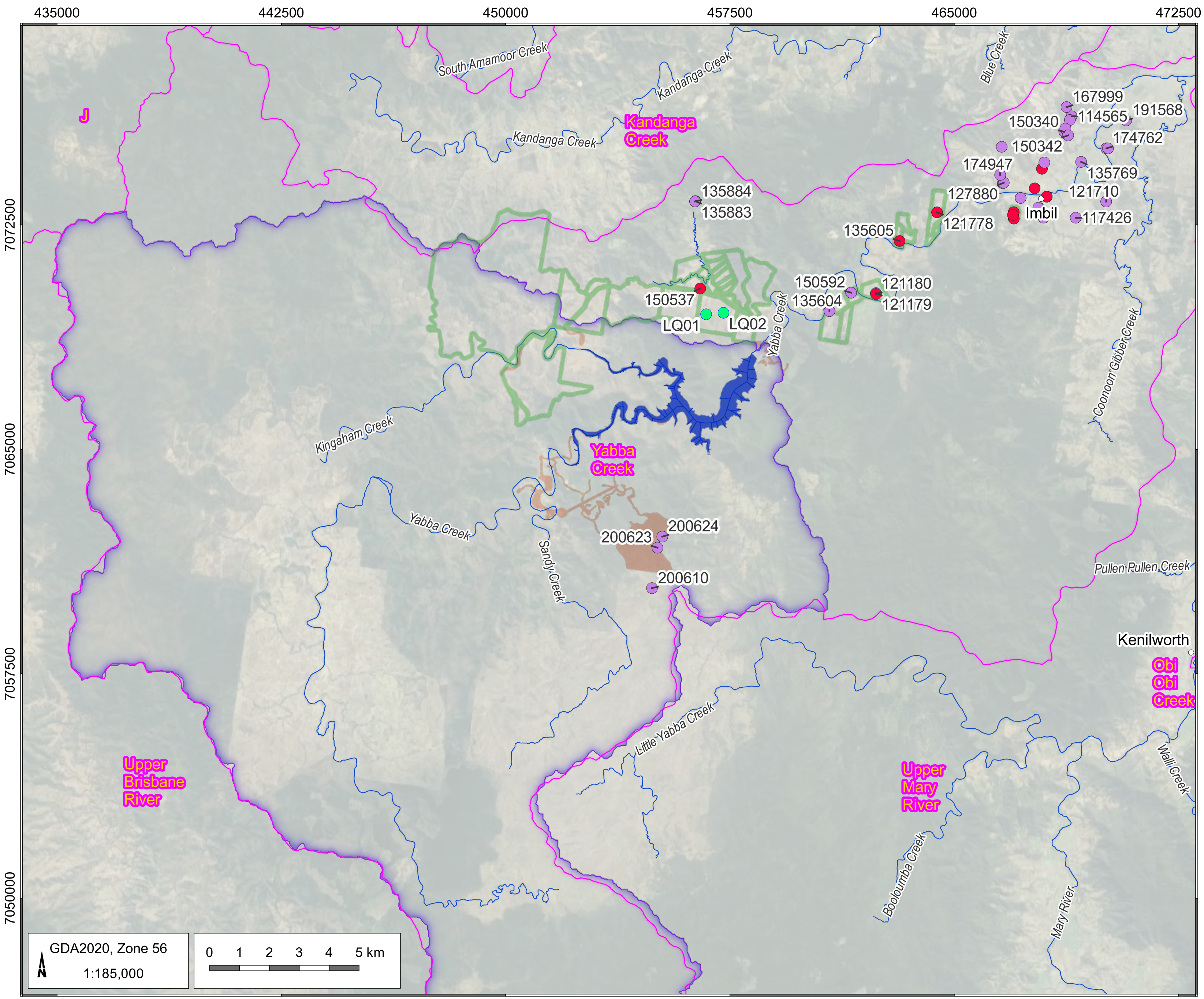
GDEs are defined as ecosystems that rely in some part for their survival on groundwater. Groundwater dependence can range from obligate to opportunistic, particularly during times of drought. Potential GDE occurrence[14], Threatened Ecological Communities (TECs)[15] and Matters of State Environmental Significance (MSES) are shown in Figure 6.9.

[14] Mapped in the Bureau of Meteorology's GDE Atlas. The Atlas shows known and potential GDEs and is the most comprehensive inventory of the location and characteristics of potential GDEs in Australia (http://www.bom.gov.au/water/groundwater/gde/map.shtml).
[15] TECs mapped by Umwelt, shapefile provided to AGE on 28/08/2024.

Potential GDEs, TECs and MSES identified were as follows:

- Moderate potential aquatic GDEs associated with Lake Borumba, Yabba Creek, Kingaham Creek, Mujimba Creek, Ante Borgan Creek and Sandy Creek. These are all classed as Riverine GDEs which potentially require access to groundwater on a permanent or intermittent basis.
  - Note: no exploratory activities are located within the reaches of Kingaham Creek, Mujimba Creek or Ante Borgan Creek.
- Overall, the Exploratory Works Project area is dominated by Low to Moderate potential terrestrial GDEs.
- High potential terrestrial GDEs are largely associated with the upstream sections of Yabba Creek and the areas directly north of the proposed underground tunnel (about halfway through and towards its deepest section). In terms of the MNES discussed in Section 1.1.1, only two Threatened Ecological Communities (TECs) were identified during recent specialist site visits and are plotted on a more zoomed in version of Figure 5.3. As shown on this map, the identified TECs largely correlates with the high potential GDEs depicted in Figure 6.9.There are also two TECs associated with the western side of Sandy Creek, located west of the proposed spoil area and staging pad area.
- High potential terrestrial GDEs are also mapped across drainage lines and the southern section of the access roads associated with the upper reservoir area.
- A MSES high ecological significance wetland occurs southwest of the proposed tunnel portal area, consistent with the TEC mapped in this same area. Apart from this, riverine wetlands are mapped along Sandy and Yabba creeks.

The GDE Atlas does not identify any subterranean GDEs in the Study area. The occurrence of GDEs is only mapped as potential occurrence and requires field confirmation by ecological surveys.



LEGEND

- Populated place
- 2024 bore census
- Drainage

Registered bores with model boundary

- Abandoned and Destroyed
- Existing

- Properties included in survey
- Lower Reservoir (Current FSL 135.01 m AHD)
- Exploratory Works Site Layouts
- Subcatchments
- Borumba dam catchment

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Registered bores

DATE
30/08/2024

AGE

FIGURE No:
6.8

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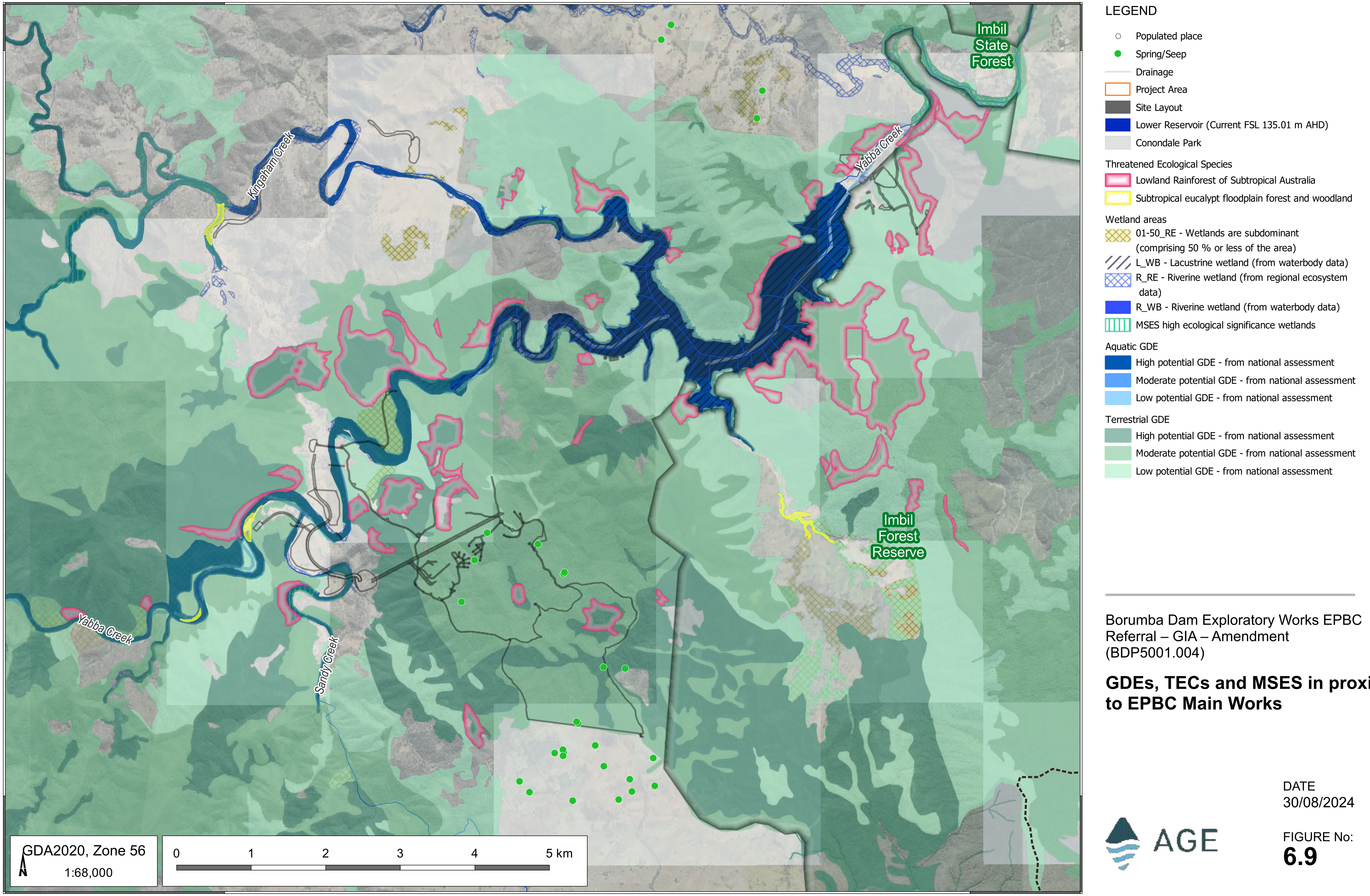

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

GDEs, TECs and MSES in proximity to EPBC Main Works

DATE
30/08/2024

AGE

FIGURE No:
6.9

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7 Causal pathway and receptors

A causal pathway is defined in this assessment as the logical chain of events either planned or unplanned that link aspects of the Exploratory Works to groundwater-dependent values or assets. Surface waters may also be impacted where they are in connectivity with the groundwater system.

The proposed subsurface exploratory works (tunnel) will involve dewatering and interference of groundwater within the fractured bedrock. This can potentially cause groundwater drawdown and change in groundwater quality in its immediate vicinity. The key groundwater issues that are considered to warrant elaboration in the following sections of this report include:

- the impact of drawdown associated with the exploratory tunnel and groundwater supply bores on receptors (refer to Section 8);
- potential contamination of the aquifer from the use of explosives (associated with the proposed excavation method) and due to oxidation within the tunnel during tunnel development; and
- poor quality leachate from spoils, stockpile materials (cementitious material and fly ash), ablution facilities, fuel storage tanks and explosives.

7.1 Cause

The construction phase of the exploratory tunnel is expected to have the most significant potential impact on the groundwater environment. As the tunnel progresses, dewatering of the surrounding aquifer unit(s) will occur which may result in drawdown of the local groundwater levels as well as potential release of contaminants as a result of exposure of the bedrock to oxygen. Oxidation of minerals within the bedrock, mixing with seepage at the rock face, can result in hydro chemical changes and the production of contaminated water.

Daily pumping of two groundwater supply bores to supplement the civil works in periods of shortened supply, with a maximum yield of 140 ML per annum. During abstraction, dewatering of the surrounding aquifer will occur which will result in drawdown of the local groundwater levels.

7.2 Pathway

The connectivity pathway between the Exploratory Works and the receptors is predominantly through the hydrogeological system as described in the HCM. Conceptualisation, using analytical models and SeepW cross sections, of the impact of the Exploratory Works tunnel and groundwater supply bores along the flow paths is analysed in more detail in Section 8. Impacts to threatened ecological communities via potential lowering of groundwater levels would be regarded as an indirect impact, because groundwater serves as a potential impact pathway between Exploratory Works Project activities and the relevant MNES.

Based on the available information the following provisional conclusions regarding the hydrogeological system, or the pathway, can be made:

- Primary groundwater receptors are aquatic and terrestrial GDEs:
  - Large areas of potential GDEs are mapped within Project area and surrounds, however these are predominantly classed as low to medium potential.
  - As indicated in Section 6.7, TECs are mapped directly north of the tunnel area, west of the spoil and staging pad areas (but west of Sandy Creek) and in the southern reaches of the upper reservoir area.
- Registered groundwater bores are not considered to be potentially affected receptors during the Exploratory Works:
  - Most registered groundwater users are downstream, close to Imbil, with only three registered groundwater users within 5 km of the Exploratory Works Project and no users within 5 km of the tunnel.
  - Groundwater is expected to be used only for small scale domestic use such as gardening or limited stock.

- Additional data is currently being gathered to inform the HCM, EVs and WQOs of groundwater:
  - Several geological lineaments have been mapped at the surface along the length of the tunnel which may indicate the presence of significant geological structures below surface, which could act as aquitards or zones of preferential flow. The presence of faults or dykes will need to be confirmed through future drilling.
  - Groundwater level data collected for the alluvium upstream of Lake Borumba (Sandy Creek and Yabba Creek) shows that the alluvium is saturated. The groundwater impact pathway is expected to primarily occur through the fractured rock aquifer but may impact the alluvial aquifer close to the tunnel portal and surrounding the groundwater supply bores.
- The Yabba Creek section downstream of the existing dam is affected by water releases by Seqwater and so is not solely reliant on groundwater. This is also supported by the observed relative deep groundwater levels and the unlikely connection between groundwater and surface water.

7.3 Receptors

The main groundwater dependent receptors associated with the Exploratory Works include:

- TECs noted in Section 1.1.1. They have been assumed to be groundwater dependent for this assessment.
- Aquatic GDEs, specifically Yabba Creek, Sandy Creek and Lake Borumba.
- Terrestrial GDEs. The presence of this receptor and groundwater dependency needs to be confirmed by the ecological studies. The tunnel is overlain by low potential GDEs.
- Registered groundwater bores according to the Queensland Groundwater Database. Limited groundwater users exist in the Study area and no groundwater users exist within a 5 km radius of the proposed underground exploratory works. As such, consideration of registered bores is retained in this assessment only as a conservative precaution.

The areas affected by groundwater drawdown will have reduced water availability where the:

- groundwater table is lowered resulting in reduced water yields in registered bores;
- groundwater table is lowered beyond the depths required for GDEs; and/or
- groundwater table is lowered resulting in reduced groundwater connectivity with Sandy Creek or Yabba Creek, which in turn decreases baseflow.

8 Conceptualisation of Groundwater Impacts

For this assessment of potential groundwater impacts, analytical and cross-sectional Seep/W models have been developed to enhance the understanding of the potential range of groundwater behaviour in responses to exploratory works infrastructure qualitatively. The section below include insight from previous numerical models and recent analytical and section models. In summary, a map is provided towards the end of this section providing expected ranges of drawdown based on this qualitative approach.

A more detailed three-dimensional numerical groundwater model is in progress and will be used to predict groundwater drawdown for the Main Works Groundwater Impact Assessment and Exploratory Works underground infrastructure quantitatively.

8.1 Tunnel assessment

As indicated in Section 2.3, two tunnel options are considered, the original FEED design (Option 1) of approximately 2 km length and a new alternative design (Option 2) of approximately 950 m in length.

8.1.1 Groundwater inflow

As the construction and calibration of the EIS updated numerical groundwater model is still in progress during the writing of this report, a series of analytical and section numerical models were applied to calculate and estimate the likely range of groundwater inflow and the likely radius of potential influence that the Exploratory Works Project may have.

8.1.1.1 Previous numerical modelling

Preliminary predictive numerical modelling was undertaken by AGE in 2022 to assess the potential impacts of the Borumba PHES Project on the local and regional groundwater regime and its risks to groundwater values as part of the early investigations. The same model results have been used to undertake this risk assessment for this Exploratory Works Project and to infer likely groundwater flow changes due to the tunnel exploratory works. The following assumptions and limitations exist:

- the alignment of the tunnel was updated slightly and therefore different from what was used in the AGE, 2022 numerical groundwater model.
- as indicated in earlier (Section 2), the tunnel portal will be located directly east of Sandy Creek and initially intersects hornblende-biotite granodiorite and then progresses through the Marumba Beds.
- it is expected that the slight alignment change will not result in significant changes in predicted groundwater inflow, due to similar tunnel dimensions and depth. However, the duration of dewatering associated with the Exploratory Works will be limited to 2 to 3 years as opposed to the long-term dewatering duration used in AGE (2022).
- higher groundwater inflows are expected along the upper weathering zone in the initial granodiorites and where connected fractures are intersected. This degree of detail has yet been quantified and collecting data required for an updated assessment is the reason for the exploratory works.

The numerical model is preliminary in nature and is subject to ongoing development. Model prediction results discussed below provide a range of results reflecting the model uncertainty.

Tunnel inflow rates

The predicted range of groundwater inflows into the subsurface infrastructure (AGE, 2022) is represented by the probability scenarios P5, P50 and P95. The occurrence of very high (P95) or very low (P5) inflows are very unlikely scenarios which require combinations of parameters that are at extremes of those randomly explored in the numerical model. The predicted peak inflow rates are provided below.

- the 95th percentile peak is 1,700 cubic metres per day (m^3/day) or 425 m^3/day/km (5 L/s/km);
- the 50th percentile peak is 940 m^3/day or 234 m^3/day/km (2.7 L/s/km); and
- the 5th percentile peak is 500 m^3/day or 125 m^3/day/km (1.4 L/s/km).

However, these predictions do not consider the potential influence of the drill and blast method on the hydraulic conductivity of the surrounding rock (i.e. to increase the flow properties in a zone and potentially increase connectivity between flow zones or hydrostratigraphic units). They also do not consider any inflow control measures that will be implemented during construction (refer to Section 9.1.1).

8.1.1.2 Analytical Methodology

The component of diffuse inflow was also estimated from an analytical solution by adopting a simple representation of the hydrogeologic setting. The steady state inflow per unit length of the tunnel (QO) can be estimated as shown in Equation 1 (Goodman et. al., 1965).

$$Qo = 2\pi KHo/2.3\log\left(\frac{2Ho}{r}\right)\ (2)$$

Where:

K	=	*bulk hydraulic conductivity of bedrock represented as a homogeneous isotropic unit*
HO	=	*depth of the tunnel below the water table*
R	=	*radius of the tunnel*

To represent more complex geological situations at an actual site in a flexible way, numerical approaches that can account for spatially distributed hydraulic properties and boundary conditions (BCs) are necessary.

Assumptions and limitations

- Bulk hydraulic conductivity ranges were used for 5 different depth zones:
  - 0.1 to 0.01 m/day for near-surface strata;
  - 0.05 to 0.001 m/day for weathered bedrock; and
  - 0.005 to 0.0001 m/day for fresh bedrock.
- The tunnel will enter weathered rock with potentially shallow groundwater and then progress into fresh bedrock.
- The range of hydraulic conductivity used may also allow for localised fracturing.

Groundwater inflows

Unmitigated inflow rates were calculated as described above for three depth zones, as indicated in Figure 8.1. Groundwater inflow per 1 km of tunnel development ranges from >20 L/s to 0.05 L/s for the weathered material, 12 to 0.72 L/s for the intermediate bedrock and 12 to 0.4 L/s for the deep bedrock. The predicted groundwater inflow rates, calibrated for the length of tunnel assumed to intersect the three depth zones, are summarised in Table 8.1.

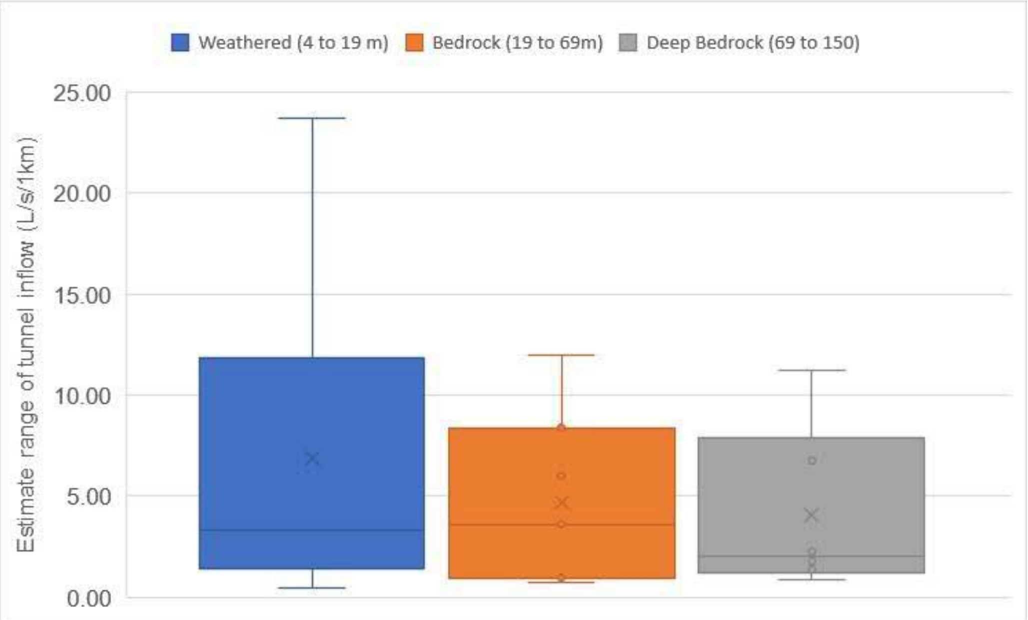

Figure 8.1 Predicted groundwater inflow range per 1 km of tunnel development

Table 8.1 Summarised predicted tunnel inflow rates

Method	Hydro Stratigraphic Unit	Approximate tunnel length (m)	Minimum inflow per length of tunnel (m^3/day)	Maximum inflow per length of tunnel (m^3/day)
Analytical model predictions	Weathered (WRA)	50	0.1	86
	Intermediate Bedrock (FRA1)	800	50	830
	Deep Bedrock (FRA2)	150	5	156
	Sum Range ((m^3/day/km)		55	1072

8.1.1.3 Summary

Predictions from the previous numerical model (AGE, 2022) estimate groundwater inflow rates to range between 125 and 425 m^3/day/km of tunnel progression and the analytical model provides a predicted range of between 55 and 1,072 m^3/day/km (mean of approximately 500 m^3/day/km). Two options for the exploratory tunnel have been proposed, tunnel option 1 is approximately 2 km and tunnel option 2 is approximately 800 m in length. The alternate tunnel option 2 is therefore expected to have a smaller impact as total inflow rates will be approximately half that of tunnel option 1. The reason for the higher range from analytical calculations is because it included higher hydraulic conductivity ranges from where the portal and tunnel enters through the shallow weathered zone where more inflow expected.

Although the numerical and analytical assessments provide a wide range of potential inflows, it should be noted that groundwater inflow management plans will be implemented to ultimately mitigate flow to 173 m^3/day (2 L/s) per 1 km of tunnel development. This upper limit for inflow management is not based on the predicted rates of groundwater inflow but are driven by:

- potential impact of tunnel drainage on the groundwater table and environmental receptors;
- technical feasibility and economics of reducing inflows below the limit by post grouting; and
- constraints in excess water management.

8.1.2 Estimated zone of influence

As the 3D numerical groundwater model is still under development during the preparation of this report, SEEP/W and analytical models were employed to assess the impact of portal and tunnel construction on the groundwater table.

8.1.2.1 Section model – Fractured Rock Aquifer

This assessment utilised a SEEP/W model cross-section to represent drawdown within the deeper Fractured Rock Aquifer. Figure 8.3 illustrates the cross-section location in the SEEP/W model relative to the tunnels.

The fractured zone's hydraulic conductivity is set at 0.0001 m/day. A constant recharge rate of 35 mm/year is applied across the model domain. Boundary conditions include constant head boundaries at the left and right sides of the model, each set 5 meters below the ground surface. Rivers and tunnels within the model are assigned a zero-pressure head to simulate free-draining conditions.

Figure 8.4 illustrates the SEEP/W results which examines the area before and after the tunnel construction in the deeper FRA. The simulation results indicate that the groundwater impact is localised in this area, with the zone of influence largely limited to the immediate vicinity of the tunnel. Based on our current understanding of the deeper geological formation in this section the deeper rock is characterised by low permeability and reduced fracturing. The rock in this area is more consolidated, with fewer fractures and lower porosity, which restricts the movement of groundwater. As a result, the extent of groundwater drawdown is limited, and the changes in the water table are limited to a small radius around the tunnel. This localised impact is indicative of the reduced ability of groundwater to move through less permeable and less fractured rock, highlighting the importance of geological conditions in determining the scale and severity of groundwater impacts due to tunnel construction.

8.1.2.2 Analytical model – Weathered Rock Aquifer

Groundwater inflow into the proposed portal/platform and shallow end of the tunnel during the construction phase was assessed using the analytical method developed by Marinelli and Niccoli (2002)[16] that provides first order estimates of steady-state inflow and drawdown in a homogenous material mass. The analytical method of Marinelli and Niccoli requires a simplification of the hydrogeological environment and is used to provide a 'broad' range of potential drawdown and inflow. The equations calculate groundwater inflow from the basement side walls and the base of the basement separately, based on the conceptual model presented in Figure 8.2.

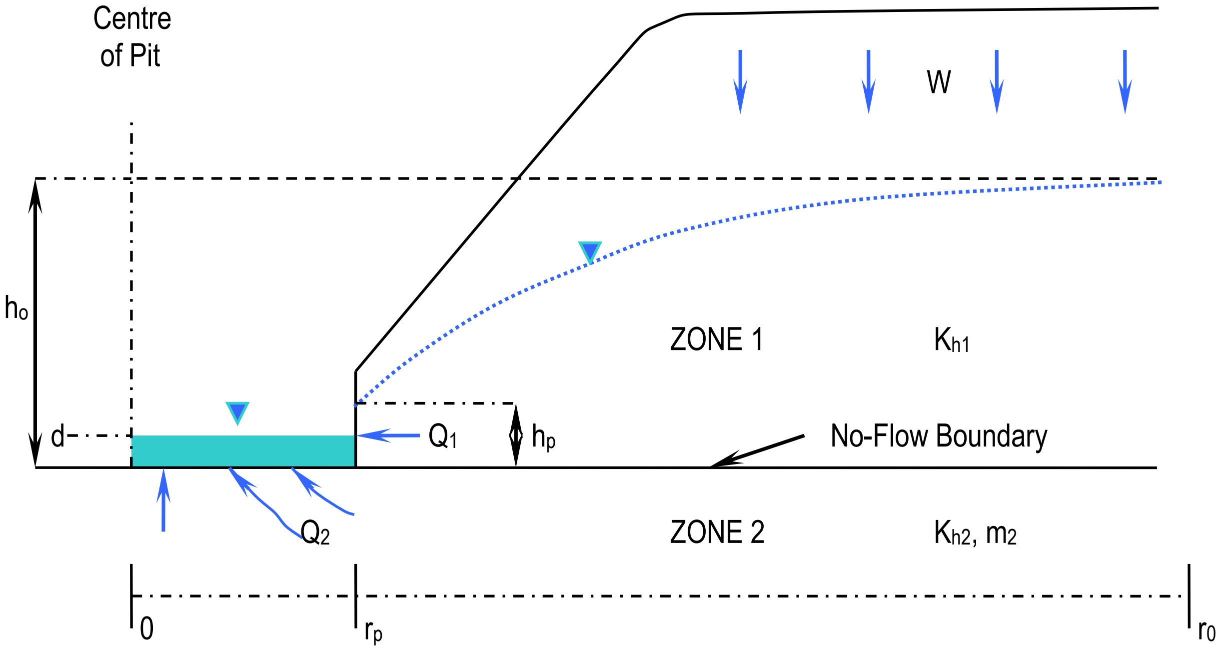

Figure 8.2 Pit Inflow Analytical Model (after Marinelli and Niccoli [2000])

Groundwater inflows are calculated for Zone 1 and Zone 2 using the following equations:

Zone 1: $$Q_1 = W \pi (r_o^2 - r_p^2) \qquad m^3/day$$

Zone 2: $$Q_2 = 4 r_p \left\langle \frac{K_{h2}}{m_2} \right\rangle (h_o - d) \qquad m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

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[16] Marinelli F and Niccoli W.L., (2000), "Simple Analytical Equations for Estimating Groundwater Inflow to a Mine Pit", Groundwater Vol. 38 No. 2, pp311-314.

The extent of drawdown due to the nett groundwater inflow then allows determination of the radius of influence on the water table by iteration from the following equation:

$$h_0 = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left[r_o^2 \ln\left(\frac{r_o}{r_p}\right) - \frac{(r_o^2 - r_p^2)}{2}\right]}$$

Where:

kh1	hydraulic conductivity value for the aquifer in Zone 1
ho	saturated thickness of aquifer
W	rainfall recharge rate
hp	the height of the aquifer seepage face in the open excavation
rp	equivalent radius of pit as a cylinder
Kh2	horizontal hydraulic conductivity value for the aquifer in Zone 2
kv2	vertical hydraulic conductivity values for the aquifer
d	depth of water level in base of pit

Table 8.2 provides a summary of the model input parameters and the model assumptions, which include:

- Natural variations in the permeability are likely to occur due to the variations in the upper weathered zone and deeper fractured rock zone. For this reason, and to assess the potential range of inflow rates to the proposed portal highwall area, the model was run using both estimated and upper range permeability estimates.
- The portal's highwall will be approximately 30 m high at its deepest point, where the tunnel excavation will start.
- To support the excavation of the basement, the standing groundwater level will need to be lowered from its current level (194 m AHD) to approximately 1 meter below the bulk excavation level (165 m AHD).
- This hydrogeological assessment applies steady-state conditions for the preliminary inflow calculations and represents the worst case. Transient numerical model applications are in progress for a more detailed assessment.

Table 8.2 Summary of model input parameters

Parameter		Parameter value
k_{h1}	- hydraulic conductivity for zone 1	0.1 to 0.04 m/day
k_{h2}	- hydraulic conductivity for zone 2	~0.04 to 0.004 m/day
k_{v2}	- vertical hydraulic conductivity zone 2	equivalent to k_{h2}
h_o	- saturated thickness	5 to 25 m
W	- rainfall recharge to aquifer	2 % of annual rainfall
h_p	- the height of seepage face in the excavation	1 m
r_p	- equivalent radius of basement as a cylinder	80 m
d	- depth of water level	4 m

Zone 1: The analytical solution for Zone 1 considers steady-state, unconfined, horizontal radial flow, with uniformly distributed recharge (from rainfall) at the water table. The solution additionally assumes:

- that groundwater flow is horizontal. The Dupuit-Forchheimer approximation (McWhorter and Sunada 1977) is used to account for changes in saturated thickness due to depression of the water table.
- the static water table is approximately horizontal.
- uniform distributed recharge occurs across the site as a result of surface infiltration. All recharge within the radius of influence (cone of depression) of the pit is assumed to be captured by the excavation.

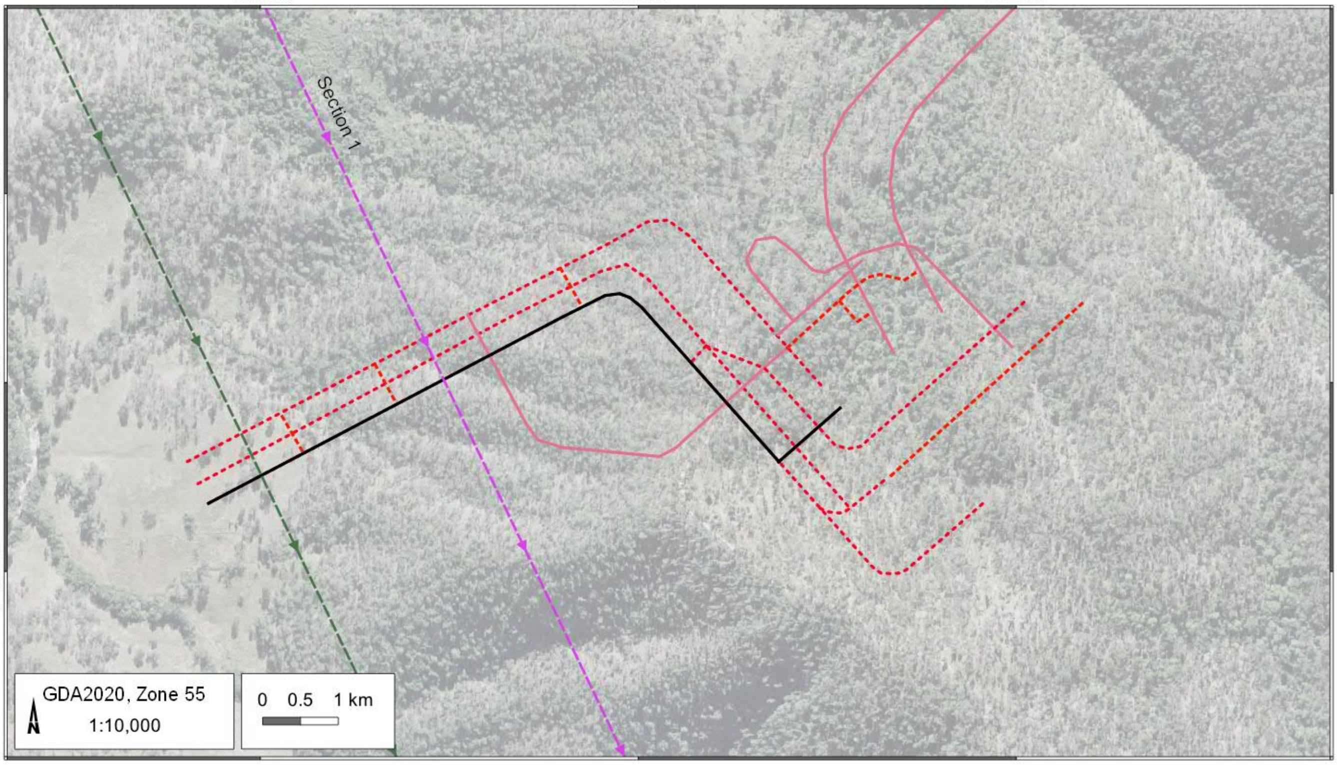
The estimated groundwater flow predicted using the Marinelli and Niccoli (2002) analytical method ranges between 0.5 to 1.5 L/s. The expected radius of influence, represented by the 1 m drawdown one, is in the order of 300 to 600 m.

8.1.2.3 Summary

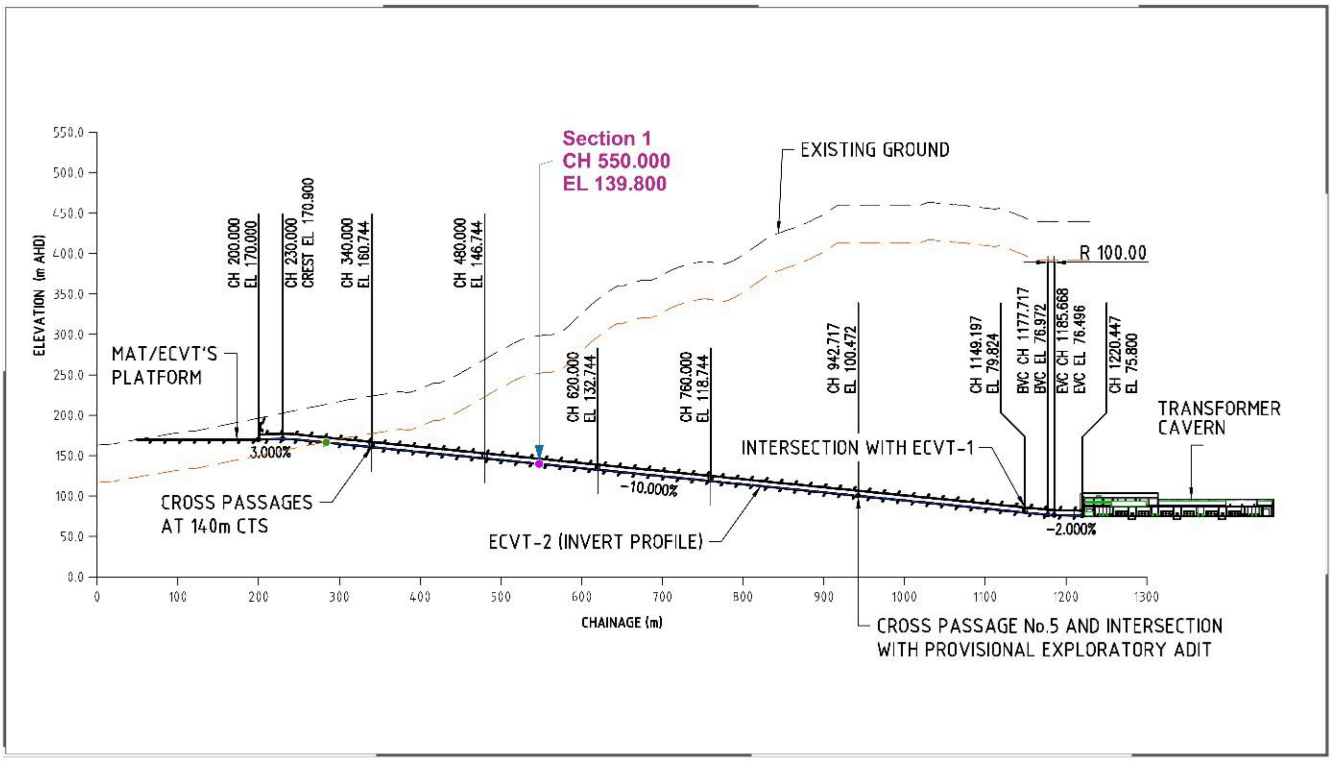
As indicated in the sections above, from the outcome of this assessment, a map was generated to present the potential zone of drawdown within the Weathered Rock Aquifer, at the tunnel portal, based on the 300 m and 600 m range provided above. As shown on Figure 8.5 the drawdown zones are presented to support this qualitative assessment, with a drawdown limit of 165 m AHD (1 m below bulk excavation level). It is expected that the drawdown distance from the tunnel would decrease as it continues into the fresh rock or fractured rock aquifer. As shown on Figure 8.5, mapped TECs and high potential GDEs falls within the predicted zone of influence, located north of the two tunnel options.

It is also important to note that the qualitative assessment used steady state applications and does not provide transient drawdown over time. Drawdown associated with the deep sections of the tunnel and the potential interconnectivity of this to surface and shallow aquifers are in progress through a MODFLOW USG 3D numerical groundwater model.

Exploratory tunnel location



ECVT-2 Longitudinal profile



LEGEND

- Cross section 1
- Watercourse
- Alternate Exploratory Tunnel
- Main Works
- ECVT-2

Borumba PHES- EPBC Exploratory Works
Groundwater Impact Assessment (BDP5001.004)

Cross-Section Location in the SEEP/W Model Relative to the Tunnels

AGE

DATE 03/09/2024

FIGURE No: 8.3

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\BDP5001.004 Borumba PHES_EPBC Amendment Variation 4\3_GIS\Workspaces\001_Deliverable1\07.02_BDP5002.004_Cross-Section Locations in the SEEP-W Model Relative to the Tunnels.qgz

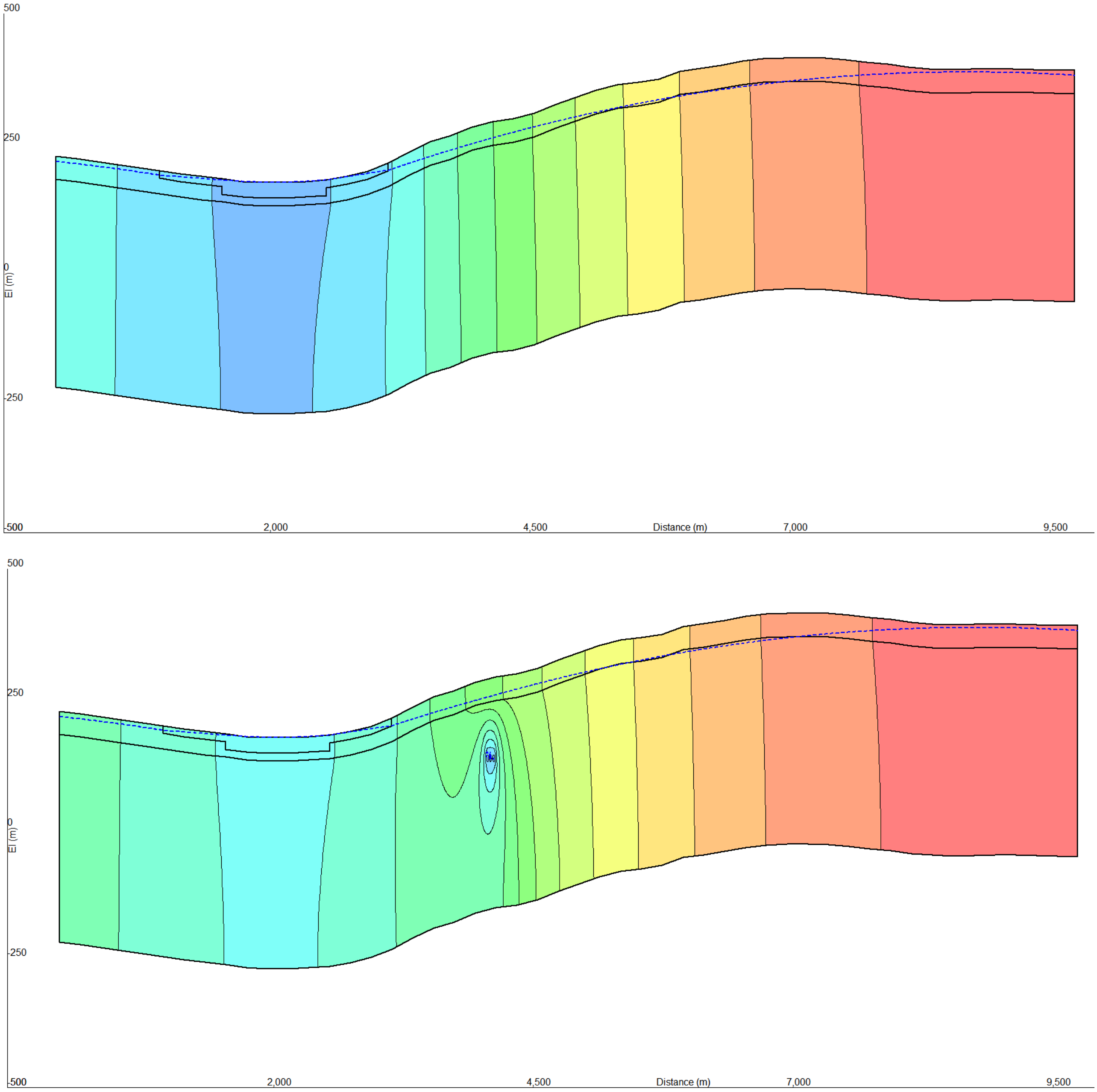


Figure 8.4 Water table profile and tunnel impact in cross-section 2 before and after tunnel construction, in deeper fractured rock, simulated in SEEP/W

8.2 Groundwater supply bore assessment

As shown in Table 8.3 two groundwater supply bores are planned to be used as construction water supply sources. The bores are planned to be drilled about 2 km north of the proposed tunnel portal area within the proposal construction laydown area and to supply 140 ML/a.

8.2.1 Forward simulation

An analytical approach was taken to predict the anticipated cone of depression around each of the bores after two years of production. These predictions were completed by using the Barker[17] and Moench[18] analytical methods for confined fractured rock and unconfined aquifers in AQTESOLV[19]. A software forward solution function allows a borehole to be pumped at a set rate for a specific period into the future. This forward simulation utilises the hydraulic parameters determined for each borehole using appropriate equations that show a good fit.

8.2.1.1 Assumptions and limitations

As these boreholes have not been drilled yet, the following assumptions were made to assess their potential impact:

- as shown on Figure 8.5 the proposed supply bores are planned to be drilled within the Marumba Beds and the Mt Mia Serpentinite;
- based on nearby monitoring bore information (YU01-MB002 and YU01-MB004), hydraulic conductivity is typically in the order of 0.004 to 0.04 m/d in the fresh rock and higher in shallow weathering profiles at about 0.1 m/d;
- the aquifer system is unconfined to semi-confined but the assessment below will also consider confined and fractured rock systems to provide a arrange of potential drawdown scenarios; and
- each of the planned groundwater supply bores will have a maximum yield in the order of 2 L/s.

Table 8.3 Proposed supply bore particulars

ID	Easting	Northing	Surface RL (m)	Depth (m)
BR-GW-LR01-PB001	451245	7064724	150.39	50
BR-GW-LR01-PB002	451560	7064679	147.15	50

Note: RL = reduced level (RL) refers to equating elevations of survey points with reference to a common assumed vertical datum.

[17] Barker (1988) derived generalized radial flow model for unsteady, n-dimensional flow to a fully penetrating source in an isotropic, single- or double-porosity fractured aquifer. Barker, J.A., 1988. A generalized radial flow model for hydraulic tests in fractured rock, Water Resources Research, vol. 24, no. 10, pp. 1796-1804.

