Appendix F

Groundwater Impact Assessment

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd

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Making Sustainability Happen

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Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with BM Alliance Coal Operations Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

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Acronyms and Abbreviations

ALC	Agricultural Land Classification
ATP	Authority to Prospect
BoM	Bureau of Meteorology
BMA	BM Alliance Coal Operations Pty Ltd
BWM	Blackwater Mine
CHPP	Coal Handling and Preparation Plant
CRD	Cumulative Rainfall Departure
CSG	Coal Seam Gas
DCCEEW	Department of Climate Change, Energy, the Environment and Water
DES	Department of Environment and Science
DRDMW	Department of Regional Development, Manufacturing and Water
EA	Environmental Authority
EP Act	Environmental Protection Act 1994
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EV	Environmental Value
GAB	Great Artesian Basin
GDE	Groundwater Dependent Ecosystems
GHB	General Head Boundaries
GMA	Groundwater Management Area
GWDB	Registered Bore Database
HES	High Ecological Significance
IESC	Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Development
LOR	Limit of Reporting
LOX	Limit of Oxidation
MNES	Matter of National Environmental Significance
NGIS	National Groundwater Information System
PAA	Priority Agricultural Areas
PALU	Priority Agricultural Land Use
PCA	Potential Commercial Areas
PL	Petroleum Lease
RCM	Rangal Coal Measures
ROM	Run of Mine
SCA	Strategic Cropping Areas
SILO	Scientific Information for Landowners
SLR	SLR Consulting Australia Pty Ltd

TLF	Train Loadout Facilities
TSF	Tailings Storage Facility
TVM	Time Variant Materials
UWIR	Underground Water Impact Report
VWP	Vibrating Wire Piezometer
Water Act	*Water Act 2000*
WQO	Water Quality Objective
WRP	Water Resource Plan

1.0 Introduction

1.1 Overview

SLR Consulting Australia Pty Ltd (SLR) was engaged by BM Alliance Coal Operations Pty Ltd (BMA) to assess the potential impacts of the proposed Blackwater Mine - North Extension Project (the Project) on groundwater values.

The assessment has been prepared to support the assessment of the Project under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and to support an application to amend the existing Environmental Authority (EA) for the Blackwater Mine (BWM) under the Queensland *Environmental Protection Act 1994*.

The scope of this study is to:

- Describe the existing hydrogeological environment of the Project area and surrounds.
- Assess the potential impacts of the proposed extension of open cut mining on the groundwater system.
- Propose measures to manage or mitigate impacts on groundwater environmental values.

The study area for the purpose of this assessment is shown on **Figure 1-1** and is defined as the extent of the groundwater model domain (refer to **Section 6.3.1** for a description and extent), which includes the Project area and surrounds. The scope of this groundwater impact assessment is focused on the open cut mining operations proposed within the Project area, with cumulative impacts considered from other mines in the study area.

1.2 Project Background

The Blackwater Mine (BWM) is located approximately 20 kilometres (km) south-west of Blackwater in the Bowen Basin, Queensland (**Figure 1-1**). BWM's Mining Leases (MLs) include ML1759, ML1760, ML1761, ML1762, ML1767, ML1771, ML1772, ML1773, ML1792, ML1800, ML1812, ML1829, ML1860, ML1862, ML1907, ML70091, ML70103, ML70104, ML70139, ML70167 and ML70329 (**Figure 1-1**).

The BWM has been in operation since 1967 and operates in accordance with, amongst other authorisations, Environmental Authority (EA) EPML00717813, granted under the Environmental Protection Act 1994 (Qld) (EP Act). The BWM produces up to 16 million tonnes per annum (Mtpa) of product coal.

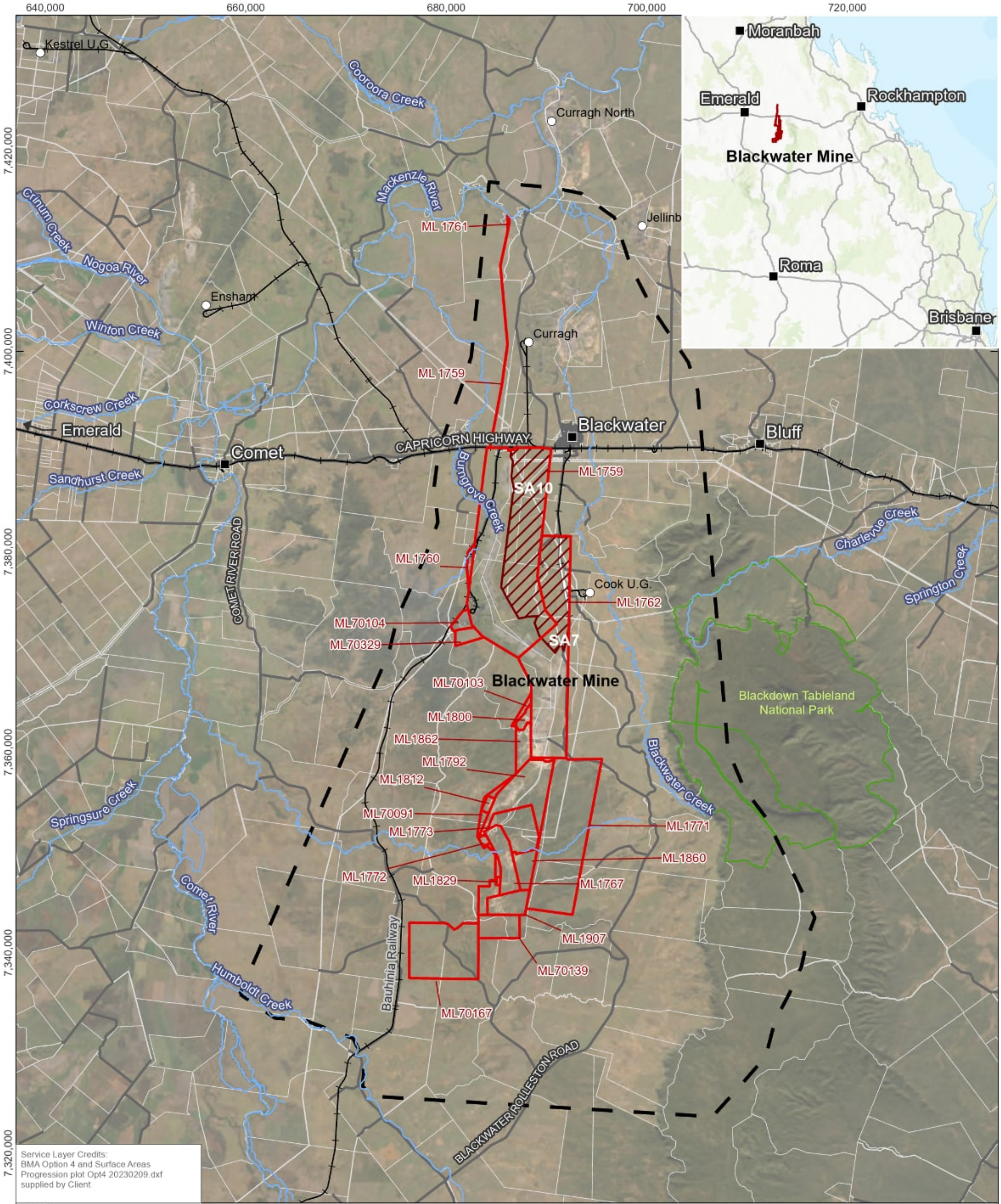
BMA seek relevant State and Federal approvals to extend the current mining operation through the BWM – North Extension Project (the Project). The Project would extend the mining area of the existing BWM to within Surface Area (SA)10 on ML1759 and SA7 on ML1762 (**Figure 1-1**and **Figure 1-2**) and increase BWM production to up to 17.6 Mtpa (product coal). Importantly, the Project should be viewed in the context that it is an extension and continuation of ongoing mining operations on a portion of the significantly larger BWM mining operation.

The key elements of the Project include, but are not limited to, the following:

- Vegetation clearing, the removal and stockpiling of topsoil material, drilling and blasting of overburden and interburden material.
- Removal of overburden and interburden material (dragline and truck and shovel/excavator methods) to uncover coal, which is placed as back fill in the mined-out pit voids (in-pit spoil dumps) as mining advances.

- Open cut mining (truck and shovel/excavator methods) of ROM coal from the coal measures in SA10 on ML1759 and SA7 on ML1762.
- Continued use of BWM infrastructure (e.g. Coal Handling and Preparation Plant [CHPP], Thermal Coal Plant [TCP], RoM and product stockpiles, train load-out, water management system and other supporting infrastructure).
- Continued disposal of rejects and tailings in accordance with the EA.
- Construction and operation of new or relocated infrastructure within SA10 on ML1759 and SA7 on ML1762 to facilitate and/or support the open cut mining extension such as back access roads, access tracks, water management infrastructure and powerlines, laydown areas and build pads.
- A new dragline crossing across Deep Creek.
- Ongoing exploration activities within ML1759 and ML1762.
- Progressive rehabilitation of the mine site.

SA7 on ML1762 and SA10 on ML1759 cover a total area of approximately 9,010 hectares (ha). The extent of the proposed Project open cut mining area and out of pit disturbance areas is approximately 3,761 ha. If approved, and subject to customer demand, the extension is projected to extend mining at the BWM to within SA7 on ML1762 and SA10 on ML1759 from 2025 to 2085.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:500,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Coal Mine
- Railway
- Road
- Watercourse
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area
- National Park
- Cadastre

BLACKWATER MINE - NORTH EXTENSION PROJECT

PROJECT LOCATION

SLR

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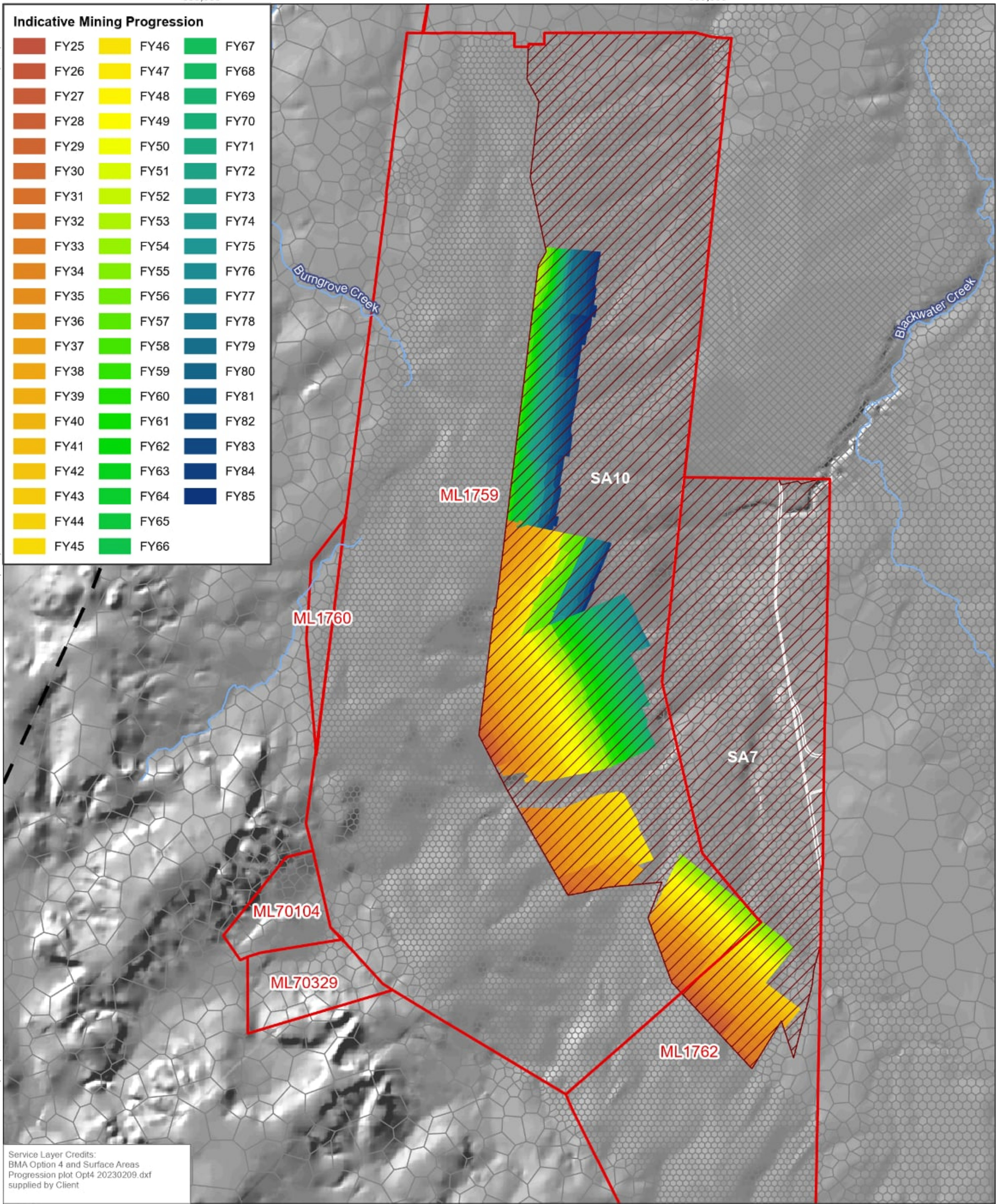
FIGURE 1-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F01_1_Site_Location



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

PROJECT MINING PROGRESSION

SLR

FIGURE 1-2

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F01_2_Mine Progression

1.3 Study Objectives

This groundwater assessment was undertaken in accordance with the Queensland government requirements under Chapter 3 of the *Water Act 2000* (Qld) (Water Act), the *Environmental Protection Act 1994* (EP Act) and the Commonwealth government requirements under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act), (specifically the Water Trigger, refer to **Section 2.1.1**).

To achieve regulatory requirements the groundwater assessment includes:

- A description of the existing hydrogeological environment.
- An assessment of the potential impacts of mining on the groundwater environment.
- Proposed management and mitigation measures.

In compiling these elements of the groundwater assessment, the scope of work detailed in this report was to:

- Summarise the relevant Queensland and Commonwealth environmental regulatory framework.
- Review relevant groundwater, geotechnical and environmental reports to characterise the geological and hydrogeological setting of the Project.
- Review publicly available hydrogeological data such as the Queensland Government's spatial data system (Queensland Globe) and the Bureau of Meteorology's (BoM) National Groundwater Information System (NGIS).
- Characterise the existing groundwater resources, including properties and quality.
- Conceptualise the groundwater regime of the Project area and study area.
- Assess the potential interaction between surface water and groundwater.
- Construct and calibrate a numerical groundwater flow model suitable for the assessment of potential impacts of the Project, in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012) and Murray Darling Basin Commission guidelines (Middlemis et al., 2001).
- Perform predictive modelling for the scale and extent of mining impacts upon groundwater levels, groundwater quality and groundwater users at various stages during mine operations and post-mining.
- Perform predictive modelling of the cumulative impacts of the Project and surrounding mines.
- Assess the extent of groundwater impacts to groundwater users and environmental values due to the Project, including through long-term impacts on regional groundwater interception, groundwater drawdown, incidental water impact and post mining equilibrium.
- Document any groundwater dependent ecosystems (GDEs) in the vicinity of the Project that could be impacted by the Project resulting from short and/or long-term changes in the quantity and quality of groundwater.
- Assess potential third-party impacts (i.e. privately-owned bores) as a result of changes to the regional groundwater system due to the Project.
- Develop reasonable and practicable mitigation and management strategies where potential adverse impacts are identified.
- Outline proposed groundwater monitoring network and groundwater management.

2.0 Legislative Requirements and Relevant Guidelines

2.1 Legislation

Relevant legislation in relation to taking or interfering with groundwater resources in the study area is as follows:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Queensland *Water Act 2000* (Water Act):
  - Water Plan (Fitzroy Basin) 2011.
  - *Environmental Protection (Underground Water Management) and Other Legislation Amendment Act 2016* (Qld).
- *Queensland Environmental Protection Act 1994* (EP Act).
  - *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity).

The following sections summarise Commonwealth and Queensland groundwater legislation and policy relevant to the Project.

2.1.1 Commonwealth Environment Protection and Biodiversity Act 1999

The EPBC Act is administered by the Department of Climate Change, Energy, the Environment and Water (DCCEEW). The EPBC Act is designed to protect national environmental assets, known as Matters of National Environmental Significance (MNES). Under the 2013 amendment to the EPBC Act, potentially significant impacts on groundwater resources were included where they pertain to a coal seam gas (CSG) or large coal mine development, known as the 'water trigger'.

The Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) is a statutory committee established under the EPBC Act that provides scientific advice to the Commonwealth Environment Minister and relevant State ministers. Guidelines have been developed in order to assist the IESC in reviewing CSG or large coal mining development proposals that are likely to have significant impacts on water resources. This includes completion of an independent peer review of numerical groundwater modelling in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al., 2012). The IESC information requirements checklist is presented in **Table 2-1**, with details on where aspects have been addressed and documented within the report.

Table 2-1 IESC Information Requirements Checklist

Assessment Item - Description of Proposal	
Context and Conceptualisation	**Section in Report**
Provide a regional overview of the proposed project area including a description of the geological basin; coal resource; surface water catchments; groundwater systems; water-dependent assets; and past, present and reasonably foreseeable coal mining and CSG developments.	Section 3, Section 4 and Section 5
Describe the proposal's location, purpose, scale, duration, disturbance area, and the means by which it is likely to have a significant impact on water resources and water-dependent assets.	Section 1 and Section 7
Describe the statutory context, including information on the proposal's status within the regulatory assessment process and any applicable water management policies or regulations	Section 2
Describe how impacted water resources are currently being regulated under state or Commonwealth law, including whether there are any applicable standard conditions.	Section 2
Assessment Item – Risk Assessment	**Section in Report**
Identify and assess all potential environmental risks to water resources and water-related assets, and their possible impacts. In selecting a risk assessment approach consideration should be given to the complexity of the project, and the probability and potential consequences of risks.	Section 7
Incorporate causal mechanisms and pathways identified in the risk assessment in conceptual and numerical modelling. Use the results of these models to update the risk assessment.	Section 5.6, 5.7 and Section 6
Assess risks following the implementation of any proposed mitigation and management options to determine if these will reduce risks to an acceptable level based on the identified environmental objectives.	Section 8
The risk assessment should include an assessment of: • all potential cumulative impacts which could affect water resources and water-related assets, and mitigation and • management options which the proponent could implement to reduce these impacts.	Section 7 and Section 8
Assessment Item – Groundwater	
Context and Conceptualisation	**Section in Report**
Describe and map geology at an appropriate level of horizontal and vertical resolution including: • Definition of the geological sequence(s) in the area, with names and descriptions of the formations and accompanying surface geology, cross-sections and any relevant field data. • Geological maps appropriately annotated with symbols that denote fault type, throw and the parts of sequences the faults intersect or displace.	Section 4
Provide data to demonstrate the varying depths to the hydrogeological units and associated standing water levels or potentiometric heads, including direction of groundwater flow, contour maps, and hydrographs. All boreholes used to provide this data should have been surveyed.	Section 4 and Section 5.3

Assessment Item - Description of Proposal	
Define and describe or characterise significant geological structures (e.g. faults, folds, intrusives) and associated fracturing in the area and their influence on groundwater – particularly groundwater flow, discharge or recharge. Site-specific studies (e.g. geophysical, coring/ wireline logging etc.) should give consideration to characterising and detailing the local stress regime and fault structure (e.g. damage zone size, open/closed along fault plane, presence of clay/shale smear, fault jogs or splays). Discussion on how this fits into the fault's potential influence on regional-scale groundwater conditions should also be included.	Section 5.2
Provide hydrochemical (e.g. acidity/alkalinity, electrical conductivity, metals, and major ions) and environmental tracer (e.g. stable isotopes of water, tritium, helium, strontium isotopes, etc.) characterisation to identify sources of water, recharge rates, transit times in aquifers, connectivity between geological units and groundwater discharge locations.	Section 5.4
Provide site-specific values for hydraulic parameters (e.g. vertical and horizontal hydraulic conductivity and specific yield or specific storage characteristics including the data from which these parameters were derived) for each relevant hydrogeological unit. In situ observations of these parameters should be sufficient to characterise the heterogeneity of these properties for modelling.	Section 5.2
Describe the likely recharge, discharge and flow pathways for all hydrogeological units likely to be impacted by the proposed development.	Section 5.3
Provide time series level and water quality data representative of seasonal and climatic cycles.	Section 5.3 and Section 5.4
Assess the frequency (and time lags if any), location, volume and direction of interactions between water resources, including surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water.	Section 5.3.7 and Section 5.6
Analytical and Numerical Modelling	**Section in Report**
Provide a detailed description of all analytical and/or numerical models used, and any methods and evidence (e.g. expert opinion, analogue sites) employed in addition to modelling.	Appendix B
Provide an explanation of the model conceptualisation of the hydrogeological system or systems, including multiple conceptual models if appropriate. Key assumptions and model limitations and any consequences should also be described.	Section 5.6
Undertake groundwater modelling in accordance with *the Australian Groundwater Modelling Guidelines* (Barnett et al. 2012), including independent peer review.	Section 6 and Appendix B
Consider a variety of boundary conditions across the model domain, including constant head or general head boundaries, river cells and drains, to enable a comparison of groundwater model outputs to seasonal field observations.	Appendix B
Calibrate models with adequate monitoring data, ideally with calibration targets related to model prediction (e.g. use baseflow calibration targets where predicting changes to baseflow).	Appendix B

Assessment Item - Description of Proposal	
Undertake sensitivity analysis and uncertainty analysis of boundary conditions and hydraulic and storage parameters, and justify the conditions applied in the final groundwater model (see Middlemis and Peeters 2018).	Appendix B
Describe each hydrogeological unit as incorporated in the groundwater model, including the thickness, storage and hydraulic characteristics, and linkages between units, if any.	Appendix B
Provide an assessment of the quality of, and risks and uncertainty inherent in, the data used to establish baseline conditions and in modelling, particularly with respect to predicted potential impact scenarios.	Appendix B
Describe the existing recharge/discharge pathways of the units and the changes that are predicted to occur upon commencement, throughout, and after completion of the proposed project.	Section 5.3 and Section 6.4.4
Undertake an uncertainty analysis of model construction, data, conceptualisation and predictions (see Middlemis and Peeters 2018).	Appendix B
Describe the various stages of the proposed project (construction, operation and rehabilitation) and their incorporation into the groundwater model. Provide predictions of water level and/or pressure declines and recovery in each hydrogeological unit for the life of the project and beyond, including surface contour maps for all hydrogeological units.	Section 6 and Appendix B
Provide a program for review and update of models as more data and information become available, including reporting requirements.	Appendix B
Identify the volumes of water predicted to be taken annually with an indication of the proportion supplied from each hydrogeological unit.	Section 6.4.1 and Appendix B
Provide information on the magnitude and time for maximum drawdown and post-development drawdown equilibrium to be reached.	Section 6 and Appendix B
Undertake model verification with past and/or existing site monitoring data.	Appendix B
Impacts to Water Resources and Water-Dependent Assets	**Section in Report**
Provide an assessment of the potential impacts of the proposal, including how impacts are predicted to change over time and any residual long-term impacts. Consider and describe: • any hydrogeological units that will be directly or indirectly dewatered or depressurised, including the extent of impact on hydrological interactions between water resources, surface water/groundwater connectivity, inter-aquifer connectivity and connectivity with sea water. • the effects of dewatering and depressurisation (including lateral effects) on water resources, water-dependent assets, groundwater, flow direction and surface topography, including resultant impacts on the groundwater balance. • the potential impacts on hydraulic and storage properties of hydrogeological units, including changes in storage, potential for physical transmission of water within and between units, and estimates of likelihood of leakage of contaminants through hydrogeological units. • the possible fracturing of and other damage to confining layers.	Section 5.5 and Section 7

Assessment Item - Description of Proposal	
For each relevant hydrogeological unit, the proportional increase in groundwater use and impacts as a consequence of the proposed project, including an assessment of any consequential increase in demand for groundwater from towns or other industries resulting from associated population or economic growth due to the proposal.	
Describe the water resources and water-dependent assets that will be directly impacted by mining or CSG operations, including hydrogeological units that will be exposed/partially removed by open cut mining and/or underground mining.	Section 5.5
For each potentially impacted water resource, provide a clear description of the impact to the resource, the resultant impact to any water-dependent assets dependent on the resource, and the consequence or significance of the impact.	Section 7
Describe existing water quality guidelines, environmental flow objectives and other requirements (e.g. water planning rules) for the groundwater basin(s) within which the development proposal is based.	Section 2 and Section 5.4
Provide an assessment of the cumulative impact of the proposal on groundwater when all developments (past, present and/or reasonably foreseeable) are considered in combination.	Section 6.4.2.2
Describe proposed mitigation and management actions for each significant impact identified, including any proposed mitigation or offset measures for long-term impacts post mining.	Section 8
Describe the water resources and water-dependent assets that will be directly impacted by mining or CSG operations, including hydrogeological units that will be exposed/partially removed by open cut mining and/or underground mining.	Section 8
Data and Monitoring	**Section in Report**
Provide sufficient data on physical aquifer parameters and hydrogeochemistry to establish pre-development conditions, including fluctuations in groundwater levels at time intervals relevant to aquifer processes.	Section 5.2 and Section 5.3
Provide long-term groundwater monitoring data, including a comprehensive assessment of all relevant chemical parameters to inform changes in groundwater quality and detect potential contamination events.	Section 5.4
Develop and describe a robust groundwater monitoring program using dedicated groundwater monitoring wells – including nested arrays where there may be connectivity between hydrogeological units – and targeting specific aquifers, providing an understanding of the groundwater regime, recharge and discharge processes and identifying changes over time.	Section 5.1
Ensure water quality monitoring complies with relevant National Water Quality Management Strategy (NWQMS) guidelines (ANZG 2018) and relevant legislated state protocols (e.g. QLD Government 2013).	Section 8.3.1
Develop and describe proposed targeted field programs to address key areas of uncertainty, such as the hydraulic connectivity between geological formations, the sources of groundwater sustaining GDEs, the hydraulic properties of significant faults, fracture networks and aquitards in the impacted system, etc., where appropriate.	No studies proposed.

Assessment Item - Description of Proposal	
Assessment Item – Water-dependent assets	
Context and conceptualisation	**Section in Report**
Identify water-dependent assets, including: • water-dependent fauna and flora and provide surveys of habitat, flora and fauna (including stygofauna) (see Doody et al. 2019). • public health, recreation, amenity, Indigenous, tourism or agricultural values for each water resource.	Section 5.5, Section 5.6 and Section 5.7 BWM North Extension Project - MNES report (EMM, 2023) Aquatic Ecology Impact Assessment (ESP, 2023)
Estimate the ecological water requirements of identified GDEs and other water-dependent assets (see Doody et al. 2019).	Section 5.7 BWM North Extension Project - MNES report (EMM, 2023) Aquatic Ecology Impact Assessment (ESP, 2023)
Identify the hydrogeological units on which any identified GDEs are dependent (see Doody et al. 2019).	Section 5.6.1 and 5.7 BWM North Extension Project - MNES report (EMM, 2023)
Identify GDEs in accordance with the method outlined by Eamus et al. (2006). Information from the GDE Toolbox (Richardson et al. 2011) and GDE Atlas (CoA 2017a) may assist in identification of GDEs (see Doody et al. 2019).	Sections 5.5.1, 5.6 and 5.7 BWM North Extension Project - MNES report (EMM, 2023)
Provide an outline of the water-dependent assets and associated environmental objectives and the modelling approach to assess impacts to the assets.	Section 6 and Section 7
Describe the conceptualisation and rationale for likely water-dependence, impact pathways, tolerance and resilience of water-dependent assets. Examples of ecological conceptual models can be found in Commonwealth of Australia (2015).	Section 5.7
Describe the process employed to determine water quality and quantity triggers and impact thresholds for water-dependent assets (e.g. threshold at which a significant impact on an asset may occur).	Section 7
Impacts, risk assessment and management of risks	**Section in Report**
Provide an assessment of direct and indirect impacts on water-dependent assets, including ecological assets such as flora and fauna dependent on surface water and groundwater, springs and other GDEs (see Doody et al. 2019).	EMM, 2023
Provide estimates of the volume, beneficial uses and impact of operational discharges of water (particularly saline water), including potential emergency discharges due to unusual events, on water-dependent assets and ecological processes.	Section 7.3
Describe the potential range of drawdown at each affected bore, and clearly articulate of the scale of impacts to other water users.	Section 7.2.1
Assess the overall level of risk to water-dependent assets through combining probability of occurrence with severity of impact.	Section 7

Assessment Item - Description of Proposal	
Indicate the vulnerability to contamination (e.g. from salt production and salinity) and the likely impacts of contamination on the identified water-dependent assets and ecological processes.	Section 7.4
Identify the proposed acceptable level of impact for each water-dependent asset based on leading-practice science and site-specific data, and ideally developed in conjunction with stakeholders.	Section 7.2
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion and habitat fragmentation of water-dependent species and communities.	Section 8
Propose mitigation actions for each identified impact, including a description of the adequacy of the proposed measures and how these will be assessed.	Section 8
Data and Monitoring	**Section in Report**
Identify an appropriate sampling frequency and spatial coverage of monitoring sites to establish pre-development (baseline) conditions, and test potential responses to impacts of the proposal (see Doody et al. 2019).	Section 8.2
Develop and describe a monitoring program that identifies impacts, evaluates the effectiveness of impact prevention or mitigation strategies, measures trends in ecological responses and detects whether ecological responses are within identified thresholds of acceptable change (see Doody et al. 2019).	BWM North Extension Project - MNES report (EMM, 2023)
Consider concurrent baseline monitoring from unimpacted control and reference sites to distinguish impacts from background variation in the region (e.g. BACI design, see Doody et al. 2019).	Section 8.2
Describe the proposed process for regular reporting, review and revisions to the monitoring program.	Section 8.3.3
Ensure ecological monitoring complies with relevant state or national monitoring guidelines (e.g. the DSITI guideline for sampling stygofauna (QLD Government 2015)).	BWM North Extension Project - Aquatic Ecology Impact Assessment (ESP, 2023)
Assessment Item – Water and salt balance, and water quality	**Section in Report**
Provide a quantitative site water balance model describing the total water supply and demand under a range of rainfall conditions and allocation of water for mining activities (e.g. dust suppression, coal washing etc.), including all sources and uses.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)
Provide estimates of the quality and quantity of operational discharges under dry, median and wet conditions, potential emergency discharges due to unusual events and the likely impacts on water-dependent assets.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)
Describe the water requirements and on-site water management infrastructure, including modelling to demonstrate adequacy under a range of potential climatic conditions.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)
Provide salt balance modelling that includes stores and the movement of salt between stores, and takes into account seasonal and long-term variation.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)

Assessment Item - Description of Proposal	
Assessment Item – Cumulative Impacts	
Context and conceptualisation	**Section in Report**
Provide cumulative impact analysis with sufficient geographic and temporal boundaries to include all potentially significant water-related impacts.	Section 6
Consider all past, present and reasonably foreseeable actions, including development proposals, programs and policies that are likely to impact on the water resources of concern in the cumulative impact analysis. Where a proposed project is located within the area of a bioregional assessment consider the results of the bioregional assessment.	Section 3.3.2 and Appendix B
Impacts	**Section in Report**
Provide an assessment of the condition of affected water resources which includes: • identification of all water resources likely to be cumulatively impacted by the proposed development • a description of the current condition and quality of water resources and information on condition trends • identification of ecological characteristics, processes, conditions, trends and values of water resources • adequate water and salt balances, and • identification of potential thresholds for each water resource and its likely response to change and capacity to withstand adverse impacts (e.g. altered water quality, drawdown).	Section 5.3, Section 5.4 and Section 7
Assess the cumulative impacts to water resources considering: • the full extent of potential impacts from the proposed project, (including whether there are alternative options for infrastructure and mine configurations which could reduce impacts), and encompassing all linkages, including both direct and indirect links, operating upstream, downstream, vertically and laterally • all stages of the development, including exploration, operations and post closure/decommissioning • appropriately robust, repeatable and transparent methods • the likely spatial magnitude and timeframe over which impacts will occur, and significance of cumulative impacts, and • opportunities to work with other water users to avoid, minimise or mitigate potential cumulative impacts.	Section 7
Mitigation, monitoring and management	**Section in Report**
Identify and consider landscape modifications (e.g. voids, on-site earthworks, and roadway and pipeline networks) and their potential effects on surface water flow, erosion, sedimentation and habitat fragmentation of water-dependent species and communities.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)
Assess the adequacy of modelling, including surface water and groundwater quantity and quality, lake behaviour, timeframes and calibration.	Appendix B
Provide an evaluation of stability of void slopes where failure during extreme events or over the long term (for example due to aquifer	BWM North Extension Project – Land Resources Assessment (SLR, 2023a)

Assessment Item - Description of Proposal	
recovery causing geological heave and landform failure) may have implications for water quality.	
Provide an assessment of the long-term impacts to water resources and water-dependent assets posed by various options for the final landform design, including complete or partial backfilling of mining voids. Assessment of the final landform for which approval is being sought should consider: • groundwater behaviour – sink or lateral flow from void. • water level recovery – rate, depth, and stabilisation point (e.g. timeframe and level in relation to existing groundwater level, surface elevation). • seepage – geochemistry and potential impacts. • long-term water quality, including salinity, pH, metals and toxicity. • measures to prevent migration of void water off-site. For other final landform options considered sufficient detail of potential impacts should be provided to clearly justify the proposed option.	Section 6.6.4 and Section 7.4.2
Evaluate mitigating inflows of saline groundwater by planning for partial backfilling of final voids.	BWM North Extension Project - Surface Water Resources Assessment (SLR, 2023)
Assess the probability of overtopping of final voids with variable extremes, and management mitigations.	Section 6.4.4
Assessment Item – Acid-forming materials and other contaminants of concern	**Section in Report**
Identify the presence and potential exposure of acid-sulphate soils (including oxidation from groundwater drawdown).	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)
Describe handling and storage plans for acid-forming material (co-disposal, tailings dam, and encapsulation).	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)
Identify the presence and volume of potentially acid-forming waste rock, fine-grained amorphous sulphide minerals and coal reject/tailings material and exposure pathways.	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)
Assess the potential impact to water-dependent assets, taking into account dilution factors, and including solute transport modelling where relevant, representative and statistically valid sampling, and appropriate analytical techniques.	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)
Identify other sources of contaminants, such as high metal concentrations in groundwater, leachate generation potential and seepage paths.	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)
Describe proposed measures to prevent/minimise impacts on water resources, water users and water-dependent ecosystems and species.	BWM North Extension Project - Geochemistry Assessment (Terrenus, 2022)

2.1.2 Queensland Water Act 2000

The Water Act, supported by the subordinate *Water Regulation 2016*, is the primary legislation regulating groundwater resources in Queensland. The purpose of the Water Act is to advance sustainable management and efficient use of water resources by establishing a system for planning, allocation and use of water.

The statutory right of a tenure holder to take or interfere with underground water is granted as part of the Mining Lease approval under the *Mineral Resources Act 1989* (Qld) (MR Act), if the taking or interference with that water is necessarily and unavoidably obtained in the process of extracting the mineral resource. This water is termed 'associated water'. In developing the Project, BMA is proposing to exercise its underground water rights as part of planned mining activities. Chapter 3 of the Water Act then deals with the management of water related impacts resulting from such an exercise of underground water rights, including where the exercise of underground water rights had happened prior to the commencement of the Water Legislation Amendment Act 2016 per s1283 of the Water Act 2000 (Qld). As this occurred on ML1759 and ML1762 (per correspondence to DES on 3 March 2017), no additional water licence or Underground Water Impact Report (UWIR) is required to be prepared for the Project.

2.1.2.1 Management Framework Relevant to the Project

The Water Act is enacted under a framework of catchment specific Water Resource Plans (WRPs). A WRP provides a management framework for water resources in a plan area, and includes outcomes, objectives and strategies for maintaining balanced and sustainable water use in that area. Resource Operations Plans implement the outcomes and strategies of WRPs. Groundwater Management Areas (GMAs) and their component groundwater units are defined under WRPs. Authorisation is required to take non-associated groundwater from a regulated GMA or groundwater unit for specified purposes. The specified purposes are defined under a WRP, the Water Regulation 2016 or a local water management policy.

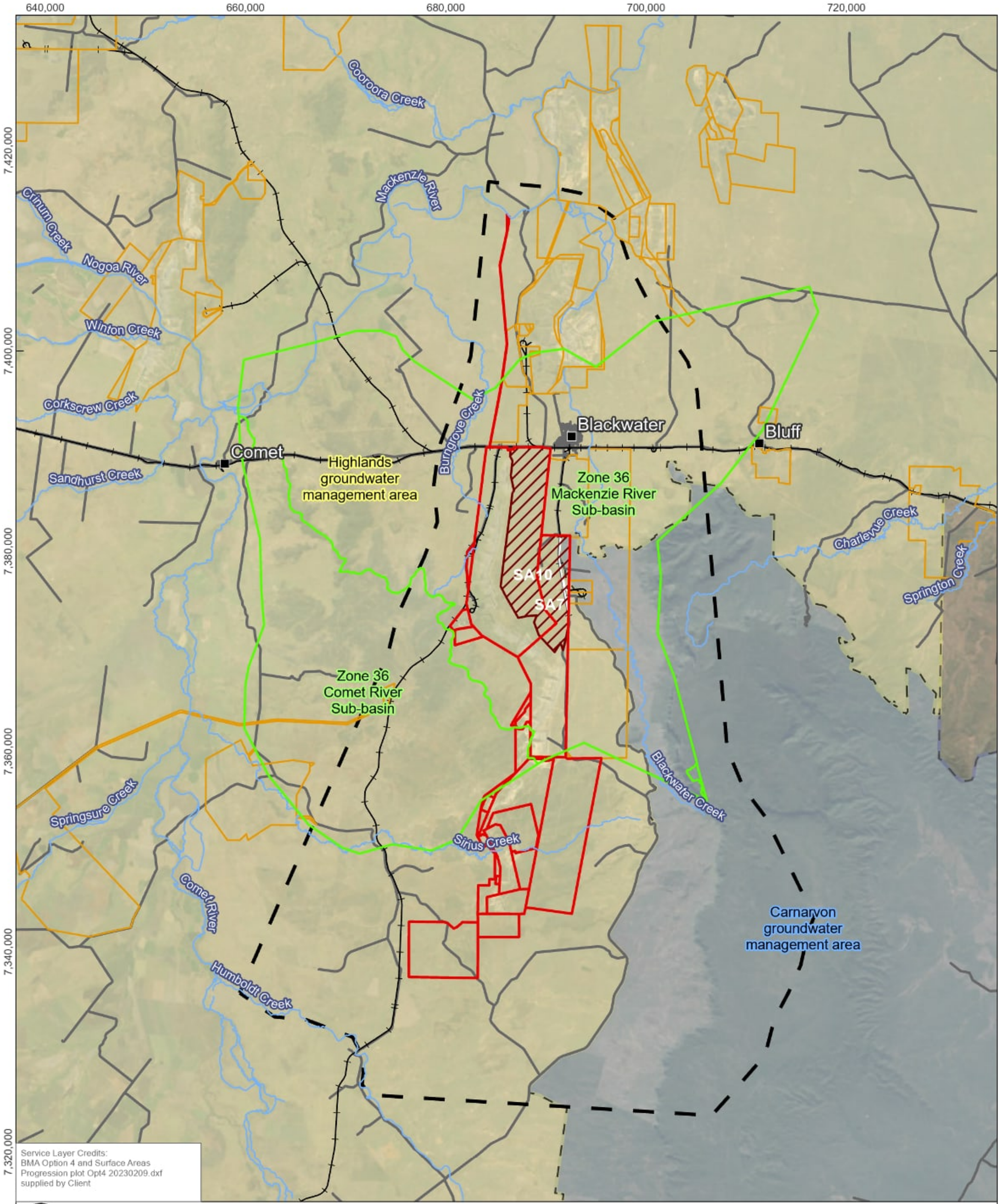
Surface water resources within the Project area fall within the Water Plan (Fitzroy Basin) 2011, Upper Mackenzie River.

As part of the Project, BMA is proposing to continue to exercise underground water rights during the period in which resource activities will be carried out within ML1759 and ML1762. The Project will affect groundwater within the Highlands GMA under the Water Plan (Fitzroy Basin) 2011, as shown on **Figure 2-1**. This relates to both Groundwater Unit 1 (containing aquifers of the Quaternary alluvium) and Groundwater Unit 2 (sub-artesian aquifers).

2.1.2.2 Water Act Declared Watercourses and Drainage

The Water Act includes criteria for determining watercourses that require authorisation under the Water Act to take water, interfere with the flow of water, take quarry material or excavate and place fill in a watercourse. The Water Act also includes criteria for drainage features that may require authorisation to take or interfere with overland flow. In the northern study area, Blackwater Creek, the lower part of Taurus Creek and Burngrove Creek are defined as a watercourse under the Water Act criteria, and several small tributaries of these watercourses that traverse the Project area are defined as drainage features.

These watercourses and drainage features may be relevant to the groundwater assessment for the Project if there is a component of surface water-groundwater interaction associated with them.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:500,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- Railway
- Road
- Watercourse
- Mining Lease
- Study Area
- EPP Water and Biodiversity, WQ1310 Zones
- Carnarvon Groundwater Management Area
- Highlands Groundwater Management Area
- BWM Mining Lease
- BWM North Extension Project Area

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

GROUNDWATER MANAGEMENT AREAS AND CHEMISTRY ZONES

FIGURE 2-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F02_1_GMA_Chem Zones

2.1.3 Environmental Protection (Water and Wetland Biodiversity) Policy 2019

The EPP Water and Wetland Biodiversity aims to achieve objectives set out by the EP Act, and is applicable to all Queensland waters. Environmental values (EVs) and water quality objectives (WQOs) are determined for Queensland waters, in alignment with the EPP Water and Wetland Biodiversity.

EPP Water and Wetland Biodiversity provides a framework to achieve the water and wetland objectives that are set out by the EP Act through:

- Identifying environmental values and management goals for Queensland waters.
- Providing state water quality guidelines and WQOs to enhance or protect the environmental values.
- Providing a framework for making consistent, equitable and informed decisions.
- Monitoring and reporting on the condition of Queensland waters.

Groundwater resources within the vicinity of the Project are scheduled under the EPP Water and Wetland Biodiversity as Schedule 1 Plan WQ1310 Groundwaters. The Project falls under groundwater chemistry Zone 36 of this Plan. The legislated EVs for these groundwaters are:

- Biological integrity of aquatic ecosystems.
- Human use EVs:
  - Suitability of water supply for irrigation.
  - Farm water supply/use.
  - Stock watering.
  - Drinking water supply.
  - Industrial use.
  - Cultural and spiritual values.

The EPP Water and Wetland Biodiversity also provides limited water quality objectives for underground aquatic ecosystem protection in Fitzroy Basin groundwaters. These WQOs provided in the EPP Water and Wetland Biodiversity are classified by groundwater depth and regional chemistry zone.

Surface water resources within the vicinity of the Project are scheduled under the EPP Water and Wetland Biodiversity as:

- Waters of the Mackenzie southern tributaries of the Upper Mackenzie Sub-basin (WQ1304).
- Waters of the Comet River eastern tributaries of the Comet River Sub-basin (WQ1307).

The legislated EVs for these surface waters are:

- Biological integrity of aquatic ecosystems.
- Human use EVs:
  - Suitability of water supply for irrigation (not for WQ1304).
  - Farm water supply/use.
  - Stock watering.
  - Human consumption.

- Primary recreation.
- Secondary recreation.
- Visual recreation.
- Drinking water supply.
- Industrial water supply.
- Cultural and spiritual values.

The surface water WQOs for the Waters of the Mackenzie southern tributaries of the Upper Mackenzie Sub-basin (WQ1304) may be relevant to the groundwater assessment for the Project if there is a component of surface water-groundwater interaction associated with them.

2.1.4 Environmental Authority

Under the EP Act, an environmental assessment is required as part of the application for an Environmental Authority (EA), or the application for an amendment to an existing EA, to undertake an environmentally relevant activity. The process assesses the potential environmental impacts of the Project, and how impacts should be avoided, minimised and managed. The Department of Environment and Science (DES) is responsible for the administration and delivery of applications for an EA, and amendment applications. The current operations are approved under EA EPML00717813.

2.2 Relevant Guidelines

There are several available guidelines designed to assist proponents to meet the relevant legislative requirements to complete a groundwater assessment for coal mining proposals such as the Project. These guidelines are:

- *Information guidelines for proponents preparing coal seam gas and large coal mining development proposals* – EPBC Act.
- *Information Guidelines Explanatory Note. Uncertainty analysis—Guidance for groundwater modelling within a risk management framework* – EPBC Act.
- *Information Guidelines Explanatory Note. Assessing groundwater-dependent ecosystems* – EPBC Act.
- *Australian Groundwater Modelling Guidelines.* Waterlines report. National Water Commission, Canberra, 2012.

3.0 Existing Conditions

3.1 Climate

The Central Highlands region of Queensland has a sub-humid, sub-tropical climate, with distinct wet and dry seasons. Historical climate data was obtained for the period from January 1970 to December 2022 from the Scientific Information for Landowners (SILO) database (Queensland Government, 2023) for the Project area (latitude -23.70, longitude 148.85). Data from the BWM weather station is limited to a short record of rainfall data. Therefore, the SILO climate record for the tile centred on -23.70, 148.85, which lies within the boundaries of the Project area, is used to understand long-term climate trends for the study area. Long-term average monthly rainfall, estimated actual evapotranspiration and potential evaporation is presented on **Figure 3-1**. The study area is characterised by a long-term average annual rainfall of approximately 549 mm, wetter conditions during the summer months of December, January and February (average rainfall of 83 mm, 87 mm and 77 mm respectively) and relatively dry conditions during the remainder of the year, with evaporation and evapotranspiration exceeding rainfall throughout the year. Furthermore, throughout the year, evaporation is approximately two to three times greater than rainfall (**Figure 3-1**). Within the study area, the highest rate of evapotranspiration occurs along creek lines, where the water table is closer to ground surface and deeper-rooted vegetation is present.

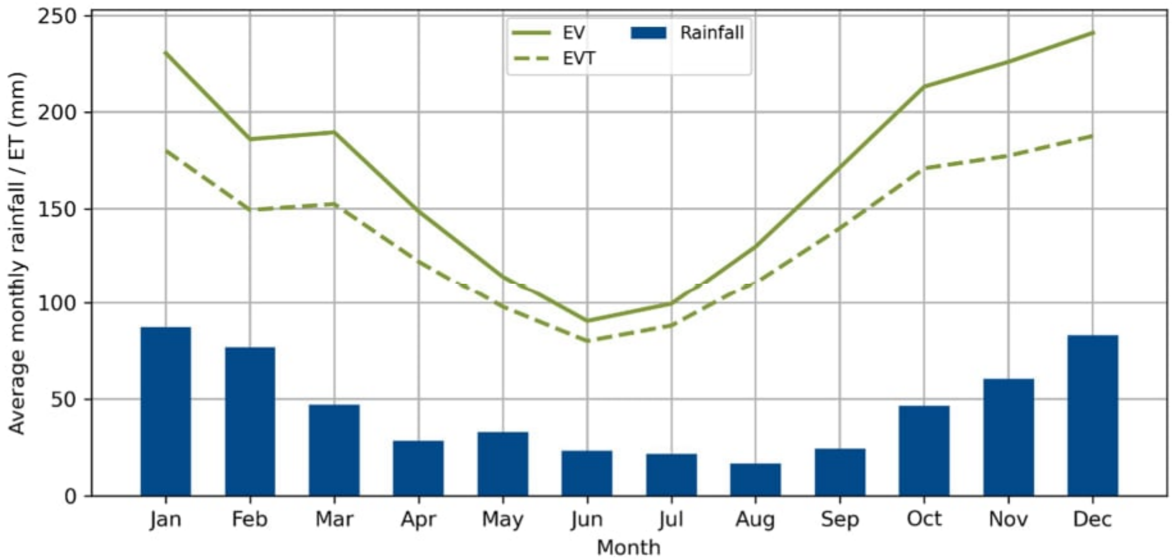


Figure 3-1 Average Monthly Rainfall, Evapotranspiration and Evaporation at SILO Location (1970-2022)

Figure 3-2 shows the long-term annual rainfall (January 1970 through December 2022), with wet years represented above the 80th percentile of annual rainfall and dry years represented below the 20th percentile of annual rainfall. Of the most recent five years, 2022 is considered to be a wet year while 2019 is characterised as a dry year.

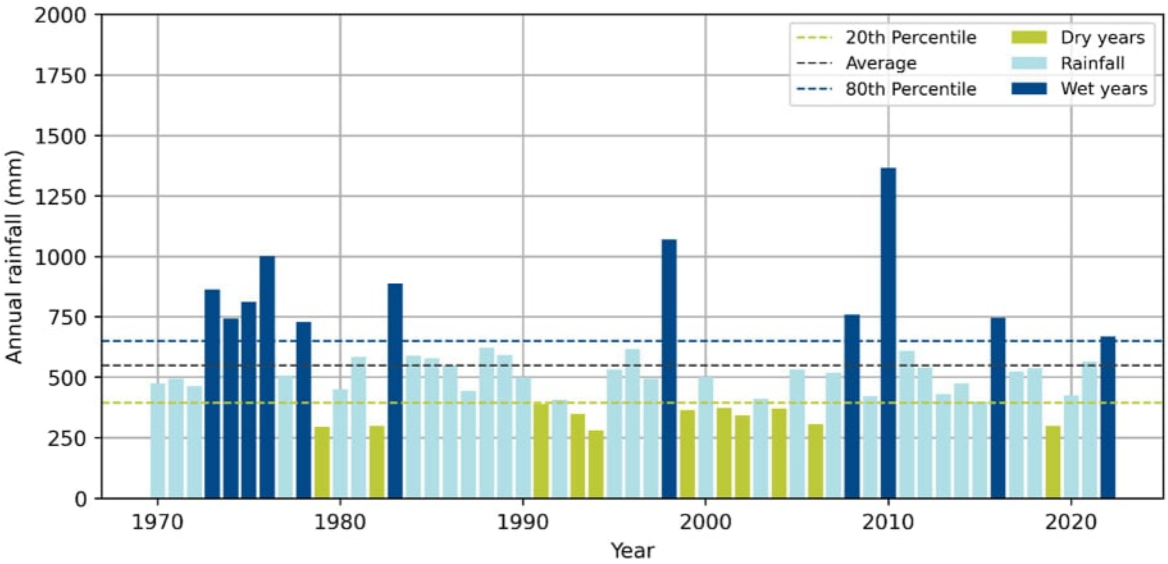


Figure 3-2 Long-term Annual Rainfall

To place recent rainfall years into a historical context and visualise long term rainfall trends, a cumulative rainfall departure (CRD) was calculated, as presented on **Figure 3-3.** A falling slope in the CRD indicates periods of rainfall below the long-term average, a rising slope in the CRD represents periods of rainfall above the long-term average, and a flattening in the CRD are periods average rainfall.

Figure 3-3 presents a truncated graph of the CRD and the monthly rainfall record (1970 – 2022) from the year 2000 onwards. Overall, as shown in **Figure 3-3**, below average rainfall conditions were observed from 2000 to 2008, 2013 to 2016, and 2018 to 2020 while a series of above average rainfall conditions were observed in late 2010 to early 2011 and in 2022.

In addition, CRD is used to assess the recharge of groundwater via rainfall. Where observed groundwater level trends mimic the pattern of the CRD curve, it is considered that natural fluctuations in the groundwater table can result from temporal changes in rainfall recharge to groundwater systems. Typically, changes in groundwater elevation can reflect the deviation between the long-term monthly (or yearly) average rainfall, and the actual rainfall, as illustrated by the CRD. The CRD and observed groundwater levels are discussed as a means to characterise climatic conditions within the assessment of groundwater levels (refer to **Section 5.2**).

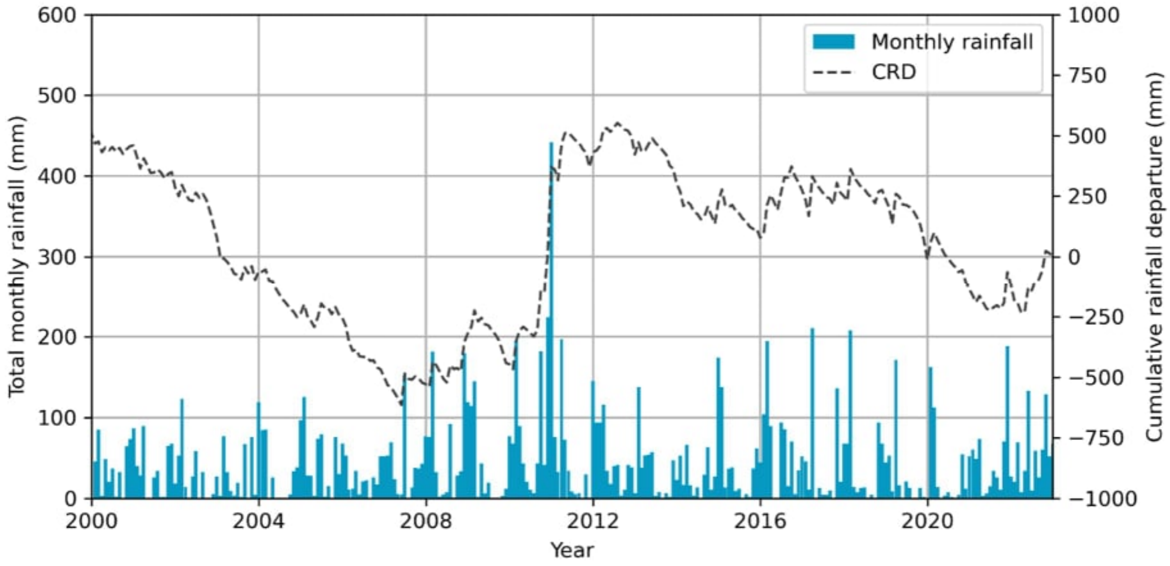


Figure 3-3 Monthly Rainfall and CRD

Rainfall data from the Site weather station is available for October 2017 to September 2018. A comparison between monthly rainfall, as recorded at the Site weather station, and monthly rainfall from the SILO climate record is presented on **Figure 3-4**. The two data sets generally correlate well over the overlapping period, which justifies using the SILO climate record data set for the CRD and the climate input for the Project groundwater modelling (**Section 6.0**).

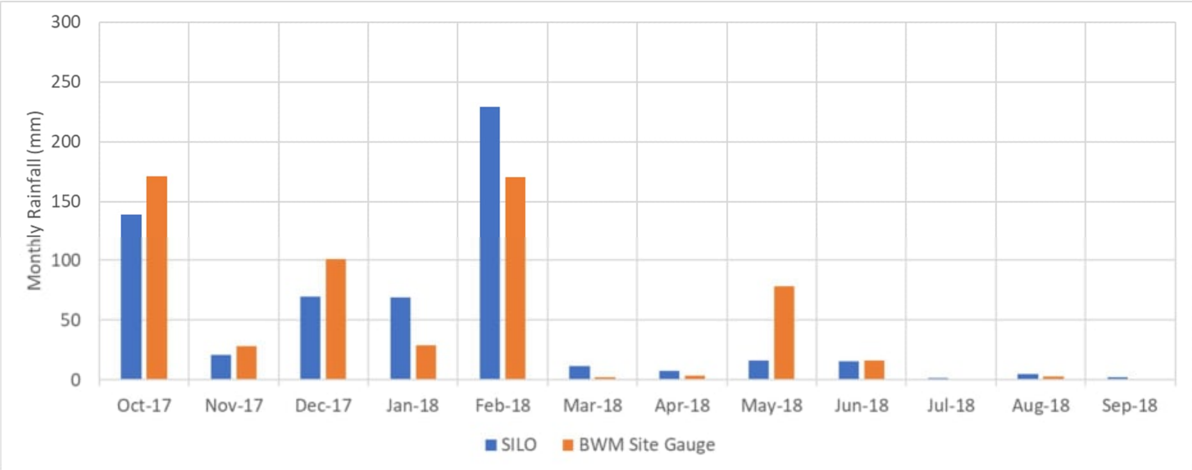


Figure 3-4 Monthly Rainfall at the BWM Site Station and SILO Data Location (2017-2018)

3.2 Topography and Drainage

The study area topography is relatively flat, with elevations of 280 mAHD in the south to around 150 mAHD in the north, at an average gradient of between 1:100 and 1:240. To the south of BWM, there are hills with elevations around 350 mAHD, which form the catchment divide between the Mackenzie and the Comet sub-catchments (**Figure 3-5**). Approximately 10 to 15 km to the east of BWM, toward the eastern boundary of the study area, there is an outcrop of the Clematis Group sandstone, which reaches an elevation up to 750 mAHD.