[18] Moench, A.F., 1997. Flow to a well of finite diameter in a homogeneous, anisotropic water-table aquifer, Water Resources Research, vol. 33, no. 6, pp. 1397-1407.

[19] Duffield, G.M., 2007. AQTESOLV for Windows Version 4.5 User's Guide, HydroSOLVE, Inc., Reston, VA.

As with all groundwater models, it is based on a simplification of the groundwater system, and the analytical method applied here further simplified the systems by using average hydraulic properties. The key limitations of analytical modelling for this bore field assessment are listed below:

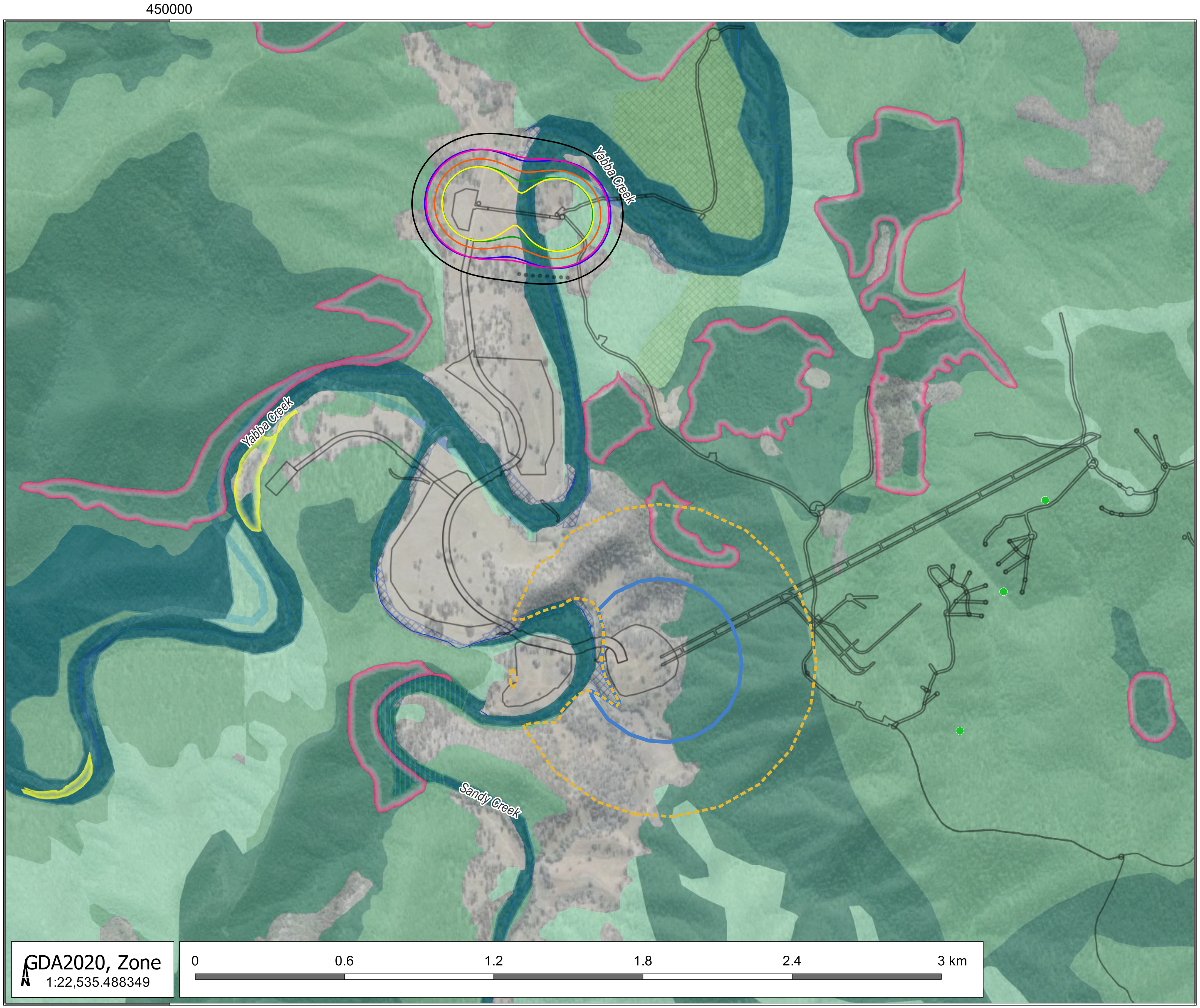
1. Contributions from rainfall recharge, as well as any losses incurred due to evaporation and evapotranspiration, have not been incorporated into the calculations.
2. As discussed in previous sections of this report, the Project area's groundwater environment is dominated by fractured rock aquifers, which contain discrete fracture networks. The analytical equations used cannot account for distinct flow in discrete fracture networks but rather use a combination of matrix and fracture flow (double porosity). Subsequently, aquifers are simulated as homogenous, and drawdown is calculated radially. In contrast, in reality, fractured aquifers would be heterogeneous, and drawdown would likely first propagate along connected fractures where permeabilities are higher.
3. Any interconnectivity with the local alluvium systems was disregarded.

8.2.1.2 Estimate zone of influence

As shown on Figure 8.5, the probable cone of depression, represented by the 1 m drawdown contour line, will be between 150 and 300 m from each of the proposed boreholes. Because the bores will not be able to sustain any significant production at the lower end of the hydraulic conductivity range (0.004 m/day), the range presented on the map used a higher hydraulic conductivity range of 0.11 to 0.04 m/day.

It could therefore be concluded that the proposed production of 140 ML/yr, may not be sustainable. It is recommended to update the impact prediction when more aquifer data is available from the area and in particular from the proposed drilling locations.

From the preliminary analytical calculations, the zone of influence presented on Figure 8.5 incorporates a portion of Yabba Creek (between 170 and 500 m) and may result in some reduction of baseflow towards the creek during the dry season. It also includes a small mapped riverine wetland zone within the northern part of the predicted zone of influence.



LEGEND
- Populated place
- Spring/Seep
- Drainage
- Project Area
- Site Layout
- Conondale Park
- Lower Reservoir (Current FSL 135.01 m AHD)

Threatened Ecological Species
- Lowland Rainforest of Subtropical Australia
- Subtropical eucalypt

Wetland areas
- 01-50_RE - Wetlands are subdominant (comprising 50 % or less of the area)
- L_WB - Lacustrine wetland
- R_RE - Riverine wetland
- R_WB - Riverine wetland
- MSES high ecological significance wetlands

Terrestrial GDE
- High potential GDE
- Moderate potential GDE
- Low potential GDE

Aquatic GDE
- High potential GDE

Predicted Supply Bore Drawdown
- K 0.04 confined
- K 0.04 fractured
- K 0.04 unconfined
- K 0.11 confined
- K 0.11 fractured
- K 0.11 unconfined

Predicted Tunnel Drawdown (WRA)
- 600 m
- 300 m

Borumba Dam Exploratory Works EPBC Referral – GIA – Amendment (BDP5001.004)

Qualitative impact assessment range of potential drawdown

AGE

DATE
03/09/2024

FIGURE
8.5

G:\Projects\BDP5001.004 Borumba PHES_EPBC Amendment Variation 4\3_GIS\Workspaces\002_Deliverable2\06.09_BDP5001_Qualitative Impact.qgz

9 Impact and Risk Assessment

The following sections will discuss the potential impacts associated with the proposed exploratory works activities. Several factors affect the inherent risk associated with components of the works, primarily location, extent, type of activity and duration of the activity.

9.1 Risk significance assessment

The risk assessment is based on the 2014 Commonwealth Environmental Management Plan Guidelines which set out a qualitative approach to rating environmental risks. Each environmental risk is given a rating in terms of likelihood and consequence, as outlined in Section 3.1.5

The risk assessment approach is receptor focused and utilises the Source-Pathway-Receptor principle. The primary groundwater receptors are outlined in Section 7. The groundwater risks are considered for potential impacts to groundwater quantity and quality.

Table 9.1 summarises the potential **unmitigated** impacts associated with each of the exploratory activities. The risk significance ratings are provided in Table 9.2 and discussed in the sub-sections below for risks associated with the construction and operational phases.

Table 9.1 Summary of potential impacts associated with the exploratory activities prior to mitigation

Exploratory Works Activity	Potential Impacts Prior to Mitigation
Water Infrastructure To provide raw water to operate drilling rigs and dust suppression and materials moisture conditioning associated with surface civil works construction.	Although limited, associated increase / change in groundwater quality (salinity), groundwater contamination could occur in the event of oil spills and other chemical spills at the surface, seeping into the subsurface, during drilling activities.
Yabba Creek and Sandy Creek Crossings Installation of bridges to enable heavy and long vehicle access to the exploratory drilling portal during high flow events.	Very limited to insignificant impacts expected. Paved and hardened platforms resulting in temporary reduction in groundwater recharge over small areas. Impeding flow within the creeks during construction.
Spoils Stockpile To store excess material (~395,000 m^3) excavated from within the exploratory tunnel.	Potential production of poor-quality leachate and seepage into shallow groundwater aquifers.
Explosives Store To store explosive materials used within the exploratory tunnel drill-and-blast operations.	Very limited to insignificant impacts expected. Paved and hardened platforms resulting in reduction in direct groundwater recharge into the subsurface. Groundwater contamination could occur in the event of a fire, explosive event or other emergency situation.
Portal Pad To situate plant and equipment (water infiltration, ventilation, temporary excavated material, general with fuel storage) that is required to be located at the entrance of the tunnel portal.	Compacted gravel and hardened platforms resulting in temporary reduction in groundwater recharge over small areas. Management of potentially contaminated water emanating from the tunnel. Groundwater contamination could occur in the event of oil spills and other chemical spills.
Support & Staging Area To situate support facilities associated with the underground tunnelling operation.	Compacted gravel and hardened platforms resulting in temporary reduction in groundwater recharge over small areas. Groundwater contamination could occur in the event of oil spills and other chemical spills. Poor quality runoff from stockpile materials (cement, fly ash), ablution facilities, fuel storage to operate generators.

Exploratory Works Activity	Potential Impacts Prior to Mitigation
Access Control & Washdown Facilities To prevent access to the site by members of the general public, and to enable vehicles and plant entering the site to be washed down for biosecurity purposes.	Compacted gravel and hardened platforms resulting in temporary reduction in groundwater recharge over small areas. Seepage of contaminated water from washdown discharge.
Exploratory Tunnel To obtain geotechnical information on the conditions at the location of the proposed underground Powerhouse Cavern.	The construction of the tunnel may intercept groundwater and have localised impacts including: - Lowering of regional and local groundwater levels and associated impacts on sensitive terrestrial vegetation communities. Groundwater impacts will be more pronounced around/along geological structures and likely localised. - Altering hydraulic conductivity through drill and blast. - Leachate from explosives and oxidation of exposed bedrock resulting in contaminated water runoff and seepage.
Groundwater Supply Bores To supplement civil works water supply, with a total combined yield of 140 ML per annum.	Lowering of local groundwater levels within a potential 150 to 300 m radius of the bores. Potential reduced flow within the Yabba Creek.

9.1.1 Construction phase

Construction phase (or exploratory activities) impacts on groundwater values of the Project area relate mainly to change in groundwater levels and potential availability to receptors, and to a lesser degree on groundwater quality. Provided that the proposed mitigation measures are implemented successfully, the construction phase of Project present a low to medium residual risk to the groundwater values of the area. The key groundwater impacts are discussed below with brief detail of mitigation measures also mentioned to understand any residual risks.

- **Impacts**:
  - Construction of the tunnel will include some dewatering of the Weathered Rock Aquifer and Fractured Rock Aquifer of the Marumba Beds, which will create localised groundwater impacts. The impacts are likely limited in extent but there will be a risk of short-term reduced water availability to the mapped GDEs and TECs, limited to the areas above and immediate surroundings to the tunnel (Figure 8.5).
  - Discharged dewatering water can potentially be contaminated (deeper aquifer may have higher salinity than shallow aquifer) during construction activities and disposal of this water will require management to ensure the Mary Basin water quality objectives are met.
  - Introduction of contaminants to the aquifer associated with the explosives, for example ammonium nitrate and lead.
  - Oxidation of exposed bedrock, resulting in natural chemical changes within the host rock. Net Acid Generation testing has classified the rock from 20 samples as non-acid generating.
  - Exposure of the aquifer to contaminants via infiltration from surface infrastructure or runoff. Identified contaminant sources include diesel storage tanks, cement and fly ash stockpiles, ablution facilities and the explosives store.
- **Mitigation**:
  - A water management plan for the exploratory works will be developed to ensure that the overall groundwater inflow management, reuse of water, storage of water and treatment plan is implemented for the exploratory works. This will include implementation of triggers and thresholds as well as trigger action response plans (TARPS) to manage the groundwater inflow, reuse and treatment options.

- Options that is currently investigated include:
  - Strategies to control groundwater inflows are outlined in Section 2.3 Groundwater inflow performance criteria are designed to limit tunnel inflows to a level which are likely to minimise environmental impacts. Additional benefits include lower water treatment and disposal costs and lower construction water management issues (pumping). For this purpose, water inflow into any section of the tunnel shall be limited to 2 L/s for any one-kilometre length of tunnel.
  - Groundwater emanating from the tunnel will be diverted to a dirty water containment dam (such as tanks and turkey's nest) and tested for contaminants. Contaminated water will be stored in the containment dam before treatment for reuse or diverted to Water Storage Tanks where volumes exceed the capacity of the containment dam.
  - Beneficial reuse of process water in construction activities.
  - Discharge of excess treated water to the environment.
  - Offsite disposal at licenced facilities.
- All contaminant containment facilities should be bunded.
- The spoils will consist of effective drainage to capture any leachate.
- Geochemical testing of stockpile material will be implemented routinely.
- Runoff will be diverted away from the portal pad.
- Sediment control devices will be in place.
- The construction environment management plan (CEMP) will address the following aspects:
  - to ensure groundwater levels is monitored;
  - groundwater quality are monitored;
  - monitoring the health of the TECs surrounding the tunnel; and
  - criteria for trigger action response plans and the overall management of water during the exploratory phase.

9.1.2 Operational phase

The impacts associated with the operational phase of the exploratory activities are discussed below:

- **Impacts**:
  - It is expected that the long term inflow rate into the tunnel will be managed not to exceed 2 L/s/km, although this is a relative small volume over a 1km stretch, it will result in a potential dissipation of drawdown zones further away from the tunnel and the need to continuously manage groundwater at a rate of approximately 172 m^3/day for the shorter tunnel (Option 2) and 344 m^3/day for the longer tunnel option (Option 1).
  - Reduced recharge to the aquifer due to creation of hardstand areas associated with the spoils stockpile, explosives store, support and staging area, portal pad, encampment areas, etc. This could also result in a localised reduction in baseflow seepage to the creeks.
  - Localised dewatering of the aquifer in the vicinity of two groundwater supply bores adjacent to Yabba Creek. Lowered water table resulting in reduced baseflow to the creek.
- **Mitigation:**
  - Ongoing water management practices as listed above in Section 9.1.1.
  - The impact of reduced recharge from hardstand areas is considered to be low, and no mitigation is recommended.
  - Monitor changes in water levels around the groundwater supply bores and visual monitoring of GDEs.

Table 9.2 Risk significance assessment

No.	Risk description and controls				Risk level (without controls)			Avoidance and mitigation measures	Risk level (post controls)			Risk treatment plan
	Activity / Action	Environmental value impacted	Impact	Impact description	Likelihood	Consequence	Risk level		Likelihood	Consequence	Risk level	
1	Construction	Private bores	Reduced water levels as a result of drawdown	Dewatering of the aquifer during tunnel exploratory works. Tunnel inflow rates are expected to be in the order of 125 to 425 m^3/day/km over the 2-year lifespan of the tunnel progression. No known private bores located within a 5 km radius of the tunnel, therefore the impact to this receptor is considered to be negligible.	Unlikely	Moderate	Low	Risk is low, no mitigation required.	Unlikely	Moderate	Low	Monitor change in water levels during construction. If the tunnel will be decommissioned and given grouting of the tunnel during construction inflow would be significantly reduced. If works continue the monitoring will be reinstated and continue over the long term.
2	Construction	Private bores	Altered water quality	Seepage of surface contaminants into the underlying aquifer as a result of: • Oil and other chemical spills related to the use of generators, fuel storage tanks, cement and fly ash stockpiles, ablution facilities, etc. • Production of leachate from spoils stockpile or from explosives store in the event of a fire, explosive event or other emergency situation. • Contaminated water storage facilities.	Unlikely	High	Medium	Prevention measures include: • Geotextile liner and daily geochemical testing of stockpile material. • Runoff will be diverted away from the portal pad. • Sediment control devices in place. • Water from tunnel will be diverted to dirty water containment and tested. • Dirty water dam will be periodically cleaned and sludge disposed in spoils area. • Groundwater emanating from the tunnel will be diverted to a dirty water containment dam (turkey's nest) and tested for contaminants. Contaminated water will be stored in the containment dam before treatment for reuse or diverted to Emergency Water Storage Tanks where volumes exceed the capacity of the containment dam.	Unlikely	Minor	Low	Monitor water quality of groundwater users within the predicted zone of influence during the construction, operation and decommission phases.

No.	Risk description and controls				Risk level (without controls)			Avoidance and mitigation measures	Risk level (post controls)			Risk treatment plan
	Activity / Action	Environmental value impacted	Impact	Impact description	Likelihood	Consequence	Risk level		Likelihood	Consequence	Risk level	
3	Construction	Private bores	Altered water quality	Contamination of the local aquifer as a result of tunnel development: • Introduction of contaminants related to the explosives, most notably nitrate. Lead has been identified as an additional risk linked to the detonators used. • Oxidation of exposed bedrock, resulting in natural chemical changes within the host rock. Net Acid Generation testing has classified the rock from 20 samples as non-acid generating.	Unlikely	High	Medium	Cementation of the tunnel and grouting fractures will reduce oxidation ingress within the tunnel and reduced exposure of the aquifer to contaminants. Use alternative detonators that does not release contaminants like lead. Zone of influence needs to be modelled to confirm extent of impact and the groundwater users confirmed to determine if this receptor is at risk. Current information suggests that the risk is low. Confirm exitance of any private groundwater users in cone of depression area. If any users identified in the potential zone of influence monitor groundwater during the construction, operation and decommission phases.	Unlikely	Moderate	Low	Monitor water quality of groundwater users within the predicted zone of influence during the construction, operation and decommission phases.
4	Construction	Moderate potential aquatic GDE- Sandy Creek, Yabba Creek, Lake Borumba Identified MNES (see Sections 1.1.1 and 6.7)	Reduced baseflow Lowering of shallow groundwater levels	Dewatering of the aquifer during tunnel exploratory works and lowered water table resulting in reduced baseflow seepage into the local creeks and reservoir. Areas of TEC could be impacted where roots depend on shallow and medium depth groundwater. Only areas directly above and within a direct vicinity of the underground exploratory workings are likely to be impacted upon. It is expected to see higher groundwater flow along the shallow portion of the tunnel (between 0 and ~50 m) where it intersects the weathered aquifer. Overall lower flows are expected from the deeper formation (>50 m), expect for preferential flow along geological structures (where and if occurred).	Possible	High	Medium	Dewatering is unavoidable, but cementation of the tunnel and grouting fractures will reduce tunnel inflow and drawdown. Additional post-grouting treatment will be applied to the tunnel during construction if impacts are observed at surface, as determined through implementation of the Groundwater Management Plan.	Possible	Moderate	Medium	Monitor change in water levels within the creeks and adjacent boreholes during construction, operation and decommission phases to assess drawdown and rebound over time. Visual monitoring of GDEs and TECs.
5	Construction	Low Potential Terrestrial GDE- natural reserve	Reduced water levels	Dewatering of the aquifer during tunnel development may result in lowered water levels which may affect groundwater dependent terrestrial vegetation. A portion of the tunnel is overlain by low potential terrestrial GDEs, the presence of which need to be confirmed.	Unlikely	Moderate	Low	Risk is low, no mitigation required.	Unlikely	Moderate	Low	Monitor change in water levels during construction, operation and decommission phases to assess drawdown and rebound over time.

No.	Risk description and controls				Risk level (without controls)			Avoidance and mitigation measures	Risk level (post controls)			Risk treatment plan
	Activity / Action	Environmental value impacted	Impact	Impact description	Likelihood	Consequence	Risk level		Likelihood	Consequence	Risk level	
6	Operational	Private bores	Reduced water levels as a result of reduced recharge	Compacted gravel and hardened platforms resulting in temporary reduction in groundwater recharge over small areas. Hardened areas are expected to cover a cumulative area of ~13 ha.	Rare	Minor	Low	Risk is low, no mitigation required. No known private bores located within a 5 km radius of the hardened platform areas, therefore the impact to this receptor is considered to be low.	Rare	Minor	Low	Monitor change in water levels during construction, operation and decommission phases to assess drawdown and rebound over time.
7	Operational	Moderate potential aquatic GDE- Sandy Creek, Yabba Creek, Lake Borumba	Reduced baseflow	Paved and hardened platforms resulting in temporary reduction in baseflow seepage over small areas	Possible	Minor	Low	Risk is low, no mitigation required.	Possible	Minor	Low	Monitor change in water levels within the Creeks and adjacent boreholes during construction, operation and decommission phases to assess drawdown and rebound over time.
8	Operational	Private bores	Reduced water levels as a result of drawdown	Dewatering of the aquifer during abstraction from the groundwater supply bores. Predicted zone of impact is within 300 m of the bores. Impact is limited to Queensland Hydro property; no private bores present within the ZOI.	Unlikely	Moderate	Low	Risk is low, no mitigation required.	Unlikely	Moderate	Low	Monitor water levels in nearby bores to establish and monitor changes to the ZOI.
9	Operational	Moderate potential aquatic GDE- Yabba Creek, Lake Borumba	Reduced baseflow	Abstraction from the groundwater supply bores will result in lowered water table resulting in reduced baseflow seepage into the local creeks and reservoir.	Possible	High	Medium	Ensure that bore construction only targets deeper fractured rock aquifer and not shallow alluvial deposits. Determine triggers for monitoring drawdown and incorporate into Trigger Action Response Plan. Assess options for alternative water supply when trigger limits exceeded.	Possible	Moderate	Medium	Monitor change in water levels within the creeks and adjacent boreholes during construction, operation and decommission phases to assess drawdown and rebound over time. Visual monitoring of GDEs and TECs.
9	Operational	Low Potential Terrestrial GDE	Reduced water levels	Abstraction from the groundwater supply bores will result in lowered water table which may affect groundwater dependent terrestrial vegetation. A portion of the predicted ZOI of the groundwater supply bores is overlain by low potential terrestrial GDEs, the presence of which need to be confirmed.	Possible	Minor	Low	Risk is low, no mitigation required.	Possible	Minor	Low	Monitor change in water levels during construction, operation and decommission phases to assess drawdown and rebound over time.

10 Groundwater management plan

Queensland Hydro developed a draft CEMP including a:

- Preliminary Erosion and Sediment Control Plan (ESCP) in line with International Erosion Control Association guidelines (2008) or NSW "Blue book".
- Spoil Management Plan and a Waste Management Plan (including contaminated spoil management plan).

Full details of the CEMP will not be presented here, but the key components of relevance to managing groundwater are, summarised in Table 10.1.

Table 10.1 Groundwater management measures

Activity	Management and Control Measures
Spoils Stockpile	Prevention measures include effective drainage to capture leachate and routine geochemical testing of stockpile material. If main works proceed, material will be crushed and used for access track sheeting.
Explosives Store	Materials will be bunded.
Portal Pad	Runoff will be diverted away from the portal pad. Runoff from the pads will be directed into the ESC system. Sediment control devices in place.
Support & Staging Area	Runoff will be diverted away from the portal pad. Sediment control devices in place.
Exploratory Tunnel	Inflow control measures including grouting of fractures and cementation of the tunnel. Groundwater emanating from the tunnel will be diverted to a dirty water containment dam (such as tanks or turkey's nest) and tested for contaminants. Contaminated water will be stored in the containment dam before treatment for reuse or diverted to Water Storage Tanks where volumes exceed the capacity of the containment dam. Alternatively water may also be released to the environment if it meets water quality criteria.

The effectiveness of these management measures will be assessed through continuous groundwater and surface water monitoring throughout the lifespan of the exploratory works. As outlined below the CEMP will be updated with additional groundwater management aspects.

10.1 Groundwater monitoring plan

In principle, the groundwater monitoring design aims to detect groundwater impacts, so that appropriate trigger action response plans can be implemented, causes investigated and effectiveness of the management plan evaluated. This may necessitate revision of groundwater controls to reduce impacts.

As explained in Section 3.1.3 the groundwater monitoring network currently consists of 24 monitoring bores and one VWP. All bores are equipped with data loggers that are connected to a low orbit satellite telemetry system. Groundwater level and salinity are recorded on set intervals (hourly) and data will be continuously downloaded for review. The monitoring bores will be sampled monthly for a period of one year prior to the construction phase for the suite of parameters listed in Table 10.2.

It is proposed that short-style monitoring reports be developed quarterly and more detailed reports annually. It is likely that the interval for water quality monitoring be quarterly or bi-annually for the exploratory period. Groundwater monitoring will continue for the main works if the Borumba PHES Project proceeds. If the main works do not proceed, groundwater monitoring will continue during the decommissioning phase.

Table 10.2 Groundwater quality parameters

Wide range of parameters for baseline assessment
Physico-chemical parameters - pH, electrical conductivity, total dissolved solids (TDS), SAR and Hardness by calc'
Major cations - calcium, magnesium, sodium and potassium
Major anions – chloride, sulfate, fluoride and bromide
Alkalinity - total, carbonate and bicarbonate
Metals (total and dissolved) - Al, As, B, Ba, Be, Cd, Co, Cr, Cu, Fe, Hg, Mo, Mn, Ni, Pb, Se, Sr, V, Zn, and dissolved silica
Ionic checks – total anions, total cations and ionic balance

The groundwater monitoring network will be annually reviewed, and additional locations identified where find necessary.

10.2 Overall groundwater management

The groundwater monitoring program and management will adhere to the Monitoring and Sampling Manual (Queensland Department of Environment and Science, 2018) and *Using monitoring data to assess groundwater quality and potential environmental impacts*" by DESI (2021).

U.S. Interstate Technology & Regulatory Council (ITRC 2013) guidelines will be adopted to assess groundwater triggers. These guidelines recommend at least eight to ten background measurements when constructing limits. Once this baseline data is gathered, groundwater trigger action response plans (TARPs) will be developed for groundwater levels, quality and GDEs. The TARPS will form part of the CEMP.

10.3 Tunnel groundwater management

In consultation with QH, a detailed groundwater management plan will be developed by the appointed contractor. This plan will include, but not limited to:

- Testing and storage of materials to be used.
- Dewatering of underground works plan.
- Implementation of water inflow criteria and management plan, including pre-and post grouting plans,
- Discharge and storage plans.
- Sediment control plans.
- Measurement of flow and groundwater quality monitoring plan.
- Groundwater flow and hydraulic property testing plan.

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Appendix A

Water Quality Objectives

Table A 1 Beneficial use water quality guidelines

Parameter	Unit	ANZECC Guidelines			NHMRC Guidelines	Mary River EVs (Freshwater lakes/reservoirs)[d]
		Short Term Irrigation	Long Term Irrigation	Stock Water	Drinking Water	
Physical Parameters	-	-	-	-	-	-
pH	pH Units	6.0 - 8.5	6.0 - 8.5	-	6.5 - 8.5[b]	-
Total Dissolved Solids (calc)	mg/L	-	-	3000 - 13000	600[b]	-
Major Ions	-	-	-	-	-	-
Sulfate as SO_4 - Turbidimetric	mg/L	-	-	1000 - 2000	500[a] / 250[b]	-
Chloride	mg/L	-	40	-	250[b]	-
Fluoride	mg/L	2.0	1.0	2	1.5[a]	-
Calcium	mg/L	-	-	1000	-	-
Sodium	mg/L	-	-	-	180[b]	-
Nutrients	-	-	-	-	-	-
Ammonia as N	mg/L	-	-	-	0.5[b]	0.01
Nitrite as N	mg/L	-	-	30	3[a]	-
Nitrate as N	mg/L	-	-	-	50[a]	-
Nitrite + Nitrate as N	mg/L	-	-	400	-	-
Total Kjeldahl Nitrogen as N	mg/L	-	-	-	-	-
Total Nitrogen as N	mg/L	25 - 125	5	-	-	0.35
Total Phosphorus as P	mg/L	0.8 - 12	0.05	-	-	0.01
Organic Nitrogen	mg/l	-	-	-	-	0.33
Reactive Phosphorus as P	mg/L	-	-	-	-	0.005
Dissolved Metals	-	-	-	-	-	-

Parameter	Unit	ANZECC Guidelines			NHMRC Guidelines	Mary River EVs (Freshwater lakes/reservoirs)[d]
		Short Term Irrigation	Long Term Irrigation	Stock Water	Drinking Water	
Aluminium	-	-	-	-	-	-
Arsenic	mg/L	-	-	-	0.01	-
Beryllium	mg/L	-	-	-	0.06	-
Boron	mg/L	-	-	-	4	-
Cadmium	mg/L	-	-	-	0.002	-
Chromium	mg/L	-	-	-	0.05	-
Copper	mg/L	-	-	-	2	-
Lead	mg/L	-	-	-	0.01	-
Manganese	mg/L	-	-	-	0.5	-
Mercury	mg/L	-	-	-	0.001	-
Nickel	mg/L	-	-	-	0.02	-
Selenium	mg/L	-	-	-	0.01	-
Total Metals	-	-	-	-	-	-
Aluminium	mg/L	5	-	5	0.2[b +]	-
Arsenic	mg/L	2.0	0.1	0.5	0.01[a]	-
Barium	mg/L	-	-	-	2[a]	-
Beryllium	mg/L	0.5	0.1	-	0.06[a]	-
Boron	mg/L	refer to guideline	0.5	5.0	4[a]	-
Cadmium	mg/L	0.05	0.01	0.01	0.002[a]	-
Chromium	mg/L	1.0	0.1	1.0	0.05[a]	-
Cobalt	mg/L	0.10	0.05	1.0	-	-

Parameter	Unit	ANZECC Guidelines			NHMRC Guidelines	Mary River EVs (Freshwater lakes/reservoirs)[d]
		Short Term Irrigation	Long Term Irrigation	Stock Water	Drinking Water	
Copper	mg/L	5.0	0.2	0.5 - 5	2[a] / 1[b]	-
Iron	mg/L	10.0	0.2	-	0.3[b]	-
Lead	mg/L	5.0	2.0	0.1	0.01[a]	-
Lithium	mg/L	2.5	2.5	-	-	-
Manganese	mg/L	10.0	0.2	-	0.5[a] / 0.1[b]	-
Mercury	mg/L	0.002	0.002	0.002		-
Molybdenum	mg/L	0.05	0.01	0.15	0.05[a]	-
Nickel	mg/L	2.0	0.2	1	0.02[a]	-
Selenium	mg/L	0.05	0.02	0.02	0.01[a]	-
Uranium	mg/L	0.10	0.01	0.2	0.017[a]	-
Vanadium	mg/L	0.5	0.1	-	-	-
Zinc	mg/L	2.0	2.0	20	3[b]	-
Oil and Grease	-	-	-	-		-
Oil and Grease	µg/L	-	-	-	0.001[a]	-
BTEX	-	-	-	-		-
Benzene	µg/L	-	-	-	0.001[a]	-
Toluene	µg/L	-	-	-	0.8[a]	-
Ethylbenzene	µg/L	-	-	-	0.3[a]	-

Notes: a NHMRC Health Guidelines for Drinking Water (2019).

b NHMRC Aesthetic Guidelines for Drinking Water (2019).

c as hydrogen sulfide.

d Environmental Protection (Water) Policy 2009: Mary River environmental values and water quality objectives, Basin no. 138, July 2010.

Appendix B

Queensland Water Quality Salinity Classification Range

Table B 1 Guide to typical salinity classification ranges for waters (Queensland Government, science notes L137)

Type	EC (µS/cm)	TDS (mg/l)
Distilled water	1	0.67
Rainfall	30	20
Freshwater	0 to 1500	0 to 1000
Great Artesian Basin Water	700 to 1000	470 to 670
Brackish water	1500 to 15000	1000 to 10050
Upper limit recommended for drinking	1600	1070
Seawater	55000	36850
Tolerances of livestock to salinity in drinking water (at these values, animals may have an initial reluctance to drink, but stock should adapt without loss of production)		
– beef cattle	5970 to 7460	4000 to 5000
– dairy cattle	3730 to 5970	2500 to 4000
– sheep	7460 to 14925	5000 to 10000
– horses	5970 to 8955	4000 to 6000
– poultry	2985 to 4475	2000 to 3000
General limits for irrigation		
– Salt sensitive crops	650	435
– Moderately salt sensitive crops	1300	870
– Salt tolerant crops	5200	3485
– Generally, too saline for crops	8100	5430

Appendix C

Water Quality and Water Level Trend Graphs

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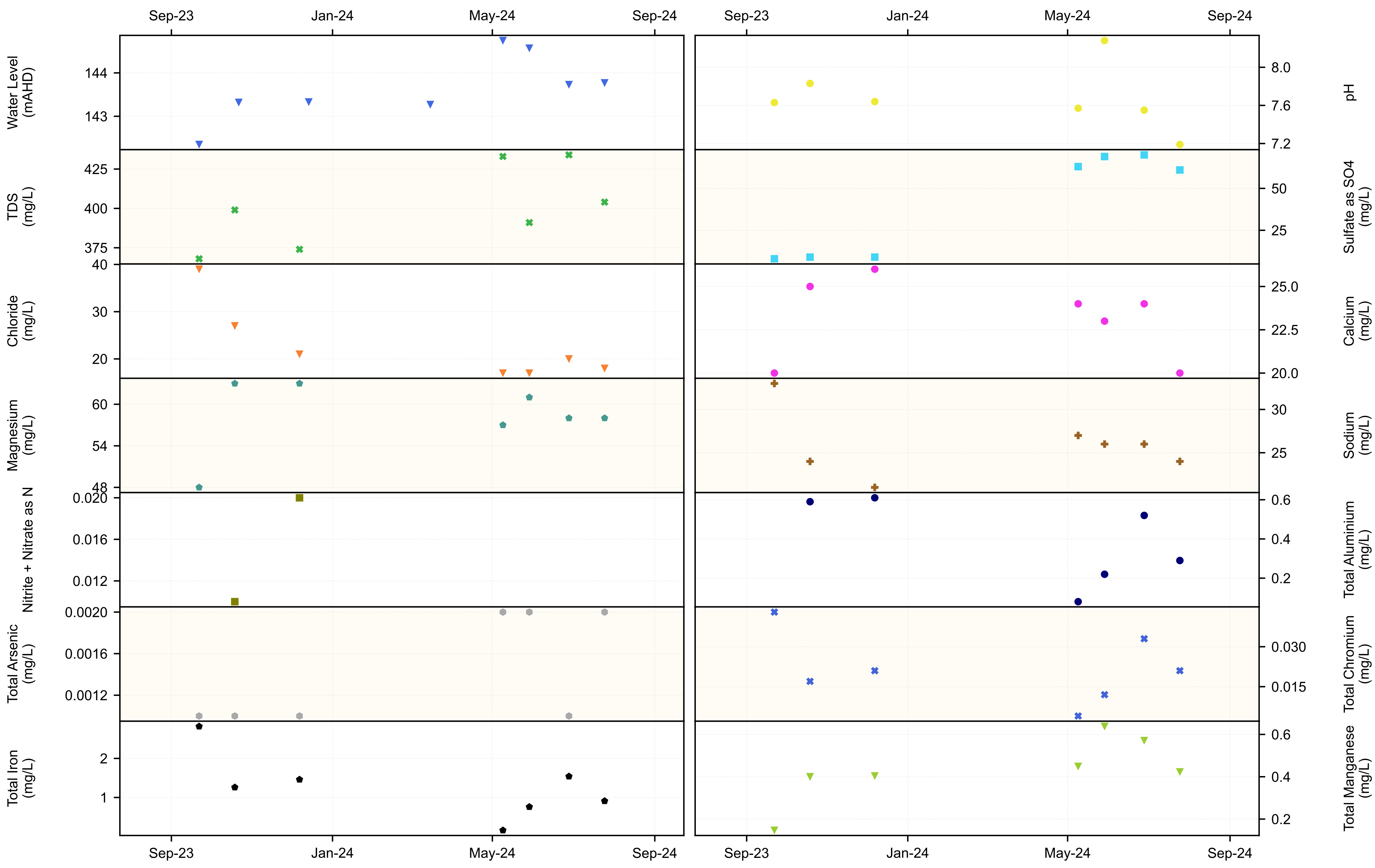

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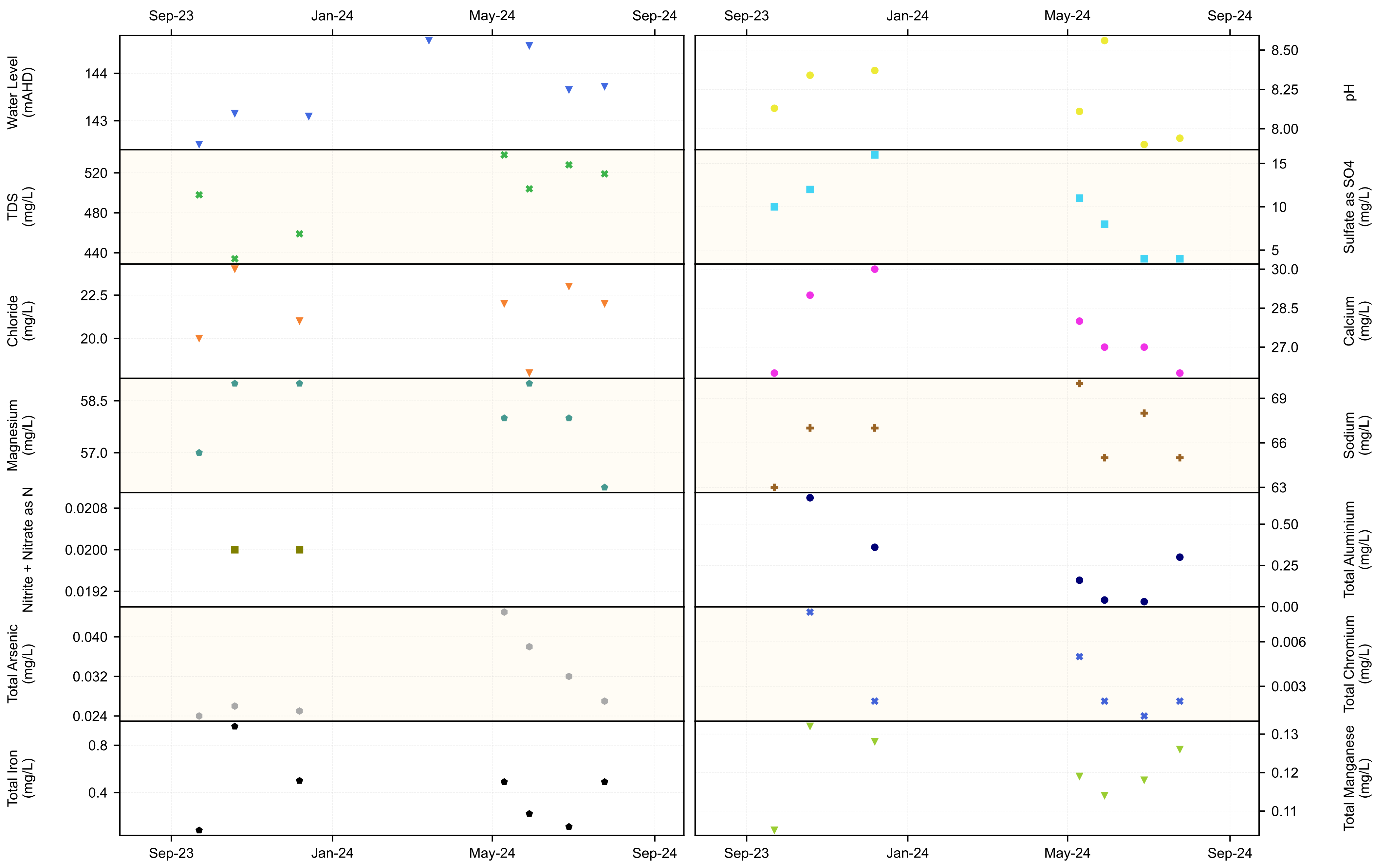

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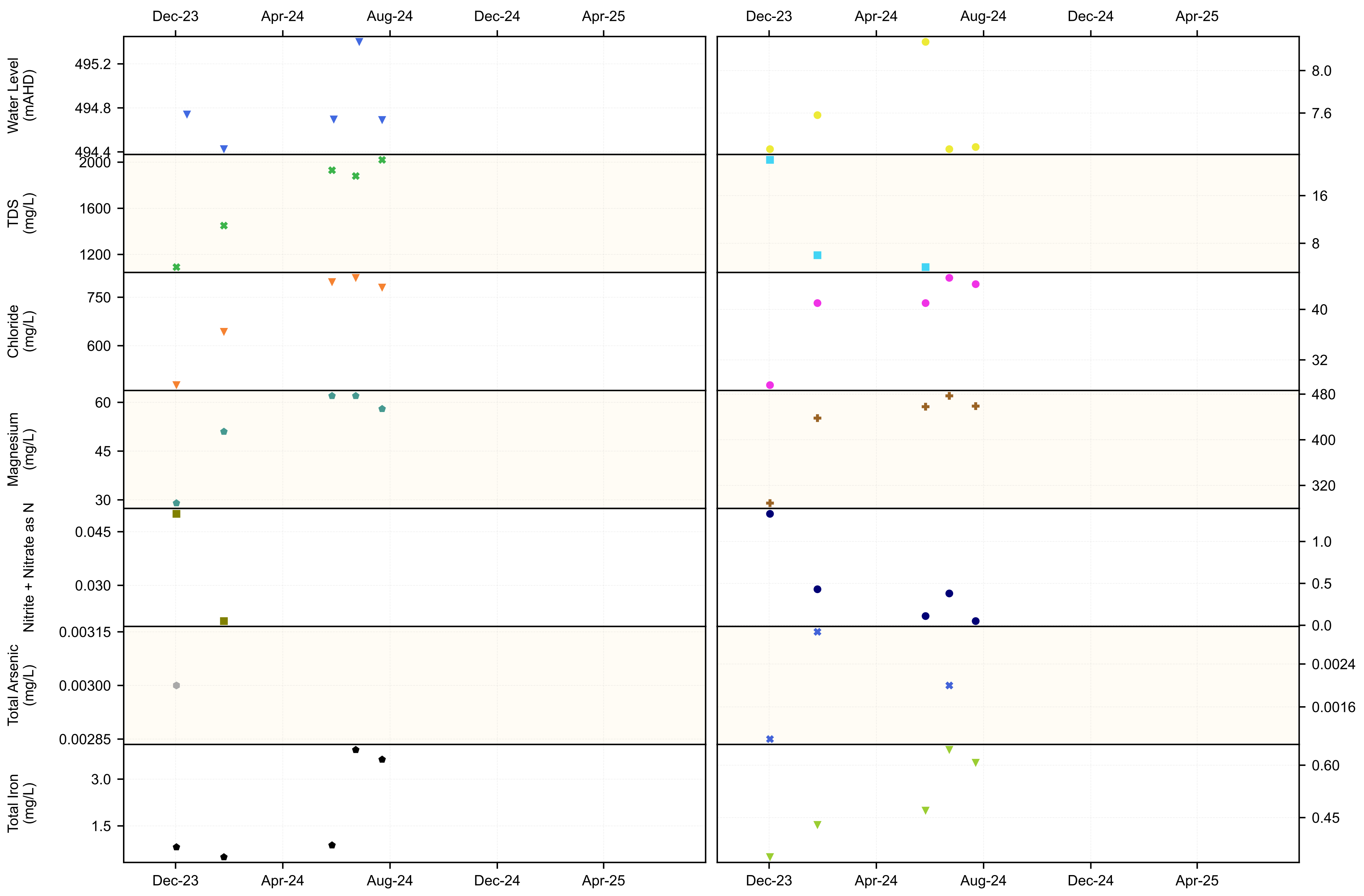

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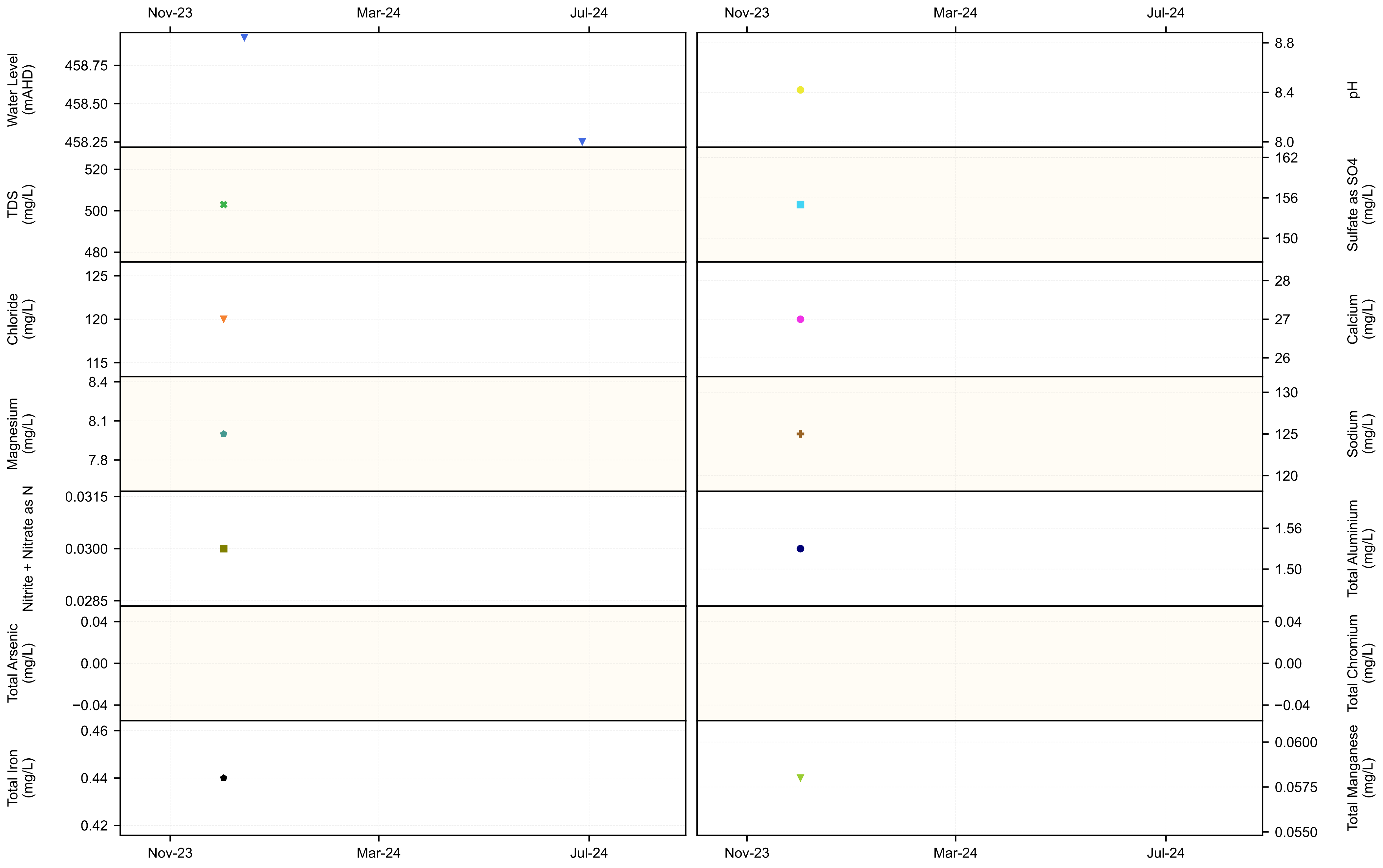

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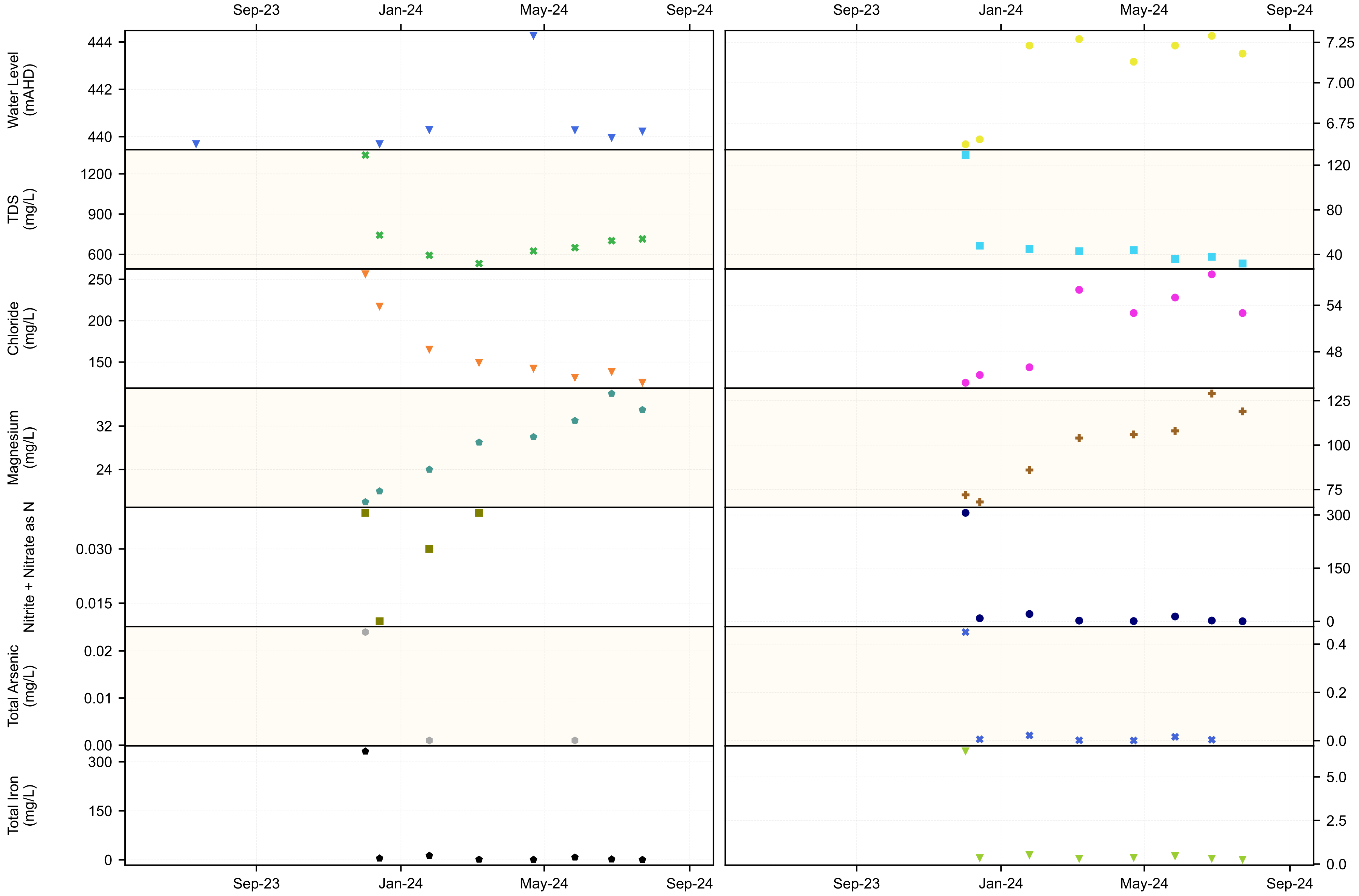

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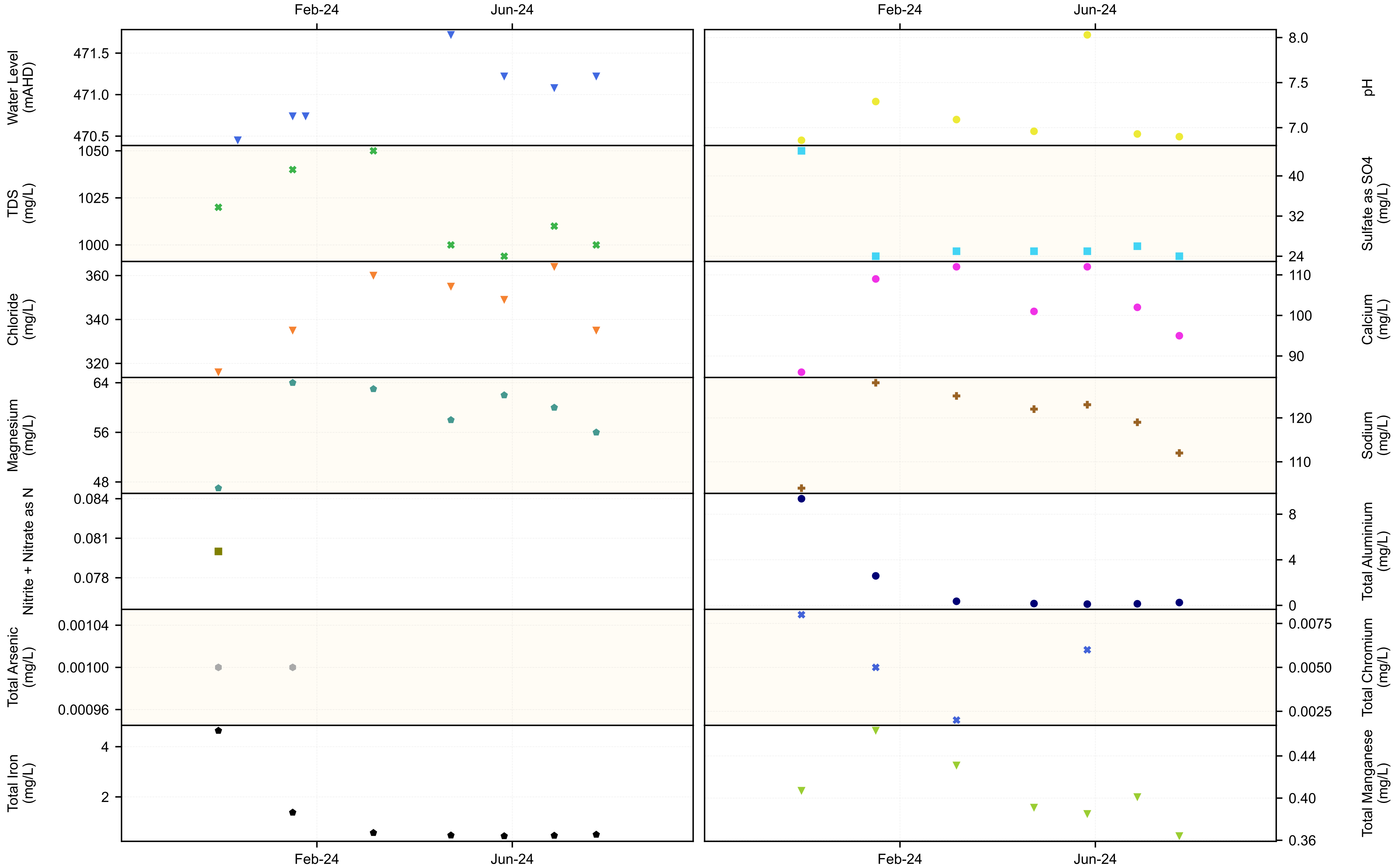

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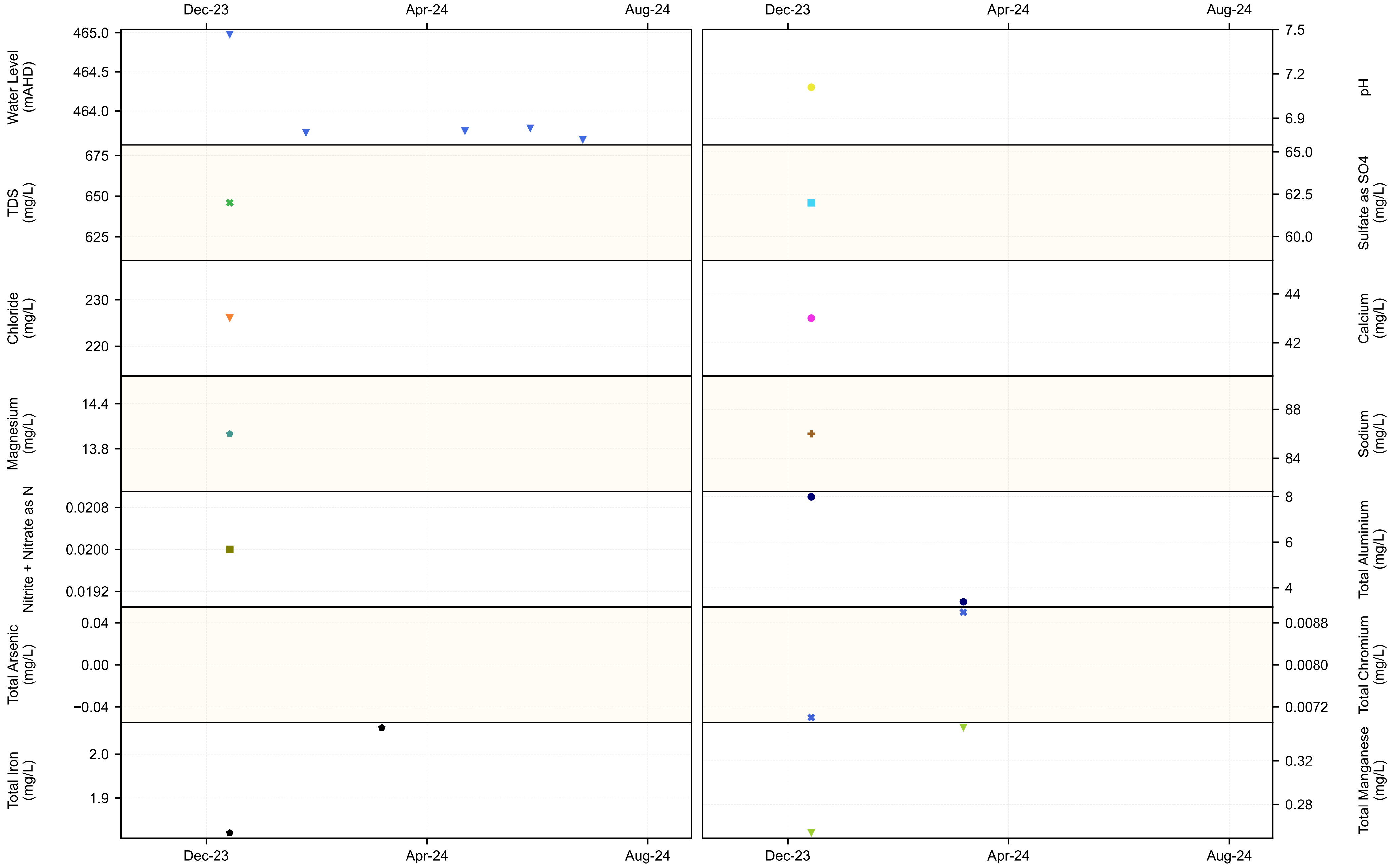

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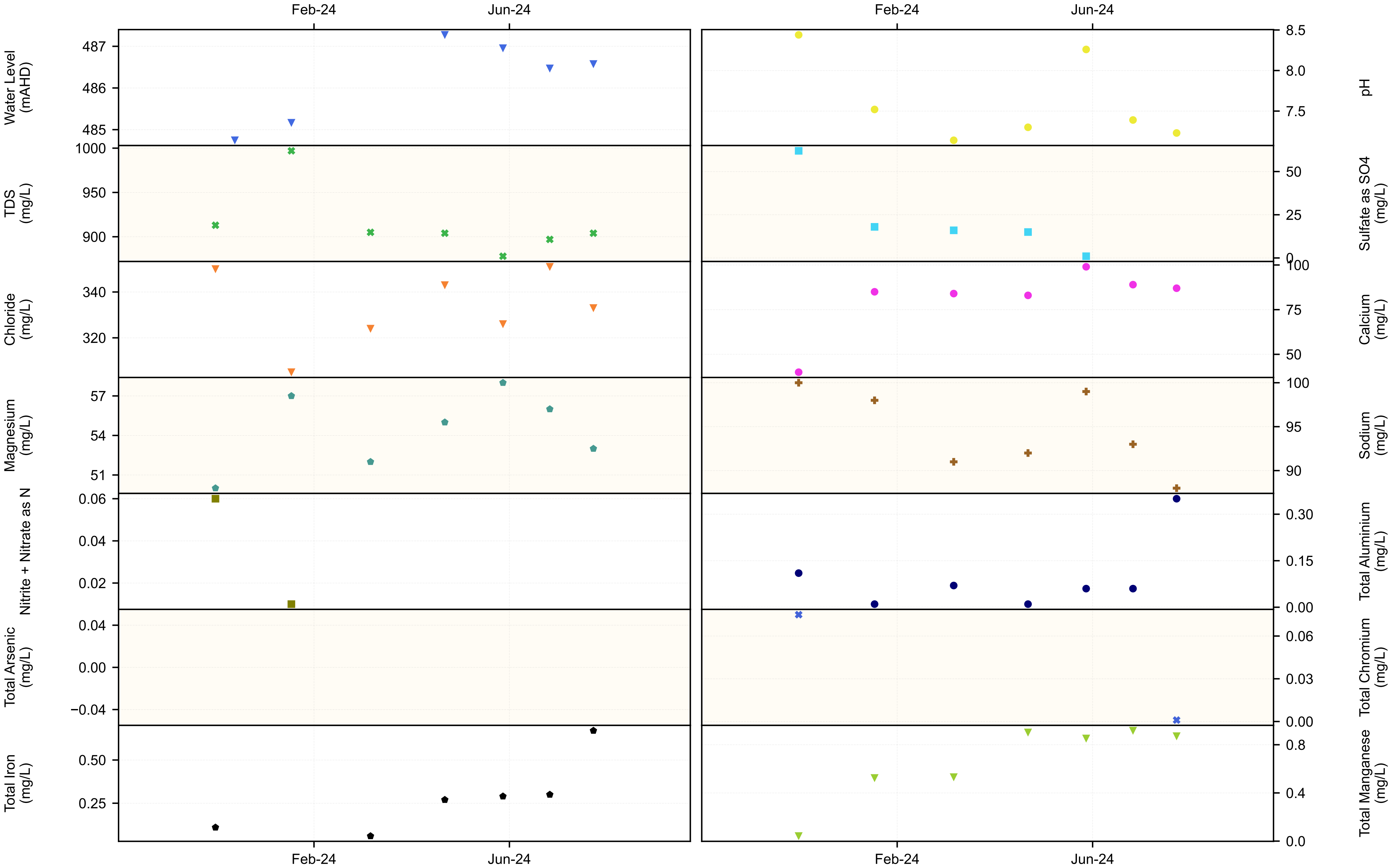

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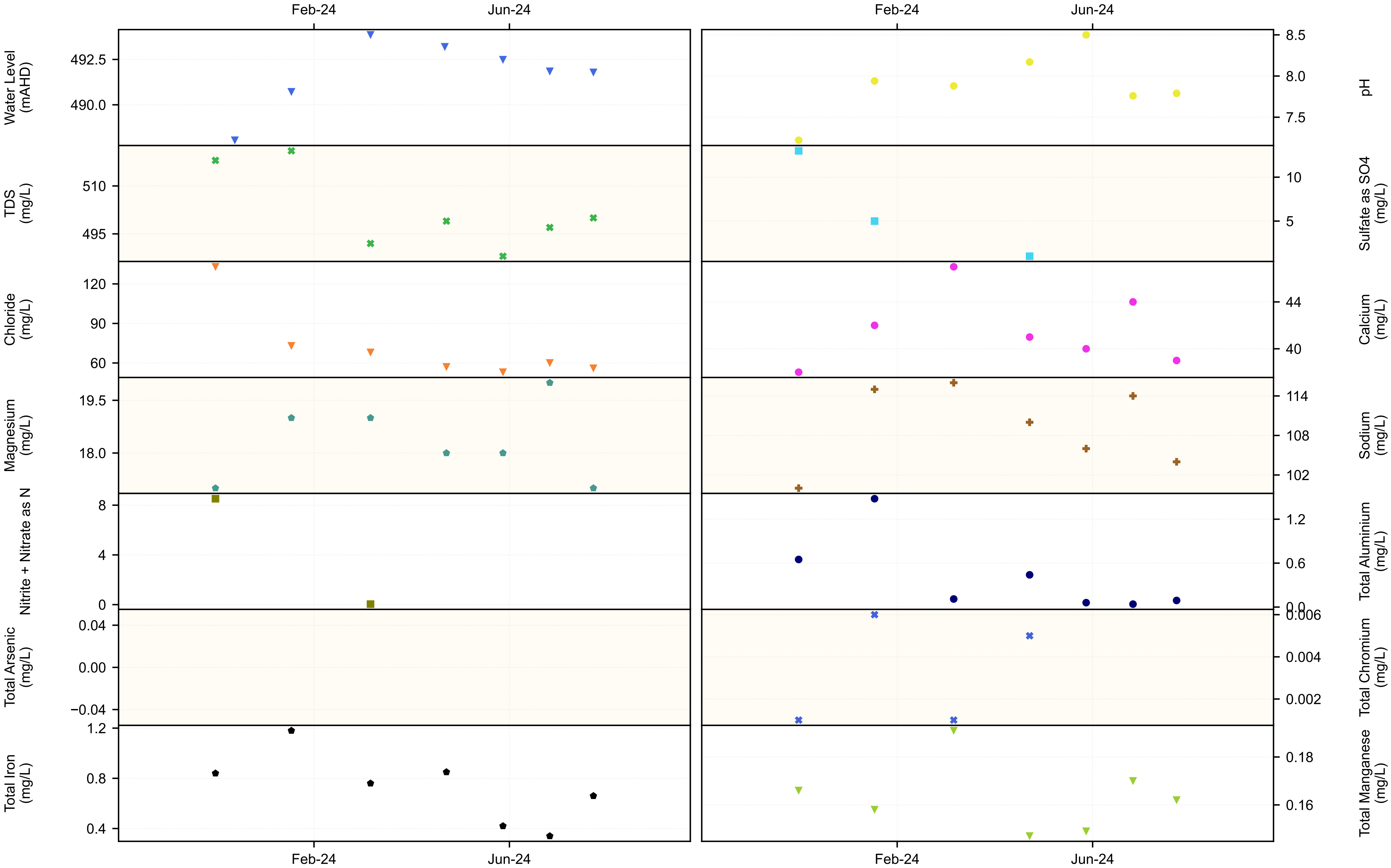

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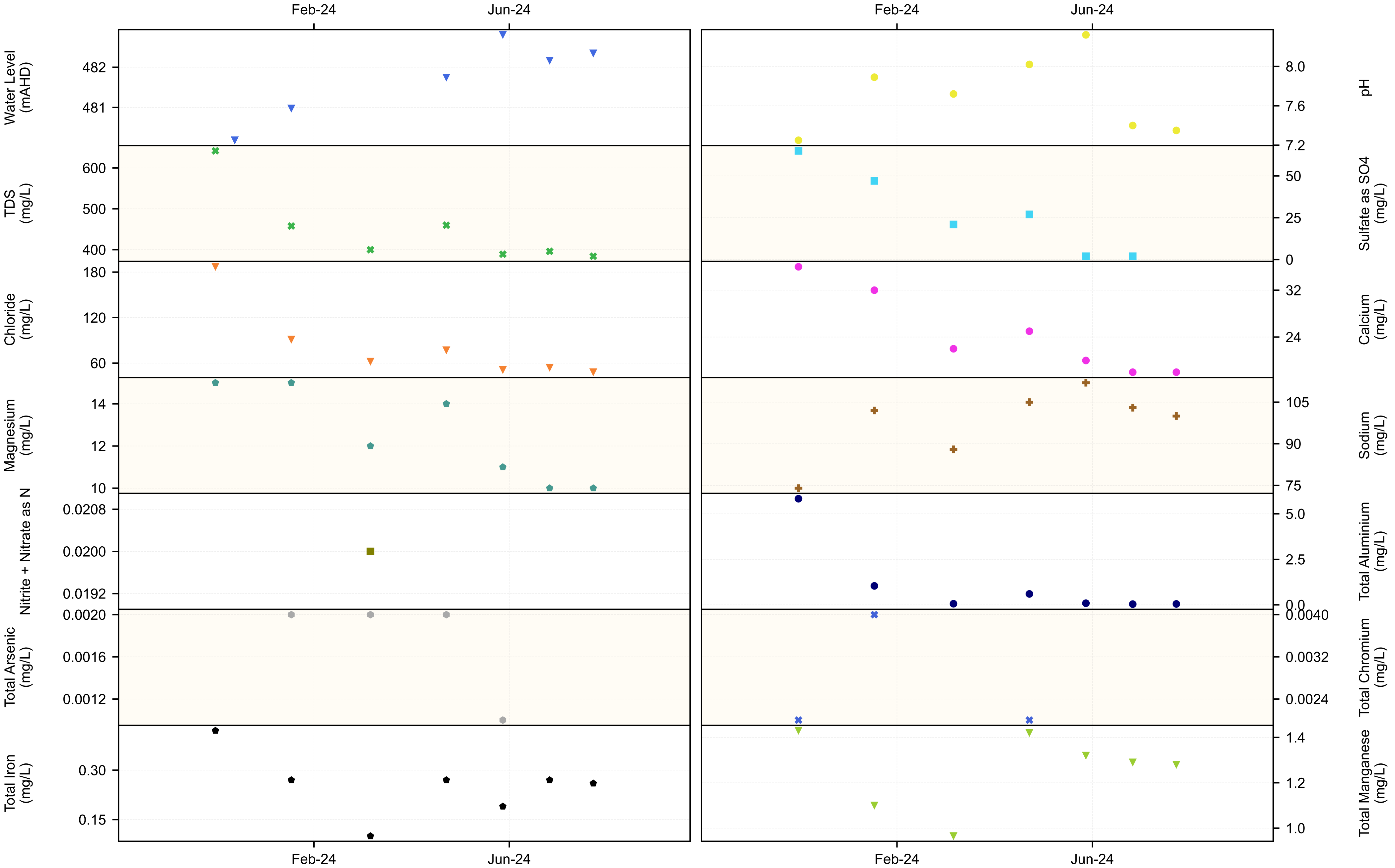

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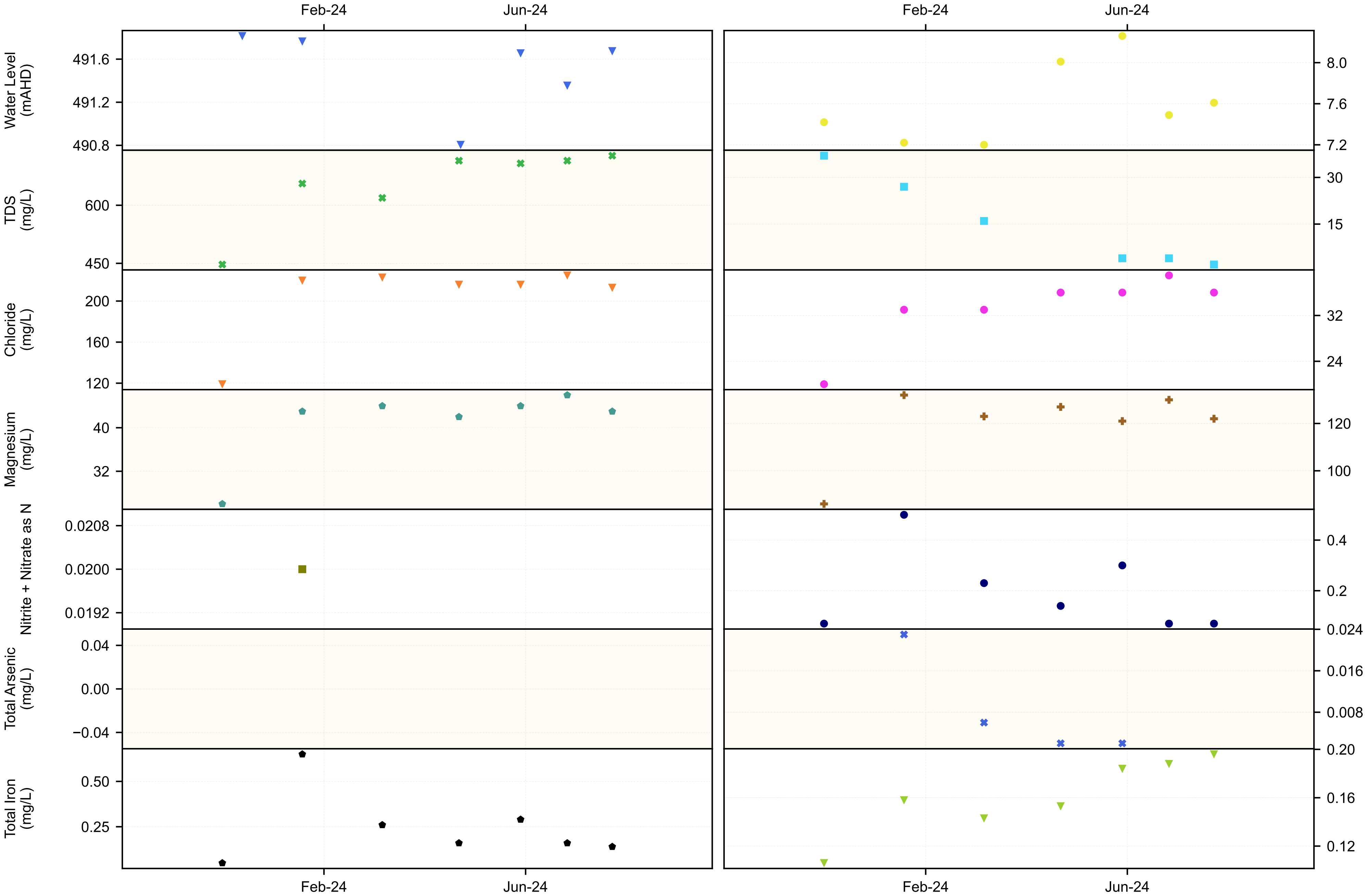

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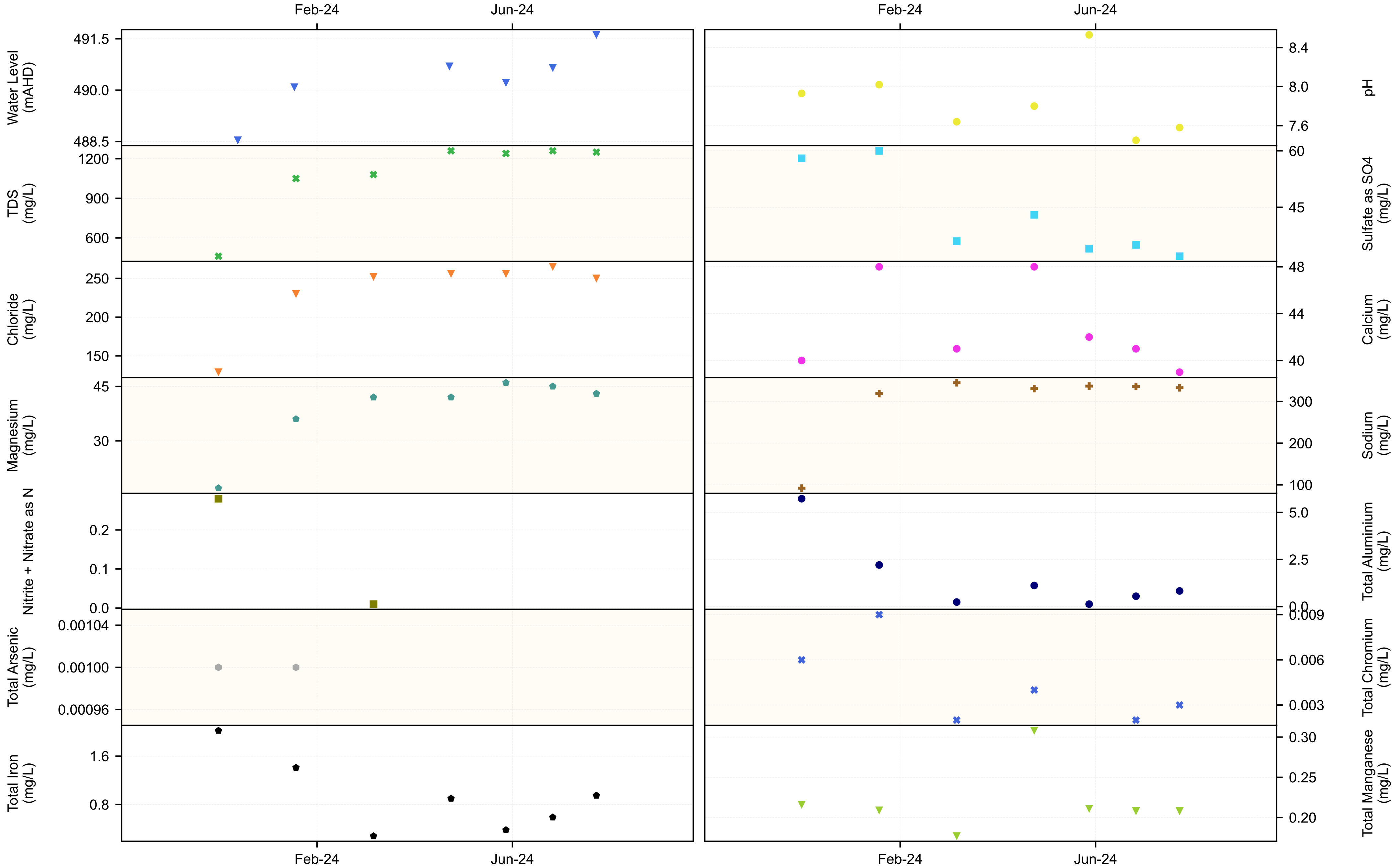

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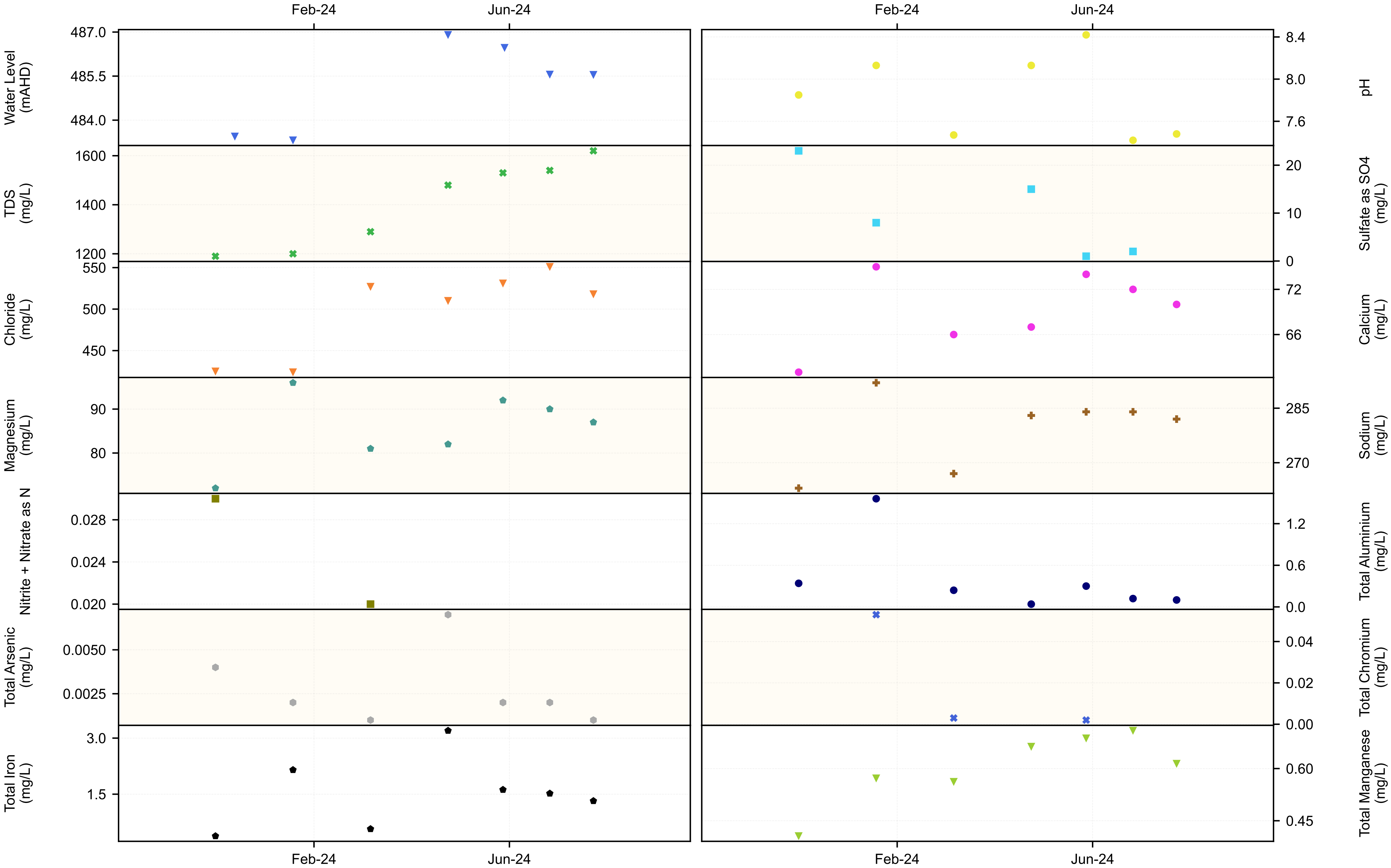

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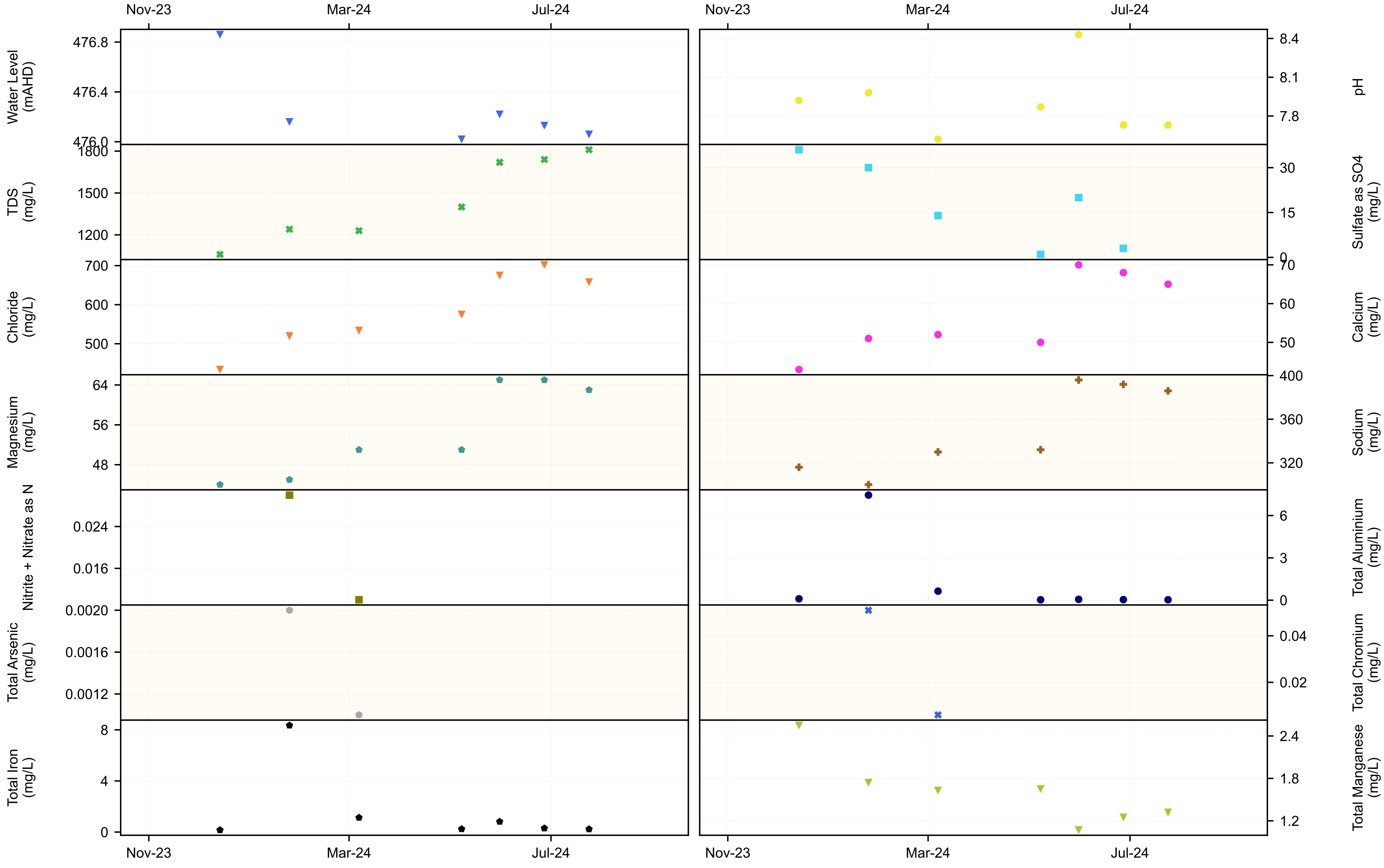

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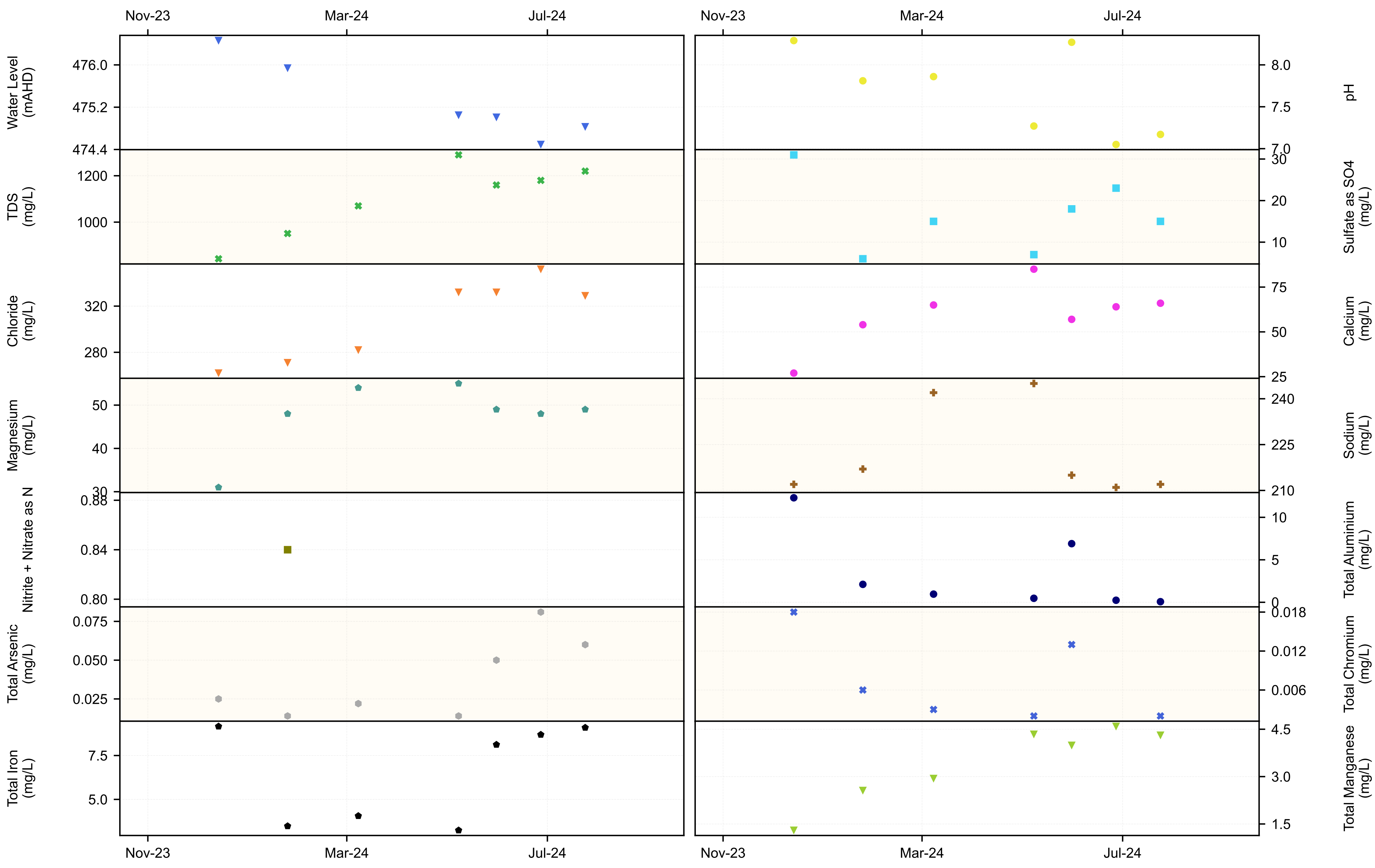