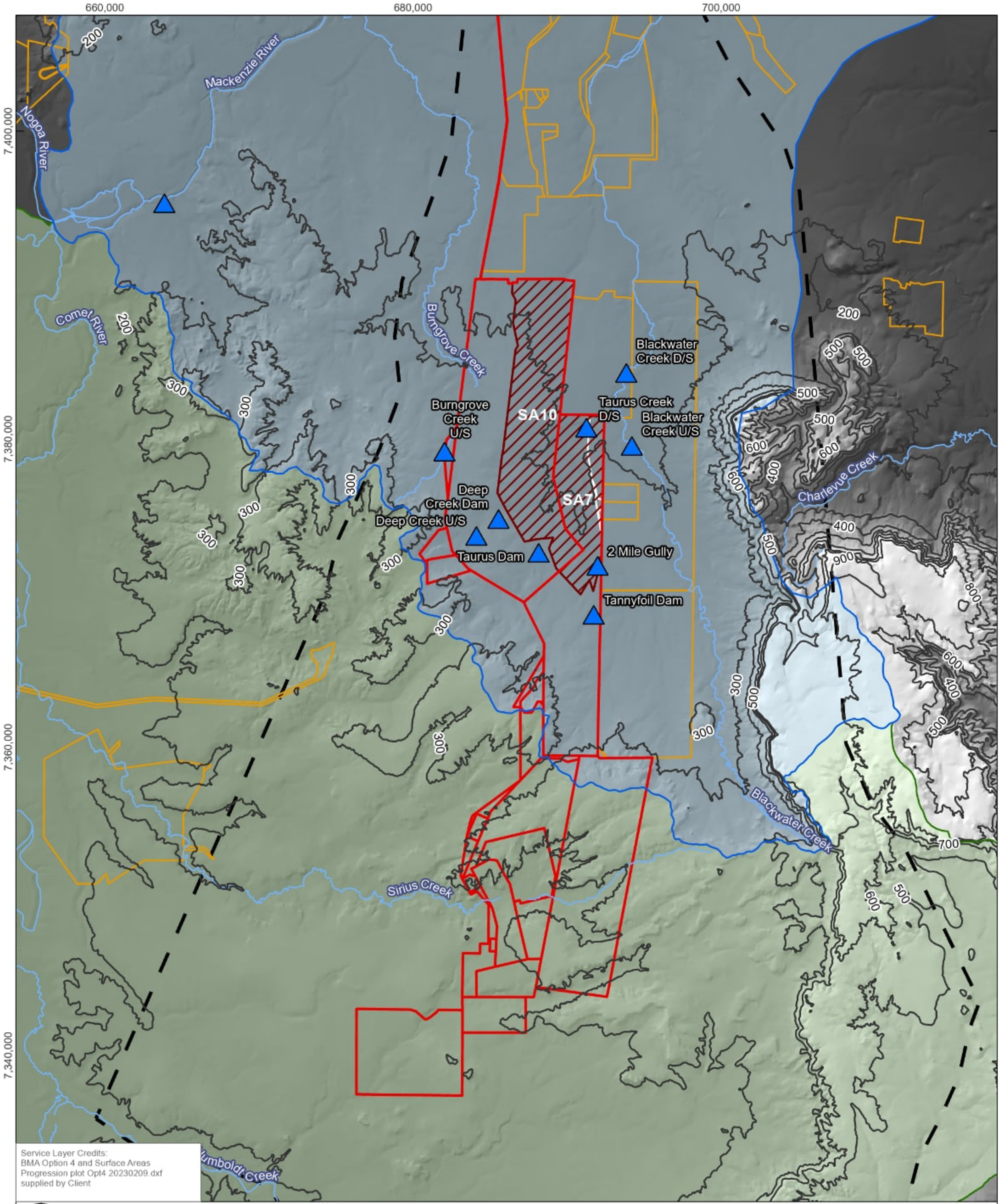
BWM is located across two surface sub-catchments of the Water Plan (Fitzroy Basin) 2011:

- The Upper Mackenzie sub-catchment, which is located within the northern portion of BWM.
- The Comet sub-catchment, which is located within the southern portion of BWM.

The surface drainage comprises several ephemeral creeks that are tributaries of the Mackenzie and Comet Rivers. Creeks that flow in the Upper Mackenzie sub-catchment drain from south to north towards the Mackenzie River, whilst creeks that flow in the Comet sub-catchment drain from north to south towards the Comet River. The study area is located in the Mackenzie sub-catchment and the most prominent drainage feature in the area is Blackwater Creek.

The ephemeral creeks have intermittent flow, and typically only contain water after high intensity rainfall events (AGE, 2003). **Figure 3-6** shows the average daily water level measurements in Blackwater Creek (Blackwater Creek D/S monitoring point as shown on **Figure 3-5**) compared to the daily rainfall (SILO climate record, refer to **Section 3.1**). After large rainfall events, generally considered to exceed approximately 30 mm/day, the creek records flow. The flows subsequently recede during drier periods. For a more detailed discussion on the drainage, refer to the Surface Water Assessment report (SLR, 2023).

Groundwater interaction with ephemeral creeks is considered unlikely within the study area for the alluvium and underlying Regolith. Groundwater and surface water interaction is discussed in more detail in **Section 5.6.2**.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:325,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Surface Water Monitoring Site
- Watercourse
- Topographic Contour (mAHD)
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Fitzroy Basin (2011) Water Plan Sub-catchment

- Comet
- Upper Mackenzie

Elevation (m)

925

28

SLR

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Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F03_5_Topography and Drainage

BLACKWATER MINE - NORTH EXTENSION PROJECT

TOPOGRAPHY, DRAINAGE AND WATER PLANS

FIGURE 3-5

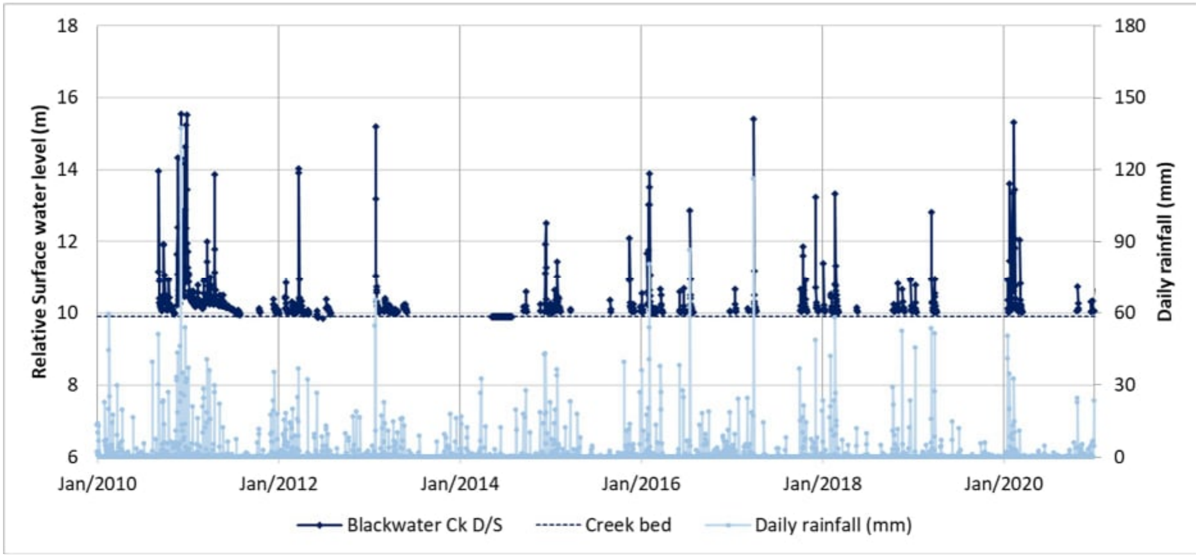


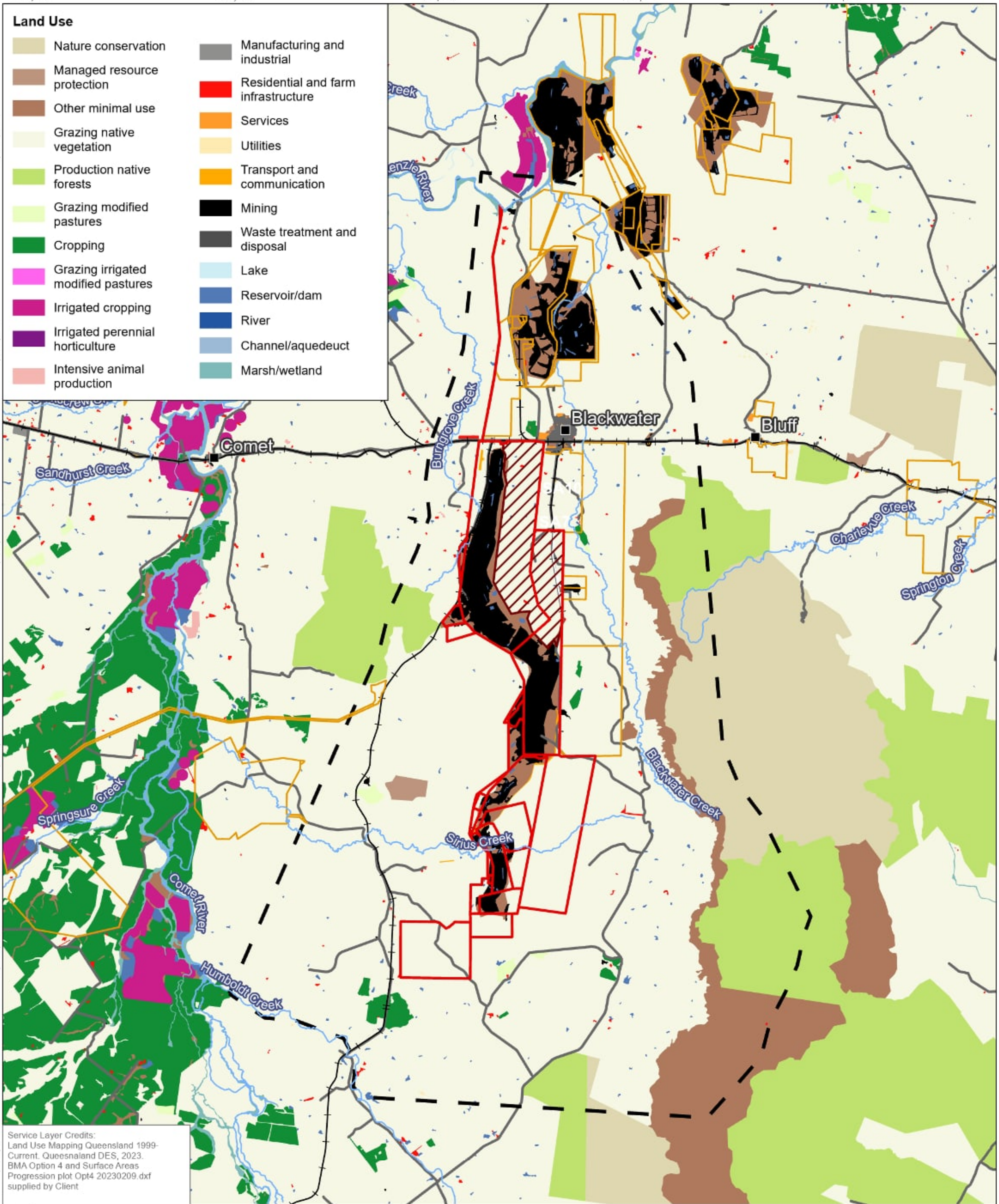
Figure 3-6 Average Daily Water Levels in Blackwater Creek D/S plotted against Daily Rainfall

3.3 Land Use

Land use in the study area (**Figure 3-7**) is predominately coal mining and coal seam gas (CSG) exploration, and agriculture in the form of cattle grazing. These land uses are discussed in the sections below.

3.3.1 Agriculture

The mapped land use in the study area and surrounds is shown on **Figure 3-7.** The predominant agricultural use is grazing, with a few scattered small cropping areas. No intense agricultural uses were mapped. Agricultural use within the Project area is predominantly “grazing native vegetation”.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:500,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Railway
- Road
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

SURROUNDING LAND USES

SLR

FIGURE 3-7

3.3.2 Mining

The Project lies within an existing mining precinct with several coal mines operating nearby. **Table 3-1** lists operating mines, advanced projects and mines in care and maintenance within 50 km of the study area. Operating mines and advanced projects which are located within 50 km from the Project are shown on in **Figure 3-8.** Mines that have been included in the cumulative impact assessment are discussed in more detail in **Section 3.3.2.1** to **3.3.2.3**.

3.3.2.1 Cook Colliery

The Cook Colliery adjoins the Project and is an underground mine owned by QCoal following its acquisition from Bounty Mining in 2020. The underground metallurgical mine had been in care and maintenance since December 2019 until its return to operational status in February 2022.

The mine is located to the east of BWM on ML1768, ML1769, ML1779, ML1799 and ML7357. Mining has been undertaken at Cook Colliery for more than 20 years from the Argo coal seams of the Rangal Coal Measures. The Argo average thickness is 4.5 m although is variable ranging from 0.5 m to 10 m due to faulting. The depth of the Argo Seam varies from 150–170 m in the western areas to 270–290 m depth in the seam split zone. Cook Colliery was placed under ‘care and maintenance’ following partial water inundation in March 2017 that flooded some sections of the underground workings. Following the flooding event, a change has been adopted and Cook Colliery now operates as a Bord and Pillar mine. Underground workings of the Cook Colliery are Bord and Pillar and occur within 500 m of open-cut BWM workings.

3.3.2.2 Minyango Mine

The Minyango Mine, owned by Constellation Mining, also adjoins the Project and is a proposed underground mine located on ML80173. The Minyango Project Approvals proposed to extract coal from the Aries and Pollux coal seams of the Rangal Coal Measures and is anticipated to have a peak production of 9 Mtpa of ROM coal and a mine life of approximately 25 years (AGE, 2013).

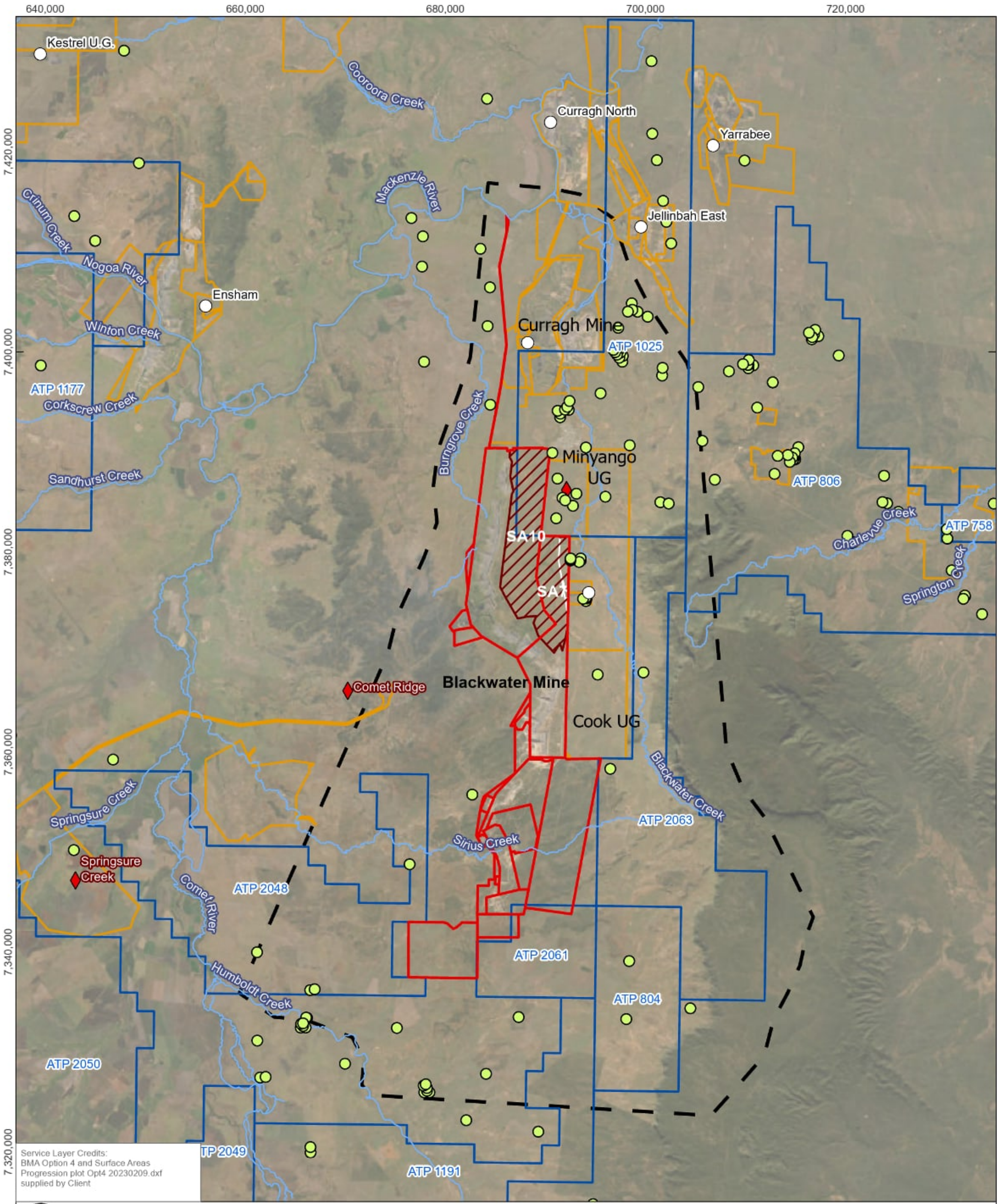
3.3.2.3 Curragh Mines

Coronado currently operates the Curragh coal mines, which are located adjacent to the Project and approximately 8 km north of Blackwater Township. The Curragh coal mine operation includes Curragh Mine, Curragh East Mine and Curragh North Mine. The mines began operations in 1983 and extract coal from the Aries, Pisces, Castor and Pollux coal seams of the Rangal Coal Measures.

Table 3-1 Current Mining Operations and Advanced Projects within 50 km of the Project

Mine	Status	Type	Planned Start	Planned End	Distance from Project (km)	Target Coal	Surface Water Catchment
Curragh, Curragh East*	Operating	Open cut	1983	2021	20	Rangal Coal Measures	Upper Mackenzie
Bluff	Operating	Open cut	2013	2031	30	Rangal Coal Measures	Lower Mackenzie
Jellinbah	Operating	Open cut	1989	Unknown	35	Rangal Coal Measures	Upper Mackenzie
Ensham	Operating	Open cut and Underground	1991	2028	40	Rangal Coal Measures	Nogoa
Yarrabee	Operating	Open cut	1994	Unknown	45	Rangal Coal Measures	Upper Mackenzie
Springsure Creek	Advanced Project	Underground	2012	Unknown	50	Rangal Coal Measures	Comet
Minyango*	Operating	Underground	2015	2040	Adjoining	Rangal Coal Measures	Upper Mackenzie
Comet Ridge	Advanced Project	Open cut	Unknown	Unknown	16	Rangal Coal Measures	Comet
Cook Colliery*	Operating	Underground	1973	2028	Adjoining	Rangal Coal Measures	Upper Mackenzie

Notes: * mine included in the cumulative impact assessment (calibration and/or prediction phase).



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:500,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Coal Mine
- Advanced Coal Project
- CSG Bore
- Watercourse
- Study Area
- BWM Mining Lease
- Mining Lease
- BWM North Extension Project Area
- Exploration Permits for Petroleum

BLACKWATER MINE - NORTH EXTENSION PROJECT

SURROUNDING MINES AND CSG PROJECTS

SLR

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FIGURE 3-8

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F03_8_Surrounding Mine

3.3.3 Petroleum

Currently, there are no active CSG fields within 30 km of the Project. **Table 5-1** lists the Authority to Prospect (ATP) within a 10 km buffer of ML1759 and ML1762. These APTs have the potential to be developed into CSG extraction leases in the future, however, given there are no licences or firm plans in place to extract gas, CSG activities were not included in this study's cumulative impact assessment. **Figure 3-8** shows the regional ATPs and CSG wells (exploration only). No CSG extraction or monitoring bores were identified within 20 km of the BWM mining lease area.

Table 3-2 Exploration Permits within 10 km of ML1759 and ML1762

Allocation Type	Permit Number	Purpose	Expiry Date	Holder
Authority to Prospect	ATP 1025	Petroleum	2033	BOW CSG PTY LTD
Authority to Prospect	ATP 2063	Petroleum	2027	COMET RIDGE MAHALO FAR EAST PTY LTD

4.0 Geology

The Project is located in the Bowen Basin, which is one of five major foreland sedimentary basins which were formed along the eastern side of Australia during the Permian geologic period. The Bowen Basin is the largest productive coal basin in Australia. The north-south oriented Bowen Basin stretches from Townsville in the north, to the Queensland-New South Wales border in the south.

The stratigraphic sequence of the study area is presented in **Table 4-1**. From youngest to oldest, the stratigraphic sequence across the study area comprises of unconsolidated Quaternary aged sediments unconformably overlying consolidated Permian and Triassic aged sequences (**Figure 4-1**). The Permian and Triassic strata form regular layered fluvio-deltaic sedimentary sequences, while the Quaternary sediments are more complex and irregular. The coal deposits extracted from BWM are found within the Rangal Coal Measures, which is the uppermost Permian unit (**Figure 4-2**). Tertiary aged basalts, in the form of remnant lava flows, are found to the south but are not present in the study area.

The Rangal Coal Measures at BWM outcrop in the west of the pits and dip down to the east of the pits. In the Project area, the strike is along the north-south direction. West of the pits is an anticline structure, which means that further west, the coal seams dip to the west (**Figure 4-2**).

The surface geology of the study area is dominated by the outcropping Permian Coal Measures to the west of BWM and the overlying Rewan Group in the east of the BWM (**Figure 4-1**). Overlying these basal units, Tertiary Sediments and Quaternary alluvium are present as cover. At the eastern extents of the study area, the Clematis Group outcrops with a dramatic change in topography associated with the comparatively weathering resistant sandstones of that geologic unit (refer to **Section 3.2**).

Figure 4-3 shows an east to west geological cross section through the Project area. For the location of the cross section refer to **Figure 4-2** (Cross Section A-A').

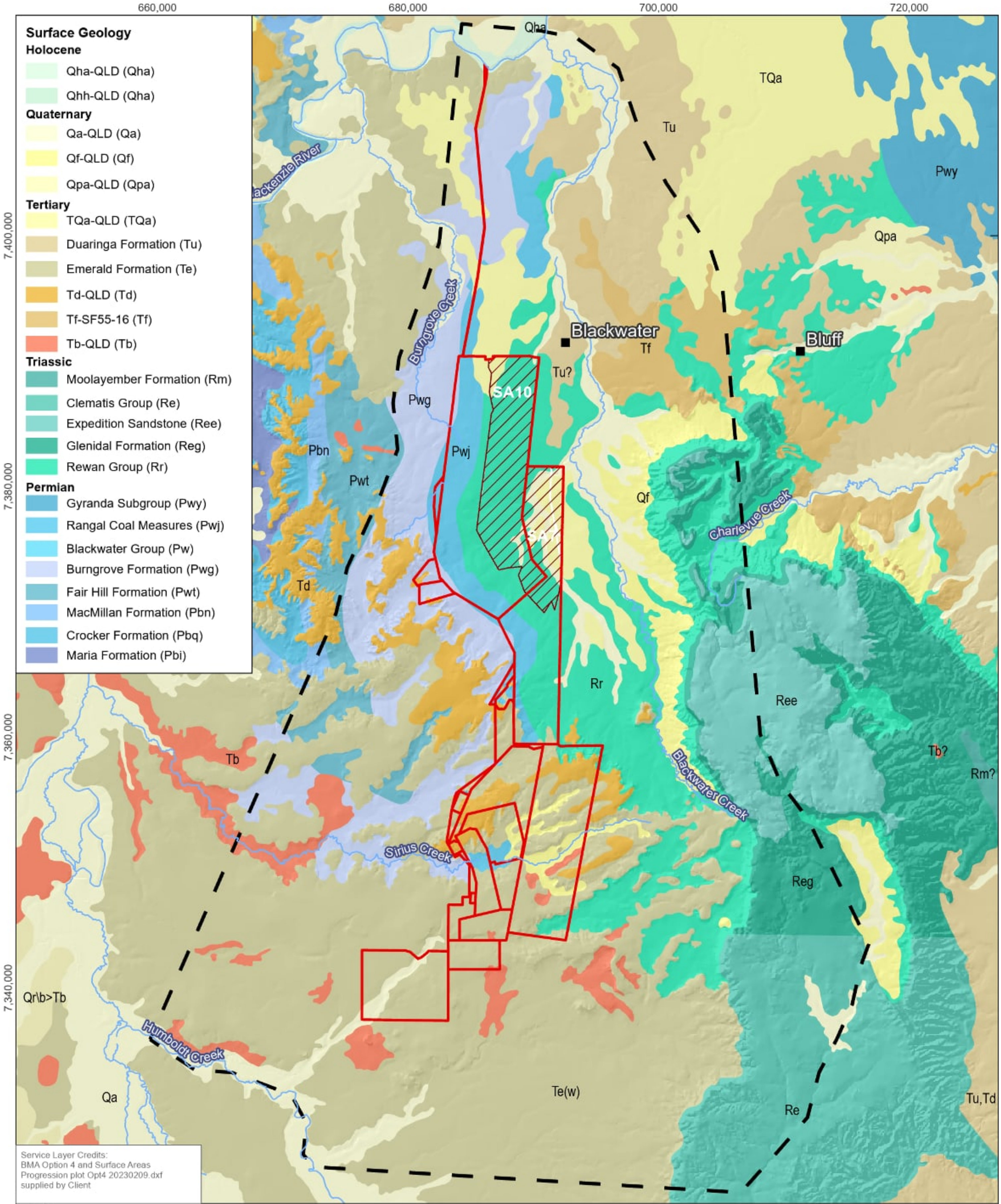
Each of the main stratigraphic units, relevant to the Project, is discussed in **Section 4.1** to **Section 4.5**, and details on the structural geology is provided in **Section 4.7**.

Table 4-1 Summary of Stratigraphy in the Study Area

Age	Unit	Thickness[1] (m)	Description
Quaternary	Alluvium	0.5–12	Alluvium - silt, clay, sand and gravel.
Tertiary	Basalt	30	Weathered basalt soils, residual basalt. Moderately weathered and fresh basalt. Does not outcrop.
	Sediments	30	Clays, sandstones, sands, gravels, often poorly consolidated (Tu, Te(w), Tf and TQa). Regional mapping shows highly weathered Tertiary Sediments display some areas of duricrust (Td) and partially cemented fanglomerate (Tf).
Triassic	Clematis Sandstone	100–800	Weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate.
	Rewan Group	50–300	Lithic sandstone, pebbly lithic sandstone, green to reddish brown mudstone and minor volcanilithic pebble conglomerate (at base); deposited in a fluvial-lacustrine environment. Occur 2 m to 6 m above the Aries seam.

Age	Unit	Thickness[1] (m)	Description
Permian	Rangal Coal Measures	100	Feldspathic and lithic sandstone, carbonaceous mudstone, siltstone, tuff and coal seams. Coal seams include the Aries, Castor, Pollux and Orion and Pisces seams. The Pollux and Orion seams commonly coalesce into a single seam, which is referred as the Argo seam.
	Burngrove Formation	170	Sandstones, siltstones and mudstones, and banded coal seams frequently interbedded with tuff and tuffaceous mudstones - coal seams include the Virgo and Leo seams.

Note: Source AGE (2008), AGE (2013) and EMM (2019).



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0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area

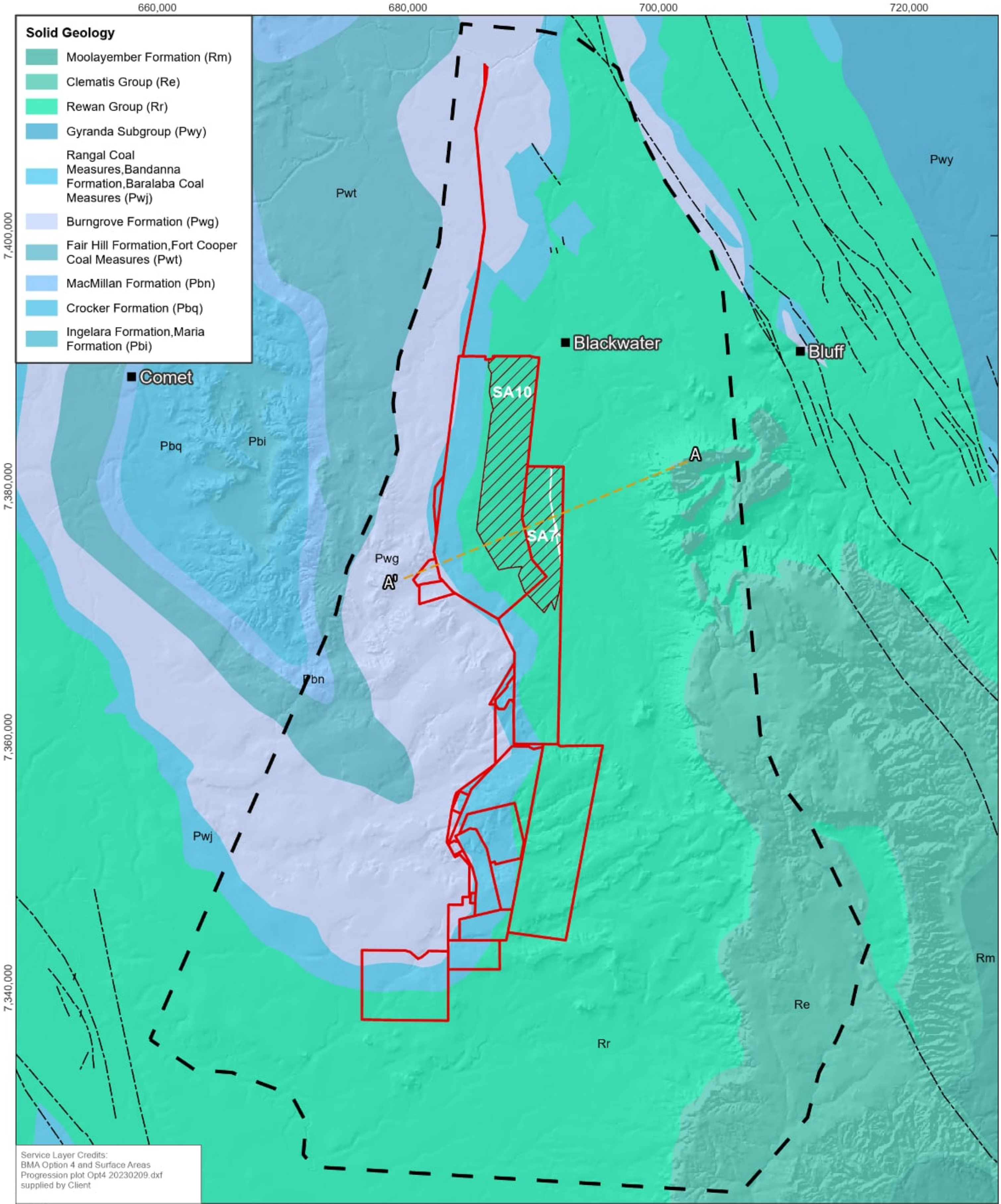
BLACKWATER MINE - NORTH EXTENSION PROJECT

SURFACE GEOLOGY

SLR

FIGURE 4-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F04_1_Surface Geology



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Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- East-West Cross Section
- Basin Scale Fault
- BWM Mining Lease
- BWM North Extension Project Area

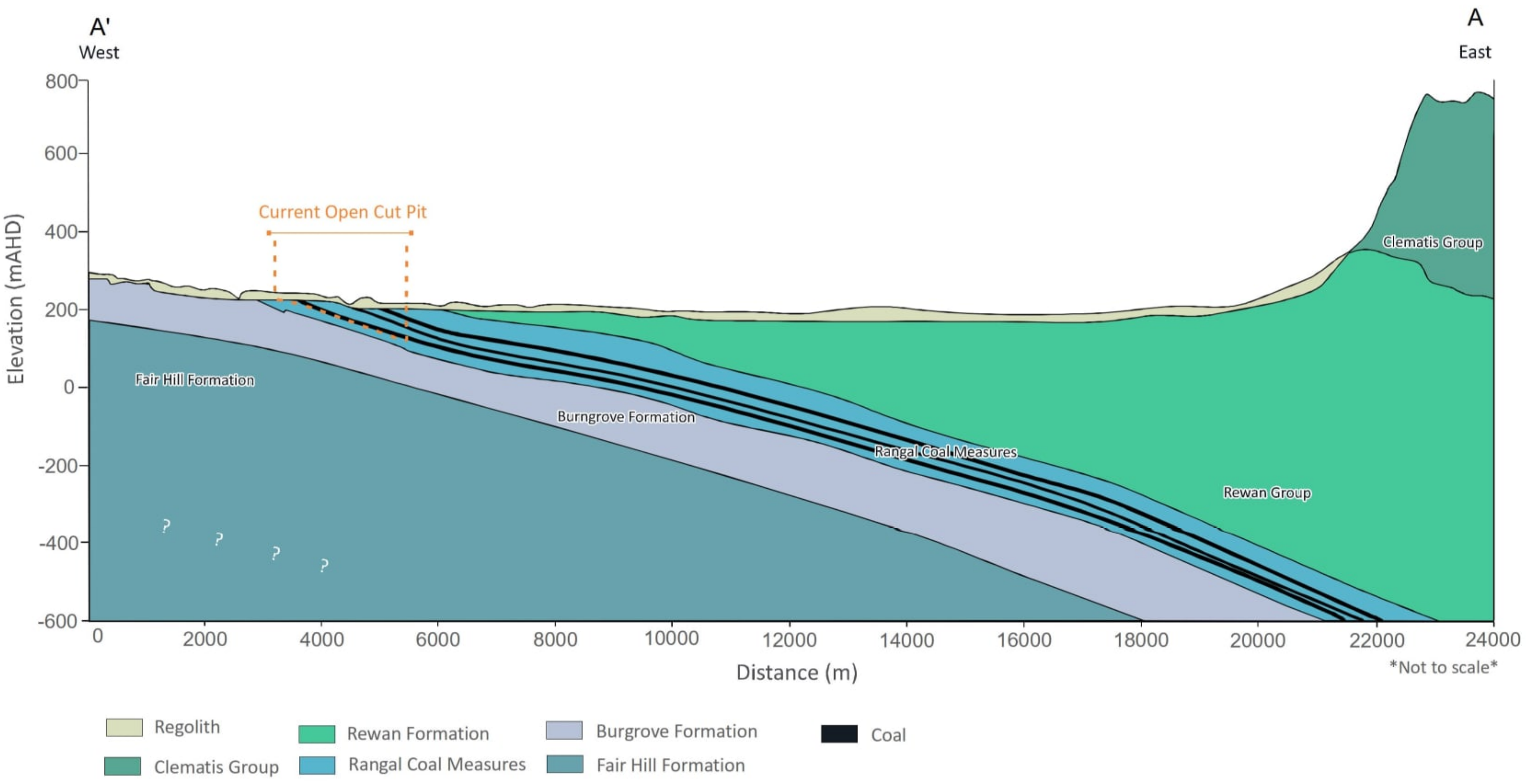
BLACKWATER MINE - NORTH EXTENSION PROJECT

SOLID GEOLOGY

SLR

FIGURE 4-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F04_2_Solid Geology



Date Drawn: 26-Nov-2023

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BLACKWATER MINE - NORTH EXTENSION PROJECT

GEOLOGICAL CROSS SECTION ACROSS THE STUDY AREA

FIGURE 4-3

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro.aprx\620014601_GW_F04_3_Geological Cross Section

4.1 Quaternary Sediments

The Quaternary age alluvial sediments unconformably overlie the Triassic age Rewan Group and Permian age coal measures. The unit consists of a thin surficial cover of generally unconsolidated clays, silts, sands and gravels associated with floodplains of the major drainage channels, primarily Blackwater creek. The alluvial sequence varies in thickness from 0.5 to 12 m according to drilling data.

Recent drilling at BWM has shown that alluvium associated with the creeks is not always present or the areal extent is limited. In 2020, four bores were attempted to be installed into the alluvium, however only one bore intersected alluvial sediments (AGE, 2020). In 2021 another bore targeted the alluvium, however upon drilling the alluvial sediments were not extensive at the site so the bore was installed into the Tertiary instead (HydroFS, 2021).

4.2 Tertiary Sediments and Basalt

Tertiary Sediments and basalts unconformably overlay the Triassic and Permian units. The sedimentary unit consists primarily of claystone, siltstone and sandstones. The unit varies in thickness, typically ranging from 5 to 50 m with a maximum thickness of 115 m. To the south and southwest of the study area, basalt flows are present (**Figure 4-1**). The basalts have been described as having varying degrees of weathering and thickness, from moderately weathered thin flows (intersected in the Humboldt area) to thicker and more fresh flows (South Marshmead area). The basalt flows vary in thickness ranging from 10 to 42 m (AGE, 2003). The basalt occurs in the study area (groundwater model domain), but not in the Project area.

4.3 Triassic Clematis Group

The Clematis Group unconformably overlies the Rewan Group and outcrops on the eastern margins of the study area (**Figure 4-3**), where it forms an elevated plateau. The unit is comprised of weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate. In the study area, the Clematis Group is made up of the Glenidal Formation and Expedition Sandstone members which are estimated to form an average thickness in the range of 100 to 800 m (Geoscience Australia, 2021).

4.4 Triassic Rewan Group

The Rewan Group overlies the Permian Coal Measures and occurs as in-fill material, thickening to the east with the dip of the coal measures and thin to the west where the coal measures occur at outcrop (**Figure 4-3**). Where present, the Rewan Group has a distinct greenish tint (non-marine deposits containing glauconite) in colour and is composed of siltstone and mudstone, with interbeds of lithic and volcanic sandstones.

Based on exploration drill holes and groundwater bore holes in the study area, the Rewan Group is comprised of siltstone and mudstone, with interbeds of lithic and volcanic sandstones and is of variable thickness ranging between 50 and 300 m.

4.5 Permian Rangal Coal Measures

The Rangal Coal Measures underlie the Rewan Group and outcrop to the west of the mine (**Figure 4-3**). This unit consists of interbedded sandstone, siltstone, mudstone, and coal with tuff (towards the base) and has a thickness of up to 100 m in the study area. The three main economic coal seams are the Aries, Castor and Pollux Seam. This naming convention applied regionally. For operational reasons, the coal seams follow a different naming convention at BWM: Aries Seam is referred to as the Top Seam, the Castor Seam is referred to as the Middle Seam and the Pollux Seam is referred to as the Lower Seam.

The splitting and occurrence of seams is shown in **Figure 4-4**. The principal coal seams in the BWM area in descending order are the Top Seam (also known as TFULL), Middle Seam (MFULL) and Middle split (MB), Lower Seam (LFULL) and Lower split (L01). Minor seams include the Upper Top (UT), Top Rider (TR), Middle Rider (MR) and Lower and Upper Rider (LUR) seams.

The Pollux and Orion seams create the thick Argo seam (CD) in the southern South Blackwater Mine area. To the north, the Orion and Pollux Seams coalesce into the Lower (LFULL) Seam. This seam splits into the lower split (L01) and the Middle seam (MFULL). Between the Deep Creek/Wilpeena and Blackwater pit areas the Middle Seam coalesces with the Aries and Castor Seams.

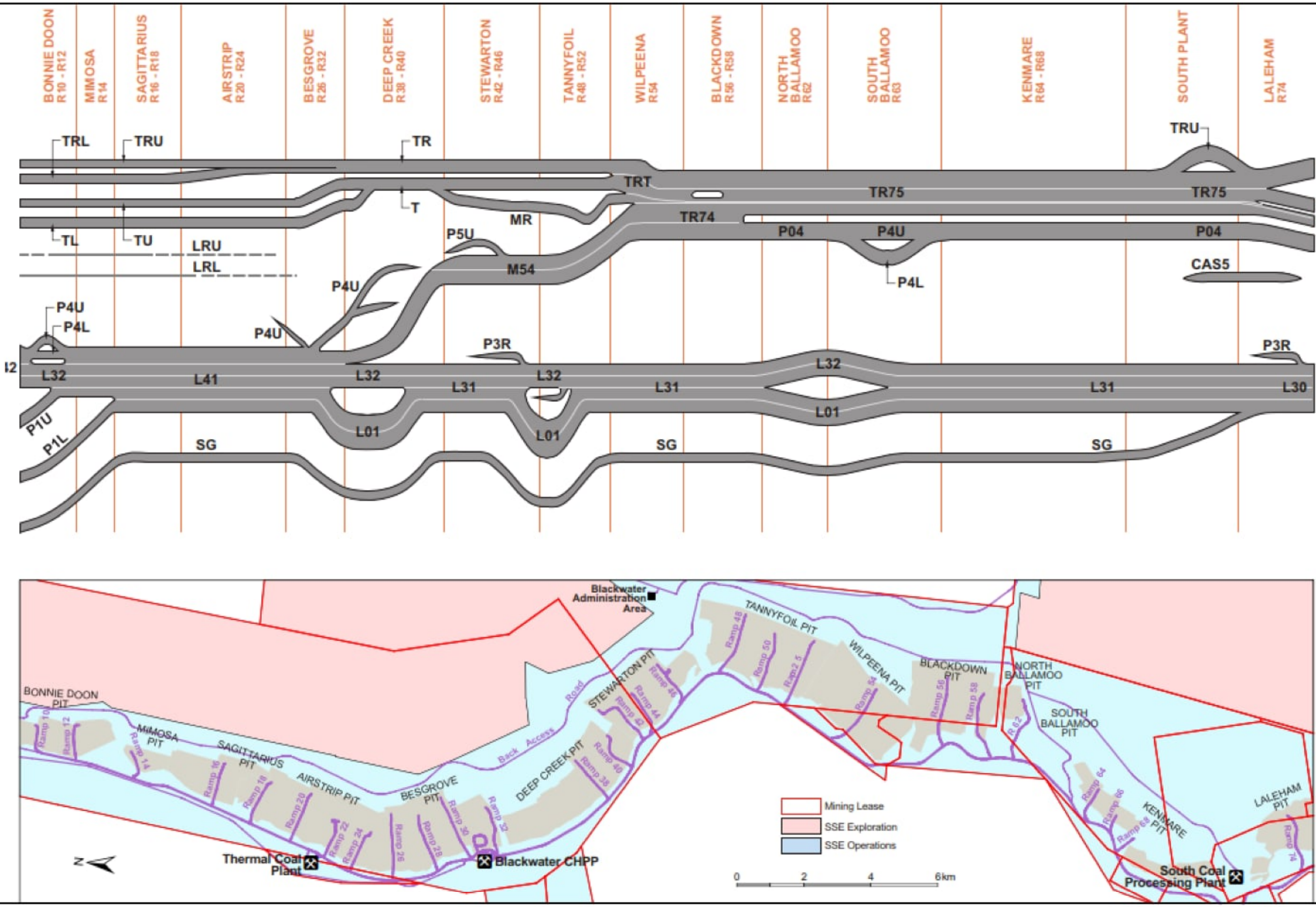
4.6 Burngrove Formation

The Burngrove Formation is comprised of mudstone, siltstone, sandstone, coal and tuff. The Rangal Coal Measures conformably overlie the coal bearing Burngrove Formation. The Burngrove Formation is considered the basement formation for this assessment.

4.7 Structural Geology

The structural geology in the region is characterised by gently folded consolidated sediments and a major north to north-west striking fault system which forms the Jellinbah thrust fault (AGE, 2013). A series of easterly dipping thrust faults occur parallel to the Jellinbah thrust, including the Shotover fault (occurring to the east of the study area where the Clematis Group outcrops) and the Como Fault that runs through the Curragh Mine (**Figure 4-5**) (Mallet et al., 1985). Regionally the structure is defined as a faulted monoclinal limb (AGE, 2013).

The strata in the vicinity of the Blackwater Mine are heavily influenced by a series of easterly dipping north to northwest striking faults (AGE, 2008). The Shotover Fault is of major importance as there is a displacement of up to 3,000 m (AGE, 2013). Locally, thrust faulting that occurs within the Blackwater mine may be attributed to thrusts occurring in the footwall of the Shotover Fault. Local structure is influenced by strike slip movement of basement rocks. Local fault displacement is reported to be less than five meters on average but can reach up to 20 m (AGE, 2008). **Figure 4-5** shows the numerous local faults mapped within the study area. The local faults were mapped by BMA and the regional faults were sourced from the public database.



BLACKWATER MINE - NORTH EXTENSION PROJECT

BMA
BHP Mitsubishi Alliance

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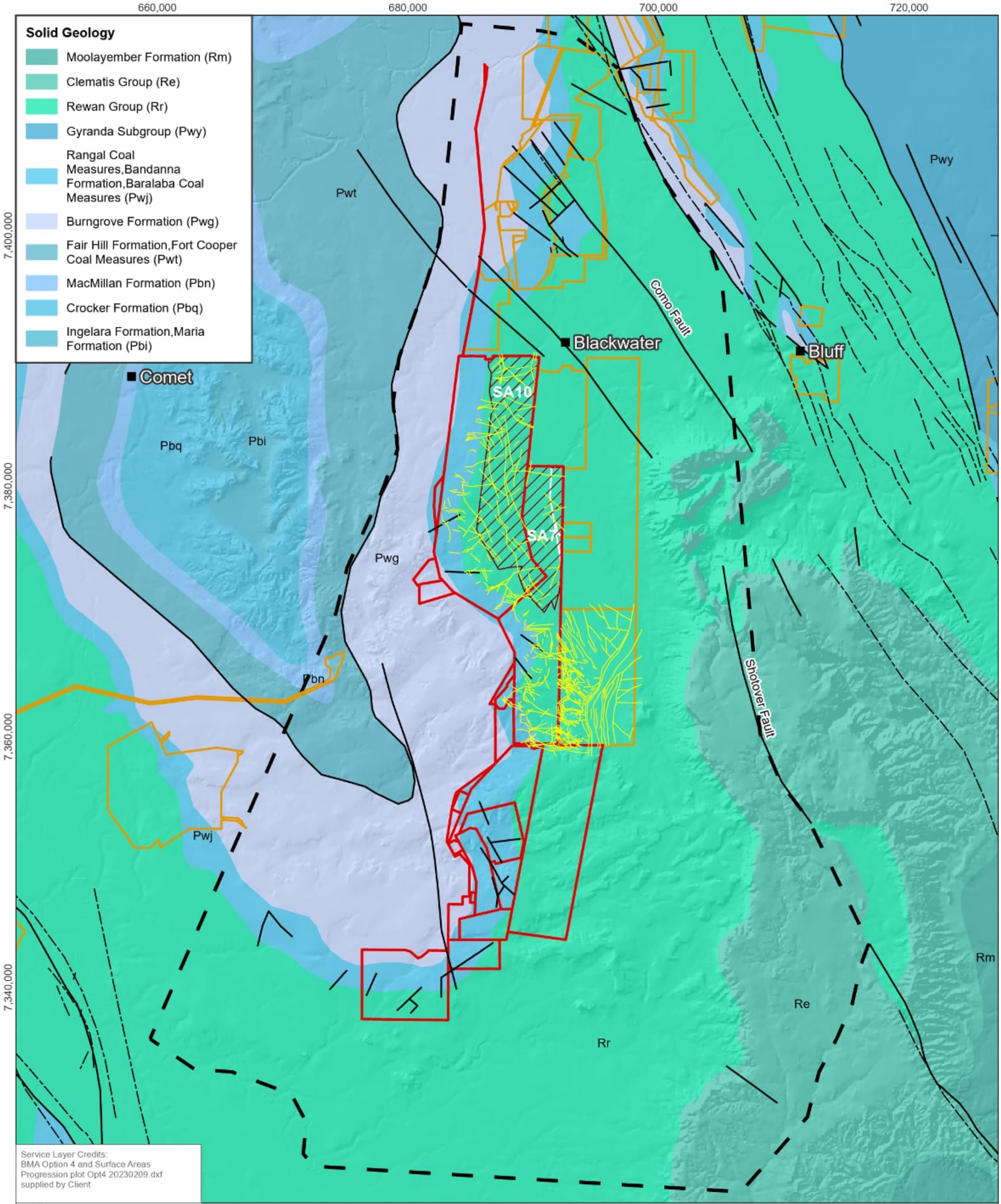
SCHEMATIC SEAM STRATIGRAPHY AND SPLIT DIAGRAM

FIGURE 4-4

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F04_04_Schematic Seam Stratigraphy and split diagram1



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Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- Basin Scale Fault (1995)
- Basin Scale Fault
- Local Fault
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

LOCAL AND REGIONAL FAULTS

SLR

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FIGURE 4-5

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F04_5_Model Faults

5.0 Hydrogeology

This section discusses each of the hydrogeological units relevant to the Project, describing groundwater hydrology (groundwater occurrence, hydraulic gradients, recharge and discharge), hydraulic properties, groundwater quality, and groundwater use and management. The conceptual hydrogeological model for the study area, refined with the most recent groundwater monitoring dataset with a focus on the Project, is summarised in **Section 5.6**.

The local hydrostratigraphic units are described below, from the shallowest (Alluvium) to the deepest (Burngrove Formation):

- **Alluvium** - Alluvial deposits are associated with local creeks. In recent years, the alluvium local to the study area has been found dry.
- **Regolith** - Unconsolidated surface layer of weathered rock which may provide a preferential flow pathway for groundwater if levels exceed the base of weathering.
- **Clematis Group** - outcrops on the eastern margins of the study area, where it forms an elevated plateau. The unit is comprised of weathering resistant medium to coarse grained quartzose to sublabile and micaceous sandstone, siltstone, mudstone and conglomerate.
- **Rewan Group** - A regional scale aquitard comprising mudstones interbedded with siltstone and fine to medium grained labile sandstone. However, permeability testing indicates hydraulic conductivity values may be higher in the upper weathered zone of the unit.
- **Rangal Coal Measures (RCM)** - Previous investigations (EMM, 2020) identified this formation as a regional aquifer. Groundwater flow is primarily within the coal seams (via interconnected cleats and fractures), which are confined by low permeability overburden and interburden that essentially form aquitards. The coal measures are highly faulted resulting in “compartmentalisation” with coal seams juxtaposed against lower permeability interburden. Recharge to this unit occurs via direct infiltration where the unit outcrops or sub-crops.
- **Burngrove Formation** - outcrops to the west of BWM and dips east below the Rangal Coal Measures. It is largely regarded an aquitard comprising interbedded siltstone, carbonaceous and tuffaceous shales, mudstone, and thin coal seams. However, several landholder bores are apparently screened within this formation locally (assuming the registered bore database aquifer attribution is correct) suggesting it includes permeable horizons that can support low yields. This formation is considered the basement for the purposes of this assessment.

5.1 Groundwater Monitoring

The existing BWM groundwater monitoring network, as summarised in **Table 5-1**, consists of 17 monitoring bores which are required to be monitored under the BWM EA conditions (EA compliance bores), and 26 additional Project-specific groundwater monitoring bores and/or vibrating wire piezometers (VWPs). The 17 EA compliance bores are required to be monitored on a quarterly basis to fulfill condition I1 of the EA EPML00717813 permit. The 26 additional Project-specific groundwater bores and/or VWPs are monitored monthly, since installation in 2020 and 2021, to collect baseline monitoring data for the Project. Groundwater level data for select bores are available from 2009.

Of 43 bores in the groundwater monitoring network, four of the monitoring bores (MB3, MB5, MB6 and MB18) are likely to be destroyed and removed from the monitoring program as mining progresses.

The location of groundwater bores in the BWM monitoring bore network is presented on **Figure 5-1**. The monitoring bores are displayed with different markers for each of the target formation. **Figure 5-1** further shows how the bores were geographically grouped to aid in data analysis. The terms used for these groups are:

- Northern Area.
- Bonnie Doon Area (sub-set of Northern Area with a cluster of bores).
- Central Area.
- Southern Area

The first three areas (Northern Area, Bonnie Doon Area and Central Area) overlap with the Project area and hence data from these three areas is considered most relevant for this assessment. Data from the Southern Area was included for the general description of the study area and is relevant to the numerical groundwater model.