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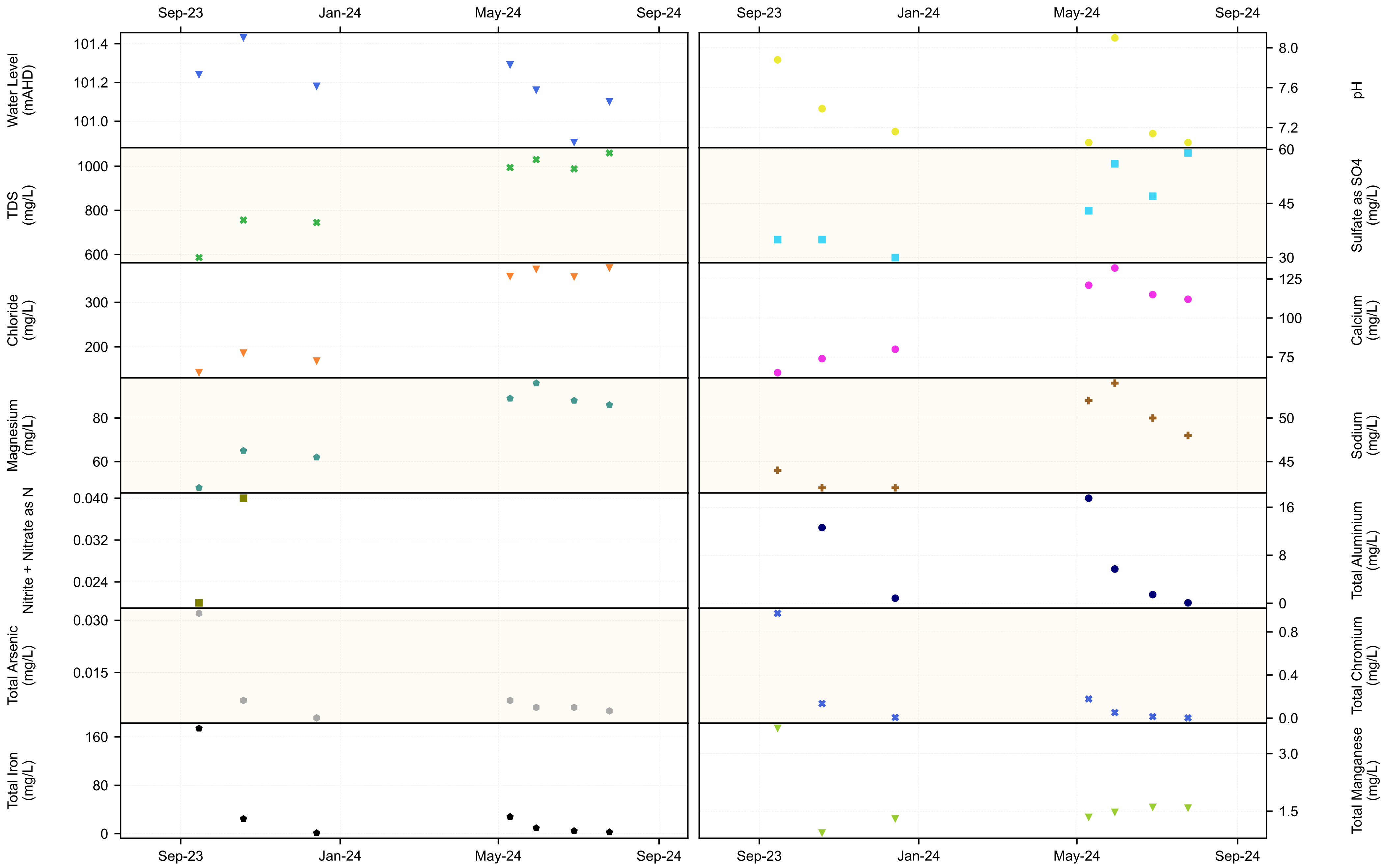

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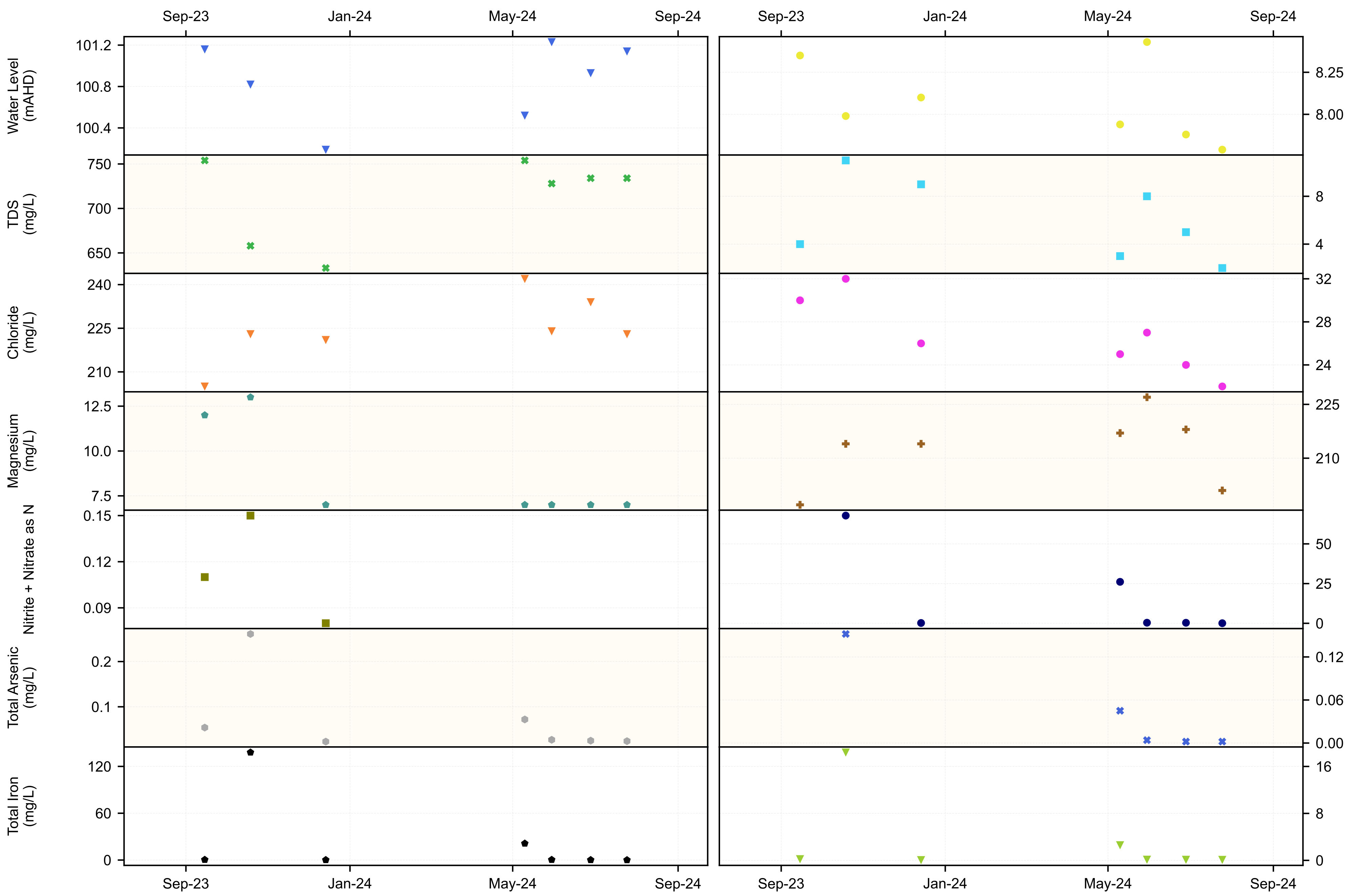

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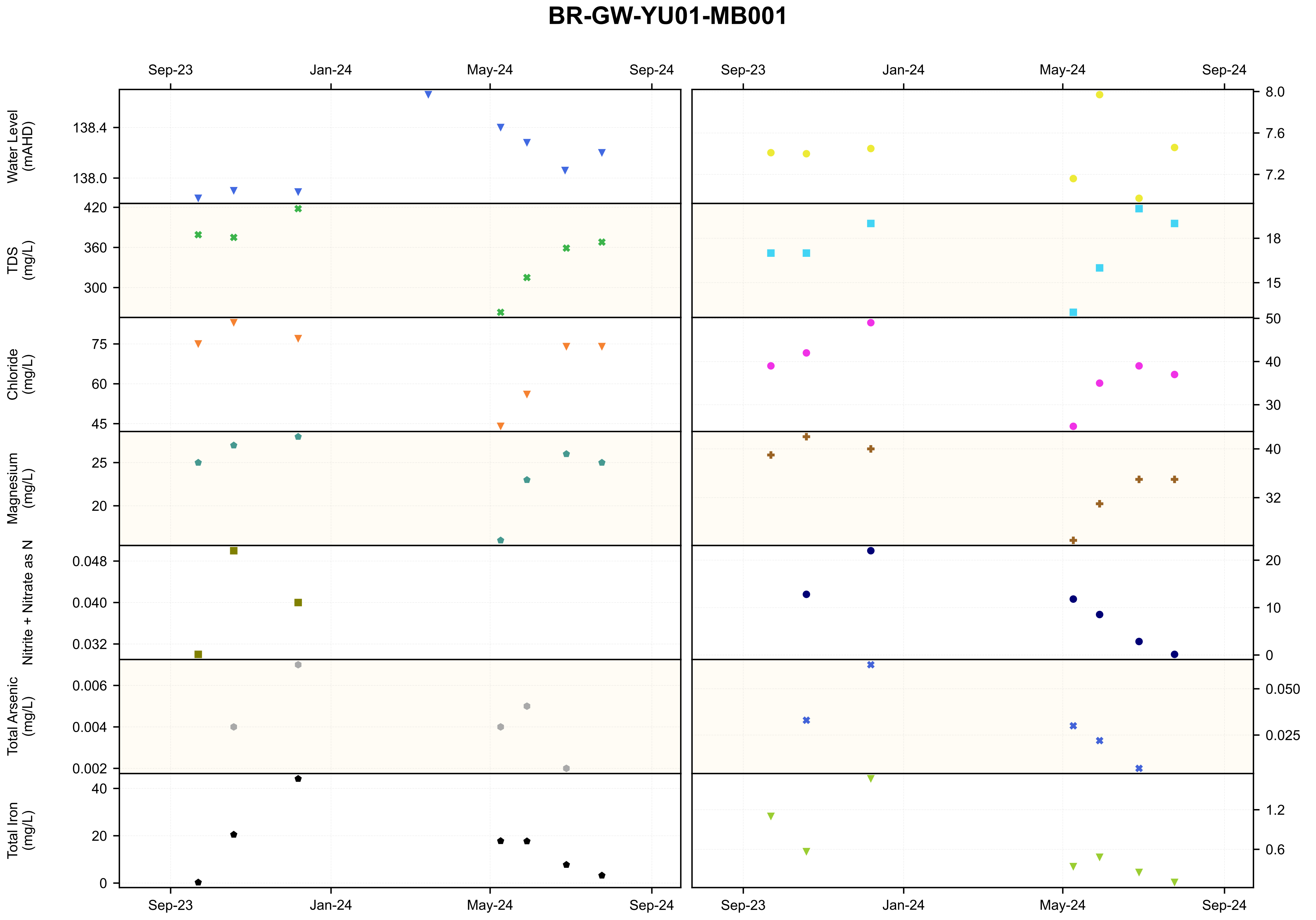
Groundwater level and quality plots



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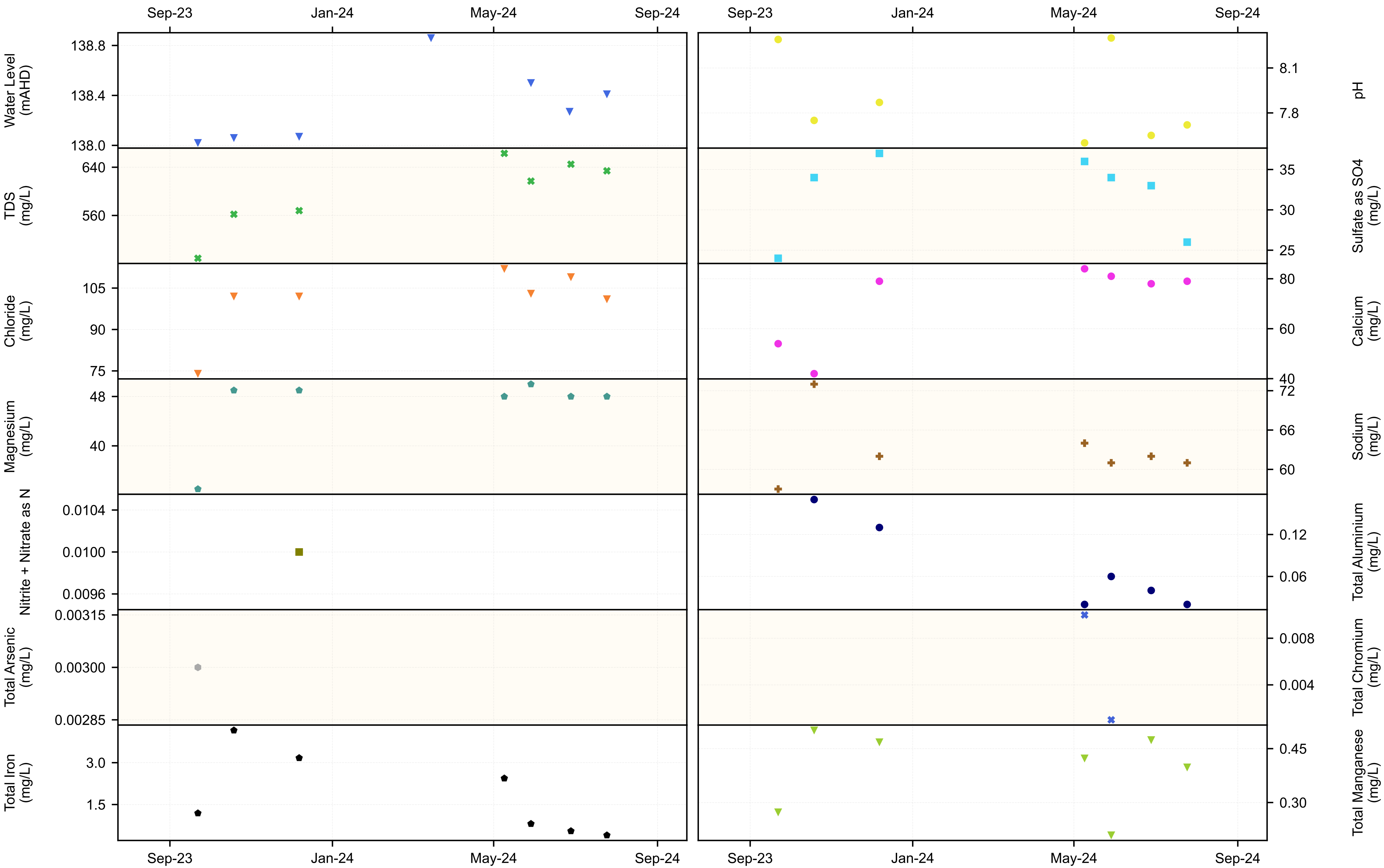

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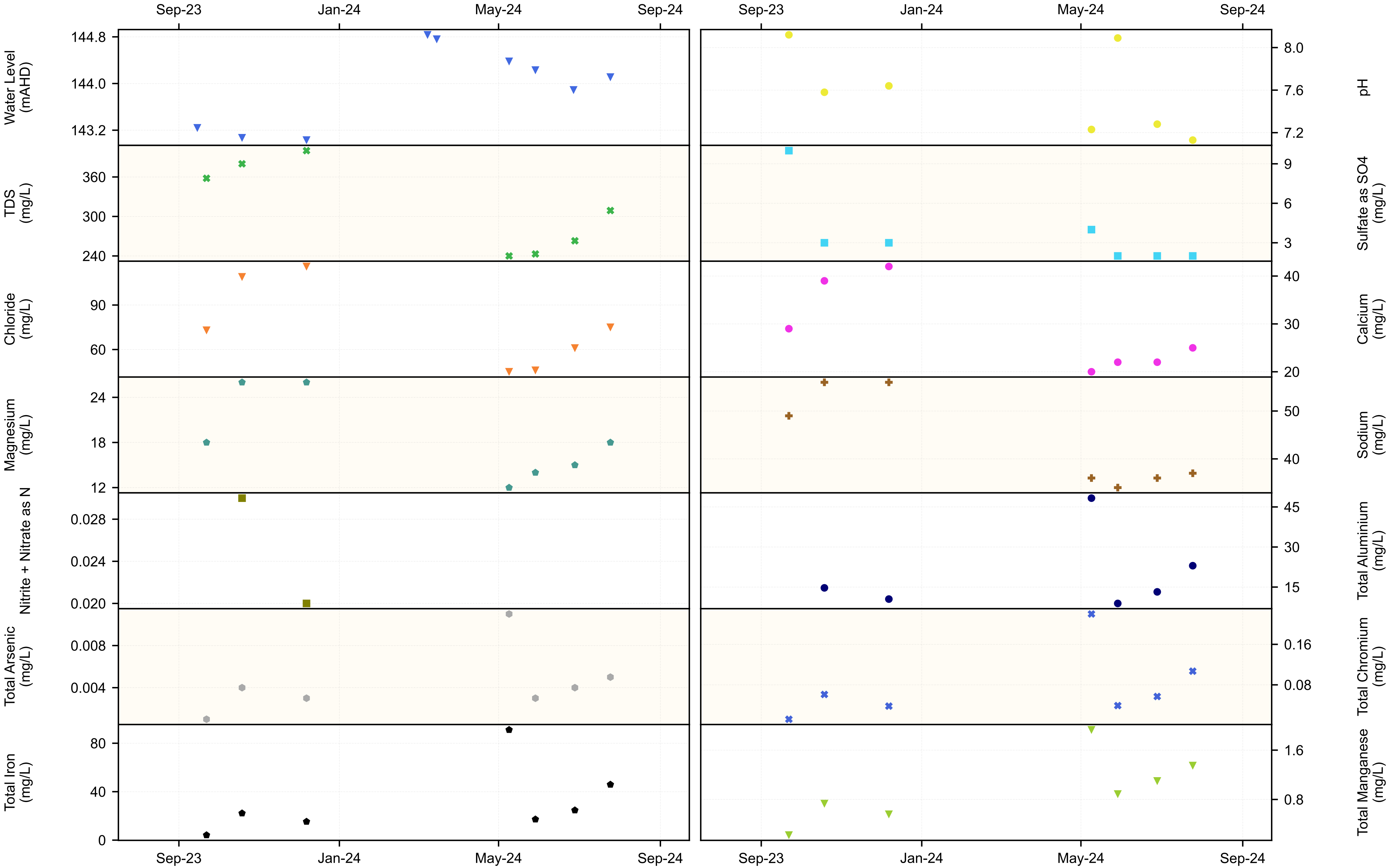

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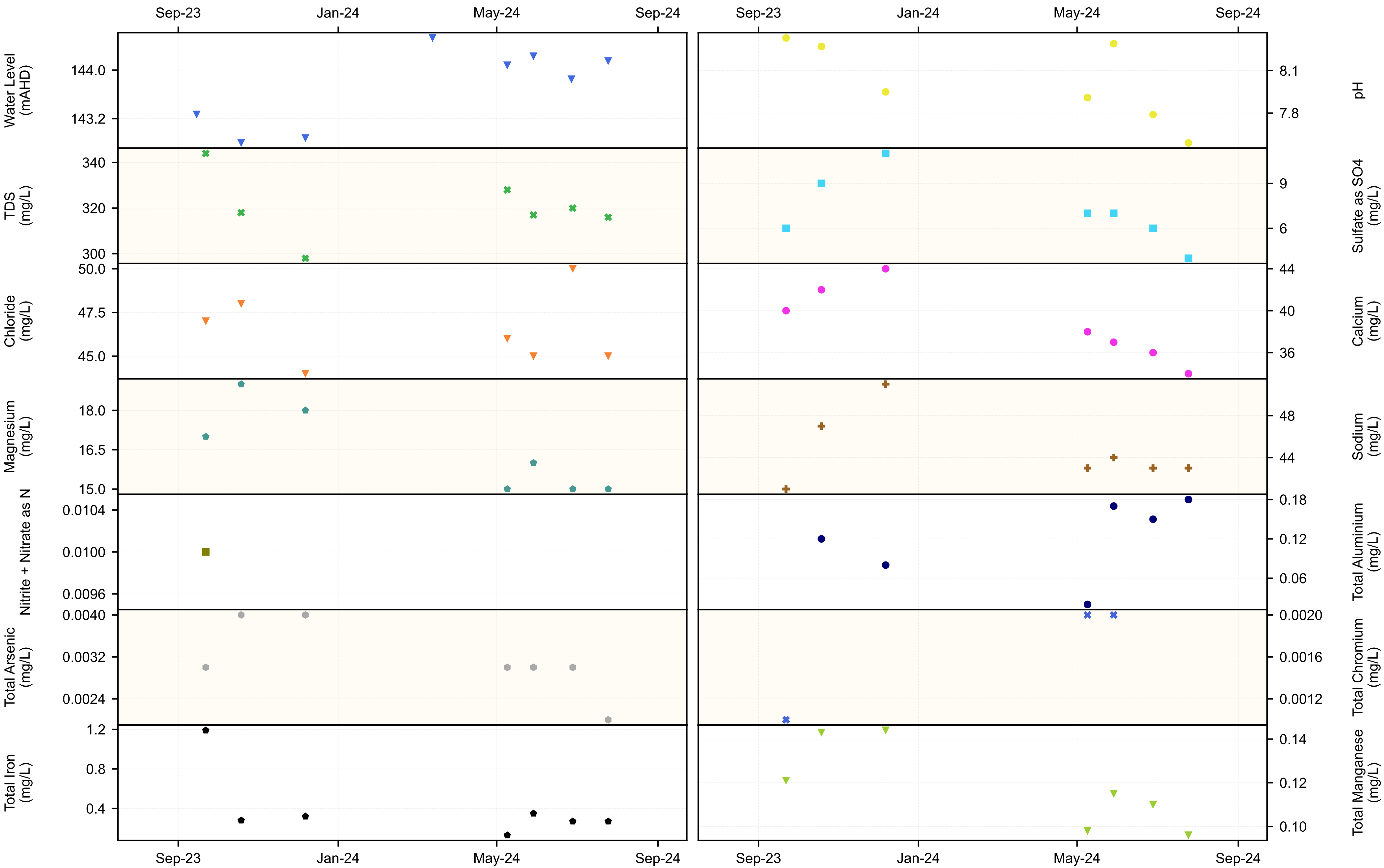

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Groundwater level and quality plots

Appendix D

Factual Report

Australasian Groundwater & Environmental Consultants

Report on

Borumba Dam PHES Field Investigation Factual Report

Prepared for
Queensland Hydro Pty Ltd

Project No. BDP5001.001
April 2024

ageconsultants.com.au

ABN 64 080 238 642

Document details and history

Document details

Project number	BDP5001.001
Document title	Borumba Dam PHES Field Investigation Factual Report
Site address	Borumba Dam, Imbil, QLD
File name	BDP5001.001_Borumba Dam Factual Report_v02.01.docx

Document status and review

Edition	Comments	Author	Authorised by	Date
v01.01	Draft for progress only	CP/GV	PL	05/01/2024
v02.01	Second draft, updated information for the upper reservoir and spring survey.	CP	PL	08/02/2024
V03.01	Update bore census section, add chemistry data to appendix.	CP		19/04/2024

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Table of contents

List of figures

List of tables

Table of contents

List of appendices

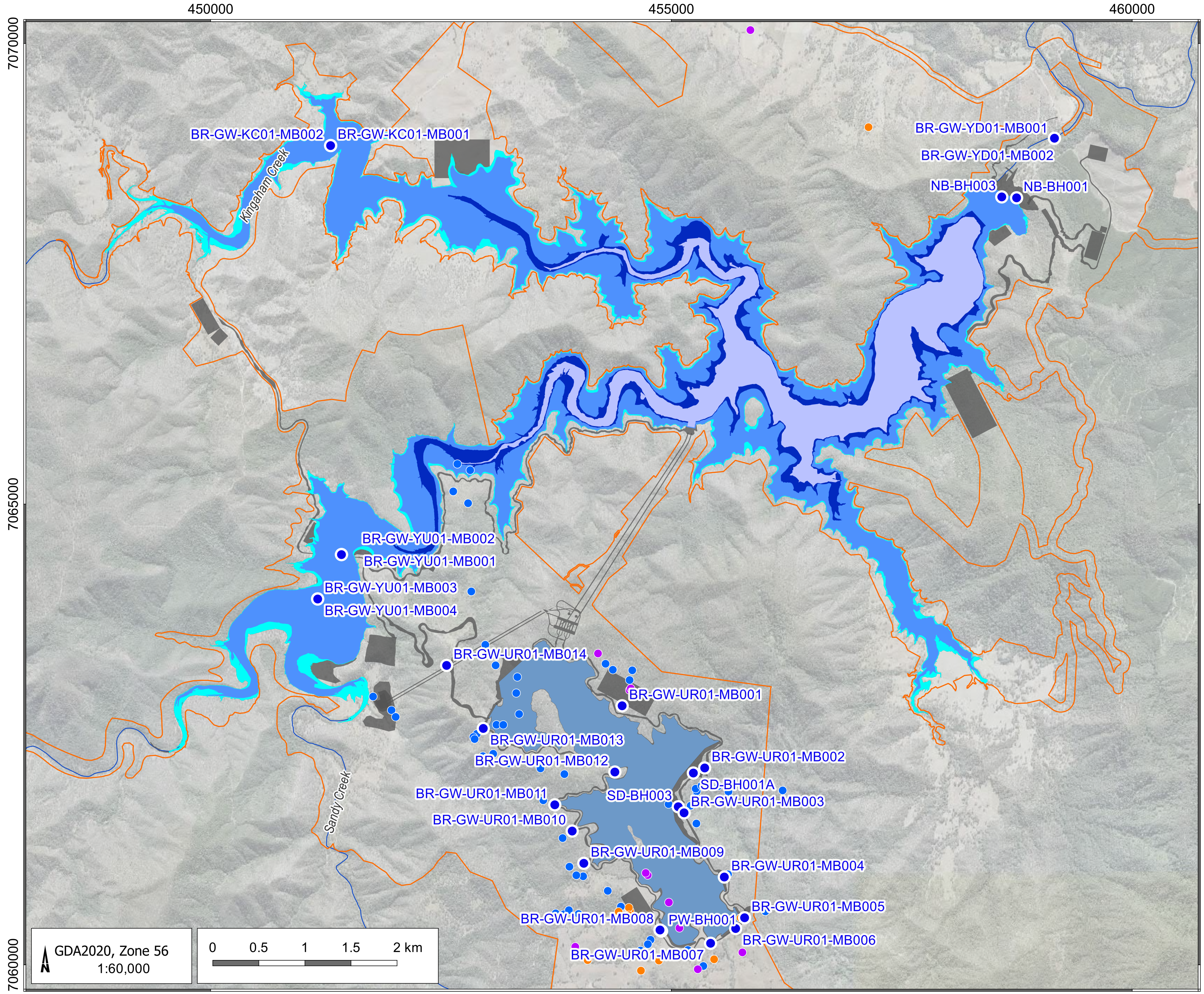
Borumba Dam PHES Field Investigation Factual Report

1 Introduction

In June 2021, Powerlink Queensland (PQ) was engaged by the Queensland Government to prepare a detailed analytical report (DAR) and front-end engineering design (FEED) for the Borumba Pumped Hydro Project (BPHP) proposed to be based at the existing Lake Borumba. The primary objective of the BPHP is to provide long-duration, high-capacity dispatchable energy to the Queensland grid, which can be used to increase system stability and reliability of supply.

In September 2022, the project was transferred from PQ to Queensland Hydro (QH). Queensland Hydro is responsible for the design, delivery, operation and maintenance of Queensland's long duration pumped hydro energy storage assets.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were engaged by QLD Hydro to oversee the drilling and construction of all groundwater monitoring infrastructure that was designed by SMEC and undertake testing to obtain hydraulic properties of strata units. The location of all groundwater monitoring infrastructure is shown in Figure 1.1 and includes twenty-two (22) standpipe bores. This factual report provides results of the site investigation.



LEGEND

- Completed bores
- Drainage
- Project Area

Water area

- Lower Reservoir (Current MOL 130 mAHD)
- Lower Reservoir (Current FSL 135.01 mAHD)
- Lower reservoir (Planned FSL 155 mAHD)
- Lower Reservoir (Planned Q100 158.03 mAHD)
- Upper reservoir (Planned FSL 490.5 mAHD)

Springs Surveyed

- Type 1
- Type 2
- Type 3

Borumba Dam - EIS (BDP5002.001)

Location of monitoring bores and spring survey areas

AGE

DATE
19/04/2024

FIGURE No:
1.1

G:\Projects\BDP5002.001 Borumba Dam - Pioneer EIS\3_GIS\Workspaces\001_Deliverable1\11.00_BDP5002.001_Location of monitoring bores and spring survey areas.qgz

2 Scope of Work

The objective of the site investigations is to provide information towards conceptualisation of the site hydrogeology, environmental impact statement and expand the current groundwater monitoring network.

Specific onsite tasks for the investigation included:

- Completion of a bore census and spring survey.
- Monitoring bore installation, testing and installing equipment:
  - supervise drilling of groundwater bores at selected locations;
  - undertake falling/rising head tests; and
  - install monitoring equipment at new bores and selected existing bores.
- Undertake groundwater monitoring for an agreed duration (nominally 3 months) before the next phase of EIS assessment.

3 Drilling and bore construction

The drilling and construction of the investigation bores commenced on 5 September 2023. The drilling contractor, Terratest Group, is a Class 2 licensed water bore driller engaged by QLD Hydro to undertake these works. The bores were drilled and constructed in accordance with design specifications provided by SMEC and amended by AGE where necessary. An AGE hydrogeologist was onsite for the duration of the field program to provide technical guidance, oversee bore construction and collect groundwater data.

3.1 Drilling

All boreholes were augured, using a 150 auger TC drill bit, through the residual soil and weathered zone until refusal was met. The drilling method was then changed to either air rotary, wash bore or diamond core drilling. The AGE hydrogeologist logged the geology from the chips and from the cored sections. Seepage intersected during airlifting was typically too low to obtain yields or in situ water chemistry data during air rotary drilling. The mud tanks were tested in situ at the upper reservoir boreholes during drilling. Indicative water quality measurements of electrical conductivity (EC), pH and temperature were obtained with a field calibrated water quality meter. Airlifted yields and water quality data recorded during drilling are provided in Section 3.3.

- Air rotary drilling was the preferred methodology for the boreholes sited at the lower dam, as this method is quick and allows for geological logging by examining chip fragments.
- Wash bore drilling was the preferred methodology in areas where serpentinite was the expected lithology, due to the risk of asbestos within the rock. Wash boring was selected to reduce the risk of environmental contamination and as a health and safety protective measure. The water from the mud tanks was removed by vacuum trucks and safely disposed.
- Diamond core drilling was the preferred methodology for boreholes sited at the upper reservoir to allow for the collection of geotechnical data by Engeo. These boreholes were also packer tested at 6 m intervals.

Bore logs, created in Strater 5, are available in Appendix B.

Table 3.1 Borehole drilling methodology and depths

Drilling Method	Auger	Air Rotary	Wash Bore	Coring
Bit diameter	**150 mm Auger TC**	**126 mm Downhole Hammer**	**100 mm TCI Tricone**	**94 mm Diamond Core**
BR-GW-KC01-MB001	0 - 3 m	-	3 - 10 m	-
BR-GW-KC01-MB002	0 - 2.5 m	-	2.5 - 30 m	-
BR-GW-YD01-MB001	0 - 6 m	-	-	-
BR-GW-YD01-MB002	0 - 7 m	7 - 30 m	-	-
BR-GW-YU01-MB001	0 - 4 m	-	4 - 6 m	-
BR-GW-YU01-MB002	0 - 5 m	-	5 - 25 m	-
BR-GW-YU01-MB003	0 - 4.7 m	4.7 - 6 m	-	-
BR-GW-YU01-MB004	0 - 1.6 m	1.6 - 30 m	-	-
BR-GW-UR01-MB001	0 - 1 m	-	-	1 - 50 m
BR-GW-UR01-MB002	0 - 3 m	-	-	3 - 25 m
BR-GW-UR01-MB003	0 - 2.5 m	-	-	2.5 - 28 m
BR-GW-UR01-MB004	0 - 2.5 m	-	-	2.5 - 50 m
BR-GW-UR01-MB005	0 - 4 m	-	-	4 - 30 m
BR-GW-UR01-MB006	0 - 2.8 m	-	-	2.8 - 35 m
BR-GW-UR01-MB007	0 - 3 m	-	-	3 - 35 m
BR-GW-UR01-MB008	0 - 4.7 m	-	-	4.7 - 30 m
BR-GW-UR01-MB009	0 - 1.8 m	-	-	1.8 - 50 m
BR-GW-UR01-MB010	0 - 4.5 m	-	-	4.5 - 50 m
BR-GW-UR01-MB011	0 - 4.5 m	-	-	4.5 - 50 m
BR-GW-UR01-MB012	0 - 1.6 m	-	-	1.6 - 50 m
BR-GW-UR01-MB013	0 - 1.4 m	-	-	1.4 - 50 m
BR-GW-UR01-MB014	0 - 1.4 m	-	-	1.4 - 300 m

3.2 Bore construction

Bore construction was completed in accordance with the Minimum Construction Requirements for Water Bores in Australia (NUDLC, 2020). Bore construction details are presented in Table 3.2 and graphic bore logs are provided in Appendix A.

Monitoring bores were constructed using 50 mm PN18 uPVC casing and 1 mm aperture slotted screens. A filter pack comprising 3 to 5 mm washed quartz gravel was installed in the annulus opposite the screened interval. A bentonite seal, followed by cement grout, were then placed above the filter pack to isolate the screened formation aquifer from overlying formations. Each monitoring bore was completed with a concrete slab, a lockable protective monument and a marker flag. Refer to Figure 3.1 for schematic of standard bore construction design.

Table 3.2 Monitoring bore construction details

Bore ID	Easting	Northing	Ground level elevation (m AHD)[1]	Drilled depth	Slotted interval	Filter pack interval	Screened geology
	(z55 m E)	(z55 m N)		(m bgl)	(m bgl)	(m bgl)	
BR-GW-KC01-MB001	451303	7068892	150.81	10	4 - 6	3.5 - 10	Alluvium
BR-GW-KC01-MB002	451302	7068891	150.81	30	24 - 30	23 - 30	Serpentinite
BR-GW-YD01-MB001	459157	7068970	103.81	6	3 - 6	2.5 - 6	Alluvium
BR-GW-YD01-MB002	459158	7068971	103.83	30	24 - 30	23 - 30	Phyllite
BR-GW-YU01-MB001	451420	7064452	140.95	6	3 - 6	2.5 - 6	Weathered Serpentinite
BR-GW-YU01-MB002	451420	7064451	140.95	25	19 - 25	18 - 25	Serpentinite
BR-GW-YU01-MB003	451161	7063970	148.1	6	3 - 6	2.5 - 6	Alluvium
BR-GW-YU01-MB004	451162	7063969	148.1	30	24 - 30	23 - 30	Alluvium
BR-GW-UR01-MB001	454466	7062810	508.82	50	16 - 22	15 - 23	Metasediments
BR-GW-UR01-MB002	455362	7062135	477.79	25	13 - 19	12 - 20	Granodiorite
BR-GW-UR01-MB003	455138	7061648	466.9	28	22 - 28	21 - 28	Granodiorite
BR-GW-UR01-MB004	455575	7060951	485.48	50	10 - 16	9 - 17	Granodiorite
BR-GW-UR01-MB005	455795	7060509	481.51	30	12 - 18	11 - 19	Granodiorite
BR-GW-UR01-MB006	455698	7060392	490.64	35	29 - 35	28 - 35	Granodiorite
BR-GW-UR01-MB007	455426	7060232	494.64	35	18 - 24	17 - 25	Granodiorite
BR-GW-UR01-MB008	454877	7060376	486.06	30	8 - 14	7 - 15	Granodiorite
BR-GW-UR01-MB009	454050	7061100	506.85	50	37 - 43	36 - 44	Granodiorite
BR-GW-UR01-MB010	453924	7061450	506.23	50	11 - 20	10 - 21	Granodiorite
BR-GW-UR01-MB011	453735	7061735	500.55	50	36 - 42	35 - 43	Granodiorite
BR-GW-UR01-MB012	454387	7062091	503.07	50	36 - 42	35 - 43	Metasediments
BR-GW-UR01-MB013	452959	7062564	506.76	50	29 - 35	28 - 35	Metasediments
BR-GW-UR01-MB014	452561	7063248	430.07	300	N/A	N/A	Metasediments

Notes: [1] Surveyed co-ordinates in GDA2020 zone 56 (surveyed data provided by SMEC).
m bgl = metres below ground level.
N/A – Not Applicable as not constructed as a monitoring bore.

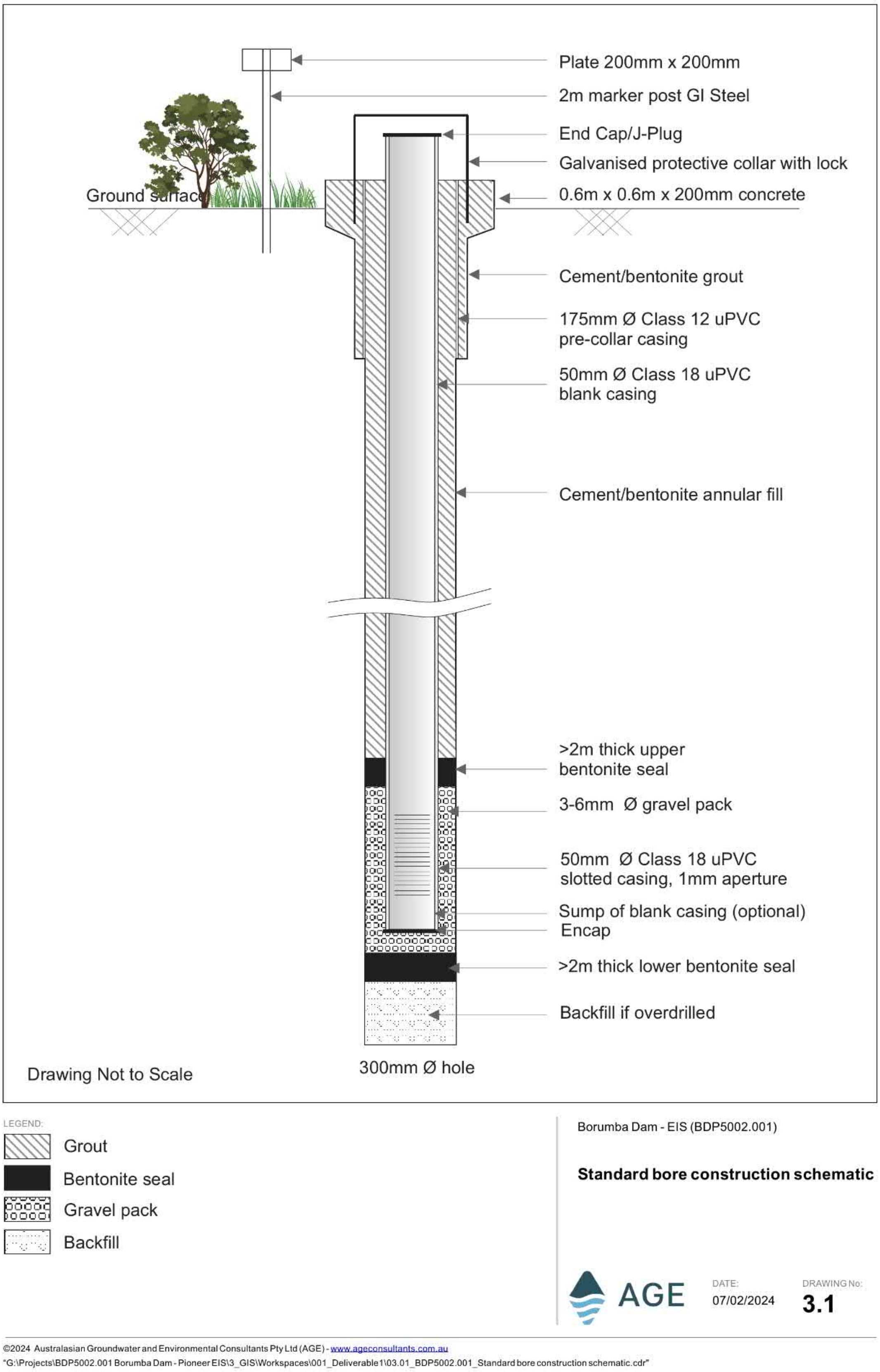


Figure 3.1 Standard bore construction schematic

3.3 Bore development

Monitoring bores were developed using a high pressure rated air supply line inserted into the bore casing just above the base of the bore. A rig-mounted air compressor was used for the bore development process. Airlift water samples were collected for testing of field parameters (i.e., pH, EC, and flow rate). The EC and pH were measured using a Myron water quality meter, calibrated prior to undertaking any sampling, using factory-supplied calibration standard solutions. Airlift yields were measured during bore development using a calibrated measuring container and a stopwatch. Refer to Table 3.3 for a summary of recorded field parameters during development.

Monitoring bores BR-GW-KC01-MB001, BR-GW-KC01-MB002, BR-GW-YU01-MB001, and BR-GW-YU01-MB002 were developed by plastic disposable bailers as these boreholes could not be airlifted due to the risk of asbestos from the intersected serpentinite.

Development was considered satisfactory when recorded field parameters stabilised within 10% of three consecutive readings and the water was free from sediment or until the borehole ran dry.

Table 3.3 Borehole development details

BH ID	Date & Time Completed	Duration (min)	Airlift yield (L/s)	EC (uS/cm)	pH	Comments
BR-GW-KC01-MB001	21/09/2023 @ 11:42	27	N/A	438.8	7.04	Bailed to develop
BR-GW- KC01-MB002	21/09/2023 @ 13:26	130	N/A	789.1	6.97	Bailed to develop
BR-GW-YD01-MB001	07/09/2023 @ 9:25	35	0.016	646	6.89	Very low seepage, purged until dry
BR-GW-YD01-MB002	07/09/2023 @ 8:45	15	0.016	1001	6.90	Very low seepage, purged until dry
BR-GW-YU01-MB001	21/09/2023 @ 9:30	30	N/A	587.7	7.04	Bailed to develop
BR-GW-YU01-MB002	21/09/2023 @ 10:30	60	N/A	760.9	7.05	Bailed to develop
BR-GW-YU01-MB003	13/09/2023 @ 9:02	30	0.002	487.5	7.07	No drawdown during development of YU01 MB004
BR-GW-YU01-MB004	13/09/2023 @ 8:28	32	3.2	523.3	7.05	Higher flow observed
BR-GW-UR01-MB001	01/12/2023 @ 11:55	20	0.025	749	8.03	Yield too low to continue longer
BR-GW-UR01-MB002	01/12/2023 @ 13:22	10	0.006	872	8.34	Yield too low to continue longer
BR-GW-UR01-MB003	01/12/2023 @ 13:47	18	0.003	995	7.82	Yield too low to continue longer
BR-GW-UR01-MB004	01/12/2023 @ 14:18	14	0.006	1348	8.03	Yield too low to continue longer
BR-GW-UR01-MB005	02/12/2023 @ 09:26	11	0.003	841	8.01	Yield too low to continue longer
BR-GW-UR01-MB006	02/12/2023 @ 08:56	24	>1	1454	8.11	Water clear and flow constant
BR-GW-UR01-MB007	02/12/2023 @ 08:16	30	0.018	766	8.32	Yield too low to continue longer
BR-GW-UR01-MB008	02/12/2023 @ 07:42	20	0.016	872	7.60	Yield too low to continue longer

BH ID	Date & Time Completed	Duration (min)	Airlift yield (L/s)	EC (uS/cm)	pH	Comments
BR-GW-UR01-MB009	02/12/2023 @ 07:03	23	0.05	625	8.38	Yield too low to continue longer
BR-GW-UR01-MB010	01/12/2023 @ 15:38	18	0.03	730	8.42	Yield too low to continue longer
BR-GW-UR01-MB011	01/12/2023 @ 14:57	23	>0.5	1897	8.35	Grout not fully set and SS increase
BR-GW-UR01-MB012	01/12/2023 @ 10:40	18	0.05	2285	8.43	Yield too low to continue longer
BR-GW-UR01-MB013	01/12/2023 @ 10:25	10	0.003	2245	8.54	Yield too low to continue longer, SS remain high

4 Groundwater levels and loggers

4.1 Groundwater levels

Groundwater levels were measured with a water level dipper in all monitoring bores following the completion of drilling and bore development, refer to Table 4.1.

Table 4.1 Water level details

Bore ID	Lithology	Date Recorded	Standing Water Level	
			m bgl	m AHD
BR-GW-KC01-MB001	Alluvium	22/10/2023	8.08	145.92
BR-GW- KC01-MB002	Serpentinite	19/10/2023	8.25	145.75
BR-GW-YD01-MB001	Alluvium	19/10/2023	2.93	110.07
BR-GW-YD01-MB002	Phyllite	19/10/2023	3.54	109.46
BR-GW-YU01-MB001	Weathered Serpentinite	19/10/2023	3.40	155.60
BR-GW-YU01-MB002	Serpentinite	19/10/2023	3.22	155.78
BR-GW-YU01-MB003	Alluvium	19/10/2023	5.59	148.41
R-GW-YU01-MB004	Alluvium	19/10/2023	5.86	148.14
BR-GW-UR01-MB001	Metasediments	01/12/2023	5.36	503.46
BR-GW-UR01-MB002	Granodiorite	01/12/2023	17.83	459.96
BR-GW-UR01-MB003	Granodiorite	01/12/2023	22.74	444.16
BR-GW-UR01-MB004	Granodiorite	01/12/2023	14.89	470.59
BR-GW-UR01-MB005	Granodiorite	14/12/2023	16.5	465.00
BR-GW-UR01-MB006	Granodiorite	02/12/2023	5.28	485.365
BR-GW-UR01-MB007	Granodiorite	02/12/2023	4.3	490.34
BR-GW-UR01-MB008	Granodiorite	02/12/2023	4.95	481.11
BR-GW-UR01-MB009	Granodiorite	02/12/2023	14.93	491.92
BR-GW-UR01-MB010	Granodiorite	01/12/2023	6.92	499.31
BR-GW-UR01-MB011	Granodiorite	01/12/2023	16.93	483.62
BR-GW-UR01-MB012	Metasediments	01/12/2023	18.92	484.15
BR-GW-UR01-MB013	Metasediments	01/12/2023	29.33	477.43

Notes: m bgl = metres below ground level.
m AHD = metres Australian Height Datum.