Table 5-1 Monitoring Network

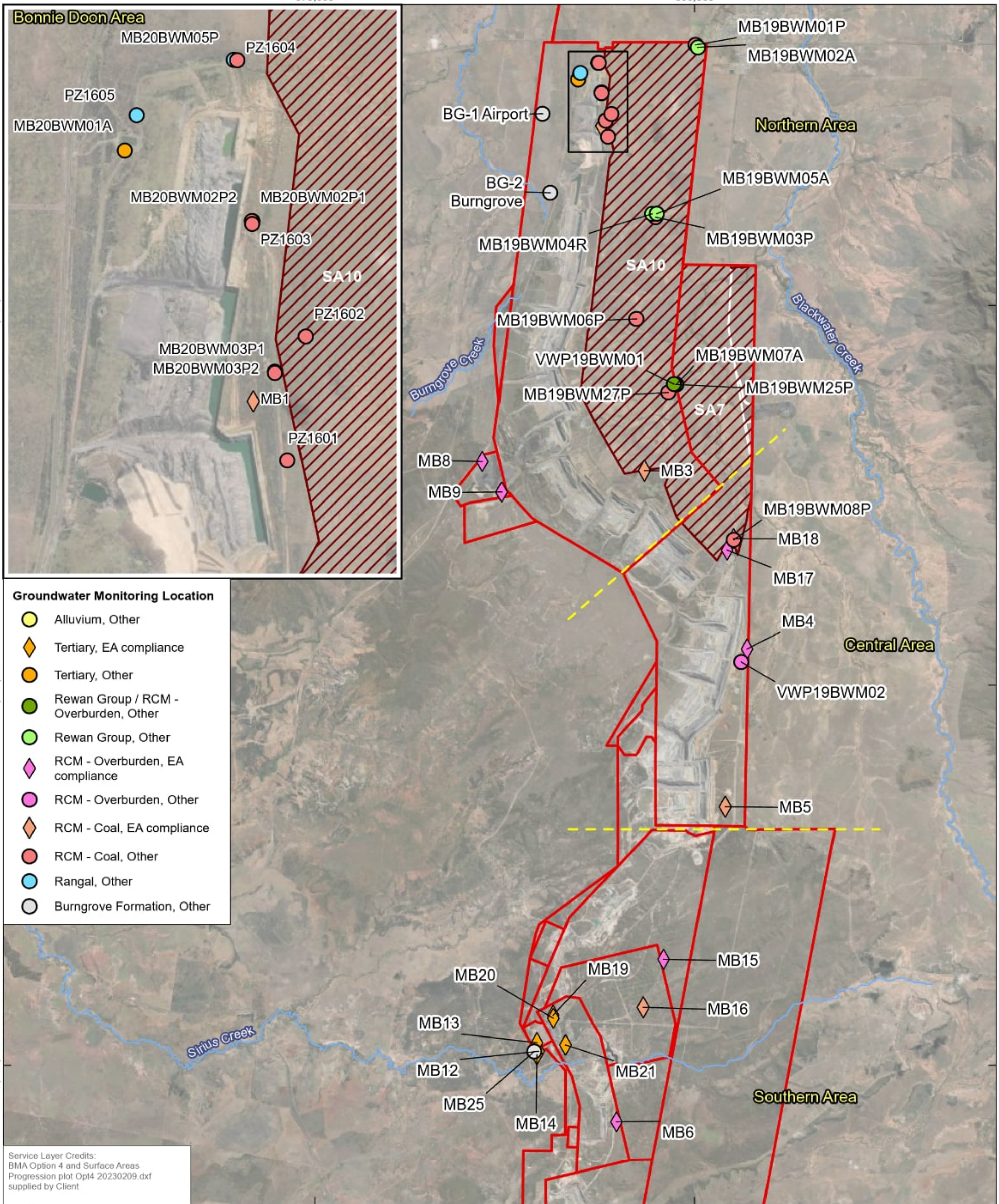
Monitoring Point	Easting (GDA 94)	Northing (GDA 94)	TOC (mAHD)	Depth* (mbgl)	Target Unit	Purpose
MB1	686331	7387080	201.1	58.3	RCM - Coal	EA compliance
MB3	688011	7373473	220	78.1	RCM - Coal	EA compliance
MB4	692071	7366434	250.2	52	RCM - Overburden	EA compliance
MB5	691205	7360205	277.2	100+	RCM - Coal	EA compliance
MB6	686915	7347772	320.1	48.7	RCM - Overburden	EA compliance
MB8	681616	7373831	249	17	RCM - Overburden	EA compliance
MB9	682377	7372625	245	12.3	RCM - Overburden	EA compliance
MB12	683841	7350555	277.8	3.5	Tertiary	EA compliance
MB13	683775	7350893	284.3	8.4	Tertiary	EA compliance
MB14	683772	7350421	264.2	8.8	Tertiary	EA compliance
MB15	688771	7354179	296.9	140	RCM - Overburden	EA compliance
MB16	687965	7352288	281.5	109	RCM - Coal	EA compliance
MB17	691279	7370332	227.2	67	RCM - Overburden	EA compliance
MB18	691537	7370787	221.3	39.4	RCM - Overburden	EA compliance

Monitoring Point	Easting (GDA 94)	Northing (GDA 94)	TOC (mAHD)	Depth* (mbgl)	Target Unit	Purpose
MB19	684417	7351974	310.7	18.8	Tertiary	EA compliance
MB20	684424	7351853	311.3	30.6	Tertiary	EA compliance
MB21	684900	7350805	263.8	29.2	Tertiary	EA compliance
MB25	683666	7350549	284	25	Burngrove	Background – Blackwater South
MB19BWM01P	690037	7390281	169.6	192	RCM - Coal	Background – Blackwater North
MB19BWM02A	690127	7390182	168.5	17	Rewan	Background – Blackwater North
MB19BWM03P	688454	7383473	202.7	234	RCM - Coal	Background – Blackwater North
MB19BWM04R	688315	7383604	203.6	50	Rewan	Background – Blackwater North
MB19BWM05A	688501	7383611	203.6	15	Rewan	Background – Blackwater North
MB19BWM06P	687698	7379464	214.6	192	RCM - Coal	Background – Blackwater North
MB19BWM07A	689279	7376877	198.6	7	Quaternary	Background – Blackwater North
MB19BWM08P	691542	7370739	224.6	198	RCM - Coal	Background – Blackwater North
MB19BWM25P	689259	7376879	192.6	20	Rewan	Background – Blackwater North
MB19BWM27P	688958	7376559	198.5	198	RCM - Coal	Background –

Monitoring Point	Easting (GDA 94)	Northing (GDA 94)	TOC (mAHD)	Depth* (mbgl)	Target Unit	Purpose
						Blackwater North
MB20BWM01A	685394.8	7388907	187.5	10	Tertiary	Background – Bonnie Doon
MB20BWM02P1	686324.7	7388394	192.6	36	Rangal	Background – Bonnie Doon
MB20BWM02P2	686320.2	7388394	192.7	66	RCM - Coal	Background – Bonnie Doon
MB20BWM03P1	686488.6	7387295	199.3	86	Rangal	Background – Bonnie Doon
MB20BWM03P2	686489.5	7387287	199.4	109	RCM - Coal	Background – Bonnie Doon
MB20BWM05P	686190.3	7389569	190.5	47	Rangal	Background – Bonnie Doon
BG-1 Airport	683994	7387561	200.5	76	Burngrove	Background – Blackwater North
BG-2 Burngrove	684300	7384441	211.9	40	Burngrove	Background – Blackwater North
PZ1601	686580	7386650	205.0	106	RCM - Coal	Background – Bonnie Doon
PZ1602	686714	7387553	200.8	104	RCM - Coal	Background – Bonnie Doon
PZ1603	686323	7388372	194.7	82	RCM - Coal	Background – Bonnie Doon
PZ1604	686215	7389566	191.4	53	RCM - Coal	Background – Bonnie Doon
PZ1605	685482	7389166	187.6	53	RCM - Coal	Background – Bonnie Doon
VWP19BWM01	689178	7376893	198.0	46	Rangal Coal Measures (Sandstone overburden)	Background Blackwater North

Monitoring Point	Easting (GDA 94)	Northing (GDA 94)	TOC (mAHD)	Depth* (mbgl)	Target Unit	Purpose
				104	Rangal Coal Measures (Sandstone overburden)	
				125	Rangal Coal Measures (Tops)	
				154	Rangal Coal Measures (Sandstone interburden)	
				186	Rangal Coal Measures (Lowers)	
VWP19BWM02	691839	7365920	249.0	88	Rangal Coal Measures (Sandstone overburden)	Background Blackwater North
				101	Rangal Coal Measures (Tops)	
				112	Rangal Coal Measures (Mids)	
				127	Rangal Coal Measures (Lowers)	
				149	Rangal Coal Measures (Sandstone interburden)	

* Depth refers to bore depth for stand pipes and sensor depth for VWPs
mbgl – metres below ground level
TOC – Top of Casing



0 2.5 5 km

Coordinate System: GDA2020 MGA Zone 55
Scale: 1:200,000 at A4
Project Number: 620.014601
Date Drawn: 04-Dec-2023
Drawn by: NT

LEGEND

Watercourse
BWM Mining Lease
BWM North Extension Project Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

GROUNDWATER MONITORING NETWORK

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose

FIGURE 5-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_1_Monitoring Bore

5.2 Hydraulic Properties

Hydraulic properties of hydraulic conductivity and storativity have been measured by various techniques at different locations in the vicinity of BWM. Results can differ depending on the techniques employed. Falling head or slug tests are at best an approximation of hydraulic conductivity and provide an estimate generally within one order of magnitude. Packer testing conducted during drilling programs is considered a more reliable measure of hydraulic conductivity, providing an estimate over the interval tested. Test pumping is the most reliable method of measuring hydraulic conductivity and has the advantage of identifying recharge or barrier boundaries if they are present. In addition, if during test pumping drawdown is measured in observation bores, the aquifer storativity can be calculated.

Within the study area, the coal seams are the main groundwater bearing units within the Permian sequences, with low hydraulic conductivity interburden generally confining the individual seams. Sedimentary consolidation processes cause the coal seams to display dual porosity characteristics, with a primary matrix porosity and a secondary (dominant) porosity provided by diagenic fractures (joints and cleats). Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures.

5.2.1 Northern Area

In the BWM Northern Area, two field hydraulic testing campaigns were recently undertaken (AGE, 2020 and HydroFS, 2021). The results for estimated hydraulic conductivities from slug tests are presented in **Table 5-2**. Results for the Rewan Group show higher hydraulic conductivities in the shallowed weathered zone, and lower hydraulic conductivity in the deeper part of the unit considered more representative of the true formation. The results for the Rangal Coal Measures are predominantly representative of coal (Aries Coal Seam). One test was taken at a zone with coal and interburden present. The geometric mean of the coal hydraulic conductivity is estimated at 0.003 m/day, however the results span over three orders of magnitude (0.00003 m/day to 0.056 m/day). The locations of the bores tested in these campaigns are shown on **Figure 5-2**.

Table 5-2 Blackwater Northern Area Slug Test Results

Bore	Aquifer Unit	Bore Depth (m)	Hydraulic Conductivity (m/day)	Source
Rewan Group				
MB19BWM02A	Siltstone (Weathered Rewan)	15	0.39	AGE, 2020
MB19BWM25P	Sandstone (Weathered Rewan)	20	0.002	AGE, 2020
MB19BWM04R	Sandstone (Rewan)	80	0.0008	AGE, 2020
Rangal Coal Measures				
MB20BWM02P2	Permian (coal)	66	0.00028	HydroFS, 2021
MB20BWM03P1	Permian (coal and sandstone interburden)	86	0.056	HydroFS, 2021
MB20BWM03P2	Permian (coal)	109	0.015	HydroFS, 2021
MB19BWM01P	Aries Coal Seam	171	0.033	AGE, 2020
MB19BWM06P	Aries Coal Seam	186	0.00007	AGE, 2020

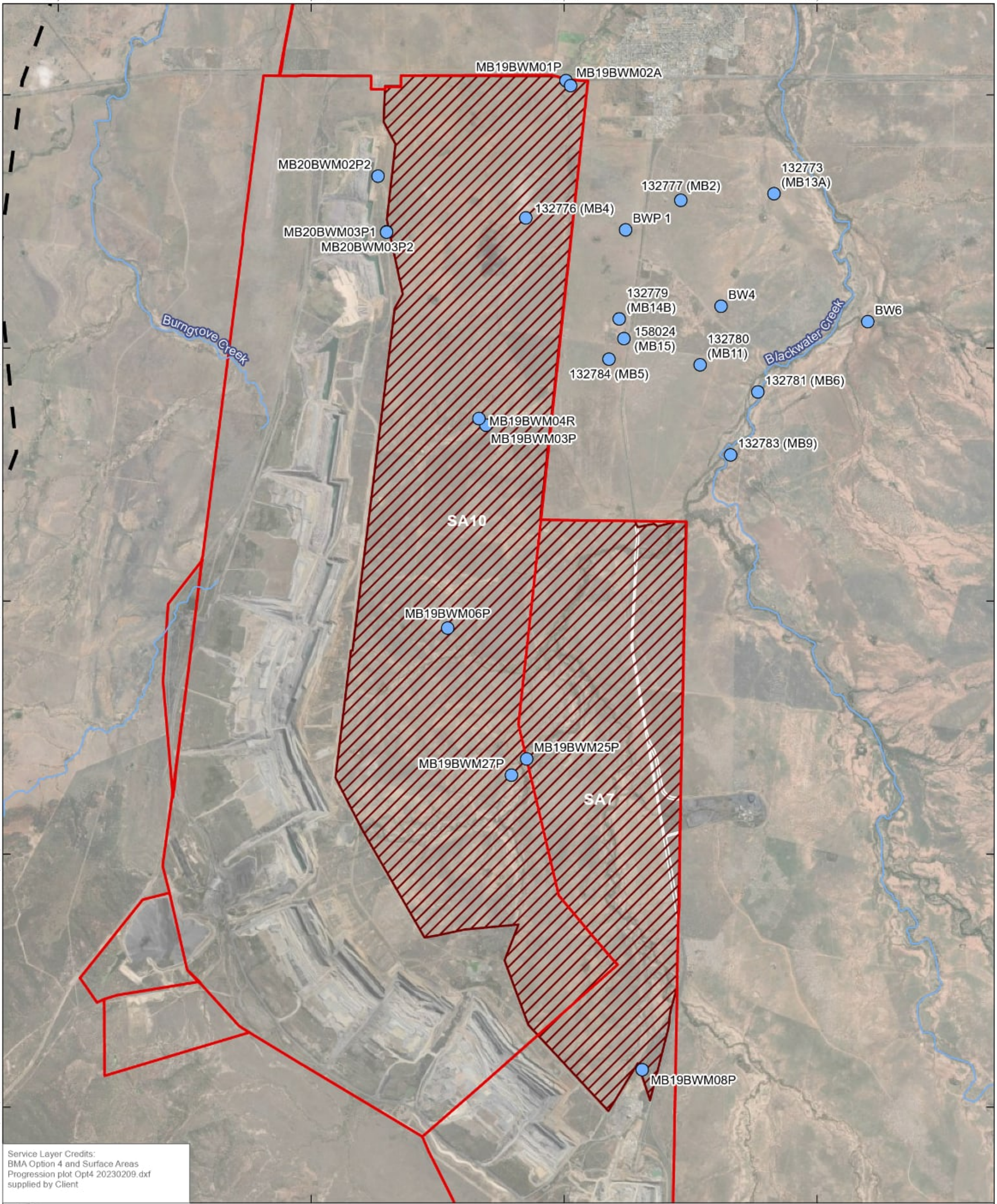
Bore	Aquifer Unit	Bore Depth (m)	Hydraulic Conductivity (m/day)	Source
MB19BWM27P	Aries Coal Seam	189	0.027	AGE, 2020
MB19BWM08P	Aries Coal Seam	198	0.024	AGE, 2020
MB19BWM03P	Aries Coal Seam	231.5	0.00003	AGE, 2020

Falling-head tests were undertaken on several monitoring bores within ML80173 as part of the proposed Minyango Project (AGE, 2013). The hydraulic conductivity derived from the falling-head tests are summarized in **Table 5-3**. The Blackwater Creek alluvium has the highest estimated hydraulic conductivity of 0.4 m/day, with the Rewan Group estimated hydraulic conductivity ranging over two orders of magnitude between 0.00015 and 0.055 m/day. The measured hydraulic conductivity of one sample from the Aries Seam was 0.003 m/day which is within the range of results obtained for the Rewan Group. The locations of the tested bores are shown on **Figure 5-2**.

Table 5-3 Minyango Falling-Head Tests

Bore	Unit	Bore Depth (m)	Hydraulic Conductivity (m/day)
132783 (MB9)	Blackwater Creek Alluvium	13	0.4
132776 (MB4)	Rewan Group	33	0.015
132784 (MB5)	Rewan Group	47	0.00015
132781 (MB6)	Rewan Group	41	0.0075
132780 (MB11)	Rewan Group	53	0.055
132773 (MB13A)	Rewan Group	16	0.01
132778 (MB14A)	Rewan Group	35	0.0058
132779 (MB14B)	Rewan Group	23	0.0008
158024 (MB15)	Rewan Group	23	0.055
132777 (MB2)	Aries Seam	226	0.003

In addition, several campaigns of drill stem testing of the coal seams within the north and centre of Blackwater have previously been undertaken. Aquifer parameters derived from drill stem tests are summarised in **Table 5-4** (EMM, 2019). The locations of the tested bores are shown on **Figure 5-2.**



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

0 1 2 km

LEGEND

- Hydraulic Testing Location
- Watercourse
- BWM Mining Lease
- BWM North Extension Project Area
- Study Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

HYDRAULIC TESTING DATA LOCATIONS

SLR

FIGURE 5-2

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_2_Hydraulic Testing Data Locations

Table 5-4 Drill stem Test Results (EMM, 2019)

Bore	Coal Seam	Test Depth (m)	Hydraulic Conductivity (m/day)
Blackdown 3	Aries/Castor	574	0.00014
	Virgo	657	0.000017
	Leo/Aquarius	713	0.000017
Blackdown 4	Aries	861	0.000058
	Castor	873	0.000042
BW6	Aries	348–355	0.00019
BW4	Pollux	222–235	0.081
BWP 1	Aries	252–258	0.149
	Castor	265–270	0.094
	Pollux	280=–288	0.032

5.2.2 Southern Area

A series of test pumping programs have been previously undertaken on the coal bearing strata in the South Blackwater area. **Table 5-5** shows the resulting estimated hydraulic parameters including hydraulic conductivity and storativity, collated from these investigations (EMM, 2019).

Table 5-5 Hydraulic Parameters (South Blackwater Area)

Area	Method	Unit	Hydraulic Conductivity (m/day)	Storativity
Kennedy Pit Area	Pumping Test	Argo Seam	3.2 to 8.1	$1.3x10^{-4}$ to $3.4x10^{-4}$
		Aries and Castor Seam	5	$1.3x10^{-4}$ to $3.4x10^{-4}$
		Fresh overburden and interburden	0.75 to 1.75	$3.5x10^{-5}$ to $9.1x10^{-5}$
		Overburden – Weathered and Tertiary	0.7	$3.0x10^{-3}$
		Floor Strata	0.05	$3.5x10^{-5}$ to $9.1x10^{-5}$
Kennedy Pit Area	Pumping Test	Pollux/Argo Seam	6.4	-
Laleham Pit Area	Unknown	Argo Seam	1.3 to 1.9	$1.0x10^{-4}$
South Marshmead	Unknown	Argo Seam	1.5	-

Test pumping conducted by AGC in 1990 was undertaken over 48 hours at a rate of 2.3 L/s with water levels recorded in several observation bores. Drawdown was observed in all bores with the furthest located 820 m from the pumping bore, recording a maximum drawdown of 0.15 m (EMM, 2019).

AGE (2003) conducted test pumping of the Pollux/Argo seam within the Kennedy pit area. The test pumping program was conducted at a rate of 1.5 L/s for 72 hours. The recorded drawdown after 72 hours of pumping was 2.11 m and 0.855 m at distances of 612 m and 1,150 m respectively. Analysis of the test pumping data indicated a hydraulic conductivity of 6 m/day. The exact location of the pumping bore is not known.

Douglas and Partners (1997) reported the hydraulic parameters for the Argo Seam within the Laleham and South Marshmead pit area. The type of testing and location of the test bores are not reported.

5.2.3 Faults

The mapped local faults (**Figure 4-5**) show a displacement of a maximum of 5m (EMM, 2021). Site specific testing of the faults has not been undertaken to derive hydraulic properties of the fault zones or assess whether the faults act as conduits or barrier to groundwater flow. However, they are anticipated to act more as barriers than conduits because the faults compartmentalise the coal seam geology and Permian groundwater flow is dominated by water movement within these seams.

As identified by Jourde *et al*. (2002), faulting can result in higher permeabilities within strata parallel with the fault plane, and lower permeabilities within strata perpendicular to the fault plane. However, this can also be dependent on whether faults are currently active (Paul *et al.*, 2009). Faulting has been inactive within the Bowen Basin for over 140 million years (Clark *et al.*, 2011), indicating that the fault zones are less likely to act as conduits to flow; this relates to filling of the fractured pore spaces over time through hydrothermal alteration and mineralisation (Uysal *et al.*, 2000). Drill core logs from the Bowen Basin generally show that where fractures and faults have been geologically logged, many fractures are “healed” with calcite and siderite. This indicates that although the system contains a fracture network, many of the existing fractures are cemented, which reduces the effective permeability of the fracture when compared to any open fracture network (SLR, 2020).

Based on a detailed literature review of the effect of faulting on groundwater flow, Coffey (2014) has developed a conceptual model for fault zone hydraulic characterisation in the Bowen Basin (**Figure 5-3**), largely based on Jourde *et al.* (2002) and Flodin *et al.* (2001). This conceptualisation provides a means of inferring hydraulic conductivities of the fault core and the fault damage zone from regional hydraulic conductivity, with the fault core typically one to three orders of magnitude lower conductivity than the regional host rock, and the damage zone approximately an order of magnitude higher.

For this assessment, only one major fault was included in the groundwater model (refer to **Section 6.3.2**). This fault, the Shotover fault, was included as a no flow boundary, based on the understanding that the fault core has a lower hydraulic conductivity than the host rock.

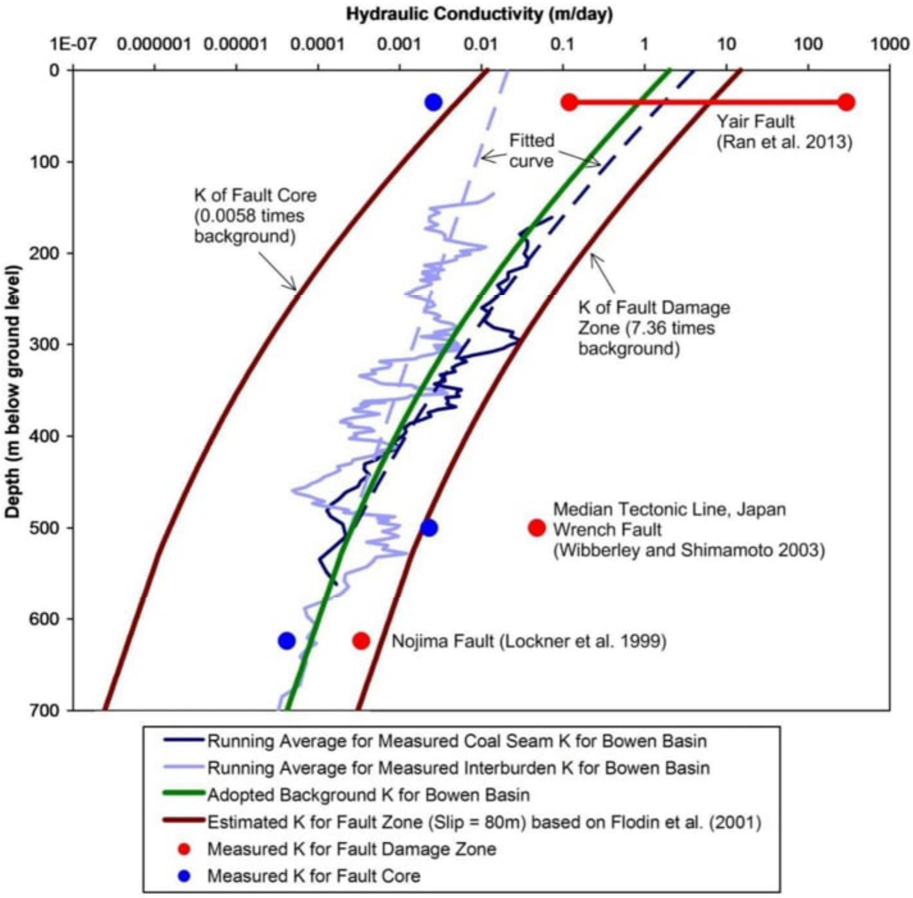


Figure 5-3 Faulting Conceptual Model Developed by Coffey (2014)

5.3 Groundwater Distribution, Flow, Recharge and Discharge

All hydrographs shown in this section show the water level in metres Australian Height Datum (mAHD). The hydrographs showing the water level as metres below ground level (mbgl) are presented in **Appendix A-1**.

5.3.1 Quaternary Sediments (Alluvium)

Based on intrusive investigation works (**Section 4.1**), it is considered that the horizontal extent of the alluvium within the study area is likely smaller than mapped on the regional surface geology map (**Figure 4-1**). Where it is present, the alluvium is generally dry, with saturated areas only found in few locations. Where saturated, the alluvium may facilitate recharge to underlying geological units.

There is one groundwater monitoring bore, MB19BWM07A screened in alluvium within the Project area, however it has been found dry since installation. Recent drilling campaigns in the alluvium at North Blackwater (2020 and 2021) revealed either an absence of alluvium, and/or dry conditions. In 2020, four bores were planned to be installed into the alluvium, however only one of the four locations (bore MB19BWM07A) intersected alluvium, which was unsaturated (AGE, 2020). Two of the planned bores were installed in the Rewan instead (MB19BWM02A and MB19BWM05A) and one was abandoned (drilling attempt near the creek line between MB19BWM06P and MB19BWM08P). In 2021, during an additional drilling campaign, bore MB20BWM01A initially targeted alluvium but again due to the lack of alluvial sediments at the site, the bore was installed into the deeper Rewan Group (HydroFS, 2021).

AGE (2013) reviewed available groundwater level data for the Minyango Project. Three of the four monitoring bores screened in alluvium were dry. The only bore that encountered water (Minyango-MB9) revealed a limited saturated thickness of less than 0.8 m, with a depth to water level of 10.8 mbgl. The monitoring data for MB9 showed a steady decline between December 2012 to September 2013, and showed no correlation with rainfall. AGE (2013) determined that, for bore MB9, recharge is likely limited by the surficial clay above alluvium and that the alluvium is likely compartmentalised, with limited connectivity between saturated alluvium areas, separated by clay lenses and outcropping bedrock.

Due to the lack of saturated monitoring locations in the alluvium within the study area, it is not possible to map the horizontal groundwater flow direction in this unit. However, where saturation does exist, groundwater flow in the alluvium is expected to mirror topography, and flow towards the north of the Project at North Blackwater and towards the southwest at South Blackwater. Discharge from this aquifer is generally considered to be via evapotranspiration and leakage to underlying aquifers.

5.3.2 Tertiary Sediments

Seven bores are screened in the Tertiary Sediments: MB20BWM01A, MB12, MB13, MB14, MB19, MB20 and MB21. MB20BWM01A is located in the Northern area, east of the Bonnie Doon Pit while the remaining bores are all located within the Southern area (**Figure 5-1**).

Northern Area

MB20BWM01A was drilled in 2020 and has remained dry since instillation. In this area the Tertiary Sediments are relatively thin (i.e. less than 15 m thick) and underlain by the Rewan Group (east of the mining area), the Permian units of the Rangal Coal Measures (within the mining area) and the Burngrove Formation (west of the mining area). The Tertiary Sediments primarily consist of highly to extremely weathered sandstone and mudstone of the Duaringa Formation and forms the bulk of the Regolith. In the Northern Area, the Tertiary Sediments are expected to be mostly dry, as indicated by recent drilling (AGE, 2020 and HydroFS, 2021) as well as historical observations at Minyango (AGE, 2013). As per the alluvium, recharge is expected to be low due to the presence of surficial clays. Although no groundwater monitoring data is available, groundwater flow in the Tertiary Sediments is expected to mirror topography and flow towards the north.

Southern Area

Based on drilling results, the Tertiary Sediments in the Southern Area are thicker on average than in the Northern Area. In this area they primarily consist of claystone, siltstones, sandstones and interbedded basalt of the Emerald Formation.

Groundwater levels for the six monitoring bores screening the Tertiary Sediments vary from approximately 245 mAHD (MB21) to 280 mAHD (MB13) (**Figure 5-4**). Following the commencement of water level measurement in 2011, all bores have seen a steady decrease in water level, interrupted only by relatively short-term response to large rainfall events. This long term decline reflects a long term response to the very high rainfall observed in 2011. MB13 is characteristic in displaying a steady or increasing water level since 2019. Otherwise the bores display levels that are consistent with the assumed flow pattern for the regional Tertiary units, following a subdued reflection of topography.

Groundwater quality (**Section 5.4**) is generally saline (**Table 5-8**), which would suggest a low to very low recharge rate for the Tertiary Sediments. However, there is significant variability in salinity levels for bore MB12 and MB13, which also have the highest groundwater elevation of the Southern Area bores.

Discharge is considered to be primarily through evapotranspiration and leakage to underlying aquifers.

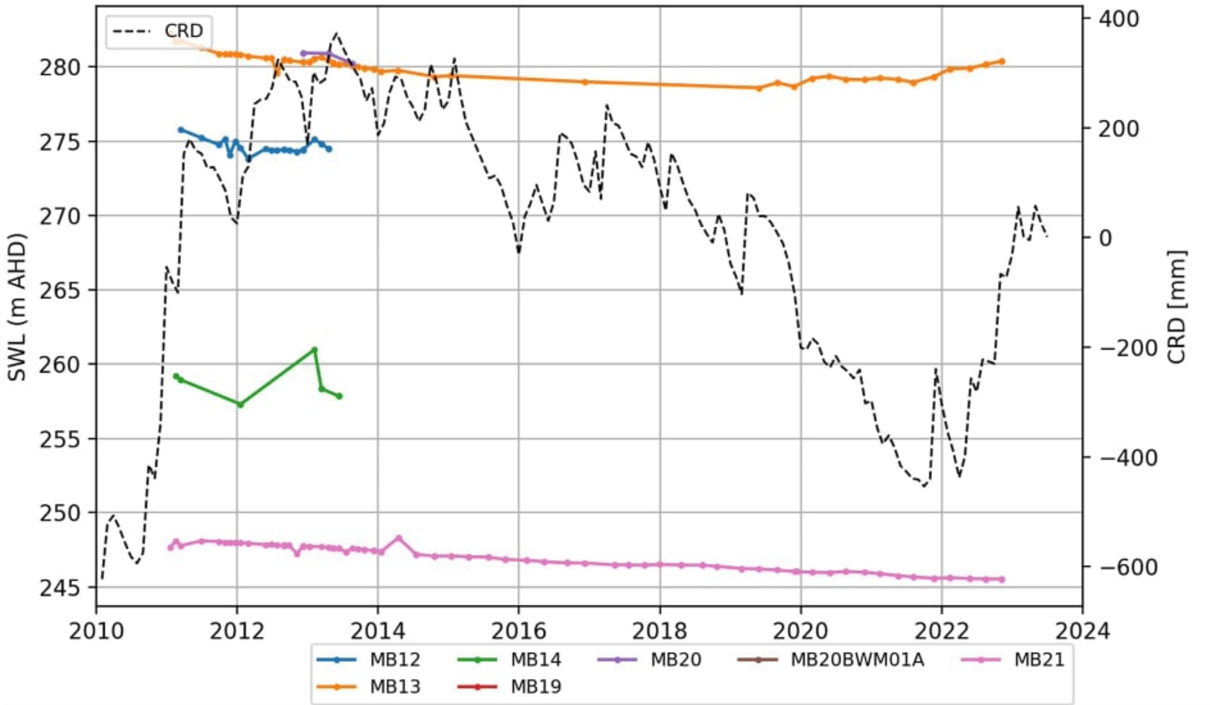


Figure 5-4 Standing Water Level in the Tertiary Sediment Bores

5.3.3 Clematis Group

The aquifer forming Clematis Group sandstones are distinguished by coarse grain size, with less interbedded shale and siltstone than the non-aquifer forming Clematis Group units. There are no registered bores within the Clematis Group sandstone, as the sandstone outcrops in elevated rugged areas in Arthur's Bluff State Forest, Shotover State Forest and Blackdown Tableland National Park. Claystones of the Rewan Group directly underlie the Clematis Group, forming an aquitard between the Clematis Group and the deeper Permian Coal Measures.

5.3.4 Rewan Group

The Rewan Group is considered low yielding, with any groundwater having limited potential for beneficial use due to the typically fine-grained, clay-bound nature of the sediments. Regionally across the Bowen Basin, the Rewan Group is considered an aquitard (DNRM, 2016).

Despite acting as a regional aquitard, four bores are screened in the Rewan Group observing saturated horizons: MB19BWM02A, MB19BWM04R, MB19BWM05A, MB19BWM25P, which are all located within the Blackwater Northern area. Groundwater levels vary from approximately 160 mAHD (MB19BWM02A) to 180 mAHD (MB19BWM25P). Bore MB19BWM05R has been found to be consistently dry since installation in 2020. Despite the relatively short monitoring period, there has been some response to broad climatic trends, with MB19BWM02A and MB19BWM25P declining in line with CRD trend and responding following relatively wet period post 2022. MB19BWM04R contrasted to this trend, showing increasing groundwater level throughout monitoring. All bores in this unit do not respond to short term CRD peaks, indicating a degree of insulation from short term recharge events (**Figure 5-5**).

Recharge to the Rewan Group is likely very low due to the low hydraulic conductivity of the interbedded fine grained clay horizons restricting infiltration. Elevated salinity concentrations (**Section 5.4**) are consistent with high groundwater residence times concentrating salts (**Table 5-8**). Recharge is expected to occur via leakage from the overlying Quaternary and Tertiary units. Monitored standing water levels indicate a flow toward the north of the Project (i.e. consistent with topographical gradients).

Discharge from this unit is expected to be through lateral flow to the north, with low vertical hydraulic conductivity limiting potential leakage to underlying units. Hydraulic connection between MB19BWM02A and a nearby tributary to Blackwater Creek is unlikely since the creek bed elevation (168 mAHD) is seven meters above the standing water level at the bore (161 mAHD). Based on the observed response to short term rainfall events in the Rewan Group, the insulation of this unit from recharge events makes it unlikely that there would be short term increases in groundwater pressure (post-rainfall) that would be of sufficient magnitude to result in discharge to surface water features.

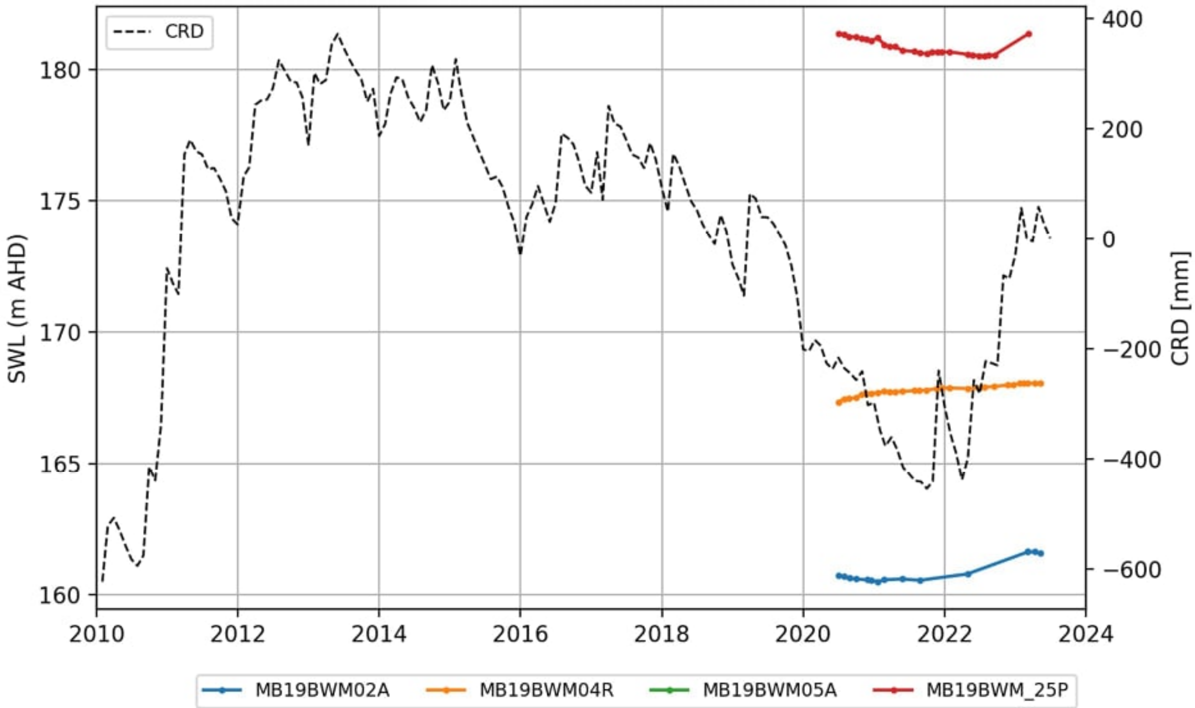


Figure 5-5 Standing Water Level in the Rewan Group

5.3.5 Rangal Coal Measures

5.3.5.1 Northern Area and Bonnie Doon

Groundwater levels are available for 14 bores screened in the coal seams and interburden of the Rangal Coal Measures in the Northern Area, of which the groundwater elevation of five bores (screened within the coal seam) are presented on **Figure 5-6**. The groundwater elevation of 10 bores in the Bonnie Doon Area are presented on **Figure 5-7**.

In the Northern Area, **Figure 5-6** shows that of the five bores, MB3 has the longest record and shows a slight decrease in water levels over time. The closest open-cut pit is located 1.2 km southwest of MB3. The general gradient for these bores is from south to north (i.e. highest water level in the south at MB3 and lowest water level at MB19BWM01P in the north). An exception for this is MB19BWM06P, which recorded the highest water levels; it is considered that this is potentially indicative of compartmentalisation of the coal seams.

Groundwater elevation trend in MB3 shows two main features: brief groundwater level rise (~0.3 m) in 2011 coinciding with very large flooding events, and a subsequent long term declining trend (~2 m) likely to be associated with mine dewatering. For the remaining bores in the Northern Area, while the monitoring period is relatively limited (less than five years). Monitoring has remained relatively consistent, with subdued reaction to long term climatic trends. MB19BWM03P has displayed anomalous response relative to other bores, with fluctuations of up to 2 m between measurements. Investigating the long term (CRD) and short term climatic data (individual rainfall events), the variability is considered disconnected from rainfall response. Logger data shows very slow groundwater level recovery following monitoring events, indicating that the bore is either observing a very low hydraulic conductivity horizon within this unit, or that the screen is partially blocked and un-representative of regional groundwater level.

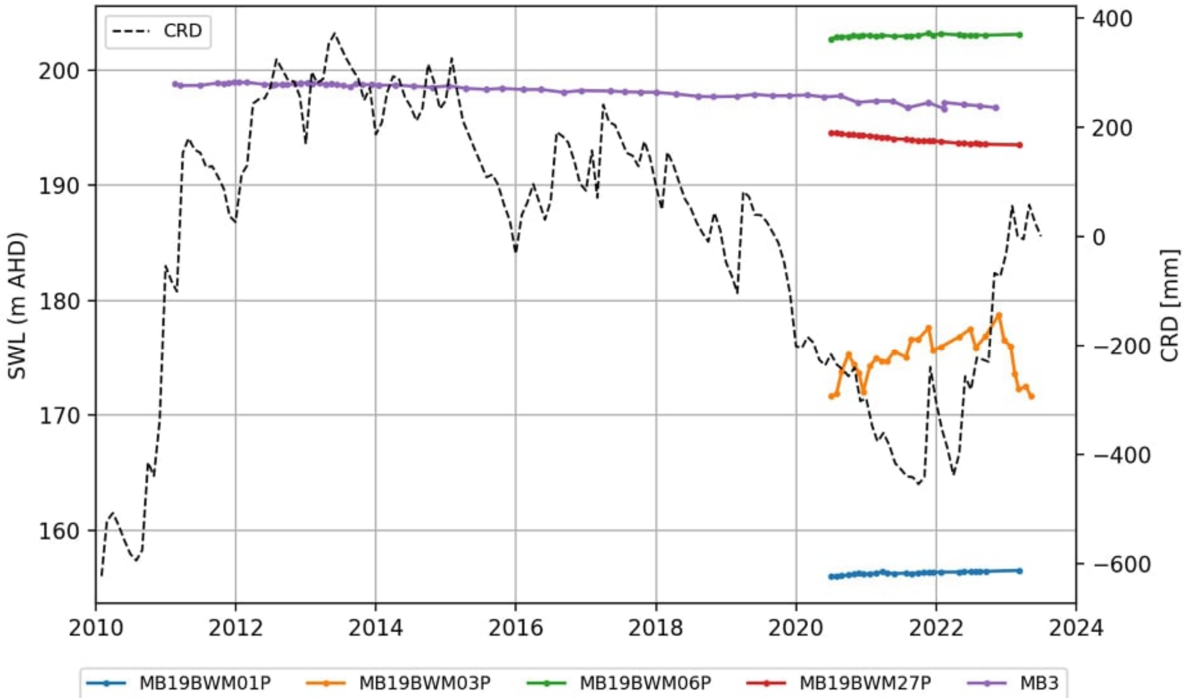


Figure 5-6 Standing Water Level in the Rangal Coal Measures, Northern Area

Hydrographs for water level monitoring in the Bonnie Doon Area are displayed in **Figure 5-7**. Seven of the bores targeting the Rangal Coal Measures are screened in coal seams and three in the interburden (MB20BWM02P1, MB20BWM03P1 and MB20BWM05P). The water level in the adjacent Bonnie Doon Pit lake is at between 128 and 142 mAHD (**Figure 5-8**).

Groundwater elevation at MB1, which has the longest monitoring record, has gradually increased since cessation of Bonnie Doon Pit mining in 2016. This is considered to be a hydraulic response of the aquifer returning to equilibrium following the removal of dewatering stressors, rather than an indication of recharge from the pit lake. The other nine bores in the Bonnie Doon Area were installed in 2020 and have a relatively short monitoring record. Ground water levels vary from approximately 130 mAHD to 155 mAHD within a relatively small area. This is reflective of the different horizons monitored by each bore, and the degree of compartmentalisation in the aquifer/aquitard system.

The bores MB20BWM02P1 (overburden) and MB20BWM02P2 (coal seam) show that whilst the bore monitoring the coal seam has a water elevation similar to that of the pit lake, the bore observing the interburden shows water levels 20 m above the pit lake level. Based on this observation, it is likely that the coal seams down dip (to the east) are well connected to the open cut pits, whereas the interaction with the lower permeability overburden is limited, consistent with it having more aquitard like properties. Vertical hydraulic gradients in this area remain consistently downwards due to this disconnect. MB20BWM02P2 water level shows some response to climatic trends, though there may be some hydraulic connection with the nearby pit lake, given proximity and coal seam outcrop.

FY16_PZ_2, FY16_PZ_3 and FY16_PZ_4 show inconsistent measurements at the start of their monitoring datasets before settling into steady water levels that are relatively isolated from climatic response. This could be attributed to stabilisation of the local groundwater environment following bore installation.

Installed in roughly the same collar location, but in different points in the stratigraphy, MB20BWM03P1 and MB20BWM03P2 display similar water levels (around 142 mAHD). Initially, MB20BWM03P2 water level was around 0.5 m higher, however this flipped in 2022, likely due to recovery response in the interburden stratigraphy.

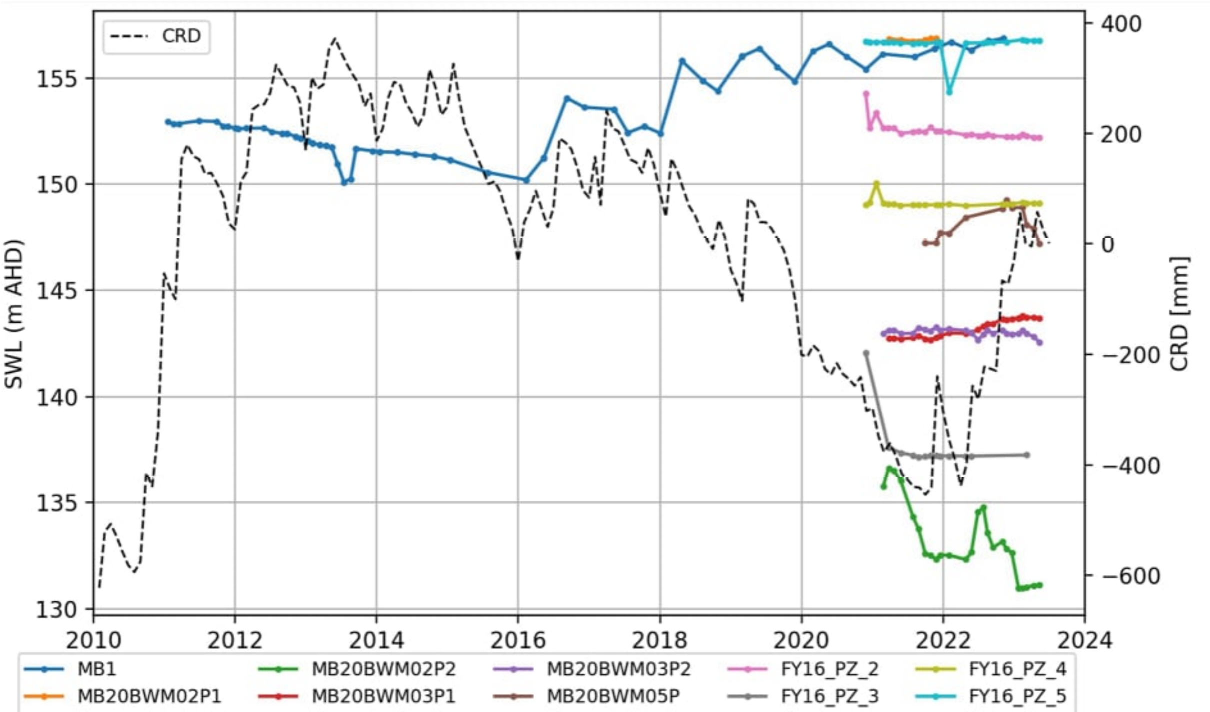


Figure 5-7 Standing Water Level in the Rangal Coal Measures, Bonnie Doon Area

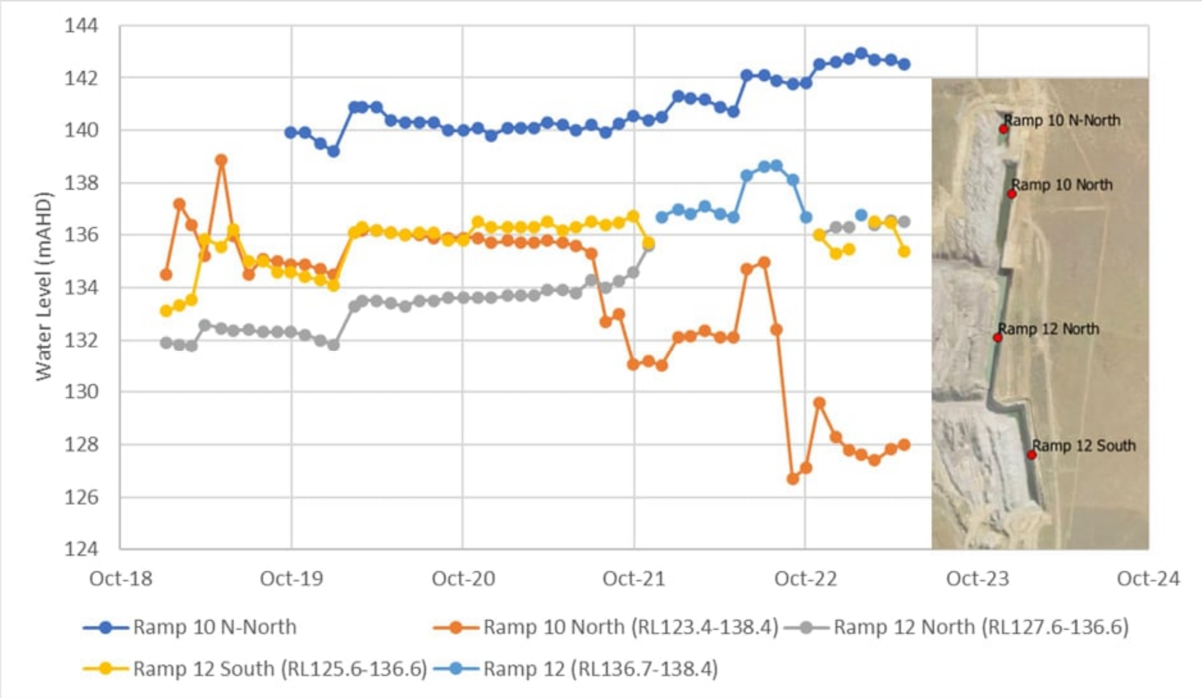


Figure 5-8 Surveyed Water Level for Bonnie Doon Surface Water Storage Areas

Figure 5-9 shows the groundwater levels for bores MB8 and MB9, which are associated with an above ground tailings storage facility. Both bores are located at the western end of the mine, where the RCM outcrop. Bore MB9 shows stable water level observations, whereas groundwater levels MB8 appear to have some variability of 4 m.

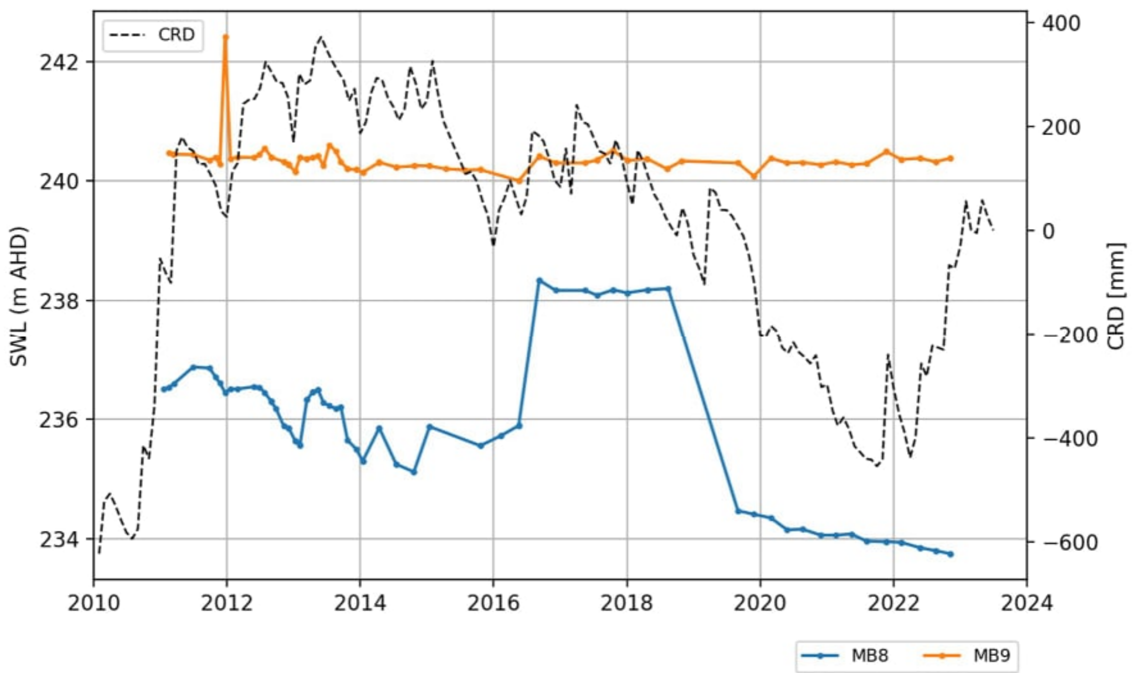


Figure 5-9 Standing Water Level in the Rangal Coal Measures, near TSF

5.3.5.2 BWM Central

Groundwater levels at BWM central are observed at MB4, MB5, MB17, MB18 and MB19BWM08P. For location of the bores, refer to **Figure 5-1**.

Figure 5-10 shows that the groundwater elevation in the Central Area varies from approximately 192 mAHD to 210 mAHD with groundwater levels overall increasing at MB18 (which screens the overburden and is the bore with the longest monitoring record) and overall decreasing at MB4 (which intersects the overburden).

MB19BWM08P (coal seam) and MB18 (overburden) are located approximately 50 m apart horizontally, though screen sections are separated by ~150 vertical metres. MB19BWM08P shows a water level of 211 mAHD, whereas the water level at MB18 is around 201 mAHD, indicating a gradient from the confined coal seams into the aquitard overburden material. A key element of the MB18 hydrograph is the step change that occurred from March to September 2013. Erroneous or anomalous measurements were observed at some of the other monitoring bores for this period, and this complicates the interpretation of the likely source of this step change. It is possible a change was made to headworks or the reference point at the bore collar.

MB17, installed in the overburden material a further 500m to the southwest of MB18, showed response that is broadly in line with climatic trends from 2011 to 2017. Post 2017, the water level remained at around 196 despite a long-term decrease in climatic trend, even rising slightly towards end of monitoring dataset in 2020. Based on the relationship between MB17 and MB18, it is considered that there is relatively poor connection within the overburden units.

MB5 (coal seam), displays significant variability in groundwater level that cast doubt on the reliability of the monitoring data from this bore. Clustered results in mid-2012 through 2014 (ignoring July 2013 monitoring point) show groundwater level in the coal seam declining at a consistent rate in contrast to climatic trend. This may be attributed to influence of dewatering at the Ramp 56 South mining void approximately 1 km to the west of the bore.

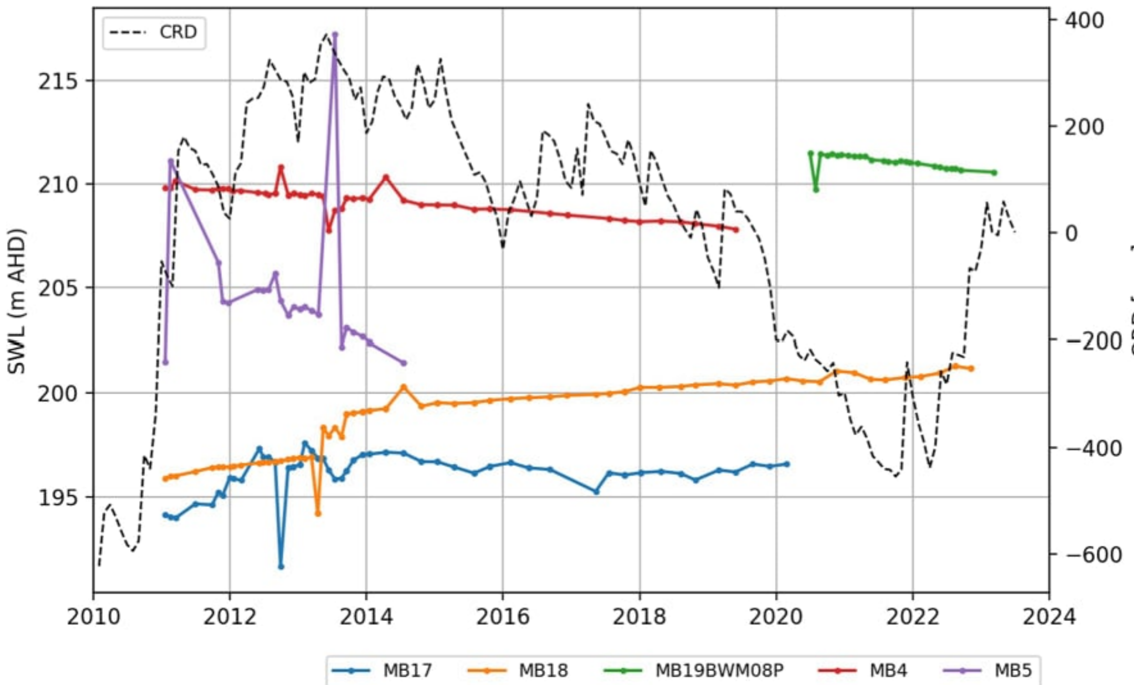


Figure 5-10 Standing Water Level in the Rangal Coal Measures, BWM Central

5.3.5.3 BWM South

The Southern Area is attributed to the BWM South. **Figure 5-11** shows the groundwater levels at bores MB6, MB15 and MB16 (refer to **Figure 5-1** for bore location). Groundwater levels indicate flow direction in the overburden to the north (from MB6 to MB15), in line with topographic gradients. The increasing water level trend observed at MB15 is thought to be related to recovery of water into the adjacent Kenmare underground workings (EMM, 2021).

Groundwater levels in the interburden are not correlated with the CRD. The water quality (**Section 5.4**) in the coal seams is mostly saline (**Table 5-8**) which could be due to low recharge rates and concentration of salts. Recharge is expected to occur primarily via leakage from the overlying Quaternary and Tertiary units, with greater recharge occurring in areas where the seams outcrops.

As reviewed in EMM (2021), previous investigations have generally considered the overburden and interburden sequences within the Rangal Coal Measures to be relatively impermeable and aquitards. Where saturated conditions exist, groundwater flow is likely toward the mine in proximity of the pits.

Since mid-2020, a stepwise decrease and then further slower decreasing trend were observed at MB6. There was no information provided about mining in the vicinity of this bore that could explain the sudden change, however this cannot be excluded as a cause. A QA/QC report on the water quality results (EMM, 2021a) stated that "*The screened interval for this bore is positioned above the current water level in the bore and it is likely that water is cascading down the inside of the bore*." Notably, the screened interval at this bore is at 11.7 to 25.7 mbgl, with the total bore depth at 48.7 mbgl. Since 2021, the bore recorded water levels below the screen. The study concluded that the bore construction might be compromised.

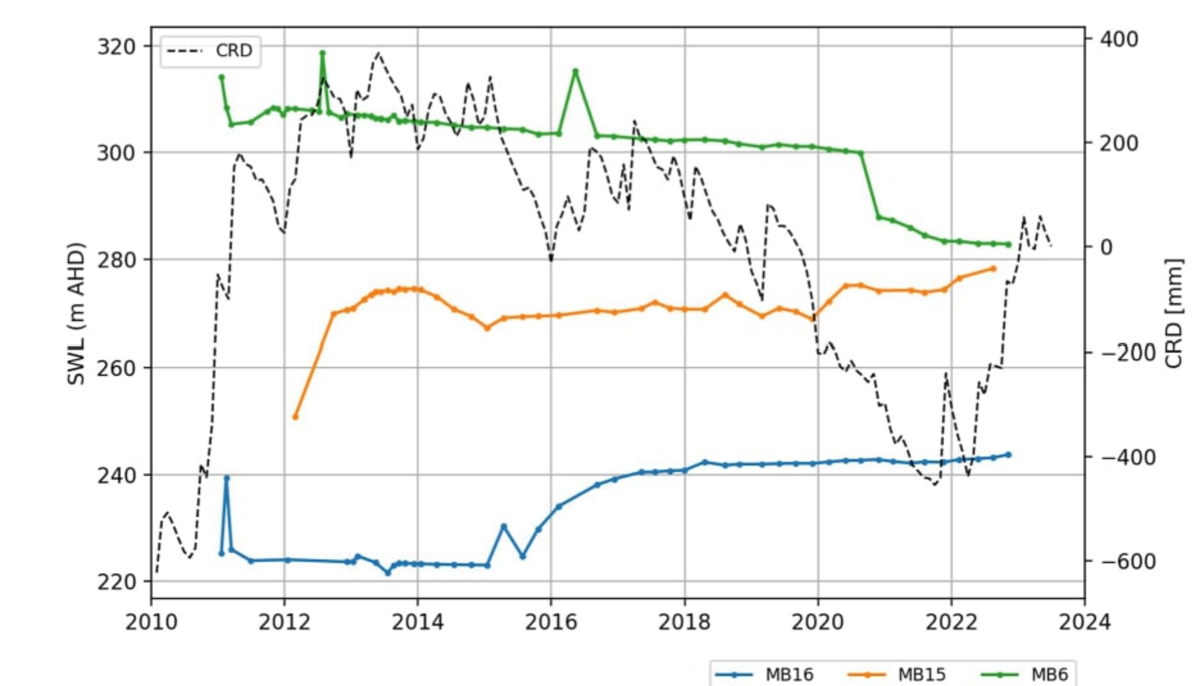
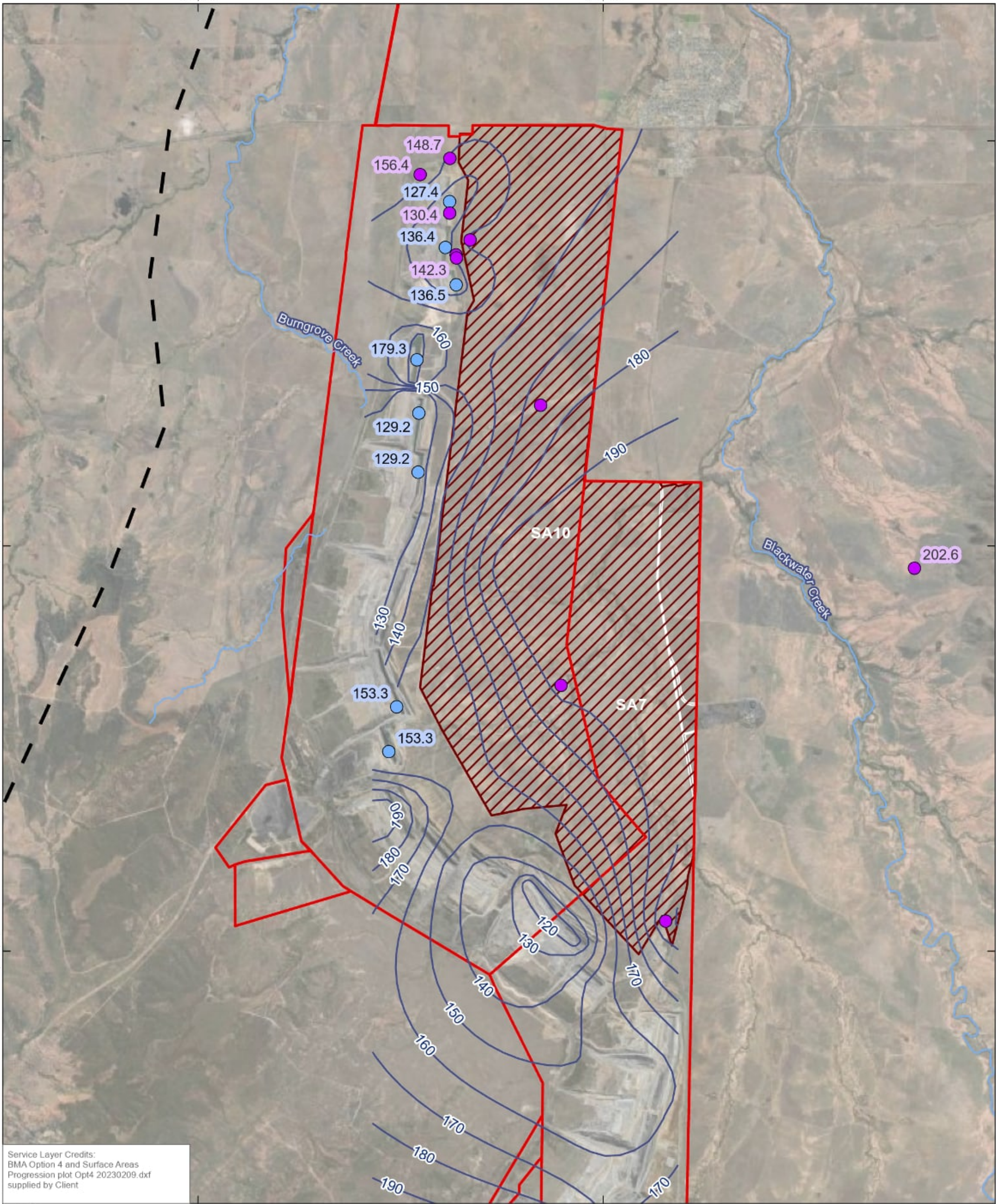


Figure 5-11 Standing Water Level in the Rangal Coal Measures – BWM South

5.3.5.4 Summary

An analysis of groundwater level trends in the Permian coal seams against the CRD indicate that the groundwater regime in the Permian coal seams is somewhat insulated from short term climatic effects, though depth and conductivity of the monitored horizon clearly influences this response. Through hydraulic connection with the mining areas there is some response in regional groundwater to mining depressurisation. Water quality (**Section 5.4**) in the Rangal Coal Measures seams are mostly saline (**Table 5-8**) which suggest long residence times related to low recharge rates and slow flow, resulting in water-rock interaction. Recharge to the coal seams is expected to occur primarily via leakage from the overlying Quaternary and Tertiary units, with greater recharge occurring in areas where the seams subcrop and outcrop. Based on the hydraulic gradients in overburden and coal seams, this is likely limited to the overburden horizons, with coal seam recharge occurring through mine surface water storages where the seams are hydraulically connected to the storages (e.g. in mining pits holding water), as illustrated by MB1 and lateral flow from outside of the study area (outcrop zones). Discharge from this formation is considered to be primarily through inflow to active mining areas, with a small proportion of total aquifer discharge being through horizontal flow outside of the cone of depression formed by mining void.

Groundwater level contours for the Aries seam are shown in **Figure 5-12**. The contours are based on groundwater level measurements from bores screened in the Aries seam, and on surveyed pit void water levels for March 2023. The Aries seam was selected as it has the highest number of data points and most recent data available for analysis, and it is expected that other coal seams would exhibit similar flow patterns. Pit water levels were also included to assist with the interpretation of water level contours in close proximity to the mined pits, and the observed water level elevation in the pits (where available) was used to infer the groundwater level in the Aries seam directly adjacent to the pit. The groundwater level contours show that the flow direction within the Aries seam is predominantly towards the mine, consistent with discharge to the active mine pits, as expected.



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:125,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Groundwater Level
- Pit Water Level
- Groundwater Contour (mAHD)
- Watercourse
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

GROUNDWATER LEVEL CONTOURS IN THE ARIES SEAM AND AVAILABLE PIT LAKE ELEVATIONS (MARCH 2023)

SLR

FIGURE 5-12

5.3.6 Burngrove Formation

There are two monitoring bores installed in the Burngrove Formation, both are located to the northwest of the Project. **Figure 5-13** show the standing water levels in these bores, 'BG No.1 AP' and 'BG No.2 BG'. The bores both show little variation in water level over the monitoring record, approximately 0.5 m for 'BG No.1 AP' and 1 m for 'BG No.2 BG', however these variations seem to follow the CRD and would indicate that the formation is responsive to climatic conditions. Based on observed groundwater elevations, groundwater flow is from south to north at this location, with the water level at 'BG No.2 BG' (south) being around 189 mAHD and the water level at 'BG No. 1 AP' (north) around 178 mAHD. Discharge from this formation is expected to be through lateral flow northward out of the study area.

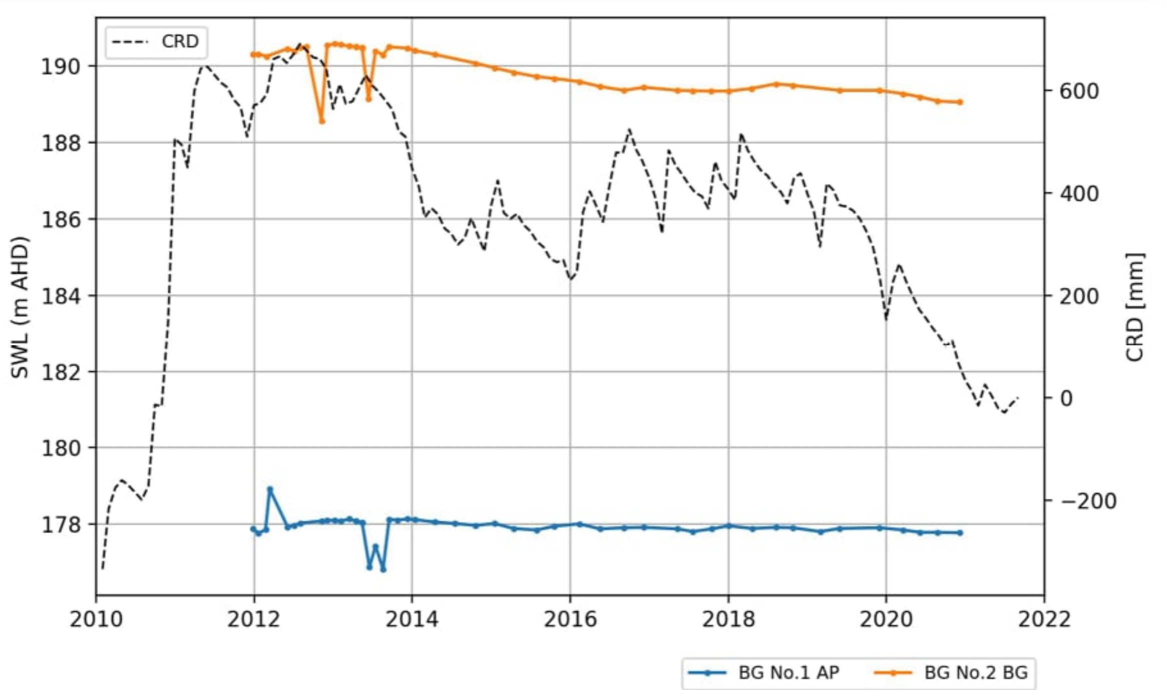


Figure 5-13 Standing Water Level in the Burngrove Formation

5.3.7 Vertical Flow between Units

There are two VWPs installed in the Project area, VWP19BWM01 and VWP19BWM02 (AGE, 2020). VWPs are groundwater level (pressure) monitoring infrastructure with multiple sensors installed at different depths allowing for collection of groundwater levels from multiple groundwater bearing zones in a single borehole. From the water pressure at each sensor, potential interactions between the groundwater bearing units can be interpreted.

VWP19BWM01 is located on ML1759 in the Northern Area, around 4 km east of the closest open-cut pit, which has a water level (or sump level) of 130 mAHD (**Figure 5-12**). The water level data for the VWP is presented in **Figure 5-14**, together with the CRD. Since the start of the recording in December 2019, the water levels in all sensors have declined continually. An exception is Sensor VW4 (Interburden 154 mbgl). The water level at that bore followed the shallower sensors (VWP1-3) closely, then increased in water levels, and has been stable at 196 mAHD since 2020. It is unknown whether this reflects the water levels in the interburden or if an instrument error is the cause for the difference in water levels. Furthermore, the Pollux seam monitoring (VW5 Pollux Seam 186 mbgl) shows flat response inconsistent with relative changes in rest of the monitoring profile and this sensor is not considered representative. **Figure 5-14** shows that the Aries Seam (VW3 Aries Seam 125 mbgl) and two vertical locations of the overburden (VW1 Overburden 46 mbgl and VW3

Overburden 104 mbgl) show similar water levels. Higher water level in the stable Aries Seam sensor (VW3 Aries Seam 125 mbgl) data post-2021 indicates that there is an upwards vertical gradient (confined aquifer) in the coal seams. This is consistent with the nested bore data discussed in **Section 5.3.5**. It is unclear if the water levels in the VWP follow a climatic pattern or are influenced by mining.

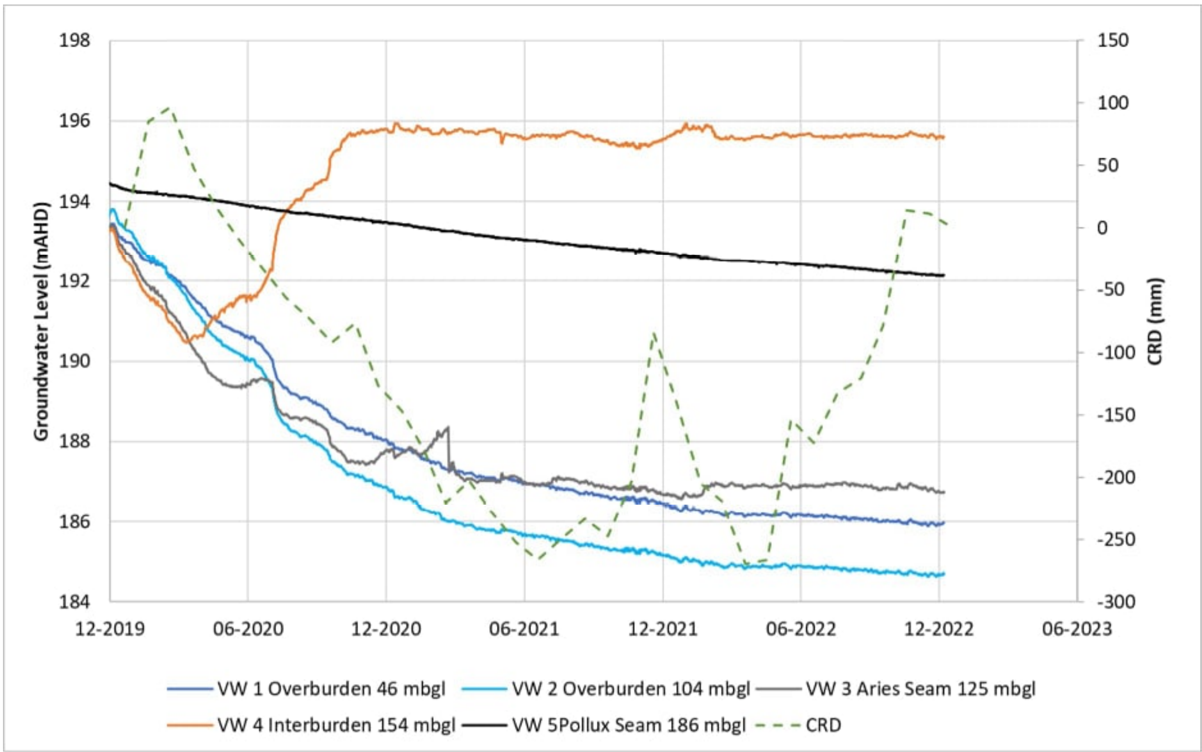


Figure 5-14 Groundwater Levels at VWP19BWM01 and CRD

VWP19BWM02 is located on ML1762 in the Central Area, around 500 m away from the closest pit (Ramp 52N). The water level data for the VWP is presented in **Figure 5-15**, together with the CRD. For this location the overburden (VW1) has a 30 m higher water level than the coal seams, which suggest a downward vertical flow gradient. In late 2022, the water level in all sensors sharply increases before fluctuating until the end of the monitoring record in a consistent pattern across all sensors (**Figure 5-15**). The similarity in responses across many of the sensors, and the timing of these responses broadly in line with when significant rainfall events or changes in mine water management may have occurred, could lead to the conclusion that these changes are climate related. However, standpipe bore MB4, which is located close by and is screened in the same formation, has historically not responded to climatic events, and hence it is more likely that the increase in water levels in late 2022 is related to a sensor error rather than a recharge event at depth.

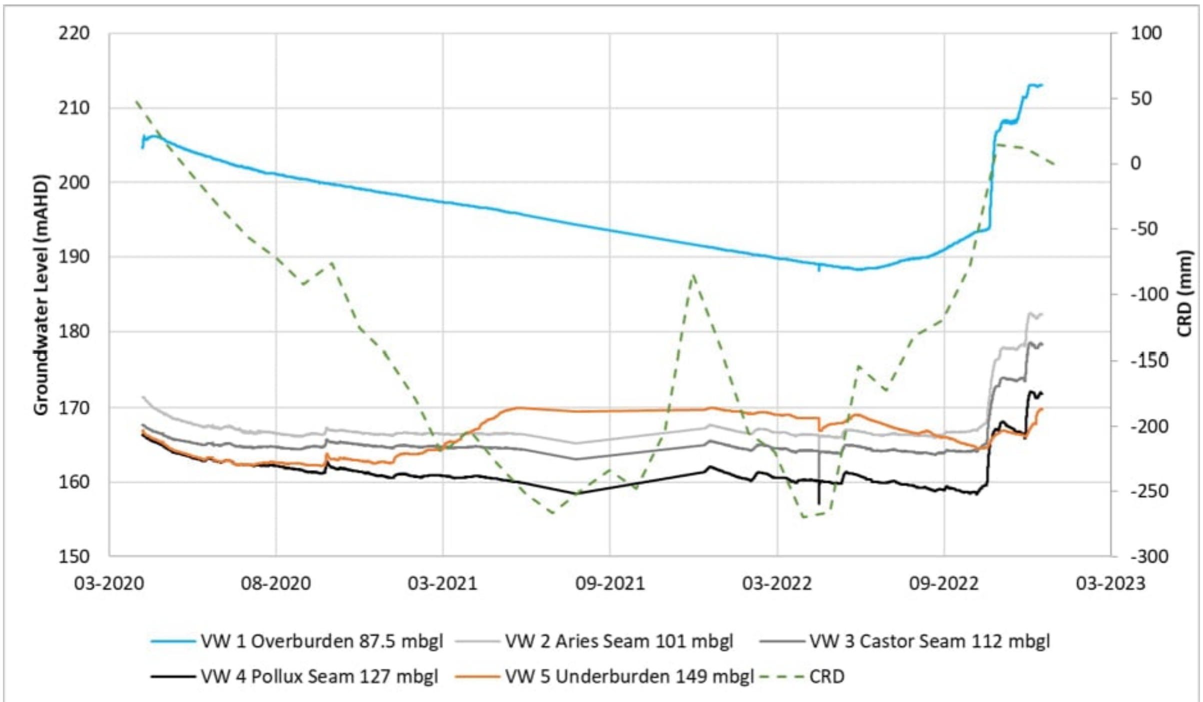


Figure 5-15 Groundwater Level at VWP19BWM02P and CRD

In addition to the VWP data, there are grouped standpipe bores where different levels within the stratigraphy are monitored with screened sections that are offset from one another vertically. These also contribute to the understanding of potential vertical groundwater gradients. Water level observations and inferred vertical flow are presented in **Table 5-6**. The locations of the bores are shown on **Figure 5-1**. The shallowest bore for both groups was found dry since installation in 2020 and for all subsequent monthly monitoring rounds. For both groups, the water levels in the Permian Coal Seam bores are higher than in the Rewan Group bores. This indicates that the Rewan Group is acting as a confining unit consistent with it being an aquitard. Groundwater pressure data shows consistent upwards gradient from the coal seams into the Rewan Group.

Table 5-6 Water Levels at Grouped Standpipe Bores

Group	Bore Name	Formation / Unit	Bore Depth (m)	Water Level (mAHD)
Group 1	MB19BWMB05A	Weathered Rewan	15	Dry
	MB19BWMB04R	Rewan Group	80	166–168
	MB19BWMB03P	Permian Coal Seam	231	172–178
Group 2	MB19BWMB07A	Alluvium	7	Dry
	MB19BWMB25P	Weathered Rewan	20	179–181
	MB19BWMB17P	Permian Coal Seam	189	193–194

5.3.8 Groundwater–Surface Water Interactions

Based on the water level data collected to date, and conceptualisations of groundwater flow within the Project area, groundwater interaction with ephemeral creeks is considered to be unlikely. As discussed in **Section 5.3.1**, the extent of alluvium is limited, both horizontally and vertically, suggesting dry conditions for most of that unit and water tables significantly below the creek beds. The Regolith (i.e. weathered Tertiary Sediments and weathered Rewan Group) is also unlikely to host significant groundwater. Where saturated, water levels in the Regolith are several meters below the base of the creek bed (**Section 5.3.4**).

At Blackwater South, intermittent hydraulic connectivity between the Regolith and surface drainages is inferred, as discussed in **Section 5.3.2**, however generally, there is no continual baseflow from the groundwater into the creeks given their ephemerality.

There is also the potential for interaction between mine surface water storages such as dams and pits, and the hydrogeological units hydraulically connected to them, as indicated by the inferred groundwater contours (**Figure 5-12**) in the Aries coal seam.

5.4 Groundwater Quality

Recent groundwater quality data (June 2020 to December 2022) are available for 17 Project bores (MB19BMW-series and MB20BMW-series). In addition, historical data are available for 25 bores across the mine site and its surroundings, for a timeframe between 2010 and 2020 (or shorter, where bores were damaged or lost). Summary statistics for all available parameters are presented in **Appendix A-2** (Table A2-1 on a per-bore basis and Table A2-2 on a per-formation basis). **Appendix A-2** also shows the Box-and-Whisker plots for selected bores.

Physicochemical parameters and metals are presented in detail in **Appendix A-2** and are discussed for each groundwater unit in **Section 5.4.1** and **Section 5.4.2**, respectively.

5.4.1 Physicochemical Parameters

Physicochemical groundwater quality parameters as listed in the current EA include:

- Major ions: calcium (Ca), sodium (Na), magnesium (Mg), potassium (K), sulphate (SO_4), chloride (Cl), Carbonate (CO_3) and bicarbonate (HCO_3).
- Electrical Conductivity (EC).
- Total Dissolved Solids (TDS).
- pH.

Major ions allow comparison of water types (ionic dominance) spatially and between aquifers. According to DES (2021), the analysis of major anions and cations enables characterisation of the groundwater regardless of the activity. The water type can also be used in conjunction with other physicochemical parameters, rainfall records and groundwater level measurements to inform groundwater flow, mixing of waters and hydrogeological processes.

Table 5-7 lists the 20th percentile, median and 80th percentile of the field pH dataset for the alluvium, Tertiary Sediments, the Rewan Group, the Rangal Coal Measures (Coal seam and interburden) and the Burngrove Formation. The waters are all slightly acidic to neutral, with median field pH values between 6.2 (Tertiary) and 7.2 (Burngrove Formation). It appears that pH generally increases with the depth of the formation, which, given rainfall pH is generally slightly acidic, is consistent with the shallower formations receiving rainfall recharge.

Table 5-7 Summary Statistics of Field pH Observations

Formation	Number of Observations	Field pH (pH units)				
		Minimum	20th percentile	Median	80th percentile	Maximum
Alluvium	NA	NA	NA	NA	NA	NA
Tertiary Sediments	138	2.9	4.2	6.2	6.6	8.1
Rewan Group	69	5.9	6.5	7.0	7.4	8.1
Rangal Coal Measures (Coal)	367	6.0	6.7	7.0	7.6	10.2
Rangal Coal Measures (Interburden)	321	4.5	6.5	6.9	7.3	8.9
Burngrove Formation	75	6.3	6.7	7.2	7.8	8.4

Table 5-8 lists the 20th percentile, median and 80th percentile for the EC (field) dataset for each formation. The most saline aquifer is the Rewan Group with a median EC of 33,864 µS/cm. The Rangal Coal Measures (Coal) shows a median EC of 18,034 µS/cm whilst both the Rangal Coal Measures (Interburden) and Burngrove Formation show a median EC around 11,000–13,000 µS/cm. The least saline formation is the Tertiary Sediments with a median EC of 7,280 µS/cm. However, even the Tertiary Sediments EC values are elevated to a point where they indicate generally poor water quality, that may not be suitable for all local beneficial uses (further discussed in **Section 5.5**).

Table 5-8 Summary Statistics of Field EC Observations

Formation	Number of Observations	Field EC (µS/cm)				
		Minimum	20th percentile	Median	80th percentile	Maximum
Alluvium	*NA*	NA	NA	NA	NA	NA
Tertiary Sediments	121	303	4,538	7,280	14,400	18,932
Rewan Group	42	4,253	4,976	33,864	34,724	37,915
Rangal Coal Measures (Coal)	310	1,203	11,601	18,034	21,388	40,000
Rangal Coal Measures (Interburden)	270	1,283	4,529	12,884	18,392	34,872
Burngrove Formation	68	5,390	6,551	11,045	15,821	19,317

A discussion of the physiochemical properties for each groundwater bearing unit is presented in **Section 5.4.1.1** to **Section 5.4.1.4**.

5.4.1.1 Alluvium

There are currently no observations available in the alluvium, due to limited groundwater presence in this unit as previously discussed. There is however groundwater quality data available from one bore that is part of the Minyango groundwater monitoring network (Minyango-MB9) (**Figure 5-2**). Sufficient data for statistical analysis for this bore is not available, although AGE (2013) notes the following:

- TDS is around 1,120 to 2,640 mg/L, indicating brackish water quality.
- Field pH is around 5, indicating acidic conditions consistent with recent rainfall recharge.
- The water type from this bore is Na-Ca-Cl-HCO_3 dominant.

5.4.1.2 Tertiary Sediments

The chemical analysis of groundwater for six bores targeting the Tertiary Sediments, from 2009 to 2022, is presented in the Piper Diagram on **Figure 5-16**. A Piper Diagram graphically represents the composition of the major ions of the groundwater samples, as expressed in chemical equivalent percentages. Results which group in a cluster represent a similar water type, with the water type defined according to the area which they plot on the Piper Diagram.

The results indicate that groundwater in the Tertiary Sediments is generally defined as sodium chloride type water and that it is dominated by sodium, potassium and chloride ions (**Figure 5-16**). The anions results are broadly scattered with groundwater in the Tertiary Sediments. A dominant sulphate signature and no dominant cations were observed at MB13, and a sodium bicarbonate type water dominated by sodium, potassium and bicarbonate ions is present at MB14. This large variation in the water type suggests that the groundwater in the Tertiary Sediments is representative of a heterogenous aquifer.

Groundwater in the Tertiary Sediments is generally saline (median EC of 7,280 µS/cm), though is highly variable and can range from fresh to saline (range of 303 to 18,932 µS/cm) (**Table 5-8**). Most bores show a large variability in EC, with the exception of MB14 that has lower EC in comparison to other bores, although MB14 has not been monitored since 2013 and has five data points.

Field pH data shows a wide range of pH (from 2.9 to 8.1) with a median value of 6.2. This data shows that the pH conditions are generally acidic consistent with receiving rainfall recharge contribution. Most bores are relatively stable, varying from around pH 5.2 to pH 6.5, with the exception of MB13 which shows much more variability (varying from pH 2.9 to pH 6.7). The lower end values for this bore, if reliable, indicate an external influence and therefore may not be considered representative of the broader aquifer for conceptualisation purposes.

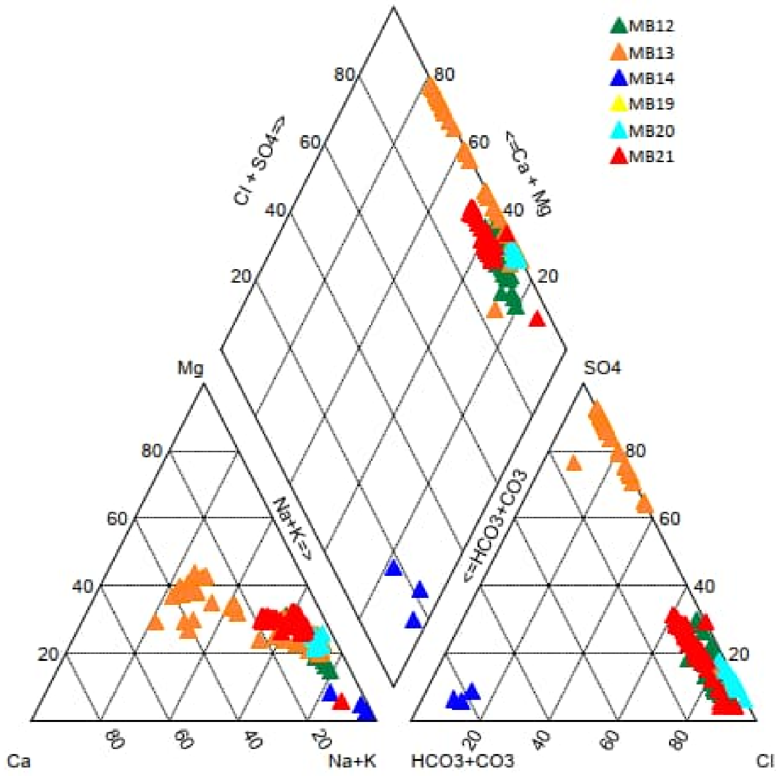


Figure 5-16 Piper Plot - Tertiary Sediments

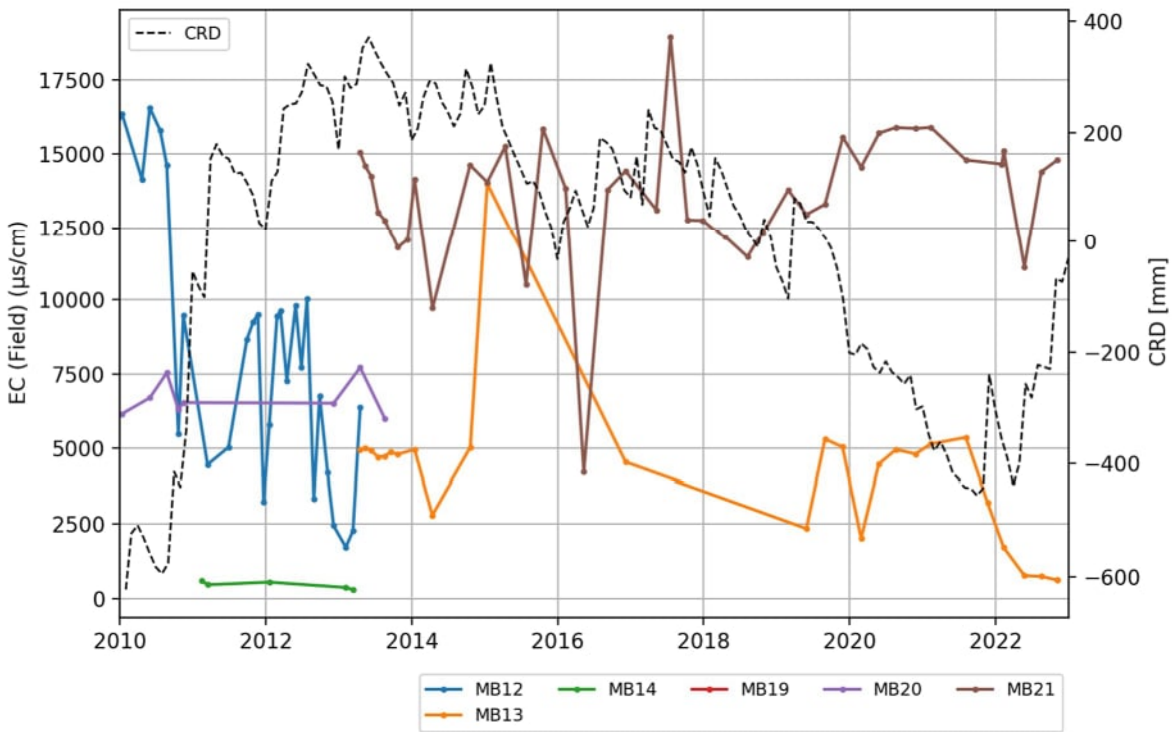


Figure 5-17 Electrical Conductivity (Field) - Tertiary Sediments

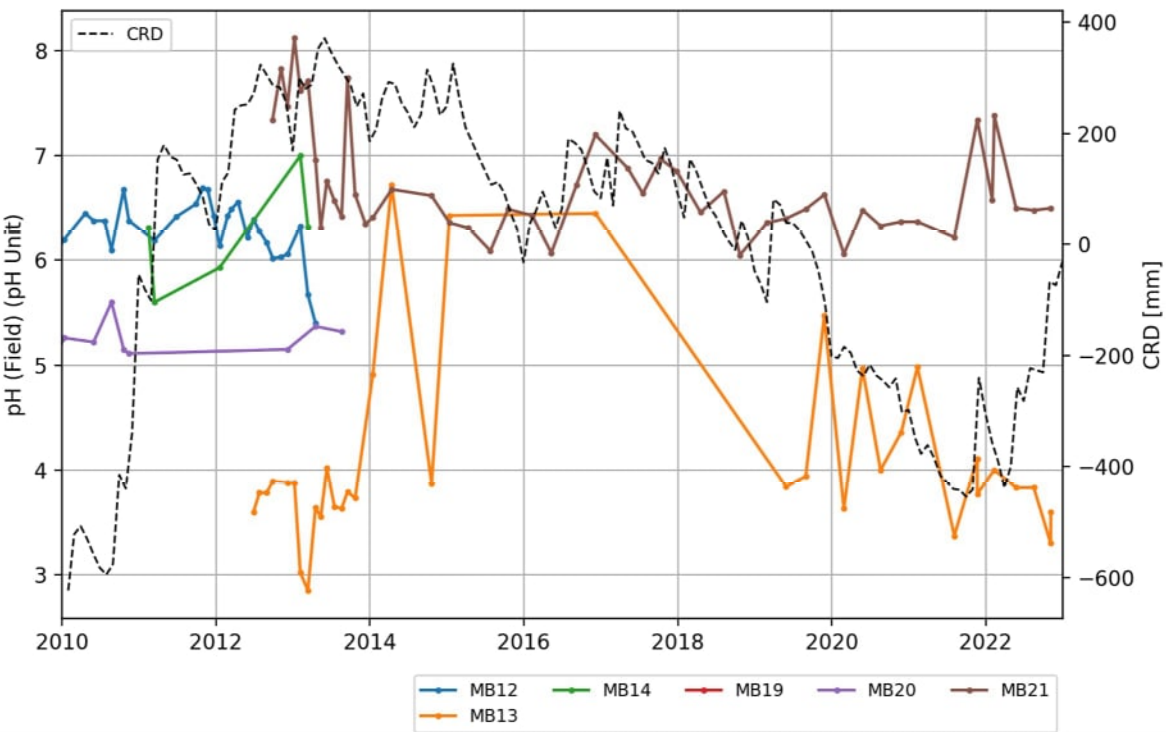


Figure 5-18 Field pH - Tertiary Sediments

5.4.1.3 Rewan Group

The chemical analysis of groundwater for two bores targeting the Rewan Group, from 2020 to 2022, is presented in the Piper Diagram on **Figure 5-19**. The results indicate that groundwater in the Rewan Group is defined as sodium chloride type water and that it is dominated by sodium, potassium and chloride ions. The results are tightly clustered which suggests that groundwater in the Rewan Group has a distinct water chemistry. Also, it appears that groundwater in the Rewan Group is dominated by chloride ions (i.e. strong acid, fully ionised in water) rather than bicarbonate ions (weak acid).

Groundwater in the Rewan Group is generally saline (median EC of 33,864 µS/cm), ranging from brackish to saline (EC range of 4,253 to 37,915 µS/cm). EC appears to be relatively stable in the available record, however, has only been monitored since 2021.

Field pH for all bores is stable pH (median value of 6.7 with a range of 5.9 to 8.1), indicating the groundwater is mildly acidic to neutral (**Figure 5-21**).

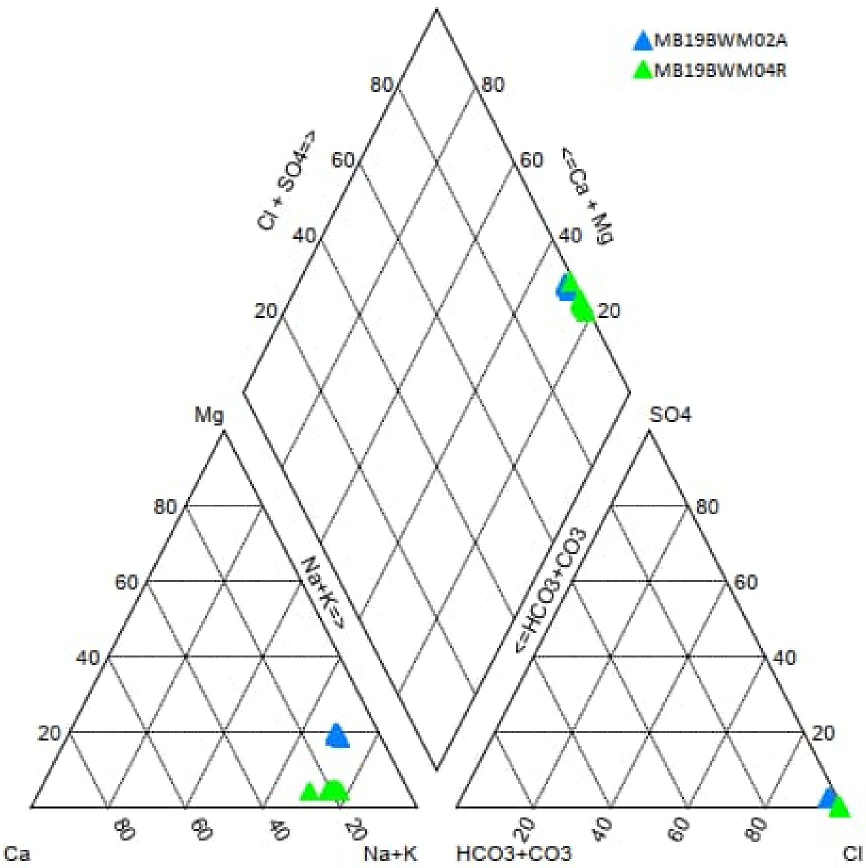


Figure 5-19 Piper plot - Rewan Group

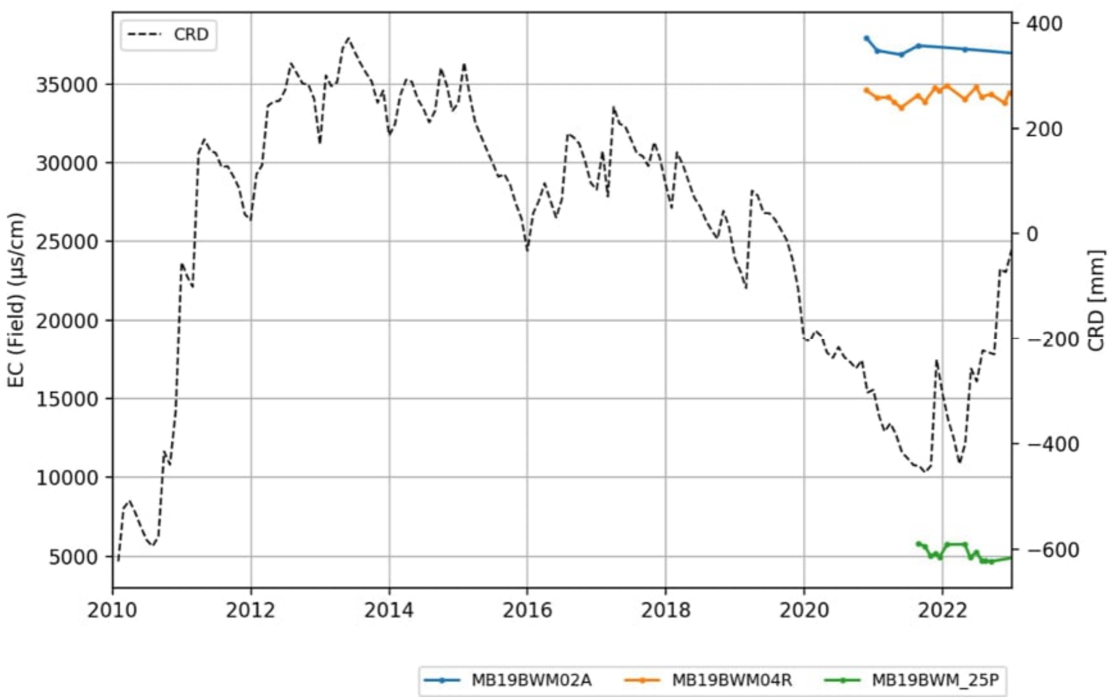


Figure 5-20 Electrical Conductivity (Field) - Rewan Group

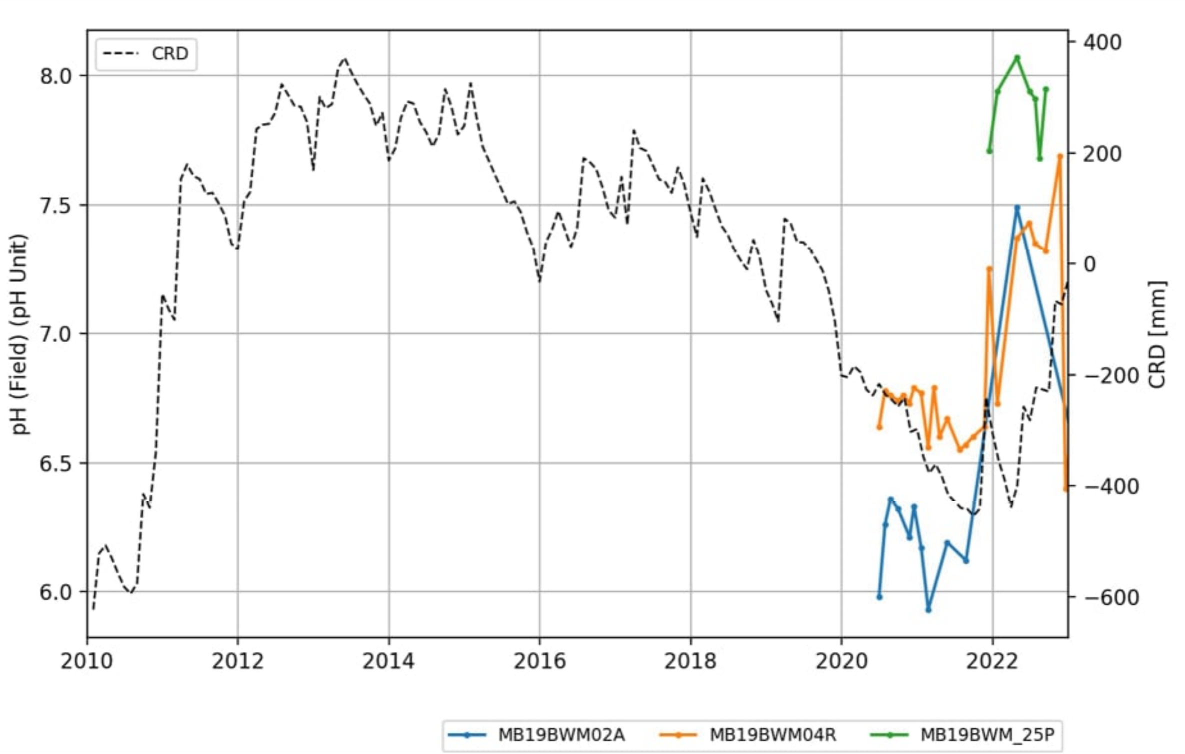


Figure 5-21 Field pH - Rewan Group

5.4.1.4 Rangal Coal Measures

The chemical analysis of groundwater for sixteen bores targeting the Rangal Coal Measures, from 2009 to 2023, is presented in the Piper Diagram on **Figure 5-22**.

The results indicate that groundwater within the Boonie Doon Area (**Figure 5-22-A**), South Area (**Figure 5-22-B**) and North Area (**Figure 5-22-C**) is defined as sodium chloride type water dominated by sodium, potassium and chloride ions, and is driven by chloride ions (i.e. strong acid, fully ionised in water) rather than bicarbonate ions (weak acid).

The results indicate groundwater within the Central Area (**Figure 5-22-D**) is generally defined as sodium chloride type water dominated by sodium, potassium, chloride and sulphate ions. However, the water type is influenced by bicarbonate ions contributed by MB17, where the ionic concentrations change over time, as indicated by a broad scatter in the plotted results for MB17 in the Piper Diagram.

Groundwater in the Rangal Coal Measures is generally saline (median EC of 13,188 µS/cm) but ranges from brackish to saline (range from 1,203 to 40,000 µS/cm) (**Table 5-8** and **Figure 5-23**).

Field pH is generally stable and near neutral, ranging from 4.5 to 10.2 with a median value of 7.0 in bores targeting coal and 6.9 in bores targeting the interburden (**Table 5-7** and **Figure 5-24**). However, outliers occur at MB19BWM01P and MB19BWM03P with field pH maximum values of 10.2 and 9.6 respectively. These bores have recently been drilled and the elevated pH may be due to water interaction with residual cement grout from the bore construction.

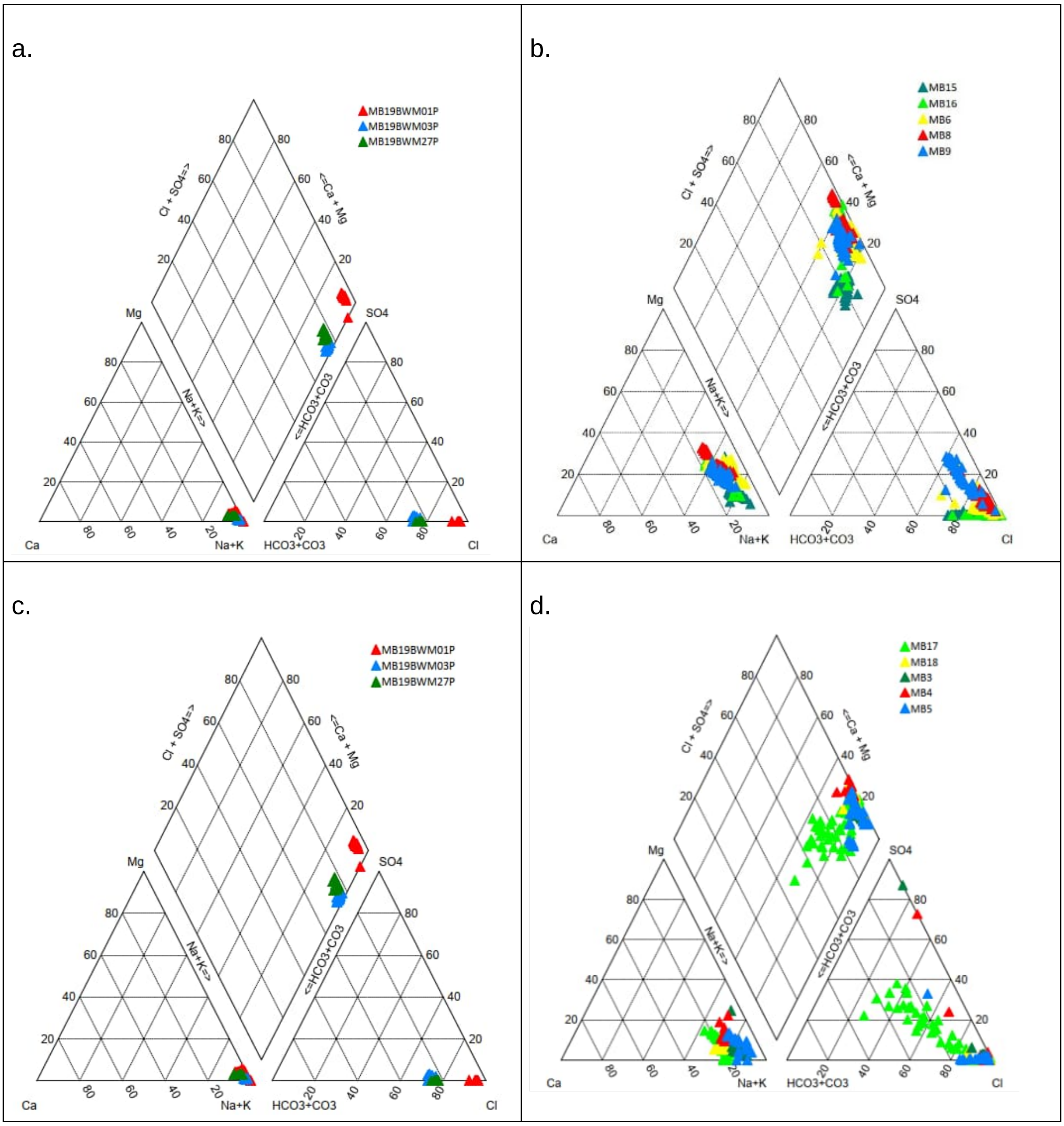


Figure 5-22 Piper Diagram - Rangal Coal Measures (a. Bonnie Doon; b. South; c. North; and d. Central)

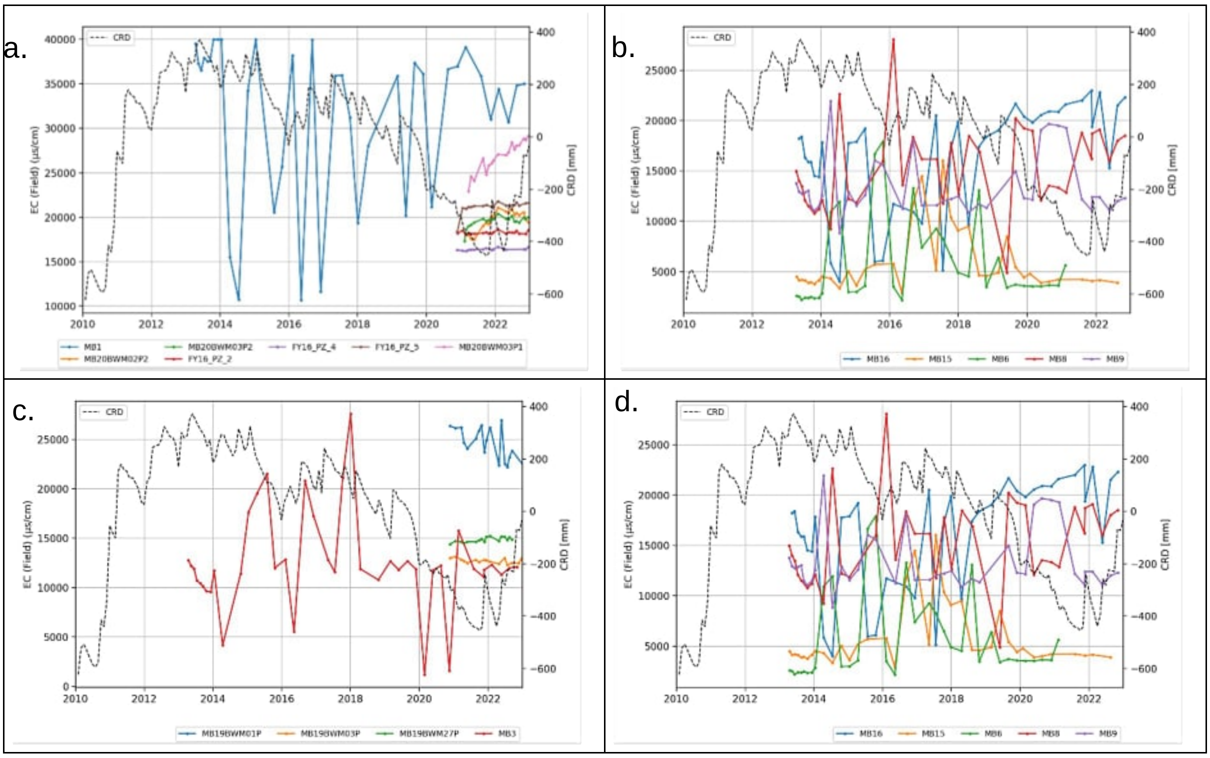


Figure 5-23 Field EC - Rangal Coal Measures (a. Bonnie Doon; b. South; c. North; and d. Central)

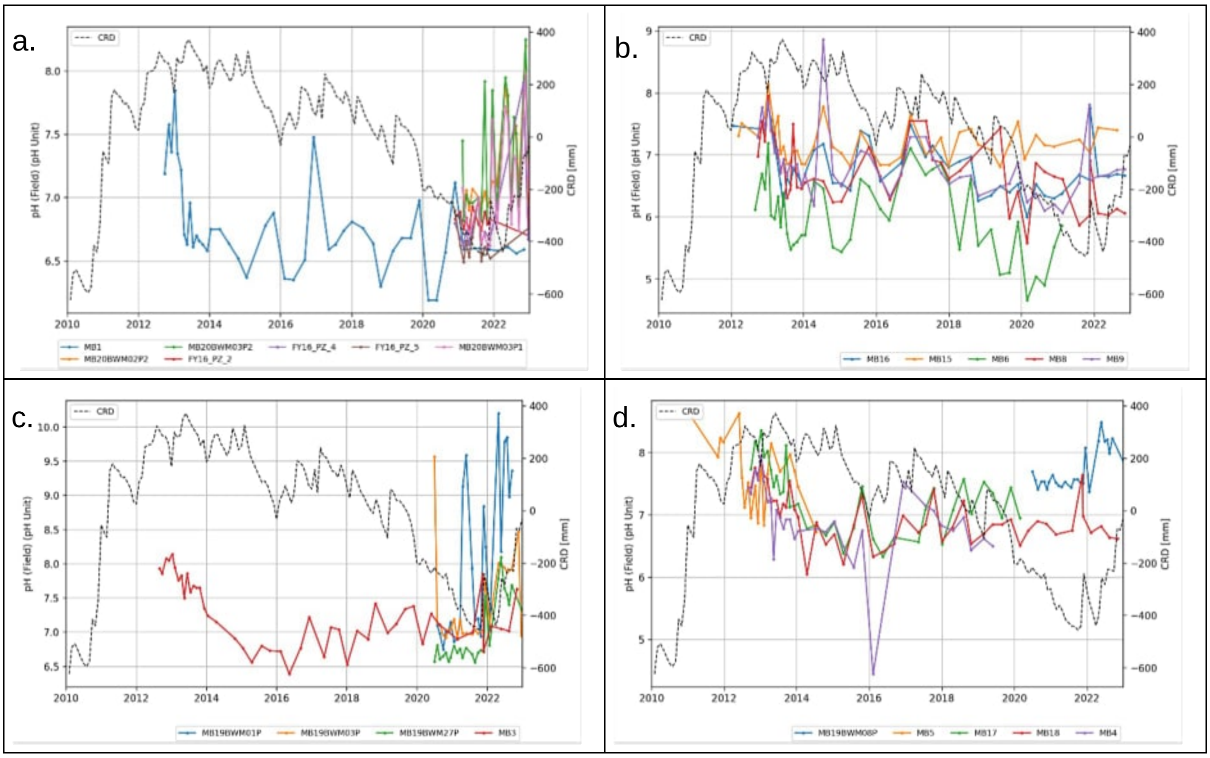


Figure 5-24 Field pH - Rangal Coal Measures (a. Bonnie Doon; b. South; c. North; and d. Central)

5.4.1.5 Burngrove Formation

The chemical analysis of groundwater for two bores targeting the Burngrove Formation, from 2011 to 2020, is presented in the Piper Diagram on **Figure 5-25**. The results indicate that groundwater in the Burngrove Formation is defined as sodium chloride type water and that it is dominated by sodium, potassium and chloride ions. The results are tightly clustered which suggests that groundwater in the Burngrove Formation has a distinct water chemistry. Also, it appears that groundwater in the Burngrove Formation is driven by chloride ions (i.e. strong acid, fully ionised in water) rather than bicarbonate ions (weak acid).