4.2 Automated data loggers

Automated water level and electrical conductivity loggers are used to provide continuous groundwater level and salinity (EC) data within standpipe monitoring bores. The instrumentation was supplied by EWS Pty Ltd and comprised a vented water level sensor, EC sensor and EWS Switch for satellite transmission of in situ data to the EWS online data portal.

These automated loggers were installed in all monitoring bores between October and December 2023.

The Switch unit was installed on the monument surrounding the PVC standpipe. The loggers were suspended by insulated cable, connected to the Switch, at approximately 1 to 2 m from the bottom of the bore (or dependent on the water levels at the time of installation, priority was given to ensuring that the loggers were submerged within the bore). The water level data loggers are vented for automatic atmospheric pressure compensation.

The loggers were synchronised to record at six hourly intervals. Details of loggers installed in the bores is provided in Table 4.2 and includes logger serial number, details of the depth to which the logger was installed, and date/time logging was commenced.

Table 4.2 Water level logger details

Location	Logger start date	Serial number	WL Logger Depth installed (m bgl)	EC Logger Depth Installed (m bgl)
BR-GW-KC01-MB001	17/10/2023	EWS18050	9.27	7.12
BR-GW- KC01-MB002	17/10/2023	EWS18055	27.47	27.10
BR-GW-YD01-MB001	17/10/2023	EWS18056	4.56	3.32
BR-GW-YD01-MB002	17/10/2023	EWS18057	27.97	27.22
BR-GW-YU01-MB001	11/10/2023	EWS18054	4.70	3.5
BR-GW-YU01-MB002	11/10/2023	EWS18053	23.74	22.51
BR-GW-YU01-MB003	26/10/2023	EWS18052	4.00	3.26
BR-GW-YU01-MB004	11/10/2023	EWS18051	27.83	27.26
BR-GW-UR01-MB001	17/10/2023*	EWS18073	20.65	19.8
BR-GW-UR01-MB002	13/10/2023*	EWS18061	18.38	18.83
BR-GW-UR01-MB003	13/10/2023*	EWS18058	27.84	27.34
BR-GW-UR01-MB004	13/10/2023*	EWS18062	17.25	16.25
BR-GW-UR01-MB005	16/10/2023*	EWS18069	17.56	17.26
BR-GW-UR01-MB006	13/10/2023*	EWS18066	33.74	32.22
BR-GW-UR01-MB007	13/10/2023*	EWS18065	23.42	22.23
BR-GW-UR01-MB008	13/10/2023*	EWS18059	13.23	12.08
BR-GW-UR01-MB009	13/10/2023*	EWS18060	42.20	41.2
BR-GW-UR01-MB010	17/10/2023*	EWS18072	19.09	18.09
BR-GW-UR01-MB011	16/10/2023*	EWS18071	41.59	40.59
BR-GW-UR01-MB012	16/10/2023*	EWS18070	40.96	36.61
BR-GW-UR01-MB013	16/10/2023*	EWS18068	34.25	33.92

Notes: m bgl = metres below ground level.
*Start date as per Orion portal. The units were installed in December 2023 and January 2024 (BR-GW-UR01-MB013).

5 Water quality sampling and analysis

Field determination for electrical conductivity (EC) and pH measured during sampling for each monitoring bore are provided in Table 5.1. The salinity of the water samples was categorised based on the National Water Commission (2011) classification provided below:

- Fresh water - <500 mg/L (< ~750 µS/cm).
- Brackish - 500 mg/L to 7,000 mg/L (~750 µS/cm to ~10,500 µS/cm).
- Saline - 7,000 mg/L to 35,000 mg/L (~10,500 µS/cm to ~53,000 µS/cm).
- Hypersaline (brine) - >35,000 mg/L (> ~53,000 µS/cm).

Water quality samples were collected after development as part of a three-month monitoring program. The laboratory results are presented in Appendix C.

Table 5.1 Field parameters of pH, EC and salinity classification

Bore ID	Screened Geology	Date	Total Dissolved Solids (TDS)	Oxidation Reduction Potential (ORP)	pH	EC (µS/cm)	Salinity classification
BR-GW-KC01-MB001	Alluvium	22/09/2023	371.6	142	7.03	568.4	Fresh
		22/10/2023	431.4	-20	7.44	602.1	
		14/12/2023	474.8	119	7.82	634.7	
BR-GW-KC01-MB002	Serpentinite	22/09/2023	533.9	140	7.02	804.8	Brackish
		19/10/2023	541.8	21	6.96	797.1	
		21/11/2023	542.2	20	7.07	755.3	
BR-GW-YD01-MB001	Alluvium	15/09/2023	602.4	72	7.12	830.5	Brackish
		19/10/2023	712.6	16	6.96	1032.0	
		14/12/2023	746.3	91	6.99	986.6	
BR-GW-YD01-MB002	Phyllite	15/09/2023	770.8	73	7.11	1048.0	Brackish
		19/10/2023	761.5	21	6.99	1108.0	
		14/12/2023	794.6	103	7.06	1047.0	
BR-GW-YU01-MB001	Weathered Serpentinite	22/09/2023	421.5	145	6.99	636.2	Fresh
		19/10/2023	424.8	80	6.94	617.2	
		7/12/2023	427.5	75	6.93	571.7	
BR-GW-YU01-MB002	Serpentinite	22/09/2023	511.0	144	7.01	771.6	Brackish
		19/10/2023	695.6	74	6.89	994.2	
		7/12/2023	695.5	62	6.92	911.7	
BR-GW-YU01-MB003	Alluvium	15/09/2023	397.3	99	7.06	544.0	Fresh
		19/10/2023	454.3	48	6.89	664.2	
		7/12/2023	466.4	50	6.94	622.7	

Bore ID	Screened Geology	Date	Total Dissolved Solids (TDS)	Oxidation Reduction Potential (ORP)	pH	EC (µS/cm)	Salinity classification
BR-GW-YU01-MB004	Alluvium	15/09/2023	349.8	100	7.06	487.5	Fresh
		19/10/2023	325.6	47	6.94	524.3	
		7/12/2023	364.8	45	6.98	487.7	
BR-GW-UR01-MB001	Metasediments	01/12/2023	NR	NR	7.51	1647.0	Brackish
		25/01/2024	1851	32	7.00	2481.0	
BR-GW-UR01-MB002	Granodiorite	01/12/2023	NR	NR	8.36	755.0	Brackish
		25/01/2024	2335	-57	6.95	3130.0	
BR-GW-UR01-MB003	Granodiorite	07/12/2023	595.8	50	7.92	768.0	Brackish
		25/01/2024	599	127	6.56	873.3	
		7/03/2024	639.7	60	7.1	852.2	
BR-GW-UR01-MB004	Granodiorite	01/12/2023	NR	NR	7.08	1238.0	Brackish
		17/01/2024	1111	64	6.79	1411.0	
		7/03/2024	1099	54	6.86	1425	
BR-GW-UR01-MB005	Granodiorite	07/12/2023	576.1	20	7.8	766.8	Brackish
		25/01/2024	847.2	36	7.75	1111.0	
		7/03/2024	1016	31	7.57	1338	
BR-GW-UR01-MB006	Granodiorite	02/12/2023	NR	NR	8.11	1454	Brackish
		18/01/2024	932.3	92	6.71	1198	
		7/03/2024	910.1	-120	7.4	1211	
BR-GW-UR01-MB007	Granodiorite	02/12/2023	NR	NR	7.90	720	Fresh
		18/01/2024	540.2	-91	7.65	709.6	
		7/03/2024	537.2	-129	7.96	721.4	
BR-GW-UR01-MB008	Granodiorite	02/12/2023	NR	NR	8.06	697.0	Fresh
		18/01/2024	501	114	7.70	663.8	

Bore ID	Screened Geology	Date	Total Dissolved Solids (TDS)	Oxidation Reduction Potential (ORP)	pH	EC (µS/cm)	Salinity classification
		7/03/2024	441.8	-109	8.36	597.9	
BR-GW-UR01-MB009	Granodiorite	02/12/2023	NR	NR	7.90	874.0	Brackish
		19/01/2024	780.9	96	6.91	1011.0	
		7/03/2024	774.1	-166	7.79	1026	
BR-GW-UR01-MB010	Granodiorite	02/12/2023	NR	NR	8.35	714.0	Fresh to Brackish
		19/01/2024	1259	82	7.68	1599.0	
		7/03/2024	1450	-117	7.95	1842	
BR-GW-UR01-MB011	Granodiorite	02/12/2023	NR	NR	7.77	1901.0	Brackish
		19/01/2024	1856	-115	7.40	2280.0	
		7/03/2024	1637	-137	8.07	2062	
BR-GW-UR01-MB012	Metasediments	14/12/2023	1420	84	7.57	1828.0	Brackish
		25/01/2024	1650	69	7.56	2248.0	
		7/03/2024	1657	-201	8.28	2078	
BR-GW-UR01-MB013	Metasediments	14/12/2023	1714	-213	8.21	2157.0	Brackish
		25/01/2024	1531	-15	7.26	2090.0	
		8/03/2024	1473	-37	7.81	1875	

Notes: µS/cm – microsiemens per centimetre.
NR – data not recorded.

6 Hydraulic testing

Aquifer tests comprising falling head and rising head tests were conducted in all monitoring bores to provide estimates of hydraulic conductivity for the screened interval. The falling head tests (FHT) were undertaken using a standard technique, where a solid slug was inserted into the bore, resulting in a displaced raised water level. The recovery of the water level over time was recorded with a water level datalogger.

In boreholes where the water level intersected the screened casing, rising head tests (RHT) were undertaken by removing a portion of water (using a bailer) from the bore, resulting in a displaced lowered water level and water level recovery was recorded. Water levels were recorded with a pressure transducer (water level logger) during the tests.

The test data was analysed using the Bouwer and Rice (1976)[1] method using curve matching techniques within AQTESOLV software (version 4.5). The results for each test are provided in Table 6.1. Additional, repeat, tests were conducted at several boreholes as a quality control measure and where the data confidence may have been low (either due to slow or insufficient recovery). Typically, a slug test is considered to be successful if over 80% recovery of the water levels is achieved.

Table 6.1 Formation permeability test results

Bore ID	BH Depth	Lithology	Test	Hydraulic conductivity m/d	Recovery (%)	Confidence interval (assigned)
BR-GW-KC01-MB001	10	Alluvium	FHT	**0.259**	62.9	Medium
BR-GW-KC01-MB002	30	Serpentinite	FHT	**0.087**	35.9	Low
BR-GW-YU01-MB001	6	Alluvium, base of weathering	FHT	**0.756**	99.8	High
BR-GW-YU01-MB002	29.5	Serpentinite	FHT	**0.111**	99.9	Low
BR-GW-YU01-MB003	6	Alluvium	FHT	**0.499**	66.1	Medium
BR-GW-YU01-MB004	30	Alluvium	FHT	**0.064**	70.3	Medium
BR-GW-YD01-MB001	6	Alluvium, base of weathering	RHT	**0.903**	99.9	High
BR-GW-YD01-MB002	25	Phyllite	FHT	**0.003**	34.8	Low
BR-GW-UR01-MB001	23.25	Metasediments	FHT	**0.015**	100	High
BR-GW-UR01-MB002	19.7	Granodiorite	FHT	**0.01**	80	Medium
BR-GW-UR01-MB003	29.11	Granodiorite	RHT	**0.0003**	73	Medium
BR-GW-UR01-MB004	30.5	Granodiorite	RHT	**0.003**	93.5	High
BR-GW-UR01-MB005	18.54	Granodiorite	RHT	**0.0001**	93.3	High
BR-GW-UR01-MB006	35	Granodiorite	FHT	**2.560**	91.4	High
BR-GW-UR01-MB006 (Repeat)	35	Granodiorite	FHT	**0.0003**	97.6	High

[1] Bouwer, H. and R.C. Rce, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

Bore ID	BH Depth	Lithology	Test	Hydraulic conductivity m/d	Recovery (%)	Confidence interval (assigned)
BR-GW-UR01-MB006 (Repeat)	35	Granodiorite	FHT	**0.003**	99.8	High
BR-GW-UR01-MB007	35	Granodiorite	RHT	**0.0005**	54.5	Medium
BR-GW-UR01-MB008	14.6	Granodiorite	FHT	**0.0001**	88.2	High
BR-GW-UR01-MB009	44.4	Granodiorite	FHT	**0.001**	98.7	High
BR-GW-UR01-MB009 (Repeat)	44.4	Granodiorite	FHT	**0.0001**	62	Medium
BR-GW-UR01-MB010	20.75	Granodiorite	RHT	**0.005**	42.2	Low
BR-GW-UR01-MB010 (Repeat)	20.75	Granodiorite	RHT	**0.001**	36.55	Low
BR-GW-UR01-MB011	43.36	Granodiorite	FHT	**0.08**	98.57	High
BR-GW-UR01-MB012	43.75	Phyllite	FHT	**0.0001**	56.8	Medium
BR-GW-UR01-MB013	36.45	Phyllite	RHT	**0.002**	100	High
BR-GW-UR01-MB014 Note: test conducted during drilling at 55.1 m depth.	55.1	Phyllite	FHT	**0.014**	87	High

Notes: m/d = metres per day.
FHT = falling head test.
RHT = rising head test.
*The representative value was calculated by averaging the results of the.

7 Bore Census

As listed in Table 7, 25 locations or properties were identified along the Bella Creek Road and Yabba Creek Road areas for further investigation, to confirm that no unregistered bores are located in these areas. These landowners were contacted by QLD Hydro in February 2023, the following summarises the outcome of that survey:

- Twelve landowners confirmed that there are no bores on their property.
- Six properties could not be accessed, either due to no response from the landowner or restricted access. Three of the registered bores that are listed as existing 'sub artesian facilities' are located on these properties. As such, the specific groundwater use of the existing bores (e.g. stock, irrigation, domestic) and demand volumes remain unknown.

One landowner confirmed that two bores had been drilled on his property. However, these are QLD Hydro bores (LQ01 and LQ02), drilled as part of the previous geotechnical investigation and have since been decommissioned. A conversation with the landowner confirmed that locals in the area typically rely on surface water (from dams or creeks) for stock watering or irrigation needs.

Table 7.1 Bore census property survey and landowner responses

Site ID	Property Lot / Plan	Address	Property name/owner	Status
1	64LX2110	[redacted]	[redacted]	Landowner confirmed no bores on property
2	64LX2110	[redacted]	[redacted]	Landowner confirmed no bores on property
3	24LX2529	[redacted]	[redacted]	Landowner confirmed no bores on property
4	9LX1191	[redacted]	[redacted]	Landowner confirmed no bores on property
5	764L37551	[redacted]	[redacted]	Landowner confirmed no bores on property
6	764L37551	[redacted]	[redacted]	Landowner confirmed no bores on property
7	1189L37732	[redacted]	[redacted]	No access.
8	1RP217108	[redacted]	[redacted]	Unknown contact details. Letter sent to property, but no response received.
9	14RP220481	[redacted]	[redacted]	Unknown contact details. Letter sent to property, but no response received. Note: Sold in January 2024
10	13RP220481	[redacted]	[redacted]	Landowner confirmed no bores on property
11	12RP220481	[redacted]	[redacted]	Landowner confirmed no bores on property
12	2RP217108	[redacted]	[redacted]	Landowner confirmed no bores on property
13	3RP218317	[redacted]	[redacted]	Landowner confirmed no bores on property
14	1250L37764	[redacted]	[redacted]	Landowner confirmed no bores on property
15	68LX1017	[redacted]	[redacted]	Landowner confirmed no bores on property
16	469L37328	[redacted]	[redacted]	Confirmed two QLD Hydro bores on property. No private bores.
RN121179	3RP12436	[redacted]	[redacted]	Unknown contact details. Letter sent to property, but no response received.
RN121180	3RP12436	[redacted]	[redacted]	Abandoned and destroyed
RN135604	2RP207523	[redacted]	[redacted]	Unknown contact details. Letter sent to property, but no response received.
RN150592	2RP168043	[redacted]	[redacted]	Unknown contact details. Letter sent to property, but no response received.

Site ID	Property Lot / Plan	Address	Property name/owner	Status
RN135605	4RP186495	[redacted]	[redacted]	Abandoned and destroyed
RN121778	3SP235875			Abandoned and destroyed
RN156353	7SP194491			Abandoned and destroyed
RN156354	7SP194491			Abandoned and destroyed
RN150729	6RP99411			Abandoned and destroyed

8 Spring survey

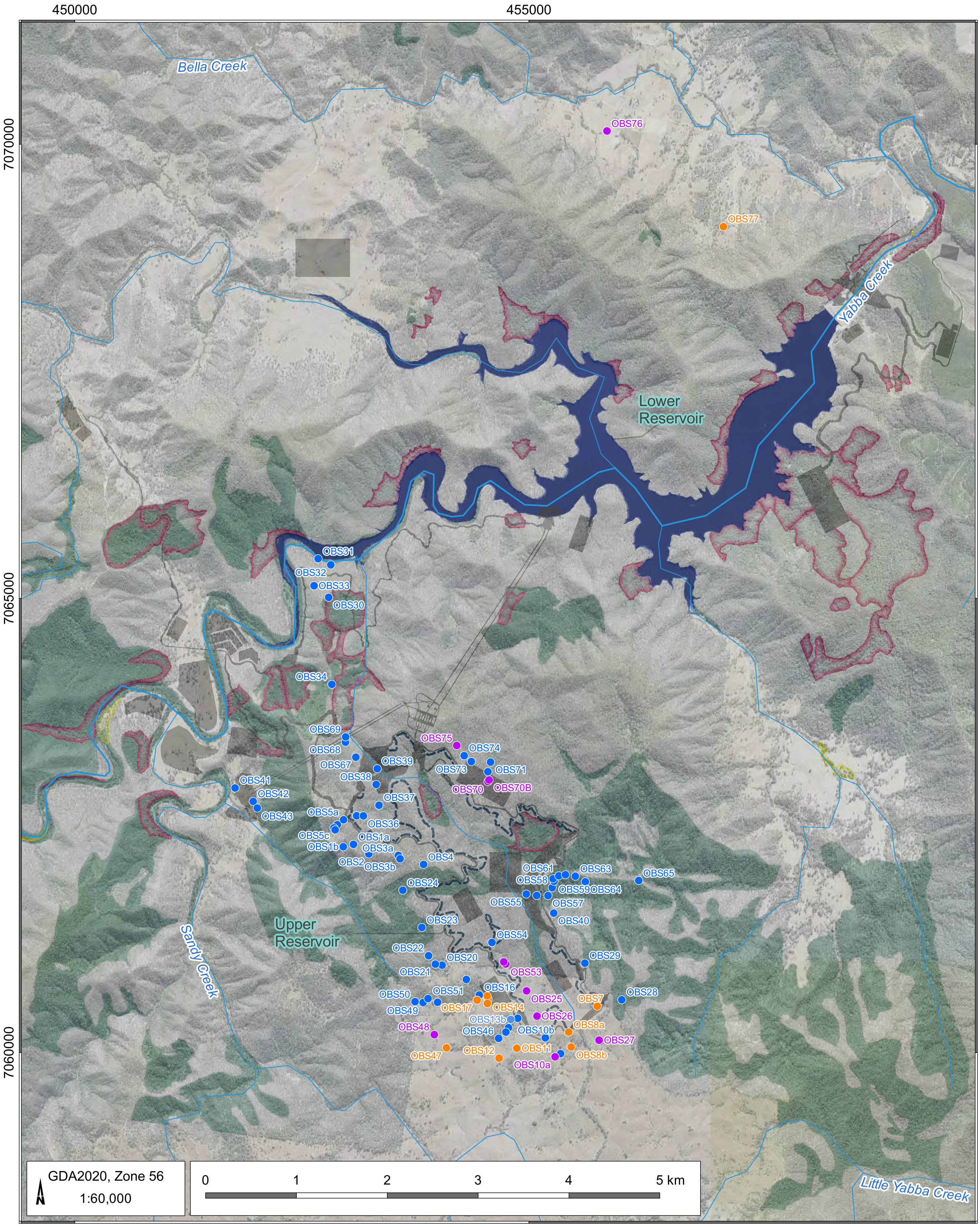
8.1 Screening spring survey

A screening spring survey was conducted in tandem with the borehole drilling supervision in October/November 2023. The objective was to perform a screening survey to identify potential seep areas which required further investigation. Although the survey was in late October/ early November, the period could be characterised as part of the dry season. Spring rains were delayed, and no major rain events occurred at least three weeks prior to the survey, only a singular rain event occurred on 2 November 2023, towards the end of the survey.

A large area was surveyed, and aspects like surface drainage, degree of visual dampness and vegetation were noted. Co-ordinates of each point were taken and a photo of the site. For the purposes of this factual report these observations were categorised into:

- Type 1 – banks of drainage gullies and lines, no flows, or seeps visible, mostly dry to slight vegetation changes.
- Type 2 - shallow groundwater table, possible ephemeral seep zone, sourced from perched groundwater within the weathered rock that seeps to the surface. Vegetation changes more apparent (related to Type 4 and Type 5, Queensland Government (2017)).
- Type 3 – similar to Type 2 but with standing/flowing water, ephemeral seep zone or perennial spring. Mostly associated with drainage gullies and creeks. Definite vegetation change (related to Type 4 and Type 5, Queensland Government (2017)). Although all the identified seeps are grouped under Type 3, the physical dynamics, flow regime and origination are still uncertain and should be assessed in more detail.

The list of the 84 survey locations is attached in Appendix D and depicted on Figure 8.1. The Type 3 and Type 2 locations are discussed in more detail below.



LEGEND

Spring Surveyed

- Type 1
- Type 2
- Type 3

Major drainage
Minor drainage
Site Layout

Water Areas

Lower Reservoir (Current FSL 135.01 m AHD)
Upper reservoir (FSL 490.5 m AHD)

Terrestrial GDE

High potential GDE - from national assessment

Threatened Ecological Communities

Lowland Rainforest of Subtropical Australia
Subtropical eucalypt floodplain forest and woodland

Borumba Dam PHES Follow Up Investigation (BDP5002.001)

Spring survey locations

AGE

DATE
19/04/2024

FIGURE No:
8.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:\Projects\BDP5001.001 Borumba Dam PHES Follow Up Investigation\3_GIS\Workspaces\001_Deliverable1\08.07_BDP5001.001_Spring survey locations.qgz

8.1.1 Type 3

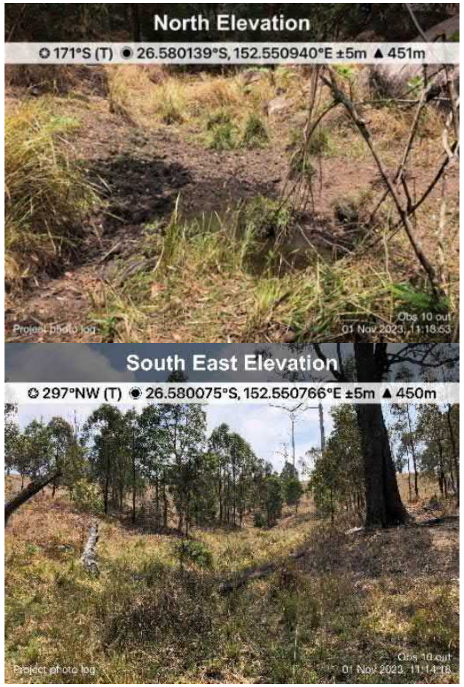
As described above, the Type 3 springs are deemed potentially significant for the EIS groundwater assessment as those represent potential seep zones or springs.

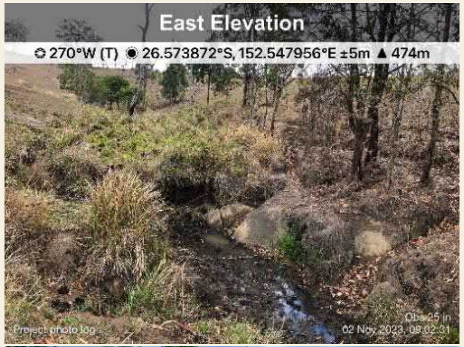
It is recommended that these sites be inspected and assessed in more detail and added to the water monitoring network and program. As shown in Figure 8.1 and Table 8.1, ten Type 3 sites at eight locations were noted during the survey. The sections below provide site photos and descriptions.

8.1.2 Type 2

As shown in Figure 8.1 and Table 8.2, ten seeping locations were noted during the survey. The sections below provide site photos and descriptions. These sites were mostly dry, with a more pertinent change in vegetation, with some damp.

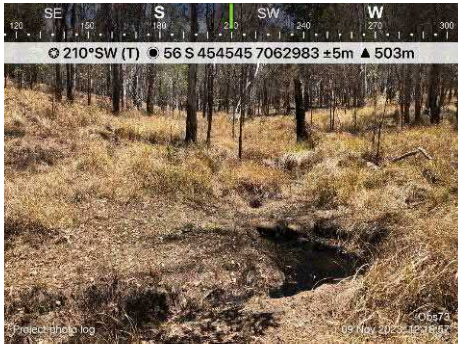
Table 8.1 Type 3 springs

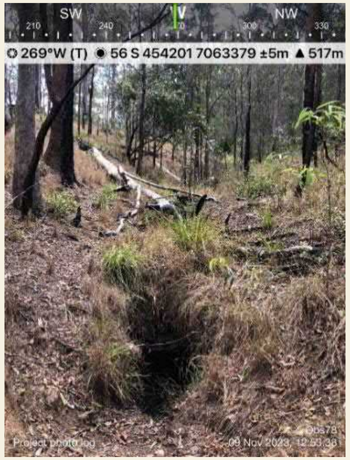
Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS10a	455287	7059950	543	Drainage to outside of Upper Reservoir. Wet area observed towards the southwestern drainage lines.	Standing/flowing water, perennial spring.	

Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS25	454973	7060676	542	Drainage line inwards to Upper Reservoir. Seepage visible. Lush green vegetation. Main UR creek, along creek bed in southern portion of UR footprint.	Standing/flowing water, perennial spring. EC = 150.1 to 317.4 TDS = 94.12 to 205.8 mg/l pH = 7.29 to 7.3	 
OBS26	455088	7060398	538	Drainage line inwards to Upper Reservoir. Seepage visible. Lush green vegetation.	Standing/flowing water, perennial spring.	

Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS27	455771	7060133	531	Drainage outwards from Upper Reservoir, confluence of two drainage lines.	Shallow groundwater table, possible ephemeral spring zone.	 
OBS48	453957	7060194	453	Visible seepage / spring at lower slopes	Standing/flowing water, perennial spring.	

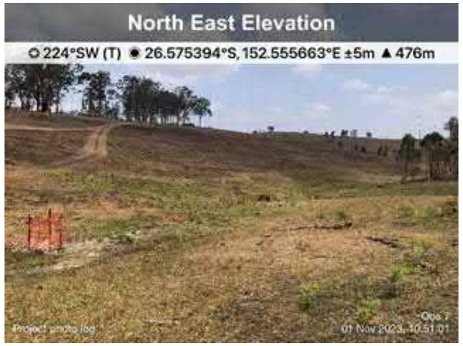
Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS53	454743	7060972	548	Main drainage in southern section of UR, flowing north. Water visible, appears like seep/spring. From this point the drainage line flows out of the open field area into the bush/ forest area.	Standing/flowing water, perennial spring.	
OBS53B	454722	7060995	539	Pool in drainage line where it forms a step down.	Standing/flowing water, perennial spring.	

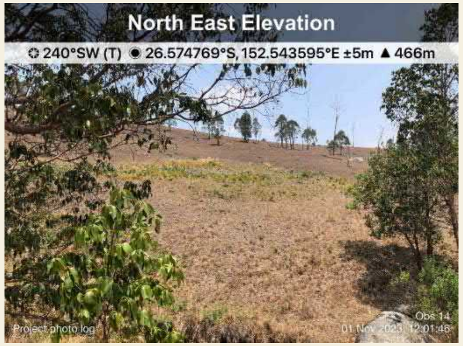
Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS70	454547	7062980	581	Drainage gully outwards from monitoring bore MB001. Pool of water in drainage line, looks like seepage/spring flow.	Standing/flowing water, perennial spring.	
OBS70B	454560	7062998	581	Drainage gully outwards from monitoring bore MB001. Pool of water in drainage line, looks like seepage/spring flow - 2nd pool about 50 m downstream from first pool. Water level is too low to visibly flow and area downstream is damp for about 5 to 10 m only.	Standing/flowing water, perennial spring.	

Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS75	454204	7063378	585	Drainage gully - pool of water in drainage line, looks like seepage/spring flow. Water level is too low to visibly flow and area downstream is damp for about 5 to 10 m only.	Standing/flowing water, perennial spring.	

Observation ID	X	Y	Z	Landscape setting	Water regime type	Photo
OBS76	455858	7070145		Seep observed next to Yabba Rd. Likely topographical or structural spring feeding into wetland/dam	Discharge observed next to road. Roadside close to dam EC = 301.7 uS/cm TDS = 364.5 mg/L pH = 6.99 Close to discharge EC = 157.7 uS/cm TDS = 107.6 mg/L pH = 6.99	 

Table 8.2 Type 2 locations

Observation ID	X	Y	Z	Landscape setting	Flow	Water regime type	Photo
OBS7	455751	7060507	-	Area prone to seepage due to shallow groundwater flow. Drainage line towards inside or UR at south east corner with rock outcrops	Dry	Shallow groundwater table, possible ephemeral spring zone.	
BS8a	455436	7060222	595	Downstream inside Upper Reservoir from saddle, drainage line.	Seepage	Shallow groundwater table, possible ephemeral spring zone.	
OBS8b	455464	7060058	556	Drainage line outside Upper Reservoir.	Seepage	Shallow groundwater table, possible ephemeral spring zone.	

Observation ID	X	Y	Z	Landscape setting	Flow	Water regime type	Photo
OBS11	454865	7060044	609	Outside Upper Reservoir drainage line. Upper portion dry but signs of seasonal seepage further downstream	Dry	Shallow groundwater table, possible ephemeral spring zone.	
OBS12	454670	7059935	588	Outside drainage line from saddle. Seepage areas observed.	Seepage	Shallow groundwater table, possible ephemeral spring zone.	
OBS14	454550	7060584	590	Drainage line from saddle out. Seepage visible on upper bank. Drainage line dry but seep areas visible only in rainy season.	Seepage	Shallow groundwater table, possible ephemeral spring zone.	

Observation ID	X	Y	Z	Landscape setting	Flow	Water regime type	Photo
OBS15	454539	7060619	576	Second drainage line from same saddle. Damp but mostly dry	Damp	Shallow groundwater table, possible ephemeral spring zone.	
OBS17	454428	7060574	565	Drainage line, damp in places.	Damp	Shallow groundwater table, possible ephemeral spring zone.	
OBS18	459541	7060537	583	Green patch of vegetation directly 'above' drainage line. Damp with seepage visible.	Seepage	Shallow groundwater table, possible ephemeral spring zone.	

Observation ID	X	Y	Z	Landscape setting	Flow	Water regime type	Photo
OBS47	454091	7060049	461	Lower valley slopes and obvious seep zone.	Damp	Shallow groundwater table, possible ephemeral spring zone.	
OBS77	457140	7069091		Land owner referred to previous seeps identified when Borumba reservoir is at a high level		Area to be visited during hydrocensus – information was obtained from QH	

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Appendix A

Photographic Logs

Borehole ID	YD01 MB001 (left) and YD01 MB002 (right)
Description	Shallow (6 m) and deep (30 m) boreholes near caravan park and downstream along Yabba Creek.

Borehole ID	YU01 MB001 (left) and YU01 MB002 (right)
Description	Shallow (6 m) and deep (25 m) boreholes adjacent to Yabba Creek, within flood zone. Evidence of previous flood destruction in this area. Boreholes drilled into serpentinite and so were not airlifted to reduce risk of asbestos contamination.

Borehole ID	YU01 MB003 (left) and YU01 MB004 (right)
Description	Shallow (6 m) and deep (30 m) boreholes upstream along Yabba Creek. Deep alluvium sequence observed at this site which made drilling difficult. The deep borehole collapsed at 10 m after drilling was initially completed and had to be re-opened. Boreholes were screened above and below a clay lens zone.

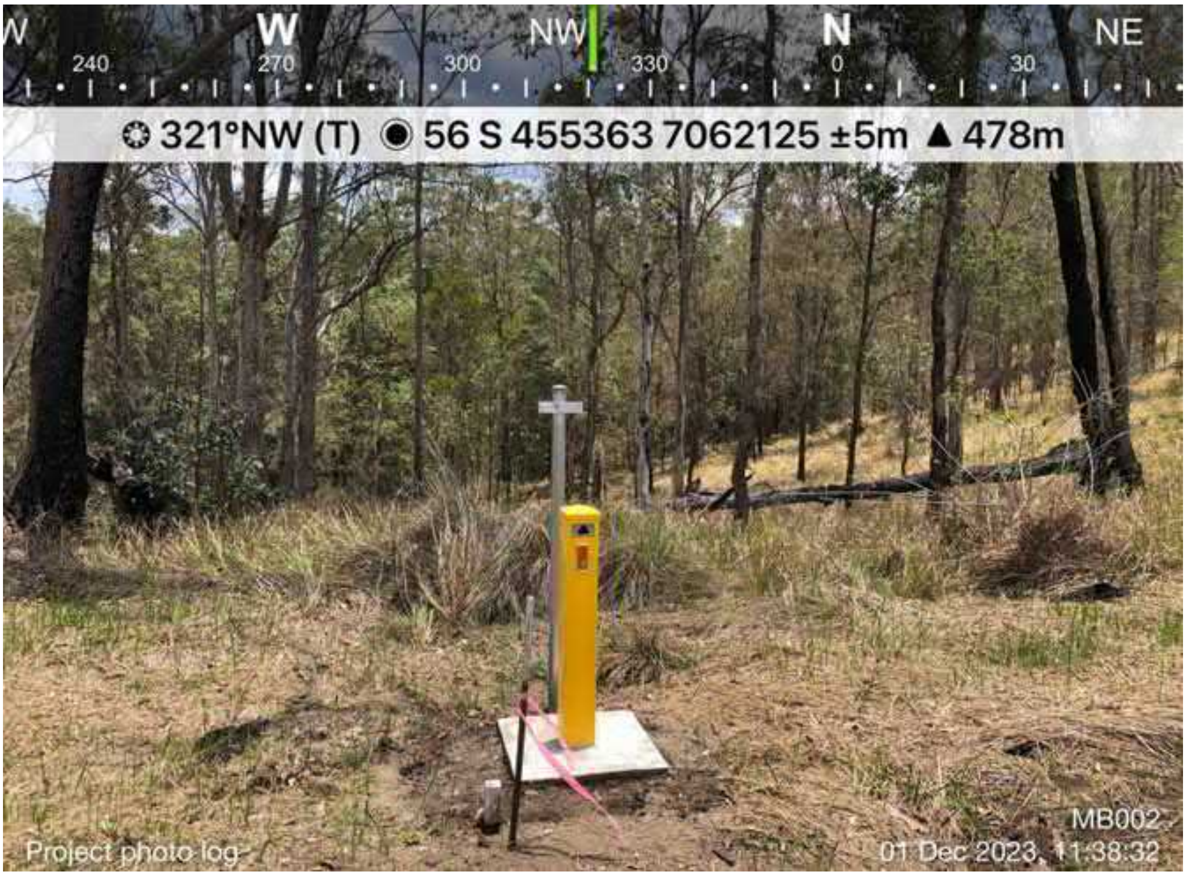
Borehole ID	KC01 MB001 (right) and KC01 MB002 (left)
Description	Shallow (10 m) and deep (30 m) boreholes adjacent to Kingaham Creek. Boreholes drilled into serpentinite and so were not airlifted to reduce risk of asbestos contamination.

Borehole ID	UR MB001

Description

Borehole ID	UR MB002

Description



Borehole ID	**UR MB003**

Description

Borehole ID	**UR MB004**

Description

Borehole ID	UR MB005

Description

Borehole ID	UR MB006

Description

Borehole ID	UR MB007

Description

Borehole ID	UR MB008

Description

Borehole ID	UR MB009

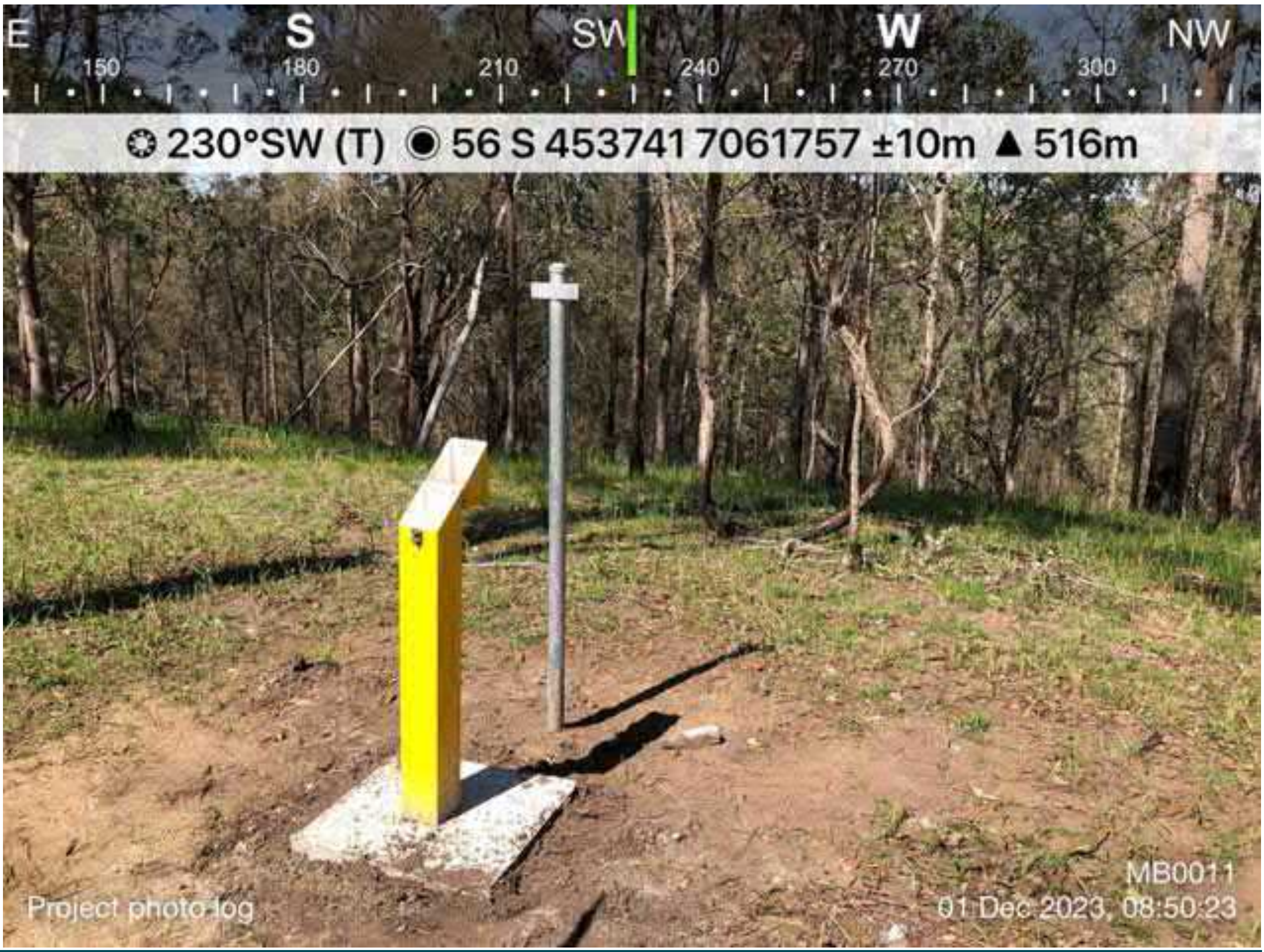
Description

Borehole ID	**UR MB010**

Description

Borehole ID	UR MB011

Description



Borehole ID	UR MB012

Description

Borehole ID	UR MB013

Description

Appendix B

Bore Logs

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-KC01-MB001

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45189**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and wash bore**

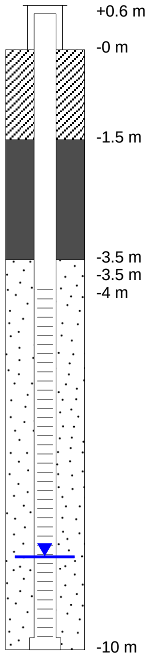
EASTING: **451303 mE**
NORTHING: **7068892 mN**
DATUM: **GDA2020 z56**
RL: **154 mAHD**
TD: **10 mBGL**

COMMENTS: **Borehole depth extended to 10m to intersect deeper alluvium zone.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	R.L. (mAHD)	Depth (mBGL)
Soil	SOIL [DCs] (5 %): fine sand, sub-rounded, lithic clasts, well graded, silty matrix 95%, low plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Sandy, slightly clayey	154 – 147	0 – 7
Alluvium	Alluvium [DCs] (0 %): lithic clasts, poorly graded, clast 100%, low plasticity, light greenish brown, low strength, extremely weathered, soft, loose, layered, granular, Alluvium - gravel layer	147 – 144	7 – 10

R.L. (mAHD) scale: 154, 152, 150, 148, 146, 144; Depth (mBGL) scale: 0, 2, 4, 6, 8, 10

Bore Construction



Bore Description

Stick up: +0.6 m

150 mm Auger TC: 0 m to 3 m (Auger)

Bentonite grout (5 %): 0 m to 1.5 m

50 mm PN18 uPVC blank casing: -0.6 m to 4 m

Australasian Groundwater & Environmental Consultants Pty Ltd
Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-KC01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45189**
LOGGED BY: **Callie Pickering**

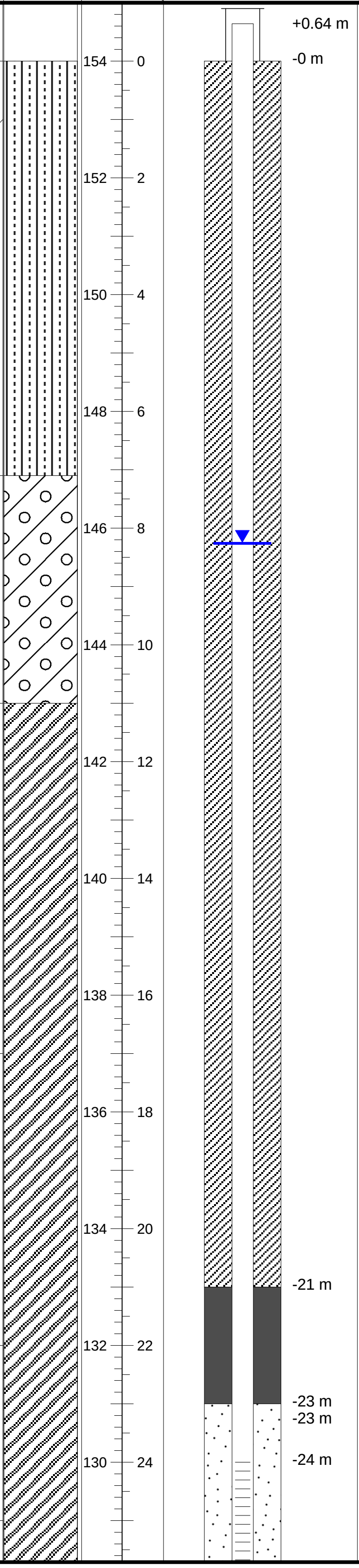
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and wash bore**

EASTING: **451302 mE**
NORTHING: **7068891 mN**
DATUM: **GDA2020 z56**
RL: **154 mAHD**
TD: **30 mBGL**

COMMENTS: **Serpentinite appears to be harder at this borehole.**

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [DCs] (5 %): fine sand, sub-rounded, lithic clasts, well graded, silty matrix 95%, low plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Mostly sand
Soil	SOIL [DCs] (5 %): sub-rounded, lithic clasts, well graded, low plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, moist, layered, granular, Mostly sand. Moist at 1m, slightly clayey. Wash bore from 2.5m.
Alluvium	Alluvium [DCs] (0 %): lithic clasts, poorly graded, clast 100%, low plasticity, light greenish brown, low strength, extremely weathered, soft, loose, layered, granular, Alluvium - sample crushed.
Serpentinite	Serpentinite [DCs] (0 %): light greenish green, medium strength, distinctly weathered firm, medium dense, laminated, crystalline, Weathered zone - wash bore crushed sample - difficult to see any detail in the sample - high serpentine concentration.
Serpentinite	Serpentinite [DCs] (0 %): light greenish green, very high strength, fresh, hard, dense, laminated, crystalline, Very hard serpentinite. High concentration of pink minerals in serpentinite between 18-19. Much less magnetite than YU01-MB002
Serpentinite	Serpentinite [DCs] (0 %): light greenish green / grey, medium strength, fresh, hard, dense, laminated, crystalline, Soft zone.