The groundwater is saline (median EC of 11,045 µS/cm, ranging from 5,390 to 19,317 µS/cm) (**Table 5-8**). Field pH data shows a pH range of 6.3 to 8.4 with a median value of 7.2 (**Table 5-7**) indicating the groundwater pH is generally neutral.

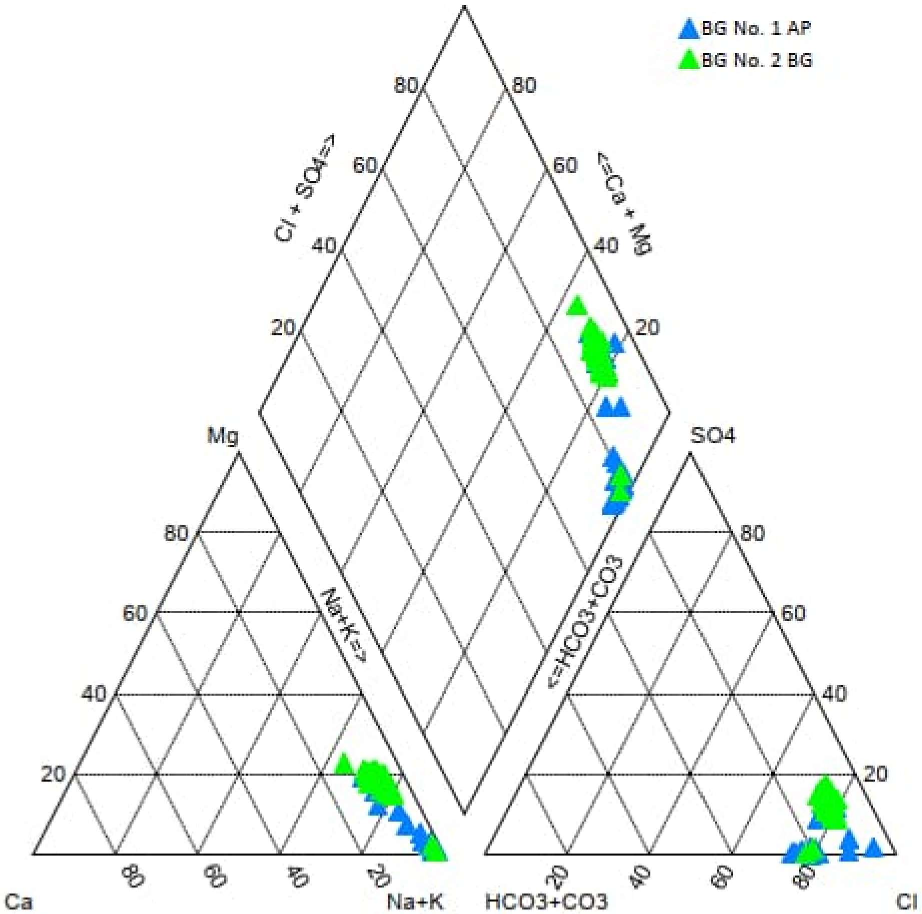


Figure 5-25 Piper Diagram - Burngrove Formation

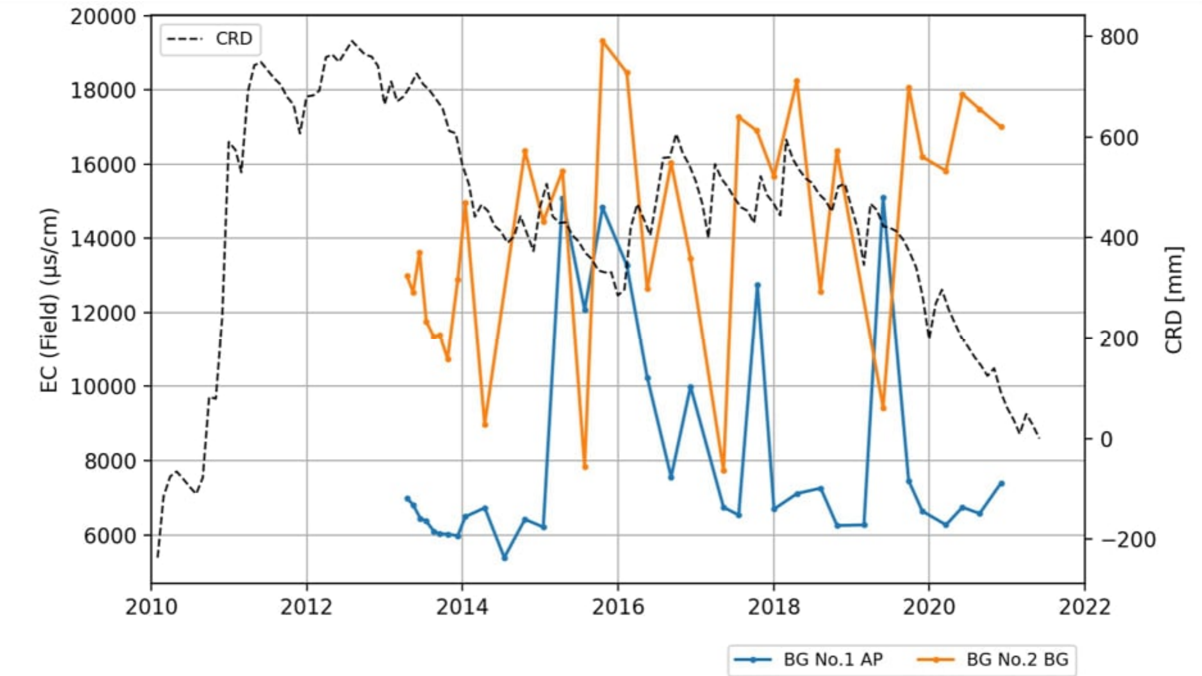


Figure 5-26 Field EC - Burngrove Formation

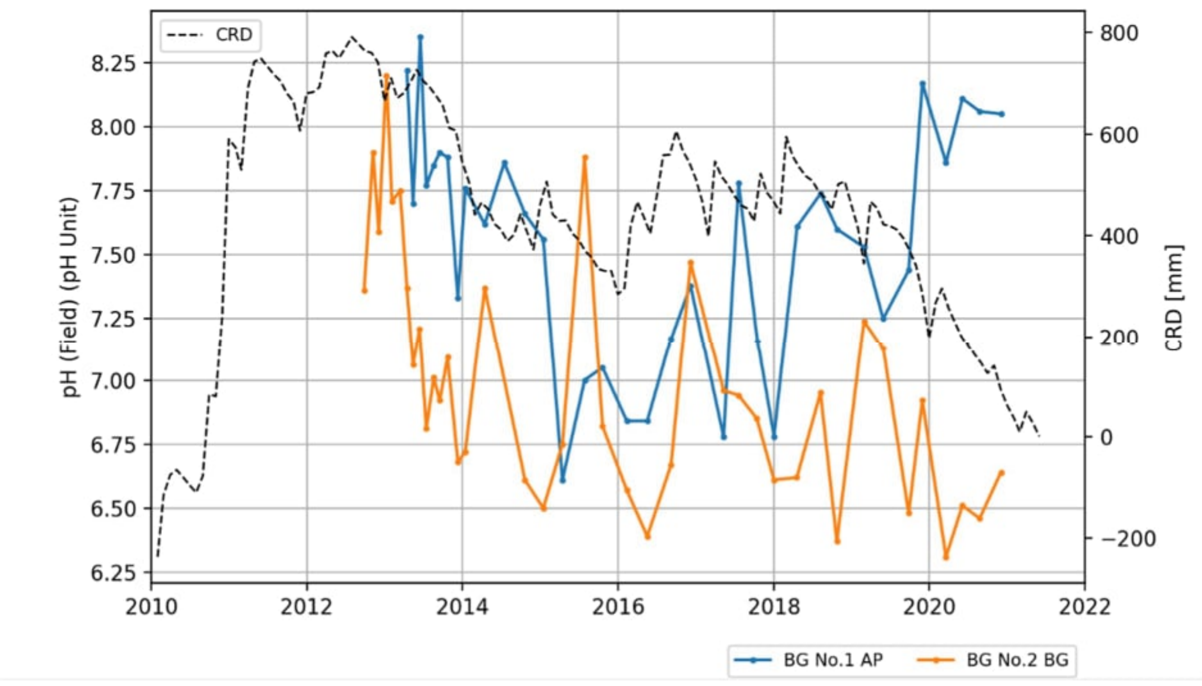


Figure 5-27 Field pH - Burngrove Formation

5.4.2 Metals

A total of eight metals and metalloids are routinely monitored as per requirements of the EA, these are iron, aluminium, silver, arsenic, mercury, antimony, molybdenum and selenium.

Available guideline values for EA metals and metalloids are shown in **Table 5-9,** namely for the ANZECC (2018) guidelines for aquatic ecosystem protection (95% limit of protection) and stock watering where available (ANZG, 2018). A summary statistic table for water quality data by bores is included as **Appendix A-2,** together with Box-and-Whisker plots.

Table 5-9 Guideline Values for EA Metals and Metalloids

EA Metal / Metalloid	Stock Watering Guideline (mg/L)	ANZECC Guideline Aquatic Ecosystem (95% protection) (mg/L)
Aluminium (Total)	5	NA
Aluminium (Dissolved)	NA	0.055[1]
Antimony (Total)	NA	NA
Antimony (Dissolved)	NA	0.009[2]
Arsenic (Total)	0.5	NA
Arsenic (Dissolved)	NA	0.013[3]
Selenium (Total)	0.02	0.005[4]
Mercury (Total)	0.002	NA
Mercury (Dissolved)	NA	0.0006
Molybdenum (Total)	0.15	NA
Molybdenum (Dissolved)	0.15	0.034[2]
Silver (Dissolved)	NA	0.00005

[1] pH must be >6.5
[2] 'Unknown %' protection limit applied in the absence of a 95% protection limit
[3] Adopted value for (AsV) (lower value)
[4] To account for bioaccumulation, the 99% protection limit was used (ANZG, 2018).

The following **Sections 5.4.1.1** to **5.4.1.5** discuss the metals parameters for which the 80th percentile of the available dataset are above the guideline values presented in **Table 5-9**. Refer to **Appendix A-2** for the full dataset statistics. For the purposes of this statistical analysis, values reported as below the laboratory Limit of Reporting (LOR) in the dataset have been assigned a value equal to half of the LOR, consistent with the relevant DES (2021) Guideline.

5.4.2.1 Alluvium

There are currently no groundwater bores monitoring bores in the alluvium, for the reasons already discussed.

5.4.2.2 Tertiary Sediments

Sufficient water quality (metals) samples have been collected from the Tertiary Sediments to conduct a statistical analysis.

The 80th percentile for metal and metalloid EA analytes when compared to available guidelines are mostly below guideline values in the Tertiary Sediments, except for Aluminium (Total) (11.9 mg/L exceeds the recommended ANZECC stock watering guideline of 5 mg/L).

The 80th percentile value for silver and selenium were not calculated since the analytical data collected for these metalloids are all below the LOR limits. However, the LORs for those analytes are currently too high to assess values against the ANZECC guidelines. BWM is in the process of developing groundwater contaminant trigger levels for Table I2 of the EA.

5.4.2.3 Rewan Group

The 80th percentile for metal and metalloid EA analytes are below guideline values in the Rewan Group.

As with the Tertiary Sediments, the 80th percentile value for silver and selenium were not calculated since the analytical data collected for these metalloids are all below the LOR limits. However, the LORs for those analytes are currently too high to assess the values against the ANZECC guidelines.

5.4.2.4 Rangal Coal Measures

The 80th percentile for metal and metalloid EA analytes are mostly below guideline values in the Rangal Coal Measures. The 80th percentile value for silver and selenium were not calculated since the analytical data collected for these metalloids are all below the LOR limits. However, the LORs for those analytes are currently too high to assess the values against the ANZECC guidelines.

5.4.2.5 Burngrove Formation

The 80th percentile for metal and metalloid EA analytes are mostly below guideline values in the Burngrove Formation. The 80th percentile value for silver and selenium were not calculated since the analytical data collected for these metalloids are all below the LOR limits. However, the LORs for those analytes are currently too high to assess the values against the ANZECC guidelines.

5.5 Groundwater Use and Management

The study area lies within the Highlands and Carnarvon GMAs under the Water Plan (Fitzroy Basin) 2011 (DEHP, 2011).

The study area covers zone 36 of the groundwater chemistry zone of WQ1310 of the EPP Water and Wetland Biodiversity. The relevant scheduled WQO are presented in the statistical summary table in **Appendix A-2**.

Environmental Values pertinent to the Project are listed in DEHP (2011b) as:

- Aquatic ecosystems.
- Irrigation.
- Farm supply/use.
- Stock water.
- Primary recreation (Comet Groundwaters only).

- Drinking water.
- Industrial use.
- Cultural and spiritual values.

As presented in **Section 5.4**, the groundwater quality in the vicinity of the Project area is typically brackish to saline and generally not suitable for drinking.

Although groundwater in the vicinity of the Project area may have cultural and spiritual values, none were identified in the literature reviewed.

5.5.1 Groundwater Dependent Ecosystems

This section summarises the desktop review in relation to groundwater dependent ecosystems (GDEs). An ecohydrogeological model is presented in **Section 5.7.**

5.5.1.1 Identification of GDEs

Ecosystems (aquatic, terrestrial and subterranean) that are dependent or partially dependent on groundwater, or that may be impacted by change in groundwater quality and levels, are referred to as groundwater dependent ecosystems (GDEs).

GDE mapping is available from:

- The Bureau of Meteorology's GDE Atlas (BoM, 2023).
- Department of Environment and Science, Queensland (2019) WetlandMaps - Interactive Maps and Wetlands Data in Queensland, (WetlandInfo website, accessed 30 November 2023. Available at: https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/get-mapping-help/wetland-maps/).

The datasets contains four main data types which can be grouped into the three categories of GDEs:

- Terrestrial GDEs, typically associated with vegetation that may access groundwater.
- Aquatic GDEs (and surface line expressions), typically associated with pooled water at surface.
- Subterranean GDEs, typically associated with subterranean fauna.

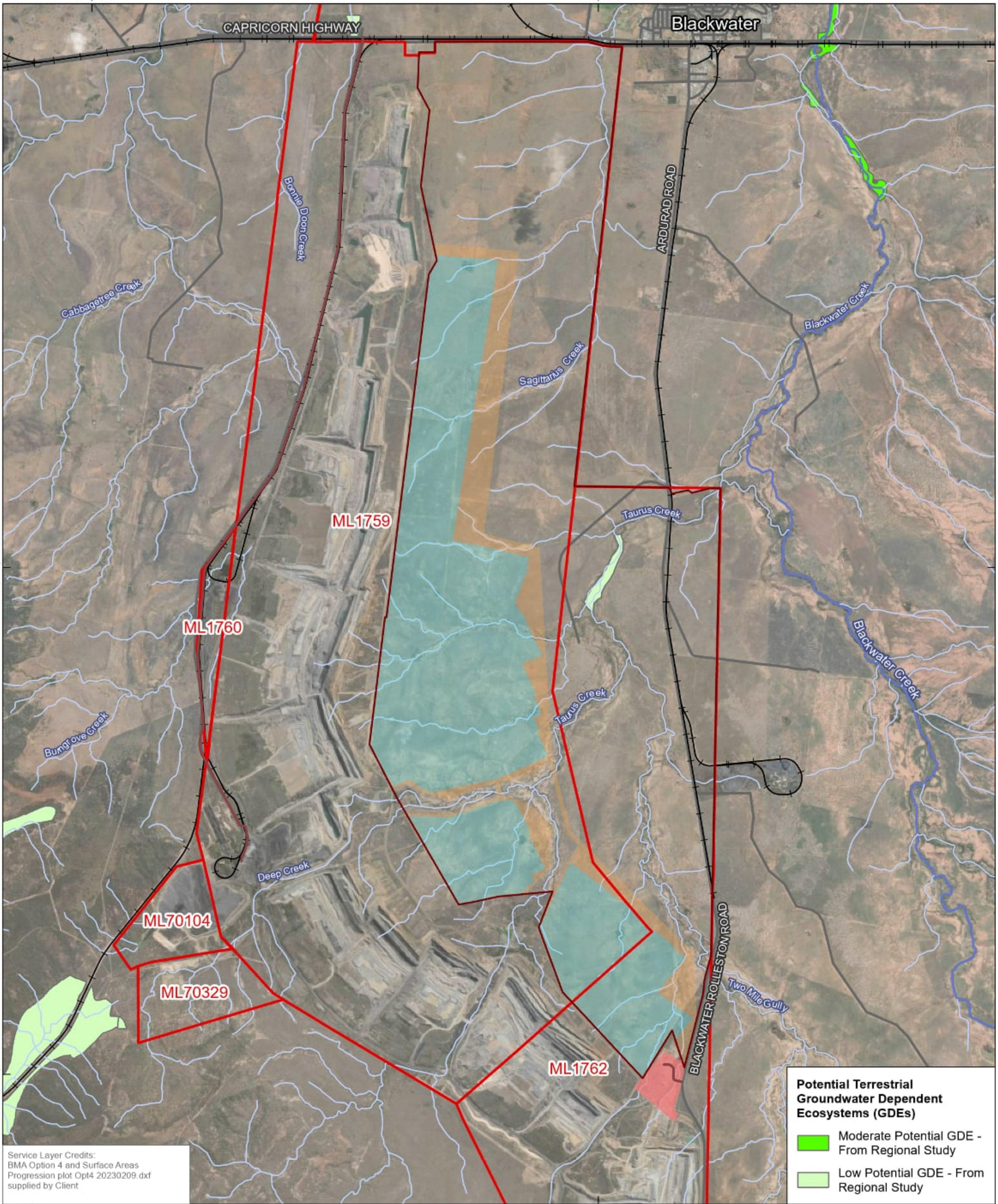
The datasets contain information on both known and potential GDE areas. The datasets were queried to assess the presence of GDEs within the Project area and surrounds.

5.5.1.2 Terrestrial GDEs

Potential terrestrial GDEs identified within the Project area and surrounds by government mapping are shown in **Figure 5-28** and summarised as follows:

- No known terrestrial GDEs are mapped within the Project area or surrounds.
- Potential terrestrial GDE areas derived with low and moderate confidence, including:
  - o In the Project area: a low confidence terrestrial GDE along Taurus Creek.
  - o Downstream of the Project area: a moderate confidence terrestrial GDE along Blackwater Creek.

The potential for the ground-truthed regional ecosystems within the Project area to represent potential terrestrial GDEs has been assessed by EMM (2023) as part of the Terrestrial Ecology MNES Assessment (EMM, 2023). EMM (2023) utilised the existing depth to water table mapping prepared by RDM Hydro Pty Ltd (RDM Hydro) et al. (2023) (described in Section 5.7.1) and information on maximum plant rooting depths to determine whether the water table exceeds or is within the rooting depths of the vegetation. **Figure 5-29** shows the ground-truthed regional ecosystems that represent potential terrestrial GDEs within the Project area (EMM, 2023).



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	07-Dec-2023
Drawn by:	NT

LEGEND

- Railway
- Mine Acces Road
- Road
- Minor Watercourse
- Major Watercourse
- BWM Mining Lease
- BWM North Extension Project Area
- Existing Mine Infrastructure Area

Indicative Project Footprint

- Proposed Out of Pit Disturbance
- Proposed Pit Extent

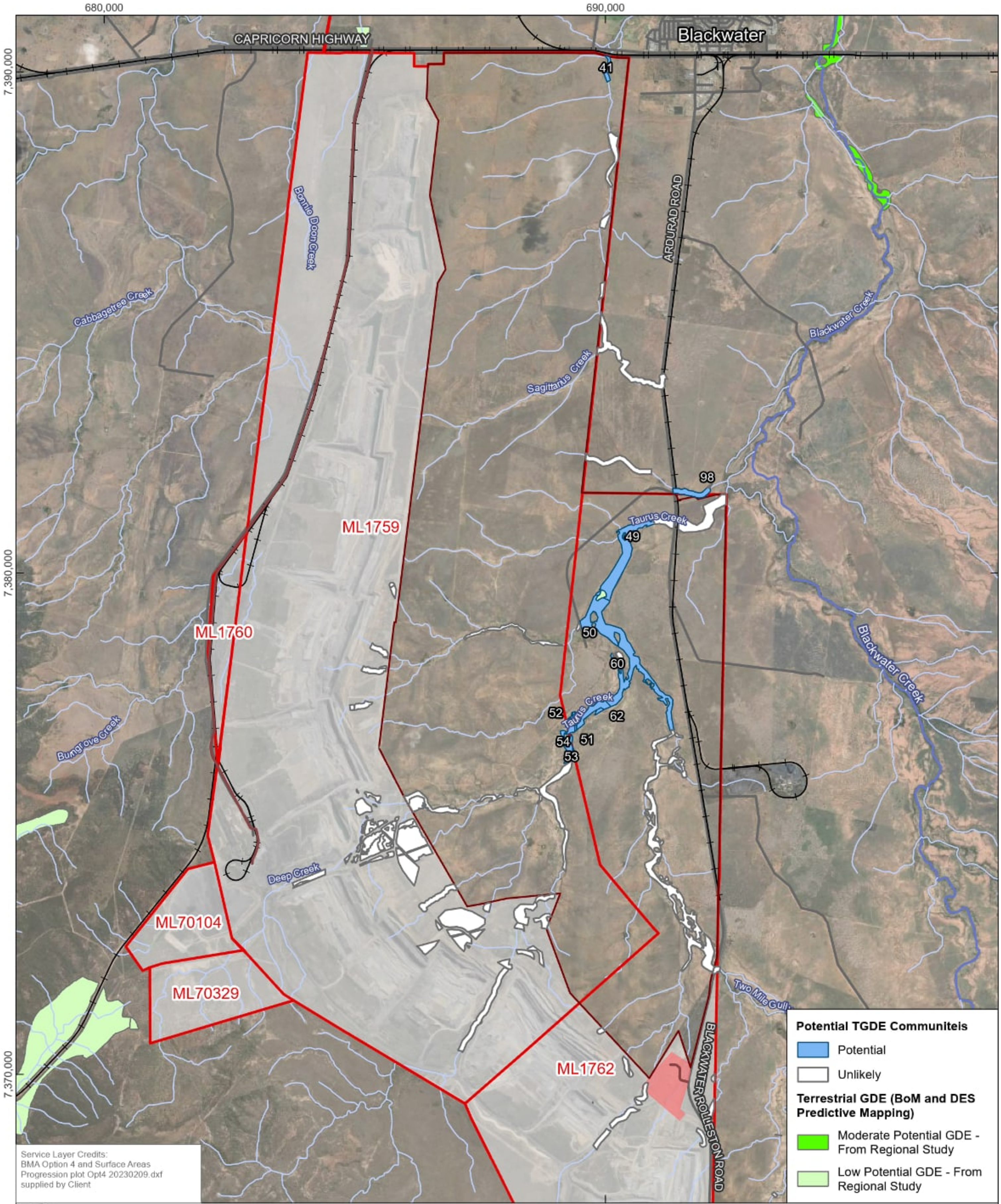
BLACKWATER MINE - NORTH EXTENSION PROJECT

PREDICTED TERRESTRIAL GROUNDWATER DEPENDENT ECOSYSTEMS (BoM AND DES PREDICTICE MAPPING)

SLR

FIGURE 5-28

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_28_GDE Terrestrial



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	12-Dec-2023
Drawn by:	NT

LEGEND

- Railway
- Road
- Mine Acces Road
- Minor Watercourse
- Major Watercourse
- Existing Blackwater Mine
- BWM Mining Lease
- BWM North Extension Project Area
- Existing Mine Infrastructure Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

POTENTIAL TERRESTRIAL GDE COMMUNITIES IN AND ADJACENT TO THE PROJECT AREA (EMM, 2023)

SLR

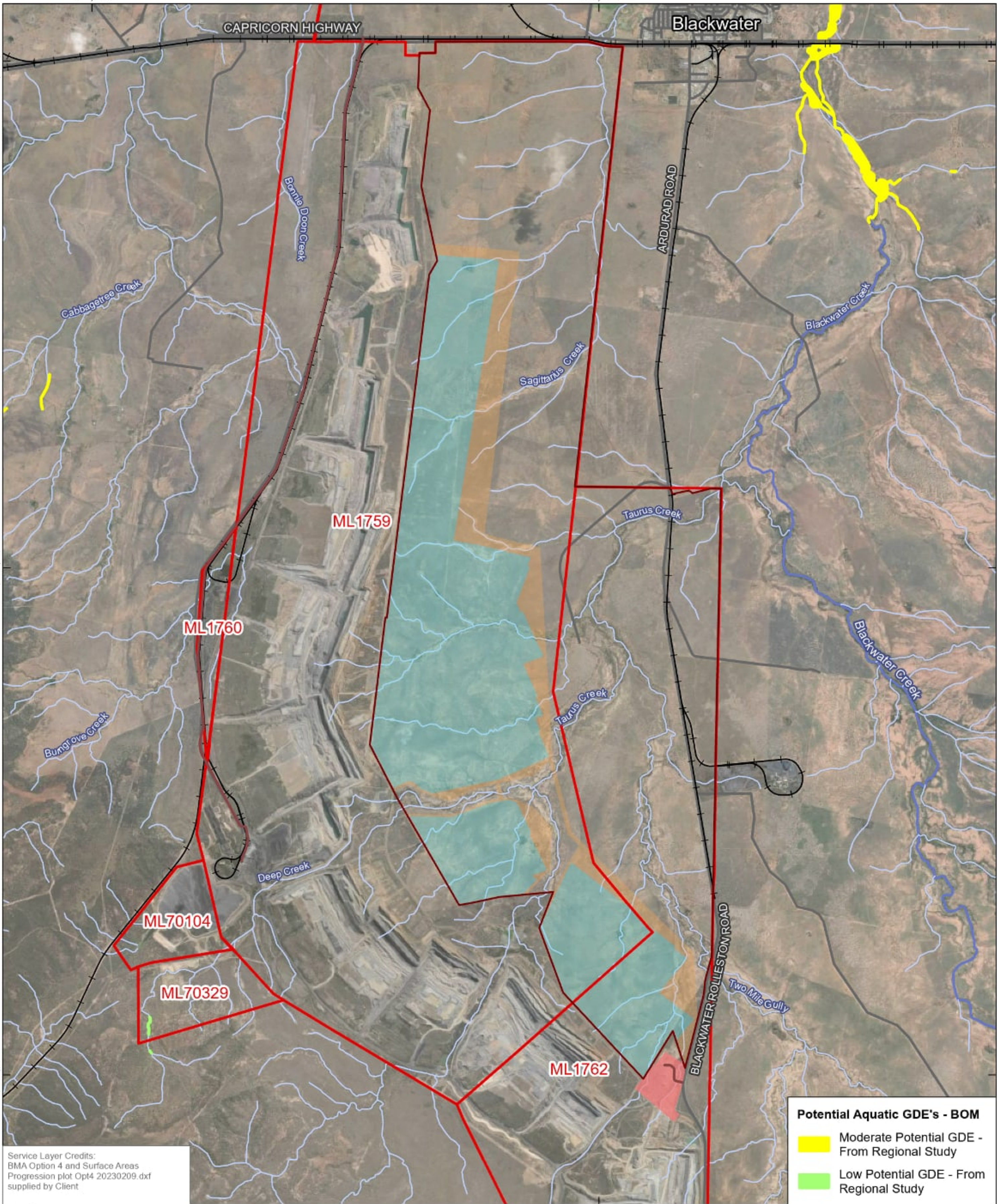
FIGURE 5-29

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_29_GDE Identified by EMM

5.5.1.3 Aquatic (Surface Expression) GDEs

Potential aquatic (i.e. surface expression) GDEs identified within the Project area or surrounds by government mapping are shown in **Figure 5-30** and summarised as follows:

- No known aquatic GDEs are mapped within the Project area or surrounds.
- Potential aquatic GDE areas derived with moderate confidence (downstream of the Project area on Blackwater Creek).
- Surface expression GDE derived with low and moderate confidence.



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	12-Dec-2023
Drawn by:	NT

LEGEND

- Railway
- Road
- Mine Acces Road
- Minor Watercourse
- Major Watercourse
- BWM Mining Lease
- BWM North Extension Project Area
- Existing Mine Infrastructure Area

Indicative Project Footprint

- Proposed Out of Pit Disturbance
- Proposed Pit Extent

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

POTENTIAL AQUATIC GDEs AND GDE SURFACE LINES WITHIN 10 KM OF THE PROJECT AREA

FIGURE 5-30

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_30_GDE_Aquatic

5.5.1.4 Potential GDE aquifer and subterranean GDE areas

Aquifers have the potential to support subterranean fauna (stygofauna) as GDE, however no potential subterranean GDE areas are mapped within 10 km of the Project area by the BoM or DES.

A stygofauna assessment conducted by Freshwater Ecology (2021) at BWM did not find any stygofauna. The assessment was a detailed investigation that involved the sampling of 10 groundwater bores in accordance with the methods defined in *Queensland Environment Protection (Water) Policy 2009 – Monitoring and Sampling Manual: 'Sampling Bores for Stygofauna'* (QEPA 2018); '*Background information on Sampling Bores for Stygofauna'* (QEPA, 2018) and following established sampling techniques used elsewhere in Australia and overseas (Hancock & Boulton 2008, Dumas & Fontanini 2001, WA EPA Guidance Statements 54 and 54a 2003 & 2007).

As discussed in **Section 5.4.1.1** to **Section 5.4.1.4** groundwater in the Project area is generally brackish to saline and generally in excess of 5,000 µS/cm. According to Hancock and Boulton (2008), most stygofauna collected from alluvial aquifers in New South Wales and Queensland prefer salinities less than 5,000 µS/cm. Therefore, there is little potential for aquifers to support subterranean fauna within the Project area.

5.5.2 Springs

A search with the QSpatial Database showed that there are no registered springs within a 10 km buffer of the Project area. The closest registered spring is located approximately 14.8 km southeast from the Project area, a distance considered significant in the context of the Project's potential groundwater related impacts such that this spring is not relevant to the Project's impact assessment.

5.5.3 Wetlands

A wetlands search was conducted using data downloaded from the QSpatial Catalogue. The downloaded dataset shows High Ecological Significance (HES) wetlands that are matters of state environmental significance. The dataset did not show any wetlands within a 10 km buffer of the Project area. The closest wetland is located approximately 19.7 km southeast from the Project area, a distance considered significant in the context of the Project's potential groundwater related impacts such that this wetland is not relevant to the Project's impact assessment.

5.5.4 Anthropogenic Groundwater Users (Landholder Bores)

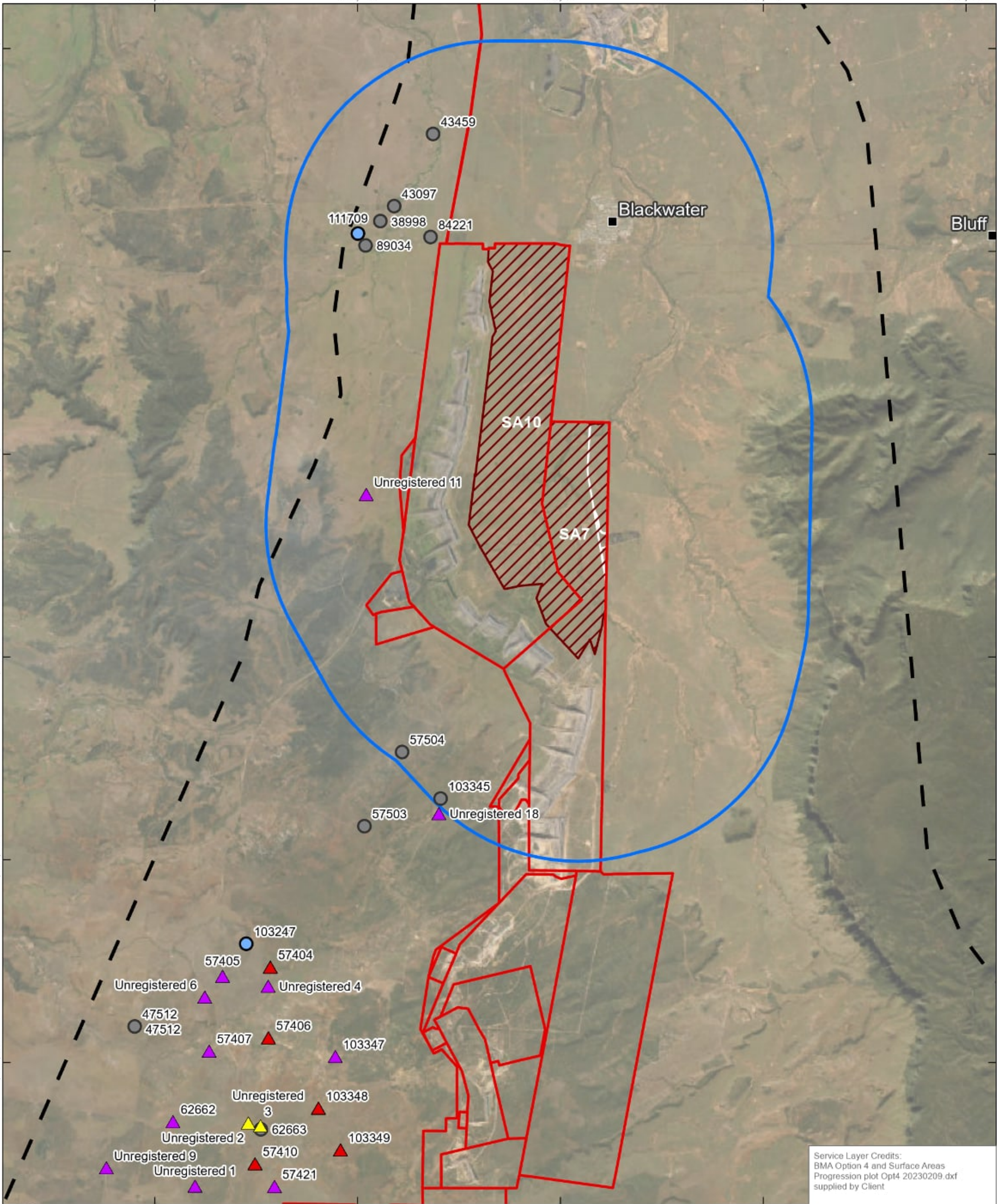
Several private bores extract groundwater in a 10 km radius from the Project area, based on assessment of the Queensland Department of Regional Development, Manufacturing and Water (DRDMW) registered bore database (GWDB). The groundwater is used for irrigation, farm supply or stock water according to the GWDB records. A field bore census was completed in 2019 (EMM, 2019) where some of these bores were subject to survey. Two rounds of visits have been undertaken, refer to **Appendix A-3** for details. The bores located within 10 km of the Project area are listed in **Table 5-10.**

Overall, anthropogenic groundwater usage is limited to the west of the Project area, mostly intersecting the Burngrove Formation. Of the eleven listed bores (**Table 5-10**) in use, four were visited as part of the bore census (EMM, 2021, **Appendix A-3**). However, all eleven bores listed in the table were considered for drawdown impact in this assessment. The location of these private bores is shown on **Figure 5-31** within the 10 km radius from the Project site.

Table 5-10 Existing Private Groundwater Bores within 10 km of the Project Area (DRDMW GWDB)

Registered RN (ID)	Part of Bore Census[1]	Easting (GDA94 z55)	Northing (GDA94 z55)	Geology	Bore Depth (m)	Use	Salinity (µS/cm)	Yield (L/s)
38998	No	681119	7391492	Burngrove Formation	36.6	Unknown	6,920	0.69
43097	No	681800	7392230	Burngrove Formation	22.9	Unknown	Brackish	0.75
43459	No	683719	7395787	Unknown	54.9	Unknown	2,260	0.76
57503	Yes	680333	7361655	Burngrove Formation	Unknown	Stock watering	1,930	
57504	Yes	682192	7365312	Burngrove Formation	Unknown	Stock watering	1,613	-
84221	No	683596	7390708	Burngrove Formation	24	Unknown	'Salty'	0.12
89034	No	680391	7390291	Unknown	Unknown	Unknown	7,200	
103345	Yes	684091	7363016	Burngrove Formation	47	Not In use	-	-
111709	No	680013	7390877	Burngrove Formation	72	Water Supply	6,150	0.2
Unregistered 11	Yes	680420	7378058	Burngrove Formation	Unknown	Stock watering	7,719	-
Unregistered 18	Yes	684004	7362319	Burngrove Formation	Unknown	Stock watering	1,715	-

[1] Visited by EMM in December 2018, documented in EMM, 2021
All other data publicly available from Queensland Government Bore Reports



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:250,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- City/Town
- Project Area 10km Buffer
- Study Area
- BWM Mining Lease
- BWM North Extension Project Area

Private Bores in Model Boundary

- Unknown
- Water Supply
- Stock (Baseline Assessment)
- Stock & Domestic (Baseline Assessment)
- Not in use

BLACKWATER MINE - NORTH EXTENSION PROJECT

PRIVATE BORES

SLR

FIGURE 5-31

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_31_Private Bores

5.6 Conceptual Hydrogeological Model

A conceptual hydrogeological model of the groundwater regime has been developed based on the review of the hydrogeological data for the Project and surrounds. It is important to note that the conceptual hydrogeological model presented herein represents an evolution of the hydrogeological understanding at BWM, building on previous conceptualisation presented by AGE (2013).

The Project is located within the southern part of the Bowen Basin, which comprises Permian aged coal measures that have been folded into a syncline structure that strikes in a north-west to south-east direction.

From youngest to oldest, the main hydrostratigraphic units underlying the Project area are:

- Quaternary alluvium including sand, silt clay, basal gravels.
- Tertiary Sediments / Regolith.
- Triassic Clematis Group.
- Triassic Rewan Group.
- Rangal Coal Measures – Target formation for mining.
- Burngrove Formation – considered the basement layer for this assessment.

The principal coal seams in the BWM area in descending order are the Aries (also known Top Seam), Castor (also known as (Middle Seam) and Pollux (also known as Lower Seam).

The coal seams are the main groundwater bearing units within the Permian sequences, with low hydraulic conductivity interburden generally confining the individual seams. The coal seams are dual porosity with a primary matrix porosity and a secondary (dominant) porosity provided by fractures (joints and cleats). Hydraulic conductivity of the coal decreases with depth due to increasing overburden pressure reducing the aperture of fractures.

5.6.1 Groundwater Levels and Flow

Groundwater level data within the alluvium is limited. The alluvium is often found to be limited in extent and thickness, and unsaturated, but may become saturated following rainfall recharge and occasional inflow from ephemeral creeks. Groundwater levels in the unconfined alluvium, where saturated, are expected to be a subdued reflection of topography, with flow toward the north of the Project at North Blackwater and towards the southwest at South Blackwater. If there are times when the alluvium is saturated, flow would still be restricted as the coarser grained alluvium (that could transmit water) is separated by clay lenses and outcropping bedrock, with limited connectivity between areas of saturated alluvium.

Recharge to the alluvium is considered to be mostly from occasional ephemeral stream flow or flooding (i.e. losing streams), with direct infiltration of rainfall also occurring rapidly where there are no substantial clay barriers in the shallow subsurface. However, recharge is expected to be low due to the presence of surficial clays. On a regional scale, discharge occurs via evapotranspiration from vegetation growing along creek beds. Minor short duration baseflow events after significant rainfall/flooding are possible, however there was no data available to support or reject this hypothesis.

Within the Tertiary Sediments and Regolith the strata is typically unsaturated at North Blackwater but saturated in the South Blackwater area. In the southern area groundwater levels in the Tertiary Sediments are variable, ranging from 2 to 32 m below ground level, and groundwater flow is towards the south.

The Triassic Rewan Group is known as a regional scale aquitard, though still may contain low yielding groundwater. There is limited hydraulic connection between the Rewan Group and underlying Permian Coal Measures due to the low vertical hydraulic conductivity nature of the strata and the overlying Triassic units confine the underlying Permian sediments. In the Permian Coal Measures, the lower permeability interbedded claystone and shale horizons (interburden) significantly reduce vertical leakage causing most groundwater flow within the Coal Measures to be along the coal seams themselves. In the Project area, groundwater flow within Permian coal seams was inferred to be towards the north for pre-mining conditions. However, with many open-cut pits in the area, groundwater within the Coal Measures now generally flows towards these pits.

Recharge is limited to areas with relatively higher hydraulic conductivity units (e.g. coarse grained sandstone and coal seams) and in areas of outcrop. Coal seam recharge is expected to occur primarily via leakage from the overlying Quaternary and Tertiary units, where the Triassic formation is not present or significantly thinned. As such, the areas with greatest control of Permian formation recharge are proximal to seam outcrops. Some recharge to the coal measures also occurs through mine surface water storages where the seams are hydraulically connected to the storages such as mining pits and waste spoil.

5.6.2 Groundwater –Surface Water Interaction

Groundwater interaction with ephemeral creeks is likely to be limited within the Project area for the alluvium and underlying Regolith, due to the limited extent and saturation of these units, and ephemeral nature of creek flow. Interaction is only likely in terms of stream flow leakage to the underlying geology during sporadic creek flow events. Where saturated, water levels in the Tertiary Sediments and Regolith appear to be several meters below the base of the creek bed, thus there would be no groundwater discharge to the creeks.

5.6.3 Groundwater Quality

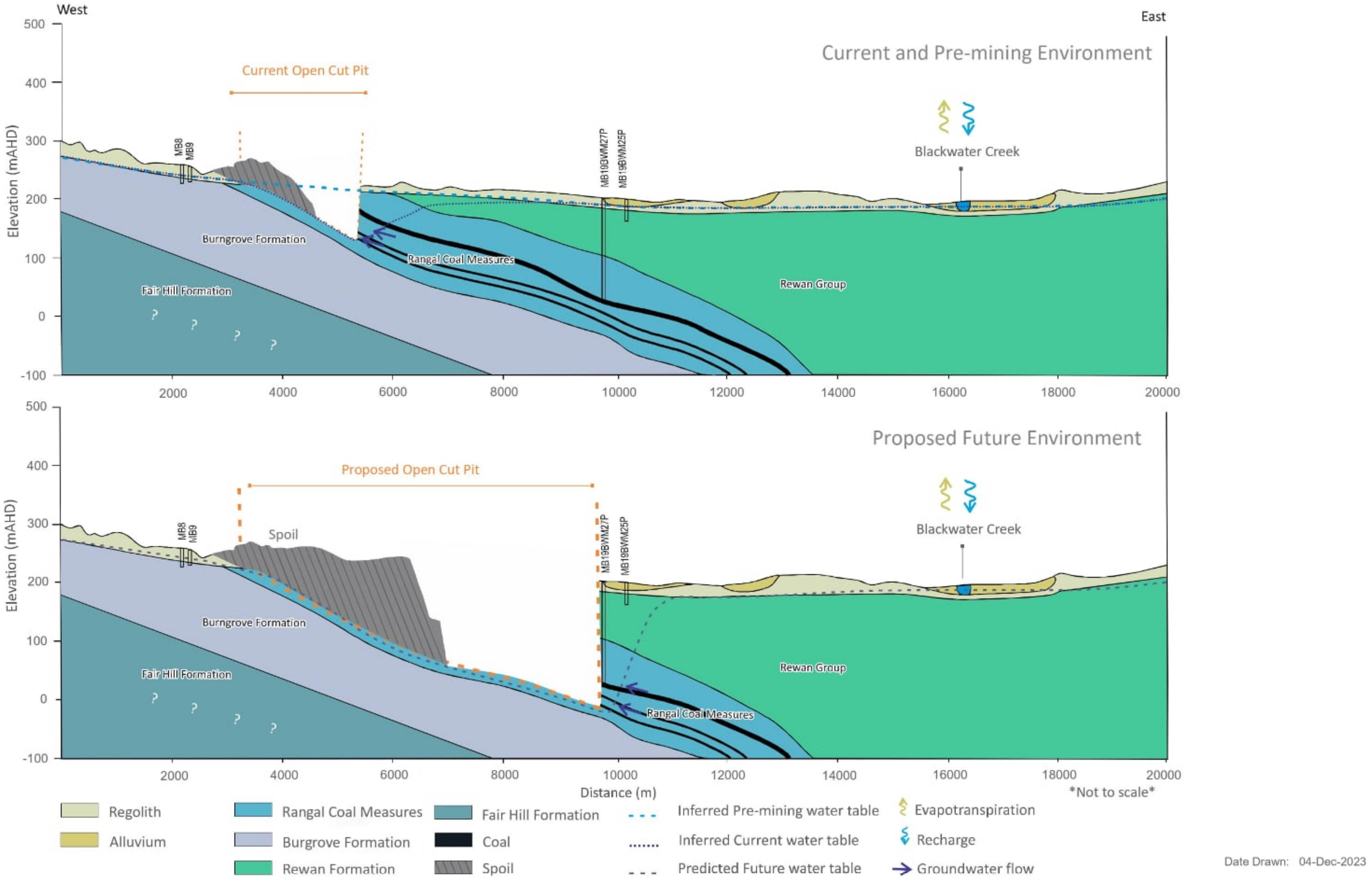
Groundwater quality within the alluvium across the study area is variable both spatially and temporally ranging from fresh to brackish but is typically brackish. The alluvium across the study area, when sufficiently saturated, is mostly suitable for stock water supply and irrigation but is not suitable for drinking water and freshwater aquatic ecosystems. Field pH results indicate groundwater is moderately acidic.

Groundwater quality in the Tertiary sediments is variable but typically more saline that the shallower alluvial groundwater.

Groundwater quality within the Rewan Group and Permian coal measures is variable ranging from brackish to saline. Groundwater within the coal measures of the Project area is not considered suitable for some livestock.

5.6.4 Mining Impacts

A conceptual hydrogeological cross section was developed for this assessment, showing the current open cut pit and proposed expanded open cut pit is presented in **Figure 5-32.** The current open cut pit is shown with the pre-mining water table and the current inferred water table. Also shown is the proposed open cut pit with the expanded pit void extending into the Rewan Group to the east. A larger footprint of spoil is depicted on the ground surface and also infilling the western part of the pit. The predicted future water table is shown to be at the base of the Rangal Coal Measures and then rising outside the western part of the pit as the influence of dewatering decreases. Throughout both scenarios the hydrogeological environment around Blackwater Creek remains unchanged.



Date Drawn: 04-Dec-2023

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

CONCEPTUAL HYDROGEOLOGICAL SECTION OF THE PROJECT AREA AND SURROUNDINGS

FIGURE 5-32

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F05_31_Conceptual Hydrogeological Section

5.7 Water Levels and Ecohydrogeological Models

5.7.1 Approach and Methodology

RDM Hydro et al. (2023) undertook a desktop assessment to identify the distribution of potential terrestrial groundwater-dependent ecosystems (TGDEs) at the BWM.

This desktop assessment was undertaken using a combination of publicly available data and reports, and proprietary raw data and reports provided by BMA. The main sources of data used in the assessment included:.

- Electronic surface geological mapping (1:100k)
- Stratigraphic and structural mapping products from the Bowen "Supermodel" (Sliwa, Babaahmadi and Esterle, 2018)
- Queensland groundwater bore database (GWBD)
- Bureau of Meteorology (BOM) data including climate data and GDE Atlas (BOM, 2017) for the Fitzroy Basin
- Queensland Government (DES) Regional Ecosystem (RE) mapping
- Data provided by BMA including:
    - Bore logs for select resource exploration bores and groundwater monitoring bores, groundwater quality and water level monitoring data.
    - Telemetered streamflow monitoring data.
    - Various GIS datasets clipped to a 10 km buffer around BWM.
    - A range of groundwater monitoring reports, ecological survey data, remote sensing and surface water reports.

A hydrogeological review was undertaken to gain an understanding of the groundwater regime with consideration of TGDEs. The focus of the review was on shallow groundwater within the rooting depth of the government mapped vegetation[1], specifically the water table depth, presence of perched aquifers and the salinity of the shallow groundwater (where the water table represents the phreatic surface below which the subsurface is saturated).

5.7.2 Water levels and Water Table Depth

RDM Hydro et al. (2023) utilised the Queensland Groundwater Bore Database (GWBD) and BWM monitoring data to develop a water table depth map. The study searched the GWBD database for all registered bores within a 35 km radius of the BWM tenements, which yielded 281 bores (bores with at least one recorded water level). This data was supplemented by adding 41 BWM monitoring bores and 11 water level measurements from unregistered bores identified during a 2018 bore audit (EMM, 2019). The combined dataset was further refined by eliminating 25 bores for various reasons, including artesian water levels, a construction depth/screen interval greater than 100 m, and construction/stratigraphy data indicating the bore is not monitoring the water table formation. The final water level data set comprised measurements from 308 bores (**Table 5-11**).

[1] The rooting depth was estimated by RDM Hydro by utilizing the likelihood of groundwater usage of various tree species found within the government mapped Regional Ecosystems. The threshold groundwater depth is an estimate of the maximum rooting depth for each of those species as provided in section 4.3 of the RDM Hydro et al. (2023) desktop assessment.

Table 5-11 Summary of bores included in the water table mapping (RDM Hydro et al, 2023)

Data Source	No. of Bores	No. of bores with water level measurements	No. of bores excluded	No. of bores included
Registered bores (GWBD)	813	281	18	263
Unregistered bores (EMM, 2019)	12	11	0	11
BWM monitoring bores	85	41	7	34
Total	**910**	**333**	**25**	**308**

The water level data was processed as follows:

- A confidence level was assigned to each bore and associated water level readings. This confidence level was relating to the number of measurement points. The longer a time series was available, the more confidence there was to have captured the temporal maximum variability at a bore.
- Bores with multiple readings were set to select the minimum (shallowest) water level reading in the record.
- All water levels were expressed as metres below ground level.
- The water level point data set was interpolated into a continuous grid across the study area of BWM using the Golden Software surface modelling software Surfer©. Various interpolation methods were tested, but universal kriging was chosen for its superior cross-validation results. A custom variogram was developed based on the input RWL data.
- The resulting potentiometric surface was produced with a grid spacing of 100 m.
- The SRTM DTM was resampled to a consistent 100 m grid size and the potentiometric surface was subtracted to produce a continuous depth to water table map.

This SLR Groundwater Impact Assessment also produced a depth to water table map at the end of the calibration period (December 2022) based on groundwater modelling results (refer to **Section 6.3.4**, **Figure 6-4**). **Figure 6-4,** based on groundwater modelling, overestimated the water table elevation in the two uppermost model layers. There were only limited observations data points available for those shallow layers for the calibration process.

Whilst both mapping methodologies have their merits and disadvantages, it was concluded that for the assessment of potential groundwater use by the terrestrial vegetation communities within the Project area, the water table map by RDM Hydro et al. (2023) is more suitable as it captures the shallow water tables at higher confidence. Accordingly, the GIS files of the RDM Hydro et al. (2023) water table mapping were provided to EMM to inform the assessment of potential impacts on terrestrial GDEs.

5.7.3 Groundwater Chemistry

Groundwater quality data from the BWM monitoring data was also assessed by RDM Hydro et al. (2023) to identify whether salinity is likely to constrain the distribution of TGDEs in the landscape. The data indicate that the Rangal Coal Measures have the highest salinities, and the Tertiary Sediments generally the lowest. Almost all electrical conductivities are less than 30,000 µS/cm and are therefore unlikely to significantly affect the distribution of TGDEs based on this threshold (RDM Hydro et al., 2023).

5.7.4 Summary of Conceptual Hydrological Model

In summary, the conceptual understanding of the hydrological regime of the BWM and its surrounds includes (RDM Hydro et al., 2023):

- Alluvial sediments are associated with larger water courses but are generally less extensive than mapped and are of limited thickness. The alluvium is mostly dry when encountered, except for when more significant thicknesses are present.
- Watercourses are ephemeral. Despite being of limited extent and thickness, alluvial sediments are likely to be episodically recharged by rainfall run-off when the watercourses host water, resulting in the presence of perched aquifers associated with the alluvium. During these times, there may be some leakage to recharge the underlying Tertiary sediments.
- The Tertiary sediments/regolith are typically unsaturated in the Project area and surrounds, but may host the water table in BWM tenements further south. The water table may lie within any formation.
- The water table is a subdued reflection of topography. It is generally in excess of 25 m below ground except in the vicinity of drainage lines and topographic lows. There is no evidence of seasonal variation or significant immediate influence of preceding rainfall events on water levels.
- The Rewan Group is a regional scale aquitard that provides vertical separation of the coal seams from the Tertiary sediments/regolith down dip of the subcrop.
- Groundwater quality in the vicinity of BWM is typically brackish to saline and tends to increase with depth. It is almost always less than 30,000 µS/cm, and therefore will have limited impact on the distribution of terrestrial GDEs.

5.7.5 Conceptual Ecohydrological Models

RDM Hydro et al. (2023) presents conceptual ecohydrological models (TGDE types and functions) which are likely to be found in the BWM area and the wider Bowen Basin based on the findings of the desktop study and previous field assessments of other GDE studies in the Bowen Basin.

The conceptual ecohydrological models include perched aquifers in alluvium (Types A and B) and systems exhibiting interactions with Tertiary and Permo-Triassic sediments (coal seams and alluvium) (Types C and D). A description of the types and function of the conceptual ecohydrological models summarised from RDM Hydro et al. (2023) is provided below.

Type A: A simplified perched seasonal groundwater system that is commonly associated with alluvium comprising sediments with higher levels of hydraulic conductivity (sandy loams and sand) is depicted in **Figure 5-33** (from RDM Hydro et al., 2023). The characteristics of Type A are as follows (RDM Hydro et al., 2023):

- Groundwater is recharged during channel flow/flooding and diminishes as the system dries through evapotranspiration or leakage into Permo-Triassic sediments below. Following recharge, groundwater perches on Permo-Triassic sediments (or another aquitard layer) at the base of the alluvium, where it is utilised by fringing riparian vegetation. Generally, groundwater depletes during drier periods, and trees then rely on residual soil moisture to support transpiration.
- These systems are relatively common features along larger drainage lines and do not provide a sustained moisture source to support riparian vegetation during drier periods, only utilising groundwater during wetter periods when groundwater is present. Consequently, this means that the vegetation does not rely on a deep continuous water table aquifer, but is using shallow, perched water that was discharged after surface water flow events.
- Type A GDE features are relatively low risk from a management perspective, although may be impacted when stream channels are breached during construction with localised impacts to TGDEs.