Graphic Log | R.L. (mAHD) | Depth (mBGL) | Bore Construction



Bore Description

Stick up: +0.64 m

150 mm Auger TC: 0 m to 2.5 m (Auger)

Bentonite grout (5 %): 0 m to 21 m

50 mm PN18 uPVC blank casing: -0.064 m to 24 m

SWL: 8.9 mTOC (22092023)

Bore development: 2.1 hours; EC: 789.1 µS/cm; pH: 6.97

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-KC01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45189**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and wash bore**

EASTING: **451302 mE**
NORTHING: **7068891 mN**
DATUM: **GDA2020 z56**
RL: **154 mAHD**
TD: **30 mBGL**

COMMENTS: **Serpentinite appears to be harder at this borehole.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
	Serpentinite [DCs] (0 %): light greenish green / grey, very high strength, fresh, hard, dense, laminated, crystalline		128 – 26 126 – 28 124 – 30	-30 m	100 mm TCI Tricone: 2.5 m to 30 m (Wash Bore)

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB001

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

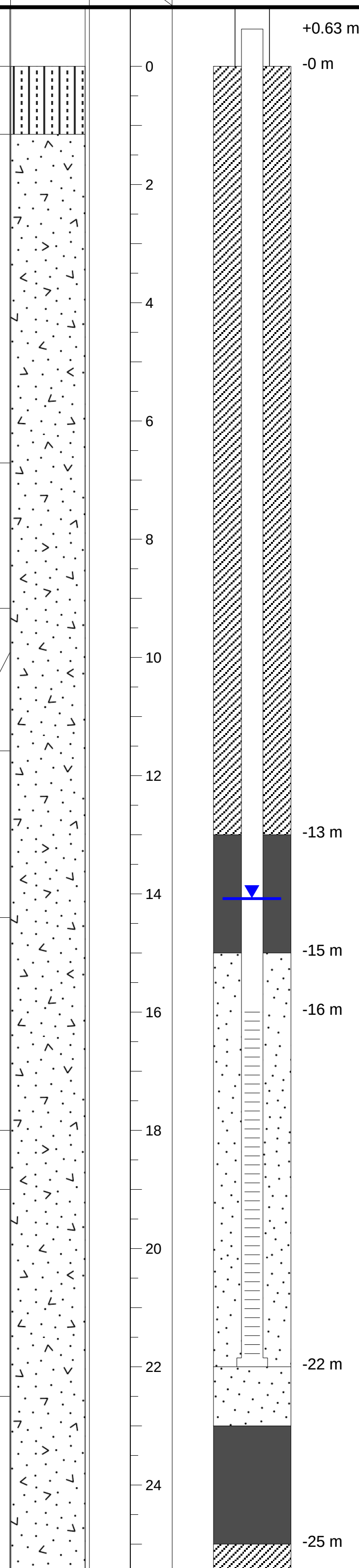
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454466 mE**
NORTHING: **7062810 mN**
DATUM: **GDA2020 z56**
RL: **508.82 mAHD**
TD: **35 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Pm]: Residual soil, not logged.
Metasediments	Metasediments [Pm]: lithic clasts, mottled bluish black / grey / white, high strength, slightly weathered, hard, medium dense, foliated, granular, Highly fractured zone. Consistent clay infill in fractures defines this section. Crushed seam 5.33-5.39, 6.57-6.72. White clasts throughout. Deformed.
Metasediments	Metasediments [Pm]: lithic clasts, mottled bluish black / grey / white, high strength, slightly weathered, hard, medium dense, foliated, granular, More competent with intermittent fractures
Metasediments	Metasediments [Pm]: lithic clasts, mottled bluish black / grey / white, high strength, fresh, hard, medium dense, foliated, granular, Consecutive fractures. Some red mottling around fractures, not extensive.
Metasediments	Metasediments [Pm]: lithic clasts, mottled bluish black / grey / white, high strength, fresh, hard, medium dense, foliated, granular, More competent with intermittent fractures
Metasediments	Metasediments [Pm]: lithic clasts, dark blackish black / grey / white, high strength, fresh, hard, medium dense, foliated, granular, Crushed seam at start until 12.12,13.27-13.55, 14.26-14.4. Intermittent fractures in between.
Metasediments	Metasediments [Pm]: lithic clasts, dark blackish black / grey / white, high strength, fresh, hard, medium dense, foliated, granular, More competent with intermittent fractures. Presence of blue and white clasts.
Metasediments	Metasediments [Pm]: lithic clasts, dark blackish black / grey / white, high strength, fresh, hard, medium dense, foliated, granular, Crushed seam. Highly fractured.
Metasediments	Metasediments [Pm]: lithic clasts, dark blackish black / white / grey, high strength, fresh, hard, medium dense, foliated, granular, Slightly less fractured, with more consistent white banding
Metasediments	

Graphic Log / R.L. (mAHD) / Depth (mBGL) / Bore Construction



Bore Description

Stick up: +0.63 m

SWL: 14.71 mTOC (5/12/2023)

Bentonite grout (5 %): 0 m to 13 m

Bentonite seal: 13 m to 15 m

3-6 mm crushed river rock: 15 m to 22 m

50 mm PN18 uPVC blank casing:

150 mm Auger TC: 0 m to 1.15 m (Auger)

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 16 m to 22 m

94 mm Series 12 Core: 1.15 m to 50 m (Diamond core)

End cap

End of hole: 50 m BGL

Gravel backfill: 25 m to 50 m

Bore development: 20 mins; EC: 749 µS/cm; pH: 8.03

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB001

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454466 mE**
NORTHING: **7062810 mN**
DATUM: **GDA2020 z56**
RL: **508.82 mAHD**
TD: **35 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
	Metasediments [Pm]: lithic clasts, dark blackish black / grey, high strength, fresh, hard, medium dense, foliated, granular, Darker, more competent, less frequent fractures.			26 28 30 32 34		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

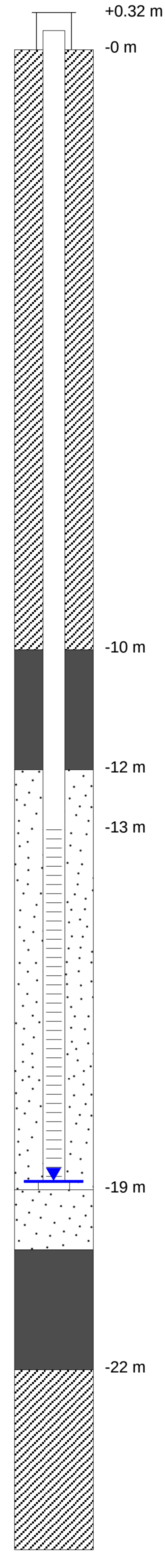
EASTING: **455362 mE**
NORTHING: **7062135 mN**
DATUM: **GDA2020 z56**
RL: **477.79 mAHD**
TD: **25 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Rg/g]: quartz clasts, Residual soil, not logged.
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, medium strength, extremely weathered, firm, massive, crystalline, Extremely weathered and loose rock. Part of transition zone between rock contact and soil.
	NO SAMPLE RETURN [Rg/g]: Core loss
Granite	GRANITE [Rg/g]: quartz clasts, grey / grey / black, medium strength, extremely weathered, firm, loose, massive, crystalline, More competent but still extremely weathered and loose rock. Part of transition zone between rock contact and soil.
	NO SAMPLE RETURN [Rg/g]: Core loss
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, medium strength, distinctly weathered firm, dense, massive, crystalline, Weathered and altered, stained, section of the core.
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, slightly weathered, firm, dense, massive, crystalline, More competent with less staining.
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline, Competent crystalline section.
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline, Granodiorite, minor fracturing
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline
Granite	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline, Granodiorite, minor fracturing
	NO SAMPLE RETURN [Rg/g]: Core loss
	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline, Granodiorite, minor fracturing
	NO SAMPLE RETURN [Rg/g]: Core loss
Granite	GRANITE [Rg/g]: quartz clasts, grey / grey / black, high strength, fresh, firm, dense, massive, crystalline, Granodiorite, minor fracturing

Graphic Log | R.L. (mAHD) | Depth (mBGL): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24

Bore Construction



Bore Description

Stick up: +0.32 m

150 mm Auger TC: 0 m to 3.1 m (Auger)
Bentonite grout (5 %): 0 m to 9.8 m
50 mm PN18 uPVC blank casing:

94 mm Series 12 Core: 3.1 m to 25 m (Diamond core)
Bentonite seal: 10 m to 12 m
3-6 mm crushed river rock: 12 m to 19 m

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 13 m to 19 m

SWL: 19.18 mTOC (13/12/2023)

End cap
Gravel backfill: 22 m to 25 m

Development airlift flow rate: 0.006 L/s

Bore development: 10 mins; EC: 872 µS/cm; pH: 8.34

End of hole: 25 m BGL

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BOREHOLE LOG

BR-GW-UR01-MB003

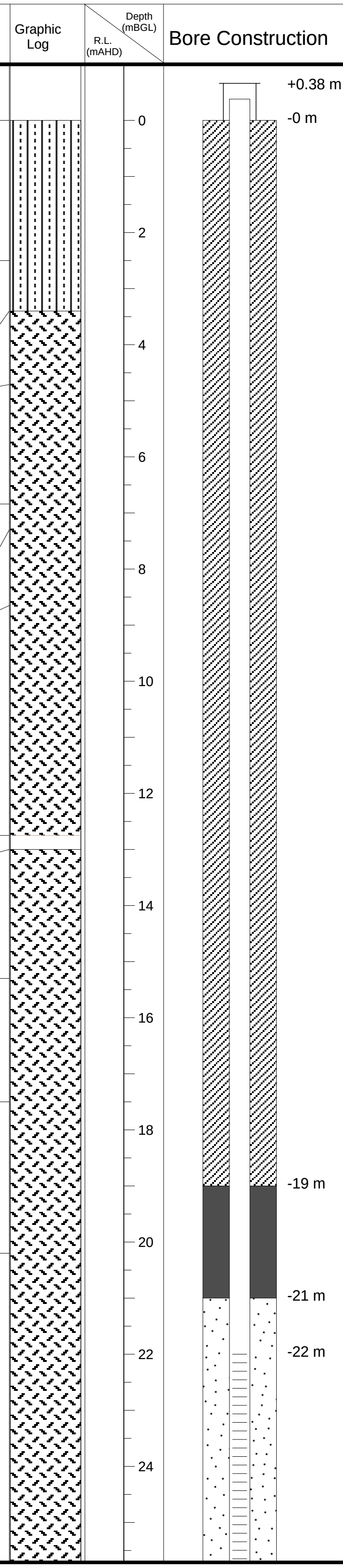
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455138 mE**
NORTHING: **7061648 mN**
DATUM: **GDA2020 z56**
RL: **466.9 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Rg/g] (1 %): coarse sand, sub-rounded, quartz clasts, well graded, silty matrix 99%, low plasticity, dark brownish yellow / white, low strength, residual soil, soft, loose, damp, bedded, granular, Well draining top soil with unweathered bedrock/regolith within silt, drier at around 2 mBGL.
Soil	SOIL [Rg/g] (2 %): fine gravel, sub-rounded, quartz clasts, well graded, silty matrix 98%, low plasticity, dark brownish yellow / black / white, low strength, residual soil, soft, loose, bedded, granular, Coarser soil.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey / black, medium strength, distinctly weathered firm, loose, massive, granular, Weathered zone. Extremely weathered rock intermixed with soil.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, high strength, fresh, hard, very dense, massive, crystalline, Hard contact with above layer. Fresh granodiorite.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, high strength, distinctly weathered hard, very dense, massive, crystalline, Upper clay layer grades into tightly fractured weathered rock.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, high strength, fresh, hard, very dense, massive, crystalline, Competent granodiorite.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline, Slight water alteration around core, significant joints with infilled weathering at 8.63-8.75, 9.91-10.10, 10.51-10.59, 11.31-11.60.
	NO SAMPLE RETURN [Rg/g]: Core loss
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline, Significant infilled weathering from 13.00-13.32. Other joints/fractures with red alteration are prevalent.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / yellow / black, medium strength, distinctly weathered firm, loose, massive, crystalline, Significantly weathered zone, discoloured yellow/red; large fractures with infilled weathering at 15.90-16.12,16.47-16.80. Other joints/fractures with red alteration are prevalent.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black, medium strength, slightly weathered, hard, dense, massive, crystalline, Lighter zone with fractures and heavily fractured zone at 19.7-19.8 with red alteration.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black / mottled, medium strength, slightly weathered, hard, dense, massive, crystalline, Competent and fresh with red infilling and alteration of fractures.



Bore Description

Stick up: +0.38 m

150 mm Auger TC: 0 m to 2.5 m (Auger)
Bentonite grout (5 %): 0 m to 19 m
SWL: 27.6 mTOC (14/12/2023)

50 mm PN18 uPVC blank casing:

94 mm Series 12 Core: 2.5 m to 50 m (Diamond core)
Bentonite seal: 19 m to 21 m

3-6 mm crushed river rock: 21 m to 28 m

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 22 m to 28 m

Development airlift flow rate: 0.003 L/s

Bore development: 18 mins; EC: 995 µS/cm; pH: 7.82

End cap

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BOREHOLE LOG

BR-GW-UR01-MB003

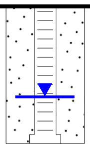
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455138 mE**
NORTHING: **7061648 mN**
DATUM: **GDA2020 z56**
RL: **466.9 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
			26		End of hole: 50 m BGL
			28	-28 m	
			30		
			32	-31 m	
			34		
			36		
			38		
			40		
			42		
			44		
			46		
			48		
			50		



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BOREHOLE LOG

BR-GW-UR01-MB004

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45210**
LOGGED BY: **Callie Pickering**

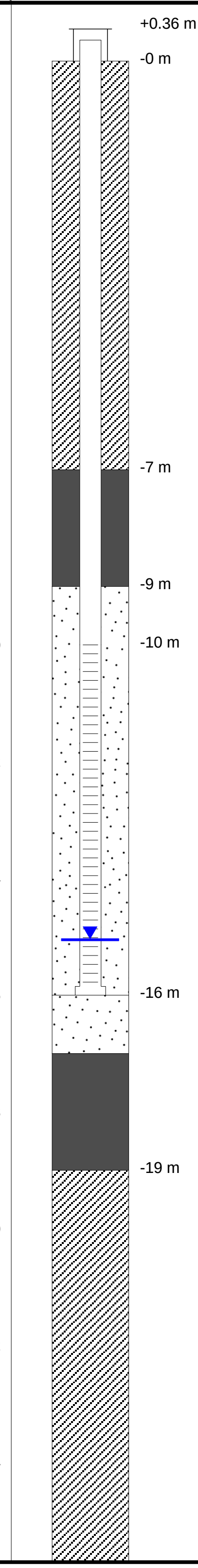
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455575 mE**
NORTHING: **7060951 mN**
DATUM: **GDA2020 z56**
RL: **485.48 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Rg/g] (5 %): fine sand, to rounded, lithic clasts, well graded, silty matrix 95%, low plasticity, light yellowish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, sandy clay.
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, damp, layered, granular, Weathered granodiorite, mixed coarse fraction.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, medium strength, distinctly weathered hard, very dense, massive, crystalline, Granodiorite, very weathered, rough surfaces and breaks easily when cutting.
No Sample Return	NO SAMPLE RETURN [Rg/g]: quartz clasts, light whitish grey, low strength, extremely weathered, soft, loose, massive, crystalline, Core loss.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, medium strength, distinctly weathered hard, very dense, massive, crystalline, Granodiorite, very weathered, rough surfaces and breaks easily when cutting. Rock crushed between 5.15 and 5.25 after core loss.
No Sample Return	NO SAMPLE RETURN [Rg/g]: quartz clasts, light whitish grey, low strength, extremely weathered, soft, loose, massive, crystalline, Core loss.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, high strength, slightly weathered, very stiff, dense, massive, crystalline, Granodiorite, slightly weathered, less rough but still breaks easily when cutting. Significant fracture between 8-8.6 m with iron staining and long vertical angle.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, high strength, slightly weathered, hard, very dense, massive, crystalline, Significant fractures at 12.55; 13.8
Dolerite	Dolerite [Rg/g]: dark greenish grey, very high strength, fresh, hard, very dense, layered, crystalline, Intrusive dolerite dyke. Tight crystals, no quartz visible. Very weathered at the fractures, iron staining.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Granodiorite becomes more competent after dyke intrusion, with no significant fractures observed. Hematite veining between 18 and 22 m.

Graphic Log | R.L. (mAHD) | Depth (mBGL): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24



Bore Description

Stick up: +0.36 m

150 mm Auger TC: 0 m to 2.5 m (Auger)
Bentonite grout (5 %): 0 m to 7 m
SWL: 15.41 mTOC (14/12/2023)

94 mm Series 12 Core: 2.5 m to 50 m (Diamond core)
Bentonite seal: 7 m to 9 m

3-6 mm crushed river rock: 9 m to 16 m

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 10 m to 16 m

BR-GW-UR01-MB004

PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **455575 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7060951 mN**
DATE DRILLED: **45210**	DRILLING METHOD: **Auger and diamond coring**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **485.48 mAHD**
		TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
				26		
				28		
				30		
				32		Development airlift flow rate: 0.006 L/s
						Bore development: 14 mins; EC: 1348 μS/cm; pH: 8.03
				34		
				36		End cap
				38		Gravel backfill: 19 m to 50 m
				40		
				42		
				44		
				46		
				48		
				50		

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BOREHOLE LOG

BR-GW-UR01-MB005

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45211**
LOGGED BY: **Callie Pickering**

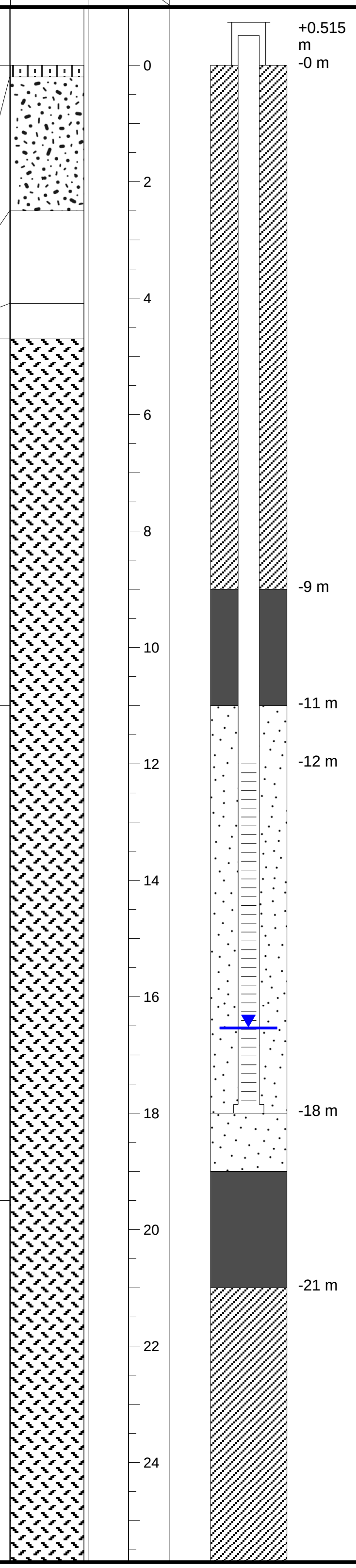
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455795 mE**
NORTHING: **7060509 mN**
DATUM: **GDA2020 z56**
RL: **481.51 mAHD**
TD: **30 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Rg/g] (2 %): silt, to sub-rounded, quartz clasts, poorly graded, silty matrix 98%, low plasticity, dark blackish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Alluvial soil, silty.
Claybound Sand	CLAYBOUND SAND [Rg/g] (10 %): medium sand, to sub-rounded, quartz clasts, well graded, clay matrix 90%, medium plasticity, mottled orangey brown / red / white, medium strength, extremely weathered, firm, medium dense, dry, layered, granular, Mottled red, black and white clay. Increasing clay content with depth.
Claybound Gravels	CLAYBOUND GRAVELS [Rg/g] (5 %): medium gravel, to sub-rounded, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish brown, very low strength, extremely weathered, firm, loose, dry, layered, granular, Gravelly section with silty clayey matrix.
No Sample Return	NO SAMPLE RETURN [Rg/g]: Core loss
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline, Fairly competent granodiorite with some mafic inclusions. Erosional fractures at 5.05, 5.21 (slight red stain), 5.88, 6.25, 6.89, 8.20, 8.52 m. Fractures/joints at 6.01, 9.55, 10.9 m.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black / mottled, high strength, distinctly weathered hard, very dense, massive, crystalline, Mafic intrusions persist with consistent red staining. Red stained open fractures at 11.9 m (midpoint) 24cm length, 12.74 (28 cm), 18.88 m.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, fresh, hard, very dense, massive, crystalline, Competent granodiorite with consistent mafic intrusions. Some red alteration but no fractures with oxidation.

Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description



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BOREHOLE LOG

BR-GW-UR01-MB005

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45211**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455795 mE**
NORTHING: **7060509 mN**
DATUM: **GDA2020 z56**
RL: **481.51 mAHD**
TD: **30 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
				26		
				28		
				30		

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BOREHOLE LOG

BR-GW-UR01-MB006

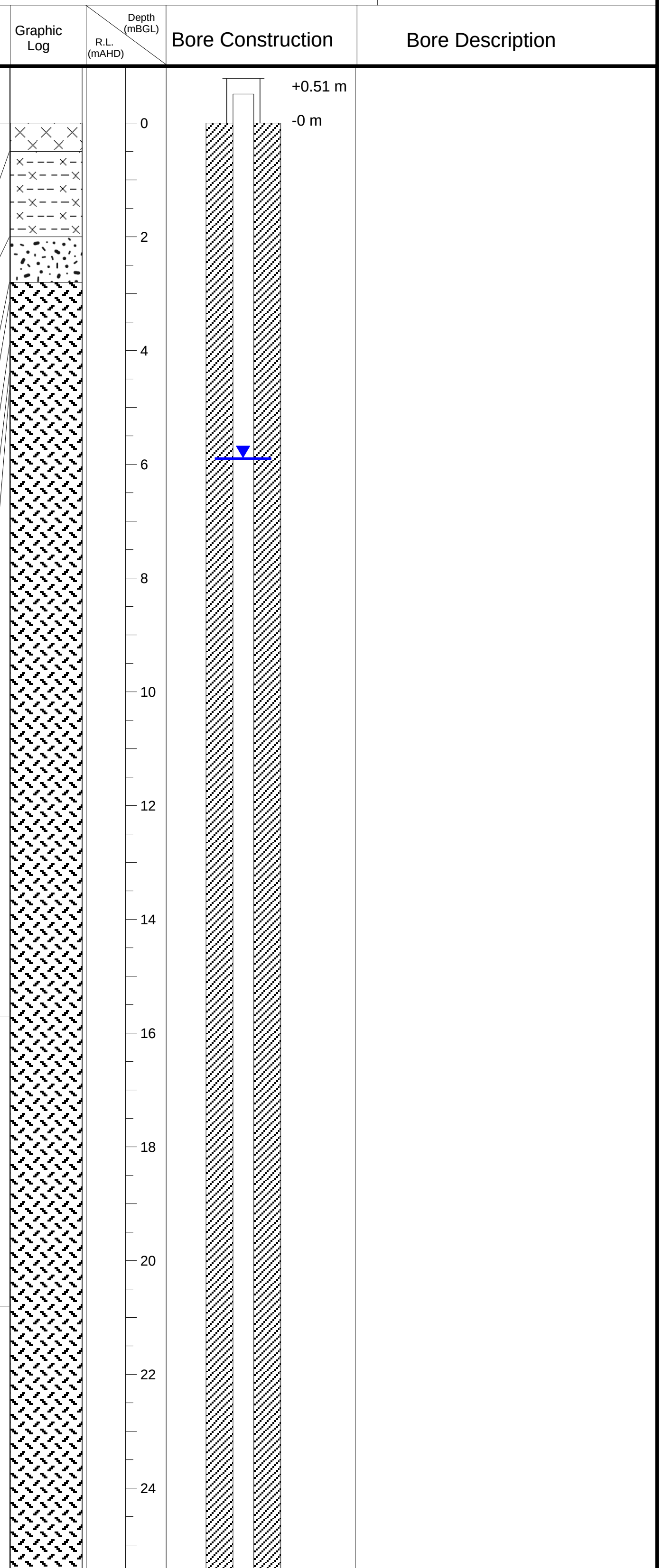
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45203**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455698 mE**
NORTHING: **7060392 mN**
DATUM: **GDA2020 z56**
RL: **490.64 mAHD**
TD: **35 mBGL**

COMMENTS: **Packer test (29.5-35m) lost water 39-72L/5 min periods.**

Stratigraphic Cloumn	Soil or Rock Field Material Description
Silt	SILT [Rg/g] (5 %): silt, to sub-angular, quartz clasts, well graded, silty matrix 95%, low plasticity, light brownish brown / black, very low strength, residual soil, very soft, very loose, dry, layered, granular, Silty, with some subangular sand.
Silty Clay	SILTY CLAY [Rg/g] (5 %): very fine sand, to sub-rounded, quartz clasts, poorly graded, clay matrix 95%, medium plasticity, light brownish brown / red, very low strength, residual soil, very soft, very loose, dry, layered, granular, Higher clay content in this layer.
Claybound Sand	CLAYBOUND SAND [Rg/g] (5 %): medium sand, to sub-rounded, quartz clasts, poorly graded, low plasticity, light greyish grey / white, very low strength, extremely weathered, soft, loose, layered, granular, New lithology boundary from 2. Weathered zone (granodiorite)
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, loose, massive, crystalline, Big fracture. Weathered zone from ~3.3-3.9.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, very low strength, extremely weathered, soft, massive, crystalline, Weathered gravel with core loss from 3.9-4.1. Total water loss at 4.4.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, medium strength, distinctly weathered firm, loose, massive, crystalline, Clay/weathered fractures at 4.4 and 4.7. Clay staining on either side of the core. Iron oxidation evident.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, fresh, hard, dense, massive, crystalline, Slight oxidation/discolouration along joints and weakness planes. Mafic inclusions throughout, presence of biotite.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, fresh, hard, dense, massive, crystalline, Slight oxidation/discolouration mottling consistent with previous section. Mafic intrusions persist. Presence of dykes 15.7-15.84, 17.57-~17.88, 18.14-18.25, 20.7-20.8.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, fresh, hard, dense, massive, crystalline, Geology similar to 4.7-15.7 with mafic intrusions, biotite and possible pyrite, and absence of lighter felsic intrusions.



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB006

PROJECT No: **BDP5001.001** PROJECT NAME: **Borumba Dam PHES** DATE DRILLED: **45203** LOGGED BY: **Callie Pickering**	DRILLING COMPANY: **Terratest** DRILLER: **Dave Coleman** DRILLING METHOD: **Auger and diamond coring**	EASTING: **455698 mE** NORTHING: **7060392 mN** DATUM: **GDA2020 z56** RL: **490.64 mAHD** TD: **35 mBGL**

COMMENTS: **Packer test (29.5-35m) lost water 39-72L/5 min periods.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
			26	-26 m	
	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, fresh, hard, dense, massive, crystalline, Large fractures and joints with mottling and iron oxidation surrounding. Geology similar to 4.7-15.7.		28 30 32 34	-28 m -29 m -35 m	

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BOREHOLE LOG

BR-GW-UR01-MB007

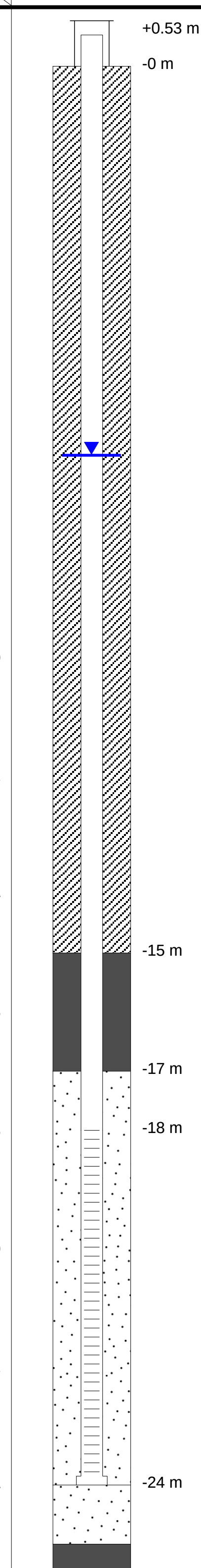
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45203**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **455426 mE**
NORTHING: **7060232 mN**
DATUM: **GDA2020 z56**
RL: **494.64 mAHD**
TD: **35 mBGL**

COMMENTS: **Very limited topsoil. No water loss or gains noted during drilling.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
Soil	SOIL [Rg/g] (10 %): medium sand, to sub-rounded, lithic clasts, well graded, clay matrix 90%, medium plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, sandy clay.			0		
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, dry, layered, granular, Weathered granodiorite, mixed coarse fraction, pyrite observed.			2		
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, moist, layered, granular, No change in lithology, slightly moist.			4		
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Significant fractures at 20.25 and 22.8.			6–24		



BOREHOLE LOG

BR-GW-UR01-MB007

PROJECT No: **BDP5001.001** PROJECT NAME: **Borumba Dam PHES** DATE DRILLED: **45203** LOGGED BY: **Callie Pickering**	DRILLING COMPANY: **Terratest** DRILLER: **Dave Coleman** DRILLING METHOD: **Auger and diamond coring**	EASTING: **455426 mE** NORTHING: **7060232 mN** DATUM: **GDA2020 z56** RL: **494.64 mAHD** TD: **35 mBGL**

COMMENTS: **Very limited topsoil. No water loss or gains noted during drilling.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
				26		
					-27 m	
				28		
				30		
				32		
				34		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB008

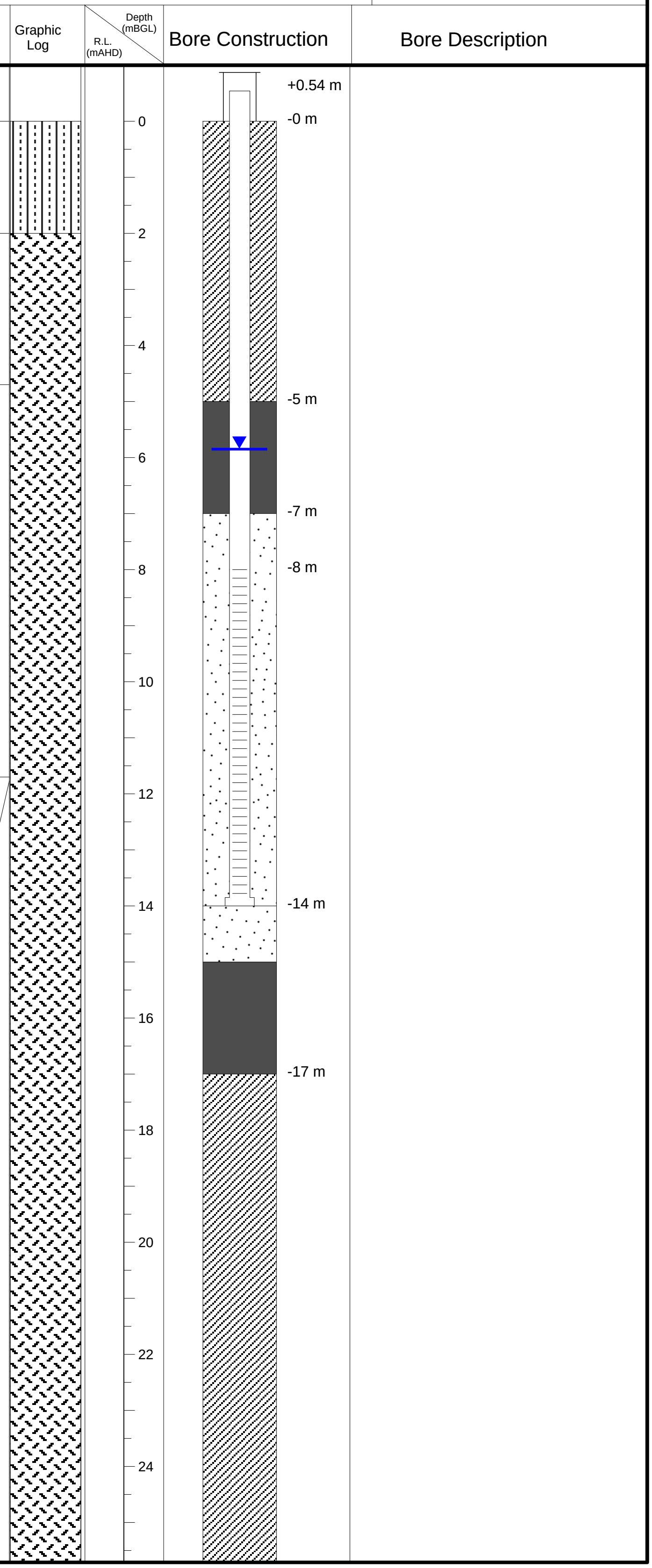
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45203**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454877 mE**
NORTHING: **7060376 mN**
DATUM: **GDA2020 z56**
RL: **486.06 mAHD**
TD: **30 mBGL**

COMMENTS: **No water loss or gains noted during drilling.**

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Rg/g] (10 %): medium sand, to sub-rounded, lithic clasts, well graded, clay matrix 90%, medium plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, sandy clay.
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, dry, layered, granular, Weathered granodiorite, mixed coarse fraction, pyrite observed.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Shear zone between 5.14- 5.18 and 7.68-7.70.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, low strength, extremely weathered, soft, loose, massive, crystalline, Core loss. Weathered material and orange staining on either side of core. Suggests aquifer.
Granite	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Competent granodiorite. No fractures after 14m.



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB008

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45203**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454877 mE**
NORTHING: **7060376 mN**
DATUM: **GDA2020 z56**
RL: **486.06 mAHD**
TD: **30 mBGL**

COMMENTS: **No water loss or gains noted during drilling.**

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
			26 28 30		

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BOREHOLE LOG

BR-GW-UR01-MB009

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45207**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

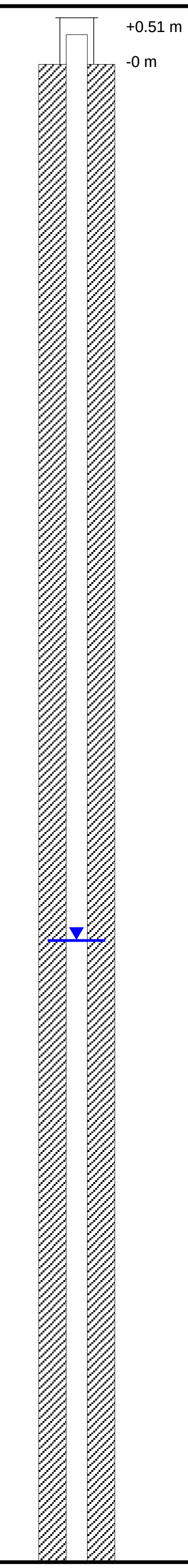
EASTING: **454050 mE**
NORTHING: **7061100 mN**
DATUM: **GDA2020 z56**
RL: **506.85 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description
Sandy Clay	SANDY CLAY [Rg/g] (3 %): fine sand, to sub-angular, quartz clasts, well graded, clay matrix 97%, medium plasticity, light brownish brown / yellow / red, very low strength, extremely weathered, very soft, loose, layered, granular, Topsoil. Friable. Exhibits 1:1 plasticity when wet.
Claybound Gravels	CLAYBOUND GRAVELS [Rg/g] (4 %): fine sand, to sub-angular, quartz clasts, well graded, clay matrix 96%, medium plasticity, light brownish brown / yellow / red, low strength, residual soil, very soft, loose, layered, granular, More gravel content. Auger 1.45-1.8. Coring from 1.8 m.
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline, Granodiorite boulder. Cored through rock until 2.55 m. Continued coring through a clay layer.
Claybound Gravels	CLAYBOUND GRAVELS [Rg/g] (50 %): coarse gravel, to sub-angular, quartz clasts, poorly graded, clay matrix 50%, medium plasticity, mottled reddish brown / yellow / mottled, medium strength, distinctly weathered firm, medium dense, massive, granular, Presence of pyrite. Core loss from 3-3.5 m.
Clay Loam	CLAY LOAM [Rg/g] (90 %): clay, to rounded, quartz clasts, well graded, clay matrix 10%, high plasticity, dark reddish brown / yellow / black, high strength, extremely weathered, stiff, dense, layered, granular, Clay layer
Claybound Gravels	CLAYBOUND GRAVELS [Rg/g] (50 %): coarse gravel, to sub-angular, quartz clasts, poorly graded, clay matrix 50%, medium plasticity, mottled reddish brown / yellow / red, medium strength, distinctly weathered firm, medium dense, layered, granular, Gravelly clay layer
Clay Loam	CLAY LOAM [Rg/g] (90 %): clay, to rounded, quartz clasts, well graded, clay matrix 10%, high plasticity, dark reddish brown / yellow / black, high strength, extremely weathered, stiff, dense, layered, granular, Clay layer
Sandy Clay	SANDY CLAY [Rg/g] (5 %): coarse gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, mottled reddish brown / yellow / black, low strength, extremely weathered, firm, loose, layered, granular, Weathered zone
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, very dense, massive, crystalline, Granodiorite
Clay Loam	CLAY LOAM [Rg/g] (90 %): clay, to rounded, quartz clasts, well graded, clay matrix 10%, high plasticity, dark reddish brown / yellow / black, high strength, extremely weathered, stiff, dense, layered, granular, Clay layer
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, distinctly weathered hard, very dense, massive, crystalline, Large fracture at 7.23-7.63 with red staining/oxidation. Quite weathered either side of the fracture.
Clay Loam	CLAY LOAM [Rg/g] (90 %): clay, to rounded, quartz clasts, well graded, clay matrix 10%, high plasticity, dark reddish brown / yellow / black, high strength, extremely weathered, stiff, dense, massive, granular, Clay layer
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, distinctly weathered hard, dense, massive, crystalline, Two fractures and continuation of weathered zone (weathering into clay)
Granite	GRANITE [Rg/g]: quartz clasts, light greyish grey / black, high strength, slightly weathered, hard, dense, massive, crystalline, 14.2 m was a very soft section which resulted in suspected core loss. Continued to lose water as drilling proceeded from this point. Significant open and weathered fracture at 15.6-15.7.
Granite	GRANITE [Rg/g]: quartz clasts, mottled greyish grey / black / red, low strength, extremely weathered, soft, loose, massive, crystalline, Mottled and regular fracturing.
Granite	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black / red, high strength, slightly weathered, hard, dense, massive, porphyritic, Fractured but not as weathered. Red staining around significant fractures in 19.04 and 21.4.
Granite	GRANITE [Rg/g]: quartz clasts, mottled greyish grey / black / red,

Graphic Log | R.L. (mAHD) | Depth (mBGL): 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24

Bore Construction



Bore Description

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB009

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45207**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454050 mE**
NORTHING: **7061100 mN**
DATUM: **GDA2020 z56**
RL: **506.85 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Granite	medium strength, distinctly weathered hard, medium dense, massive, crystalline, Slightly opened to closed fracture set with red staining.		26		
	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black / red, high strength, slightly weathered, hard, dense, massive, crystalline, Mostly competent granodiorite with intermittent fractures with red staining increasing with depth.		28, 30, 32, 34, 36, 38	-34 m; -36 m; -37 m	
	GRANITE [Rg/g]: quartz clasts, mottled greyish grey / black / red, very low strength, extremely weathered, soft, loose, massive, crystalline, Significantly weathered and fractured/jointed. Packer test has lost water.		40, 42		
	GRANITE [Rg/g]: quartz clasts, dark greyish grey / black / red, high strength, slightly weathered, hard, dense, massive, porphyritic, Presence of mafic and felsic intrusions. Mostly competent granodiorite with intermittent fractures with red staining at 44.7 and 45.24 m.		44, 46, 48	-43 m; -46 m	
	GRANITE [Rg/g]: quartz clasts, mottled greyish grey / black / red, low strength, extremely weathered, hard, loose, massive, crystalline, Loose and broken fracture centralised at 48.9 m with red staining running its length either side.				
	GRANITE [Rg/g]: quartz clasts, mottled greyish grey / black / red, very high strength, hard, dense, massive, crystalline, Competent granodiorite.		50		

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

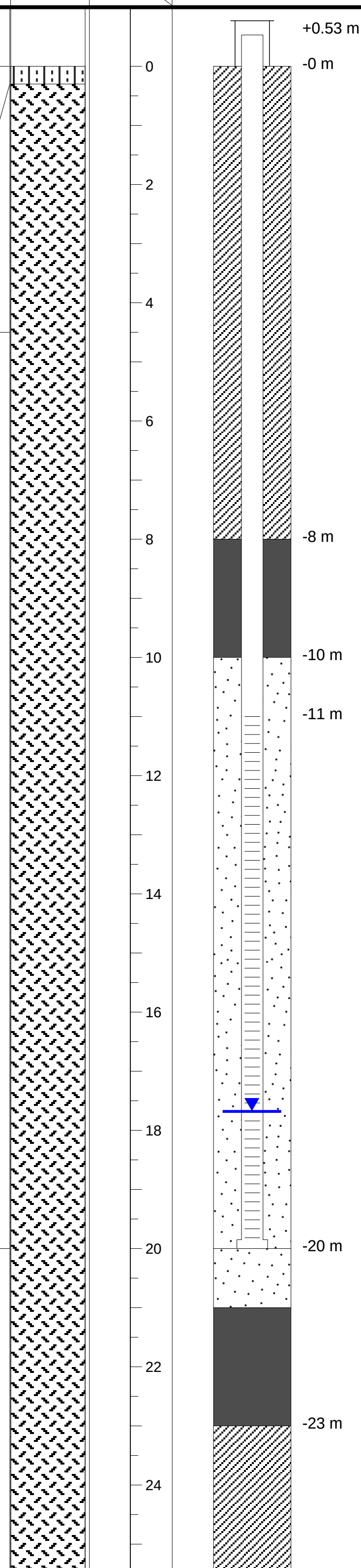
BOREHOLE LOG

BR-GW-UR01-MB010

PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **453924 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7061450 mN**
DATE DRILLED: **45208**	DRILLING METHOD: **Auger and diamond coring**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **506.23 mAHD**
		TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
Soil	SOIL [Rg/g] (10 %): medium sand, to sub-rounded, lithic clasts, well graded, clay matrix 90%, medium plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, sandy clay.				
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, dry, layered, granular, Weathered granodiorite, mixed coarse fraction, pyrite observed.				
	GRANITE [Rg/g]: quartz clasts, light whitish grey, high strength, fresh, hard, very dense, massive, crystalline, Granodiorite, very fractured. Hematite veining and fractured at 12.5 m. The core was very fractured up to 20 m and then became more competent with fewer fractures.				



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB010

PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **453924 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7061450 mN**
DATE DRILLED: **45208**	DRILLING METHOD: **Auger and diamond coring**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **506.23 mAHD**
		TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Competent granodiorite with few fractures. Some decent fracturing between 33 and 39 m but no evidence of alteration or staining to suggest these are water bearing fractures.			26 – 50 (26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50)		

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BOREHOLE LOG

BR-GW-UR01-MB011

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45207**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **453735 mE**
NORTHING: **7061735 mN**
DATUM: **GDA2020 z56**
RL: **500.55 mAHD**
TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
				+0.5 m	
Soil	SOIL [Rg/g] (10 %): medium sand, to sub-rounded, lithic clasts, well graded, clay matrix 90%, medium plasticity, light brownish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, sandy clay.		0	-0 m	
Granite	GRANITE [Rg/g] (5 %): fine gravel, to sub-angular, quartz clasts, poorly graded, clast 95%, low plasticity, light yellowish very low strength, extremely weathered, very soft, very loose, dry, layered, granular, Weathered granodiorite, mixed coarse fraction, pyrite observed.		2, 4		
	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Granodiorite, very fractured.		6		
	GRANITE [Rg/g]: quartz clasts, light whitish grey, low strength, extremely weathered, soft, loose, massive, crystalline, Core loss.				
	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Granodiorite, very fractured.		8, 10, 12, 14, 16, 18, 20		
	GRANITE [Rg/g]: quartz clasts, light whitish grey, low strength, extremely weathered, soft, loose, massive, crystalline, Core loss. Significant fracturing above and below. Orange staining. 100% water loss at 20.7m.		22		
			24		

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

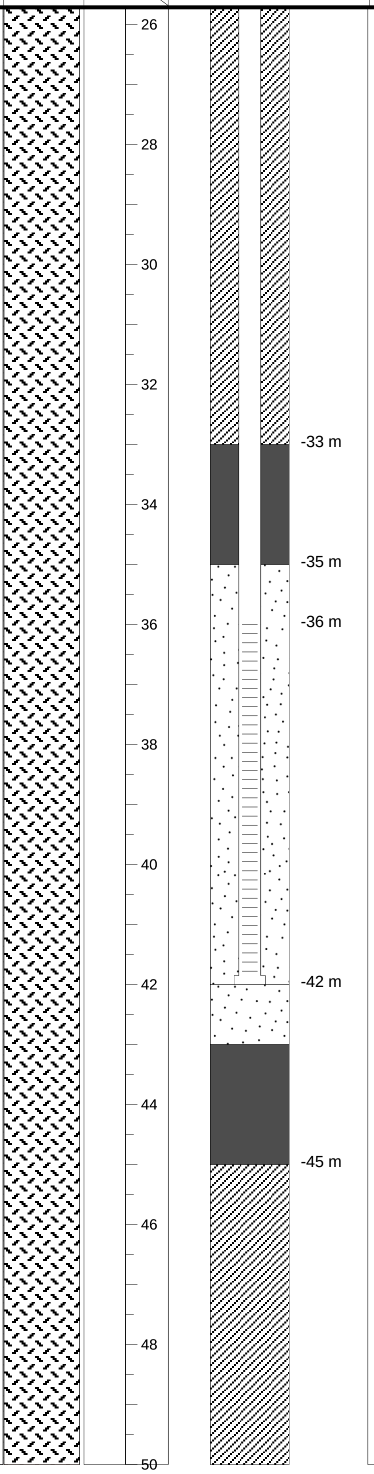
BOREHOLE LOG

BR-GW-UR01-MB011

PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **453735 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7061735 mN**
DATE DRILLED: **45207**	DRILLING METHOD: **Auger and diamond coring**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **500.55 mAHD**
		TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
	GRANITE [Rg/g]: quartz clasts, light whitish grey, very high strength, fresh, hard, very dense, massive, crystalline, Shear zone at 21.7 m, clay present. Significant fracturing and infilling at 30-30.3 m and 39.3-39.9.				



BOREHOLE LOG

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BR-GW-UR01-MB012

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **01/12/2023**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **454385 mE**
NORTHING: **7062090 mN**
DATUM: **GDA2020 z56**
RL: **503.13 mAHD**
TD: **50 mBGL**

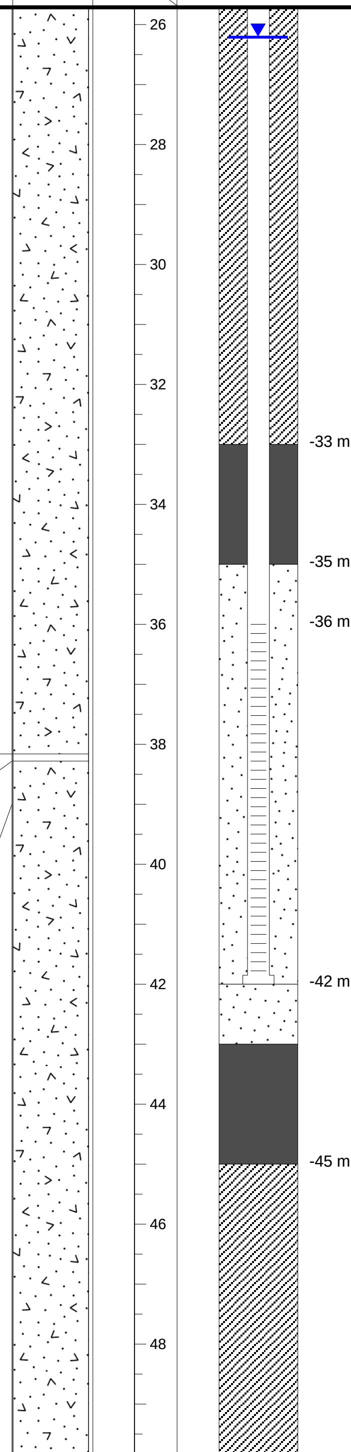
COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
				0	+0.62 m -0 m	
Claybound Sand	CLAYBOUND SAND [Pm] (5 %): fine sand, to rounded, lithic clasts, gap graded, silty matrix 95%, low plasticity, light yellowish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Clayey silty sand with rock fragments present.					
Metasediments	CLAYBOUND SAND [Pm] (5 %): very fine sand, to rounded, lithic clasts, gap graded, silty matrix 95%, low plasticity, light whitish brown, very low strength, residual soil, very soft, very loose, dry, layered, granular, Clayey silty sand with rock fragments present. Very fine grained fraction present.			2		
	Metasediments [Pm]: dark greenish black / red / mottled, high strength, slightly weathered, hard, dense, foliated, crystalline, Metasediments, banded foliation, splits along foliations easily. Strong pinkish hue in lighter bands. Significant fracturing. Long clay infilled fracture between 7.4 and 7.7m. Mostly intact but slight weathering observed until about 14 m.			4, 6, 8, 10, 12, 14		
				16, 18, 20, 22, 24		

PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **454385 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7062090 mN**
DATE DRILLED: **01/12/2023**	DRILLING METHOD: **Auger and diamond coring**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **503.13 mAHD**
		TD: **50 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Depth (mBGL)	Bore Construction	Bore Description
Metasediments	Metasediments [Pm]: dark greenish black / red / mottled, high strength, fresh, hard, dense, foliated, crystalline, Fresh competent rock, fewer fractures.	26–38	-33 m, -35 m, -36 m	
	NO SAMPLE RETURN [Pm]: Core loss.	38		
	Metasediments [Pm]: dark greenish black / red / mottled, high strength, slightly weathered, hard, dense, foliated, crystalline, Fractured zone with associated loss around angular core length until 39 m, suggesting unlogged clay or weathered rock.	38		
	Metasediments [Pm]: dark greenish black / red / mottled, high strength, fresh, hard, dense, foliated, crystalline, Fresh competent rock with fewer fractures.	38–50	-42 m, -45 m	



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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-UR01-MB013

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45223**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **452961 mE**
NORTHING: **7062560 mN**
DATUM: **GDA2020 z56**
RL: **506.67 mAHD**
TD: **35 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
					+0.53 m	
Silty Clay	SILTY CLAY [Pm] (20 %): silt, to angular, lithic clasts, gap graded, silty matrix 80%, medium plasticity, light yellowish yellow / grey / brown, very low strength, residual soil, soft, loose, dry, layered, granular, Gap graded. Medium clasts of gravel. Yellowish.			0	-0 m	
Metasediments	SILTY CLAY [Pm] (5 %): silt, to angular, lithic clasts, gap graded, silty matrix 95%, low plasticity, light greyish grey, very low strength, residual soil, very soft, very loose, dry, layered, granular, Gap graded. Medium clasts of gravel. Greyish			2		
Metasediments	Metasediments [Pm]: lithic clasts, mottled bluish black / mottled, high strength, slightly weathered, hard, medium dense, foliated, granular, Fractured argillite with shear zones that have been clay infilled and relithified.			4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24		

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BOREHOLE LOG

BR-GW-UR01-MB013

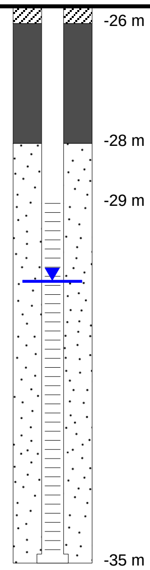
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45223**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and diamond coring**

EASTING: **452961 mE**
NORTHING: **7062560 mN**
DATUM: **GDA2020 z56**
RL: **506.67 mAHD**
TD: **35 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
				26		
	Metasediments [Pm]: lithic clasts, mottled bluish black / mottled, high strength, fresh, hard, medium dense, foliated, granular, Becomes more competent. Fewer fractures observed.			28, 30, 32, 34		



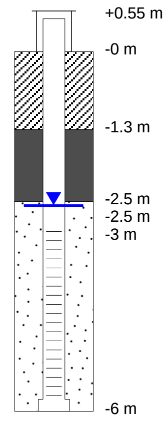
Australasian Groundwater & Environmental Consultants Pty Ltd Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006	**BOREHOLE LOG** page:1 of 1 **BR-GW-YD01-MB001**

PROJECT No: **BDP5001.001** PROJECT NAME: **Borumba Dam PHES** DATE DRILLED: **45174** LOGGED BY: **Callie Pickering**	DRILLING COMPANY: **Terratest** DRILLER: **Dave Coleman** DRILLING METHOD: **Auger and air rotary**	EASTING: **459157 mE** NORTHING: **7068970 mN** DATUM: **GDA2020 z56** RL: **113 mAHD** TD: **6 mBGL**

COMMENTS:

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)
Sand	SAND [Pm] (0 %): coarse sand, sub-rounded, quartz clasts, well graded, silty matrix 100%, low plasticity, light brownish brown, very low strength, residual soil, very stiff, very loose, dry, layered, granular		113	0
Alluvium	Alluvium [Pm] (5 %): coarse gravel, sub-rounded, lithic clasts, poorly graded, clast 95%, low plasticity, light brownish brown, low strength, extremely weathered, soft, damp, layered, granular, Sandy gravel. Wet at 4m (sand fraction increases at 4m)		111 109 107	2 4 6

Bore Construction



Bore Description

Stick up: +0.55 m

150 mm Auger TC: 0 m to 6 m (Auger)
Bentonite grout (5 %): 0 m to 1.3 m

50 mm PN18 uPVC blank casing: -0.55 m to 3 m

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BOREHOLE LOG

BR-GW-YD01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45175**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and air rotary**

EASTING: **459158 mE**
NORTHING: **7068971 mN**
DATUM: **GDA2020 z56**
RL: **113 mAHD**
TD: **30 mBGL**

COMMENTS: **Metasediments (presumed phyllite) alternates between competent and softer zones. A** few small seepage zones intersected but no significant strikes.

Stratigraphic Cloumn	Soil or Rock Field Material Description
Sand	SAND [Pm] (0 %): coarse sand, sub-rounded, quartz clasts, well graded, silty matrix 100%, low plasticity, light brownish brown, very low strength, residual soil, very stiff, very loose, dry, layered, granular, Larger quartz fraction
Alluvium	Alluvium [Pm] (10 %): cobble, sub-rounded, lithic clasts, poorly graded, clast 90%, low plasticity, mottled brownish variegated, low strength, extremely weathered, soft, loose, wet, layered, granular, 2.7m water strike
Silty Clay	SILTY CLAY [Pm] (80 %): clay, rounded, lithic clasts, well graded, clay matrix 20%, high plasticity, dark brownish brown, low strength, extremely weathered, soft, dense, moist, lens, granular, Pedometric
Alluvium	Alluvium [Pm] (30 %): coarse gravel, sub-rounded, lithic clasts, poorly graded, clast 70%, medium plasticity, mottled brownish brown, low strength, extremely weathered, soft, medium dense, moist, layered, granular, Transition clay to gravel
Alluvium	Alluvium [Pm] (10 %): coarse gravel, sub-rounded, lithic clasts, poorly graded, clast 90%, low plasticity, mottled brownish brown, low strength, extremely weathered, soft, loose, moist, layered, granular
Alluvium	Alluvium [Pm] (30 %): coarse gravel, sub-rounded, lithic clasts, poorly graded, clast 70%, medium plasticity, mottled brownish brown, low strength, extremely weathered, soft, medium dense, moist, layered, granular, Transition to weathered bedrock
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, high strength, slightly weathered, hard, moist, crystalline, Quartz fragments, pyrite veins, competent seep at 7-11 m
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, medium strength, fresh, hard, dry, crystalline, Soft, powdery chips
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, high strength, fresh, hard, dry, crystalline, Competent chips
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, medium strength, fresh, hard, dry, crystalline, Soft, powdery chips
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, high strength, fresh, hard, dry, crystalline, Competent chips.
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, high strength, fresh, hard, wet, crystalline, Competent chips.
Metasediments	Metasediments [Pm] (0 %): dark greyish grey, high strength, fresh, hard, dry, crystalline, Competent chips.

R.L. (mAHD)	Depth (mBGL)
113	0
111	2
109	4
107	6
105	8
103	10
101	12
99	14
97	16
95	18
93	20
91	22
89	24

Bore Construction: +0.64 m; -0 m; -21 m; -23 m; -23 m; -24 m

Bore Description:

Stick up: +0.64 m

150 mm Auger TC: 0 m to 7 m (Auger)

50 mm PN18 uPVC blank casing: -0.64 m to 24 m

Bentonite grout (5 %): 0 m to 21 m

SWL: 3.2 mTOC (15092023)

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Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-YD01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45175**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and air rotary**

EASTING: **459158 mE**
NORTHING: **7068971 mN**
DATUM: **GDA2020 z56**
RL: **113 mAHD**
TD: **30 mBGL**

COMMENTS: **Metasediments (presumed phyllite) alternates between competent and softer zones. A** few small seepage zones intersected but no significant strikes.

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
	Metasediments [Pm] (0 %): dark greyish grey, medium strength, fresh, hard, dry, crystalline, Soft, powdery chips		87	26		Bore development: 15 mins; EC: 1001 μS/cm; pH: 6.9 Development airlift flow rate: 0.02 L/s
	Metasediments [Pm] (0 %): dark greyish grey, high strength, fresh, hard, wet, crystalline, Competent chips. Wet at 29.5.		85	28		
			83	30	-30 m	126 mm Downhole Hammer: 7 m to 30 m (Air Rotary)

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BOREHOLE LOG

BR-GW-YU01-MB001

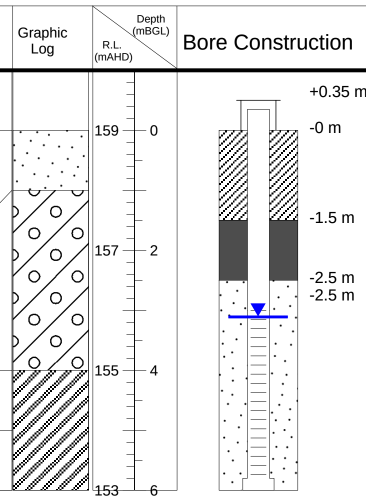
PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45187**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and wash bore**

EASTING: **451420 mE**
NORTHING: **7064452 mN**
DATUM: **GDA2020 z56**
RL: **159 mAHD**
TD: **6 mBGL**

COMMENTS: **Weathered zone has mixed fragments of serpentinite and other lithic fragments.**

Stratigraphic Cloumn	Soil or Rock Field Material Description
Sand	SAND [DCs] (0 %): coarse sand, sub-angular, lithic clasts, well graded, clast 100%, low plasticity, light brownish brown, very low strength, residual soil, very stiff, very loose, dry, layered, granular, Mostly sand
Alluvium	Alluvium [DCs] (0 %): sub-angular, lithic clasts, poorly graded, clast 100%, low plasticity, light brownish brown, very low strength, extremely weathered, soft, loose, dry, layered, granular, Sand + cobbles
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, medium strength, distinctly weathered hard, dense, crystalline, Wash bore - weathered zone
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, high strength, fresh, hard, dense, crystalline, Competent serpentinite



Bore Description

Stick up: +0.35 m

150 mm Auger TC: 0 m to 4 m (Auger)

50 mm PN18 uPVC blank casing: -0.35 m to 3 m

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BOREHOLE LOG

BR-GW-YU01-MB002

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45187**
LOGGED BY: **Callie Pickering**

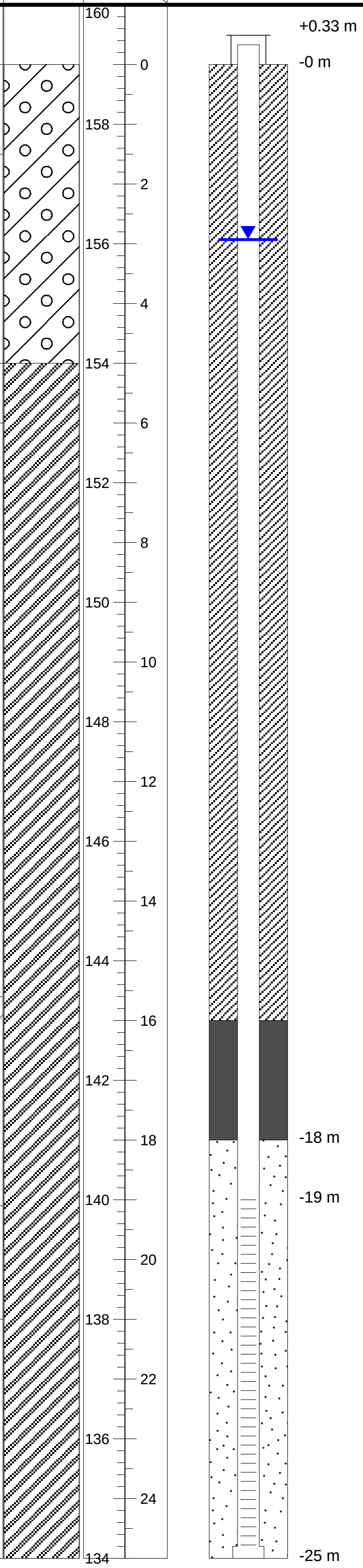
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and wash bore**

EASTING: **451420 mE**
NORTHING: **7064451 mN**
DATUM: **GDA2020 z56**
RL: **159 mAHD**
TD: **25 mBGL**

COMMENTS: **Pyrite observed within serpentinite from ±14m. Dark material is magnetite (tested in** the field). 19-21m driller lost water.

Stratigraphic Cloumn	Soil or Rock Field Material Description
Alluvium	Alluvium [DCs] (0 %): fine sand to boulder, sub-angular, lithic clasts, poorly graded, clast 100%, low plasticity, light brownish brown, very low strength, residual soil, very soft, dry, layered, granular, Loose sandy with cobbles
Alluvium	Alluvium [DCs] (5 %): fine sand to boulder, sub-angular, lithic clasts, poorly graded, clast 95%, low plasticity, light brownish brown, very low strength, extremely weathered, soft, loose, dry, layered, granular, Sand and cobbles, slightly claggy
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, medium strength, distinctly weathered hard, dense, crystalline, Mostly serpentinite - mixed with the fragments
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, high strength, fresh, hard, dense, crystalline, Competent serpentinite
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, low strength, fresh, hard, dense, crystalline, Soft fracture zone
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black / orange / mottled, high strength, fresh, hard, dense, crystalline, Evidence of carbonation (red carbonates infill in chips (refer to photos) and orange calcite)
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, low strength, fresh, hard, dense, crystalline, Soft zone/ fractured with fine chips. Possible oligoclase feldspars. Possibly through hydrothermal veining or weathering from granite.
Serpentinite	Serpentinite [DCs] (0 %): mottled greenish black, high strength, fresh, hard, dense, crystalline, Competent serpentinite

Graphic Log | R.L. (mAHD) / Depth (mBGL) | Bore Construction



Bore Description

150 mm Auger TC: 0 m to 5 m (Auger)

50 mm PN18 uPVC blank casing: -0.33 m to 19 m

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BOREHOLE LOG

BR-GW-YU01-MB003

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45181**
LOGGED BY: **Callie Pickering**

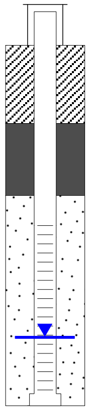
DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and air rotary**

EASTING: **451161 mE**
NORTHING: **7063970 mN**
DATUM: **GDA2020 z56**
RL: **154 mAHD**
TD: **6 mBGL**

COMMENTS: **Assumed seepage between 5-6m as noted on deep bore log. Targeted to drill above** clayey layer between 9-16m.

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)
Soil	SOIL [Pm] (0 %): fine sand to boulder, sub-rounded to angular, lithic clasts, clast 100%, low plasticity, light bluish brown / grey, very low strength, residual soil, very soft, very loose, dry, layered, granular, Topsoil, loamy, rocky		154 / 0
Alluvium	Alluvium [Pm] (0 %): fine sand to boulder, sub-rounded, lithic clasts, poorly graded, clast 100%, low plasticity, light greyish brown, very low strength, extremely weathered, soft, loose, layered, granular, Water added by driller so moisture uncertain.		152 / 2; 150 / 4; 148 / 6

Bore Construction



Bore Description

Stick up: +0.56 m

SWL: 5.42 mTOC (15092023)

150 mm Auger TC: 0 m to 4.7 m (Auger)

Bentonite grout (5 %): 0 m to 1.3 m

Bentonite seal: 1.3 m to 2.5 m

126 mm Downhole Hammer: 4.7 m to 6 m (Air Rotary)

50 mm PN18 uPVC blank casing: -0.56 m to 3 m

3-6 mm crushed river rock: 2.5 m to 6 m

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 3 m to 6 m

Australasian Groundwater & Environmental Consultants Pty Ltd Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006	**BOREHOLE LOG**	
	BR-GW-YU01-MB004	

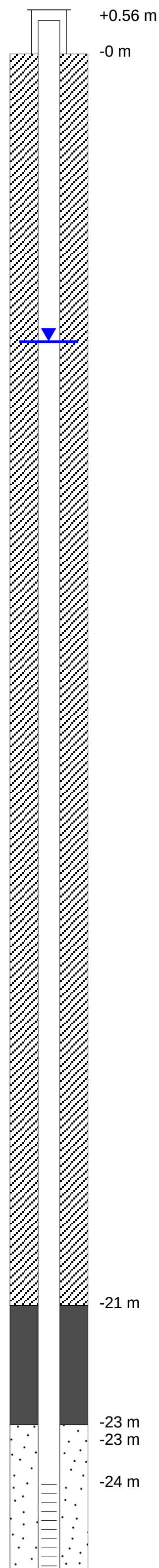
PROJECT No: **BDP5001.001**	DRILLING COMPANY: **Terratest**	EASTING: **451162 mE**
PROJECT NAME: **Borumba Dam PHES**	DRILLER: **Dave Coleman**	NORTHING: **7063969 mN**
DATE DRILLED: **45180**	DRILLING METHOD: **Auger and air rotary**	DATUM: **GDA2020 z56**
LOGGED BY: **Callie Pickering**		RL: **154 mAHD**
		TD: **30 mBGL**

COMMENTS: **The drillers struggled with this borehole because of the very rocky alluvium. Bore** collapsed at 10m when all rods were removed and had to be re-opened.

Stratigraphic Cloumn	Soil or Rock Field Material Description
Soil	SOIL [Pm] (0 %): fine sand to boulder, sub-rounded to angular, lithic clasts, clast 100%, low plasticity, light brownish brown / grey, very low strength, residual soil, very soft, very loose, dry, layered, granular, Large boulder fraction. Quite loamy, full of organic carbon (topsoil). Well draining.
Alluvium	Alluvium [Pm]: cobble, sub-angular, lithic clasts, poorly graded, clast, low plasticity, light greyish brown, low strength, extremely weathered, soft, loose, layered, granular
Alluvium	Alluvium [Pm] (5 %): cobble, sub-angular, lithic clasts, poorly graded, clast 95%, low plasticity, light greyish brown, low strength, extremely weathered, soft, loose, damp, layered, granular, Damp zone
Alluvium	Alluvium [Pm] (10 %): cobble, sub-angular, lithic clasts, poorly graded, clast 90%, low plasticity, light greyish brown, low strength, extremely weathered, soft, loose, dry, layered, granular, Dry zone
Alluvium	Alluvium [Pm] (10 %): cobble, sub-angular, lithic clasts, poorly graded, clast 90%, low plasticity, light greyish brown, low strength, extremely weathered, soft, loose, moist, layered, granular, Moist. Water strike at 6
Alluvium	Alluvium [Pm] (15 %): cobble, sub-angular, lithic clasts, poorly graded, clast 85%, low plasticity, light greyish brown, low strength, extremely weathered, soft, loose, wet, layered, granular, Wet zone
Alluvium	Alluvium [Pm] (15 %): cobble, sub-angular, lithic clasts, poorly graded, clast 85%, medium plasticity, light reddish brown, low strength, extremely weathered, soft, loose, wet, layered, granular, More competent, change in colour. Definite change in alluvium-mixed rock fragments.
Alluvium	Alluvium [Pm] (20 %): cobble, lithic clasts, poorly graded, clast 80%, medium plasticity, light reddish brown / yellow, low strength, extremely weathered, soft, loose, wet, layered, granular, Much softer, very fine clay in solution. Mud appearance. Water strike at 9m.
Alluvium	Alluvium [Pm] (15 %): cobble, quartz clasts, poorly graded, medium plasticity, light reddish brown / yellow, low strength, extremely weathered, soft, medium dense, wet, layered, granular, Mostly mixed rock fragments. Reducing clay content with depth.
Alluvium	Alluvium [Pm] (10 %): cobble, quartz clasts, poorly graded, medium plasticity, light reddish brown / yellow, low strength, extremely weathered, soft, medium dense, wet, layered, granular
Alluvium	Alluvium [Pm] (5 %): cobble, quartz clasts, poorly graded, medium plasticity, light yellowish brown / red, low strength, extremely weathered, soft, medium dense, wet, layered, granular, Colour change to more yellow white, large calcite and quartz fraction.
Alluvium	Alluvium [Pm] (5 %): cobble, quartz clasts, poorly graded, medium plasticity, light yellowish brown / red / white, low strength, extremely weathered, soft, medium dense, wet, layered, granular

R.L. (mAHD)	Depth (mBGL)
154	0
152	2
150	4
148	6
146	8
144	10
142	12
140	14
138	16
136	18
134	20
132	22
130	24

Bore Construction



Bore Description

Stick up: +0.56 m

Bentonite grout (5 %): 0 m to 21 m

Bentonite seal: 21 m to 23 m

SWL: 5.39 mTOC (15092023)

50 mm PN18 uPVC blank casing: -0.56 m to 24 m

50 mm PN18 uPVC machine slotted casing, slot aperture: 1 mm, 24 m to 30 m

150 mm Auger TC: 0 m to 1.6 m (Auger)

126 mm Downhole Hammer: 1.6 m to 30 m (Air Rotary)

3-6 mm crushed river rock: 23 m to 12.7 m

End cap

Gravel backfill: 23 m to 30 m

Development airlift flow rate: 3.2 L/s

Bore development: 32 mins; EC: 523.3 μS/cm; pH: 7.05

End of hole: 30 m BGL

BOREHOLE LOG

Australasian Groundwater & Environmental Consultants Pty Ltd

Level 2, 15 Mallon Street, Bowen Hills, Queensland 4006

BR-GW-YU01-MB004

PROJECT No: **BDP5001.001**
PROJECT NAME: **Borumba Dam PHES**
DATE DRILLED: **45180**
LOGGED BY: **Callie Pickering**

DRILLING COMPANY: **Terratest**
DRILLER: **Dave Coleman**
DRILLING METHOD: **Auger and air rotary**

EASTING: **451162 mE**
NORTHING: **7063969 mN**
DATUM: **GDA2020 z56**
RL: **154 mAHD**
TD: **30 mBGL**

COMMENTS: **The drillers struggled with this borehole because of the very rocky alluvium. Bore** collapsed at 10m when all rods were removed and had to be re-opened.

Stratigraphic Cloumn	Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD)	Depth (mBGL)	Bore Construction	Bore Description
	Alluvium [Pm] (5 %): cobble, quartz clasts, poorly graded, medium plasticity, light yellowish brown / white / red, low strength, extremely weathered, soft, medium dense, wet, layered, granular		128	26		
			126	28		
	Alluvium [Pm] (0 %): cobble, quartz clasts, poorly graded, medium plasticity, light yellowish brown / black / white, low strength, extremely weathered, soft, medium dense, wet, lens, granular, Dark blue - black clay nodule/lense.		124	30	-30 m	

Appendix C

Laboratory Results

Site ID	Units	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW-KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002
Date Sampled	-	22/09/2023	22/09/2023	22/09/2023	22/09/2023	15/09/2023	15/09/2023	15/09/2023	15/09/2023	19/10/2023	19/10/2023	22/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments
Field Parameters																	
Field pH	pH	6.99	7.01	7.03	7.02	7.06	7.06	7.12	7.11	6.94	6.89	7.4	6.96	6.89	6.94	6.96	6.99
Field Electrical Conductivity (EC)	µS/cm	636.2	771.6	568.4	804.8	544	487.5	830.5	1048	617.2	994.2	602	797.1	664.2	524.3	1032	1108
Depth to Groundwater	m TOC	3.46	3.26	9.05	8.9	5.42	5.39	3.12	3.2	3.4	3.22	8.08	8.25	5.59	5.86	2.93	3.54
Physical Parameters																	
pH	pH	7.41	8.29	7.63	8.13	8.12	8.33	7.88	8.35	7.4	7.75	7.83	8.34	7.58	8.27	7.39	7.99
Electrical conductivity	µS/cm	583	753	566	766	551	530	902	1160	-	-	-	-	-	-	-	-
Sodium Absorption Ration (SAR)	-	-	-	-	-	-	-	-	-	1.24	1.81	0.58	1.64	1.7	1.51	0.86	8.06
Total Dissolved Solids (calc)	mg/L	379	489	368	498	358	344	586	754	375	562	399	434	380	318	756	658
Hydroxide Alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	9	<1	<1	<1	24	<1	13	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	165	263	250	399	130	173	209	242	174	384	310	371	168	171	276	285
Total Alkalinity as $CaCO_3$	mg/L	165	263	250	399	130	173	209	251	174	384	310	395	168	184	276	285
Suspended Solids	-	-	-	-	-	-	-	-	-	612	36	419	34	542	20	650	2720
Major Ions																	
Sulfate as SO_4 - Turbidimetric	mg/L	17	24	8	10	10	6	35	4	17	34	9	12	3	9	35	11
Chloride	mg/L	75	74	39	20	73	47	142	205	83	102	27	24	109	48	186	223
Fluoride	mg/L	-	-	-	-	-	-	-	-	0.1	0.2	<0.1	0.1	0.1	0.3	0.1	2.5
Calcium	mg/L	39	54	20	26	29	40	65	30	42	42	25	29	39	42	74	32
Magnesium	mg/L	25	33	48	57	18	17	48	12	27	49	63	59	26	19	65	13
Sodium	mg/L	39	57	33	63	49	41	44	197	42	73	24	67	56	47	42	214
Potassium	mg/L	2	6	<1	5	3	2	3	3	2	7	<1	5	2	2	1	4
Total Anions	meq/L	5.77	7.84	6.26	8.74	4.86	4.91	8.91	10.9	6.17	11.2	7.14	8.82	6.49	5.22	11.5	12.2
Total Cations	meq/L	5.75	8.04	6.38	8.86	5.14	5.23	9.18	11.1	6.2	9.48	7.48	9.34	6.57	5.76	10.9	12.1
Ionic Balance	%	0.13	1.27	0.97	0.64	2.72	3.18	1.52	1.13	0.2	8.56	2.28	2.9	0.6	4.9	2.66	0.56
Nutrients																	
Ammonia as N	mg/L	0.08	0.04	0.05	0.01	0.01	<0.01	0.04	0.05	0.03	0.02	0.01	0.02	0.02	0.02	0.06	0.17
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.03	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.11	0.05	<0.01	0.01	0.02	0.03	<0.01	0.04	0.15
Nitrite + Nitrate as N	mg/L	0.03	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.11	0.05	<0.01	0.01	0.02	0.03	<0.01	0.04	0.15
Total Kjeldahl Nitrogen as N	mg/L	0.6	0.8	6.3	0.3	0.6	0.2	6.6	0.4	0.5	0.1	4.2	0.3	0.3	<0.1	0.9	1.1
Total Nitrogen as N	mg/L	0.6	0.8	6.3	0.3	0.6	0.2	6.6	0.5	-	-	-	-	-	-	-	-
Total Phosphorus as P	mg/L	0.02	0.01	0.01	0.04	0.12	0.02	2.15	0.04	-	-	-	-	-	-	-	-
Organic Nitrogen	mg/L	-	-	-	-	-	-	-	-	0.5	<0.1	4.2	0.3	0.3	<0.1	0.8	0.9
Reactive Phosphorus as P	mg/L	-	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	0.02	<0.01	0.01	<0.01	0.01
Dissolved Metals																	
Arsenic	mg/L	<0.001	0.002	<0.001	0.024	<0.001	0.002	0.001	0.052	<0.001	<0.001	<0.001	0.024	0.001	0.003	<0.001	0.082
Barium	mg/L	0.039	0.062	0.016	0.572	0.02	0.092	0.068	0.309	0.036	0.053	0.032	0.562	0.042	0.079	0.082	0.261
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	<0.05	<0.05	0.36	<0.05	<0.05	<0.05	0.15	<0.05	<0.05	<0.05	0.3	<0.05	<0.05	<0.05	0.17
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006
Chromium	mg/L	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.002	<0.001	<0.001	<0.001	0.001	<0.001	0.002	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.002	<0.001
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.19	0.78	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	-	-	-	-	-	-	-	-

Site ID	Units	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW-KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002
Date Sampled	-	22/09/2023	22/09/2023	22/09/2023	22/09/2023	15/09/2023	15/09/2023	15/09/2023	15/09/2023	19/10/2023	19/10/2023	22/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.87	0.269	0.053	0.098	0.124	0.08	0.51	0.134	0.296	0.046	0.321	0.097	0.384	0.13	0.499	0.184
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.003	0.002	0.02	<0.001	0.003	<0.001	0.006	0.018	0.001	<0.001	0.04	<0.001	0.003	0.001	0.007	0.012
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	0.055	<0.005	0.013	<0.005	<0.005	<0.005	0.005	<0.005	0.006	0.005	0.005
Total Metals																	
Aluminium	mg/L	-	-	-	-	-	-	-	-	12.8	0.17	0.59	0.66	14.7	0.12	12.6	67.8
Arsenic	mg/L	<0.001	0.003	0.001	0.024	0.001	0.003	0.032	0.054	0.004	<0.001	0.001	0.026	0.004	0.004	0.007	0.261
Barium	mg/L	0.047	0.065	0.022	0.604	0.034	0.101	0.719	0.333	-	-	-	-	-	-	-	-
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Boron	mg/L	<0.05	<0.05	<0.05	0.3	<0.05	<0.05	<0.05	0.19	<0.05	<0.05	0.06	0.33	<0.05	<0.05	<0.05	0.13
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0006
Chromium	mg/L	<0.001	<0.001	0.043	<0.001	0.012	0.001	0.973	<0.001	0.033	<0.001	0.017	0.008	0.061	<0.001	0.135	0.152
Cobalt	mg/L	0.003	<0.001	0.004	<0.001	0.007	<0.001	0.133	0.002	0.008	<0.001	0.005	0.002	0.019	<0.001	0.019	0.072
Copper	mg/L	0.002	0.002	0.005	<0.001	0.034	0.002	0.237	0.004	0.017	<0.001	0.005	0.001	0.1	<0.001	0.032	0.472
Iron	mg/L	0.29	1.19	2.82	0.08	4.16	1.19	174	0.46	20.5	4.16	1.26	0.96	22.2	0.28	24.6	138
Lead	mg/L	<0.001	<0.001	0.001	<0.001	0.001	<0.001	0.068	<0.001	0.004	<0.001	<0.001	<0.001	0.004	<0.001	0.009	0.154
Lithium	mg/L	-	-	-	-	-	-	-	-	0.011	0.009	0.003	0.002	0.007	0.007	0.012	0.138
Manganese	mg/L	1.1	0.273	0.147	0.105	0.222	0.121	3.66	0.222	0.565	0.501	0.4	0.132	0.733	0.143	0.931	18.4
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	-	-	-	-	-	-	-	-	0.001	0.002	0.003	0.005	0.008	0.006	0.001	0.046
Nickel	mg/L	0.004	0.002	0.062	0.002	0.01	0.001	0.84	0.019	0.016	<0.001	0.064	0.008	0.032	<0.001	0.12	0.253
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	-	-	-	-	-	-	-	-	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.46	<0.01	0.04	<0.01	<0.01	<0.01	0.05	<0.01	0.06	0.18
Zinc	mg/L	0.008	0.006	0.012	0.006	0.066	0.087	0.35	0.028	0.034	0.008	0.014	0.018	0.16	0.02	0.057	0.537
Oil and Grease																	
Oil and Grease	µg/L	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
BTEX																	
Benzene	µg/L	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	µg/L	-	-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Ethylbenzene	µg/L	-	-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	-	-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	-	-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	-	-	-	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX	µg/L	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	µg/L	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Petroleum Hydrocarbons (Silica gel clean up)																	
C6 - C9 Fraction (EP080/071)	µg/L	-	-	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<50	<50	3780	<50	<50	<50	<50	<50
C15 - C28 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<100	140	1320	<100	<100	120	<100	110
C29 - C36 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<50	<50	70	<50	<50	<50	<50	60
C10 - C36 Fraction (sum - EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<50	140	5170	<50	<50	120	<50	170

Site ID	Units	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW-KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002
Date Sampled	-	22/09/2023	22/09/2023	22/09/2023	22/09/2023	15/09/2023	15/09/2023	15/09/2023	15/09/2023	19/10/2023	19/10/2023	22/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments
Total Recoverable Hydrocarbons																	
C6 - C10 Fraction (EP080/071)	µg/L	-	-	-	-	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<100	<100	4760	<100	<100	<100	<100	<100
>C16 - C34 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<100	110	390	<100	<100	120	<100	140
>C34 - C40 Fraction (EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum - EP071 SG)	µg/L	-	-	-	-	-	-	-	-	<100	110	5150	<100	<100	120	<100	140
>C10 - C16 Fraction minus Naphthalene	µg/L	-	-	-	-	-	-	-	-	<100	<100	4760	<100	<100	<100	<100	<100
TPH(V)/BTEX Surrogates																	
1.2-Dichloroethane-D4	%	-	-	-	-	92.8	94.8	94.4	92.9	98.3	98.4	101	99.1	102	99.3	99.2	97.9
Toluene-D8	%	-	-	-	-	103	101	105	102	98.9	98.8	101	98.2	100	98.1	101	99.3
4-Bromofluorobenzene	%	-	-	-	-	113	110	118	112	103	104	107	105	111	103	110	108
Monocyclic Aromatic Hydrocarbons																	
Styrene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trimethylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Oxygenated Compounds																	
Vinyl Acetate	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
2-Butanone (MEK)	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
2-Hexanone (MBK)	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Sulfonated Compounds																	
Carbon disulfide	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Fumigants																	
2.2-Dichloropropane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromoethane (EDB)	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aliphatic Compounds																	
Dichlorodifluoromethane	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Bromomethane	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Chloroethane	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
Trichlorofluoromethane	µg/L	-	-	-	-	-	-	-	-	<50	<50	<50	<50	<50	<50	<50	<50
1.1-Dichloroethene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.2-Dichloroethene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5

Site ID	Units	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW YU01-MB001	BR-GW YU01-MB002	BR-GW-KC01-MB001	BR-GW KC01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-YD01-MB001	BR-GW-YD01-MB002
Date Sampled	-	22/09/2023	22/09/2023	22/09/2023	22/09/2023	15/09/2023	15/09/2023	15/09/2023	15/09/2023	19/10/2023	19/10/2023	22/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023	19/10/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments	Alluvium	Serpentinite	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Metasediments
1.2-Dichloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1.2-Tetrachloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aromatic Compounds																	
Chlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichlorobenzene	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Trihalomethanes																	
Chloroform	µg/L	-	-	-	-	-	-	-	-	<5	<5	7	<5	<5	<5	<5	<5
Bromodichloromethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	-	-	-	-	-	-	-	-	<5	<5	<5	<5	<5	<5	<5	<5

Note: The chemistry analysis requirements were changed twice over the course of initial monitoring to expand on the parameters analysed. This has resulted in data gaps in the above table.