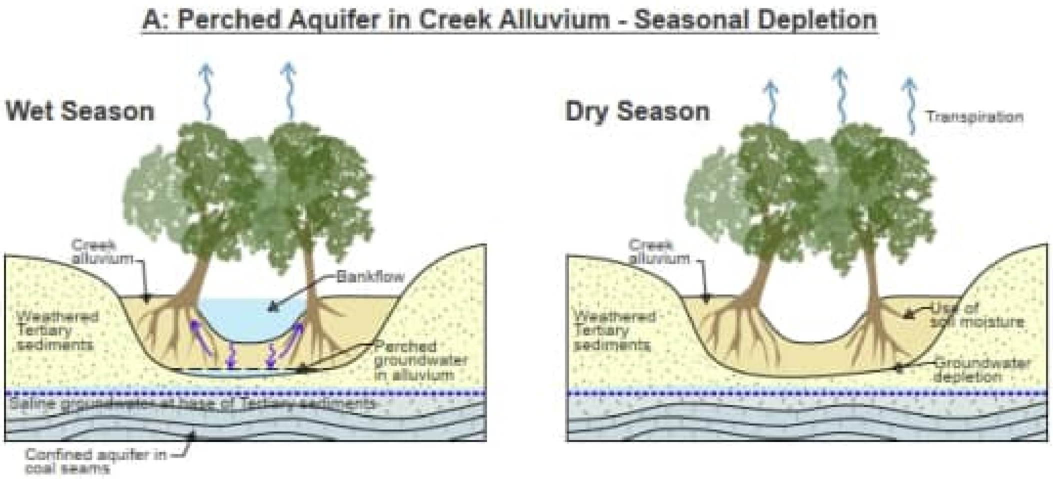


Figure 5-33 Type A - Conceptual ecohydrological model - perched aquifers in alluvium (from RDM Hydro et al. 2023)

Type B: Type B represents a more complex TGDE system and is depicted in **Figure 5-34** (from RDM Hydro et al., 2023). The characteristics of Type B are as follows (RDM Hydro et al., 2023):

- Riparian vegetation in Type B has capacity to utilise perched fresh groundwater when it is present at the base of alluvial sediments, transitioning to use soil moisture as the perched groundwater is depleted, before shifting to more saline groundwater from the underlying Tertiary sediments or Permo-Triassic geology as moisture potential in the vadose zone becomes increasingly negative.
- Trees associated with this type of GDE will typically be river red gum with dimorphic root systems, having capacity to utilise moisture from various regions in the soil profile or water table dependent on its presence and availability. Type B systems will generally only use saline water from Tertiary sediments or coal seams during

extremely dry periods and trees in Type B systems will typically show signs of vegetative stress. when all alternative moisture sources higher in the soil column are depleted.

Type B systems are difficult to confidently assess due to their limited seasonality and marginal groundwater use. They will also be subject to risk of impact if the integrity of the groundwater system in the creek alluvium, Tertiary sediments or coal seams is disturbed or disrupted.

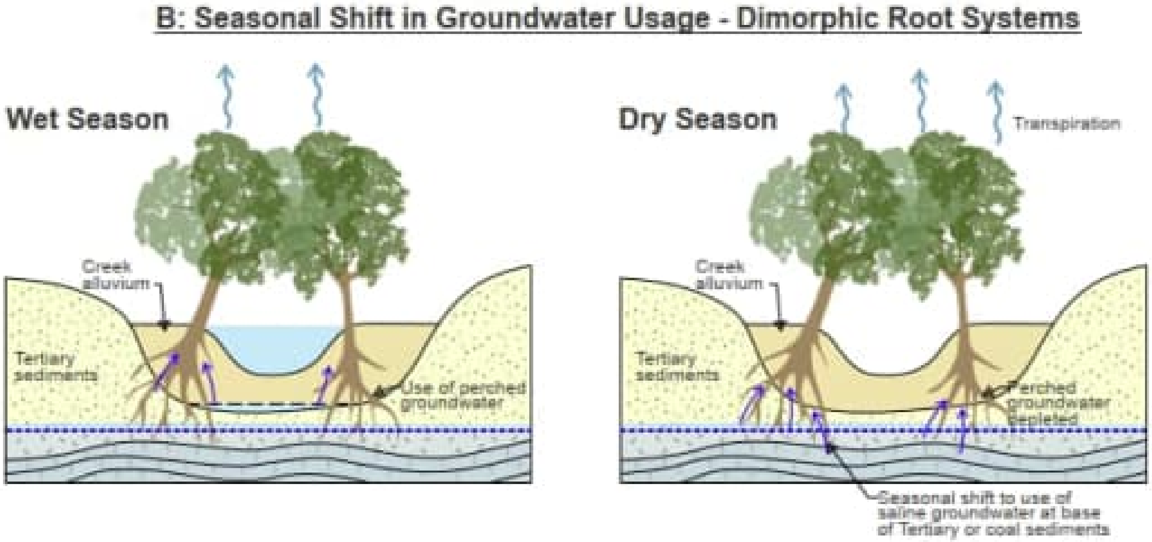


Figure 5-34 Type B - Conceptual ecohydrological model - perched aquifers in alluvium (from RDM Hydro et al., 2023)

Type C: Type C represents a riparian GDE system occurring where coal seams subcrop into thinner Tertiary and alluvial sediments, depicted in **Figure 5-35** (from RDM Hydro et al., 2023). The characteristics of Type C are as follows (RDM Hydro et al., 2023):

- The groundwater occurrence in the creek alluvium, Tertiary sediments and coal seams are interconnected with recharge to all formations occurring in association during seasonal flooding.
- Groundwater in Type C systems provide a more suitable source of groundwater to support GDE function, due to the following:
    - o The mixing of the three groundwater systems, groundwater in both the Tertiary sediments and coal seams for Type C will be fresher than in either Type A and Type B scenarios due to the hydraulic connection of the Tertiary sediments and coals to the recharge source.
    - o There may also be some seasonal buffering of the alluvial / Tertiary groundwater systems through sustained seepage out of the sub-cropping coal seams following a recharge event which will prolong the residence time of the groundwater which supports GDEs.
- Type C systems present the highest risk scenario in terms of potential impacts to TGDEs due to a more seasonally reliable source of fresh groundwater, and likely direct linkage to the coal seams being mined.

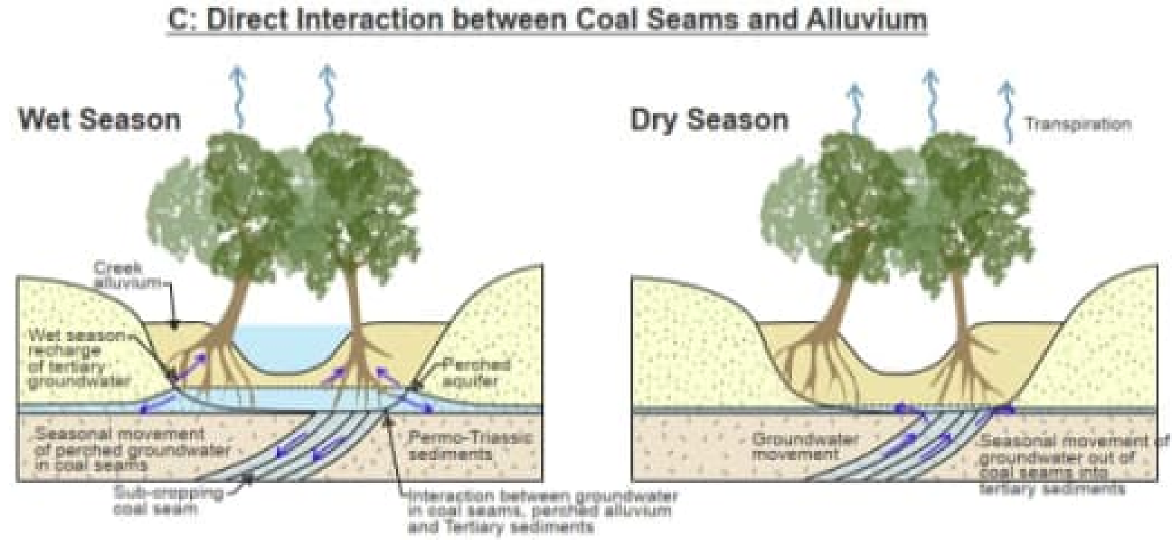


Figure 5-35 Type C - Conceptual ecohydrological model - interaction with Tertiary and Permo-Triassic sediments perched aquifers - direct interaction between Coal Seams and alluvium (from RDM Hydro et al., 2023)

Type D: Type D systems are similar to Type C, but there is an increased thickness of Tertiary sediments overlying the coal seam, as depicted in **Figure 5-36** (from RDM Hydro et al., 2023). This is more typical of the southern BWM Tenements (not within the Project area or immediate surrounds), where the Tertiary thickness is in the order of 40 m. The risks associated with a Type D system are similar to Type C, however due to the thicker Tertiary sediments, the propagation of drawdown will be slower and the magnitude of drawdown less.

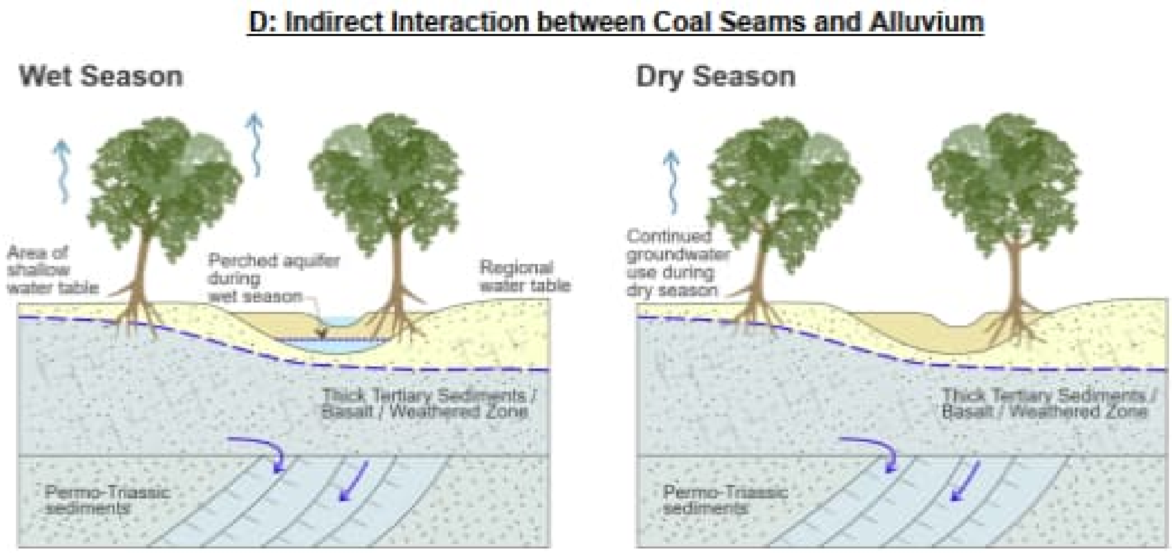


Figure 5-36 Type D - Conceptual ecohydrological model - interaction with Tertiary and Permo-Triassic sediments perched aquifers - indirect interaction between Coal Seams and alluvium (from RDM Hydro et al., 2023)

6.0 Groundwater Numerical Model

6.1 Model Objectives

Numerical groundwater modelling was undertaken to assess the impact of the Project on the groundwater regime. Full details of the modelling are presented in **Appendix B** (Groundwater Modelling Technical Report). The numerical model is based on the conceptual model outlined in **Section 5.6** and collected field data. The objectives of the modelling were to:

- Prepare a calibrated numerical groundwater model to simulate the hydrogeological conditions across the Project area.
- Estimate the groundwater inflow to the mine workings as a function of mine position and timing.
- Simulate and predict the extent and area of influence of dewatering and the level and rate of drawdown at specific locations (bores identified in **Section 5.5.4** and the EA monitoring bores for ongoing model validation).
- Simulate the post-mining recovery.
- Identify areas, where groundwater impact mitigation / control measures may be necessary.

6.2 Software

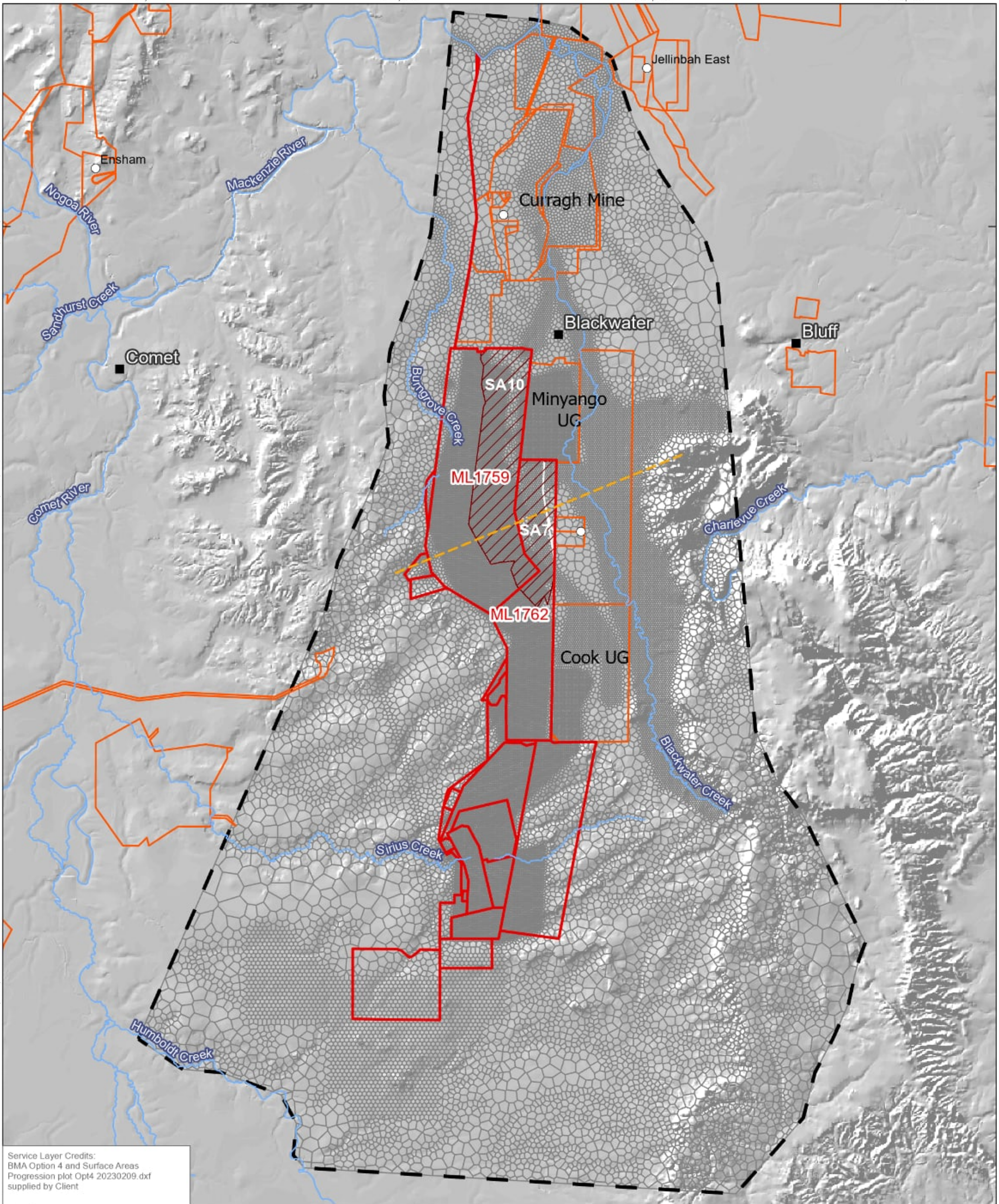
MODFLOW-USG was used as the model code (Panday *et al.*, 2013). MODFLOW-USG is a version of industry standard MODFLOW code and was determined to be the most suitable modelling code for accomplishing the model objectives. MODFLOW-USG optimises the model grid and increases numerical stability by using unstructured, variably sized cells. These cells take any polygonal shape, with variable size constraints allowing for refinement in areas of interest (i.e., geological or mining features).

6.3 Model Setup

Figure 6-1 shows the model domain. The model domain is designed large enough to allow the adjacent mines/projects to be assessed for potential cumulative impacts. At its widest extents, the model measures approximately 50 km by 90 km. The model domain was selected based on the following considerations:

- The western boundary is represented by the outcrop boundary of the Burngrove Formation, which underlies the Rangal Coal Measures and is considered the basement formation for the purpose of this modelling.
- The northern boundary extents to include the open-cut Curragh mine and is 25 km north of the Project area.
- The eastern boundary is set along the Shotover fault which is located approximately 20 km to the east of the Project area. This boundary is expected to be far outside the range of predicted Project related drawdown.

The mesh size varies between 100 m to 350 m (refer to **Appendix B** for details).



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	11-Dec-2023
Drawn by:	NT

LEGEND

- Coal Mine
- City/Town
- Watercourse
- West to East Cross Section
- Model Grid
- Model Boundary
- BWM North Extension Project Area
- BWM Mining Lease
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

MODEL DOMAIN, WATERCOURSES AND MINE PLAN

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose

FIGURE 6-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_1_Model Domain

6.3.1 Model Grid and Layers

The model domain is discretised into 14 layers, as listed in **Table 6-1**. These layers were identified in **Section 4** (Geology) and described in more detail in **Section 5** (Hydrogeology). The model layer extents (lateral and vertical) have been defined using data from the following sources:

- Blackwater site geological model.
- CSIRO Regolith depth survey (Wilford et al, 2016).
- Queensland Globe bore hole logs.
- Queensland surface geology and basement geological maps.
- OGIA model layers (OGIA, 2019).

Table 6-1 Stratigraphy - Model Layer Summary

Model Layer	Formation	Unit	Average Thickness (m)
1	Alluvium/Tertiary	Surface cover and Tertiary	8
2	Alluvium/ Weathered zone	Weathered zone / Regolith	9
3	Clematis Group	Triassic	352
4	Rewan Group (Upper)	Triassic	296
5	Rewan Group (Middle)	Triassic	178
6	Rewan Group (Lower)	Triassic	110
7	Rangal Coal Measures	Overburden	46
8		Aries seam	2
9		Interburden	22
10		Castor seam	2
11		Interburden	16
12		Pollux seam	4
13		Underburden	30
14	Burngrove Formation	Permian	177

6.3.2 Boundary Conditions

6.3.2.1 Regional Groundwater Flow

General Head Boundaries (GHB) have been specified along the southern and northern model boundaries. The GHB boundary condition is used to represent the regional flow into and out of the model area and has been assigned using GHB cells in all layers using pre-mining groundwater elevations. Groundwater will enter the model where the head set in the GHB is higher than the modelled head in the adjacent cell and will leave the model when the water level in the GHB is lower than the modelled head in the adjacent cell. The GHB conductance is calculated using the hydraulic conductivity and the dimensions of each GHB cell and is therefore variable in this model due to variable cell-size.

A no flow boundary was applied to the western boundary of the model that represents the outcrop of the Burngrove Group. A no flow boundary was also applied to the eastern boundary where the Shotover fault is located.

6.3.2.2 Watercourses

The largest local creek (Blackwater Creek) as well as minor creeks were built into the model using MODFLOW-USG RIV package.

The rivers are set with the riverbed 3 m below the surrounding topography to represent the steep-banked incised channels. The river widths were assumed to be fixed for each river in the model. The river conductance was calculated using river width, river length, riverbed thickness, and hydrogeologist experience of the vertical hydraulic conductivity (Kz) of typical riverbed alluvial material, refer to **Table 6-2** for the values used. Therefore, the river conductance is variable due to the non-constant spatial discretisation in each of the model river cells.

Table 6-2 River and Surface Water Features in the Model

Boundary	River Stage (m)	River Bed Kz (m/day)
Blackwater Creek	Warm Up Simulation (1970- 2005) - Long term annual average (2005-2023) Calibration Simulation (2005- 2023) - Historical Quarterly observations for that timeframe Predictive Simulation (2023 onwards) - Long term annual averages (2005-2023)	5.0×10^{-2}
Other Minor Creeks	0	5.0×10^{-1}

The river stage height at Blackwater Creek was based on the observations at the Blackwater Downstream Gauge (**Figure 3-6**). **Table 6-2** lists the river stage values used for the three simulation types.

The river stage height in the minor tributaries or drainage lines was set to 0 m (i.e., river stage elevation was equal to river bottom elevation). Therefore, the minor tributaries or drainage lines act as drains to the groundwater system and do not result in any recharge into groundwater, which is consistent with the conceptual model.

Mining Infrastructure

The RIV package was also used to simulate the pit lakes and dams within the area. **Table 6-3** lists how the mining infrastructure elements, such as in-pit water storages and dams, were included in the model.

Table 6-3 Mining Infrastructure in the Model

Boundary	Stage (m)	Kz (m/day)
In-pit water storages (Bonnie Doon, Mimosa pits)	Calibration Simulation (2005-2023) - Historical Quarterly observations. Predictive Simulation (2023 onwards) – No stage height applied. It was assumed that voids (Bonnie Doon) will be filled during the mining at the prediction stage.	5.0×10^{-1}
Water Storage Dams New Taurus, Tanny Foil and Deep Creek dams	Calibration Simulation (2005-2023) - Historical Quarterly observations. Predictive Simulation (2023 onwards) – Long term annual averages (2005-2023)	1.0×10^{-2}

6.3.2.3 Recharge and Evaporation

The calibrated average recharge values used in the model are presented in **Table 6-4**. These final calibrated values were based on a time-series recharge rate derived from the Australian Landscape Water Balance model (AWRA-L) Deep Drainage estimate for the project area. Details on this methodology are provided in **Appendix B** (Groundwater Modelling Technical Report).

Future climate change effects on recharge were considered during the Uncertainty Analysis and post-mining Recovery modelling. This is further detailed in **Section 7.5**.

Table 6-4 Calibrated Recharge

Model Geology Zone	% of Average Rainfall
Blackwater Creek Alluvium	0.5
Regolith	0.1
Clematis	0.3
Regolith high recharge area	1.0
Spoil	7.4

The evapotranspiration rates were applied as 1,030 mm/year, which equates to 50% of the long-term pan evaporation observations of 2,062 mm/year. This evapotranspiration rate chosen for the model lies between the actual annual evapotranspiration rate (BoM, 2022) and the SILO estimate with the FAO56 method, which are 600 mm/year and 1,600 mm/year respectively.

The rates are applied at the surface at the reported values and decrease linearly over depth to zero at the so-called extinction depth. This means that the evapotranspiration processes are most prevalent at the surface and expected to be limited to extinction depth, representing the root zone. In the model, a value of 2.5 m and 7.5 m were applied to the general area and the forested area of the National Park where the Clematis Sandstone outcrops (**Figure 4-2**).

6.3.2.4 Mining

The MODFLOW Drain (DRN) package is used to simulate mine dewatering in the model for the Project and surrounding mines. Boundary conditions for drain cells allow one-way flow of water out of the model. When the computed head drops below the pre-defined stage elevation of the drain, the drain cells become inactive. This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

Two types of mining have been considered and were implemented in the model, namely open-cut and underground mining.

To simulate open cut pits in the model, drain cells are applied to all active layers from the surface to the base of the lowermost mined seam, which is the Pollux Seam at BWM. The drain cells representing the surrounding open-cut mines were interpolated from previous reports, publicly available EIS documentation and aerial photography.

For open cut mining, Hawkins (1998) and Mackie (2009) indicate that spoil and waste rock are more permeable than the undisturbed strata. Completed open cut mining areas will be backfilled with waste overburden as the extraction proceeds. Backfilling of open cut mine areas with spoil was modelled using the Time-Variant Material (TVM) package. The model cell properties were updated to spoil properties guided by operational mine plans. Parameterisation of the spoil is based on widely industry accepted standard parameterisation as is typical for mines in the Bowen Basin (SLR, 2020; HydroSimulations, 2018). Horizontal hydraulic conductivity of 0.3 m/day and vertical hydraulic conductivity of 0.1 m/day is applied to the spoil. The storage parameters used for the spoil were a specific yield of 0.1 and a specific storage of 1×10^{-5} m^{-1}.

For the underground mines, the hydraulic properties were changed with time in the goaf and overlying fractured zone directly above each longwall panel. MODFLOW-USG Time Varying Materials (TVM) package was used to simulate changes to aquifer properties in response to mining within the overlying strata and fracture zone. A number of multipliers were used to enhance hydraulic conductivities within the fracture zone overlying coal extraction areas, with multipliers generally following a ramp function, so that the multipliers with highest values are applied to the units closest to the mined seam and then gradually decrease as the units become close to the maximum height of connective cracking. The maximum height of connective cracking was derived using the Ditton/Merrick equation (Ditton and Merrick, 2014).

6.3.3 Temporal Discretisation

A combined transient warm up and transient calibration model was developed, followed by a transient prediction model:

- A transient warm-up model from January 1970 to January 2005 with a 10 yearly time interval between 1970 and 1990 and a 15 year time interval between 1990-2005.
- Transient calibration model from January 2005 to July 2023 with quarterly time intervals to replicate influence of historical mining.
- Transient predictive model from July 2023 to July 2085 with annual time intervals.

6.3.4 Calibration Results

The calibration set up is presented in detail in **Appendix B** (Groundwater Modelling Technical Report). A result overview is summarised in this section,

The overall transient calibration statistics are presented in **Table 6-5.** The RMS error calculated for the calibrated model is 11.68 m. The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The total measured head change across the model domain is 182.5 m; therefore, the ratio of RMS to the total head change (scaled root mean square, SRMS) is 6.40%. While there is no recommended universal SRMS error, The Australian Groundwater Modelling Guidelines suggests that setting SRMS targets such as 5 or 10% may be appropriate in some circumstances (Barnett et al, 2012).

Table 6-5 Calibration Statistics

Statistic	Value
Sum of Squared residuals (m^2)	269,670.33
Mean of Squared residuals (m)	136.47
Root of Mean of Squared residuals (RMS) (m)	11.68
Scaled Root Mean Square (SRMS) (%)	**6.40%**
Sum of Absolute Residuals (m)	18,473
Mean Sum of Absolute Residual (m)	9.07
Targets within ±2 m	400
Targets within ±5 m	741
Targets within ±20 m	1836

Figure 6-2 presents the observed and simulated groundwater levels graphically as a scattergram for the initial and historic transient calibration (2005 to 2022), grouped for the Alluvium and Tertiary, Rewan Group and Permian bores respectively. Overall, there is a reasonable fit between simulations and observed levels and the residual in most calibration data points are within ± 20 m.

Figure 6-3 shows the distribution of calibration residuals.

Figure 6-4 shows the resulting depth to water table map at the end of the calibration period, i.e. for December 2022. The depth to water table map is further discussed in **Section 5.7.2**.

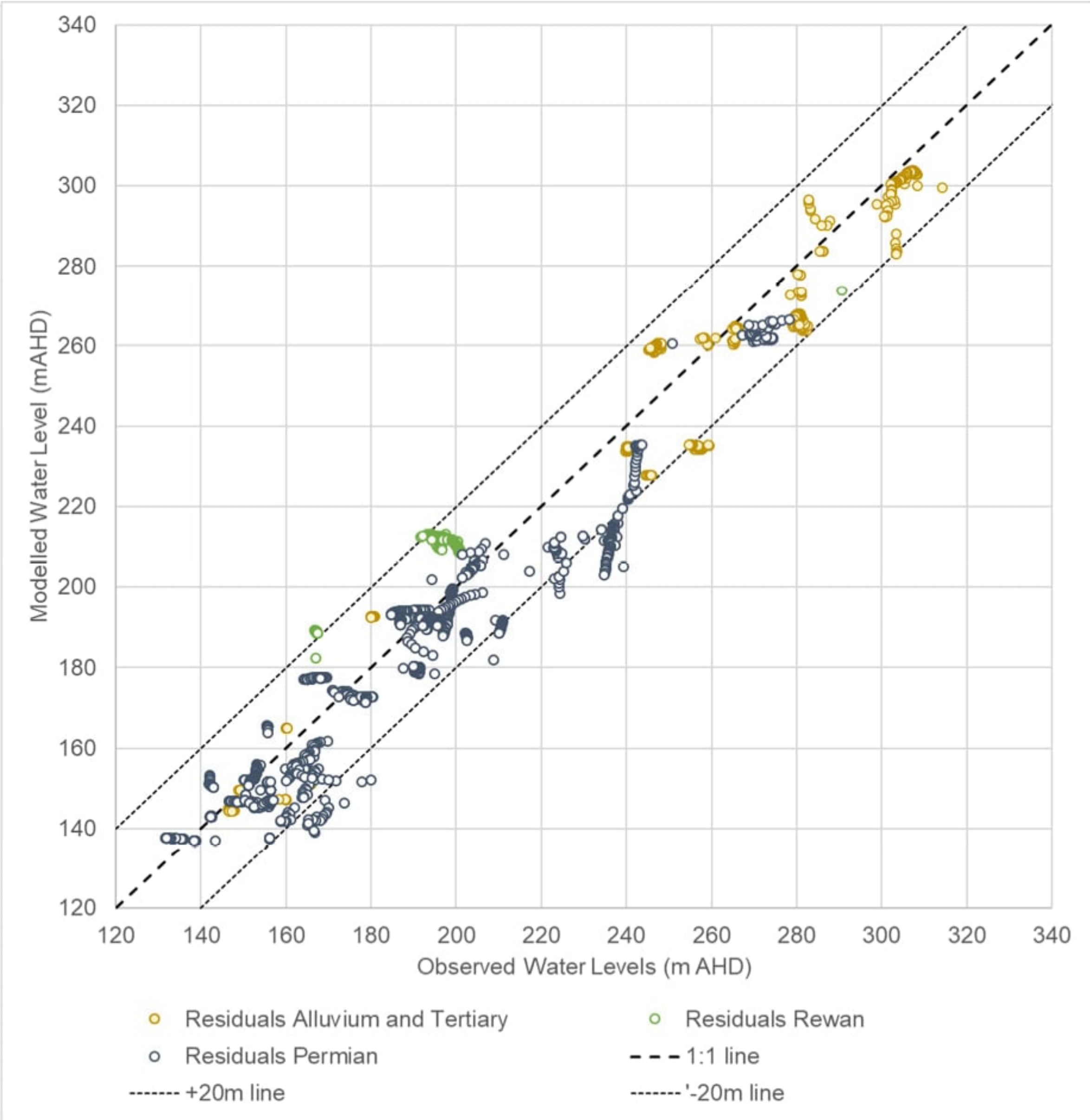
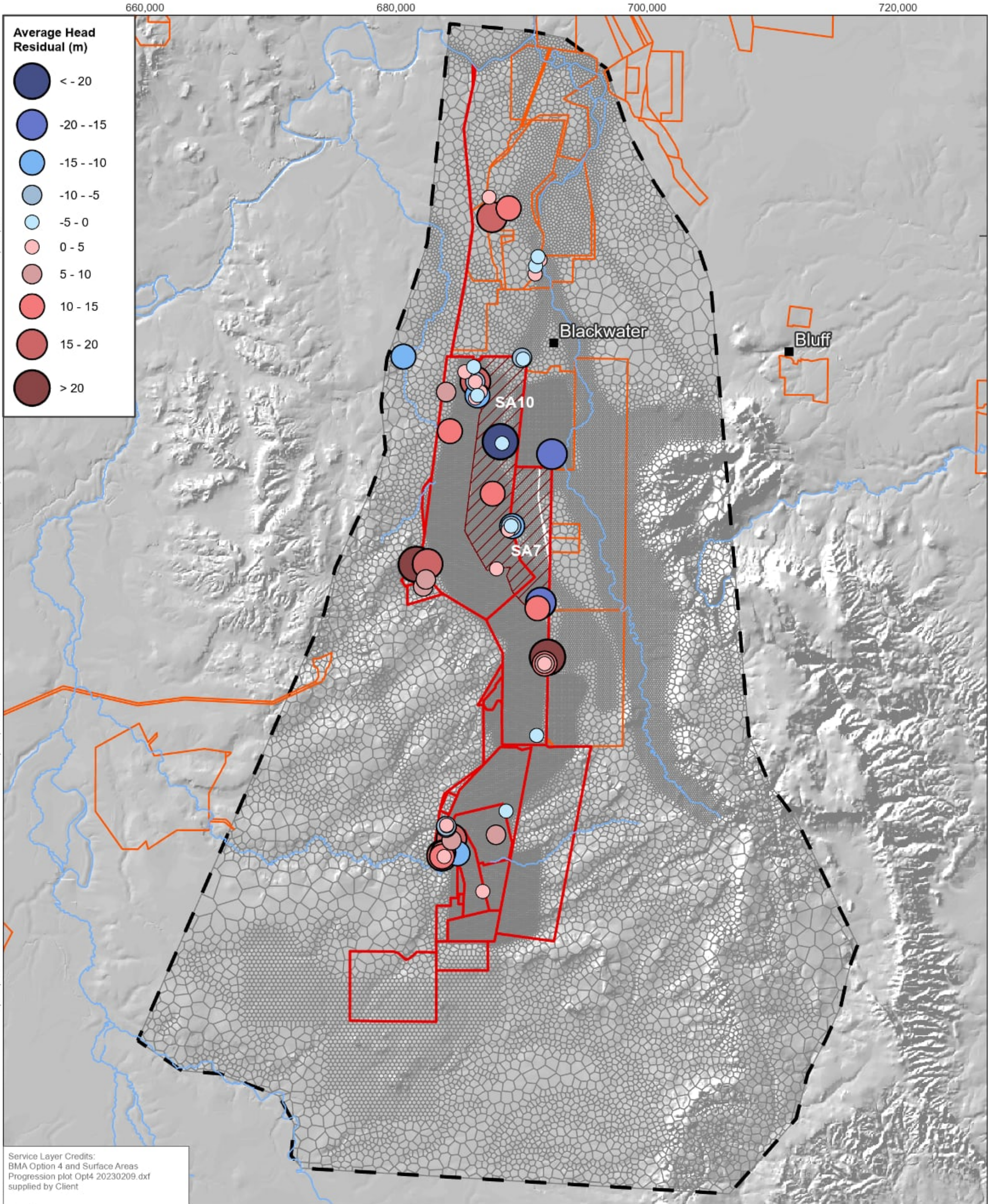


Figure 6-2 Observed vs Computed Target Water Levels



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	11-Dec-2023
Drawn by:	NT

LEGEND

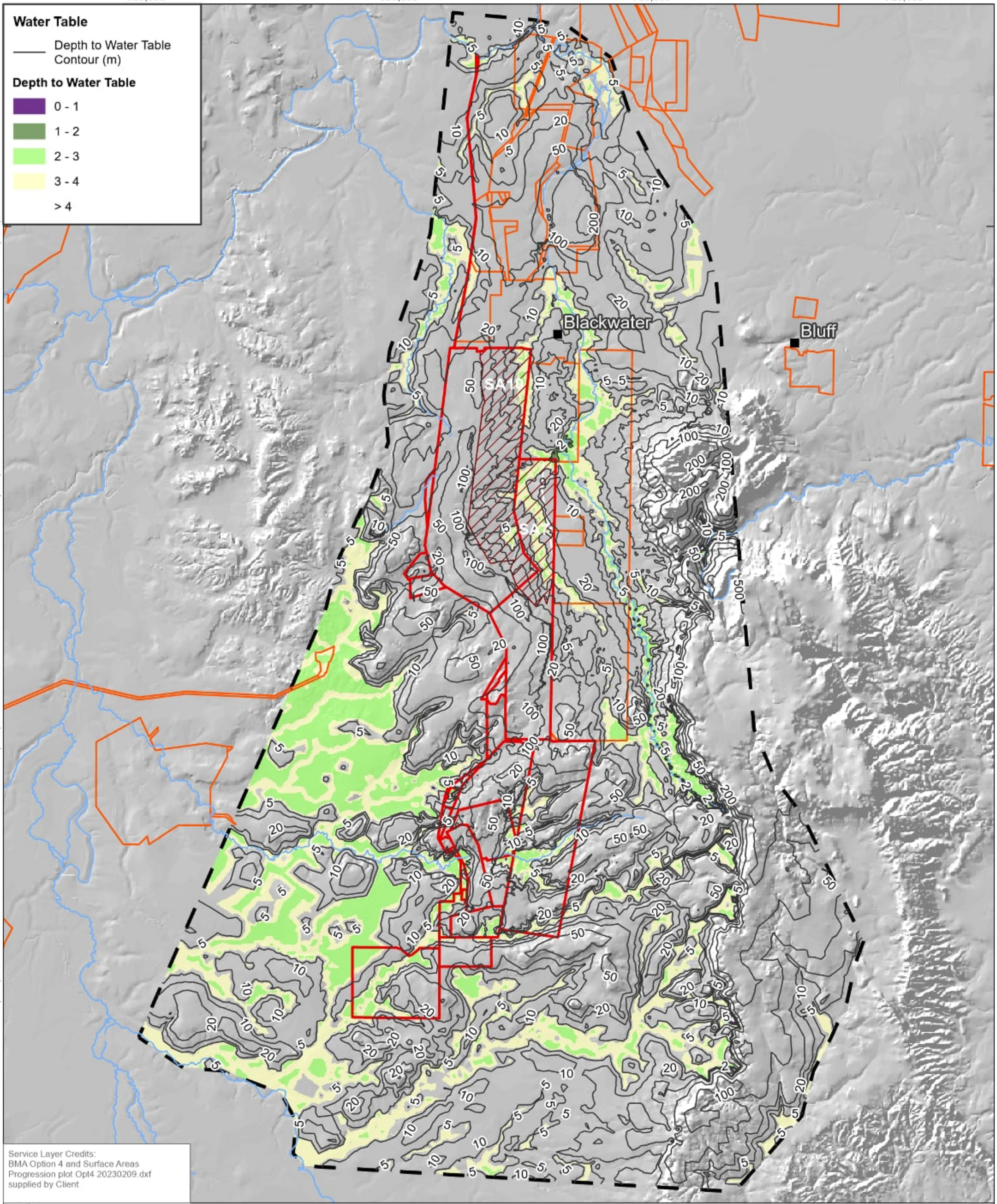
- City/Town
- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

TRANSIENT CALIBRATION AVERAGE HEAD RESIDUALS (M)

SLR

FIGURE 6-3



Coordinate System: GDA2020 MGA Zone 55
Scale: 1:400,000 at A4
Project Number: 620.014601
Date Drawn: 04-Dec-2023
Drawn by: NT

LEGEND

- City/Town
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

MODELLED DEPTH TO WATER TABLE (m) (DECEMBER 2022)

SLR

FIGURE 6-4

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_4_Modelled Depth To GWT

The computed pre-mining water balance showed that recharge was the main contribution to the groundwater. Discharge occurred via evapotranspiration and baseflow to creeks in the southwest of the model area. For the calibration period, the recharge was still a main contributor, however, additional inflow came through mine infrastructure (dams and pit lakes). Outflows included evapotranspiration, baseflow to creeks, dewatering from mining. A full discussion of the pre-mining and transient calibration water balance is presented in **Appendix B** (Groundwater Modelling Technical Report).

6.3.5 Calibrated Hydraulic Properties

Table 6-6 provides a summary of the calibrated values for horizontal and vertical hydraulic conductivity used in the model. **Figure 6-5** shows the estimated and calibrated hydraulic conductivities for five zones in the form of Box-and-Whisker plots.

Table 6-6 Calibrated Hydraulic Conductivities

Model Layer	Formation	Unit	Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kz/Kx	Specific Yield Sy	Specific Storage S_s (m^{-1})
1	Alluvium	Surface cover	1	0.1	0.02	1E-05
1	Tertiary	Surface cover	0.05	0.02	0.01	1E-05
2	Alluvium	Surface cover	1	0.1	0.02	1E-05
2	Weathered zone	Surface cover	0.025	0.01	0.002	1E-06
3	Clematis Group	Triassic	0.01	0.05	0.003	1E-06
4	Rewan Group (Upper)	Triassic	0.000005 to 0.0094	0.1	0.003	1E-06
5	Rewan Group (Middle)	Triassic	0.000005 to 0.0099	0.1	0.003	1E-06
6	Rewan Group (Lower)	Triassic	0.000005 to 0.0097	0.01	0.003	1E-06
7	Rangal Coal Measures	Overburden	0.000005 to 0.0079	0.005	0.003	5E-06
8		Aries seam	0.000005 to 0.59	0.2	0.003	1E-06
9		Interburden	0.000005 to 0.0099	0.025	0.003	3E-06
10		Castor seam	0.000005 to 0.3	0.5	0.003	3E-06
11		Interburden	0.000005 to 0.0098	0.05	0.003	3E-06
12		Pollux seam	0.000005 to 0.3	0.5	0.003	3E-06
13		Underburden	0.000005 to 0.025	0.1	0.003	1E-06
14	Burngrove Formation	Permian	0.000005 to 0.03	0.3	0.003	3E-06

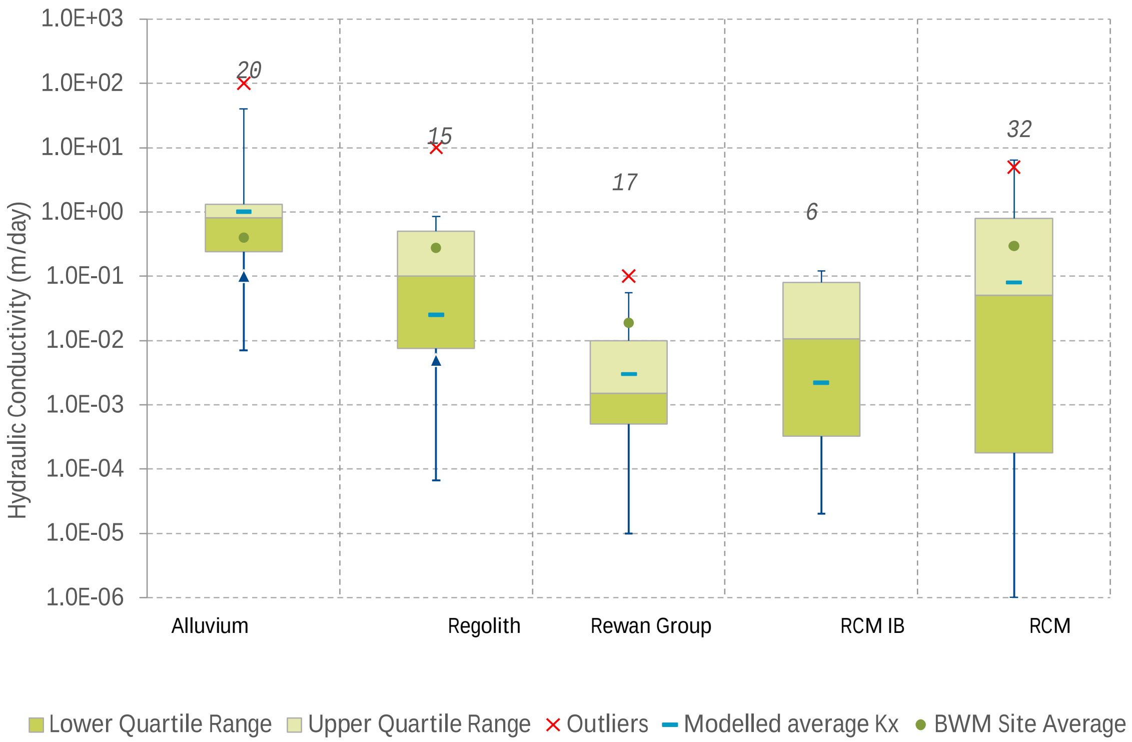


Figure 6-5 Estimated Hydraulic Conductivities vs Calibrated Hydraulic Conductivities

The calibration was followed by a Sensitivity Analysis. The horizontal hydraulic conductivity of the Tertiary, Alluvium, Weathered Zone, Overburden, Pollux Seam, Underburden and Burngrove were found to be well constrained by calibration (high identifiability). The horizontal hydraulic conductivity of the Clematis Group and Upper Rewan Group has not been able to be constrained during calibration, due to a lack of calibration targets in those formations. More detail can be found in **Appendix B** (Groundwater Modelling Technical Report).

6.4 Model Predictions

Transient predictive modelling was undertaken to simulate both the proposed mining at the Project and surrounding mines from July 2023 to June 2085. The model timing used annual stress period durations as mining progressed into the future. Transient predictive models have been developed for three model scenarios:

- Cumulative Scenario– all approved and foreseeable mining in the model area and at BWM plus the Project.
- Approved Scenario– all approved and foreseeable mining in the model area and at BWM without the Project.
- Null Run – no mining within in the model area.

The Project effects (i.e. the incremental changes) are determined by the difference between the Cumulative and Approved scenarios.

6.4.1 Predicted Groundwater Interception

The mine inflow volumes have been calculated as time weighted averages of the outflow reported by Zone Budget software for the relevant drain cells. The predicted inflows for the Cumulative inflows (Approved mining and Project) and the Incremental inflows (Project only) are presented in **Figure 6-6 a** and **b** respectively.

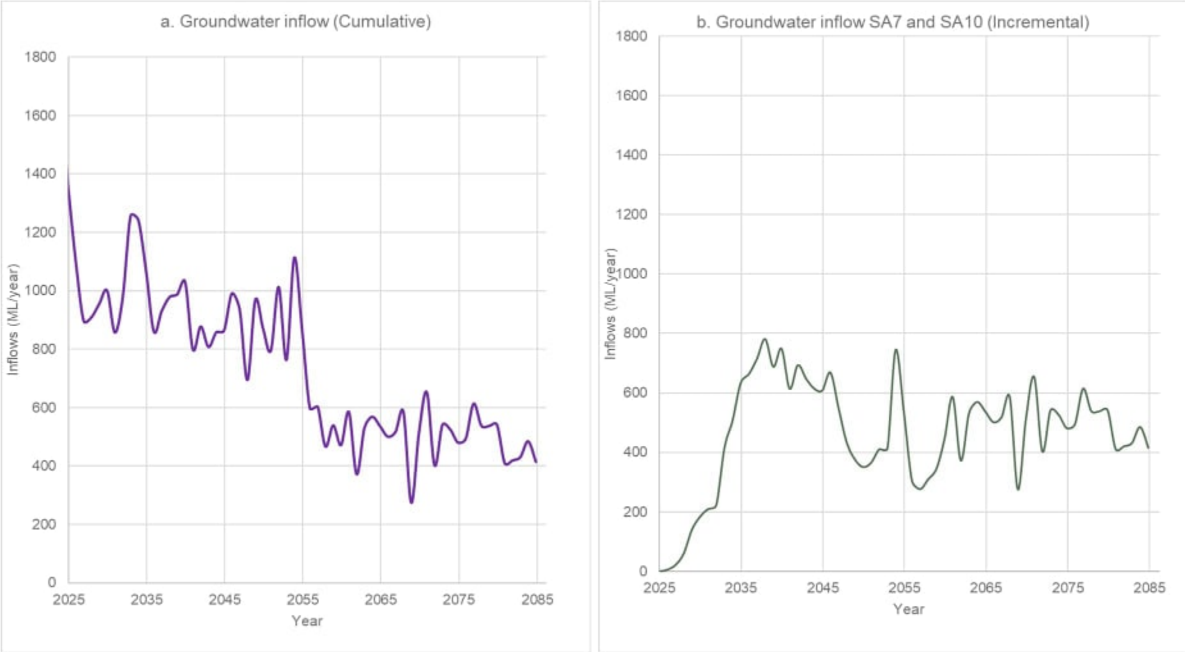


Figure 6-6 Predicted Cumulative (a) and Incremental (b) Mine Inflows

The cumulative inflows (Approved mining and Project) are predicted to reach a maximum in 2025 at 1,400 ML/year and average 735 ML/year between 2025 and 2085. Cumulative inflows are predicted to remain between 800 and 1,000 ML/year between 2025 and 2055, with inflows then decreasing to a range of 400 to 600 ML/year after 2055 until end of mining.

The incremental inflows into the mine pits on SA7 and SA10 are predicted to reach a maximum in year 2038, with a peak just below 800 ML/year (2.2 ML/day). The average inflow rate for the Project (2025 to 2085) is 470 ML/year (1.3 ML/day).

The Water Plan (Fitzroy Basin) 2011 groundwater area consists of the following:

- Groundwater Unit 1 (containing aquifers of the Quaternary alluvium).
- Groundwater Unit 2 (sub-artesian aquifers).

Planned mining operations at the Project will not intercept Quaternary alluvium at any of the proposed pits. As such, all direct groundwater take predicted by the model is from Groundwater Unit 2.

6.4.2 Predicted Maximum Drawdowns

6.4.2.1 Incremental Drawdown

Maximum incremental drawdown refers to the drawdown impact associated with the Project only and is obtained by comparing the difference in predicted aquifer groundwater levels for the Approved model scenario and the Cumulative model scenario. The maximum drawdown represents the maximum drawdown values recorded at each model cell at any time over the model duration. Predicted incremental drawdown figures are presented in panel (a) of **Figure 6-7** to **Figure 6-11**.

Figure 6-7 (a) shows that no incremental drawdown impacts are predicted for the alluvium as a result of mining at the Project. For a discussion on the potential incidental water impacts on the alluvium, see **Section 6.4.3.1**.

The maximum predicted incremental drawdowns associated with the Project within the weathered zone is shown in **Figure 6-8 (a)**. The incremental drawdown extent within the weathered zone (Layer 2) is largely confined to near the pit and is influenced by the distribution of predicted saturated zones in the weathered zone.

The groundwater model predicts that there is no incremental drawdown in the Clematis Sandstone.

The Permian coal seams are the primary aquifers targeted by the Project and will experience drawdowns as a direct result of mining at the Project. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents. **Figure 6-9 (a)** and **Figure 6-10 (a)** show the maximum predicted incremental drawdown for the Aries and Pollux Seams in the Rangal Coal Measures, respectively. The figures show that to the west, the extent of maximum predicted incremental drawdown of the Permian coal measures is limited to near the pit due to the structural geology (i.e., coal seams subcrop). The extent of maximum predicted incremental drawdown in the coal seams towards the east reaches the vicinity of Blackwater Creek (laterally at depth, not vertically into the shallow formations, such as alluvium or tertiary).

Maximum predicted incremental drawdown for the Burngrove Formation is shown in **Figure 6-11 (a)**. The figure shows that maximum predicted incremental drawdown is similar to the drawdown in the coal seams and is limited to the area of outcrop.

6.4.2.2 Cumulative Drawdown

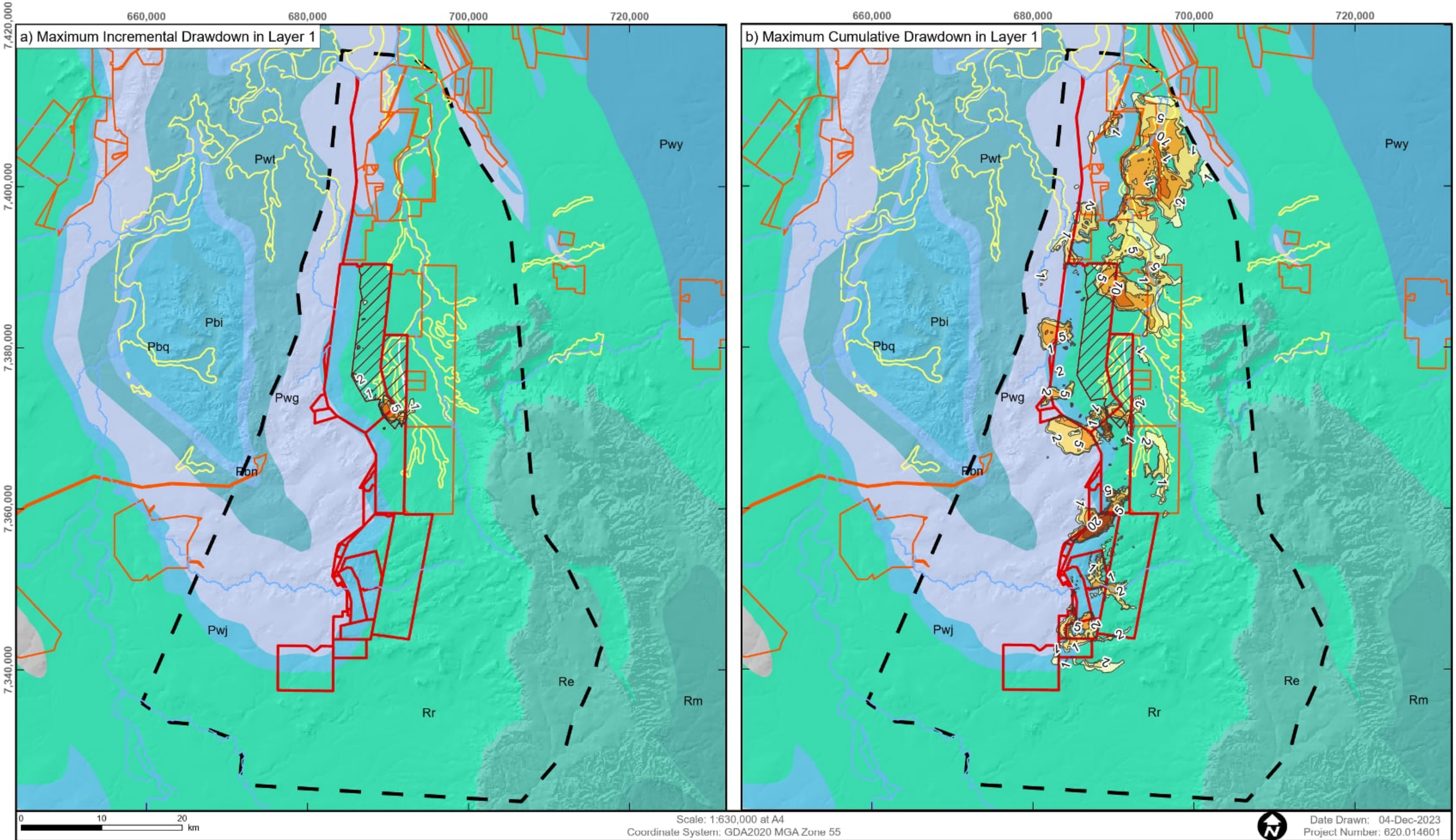
Maximum Cumulative drawdown predicted impacts are shown in panel (b) of **Figure 6-7** to **Figure 6-11**. These drawdowns represent the total impact of mining by all current mining and foreseeable mining, including the Project. The cumulative drawdown is derived by calculating the maximum difference in the groundwater levels for the Cumulative model scenario with those in a theoretical “No Mining” or Null Run scenario, for all times during the predictive model period.

Cumulative drawdown impacts for the Alluvium and Tertiary Sediments (**Figure 6-7 (b)**) show that maximum predicted cumulative drawdown impacts are in the north near Blackwater Creek. The cumulative drawdown impacts within the weathered zone (**Figure 6-8 (b)**) is more widespread.

The groundwater model predicted that there is no cumulative drawdown in the Clematis Group.

Figure 6-9 (b) and **Figure 6-10 (b)** show the maximum predicted cumulative drawdown in the Aries and Pollux seams respectively. As shown in the figures the maximum cumulative drawdown is bounded on the western side by the coal seam outcrop and predicted to extend generally a distance of approximately 5-7 km east of the mining areas. The cumulative drawdown reached the model boundary in the northeast, which coincides with a major fault. An extension of the model in that area would still result in the same drawdown, as the fault is likely to act as a barrier to flow.

Figure 6-11 (b) shows the maximum predicted cumulative drawdown in the Burngrove Formation. As shown in the figure, the maximum cumulative drawdown for this unit is similar to the predicted drawdowns in the Permian Coal Measures and predicted to extend approximately 5-7 km east of the mining areas.