Site ID	Units	BR-GW-YU01-MB001	BR-GW-YU01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-KC01-MB001	BR-GW-KC01-MB002	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB005	BR-GW-UR01-MB012	BR-GW-UR01-MB013	BR-GW-UR01-MB001	BR-GW-UR01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB004
Date Sampled	-	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Serpentinite	Alluvium	Metasediments	Granodiorite	Granodiorite	Metasediments	Metasediments	Metasediments	Granodiorite	Granodiorite	Granodiorite
Field Parameters																	
Field pH	pH	10.15	10.13	10.13	10.09	8.33	8.03	6.99	8.01	8.02	7.8	7.57	8.21	7.51	8.36	7.92	7.08
Field Electrical Conductivity (EC)	µS/cm	571.7	911.7	622.7	487.7	634.7	720.7	986.6	1047	792.1	766.8	1828	2157	1647	755	768	1238
Depth to Groundwater	m TOC	3.41	3.21	5.63	5.78	8.07	8.31	3.18	4.17	-	-	-	-	15.35	18.83	27.84	17.02
Physical Parameters																	
pH	pH	7.45	7.87	7.64	7.95	7.64	8.37	7.16	8.1	6.65	7.11	7.92	8.29	7.26	8.42	6.62	6.86
Sodium Absorption Ration (SAR)	-	1.13	1.35	1.67	1.64	0.51	1.63	0.86	9.61	2.12	2.91	8.09	6.6	9.14	5.43	2.31	2.24
Total Dissolved Solids (calc)	mg/L	418	568	400	298	374	459	745	633	743	646	1060	842	1090	503	1340	1020
Hydroxide Alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	17	<1	<1	<1	<1	<1	<1	<1	10	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	177	357	168	195	335	388	304	264	62	50	416	763	239	111	38	243
Total Alkalinity as $CaCO_3$	mg/L	177	357	168	195	335	405	304	264	62	50	416	763	239	121	38	243
Suspended Solids	-	817	12	1100	22	3590	16	292	5	580	648	38	1000	28	156	4060	191
Major Ions																	
Sulfate as SO_4 - Turbidimetric	mg/L	19	37	3	11	9	16	30	9	48	62	36	31	22	155	129	45
Chloride	mg/L	77	102	116	44	21	21	168	221	217	226	434	262	478	120	256	316
Fluoride	mg/L	0.1	0.2	0.1	0.3	<0.1	0.1	0.1	3.4	0.1	0.2	1	0.8	0.4	0.7	0.1	0.3
Calcium	mg/L	49	79	42	44	26	30	80	26	45	43	43	27	28	27	44	86
Magnesium	mg/L	28	49	26	18	63	59	62	7	20	14	44	31	29	8	18	47
Sodium	mg/L	40	62	56	51	21	67	42	214	68	86	316	212	289	125	72	104
Potassium	mg/L	2	4	3	2	<1	5	2	2	5	5	13	12	10	5	5	6
Total Anions	meq/L	6.1	10.8	6.69	5.37	7.47	9.02	11.4	11.7	8.36	8.66	21.3	23.3	18.7	9.03	10.7	14.7
Total Cations	meq/L	6.54	10.8	6.75	5.95	7.4	9.4	11	11.2	7.94	8.05	19.8	23.1	16.6	7.57	6.94	12.8
Ionic Balance	%	3.45	0.03	0.42	5.13	0.52	2.05	2.07	2.02	2.56	3.64	3.54	0.3	5.96	8.79	21.2	6.79
Nutrients																	
Ammonia as N	mg/L	0.05	0.07	0.04	0.04	0.04	0.02	0.11	0.01	<0.01	<0.01	0.07	136	0.05	0.03	<0.01	0.02
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.12
Nitrate as N	mg/L	0.04	0.01	0.02	<0.01	0.02	0.02	<0.01	0.08	0.01	0.02	<0.01	<0.01	0.05	0.03	0.04	<0.01
Nitrite + Nitrate as N	mg/L	0.04	0.01	0.02	<0.01	0.02	0.02	<0.01	0.08	0.01	0.02	<0.01	<0.01	0.05	0.03	0.04	0.08
Total Kjeldahl Nitrogen as N	mg/L	1.2	0.1	0.4	0.1	0.2	0.3	0.4	<0.1	9.2	11.8	0.7	134	2.7	3	58.4	10.8
Organic Nitrogen	mg/L	1.2	<0.1	0.4	<0.1	0.2	0.3	0.3	<0.1	9.2	11.8	0.6	<2.0	2.6	3	58.4	10.8
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.03	<0.01	<0.01	<0.01	<0.01	0.22	0.02
Dissolved Metals																	
Arsenic	mg/L	<0.001	<0.001	<0.001	0.004	<0.001	0.023	0.002	0.028	<0.001	<0.001	0.001	0.016	0.002	<0.001	<0.005	<0.001
Barium	mg/L	0.038	0.1	0.045	0.071	0.026	0.572	0.081	0.342	0.051	0.05	0.066	0.062	0.033	0.035	0.093	0.046
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.001
Boron	mg/L	<0.05	<0.05	<0.05	0.07	0.06	0.36	<0.05	0.16	0.06	0.05	0.06	0.06	<0.05	0.08	0.16	<0.05
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0001
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.005	0.002
Cobalt	mg/L	0.001	<0.001	0.001	<0.001	0.002	<0.001	0.002	<0.001	0.002	<0.001	<0.001	<0.001	0.001	<0.001	<0.005	0.002
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.007	<0.001	<0.001	0.002	<0.001	0.014	0.008
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.005	<0.001
Manganese	mg/L	0.32	0.436	0.291	0.133	0.291	0.086	1.34	0.047	0.252	0.234	2.55	0.52	0.357	0.054	0.362	0.382
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.002	<0.001	0.003	<0.001	0.022	<0.001	0.006	0.004	0.004	0.002	0.002	0.004	0.006	0.002	<0.005	0.005
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01

Site ID	Units	BR-GW-YU01-MB001	BR-GW-YU01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-KC01-MB001	BR-GW-KC01-MB002	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB005	BR-GW-UR01-MB012	BR-GW-UR01-MB013	BR-GW-UR01-MB001	BR-GW-UR01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB004
Date Sampled	-	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Serpentinite	Alluvium	Metasediments	Granodiorite	Granodiorite	Metasediments	Metasediments	Metasediments	Granodiorite	Granodiorite	Granodiorite
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.01
Zinc	mg/L	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.04	0.017	0.017	<0.005	0.068	0.006	0.13	0.041
Total Metals																	
Aluminium	mg/L	22	0.13	10.5	0.08	0.61	0.36	0.84	0.2	8.67	7.99	0.1	12.3	1.33	1.53	306	9.36
Arsenic	mg/L	0.007	<0.001	0.003	0.004	0.001	0.025	0.002	0.023	<0.001	<0.001	<0.001	0.025	0.003	<0.001	0.024	0.001
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	0.41	<0.05	0.14	<0.05	<0.05	0.05	0.06	<0.05	0.07	0.09	<0.05
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0011	<0.0001
Chromium	mg/L	0.063	<0.001	0.038	<0.001	0.021	0.002	0.006	<0.001	0.006	0.007	<0.001	0.018	0.001	<0.001	0.45	0.008
Cobalt	mg/L	0.028	<0.001	0.017	<0.001	0.006	<0.001	0.002	<0.001	0.004	0.002	<0.001	0.008	0.001	<0.001	0.236	0.003
Copper	mg/L	0.049	<0.001	0.094	0.001	0.004	<0.001	0.003	<0.001	0.012	0.021	<0.001	0.02	0.003	0.003	1.1	0.022
Iron	mg/L	44.1	3.17	15.3	0.32	1.46	0.5	1.14	0.19	4.77	1.82	0.16	9.16	0.82	0.44	332	4.64
Lead	mg/L	0.012	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	0.01	<0.001	0.002	0.22	0.002
Lithium	mg/L	0.019	0.009	0.007	0.006	0.003	0.002	0.002	0.064	0.004	0.003	0.054	0.025	0.043	0.006	0.083	0.057
Manganese	mg/L	1.67	0.468	0.56	0.144	0.404	0.128	1.3	0.063	0.336	0.254	2.55	1.3	0.337	0.058	6.47	0.407
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001
Molybdenum	mg/L	0.001	0.001	0.003	0.012	0.001	0.005	0.002	0.003	0.009	0.022	0.031	0.07	0.006	0.009	0.046	0.007
Nickel	mg/L	0.04	<0.001	0.028	<0.001	0.058	0.002	0.009	0.004	0.007	0.008	0.001	0.027	0.006	0.002	0.248	0.008
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004	0.013	<0.001	0.002	0.022	0.003
Vanadium	mg/L	0.1	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.41	0.01
Zinc	mg/L	0.077	<0.005	0.162	<0.005	<0.005	0.157	0.016	0.006	0.076	0.1	0.018	0.096	0.074	0.015	6.48	0.071
Oil and Grease																	
Oil and Grease	µg/L	6	<5	<5	<5	<5	<5	10	<5	<5	10	<5	5	9	9	----	34
BTEX																	
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	3	<2	<2	<2	<2
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	3	<1	<1	<1	<1
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Petroleum Hydrocarbons (Silica gel clean up)																	
C6 - C9 Fraction (EP080/071)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	30	<20	<20	<20
C10 - C14 Fraction (EP071 SG)	µg/L	<50	<50	120	<50	4180	<50	<50	240	100	90	<50	160	710	330	700	1130
C15 - C28 Fraction (EP071 SG)	µg/L	<100	110	120	240	1840	280	170	350	1110	880	<100	340	4980	2850	10000	15500
C29 - C36 Fraction (EP071 SG)	µg/L	<50	<50	80	<50	60	110	80	120	170	190	<50	120	1080	710	2440	3580
C10 - C36 Fraction (sum - EP071 SG)	µg/L	<50	110	320	240	6080	390	250	710	1380	1160	<50	620	6770	3890	13100	20200
Total Recoverable Hydrocarbons																	
C6 - C10 Fraction (EP080/071)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	30	<20	<20	<20
>C10 - C16 Fraction (EP071 SG)	µg/L	<100	<100	160	<100	5800	<100	<100	310	660	400	<100	180	2050	1140	3340	4970
>C16 - C34 Fraction (EP071 SG)	µg/L	<100	<100	140	210	300	330	200	360	710	720	<100	400	4620	2690	9570	14900
>C34 - C40 Fraction (EP071 SG)	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	270	200	610	900
>C10 - C40 Fraction (sum - EP071 SG)	µg/L	<100	<100	300	210	6100	330	200	670	1370	1120	<100	580	6940	4030	13500	20800
>C10 - C16 Fraction minus Naphthalene	µg/L	<100	<100	160	<100	5800	<100	<100	310	660	400	<100	180	2050	1140	3340	4970

Site ID	Units	BR-GW-YU01-MB001	BR-GW-YU01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-KC01-MB001	BR-GW-KC01-MB002	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB005	BR-GW-UR01-MB012	BR-GW-UR01-MB013	BR-GW-UR01-MB001	BR-GW-UR01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB004
Date Sampled	-	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Serpentinite	Alluvium	Metasediments	Granodiorite	Granodiorite	Metasediments	Metasediments	Metasediments	Granodiorite	Granodiorite	Granodiorite
TPH(V)/BTEX Surrogates																	
1.2-Dichloroethane-D4	%	97.6	97.5	95.7	94.3	94.2	94.3	97.3	97.6	98	99.1	98	96.3	96.5	97.4	99.7	98
Toluene-D8	%	102	99.9	100	98.8	100	100	95.8	98.2	95.3	97	97.4	95.9	98.6	97.8	99.9	98.7
4-Bromofluorobenzene	%	114	112	113	111	111	110	108	105	110	106	107	108	110	109	109	110
Monocyclic Aromatic Hydrocarbons																	
Styrene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trimethylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Oxygenated Compounds																	
Vinyl Acetate	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2-Butanone (MEK)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2-Hexanone (MBK)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Sulfonated Compounds																	
Carbon disulfide	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Fumigants																	
2.2-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromoethane (EDB)	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aliphatic Compounds																	
Dichlorodifluoromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Bromomethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloroethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Trichlorofluoromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
1.1-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.2-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1.2-Tetrachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Site ID	Units	BR-GW-YU01-MB001	BR-GW-YU01-MB002	BR-GW-YU01-MB003	BR-GW-YU01-MB004	BR-GW-KC01-MB001	BR-GW-KC01-MB002	BR-GW-YD01-MB001	BR-GW-YD01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB005	BR-GW-UR01-MB012	BR-GW-UR01-MB013	BR-GW-UR01-MB001	BR-GW-UR01-MB002	BR-GW-UR01-MB003	BR-GW-UR01-MB004
Date Sampled	-	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	07/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	14/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023
Lithology	-	Alluvium	Serpentinite	Alluvium	Alluvium	Alluvium	Serpentinite	Alluvium	Metasediments	Granodiorite	Granodiorite	Metasediments	Metasediments	Metasediments	Granodiorite	Granodiorite	Granodiorite
trans-1.4-Dichloro-2-butene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aromatic Compounds																	
Chlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trihalomethanes																	
Chloroform	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	13	<5	13	<5	<5	<5	<5	<5
Bromodichloromethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	7	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Site ID	Units	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB010	BR-GW-UR01-MB011	BR-GW-UR01-MB001	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013
Date Sampled	-	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	25/01/2024	25/01/2024	17/01/2024	18/01/2024	18/01/2024	18/01/2024	19/01/2024	19/01/2024	19/01/2024	25/01/2024	25/01/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments
Field Parameters																		
Field pH	pH	-	7.9	8.06	7.9	8.35	7.77	7	6.56	-	-	7.65	7.7	6.91	7.68	7.4	7.56	7.26
Field Electrical Conductivity (EC)	µS/cm	-	720	697	874	714	1901	2481	873.3	-	-	709.6	663.8	1011	1599	2280	2248	2090
Depth to Groundwater	m TOC	-	8.7	12.68	16.38	19.58	17.9	15.025	27	15.12	-	4.44	5.6	15.6	16.66	17.75	27.53	31.35
Physical Parameters																		
pH	pH	8.44	7.22	7.25	7.42	7.93	7.85	7.58	7.23	7.29	7.52	7.94	7.89	7.22	8.02	8.13	7.98	7.81
Sodium Absorption Ration (SAR)	-	2.49	3.39	2.61	2.98	3.07	5.4	10.8	2.56	2.4	2.02	3.7	3.73	3.56	8.48	5.26	7.38	5.18
Total Dissolved Solids (calc)	mg/L	913	518	642	447	461	1190	1450	593	1040	997	521	458	656	1050	1200	1240	951
Hydroxide Alkalinity as $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	11	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	76	178	70	162	162	494	304	172	305	203	293	165	241	564	519	393	703
Total Alkalinity as $CaCO_3$	mg/L	87	178	70	162	162	494	304	172	305	203	293	165	241	564	519	393	703
Suspended Solids	-	14	32	164	6	305	18	72	628	89	<5	160	289	37	468	80	965	974
Major Ions																		
Sulfate as SO_4 - Turbidimetric	mg/L	62	13	65	37	58	23	6	45	24	18	5	47	27	60	8	30	6
Chloride	mg/L	350	133	187	119	129	425	643	165	335	305	73	91	220	230	424	520	271
Fluoride	mg/L	0.3	0.4	0.4	0.8	0.5	0.9	0.5	0.3	0.2	0.4	0.5	0.8	0.8	1	0.9	0.9	0.8
Calcium	mg/L	40	38	36	20	40	61	41	46	109	85	42	32	33	48	75	51	54
Magnesium	mg/L	50	17	15	26	17	72	51	24	64	57	19	15	43	36	96	45	48
Sodium	mg/L	100	100	74	86	92	263	438	86	128	98	115	102	132	319	292	300	217
Potassium	mg/L	23	6	5	8	8	14	11	6	6	7	3	5	10	7	15	11	12
Total Anions	meq/L	12.9	7.58	8.03	7.36	8.08	22.3	24.3	9.03	16	13	8.02	6.84	11.6	19	22.5	23.1	21.8
Total Cations	meq/L	11	7.8	6.38	7.08	7.6	20.8	25.6	8.18	16.4	13.4	8.74	7.4	11.2	19.4	24.7	19.6	20.7
Ionic Balance	%	7.74	1.43	11.4	1.94	3.07	3.64	2.48	4.94	1.18	1.29	4.3	3.89	1.76	1.06	4.72	8.35	2.57
Nutrients																		
Ammonia as N	mg/L	0.07	0.28	0.03	0.02	0.04	7.52	0.04	0.03	0.05	0.01	0.01	0.04	0.02	0.49	7.18	0.07	60.6
Nitrite as N	mg/L	<0.01	<0.01	<0.01	<0.01	0.23	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.06	8.52	<0.01	<0.01	0.05	0.03	0.02	0.03	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.03	0.84
Nitrite + Nitrate as N	mg/L	0.06	8.52	<0.01	<0.01	0.28	0.03	0.02	0.03	<0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.03	0.84
Total Kjeldahl Nitrogen as N	mg/L	1.3	4.3	7.9	0.3	6.2	9.3	0.4	7	1.5	<0.1	0.9	3.1	0.6	4.2	9.6	1.7	62.9
Organic Nitrogen	mg/L	1.2	4	7.9	0.3	6.2	1.8	0.4	7	1.4	<0.1	0.9	3.1	0.6	3.7	2.4	1.6	2.3
Reactive Phosphorus as P	mg/L	<0.01	<0.01	0.02	0.02	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
Dissolved Metals																		
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.001	0.001	0.001	0.01
Barium	mg/L	0.012	0.016	0.043	0.013	0.044	0.03	0.029	0.057	0.05	0.027	0.013	0.03	0.015	0.046	0.023	0.042	0.106
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06	<0.05	<0.05	0.09	<0.05	0.12	<0.05
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.074	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	0.002	0.011	<0.001	0.002	<0.001	0.001	0.001	0.001	0.002	0.002	0.003	<0.001	0.002	<0.001	<0.001	<0.001
Copper	mg/L	0.002	<0.001	0.004	<0.001	0.005	0.001	<0.001	0.009	0.007	<0.001	<0.001	0.01	<0.001	0.007	<0.001	<0.001	<0.001
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	0.018	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Manganese	mg/L	0.006	0.158	1.55	0.108	0.2	0.461	0.434	0.28	0.465	0.527	0.146	1.1	0.123	0.191	0.655	1.25	2.08
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	0.003	0.004	0.047	0.002	0.017	0.002	0.007	0.004	0.02	0.006	0.005	0.009	0.006	0.024	<0.001	0.006	0.002

Site ID	Units	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB010	BR-GW-UR01-MB011	BR-GW-UR01-MB001	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013
Date Sampled	-	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	25/01/2024	25/01/2024	17/01/2024	18/01/2024	18/01/2024	18/01/2024	19/01/2024	19/01/2024	19/01/2024	25/01/2024	25/01/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.029	0.052	0.01	0.08	0.02	0.007	0.023	0.065	0.016	0.008	0.012	0.015	0.016	<0.005	<0.005	<0.005
Total Metals																		
Aluminium	mg/L	0.11	0.65	5.83	0.07	5.73	0.34	0.43	20.8	2.59	0.01	1.48	1.04	0.5	2.21	1.56	7.45	2.11
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	0.001	0.004	<0.001	0.001	0.001	<0.001	<0.001	0.002	<0.001	0.001	0.002	0.002	0.014
Beryllium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	0.14	<0.05
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0001	<0.0001
Chromium	mg/L	0.075	0.001	0.002	<0.001	0.006	<0.001	0.003	0.022	0.005	<0.001	0.006	0.004	0.023	0.009	0.053	0.051	0.006
Cobalt	mg/L	0.001	0.002	0.011	<0.001	0.003	<0.001	0.001	0.008	0.002	0.002	0.004	0.004	0.001	0.003	0.002	0.005	0.004
Copper	mg/L	0.003	0.007	0.008	0.002	0.01	0.003	0.001	0.041	0.016	<0.001	0.005	0.014	0.003	0.008	0.003	0.011	0.006
Iron	mg/L	0.11	0.84	0.42	0.05	2.02	0.38	0.5	13.1	1.38	<0.05	1.18	0.27	0.65	1.41	2.15	8.35	3.48
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	0.004	<0.001	<0.001	0.009	0.041	<0.001	0.001	<0.001	<0.001	0.003	<0.001	0.007	0.005
Lithium	mg/L	0.09	0.058	0.015	0.02	0.009	0.024	0.064	0.009	0.075	0.083	0.054	0.011	0.028	0.034	0.046	0.077	0.024
Manganese	mg/L	0.042	0.166	1.43	0.106	0.216	0.406	0.429	0.508	0.464	0.524	0.158	1.1	0.158	0.209	0.572	1.74	2.56
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.104	0.004	0.151	0.102	0.008	0.008	0.004	0.015	0.003	0.047	0.008	0.161	0.068	0.03	0.013	0.016	0.025
Nickel	mg/L	0.004	0.005	0.045	0.003	0.021	0.002	0.008	0.016	0.021	0.006	0.011	0.013	0.026	0.034	0.04	0.038	0.011
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.006	<0.001	0.002	<0.001	0.007	0.021	<0.001	<0.001	0.002	0.011	0.002	<0.001	0.005	0.03	0.02	0.006	0.006
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Zinc	mg/L	0.01	0.092	0.087	0.012	0.124	0.023	0.018	0.135	0.081	0.015	0.051	0.03	0.038	0.084	0.118	0.078	0.033
Oil and Grease																		
Oil and Grease	µg/L	<5	<5	<5	<5	14	<5	<5	<5	8	<5	<5	<5	<5	<5	<5	7	7
BTEX																		
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	µg/L	<2	8	2	4	<2	<2	<2	<2	<2	10	3	4	<2	<2	<2	<2	<2
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Sum of BTEX	µg/L	<1	8	2	4	<1	<1	<1	<1	<1	10	3	4	<1	<1	<1	<1	<1
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Total Petroleum Hydrocarbons (Silica gel clean up)																		
C6 - C9 Fraction (EP080/071)	µg/L	480	30	<20	<20	<20	70	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
C10 - C14 Fraction (EP071 SG)	µg/L	170	240	200	<50	450	80	300	90	110	<50	100	230	<50	300	160	90	110
C15 - C28 Fraction (EP071 SG)	µg/L	340	830	840	250	5210	370	600	1180	2060	<100	270	530	<100	350	320	660	350
C29 - C36 Fraction (EP071 SG)	µg/L	130	130	140	50	1140	60	70	260	460	<50	<50	80	<50	110	70	140	60
C10 - C36 Fraction (sum - EP071 SG)	µg/L	640	1200	1180	300	6800	510	970	1530	2630	<50	370	840	<50	760	550	890	520
Total Recoverable Hydrocarbons																		
C6 - C10 Fraction (EP080/071)	µg/L	480	30	<20	<20	<20	70	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
>C10 - C16 Fraction (EP071 SG)	µg/L	270	390	490	180	2030	290	390	420	440	<100	120	280	<100	340	200	320	160
>C16 - C34 Fraction (EP071 SG)	µg/L	330	770	640	140	4660	210	390	1050	2110	<100	270	510	<100	380	320	520	320
>C34 - C40 Fraction (EP071 SG)	µg/L	130	120	130	<100	350	<100	<100	<100	140	<100	<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum - EP071 SG)	µg/L	730	1280	1260	320	7040	500	780	1470	2690	<100	390	790	<100	720	520	840	480

Site ID	Units	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB010	BR-GW-UR01-MB011	BR-GW-UR01-MB001	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013
Date Sampled	-	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	25/01/2024	25/01/2024	17/01/2024	18/01/2024	18/01/2024	18/01/2024	19/01/2024	19/01/2024	19/01/2024	25/01/2024	25/01/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments
>C10 - C16 Fraction minus Naphthalene	µg/L	270	390	490	180	2030	290	390	420	440	<100	120	280	<100	340	200	320	160
TPH(V)/BTEX Surrogates																		
1.2-Dichloroethane-D4	%	93.1	99.1	89.5	88.4	97	94.6	85.7	84.3	91	88.7	89	88.5	86.9	84.3	88.6	87	84
Toluene-D8	%	94.2	95.4	103	97.9	99.5	97.1	101	94.6	95.6	95.1	94	94.3	93.4	92.7	92.1	99.5	100
4-Bromofluorobenzene	%	111	108	100	97.9	108	112	89.6	83.3	86.6	94.3	91.9	90.4	92.9	86.6	88.1	87	91.3
Monocyclic Aromatic Hydrocarbons																		
Styrene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Isopropylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Propylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3.5-Trimethylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
sec-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trimethylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
tert-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
p-Isopropyltoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
n-Butylbenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Oxygenated Compounds																		
Vinyl Acetate	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2-Butanone (MEK)	µg/L	7660	<50	<50	<50	<50	870	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
4-Methyl-2-pentanone (MIBK)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
2-Hexanone (MBK)	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Sulfonated Compounds																		
Carbon disulfide	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Fumigants																		
2.2-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.3-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.3-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromoethane (EDB)	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aliphatic Compounds																		
Dichlorodifluoromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Vinyl chloride	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Bromomethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Chloroethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Trichlorofluoromethane	µg/L	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
1.1-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Iodomethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.2-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.2-Dichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.1-Trichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1-Dichloropropylene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carbon Tetrachloride	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromomethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2-Trichloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Tetrachloroethene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Site ID	Units	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB010	BR-GW-UR01-MB011	BR-GW-UR01-MB001	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013
Date Sampled	-	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	02/12/2023	25/01/2024	25/01/2024	17/01/2024	18/01/2024	18/01/2024	18/01/2024	19/01/2024	19/01/2024	19/01/2024	25/01/2024	25/01/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments
1.1.1.2-Tetrachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
trans-1.4-Dichloro-2-butene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
cis-1.4-Dichloro-2-butene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.1.2.2-Tetrachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pentachloroethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dibromo-3-chloropropane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Hexachlorobutadiene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Halogenated Aromatic Compounds																		
Chlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
2-Chlorotoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
4-Chlorotoluene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.3-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.4-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2-Dichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.4-Trichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1.2.3-Trichlorobenzene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trihalomethanes																		
Chloroform	µg/L	<5	6	<5	16	<5	<5	<5	<5	<5	<5	<5	<5	10	<5	<5	<5	<5
Bromodichloromethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Dibromochloromethane	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromoform	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

Site ID	Units	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB005	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013	OBS26	OBS26.2	OBS25	OBS53	OBS27
Date Sampled	-	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	08/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments	Spring	Spring	Spring	Spring	Spring
Field Parameters																	
Field pH	pH	7.1	6.86	7.57	7.4	7.96	8.36	7.79	7.95	8.07	8.28	7.81	6.45	7.19	7.29	7.41	7.41
Field Electrical Conductivity (EC)	µS/cm	852.2	1425	1338	1211	721.4	597.9	1026	1842	2062	2078	1875	126	133.7	160.6	167.1	119.2
Depth to Groundwater	m TOC	NA	NA	NA	NA	1.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Physical Parameters																	
pH	pH	7.27	7.09	----	7.14	7.88	7.72	7.2	7.64	7.47	7.62	7.86	7.22	7.19	7.4	7.61	7.38
Sodium Absorption Ration (SAR)	-	2.81	2.34	----	1.92	3.61	3.75	3.3	9.04	5.2	7.79	5.37	1.69	1.54	1.75	1.82	1.37
Total Dissolved Solids (calc)	mg/L	532	1050	----	905	492	400	619	1080	1290	1230	1070	89	101	113	123	82
Hydroxide Alkalinity as $CaCO_3$	mg/L	<1	<1	----	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	<1	<1	----	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	223	293	----	216	313	218	257	660	523	389	714	55	53	59	58	47
Total Alkalinity as $CaCO_3$	mg/L	223	293	----	216	313	218	257	660	523	389	714	55	53	59	58	47
Suspended Solids	-	895	62	----	6	17	5	59	144	20	17	570					
Major Ions																	
Sulfate as SO_4 - Turbidimetric	mg/L	43	25	----	16	<1	21	16	36	<1	14	15	<1	<1	<1	<1	<1

Site ID	Units	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB005	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013	OBS26	OBS26.2	OBS25	OBS53	OBS27
Date Sampled	-	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	08/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments	Spring	Spring	Spring	Spring	Spring
Chloride	mg/L	149	360	----	324	68	62	223	252	527	534	282	8	9	14	17	9
Fluoride	mg/L	0.3	0.3	----	0.4	0.6	1.4	0.9	1.3	1	0.8	0.8	0.1	0.2	0.2	0.1	0.1
Calcium	mg/L	56	112	----	84	47	22	33	41	66	52	65	4	5	6	5	5
Magnesium	mg/L	29	63	----	52	19	12	44	42	81	51	54	4	4	5	5	4
Sodium	mg/L	104	125	----	91	116	88	123	345	267	330	242	20	19	24	24	17
Potassium	mg/L	6	5	----	8	4	4	11	6	16	12	12	<1	<1	<1	<1	<1
Total Anions	meq/L	9.55	16.5	----	13.8	8.17	6.54	11.8	21	25.3	23.1	22.5	1.32	1.31	1.57	1.64	1.19
Total Cations	meq/L	9.86	16.3	----	12.6	9.06	6.02	10.9	20.7	22	21.4	18.5	1.4	1.4	1.75	1.7	1.32
Ionic Balance	%	1.57	0.58	----	4.37	5.14	4.19	3.79	0.92	7.04	3.75	9.77					
Nutrients																	
Ammonia as N	mg/L	0.06	0.06	0.72	0.03	0.07	0.07	0.03	0.37	6	0.09	39.9	0.05	0.02	0.01	0.01	0.01
Nitrite as N	mg/L	<0.01	0.04	----	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.31	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.04	<0.01	----	<0.01	0.04	0.01	<0.01	0.01	0.02	0.01	<0.10	<0.01	0.34	<0.01	<0.01	<0.01
Nitrite + Nitrate as N	mg/L	0.04	<0.01	----	<0.01	0.04	0.02	<0.01	0.01	0.02	0.01	<0.10	<0.01	0.34	<0.01	<0.01	<0.01
Total Kjeldahl Nitrogen as N	mg/L	4.6	0.4	6.6	0.3	0.6	1	0.2	0.9	8	0.8	47.1	1.9	1	0.4	0.7	0.2
Organic Nitrogen	mg/L	4.5	0.3	5.9	0.3	0.5	0.9	0.2	0.5	2	0.7	7.2					
Reactive Phosphorus as P	mg/L	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01					
Total Nitrogen	mg/L												1.9	1.3	0.4	0.7	0.2
Total Phosphorous	mg/L												0.32	0.08	<0.01	0.04	<0.01
Dissolved Metals																	
Arsenic	mg/L	<0.001	<0.001	----	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.013	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	0.058	0.034	----	0.034	0.025	0.024	0.018	0.037	0.031	0.053	0.098	0.027	0.024	0.03	0.027	0.016
Beryllium	mg/L	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.05	<0.05	----	<0.05	<0.05	<0.05	<0.05	0.09	<0.05	0.14	0.06	<0.05	<0.05	0.05	<0.05	<0.05
Cadmium	mg/L	<0.0001	<0.0001	----	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.001	<0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	<0.001	<0.001	----	0.002	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	<0.001	<0.001
Copper	mg/L	0.007	<0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L												<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	<0.001	0.001	----	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.348	0.156	0.237	0.016	0.02
Mercury	mg/L	0.288	0.412	----	0.499	0.19	0.785	0.131	0.17	0.529	1.49	2.28	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	mg/L	<0.0001	<0.0001	----	<0.0005	<0.0001	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.002	0.003	----	0.005	<0.001	0.004	0.003	0.01	0.001	<0.001	0.003	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	mg/L	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	<0.01	<0.01	----	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.005	<0.005	<0.005	0.028	<0.005
Total Metals																	
Aluminium	mg/L	2.07	0.36	3.38	0.07	0.11	0.06	0.23	0.24	0.24	0.64	0.96	1.32	0.48	0.16	0.48	0.02
Arsenic	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.001	0.001	0.022	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	mg/L												<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001					
Cadmium	mg/L	0.06	<0.05	0.15	<0.05	<0.05	<0.05	<0.05	0.11	<0.05	0.15	0.06	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	<0.001	<0.001	0.001	<0.001
Cobalt	mg/L	0.002	0.002	0.009	<0.001	0.001	<0.001	0.006	0.002	0.003	0.006	0.003	0.005	0.002	0.005	0.002	<0.001
Copper	mg/L	0.002	<0.001	0.003	0.002	0.001	0.002	<0.001	0.001	<0.001	<0.001	0.002	0.002	0.001	<0.001	<0.001	<0.001
Iron	mg/L	0.012	0.001	0.021	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	0.003	4.57	3.98	9.9	1.32	0.4
Lead	mg/L	1.25	0.57	2.06	0.06	0.76	0.1	0.26	0.28	0.57	1.13	4.06	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	0.015	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	0.001	0.001	0.002	<0.001

Site ID	Units	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB005	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013	OBS26	OBS26.2	OBS25	OBS53	OBS27
Date Sampled	-	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	08/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments	Spring	Spring	Spring	Spring	Spring
Manganese	mg/L	0.002	0.083	0.004	0.088	0.047	0.014	0.028	0.041	0.045	0.069	0.024	0.722	0.252	0.672	0.181	0.037
Mercury	mg/L	0.299	0.431	0.35	0.531	0.191	0.965	0.143	0.177	0.562	1.63	2.94	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	0.001	<0.001
Nickel	mg/L	0.01	0.001	0.042	0.045	0.006	0.099	0.05	0.019	0.004	0.007	0.039	0.002	<0.001	<0.001	0.001	<0.001
Selenium	mg/L	0.003	0.004	0.017	0.006	0.002	0.004	0.008	0.012	0.003	0.005	0.009	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	<0.001	0.001	0.002	0.01	<0.001	<0.001	0.005	0.03	0.019	0.002	0.008	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.008	0.006	<0.005	<0.005	0.007
Oil and Grease																	
Oil and Grease	µg/L	<5	<5	----	<5	<5	<5	<5	<5	7	<5	<5					
BTEX																	
Benzene	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1					
Toluene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2					
Ethylbenzene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2					
meta- & para-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2					
ortho-Xylene	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2					
Total Xylenes	µg/L	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2					
Sum of BTEX	µg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1					
Naphthalene	µg/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5					
Total Petroleum Hydrocarbons (Silica gel clean up)																	
C6 - C9 Fraction (EP080/071)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20					
C10 - C14 Fraction (EP071 SG)	µg/L	230	190	----	960	260	460	1500	310	1500	870	330					
C15 - C28 Fraction (EP071 SG)	µg/L	820	290	----	3410	590	1290	700	450	8010	2210	860					
C29 - C36 Fraction (EP071 SG)	µg/L	180	80	----	690	220	310	210	130	1380	660	330					
C10 - C36 Fraction (sum - EP071 SG)	µg/L	1230	560	----	5060	1070	2060	2410	890	10900	3740	1520					
Total Recoverable Hydrocarbons																	
C6 - C10 Fraction (EP080/071)	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20					
>C10 - C16 Fraction (EP071 SG)	µg/L	300	190	----	1100	280	640	1500	330	1880	1120	360					
>C16 - C34 Fraction (EP071 SG)	µg/L	820	300	----	3570	660	1230	750	470	8220	2230	930					
>C34 - C40 Fraction (EP071 SG)	µg/L	<100	<100	----	550	210	230	170	110	1090	690	430					
>C10 - C40 Fraction (sum - EP071 SG)	µg/L	1120	490	----	5220	1150	2100	2420	910	11200	4040	1720					
>C10 - C16 Fraction minus Naphthalene	µg/L	300	190	----	1100	280	640	1500	330	1880	1120	360					
TPH(V)/BTEX Surrogates																	
1.2-Dichloroethane-D4	%	89	84.4	84.5	86	87.9	86.2	85.4	90.7	87.4	88.9	88.9					
Toluene-D8	%	99.6	99	97.7	98.8	99.7	98.1	98.9	99.8	97.9	101	99.9					
4-Bromofluorobenzene	%	103	103	102	103	103	103	103	106	106	108	105					
Monocyclic Aromatic Hydrocarbons																	
Styrene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Isopropylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
n-Propylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.3.5-Trimethylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
sec-Butylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2.4-Trimethylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
tert-Butylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
p-Isopropyltoluene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
n-Butylbenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Oxygenated Compounds																	
Vinyl Acetate	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					

Site ID	Units	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB005	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013	OBS26	OBS26.2	OBS25	OBS53	OBS27
Date Sampled	-	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	08/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments	Spring	Spring	Spring	Spring	Spring
2-Butanone (MEK)	µg/L	<50	<50	----	<50	<50	<50	<50	<50	90	<50	<50					
4-Methyl-2-pentanone (MIBK)	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
2-Hexanone (MBK)	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Sulfonated Compounds																	
Carbon disulfide	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	13	<5					
Fumigants																	
2.2-Dichloropropane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2-Dichloropropane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
cis-1.3-Dichloropropylene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
trans-1.3-Dichloropropylene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2-Dibromoethane (EDB)	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Halogenated Aliphatic Compounds																	
Dichlorodifluoromethane	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Chloromethane	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Vinyl chloride	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Bromomethane	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Chloroethane	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
Trichlorofluoromethane	µg/L	<50	<50	----	<50	<50	<50	<50	<50	<50	<50	<50					
1.1-Dichloroethene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Iodomethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
trans-1.2-Dichloroethene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1-Dichloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
cis-1.2-Dichloroethene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1.1-Trichloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1-Dichloropropylene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Carbon Tetrachloride	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2-Dichloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Trichloroethene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Dibromomethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1.2-Trichloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.3-Dichloropropane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Tetrachloroethene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1.1.2-Tetrachloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
trans-1.4-Dichloro-2-butene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
cis-1.4-Dichloro-2-butene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.1.2.2-Tetrachloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2.3-Trichloropropane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Pentachloroethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2-Dibromo-3-chloropropane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Hexachlorobutadiene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Halogenated Aromatic Compounds																	
Chlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Bromobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
2-Chlorotoluene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
4-Chlorotoluene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.3-Dichlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.4-Dichlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2-Dichlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
1.2.4-Trichlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					

Site ID	Units	BR-GW-UR01-MB003	BR-GW-UR01-MB004	BR-GW-UR01-MB005	BR-GW-UR01-MB006	BR-GW-UR01-MB007	BR-GW-UR01-MB008	BR-GW-UR01-MB009	BR-GW-UR01-MB0010	BR-GW-UR01-MB0011	BR-GW-UR01-MB012	BR-GW-UR01-MB013	OBS26	OBS26.2	OBS25	OBS53	OBS27
Date Sampled	-	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	07/03/2024	08/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024	14/03/2024
Lithology	-	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Granodiorite	Metasediments	Metasediments	Spring	Spring	Spring	Spring	Spring
1.2.3-Trichlorobenzene	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Trihalomethanes																	
Chloroform	µg/L	5	<5	----	<5	<5	<5	5	<5	<5	<5	<5					
Bromodichloromethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Dibromochloromethane	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					
Bromoform	µg/L	<5	<5	----	<5	<5	<5	<5	<5	<5	<5	<5					

Appendix D

Spring survey locations

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
1	OBS1a	453067	7062289	638	Drainage line back into Upper Reservoir from saddle.	Dry	-	Type 1	Drainage line. No spring.
2	OBS1b	452954	7062263	606	Steep drainage to outside of Upper Reservoir. Rock outcrops visible.	Dry	-	Type 1	Drainage line. No spring.
3	OBS2	453236	7062184	660	-	Dry	-	Type 1	Drainage line. No spring.
4	OBS3a	453561	7062167	670	Shallow saddle	Dry	-	Type 1	Drainage line. No spring.
5	OBS3b	453580	7062130	663	Steep drainage to outside of Upper Reservoir. Rock outcrops visible.	Dry	Low verdant	Type 1	Drainage line. No spring.
6	OBS4	453839	7062068	679	Upper slope of red clay area. Dence grass vegetation.	Dry	-	Type 1	Drainage line. No spring.
7	OBS5a	452958	7062560	637	Saddle at MB013	Dry	-	Type 1	Drainage line. No spring.
8	OBS5b	452889	7062505	604	Steep drainage to outside of Upper Reservoir. Rock outcrops visible	Dry	-	Type 1	Drainage line. No spring.
9	OBS5c	452852	7062471	587	Steep drainage to outside of Upper Reservoir. Rock outcrops visible	Dry	-	Type 1	Drainage line. No spring.
10	OBS6	452865	7062449	582	Steep drainage to outside of Upper Reservoir. Rock outcrops visible	Dry	Low verdant	Type 1	Drainage line. No spring.
11	OBS7	455751	7060507		Area prone to seepage due to shallow groundwater flow. Drainage line with rock outcrops	Dry	Moderate verdant	Type 2	Shallow groundwater table, possible ephemeral spring zone.
12	OBS8a	455436	7060222	595	Downstream inside Upper Reservoir from saddle, drainage line.	Seepage	High verdant	Type 2	Shallow groundwater table, possible ephemeral spring zone.
13	OBS8b	455464	7060058	556	Drainage line outside Upper Reservoir.	Seepage	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
14	OBS9	455347	7059985	552	Drainage line outside Upper Reservoir, may seep during wet season.	Dry	Low verdant	Type 1	Drainage line. No spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
15	OBS10a	455287	7059950	543	Drainage to outside of Upper Reservoir.	Standing water	-	Type 3	Standing/flowing water, perennial spring.
16	OBS10b	455179	7060159	592	Inside Upper Reservoir drainage line	-	-	Type 1	Drainage line. No spring.
17	OBS11	454865	7060044	609	Outside Upper Reservoir drainage line. Upper portion dry but signs of seasonal seepage further downstream	Dry	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
18	OBS12	454670	7059935	588	Outside drainage line from saddle. Seepage areas observed.	Seepage	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
19	OBS13a	454876	7060374	597	Top of saddle. Drainage line out is deeply eroded.	Damp	-	Type 1	Drainage line. No spring.
20	OBS13b	454799	7060361	586	Drainage line.	Dry	-		Drainage line. No spring.
21	OBS14	454550	7060584	590	Drainage line from saddle out. Seepage visible on upper bank. Drainage line dry but seep areas visible only in rainy season.	Seepage	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
22	OBS15	454539	7060619	576	Second drainage line from same saddle. Damp but mostly dry	Damp	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
23	OBS16	454452	7060630	565	Confluence of three upper drainage lines.	Dry	-	Type 1	Drainage line. No spring.
24	OBS17	454428	7060574	565	Drainage line, damp in places.	Damp	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
25	OBS18	454541	7060537	583	Green patch of vegetation directly 'above' drainage line. Damp with seepage visible.	Seepage	-	Type 2	Shallow groundwater table, possible ephemeral spring zone.
26	OBS19	454310	7060801	612	Drainage line. Dry with greenish vegetation.	Dry	-	Type 1	Drainage line. No spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
27	OBS20	454043	7060959	602	Steep side slope with granite outcrops, indications of seasonal seeps but overall dry.	Dry	-	Type 1	Drainage line. No spring.
28	OBS21	453969	7060970	587	Steep side slope with granite outcrops, indications of seasonal seeps but overall dry.	Dry	-	Type 1	Drainage line. No spring.
29	OBS22	453894	7061063	594	Steep side slope with granite outcrops, indications of seasonal seeps but overall dry.	Dry	-	Type 1	Drainage line. No spring.
30	OBS23	453820	7061374	537	Saddle area next to UR01 MB010. Drainage line out - steep side slope with granite outcrops, indications of seasonal seeps but overall dry. Some green vegetation.	Dry	Low verdant	Type 1	Drainage line. No spring.
31	OBS24	453610	7061784	531	Saddle area next to UR01 MB011. Drainage line out - steep side slope with granite outcrops, indications of seasonal seeps but overall dry. Some green vegetation.	Dry	-	Type 1	Drainage line. No spring.
32	OBS25	454973	7060676	542	Drainage line inwards to Upper Reservoir. Seepage visible. Lush green vegetation.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
33	OBS26	455088	7060398	538	Drainage line inwards to Upper Reservoir. Seepage visible. Lush green vegetation.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
34	OBS27	455771	7060133	531	Drainage outwards from Upper Reservoir, confluence of two drainage lines.	Seepage	Moderate verdant	Type 3	Shallow groundwater table, possible ephemeral spring zone.
35	OBS28	456021	7060578	526	Drainage outwards from Upper Reservoir, deeply eroded in some places.	Dry	Low verdant	Type 1	Drainage line. No spring.
36	OBS29	455615	7060981	542	Drainage from saddle, outwards from Upper Reservoir. Granite outcrops, deeply eroded.	Dry	-	Type 1	Drainage line. No spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
37	OBS30	452794	7065009	351	Track down from Walkers Top "look out" towards lake Borumba. No seepage visible on upper and mid slopes.	Dry	-	Type 1	Drainage line. No spring.
38	OBS31	452678	7065435	239	Drainage into Lake Borumba.	Dry	-	Type 1	Drainage line. No spring.
39	OBS32	452817	7065367	244	Drainage into Lake Borumba.	Dry	-	Type 1	Drainage line. No spring.
40	OBS33	452633	7065137		Steep lower and mid slope. No signs of any seepage.	Dry	-	Type 1	Drainage line. No spring.
41	OBS34	452829	7064051	449	Upper slopes.	Dry	-	Type 1	Drainage line. No spring.
42	OBS35	453102	7062604	540	Drainage below Upper Reservoir main dam wall area. Rocky outcrops.	Dry		Type 1	Drainage line. No spring.
43	OBS36	453176	7062603	523	Slopes are dry, no seepages. Some flow in creek after rains.	Dry		Type 1	Drainage line. No spring.
44	OBS37	453348	7062720	506	Slopes are dry, no seepages. Some flow in creek after rains.	Dry		Type 1	Drainage line. No spring.
45	OBS38	453317	7062948	494	Slopes are dry, no seepages. Some flow in creek after rains.	Dry		Type 1	Drainage line. No spring.
46	OBS39	453329	7063122	478	Slopes are dry, no seepages. Some flow in creek after rains.	Dry		Type 1	Drainage line. No spring.
47	OBS40	455271	7061531		Dry slopes and drainage line	Dry		Type 1	Drainage line. No spring.
48	OBS41	451763	7062910	268	Area southeast of laydown, below UR01 MB014. Potential seepage in rainy season.	Dry	Moderate verdant	Type 1	Drainage line. No spring.
49	OBS42	451963	7062762	290	Area southeast of laydown, below UR01 MB014. Potential seepage in rainy season along drainage line.	Dry	Moderate verdant	Type 1	Drainage line. No spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
50	OBS43	452008	7062689	289	Drainage line, seepage may occur during rainy season.	Dry	Moderate verdant	Type 1	Drainage line. No spring.
51	OBS44	454774	7060270	508	Saddle from bore UR01 MB008 and drainage line downslope - steep banks with no seepages. Observation is at confluence of three drainage lines	Dry	Low verdant	Type 1	Drainage line. No spring.
52	OBS45	454745	7060222	506	Small drainage line close to main drainage line with noticeable green vegetation.	Dry	Low verdant	Type 1	Drainage line. No spring.
53	OBS46	454665	7060153	499	Green vegetation in drainage line and side slopes. Drainage deeply incised.	Dry	Moderate verdant	Type 1	Drainage line. No spring.
54	OBS47	454091	7060049	461	Lower valley slopes and obvious seep zone.	Damp	High verdant	Type 2	Shallow groundwater table, possible ephemeral spring zone.
55	OBS48	453957	7060194	453	Visible seepage / spring at lower slopes	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
56	OBS49	453833	7060547	465	Drainage line	Dry	Moderate verdant	Type 1	Drainage line. No spring.
57	OBS50	453745	7060557	473	Lower slopes drainage, start of drainage line	Dry	Low verdant	Type 1	Drainage line. No spring.
58	OBS51	453888	7060591	486	Mid slope	Dry	Low verdant	Type 1	Drainage line. No spring.
59	OBS52	453993	7060550	526	Drainage gully	Dry	Low verdant	Type 1	Drainage line. No spring.
60	OBS53	454743	7060972	548	Main drainage in southern section of UR, flowing north. Water visible, appears like seep/spring. From this point the drainage line flows out of the open field area into the bush/ forest area.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
61	OBS53B	454722	7060995	539	Pool in drainage line where it forms a step down.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
62	OBS54	454592	7061209	551	Inner drainage line in bush area	Dry		Type 1	Drainage line. No spring.
63	OBS55	454970	7061741	-	Drainage line close to SD-BH003	Dry	Moderate verdant	Type 1	Drainage line. No spring.
64	OBS56	455084	7061726	524	Seasonal seep area at SD-BH003	Dry	Low verdant	Type 1	Drainage line. No spring.
65	OBS57	455209	7061725	-	Down slope of UR01 MB003. Near drainage gully (OBS40).	Dry		Type 1	Drainage line. No spring.
66	OBS58	455255	7061812	493	Small drainage gully - granite outcrop.	Dry		Type 1	Drainage line. No spring.
67	OBS59	455275	7061882	484	Steep drainage gully.	Dry		Type 1	Drainage line. No spring.
68	OBS60	455264	7061910	498	Very steep drainage gully. Granite outcop.	Dry		Type 1	Drainage line. No spring.
69	OBS61	455328	7061943	494	Drainage gully, slight change in geology, finer granite and sediments.	Dry		Type 1	Drainage line. No spring.
70	OBS62	455401	7061955	482	Gully, steep, dry.	Dry		Type 1	Drainage line. No spring.
71	OBS63	455510	7061938	477	Gully, steep, dry.	Dry		Type 1	Drainage line. No spring.
72	OBS64	455620	7061877	461	Gully, steep, dry.	Dry		Type 1	Drainage line. No spring.
73	OBS65	456208	7061891	433	Farm track downslope. Long grass.	Dry	Low verdant	Type 1	Drainage line. No spring.
74	OBS66	45502	7062142	416	Drainage gully, rocky outcrops.	Dry		Type 1	Drainage line. No spring.
75	OBS67	453093	7063249	519	Walking down to mid slopes of UR main dam area	Dry		Type 1	Drainage line. No spring.
76	OBS68	452979	7063415	467	Drainage gully west of UR main dam area. Rocky outcrops	Dry		Type 1	Drainage line. No spring.
77	OBS69	452981	7063472	463	UR main dam area	Dry		Type 1	Drainage line. No spring.
78	OBS70	454547	7062980	581	Drainage gully outwards from monitoring bore - MB001. Pool of water in drainage line, looks like seepage/spring flow.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.

No	Observation Id	X	Y	Z	Landscape setting	Flow	Flora	Type	Water regime type
79	OBS70B	454560	7062998	581	Drainage gully outwards from monitoring bore - MB001. Pool of water in drainage line, looks like seepage/spring flow - 2nd pool about 50 m downstream from first pool. Water level is too low to visibly flow and area downstream is damp for about 5 to 10 m only.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
80	OBS71	454576	7063195	569	Drainage line	Dry		Type 1	Drainage line. No spring.
81	OBS72	454547	7063089	582	Drainage line	Dry		Type 1	Drainage line. No spring.
82	OBS73	454365	7063201	581	Drainage line	Dry		Type 1	Drainage line. No spring.
83	OBS74	454286	7063266	581	Drainage line	Dry		Type 1	Drainage line. No spring.
84	OBS75	454204	7063378	585	Drainage gully - pool of water in drainage line, looks like seepage/spring flow. Water level is too low to visibly flow and area downstream is damp for about 5 to 10 m only.	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
85	OBS76	455858	7070145	-	Seep observed next to Yabba Rd. Likely topographical or structural spring feeding into wetland/dam	Standing water	High verdant	Type 3	Standing/flowing water, perennial spring.
86	OBS77	457140	7069091	-	Land owner refer to previous seeps identified when Borumba reservoir is at a high level			Type 2	

Note: * surface elevations to be re noted from available lidar GIS.

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