SLR

Service Layer Credits:

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

LEGEND

- Drawdown Contour (m)
- Watercourse
- Alluvium Extent
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

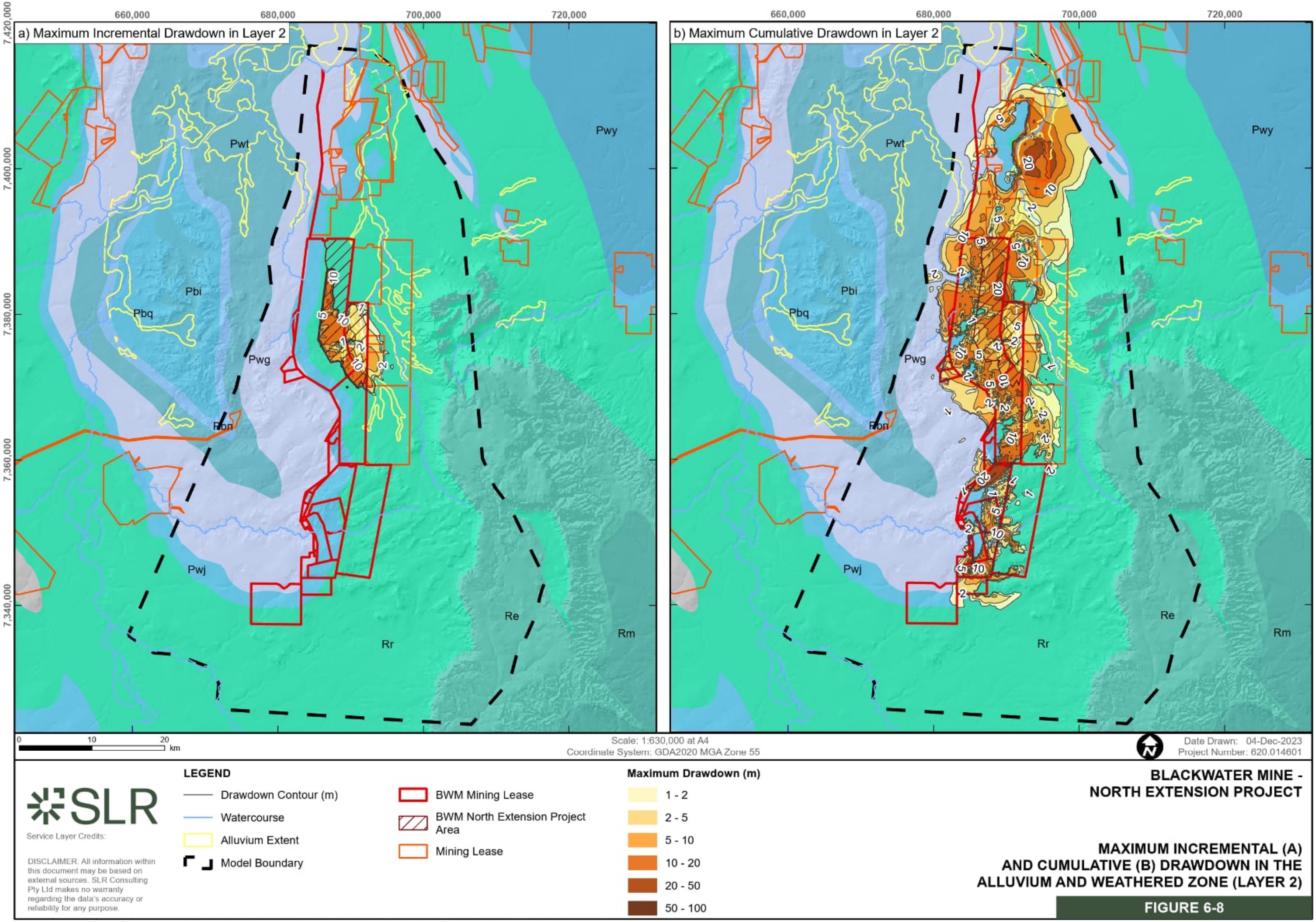
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100

BLACKWATER MINE - NORTH EXTENSION PROJECT

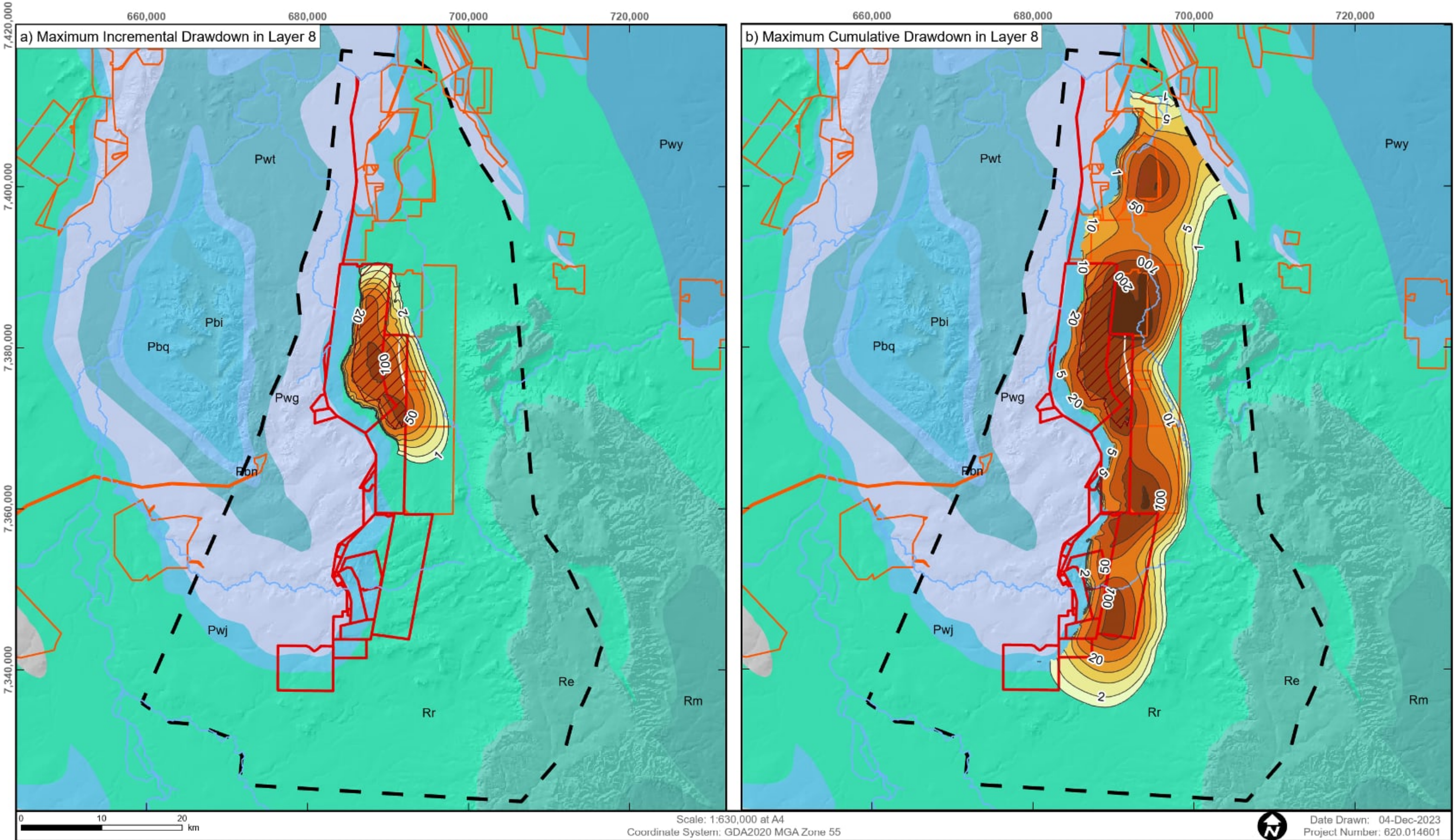
MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE ALLUVIUM AND TERTIARY (LAYER 1)

FIGURE 6-7

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_7_Incremental_Cumulative DD Layer



Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_8_Incremental_Cumulative DD Layer 2



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Service Layer Credits:

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LEGEND

- Drawdown Contour (m)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

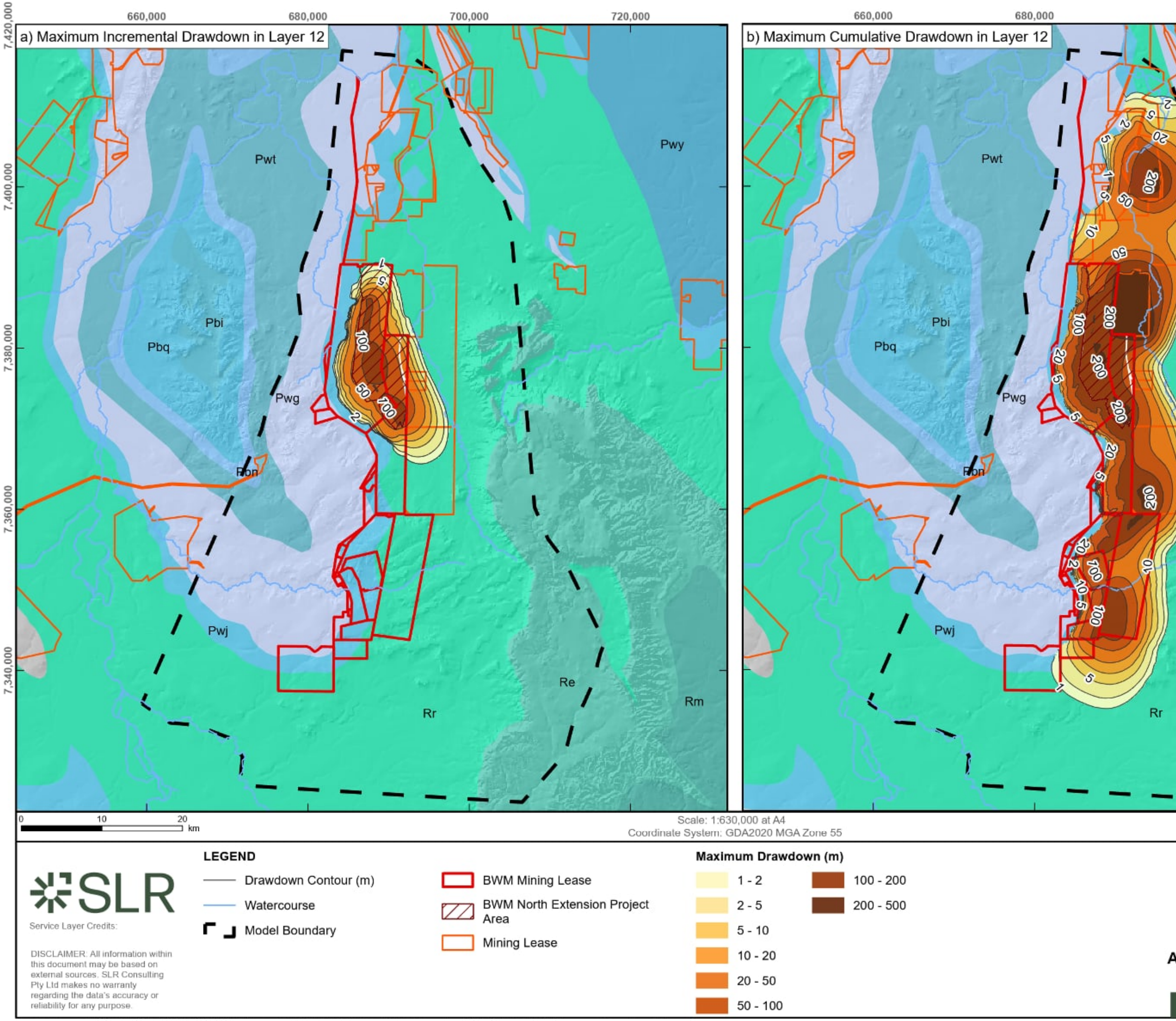
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE ARIES SEAM (LAYER 8)

FIGURE 6-9

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_9_Incremental_Cumulative DD Layer 8

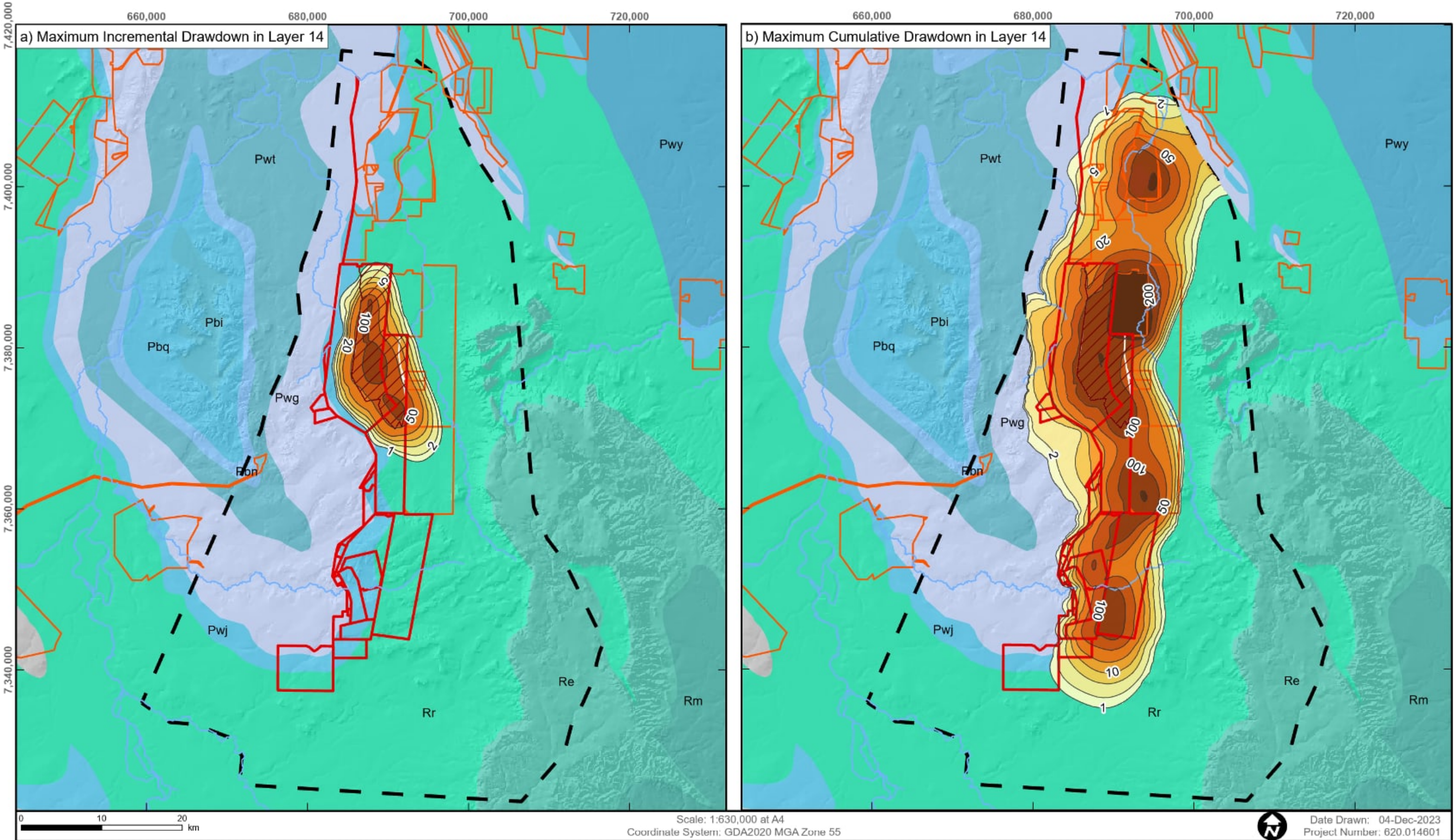


BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE POLLUX SEAM (LAYER 12)

FIGURE 6-10

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_10_Incremental_Cumulative DD Layer 12



SLR

Service Layer Credits:

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

LEGEND

- Drawdown Contour (m)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE BURNGROVE FORMATION (LAYER 14)

FIGURE 6-11

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_11_Incremental_Cumulative DD Layer 14

6.4.3 Incidental Water Impact

6.4.3.1 Influence on Alluvium

The change in alluvial water resources was estimated by comparing water budgets for alluvial zones using the Approved and Cumulative scenarios of the predictive model. Interference of the alluvial groundwater can occur due to reduced upward leakage from Permian Coal Measures that are depressurised because of mining activities. Over the extent of Quaternary alluvium of Blackwater Creek, there is a maximum flow reduction of 0.23 ML/day from the underlying formation into alluvium as a result of the Project.

Section 5.3.7 discussed the vertical flow between units. The data showed that the water levels in the Rangal Coal Measures are currently higher than in the overlying Rewan Group at the two locations that had grouped bores. There is no data confirming this upward gradient for alluvial bores. The results above can hence not be verified, however, the scale of the change in the alluvium is very minor.

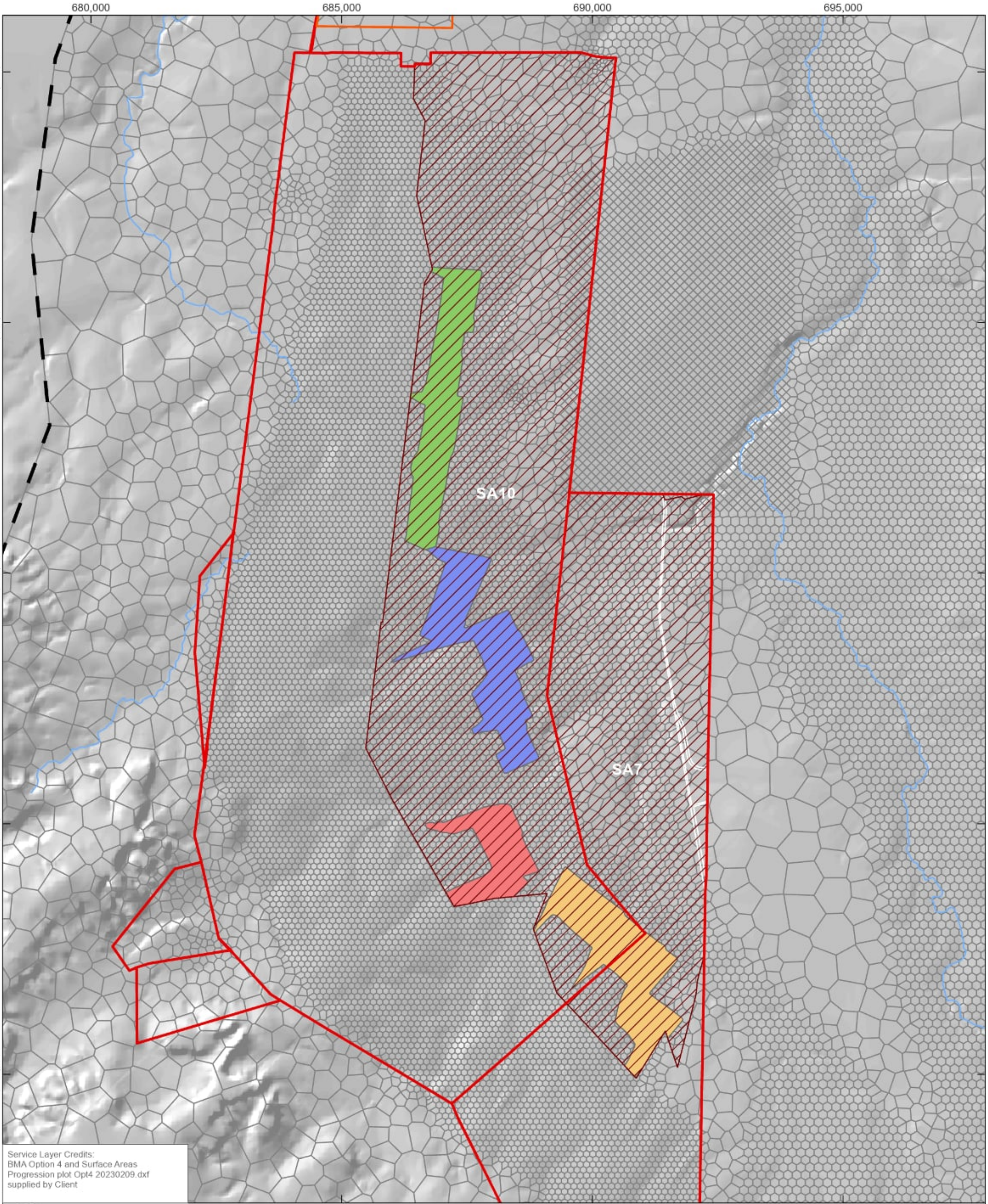
6.4.3.2 Influence on Blackwater Creek

The net groundwater flow to Blackwater Creek is 0.48 ML/day in the Null Run whilst the net groundwater flow to Blackwater Creek is 0.27 ML/day and 0.26 ML/day for the Approved and Cumulative scenarios respectively. All three scenarios indicate the flow is generally from groundwater to the Creek, however this flow is very minor (and shows that Blackwater Creek does not receive continuous amounts of baseflow).

This is the information that indicates there is a 0.01 ML/day change in net groundwater flow to Blackwater Creek.

6.4.4 Post Mining Equilibrium

The potential post mining impacts of the Project were investigated with a recovery model, commencing at the end of mining at the Project with a run time of 200 years. A transient model was created to ascertain post-mining void inflows, with all predictive model drain cells removed. At the end of mining at the Project, the properties of the final void cells were converted to values representative of a void. The void cells were assigned high horizontal and vertical hydraulic conductivities (100 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of 5.0×10^{-6} m^{-1}), to simulate free water movement within the final void. This approach is often referred to as a 'high-K' lake. The indicative location of final voids at the Project is provided in **Figure 6-12**.



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- Model Grid
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Final Void

- Void 1
- Void 2
- Void 3
- Void 4

BLACKWATER MINE - NORTH EXTENSION PROJECT

INDICATIVE FINAL VOID LOCATIONS

SLR

FIGURE 6-12

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_12_Final Void

The recovery model was run transiently with no direct recharge and evaporation onto the open void areas. From this model run, the groundwater inflows to the final voids were incorporated in the site water balance model for the Project's Surface Water Assessment prepared by SLR (2023).

A transient pit lake recovery level time series predicted by the surface water balance modelling was then incorporated into the final groundwater model recovery run. The recovery curves in the four void areas derived from the surface water modelling were integrated into the numerical groundwater model using the time variant constant head boundary condition (CHD). **Figure 6-13** shows the predicted surface water level at each void, used as the CHD for the groundwater model. As shown in the figure, the equilibrated final void water level is 57.5 mAHD, 64.3 mAHD, 120.6 mAHD and 64.0 mAHD for voids 1, 2, 3 and 4 respectively.

The recovery model was then re-run using CHD package for 200 years. The predicted final groundwater water levels are presented in **Figure 6-14**. The figure shows that all four void areas are predicted to act as a groundwater sink, which means that groundwater will flow into the voids and therefore it is unlikely that there will be an impact on groundwater quality in the surrounding groundwater environment.

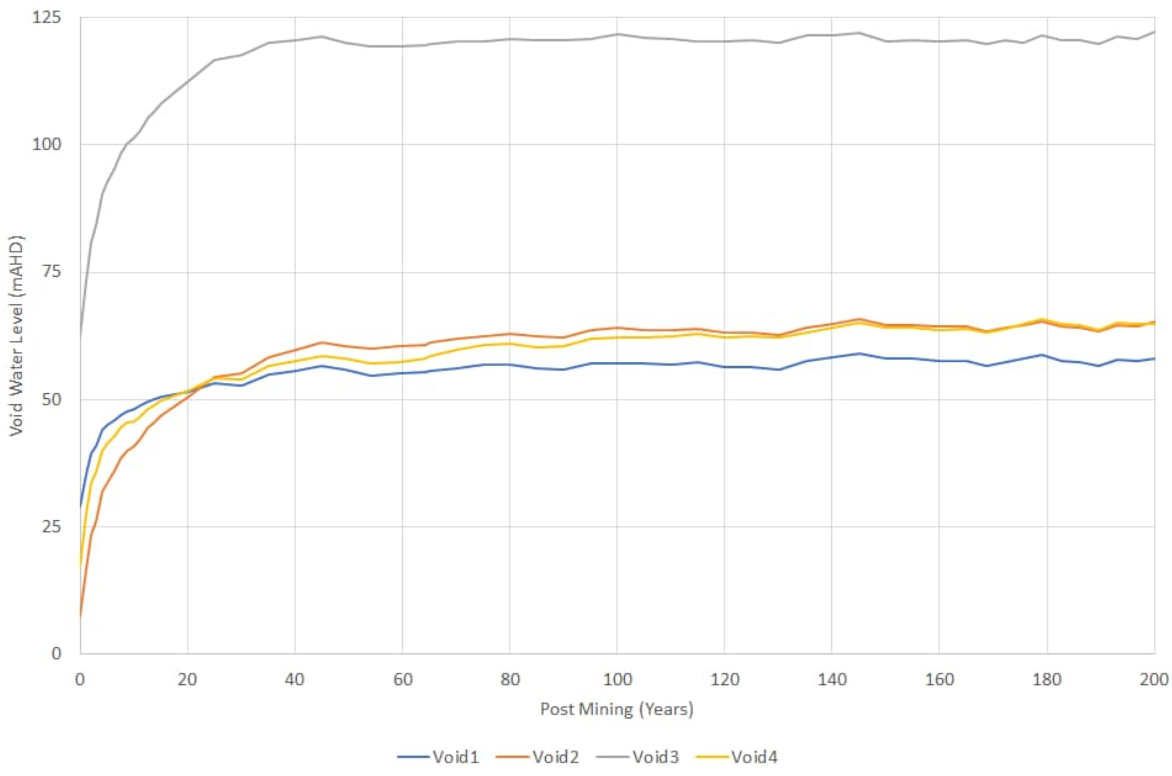
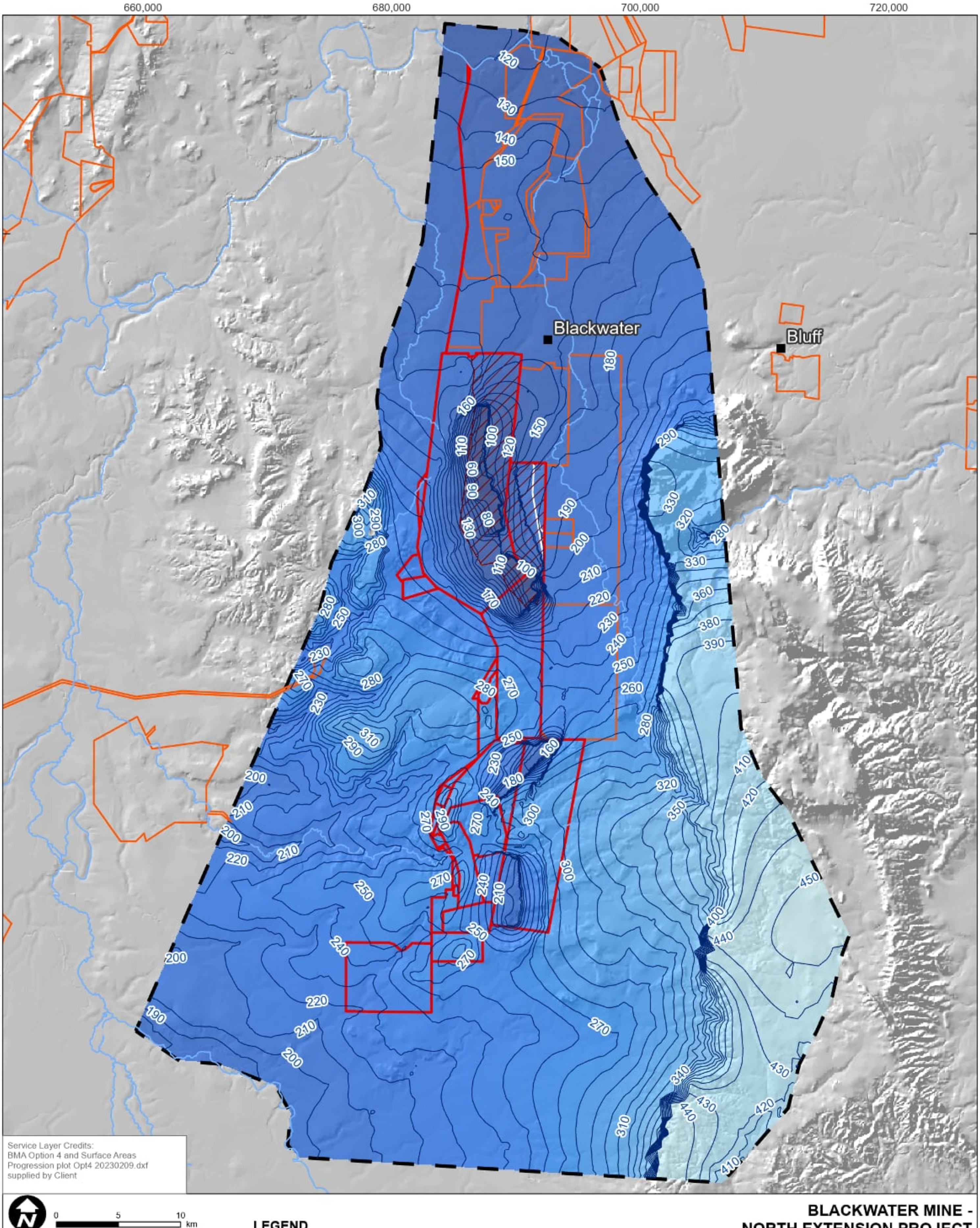


Figure 6-13 Predicted Project Final Void Water Level Recovery over Time



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

SLR

LEGEND

- City/Town
- Groundwater Level Contour (mAHD)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Groundwater Level (mAHD)

454

58

BLACKWATER MINE - NORTH EXTENSION PROJECT

GROUNDWATER TABLE RECOVERY (200 YEARS POST-MINING)

FIGURE 6-14

6.5 Sensitivity Analysis

As part of this assessment, a calibration sensitivity, calibration identifiability and prediction identifiability were undertaken. Details are presented in **Appendix B** (Groundwater Modelling Technical Report).

6.6 Uncertainty Analysis

6.6.1 Uncertainty of Mine Inflows

Figure 6-15 presents the uncertainty of groundwater inflow into the mine due to the Project from 2021 to the end of planned mining in 2085. The figure shows the predicted inflows for the base case model and different percentiles including 10th, 33rd, 67th and 90th prediction bounds. Based on the IESC (2018) guidelines these represent:

- Less than 10th percentile indicates it is very likely the outcome is larger than this value.
- 10th–33rd indicates it is likely that the outcome is larger than this value.
- 33rd–67th indicate it is as likely as not that the outcome is larger or smaller than this value.
- 67th–90th indicates it is unlikely that the outcome is larger than this value.
- Greater than 90th percentile indicates it is very unlikely the outcome is larger than this value.

The bounds in the figure demonstrate the uncertainty within the predicted inflow rate. As shown in **Figure 6-15**, the maximum predicted mine inflow in the uncertainty analysis was approximately 3,650 ML/year (10 ML/day). The inflow averages of the 10th to 90th percentiles over the time period from 2021 to 2085 were 441 ML/year (1.21 ML/day) to 1,013 ML/year (2.77 ML/day). The base case is following the 67th percentile curve, which can be interpreted that it is unlikely that the future inflow will be larger than this base case estimate.

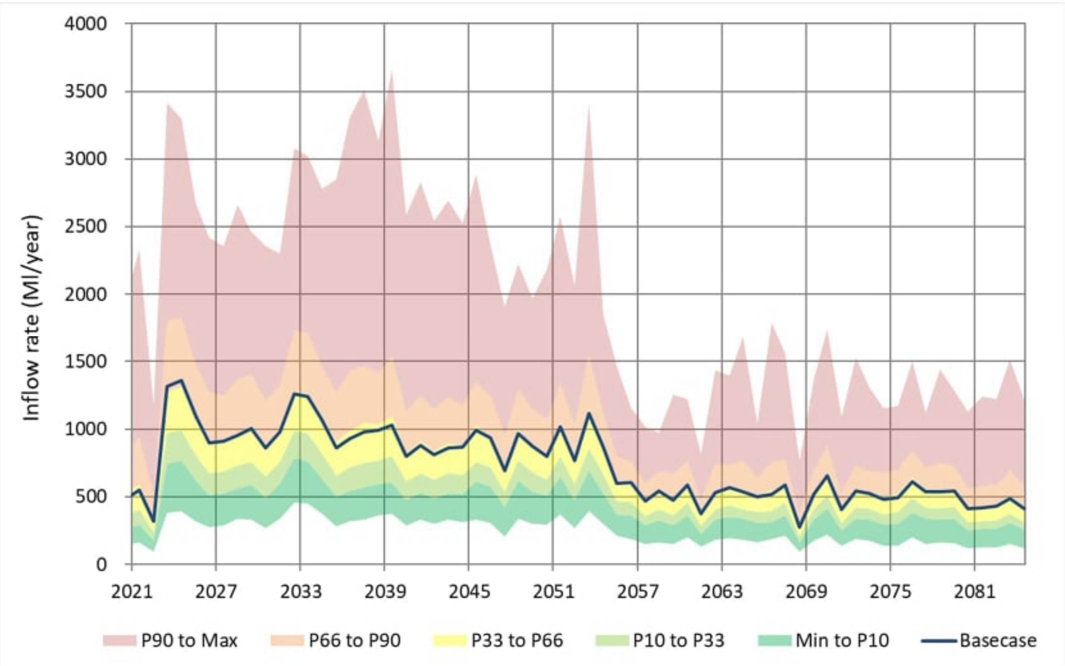


Figure 6-15 Mine Inflow Predictive Uncertainty

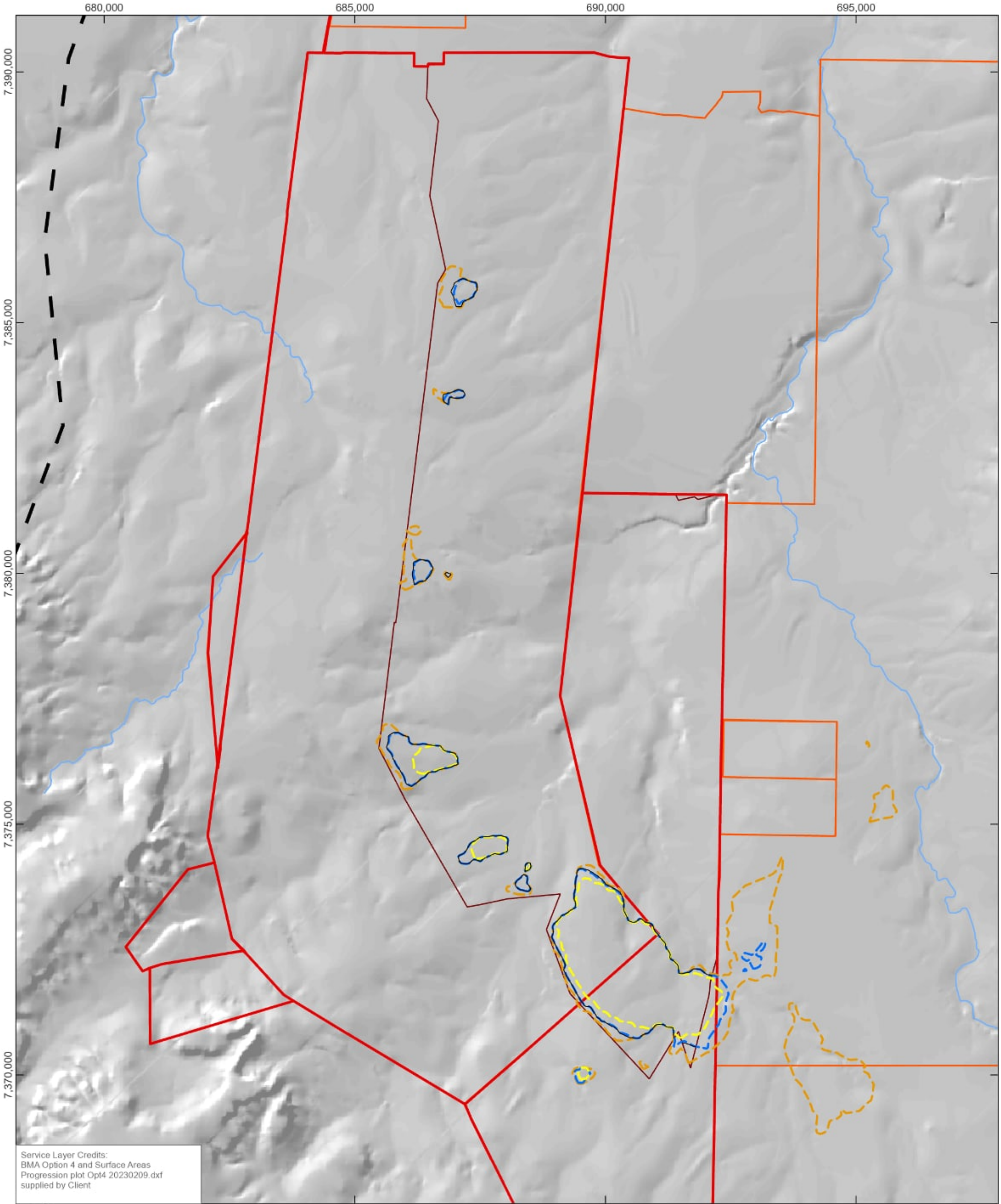
6.6.2 Groundwater Drawdowns

To illustrate the level of uncertainty in the extent of predicted Project incremental drawdown, the base case maximum drawdown and the 50th percentile maximum drawdown extent were compared to the maximum drawdown extent for the 10th and 90th percentiles.

Figure 6-16 and **Figure 6-17** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Alluvium and the Weathered Zone. The figures show that 90th percentile drawdown in localised areas extends approximately 5 km south of the Project area.

Figure 6-18 and **Figure 6-19** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Aries and Pollux Seams. The figures show that the 90th percentile drawdown in the Aries and seams extend to a maximum of approximately 7 km to the east and 9 km to the south of the Project area.

Figure 6-20 shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Burngrove Formation. The figure shows that the 90th percentile drawdown in the Burngrove Formation extends to a maximum of approximately 7 km to the east and 9 km to the south of the Project area.



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

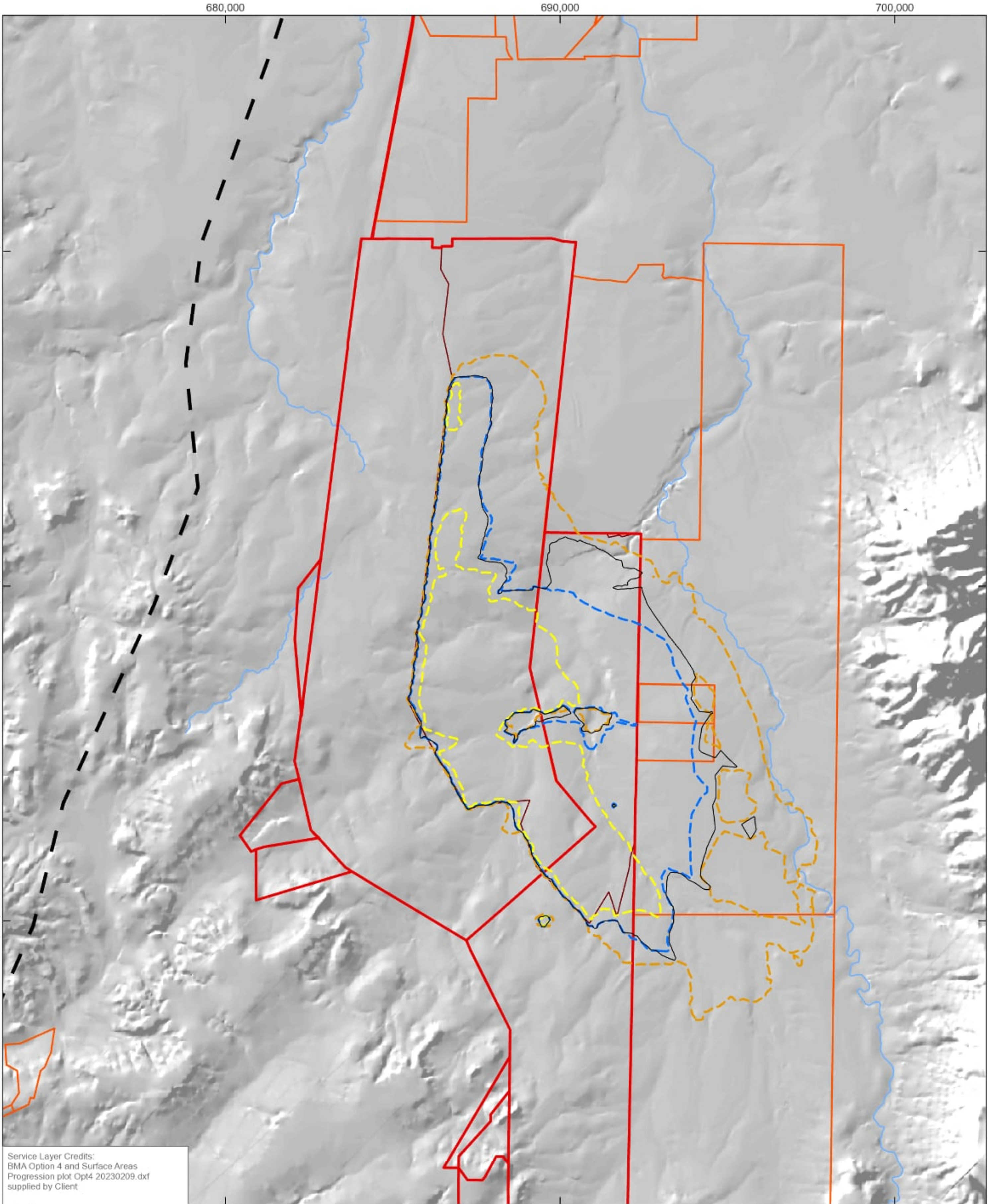
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Perentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE -
NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE ALLUVIUM AND TERTIARY (LAYER 1)

SLR

FIGURE 6-16



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

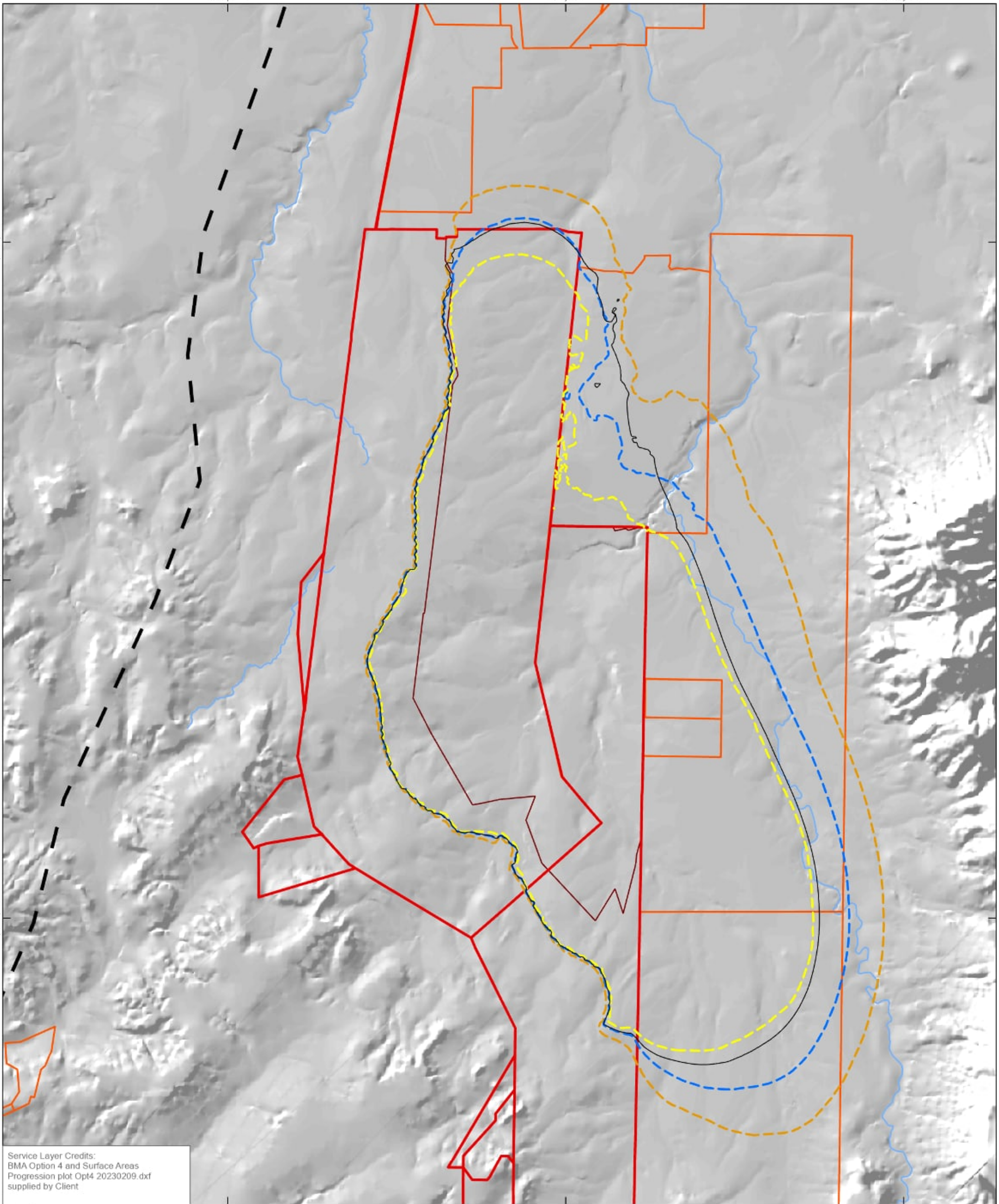
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Percentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE WEATHERED ZONE (LAYER 2)

SLR

FIGURE 6-17



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

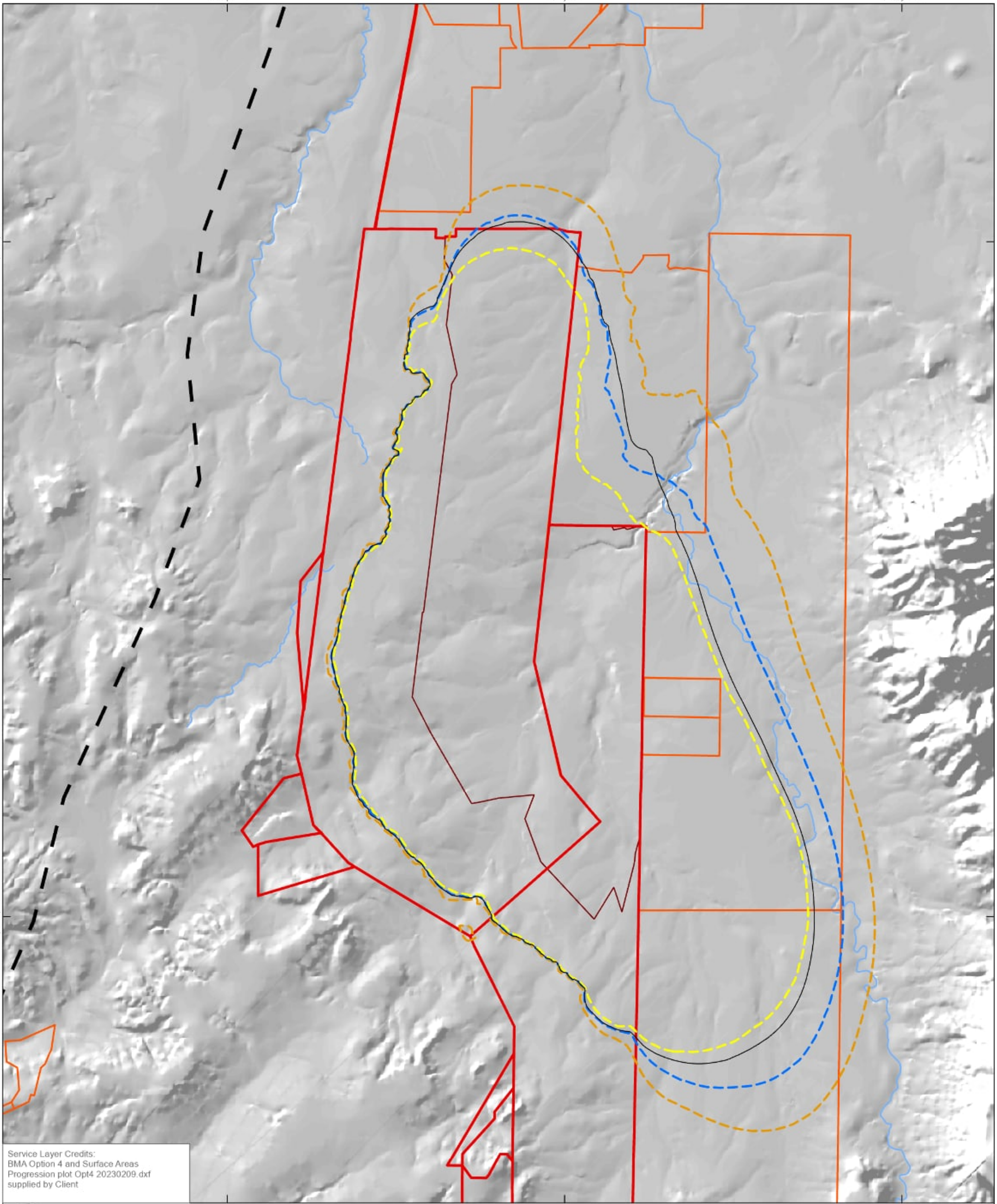
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Percentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE ARIES SEAM (LAYER 8)

SLR

FIGURE 6-18



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Percentile
- 50th Percentile
- 10th Percentile

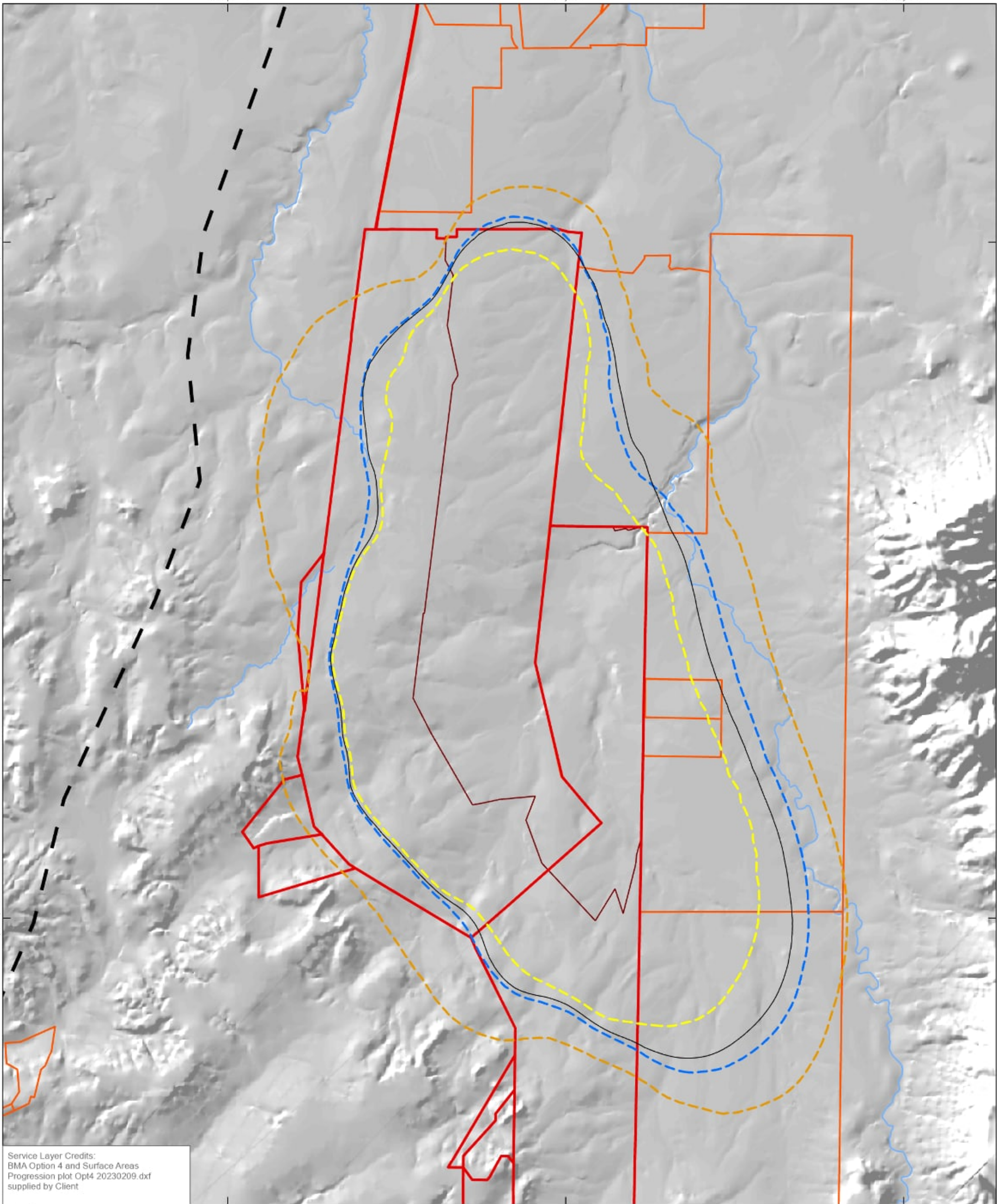
BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE POLLUX SEAM (LAYER 12)

SLR

FIGURE 6-19

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_19_Predicted 1m Max Inc DD in Layer 12



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	04-Dec-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Percentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE BURNGROVE FORMATION (LAYER 14)

SLR

FIGURE 6-20

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F06_20_Predicted 1m Max Inc DD in Layer 14

6.6.3 Uncertainty of Drawdown at Landholder Bores

Table 6-7 summarises the 95th percentile maximum drawdown at water supply bores predicted to be impacted during the mining period. The 95th percentile prediction was chosen to provide a conservative estimate of likely impacts to these bores, noting that the 95th percentile is considered to be very unlikely.

The uncertainty results show that the 95th percentile of the maximum incremental impact from the Project would be 0.54 m at bore RN84221. The highest expected 95th percentile of the cumulative maximum drawdown is 16.34 m at the same bore RN84221, which was estimated to be 9.38 m for the base case (refer to **Table 7-1**).

Table 6-7 Predicted Maximum Drawdown Impact on Landholder Bores (Uncertainty Analysis, 95th percentile)

Registered RN (ID)	Bore Name	Easting (GDA94 z55)	Northing (GDA94 z55)	Geology	Bore Depth (m)	Use	Maximum Incremental Drawdown (95th percentile) (m)	Maximum Cumulative Drawdown (95th percentile) (m)
38998	No 2 Bore	681119	7391492	Burngrove Formation	36.6	Unknown	0.09	7.82
43097	-	681800	7392230	Burngrove Formation	22.9	Unknown	0.13	10.54
43459	Top Bore	683719	7395787	Unknown	54.9	Unknown	0.05	10.34
57503	Stake Bore	680333	7361655	Burngrove Formation[1]	Unknown	Unknown	0.02	0.90
57504	Eighteen Mile Bore	682192	7365312	Unknown	Unknown	Unknown	0.01	1.00
84221	-	683596	7390708	Burngrove Formation	24	Unknown	0.54	16.34
89034	-	680391	7390291	Unknown	Unknown	Unknown	0.00	0.02
103345	JWS Bore	684091	7363016	Burngrove Formation	47	Unknown	0.18	6.50
111709	-	680013	7390877	Burngrove Formation	72	Water Supply	0.01	0.68
Unregistered 11	-	680420.5	7378058.5	Burngrove Formation	Unknown	Unknown	0.11	5.03
Unregistered 18	-	684005	7362319	Burngrove Formation	Unknown	Stock watering	0.12	5.57

6.6.4 Uncertainty of Influence on Alluvium and Surface Water Flow

The uncertainty analysis results showed that even for the 95th percentile prediction, which is a very unlikely outcome, the indirect take from the alluvium and the change in Blackwater Creek baseflow due to the Project were 0.33 ML/day and 0.15 ML/day respectively.

6.7 Model Limitations

The IESC Uncertainty analysis – *Guidance for groundwater modelling within a risk management framework* (2018) identifies four key sources of scientific uncertainty affecting groundwater model simulations:

- Structural / conceptual.
- Parameterisation.
- Measurement error.
- Scenario uncertainties.

These four sources of scientific uncertainty have been qualitatively assessed. Most of the assessed sources of uncertainty resulted in a ‘fit-for-purpose’ or ‘fit-for-purpose, future improvements possible’. The detailed assessment is presented in **Appendix B** (Groundwater Modelling Technical Report).

The model geology away from the Project area (i.e. beyond the limits of the site geological models) is interpolated and estimated from publicly available data and regional scale mapping (e.g. Queensland Government mapping and EIS documentation). Consequently, the depths, thickness and extents of the model layers away from the Project may not closely replicate reality. This is of particular note when simulating the cumulative impacts of surrounding mines.

Similarly, the timing and extent of surrounding mine activities have been largely inferred from publicly available data, and therefore an over- or under-estimation of impacts, or timing of impacts, may result due to this.

7.0 Impacts on Groundwater Resources

7.1 Highlands Groundwater Management Area

The Project does not directly intercept groundwater from Highlands Groundwater Unit 1 (Quaternary alluvium) under the Water Plan (Fitzroy Basin) 2011, meaning, all direct groundwater taken by the open cut pits for the Project is from Highlands Groundwater Unit 2 (sub-artesian aquifers). The predicted groundwater take (i.e., inflow into the pits directly associated with mining) over time is presented in **Section 6.4.1**, which indicates the cumulative groundwater take would be in the order of up to 1,400 ML/year (average 735 ML/year) from Groundwater Unit 2.

7.2 Potential Impact on Groundwater Users

7.2.1 Privately-Owned Supply Bores

Chapter 3 of the *Water Act 2000* provides bore drawdown threshold triggers of 2 m for unconsolidated aquifers, and 5 m for consolidated aquifers, to aid in the assessment of impacts to third party bore users. These criteria have been adopted for the assessment herein.

The impact assessment evaluated the drawdown at each of the eleven landholder bores identified in a 10 km radius of the Project area. **Table 7-1** lists the bores with their name, location, screened formation and use. The last two columns present the maximum incremental and cumulative drawdown predicted to occur at each location for the model base case. The results from the uncertainty analysis are listed in **Table 6-7**.

There are no predicted incremental drawdowns at any of the identified bores that exceed the Water Act bore trigger thresholds as a result of the Project. Incremental drawdown from the Project is only expected at two bores. The maximum predicted incremental drawdown is 0.07 m at bore “RN84221” and 0.01 m at Bore ‘Unregistered 11’ (**Table 7-1**). The largest maximum cumulative drawdown of 9.38 m is predicted at Bore RN84221 to the north of the mine, followed by bores RN103345, “Unregistered 11” and “Unregistered 18”, all of which have predicted cumulative drawdowns of approximately 2–4m. Seven bores are predicted to experience a maximum cumulative drawdown of 15 cm or less, which is considered insignificant.

Table 7-1 Drawdown Impact on Landholder Bores (Base case scenario)

Registered RN (ID)	Bore Name	Easting (GDA94 z55)	Northing (GDA94 z55)	Geology	Bore Depth (m)	Use	Maximum Incremental Drawdown (m)	Maximum Cumulative Drawdown (m)
38998	No 2 Bore	681119	7391492	Burngrove Formation	36.6	Unknown	0.00	0.09
43097	-	681800	7392230	Burngrove Formation	22.9	Unknown	0.00	0.08
43459	Top Bore	683719	7395787	Unknown	54.9	Unknown	0.00	0.06
57503	Stake Bore	680333	7361655	Burngrove Formation1	Unknown	Stock Watering	0.00	0.10
57504	Eighteen Mile Bore	682192	7365312	Unknown	Unknown	Stock watering	0.00	0.11
84221	-	683596	7390708	Burngrove Formation	24	Unknown	0.07	9.38
89034	-	680391	7390291	Unknown	Unknown	Unknown	0.00	0.00
103345	JWS Bore	684091	7363016	Burngrove Formation	47	Not In Use	0.00	2.23
111709	-	680013	7390877	Burngrove Formation	72	Water Supply	0.00	0.02
Unregistered 11	-	680420	7378058	Burngrove Formation	Unknown	Stock Watering	0.010	3.66
Unregistered 18	-	684004	7362319	Burngrove Formation	Unknown	Stock Watering	0.00	1.69

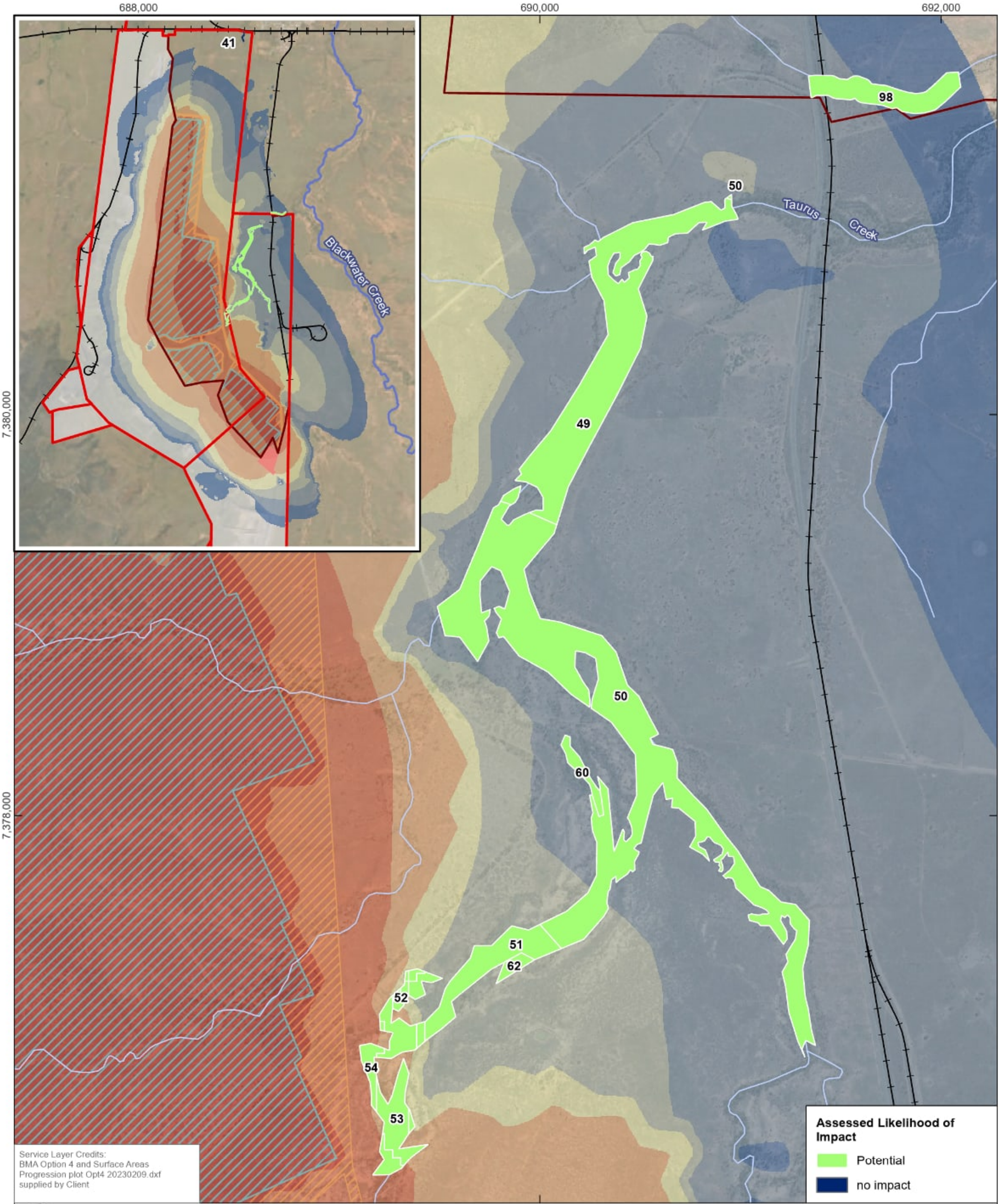
The uncertainty results showed that the 95th percentile maximum cumulative drawdown is predicted to be greater than 5 m at six water supply bores (**Table 6-7**). As per Table 2 of the IESC (2020), in terms of likelihood of exceedance, a percentile greater than 95% means that it is very unlikely that the maximum cumulative drawdown will be greater than 5 m at these bores.

7.2.2 Groundwater Dependent Ecosystems

The assessment of impact on TGDEs was undertaken by EMM (2023). The assessment was done in the following steps:

- The search radius for all potential TGDEs was the 90th percentile of the 1 m water table drawdown curve from the Uncertainty Analysis (**Section 6.6**). Using the 90th percentile for a search radius adds confidence that all potential TGDEs are captured in this assessment.
- Potential TGDEs in the search radius were identified by EMM using the depth to water table mapping (**Section 6.6**) and vegetation mapping (ground-truthed within the Project area and government RE mapping outside the Project area). As discussed in **Section 5.7.1**, the RDM Hydro et al. (2023) water table mapping was preferred for assessment of likelihood of groundwater dependency.
- Any potential TGDEs with a rooting depth within the groundwater table were then assessed to determine where there was no potential for impact, or there is a potential for impact that requires further investigation.

The results of the EMM, 2023 assessment are presented in **Figure 7-1**.



0 250 500 m

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:25,000 at A4
Project Number:	620.014601
Date Drawn:	11-Dec-2023
Drawn by:	NT

LEGEND

- Railway
- Minor Watercourse
- Major Watercourse
- BWM North Extension Project Area
- Existing Blackwater Mine
- Existing Mine Infrastructure Area

Indicative Project Footprint

- Proposed Out of Pit Disturbance
- Proposed Pit Extent

Modelled Maximum Water Table Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50- 100
- > 100

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

ASSESSED LIKELIHOOD OF IMPACT IF IDENTIFIED POTENTIAL GDEs

FIGURE 7-1

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GW_F07_1 Potential GDE impact

7.3 Potential Impacts on Surface Drainage

The change in groundwater flow to rivers and creeks due to the Project was calculated by comparing the river flow budgets for Blackwater Creek in the Cumulative scenario against the Approved scenario. This calculation showed that over the life of mine, the change of baseflow is 0.01 ML/day. Given the Blackwater Creek is highly ephemeral, the alluvium is not contributing large amounts of water and this reduction due to the Project is deemed insignificant.

7.4 Potential Impacts on Groundwater Quality

This section describes the potential sources and pathways of groundwater contamination associated with the Project.

7.4.1 In Pit Waste Rock Emplacement Areas

The in-pit waste rock emplacement areas would be rehabilitated progressively as the mining operations progress. The Project would involve progressively backfilling the open cut pit as space becomes available with water levels within backfilled areas predicted to recover back towards pre-mining levels.

7.4.2 Final Void

Four final voids are proposed within the Project area to remain post-closure. The equilibrated predicted final void water levels are listed in **Table 7-2**. All four voids have reached equilibrium in the modelled time period. The predicted final groundwater water levels are presented in **Figure 6-14.** All four void areas will act as a groundwater sink, which means that groundwater will flow into the voids driven by ongoing evaporative discharge from the void lakes.

Table 7-2 also lists the recovered groundwater levels to the east of the pits, read out from the modelling result files at a distance of approximately 250 m (one grid cell at that location is 125 m). The head difference between the groundwater and the pit lake ranges between 17.6 and 39.3 m for all pits. The head differential between pit water level and surrounding groundwater level is larger than 10 m for each pit. This is deemed enough to account for density corrections to not change the direction of hydraulic gradient.

Table 7-2 Final Voids – Equilibrium Water Levels and Groundwater Levels

Component	Equilibrium Pit Water Level (mAHD)	Groundwater Level (mAHD)[1]	Head Difference (m)
Void 1	57.5	96.8	39.3
Void 2	64.3	93.7	29.4
Void 3	120.6	138.2	17.6
Void 4	64.0	95.5	31.5

Water within the final voids would evaporate from the final void water body surface and draw in groundwater from the surrounding strata and runoff from the final void catchment areas. As the final voids would act as a sink, evaporation from the final void water bodies would overtime concentrate salts in the final void water bodies. However, the gradual increase in salinity of the final void water bodies is unlikely to pose a risk to the surrounding groundwater regime, as the final voids would remain as a groundwater sink in perpetuity.

Notwithstanding, the Surface Water Assessment prepared by SLR (2023) for the Project has modelled the equilibrated water levels as well as the potential accumulation of salt in the final void, with TDS concentrations of the final void water estimated to be between 35,000 µS/cm and 37,000 µS/cm.

7.4.3 Workshops and Storage

All workshop and fuel/chemical storage areas at BWM are developed in accordance with current Australian Standards. This includes refuelling areas and chemical storage areas designed with adequate bunding and equipped for immediate spill clean-up. These controls represent standard practice and a legislated requirement at mining operations for preventing the contamination of the groundwater regime. Therefore, there is considered to be limited potential for groundwater contamination to occur with relation to workshops and fuel/chemical storage.

7.5 Impact of Climate Change on Predictions

The Climate Future Tool (CSIRO and BOM, 2022) was interrogated for the cluster East Coast North, which is the relevant sub-cluster for the Blackwater Mine. The general rainfall projection for this cluster was summarised as:

"Natural climate variability is projected to remain the major driver of rainfall changes in the next few decades. Models show a range of results, with little change or decrease being more common particularly in winter and spring. Impact assessment in this region should consider the risk of both a drier and wetter climate."

In the Climate Futures Tool, the functionality "Explore projections" was used to quantify the predicted change in annual rainfall. There are four Representative Concentration Pathways (RCPs), which represent different greenhouse gas concentration scenarios. These are (CSIRO and BOM, 2022):

- RCP8.5 - a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise, reaching 940 ppm by 2100.
- RCP6.0 – lower emissions, achieved by application of some mitigation strategies and technologies. CO_2 concentration rising less rapidly (than RCP8.5), but still reaching 660 ppm by 2100 and total radiative forcing stabilising shortly after 2100.
- RCP4.5 - CO_2 concentrations are slightly above those of RCP6.0 until after mid-century, but emissions peak earlier (around 2040), and the CO_2 concentration reaches 540 ppm by 2100.
- RCP2.6 - the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining. The CO_2 concentration reaches 440 ppm by 2040 then slowly declines to 420 ppm by 2100.

In the projections explorer, each RCP can be assessed at different points in time (up to 2090). For the long-term post-mining recovery, the projections' change in annual rainfall was assessed for the year 2090. The results are presented in **Table 7-3**. The percentage value for each RCP indicates the percentage of models which had the corresponding outcome of percent rainfall. For example, in 2090 for RCP 2.6, 28% (8 of 29) models predicted a reduction in rainfall of more than 15%. In 2090, two of the four RCPs show a 28% and 37% likelihood respectively that rainfall will decrease by more than 15%.

Table 7-3 Change in Rainfall for Different Climate Scenarios (2090)

% Annual Rainfall Comparison	RCP 2.6 (n=29)	RCP 4.5 (n=68)	RCP 6.0 (n=22)	RCP 8.5 (n=70)
>15% (much wetter)	-	-	9%	6%
5 to 15% (wetter)	14%	15%	23%	13%
-5 to 5 (little change)	34%	29%	27%	21%
-15 to -5 (drier)	24%	40%	23%	23%
> -15% (much drier)	28%	16%	18%	37%
Notes: n refers to the number of models in each of the RCP categories				

7.5.1 Climate Impact on Predictions

The climate impact was implicitly included during the Uncertainty Analysis (refer to **Section 6.6**). The changes in recharge for the UA model runs were more than a factor 10 lower and higher respectively (refer to Appendix D of the Groundwater Modelling Technical Report). However, most runs had a recharge within the bracket of 15% lower and higher recharge respectively. Hence, all results reported in **Section 6.6** include extreme climate conditions as well as expected climate change conditions.

7.5.2 Climate Impact on Long-term Post-Mining Recovery

Table 7-4 lists the equilibrium water levels from the surface water assessment for climate extremes. The surface water assessment was based on six deterministic climate scenarios based on one of the RCP 4.5 and 8.5 models for the year 2070. The 10th and 90th percentiles of those runs are presented in comparison to the median water level estimate (50th percentile). The dry and wet climate water levels change by 3 to 5 m for the four voids from the median water level. If drier or wetter conditions should prevail, the voids would still remain sinks to the groundwater (refer to **Section 6.4.4**).

Table 7-4 Final Voids – Equilibrium Water Levels – Climate Extremes

Component	P10 Equilibrium Pit Water Level (mAHD)	P50 Equilibrium Pit Water Level (m AHD)	P90 Equilibrium Pit Water Level (m AHD)
Void 1	49.01	51.65	58.08
Void 2	59.38	61.98	68.17
Void 3	116.40	118.55	122.1
Void 4	61.98	65.55	70.98

8.0 Management and Mitigation

8.1 Mitigation Measures

8.1.1 Mine Affected Water

The mine plan for the Project includes strategies to manage mine affected water for the life of the Project.

Groundwater inflows to the open cut pits during mining operations would be pumped out (along with any surface water) via in-pit sumps if the groundwater doesn't passively evaporate on the pit face or from the pit floor. The groundwater inflows would be collected and contained within the mine water management system.

Waste rock material would be emplaced in-pit as the space becomes available and will in some areas form the walls of the final voids. As outlined in **Section 7.4.2**, groundwater within each of the four final voids is predicted to remain below pre-mining levels. Therefore, it is anticipated that the final voids would act as a groundwater sink, capturing water associated with in-pit rejects.

As documented in SLR (2023), an up-catchment diversion system would also be developed to divert surface water flows away from the disturbed areas associated with the Project. Flood levees and/or flood protection landforms during operations designed to an 0.1% Annual Exceedance Probability (AEP) flood event would also be developed to prevent inundation of the open cut pits.

8.1.2 Groundwater Use

The potential impacts on groundwater users (privately-owned bores) are described in **Section 7.2**. The incremental drawdown at privately-owned bores is not predicted to exceed relevant bore trigger thresholds in the Chapter 3 of the Water Act, and therefore there are no existing privately-owned bores that would be impacted by the Project to a degree that may require mitigation.

8.2 Groundwater Management

8.2.1 Groundwater Monitoring Program

A groundwater monitoring program is conducted at BWM in accordance with Schedule I (Groundwater) of EA EPML00717813. Recording of groundwater levels will continue in accordance with the EA and will allow natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from mining activities. Groundwater quality sampling will also continue in accordance with the EA to provide longer term baseline groundwater quality and to detect any changes in groundwater quality during and post mining.

The current EA groundwater monitoring locations (Table I1, Schedule I Groundwater) are in the process of being revised in consultation with DES. The proposed monitoring locations and frequency are provided in **Table 8-1**.

Groundwater quality trigger levels for the BWM are being developed by BMA in consultation with DES and in consideration of the DES guideline on *Using monitoring data to assess groundwater quality and potential environmental impacts* (DES, 2021). The BWM Groundwater Monitoring and Management Program will be reviewed every two years by an appropriately qualified person.

Table 8-1 Groundwater Monitoring Locations and Frequency

Monitoring Location	Aquifer type	Easting (GDA94)	Northing (GDA94)	Monitoring Frequency
Compliance Bores				
MB1	Permian coal (TU seam)	686331	7387080	Quarterly
MB21	Tertiary Sediments	684900	7350805	Quarterly
MB18	Permian Sandstone	691537	7370787	Quarterly
BWM_MB02_01[1]	Permian Interburden	691748	7362713	Quarterly
BWM_MB02_02[1]	Permian Coal (M54 seam)	691736	7362715	Quarterly
BWM_MB03_01[1]	Alluvium	692229	7381516	Quarterly
BWM_MB03_02[1]	Rewan Group	692232	7381521	Quarterly
BWM_MB12_01[1]	Tertiary Sediments	687874	7355898	Quarterly
BWM_MB12_02[1]	Permian Coal (P04 seam)	687874	7355898	Quarterly
BWM_MB14_01[1]	Permian Interburden	683649	7350258	Quarterly
BWM_MB14_02[1]	Permian Interburden	683649	7350258	Quarterly
BWM_MB15_01[1]	Tertiary sediments	686662	7347631	Quarterly
BWM_MB17_01[1]	Basalt	684014	7343177	Quarterly
BWM_MB17_02[1]	Tertiary (BUTE)	684014	7343177	Quarterly
MB19BWM01P	Permian Coal (Aries Seam)	690037	7390281	Quarterly
MB19BWM02A	Permian Interburden (siltstone)	690127	7370182	Quarterly
MB19BWM08P	Permian Coal (Aries Seam) & Siltstone	691542	7370739	Quarterly
MB19BWM27P	Permian Coal (Aries Seam) & Siltstone	688958	7376559	Quarterly
MB20BWM03P2	Permian (L41 seam)	686499	7387292	Quarterly
BG-1	Burngrove Formation	683994	7387561	Quarterly
BG-2	Burngrove Formation	684300	7384441	Quarterly

[1] Trigger levels have not yet been developed for these bores due to the limited available monitoring dataset. Monthly monitoring will occur until a suitable dataset is available to set trigger levels.

8.2.2 Data Management and Reporting

Routine groundwater monitoring would be conducted in accordance with any updated EA. Data will be stored within a consolidated groundwater database. Quality assurance and quality control procedures are in place to help ensure the accuracy of data entered within the database. Notification to DES and investigation into the cause of any exceedance would be undertaken in accordance with the requirements of the EA.

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Appendix A-1 Water Level Plots

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd
SLR Project No.: 620.014601.00006 R01

11 December 2023

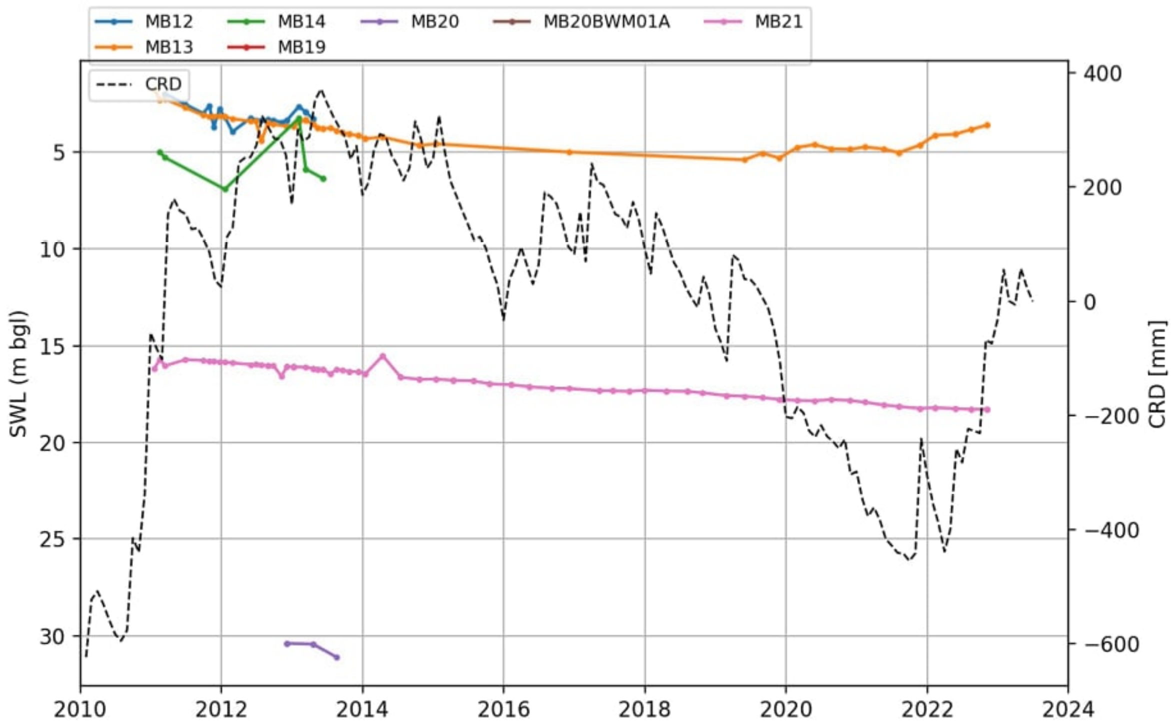


Figure A1-1 SWL (Tertiary) in mbgl

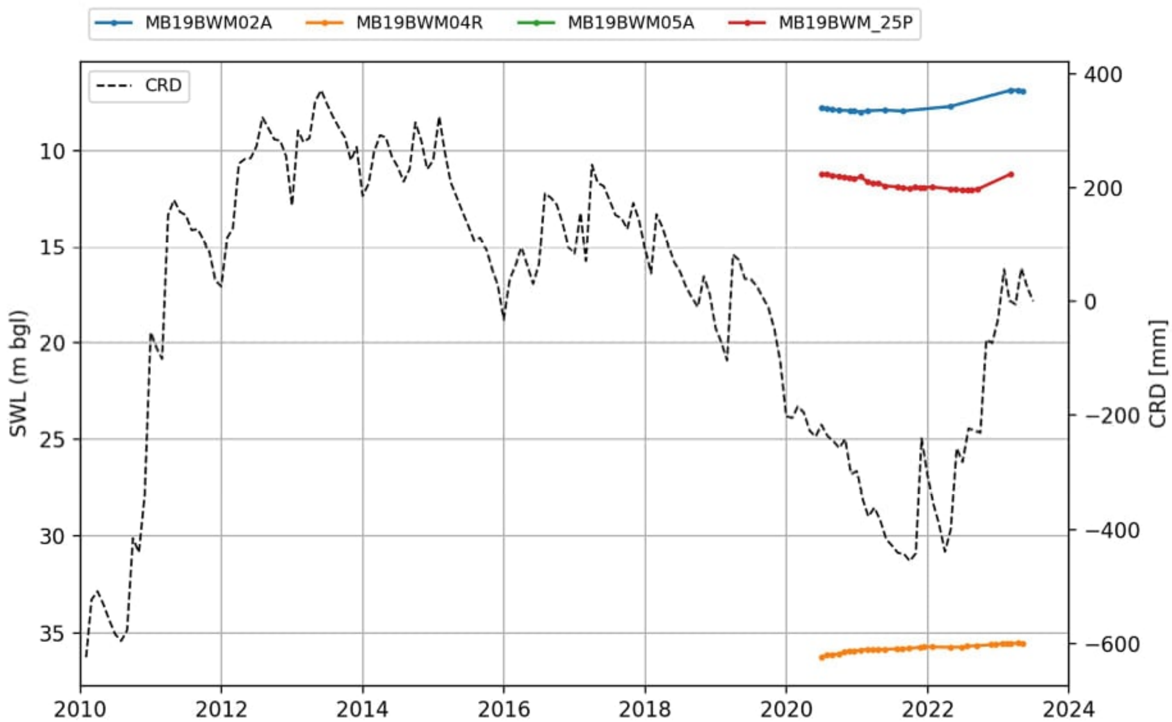


Figure A1-2 SWL (Rewan) in mbgl

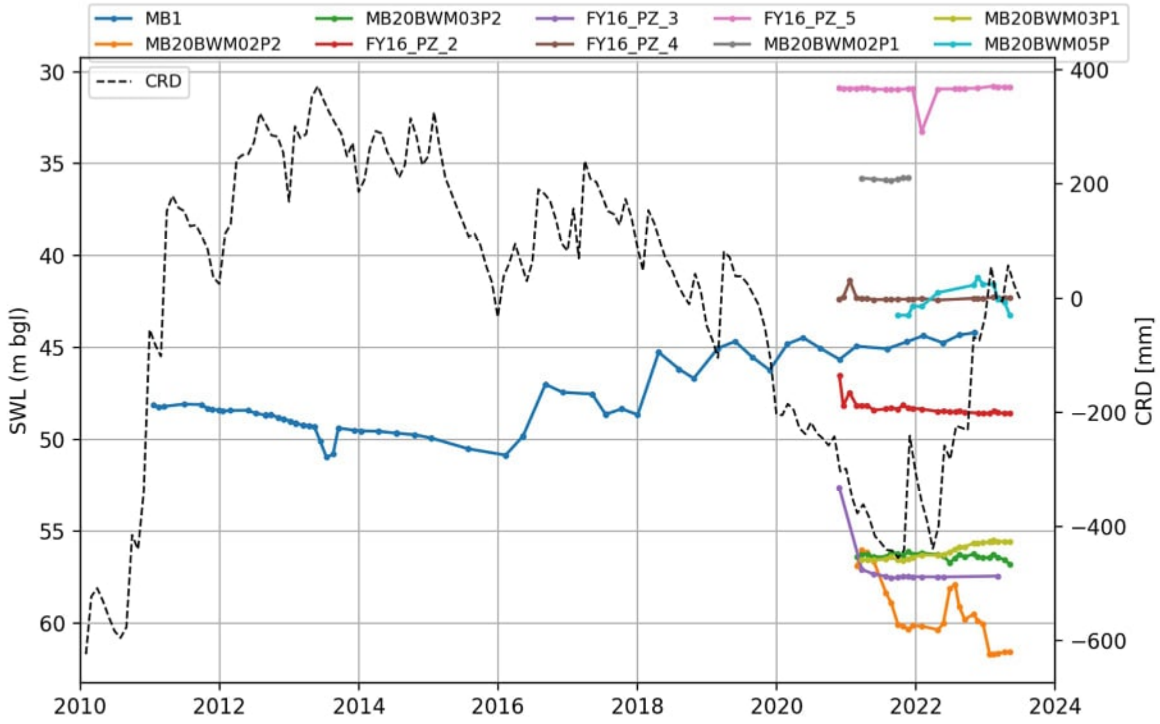


Figure A1-3 SWL (Rangal Coal Measures, Bonnie Doon) in mbgl

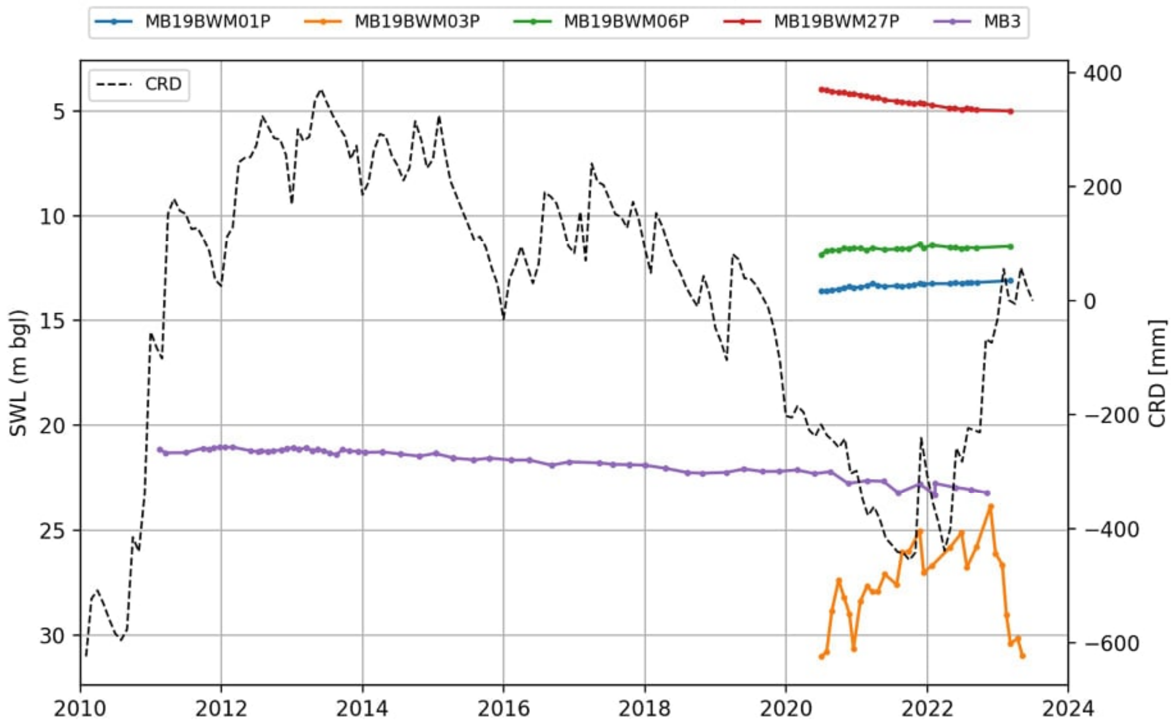


Figure A1-4 SWL (Rangal Coal Measures, Northern Area) in mbgl

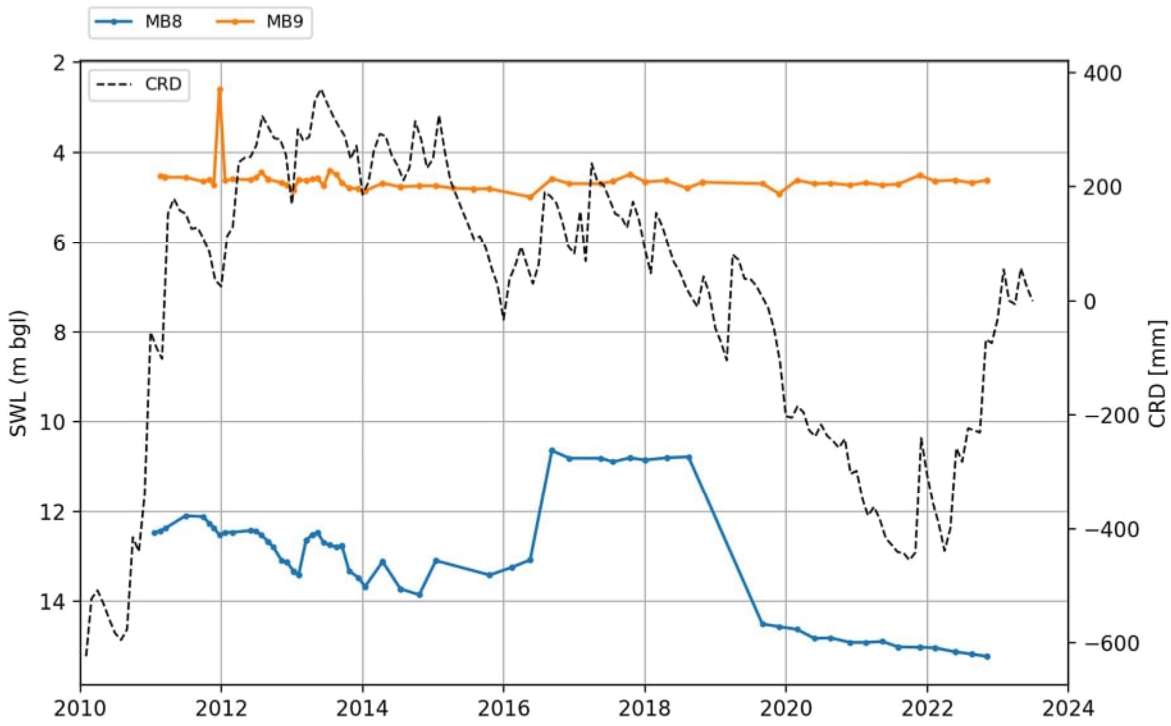


Figure A1-5 SWL (Rangal Coal Measures, near TSF) in mbgl

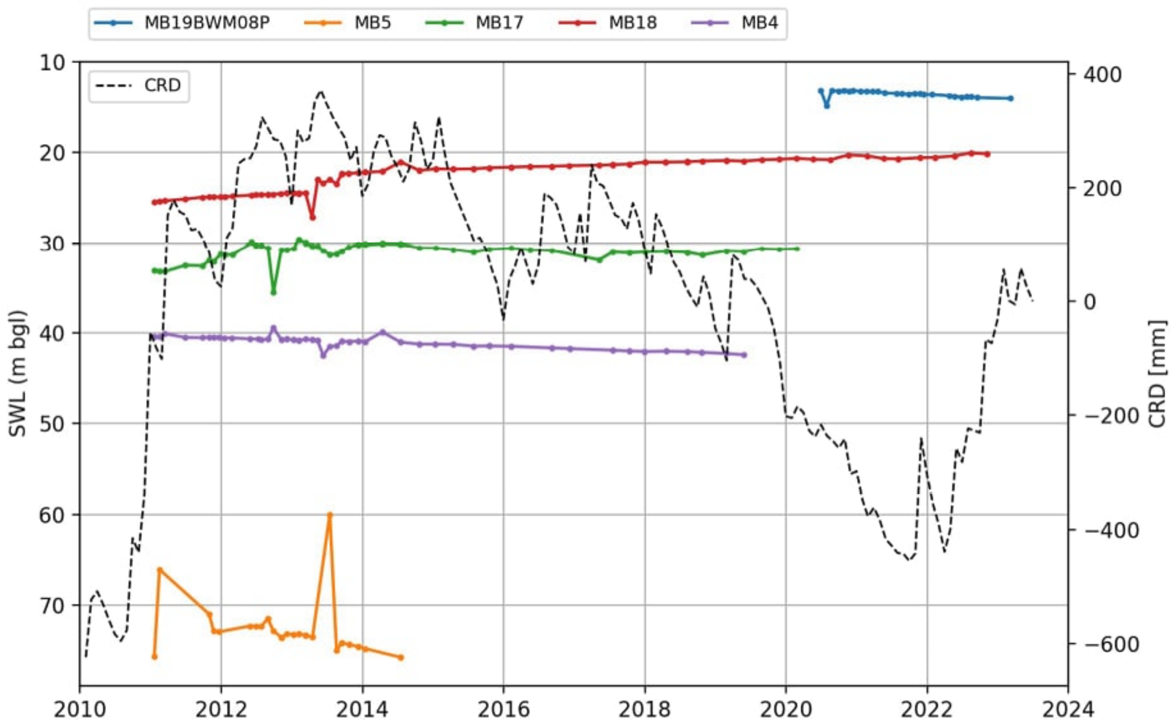


Figure A1-6 SWL (Rangal Coal Measures, BWM Central) in mbgl

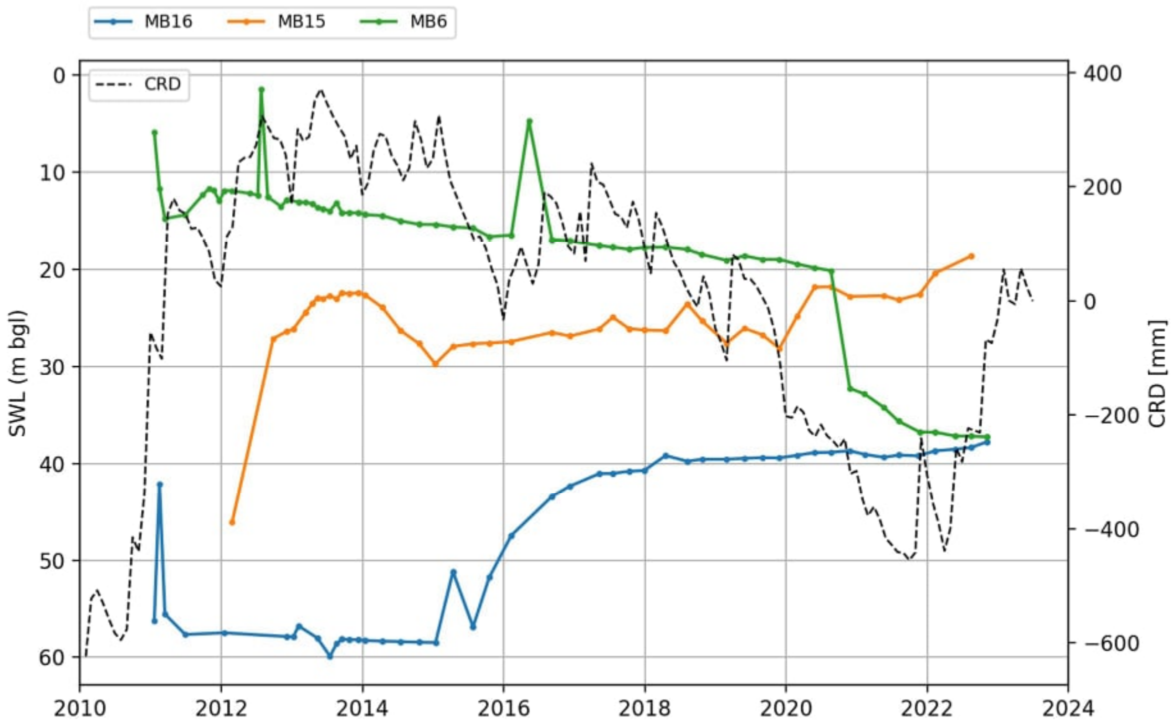


Figure A1-7 SWL (Rangal Coal Measures, BWM south) in mbgl

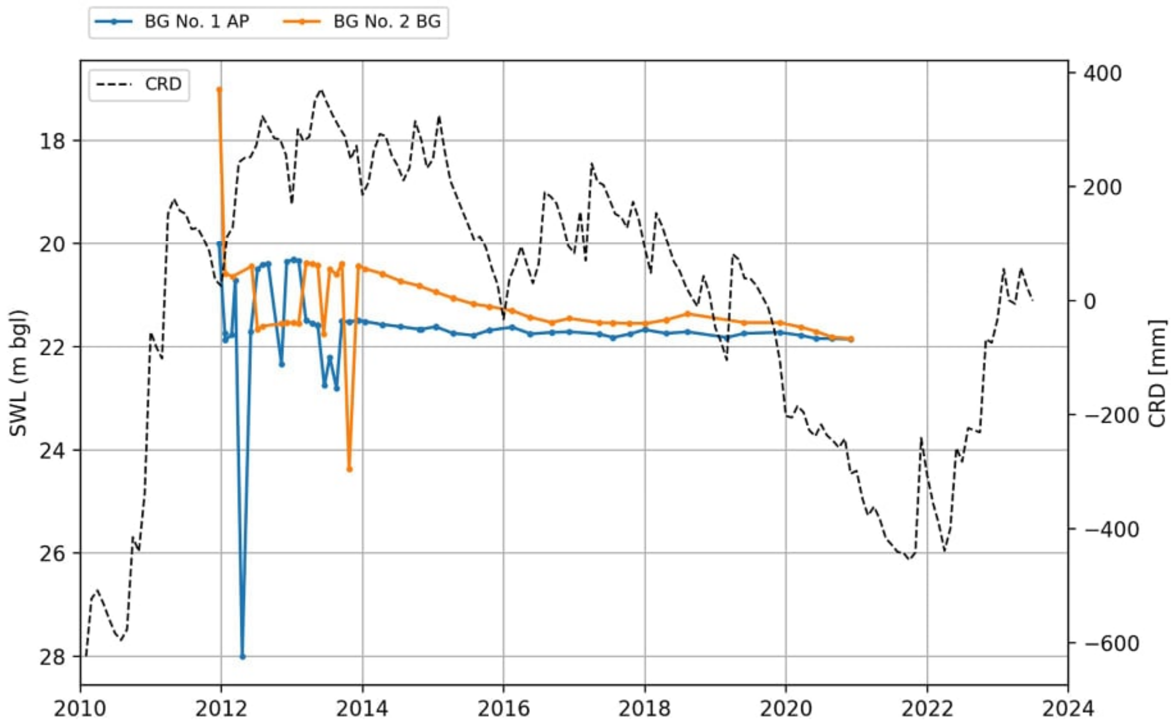


Figure A1-8 SWL (Burngrove) in mbgl

Appendix A-2 Water Quality Summary Tables and Box-and-Whisker Plots

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd
SLR Project No.: 620.014601.00006 R01

11 December 2023

Appendix A2, Table A2-1 Groundwater Monitoring Statistics per Bore

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
BG No.1 AP	Burngrove	EC (Field)	35	5390	6266	6730	10046	15098
BG No.1 AP	Burngrove	pH (Field)	35	6.61	7.138	7.62	7.884	8.35
BG No.1 AP	Burngrove	Aluminium (Diss)	40	0.01	0.01	0.01	0.01	0.04
BG No.1 AP	Burngrove	Aluminium (Total)	40	0.01	0.068	0.19	0.648	3.82
BG No.1 AP	Burngrove	Antimony (Diss)	40	0.001	0.001	0.001	0.001	0.001
BG No.1 AP	Burngrove	Antimony (Total)	40	0.001	0.001	0.001	0.001	0.001
BG No.1 AP	Burngrove	Arsenic (Diss)	40	0.001	0.001	0.001	0.001	0.002
BG No.1 AP	Burngrove	Arsenic (Total)	40	0.001	0.001	0.001	0.001	0.003
BG No.1 AP	Burngrove	Bicarbonate Alkalinity as CaCO3	40	516	602	634	672.2	812
BG No.1 AP	Burngrove	Calcium (Diss)	39	16	18	24	41.6	442
BG No.1 AP	Burngrove	Carbonate Alkalinity as CaCO3	40	1	1	12.5	39.6	130
BG No.1 AP	Burngrove	Chloride	40	1440	1650	1745	1932	7150
BG No.1 AP	Burngrove	Electrical Conductivity (Lab)	40	6190	6418	6535	6952	21500
BG No.1 AP	Burngrove	Hydroxide Alkalinity as CaCO3	40	1	1	1	1	1
BG No.1 AP	Burngrove	Iron (Diss)	40	0.05	0.05	0.05	0.104	0.8
BG No.1 AP	Burngrove	Iron (Total)	40	0.09	0.258	0.645	1.52	5.22
BG No.1 AP	Burngrove	Magnesium (Diss)	39	6	6	8	27	316
BG No.1 AP	Burngrove	Molybdenum (Diss)	40	0.001	0.001	0.001	0.001	0.005
BG No.1 AP	Burngrove	Molybdenum (Total)	40	0.001	0.001	0.001	0.001	0.003
BG No.1 AP	Burngrove	pH (Lab)	40	7.36	8.058	8.345	8.492	8.9
BG No.1 AP	Burngrove	Potassium (Diss)	39	5	6	6	7.4	26
BG No.1 AP	Burngrove	Selenium (Diss)	40	0.01	0.01	0.01	0.01	0.01
BG No.1 AP	Burngrove	Selenium (Total)	40	0.01	0.01	0.01	0.01	0.01
BG No.1 AP	Burngrove	Silver (Diss)	40	0.001	0.001	0.001	0.001	0.001
BG No.1 AP	Burngrove	Silver (Total)	40	0.001	0.001	0.001	0.001	0.001
BG No.1 AP	Burngrove	Sodium (Diss)	39	1230	1340	1400	1522	3870
BG No.1 AP	Burngrove	Sulphate as SO4 2-	40	1	1	2	33.2	839

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
BG No.1 AP	Burngrove	Total Alkalinity as CaCO3	40	516	620	660.5	691	812
BG No.1 AP	Burngrove	Total Dissolved Solids (Lab)	40	3250	3618	3750	4060	14400
BG No.1 AP	Burngrove	Mercury (Diss)	35	0.0001	0.0001	0.0001	0.0001	0.0005
BG No.1 AP	Burngrove	Mercury (Total)	38	0.0001	0.0001	0.0001	0.0001	0.001
BG No.2 BG	Burngrove	EC (Field)	33	7745	11538	14960	17161	19317
BG No.2 BG	Burngrove	pH (Field)	40	6.31	6.602	6.92	7.37	8.2
BG No.2 BG	Burngrove	Aluminium (Diss)	39	0.01	0.01	0.01	0.01	0.18
BG No.2 BG	Burngrove	Aluminium (Total)	39	0.01	0.088	0.25	0.584	4.44
BG No.2 BG	Burngrove	Antimony (Diss)	39	0.001	0.001	0.001	0.001	0.001
BG No.2 BG	Burngrove	Antimony (Total)	39	0.001	0.001	0.001	0.001	0.002
BG No.2 BG	Burngrove	Arsenic (Diss)	39	0.001	0.001	0.001	0.001	0.002
BG No.2 BG	Burngrove	Arsenic (Total)	39	0.001	0.001	0.001	0.001	0.003
BG No.2 BG	Burngrove	Bicarbonate Alkalinity as CaCO3	39	683	732.6	801	875	919
BG No.2 BG	Burngrove	Calcium (Diss)	38	122	138	203.5	305	477
BG No.2 BG	Burngrove	Carbonate Alkalinity as CaCO3	39	1	1	1	1	12
BG No.2 BG	Burngrove	Chloride	39	3350	4024	4670	5154	5480
BG No.2 BG	Burngrove	Electrical Conductivity (Lab)	39	11100	12300	14800	16400	17900
BG No.2 BG	Burngrove	Hydroxide Alkalinity as CaCO3	39	1	1	1	1	1
BG No.2 BG	Burngrove	Iron (Diss)	39	0.05	0.05	0.19	0.376	0.74
BG No.2 BG	Burngrove	Iron (Total)	39	0.1	0.346	0.84	2.466	14
BG No.2 BG	Burngrove	Magnesium (Diss)	38	221	267	377.5	448.8	506
BG No.2 BG	Burngrove	Molybdenum (Diss)	39	0.001	0.001	0.001	0.001	0.007
BG No.2 BG	Burngrove	Molybdenum (Total)	39	0.001	0.001	0.001	0.001	0.007
BG No.2 BG	Burngrove	pH (Lab)	39	7.06	7.334	7.64	7.878	8.32
BG No.2 BG	Burngrove	Potassium (Diss)	38	10	12	13	14	38
BG No.2 BG	Burngrove	Selenium (Diss)	39	0.01	0.01	0.01	0.01	0.01
BG No.2 BG	Burngrove	Selenium (Total)	39	0.01	0.01	0.01	0.01	0.01
BG No.2 BG	Burngrove	Silver (Diss)	39	0.001	0.001	0.001	0.001	0.001
BG No.2 BG	Burngrove	Silver (Total)	39	0.001	0.001	0.001	0.001	0.001
BG No.2 BG	Burngrove	Sodium (Diss)	38	2050	2428	2665	2982	3180

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
BG No.2 BG	Burngrove	Sulphate as SO4 2-	39	583	734.8	1090	1394	1720
BG No.2 BG	Burngrove	Total Alkalinity as CaCO3	39	683	732.6	801	875	919
BG No.2 BG	Burngrove	Total Dissolved Solids (Lab)	38	6800	7800	9845	11100	11700
BG No.2 BG	Burngrove	Mercury (Diss)	34	0.0001	0.0001	0.0001	0.0001	0.0001
BG No.2 BG	Burngrove	Mercury (Total)	38	0.0001	0.0001	0.0001	0.0001	0.0002
FY16_PZ_2	RCM Coal	EC (Field)	22	18026	18139.6	18229	18424.8	18612
FY16_PZ_2	RCM Coal	pH (Field)	17	6.7	6.758	6.84	7.14	7.87
FY16_PZ_2	RCM Coal	Aluminium (Diss)	18	0.01	0.01	0.01	0.01	0.05
FY16_PZ_2	RCM Coal	Aluminium (Total)	18	0.1	0.158	0.43	0.496	3.77
FY16_PZ_2	RCM Coal	Antimony (Diss)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_2	RCM Coal	Antimony (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_2	RCM Coal	Arsenic (Diss)	18	0.001	0.001	0.001	0.001	0.005
FY16_PZ_2	RCM Coal	Arsenic (Total)	18	0.001	0.001	0.001	0.001	0.002
FY16_PZ_2	RCM Coal	Bicarbonate Alkalinity as CaCO3	17	420	504.4	533	544.8	565
FY16_PZ_2	RCM Coal	Calcium (Diss)	17	123	139.6	159	171.6	206
FY16_PZ_2	RCM Coal	Carbonate Alkalinity as CaCO3	17	1	1	1	1	10
FY16_PZ_2	RCM Coal	Chloride	18	5870	6248	6425	6526	6700
FY16_PZ_2	RCM Coal	Electrical Conductivity (Lab)	16	15900	17500	18000	18100	18400
FY16_PZ_2	RCM Coal	Hydroxide Alkalinity as CaCO3	17	1	1	1	1	1
FY16_PZ_2	RCM Coal	Iron (Diss)	14	0.51	0.646	0.69	0.82	1
FY16_PZ_2	RCM Coal	Iron (Total)	18	0.73	0.976	1.325	1.46	4.83
FY16_PZ_2	RCM Coal	Magnesium (Diss)	17	95	100.2	103	106	109
FY16_PZ_2	RCM Coal	Molybdenum (Diss)	18	0.001	0.001	0.002	0.0026	0.005
FY16_PZ_2	RCM Coal	Molybdenum (Total)	18	0.002	0.002	0.003	0.003	0.005
FY16_PZ_2	RCM Coal	pH (Lab)	25	6.84	6.942	7.54	8.104	8.32
FY16_PZ_2	RCM Coal	Potassium (Diss)	17	16	17	17	17	18
FY16_PZ_2	RCM Coal	Selenium (Diss)	18	0.01	0.01	0.01	0.01	0.05
FY16_PZ_2	RCM Coal	Selenium (Total)	18	0.01	0.01	0.01	0.01	0.01
FY16_PZ_2	RCM Coal	Silver (Diss)	18	0.001	0.001	0.001	0.001	0.005
FY16_PZ_2	RCM Coal	Silver (Total)	18	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
FY16_PZ_2	RCM Coal	Sodium (Diss)	17	3600	3612	3740	3846	3910
FY16_PZ_2	RCM Coal	Sulphate as SO4 2-	18	1	1	1	1	10
FY16_PZ_2	RCM Coal	Total Alkalinity as CaCO3	18	420	505.8	530	544.6	565
FY16_PZ_2	RCM Coal	Total Dissolved Solids (Lab)	16	10300	11200	11350	11700	11800
FY16_PZ_2	RCM Coal	Mercury (Diss)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_2	RCM Coal	Mercury (Total)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_2	RCM Coal	Ammonia as N	7	4.58	4.614	4.66	4.752	5
FY16_PZ_2	RCM Coal	Barium (Diss)	7	34	34.44	34.9	35.88	39.6
FY16_PZ_2	RCM Coal	Barium (Total)	7	32.8	34.88	36	38.04	38.5
FY16_PZ_2	RCM Coal	Beryllium (Diss)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_2	RCM Coal	Beryllium (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_2	RCM Coal	Lead (Diss)	18	0.001	0.001	0.001	0.001	0.005
FY16_PZ_2	RCM Coal	Lead (Total)	18	0.001	0.001	0.002	0.0026	0.006
FY16_PZ_2	RCM Coal	Manganese (Diss)	18	0.012	0.018	0.0195	0.0316	0.038
FY16_PZ_2	RCM Coal	Manganese (Total)	18	0.023	0.025	0.026	0.0384	0.06
FY16_PZ_2	RCM Coal	Nickel (Diss)	18	0.002	0.003	0.0045	0.006	0.017
FY16_PZ_2	RCM Coal	Nickel (Total)	18	0.004	0.006	0.0095	0.0138	0.024
FY16_PZ_2	RCM Coal	Nitrate as N	6	0.01	0.01	0.01	0.01	0.01
FY16_PZ_2	RCM Coal	Zinc (Diss)	18	0.13	0.2736	0.822	1.024	2.14
FY16_PZ_2	RCM Coal	Zinc (Total)	18	0.258	0.5114	0.9285	1.126	2.17
FY16_PZ_3	RCM Coal	Aluminium (Diss)	3	0.01	0.01	0.01	0.01	0.01
FY16_PZ_3	RCM Coal	Arsenic (Diss)	3	0.001	0.001	0.001	0.001	0.001
FY16_PZ_3	RCM Coal	Iron (Diss)	3	0.05	0.05	0.05	0.05	0.05
FY16_PZ_3	RCM Coal	Molybdenum (Diss)	3	0.001	0.001	0.001	0.001	0.001
FY16_PZ_3	RCM Coal	Selenium (Diss)	3	0.01	0.01	0.01	0.01	0.01
FY16_PZ_3	RCM Coal	Silver (Diss)	3	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	EC (Field)	16	16183	16299	16367	16486	16816
FY16_PZ_4	RCM Coal	pH (Field)	16	6.62	6.67	6.745	7	7.91
FY16_PZ_4	RCM Coal	Aluminium (Diss)	17	0.01	0.01	0.01	0.01	0.02
FY16_PZ_4	RCM Coal	Aluminium (Total)	16	0.03	0.05	0.07	0.17	0.66
FY16_PZ_4	RCM Coal	Antimony (Diss)	7	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
FY16_PZ_4	RCM Coal	Antimony (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	Arsenic (Diss)	17	0.001	0.001	0.001	0.001	0.002
FY16_PZ_4	RCM Coal	Arsenic (Total)	16	0.001	0.001	0.001	0.002	0.002
FY16_PZ_4	RCM Coal	Bicarbonate Alkalinity as CaCO3	16	867	990	1040	1070	1110
FY16_PZ_4	RCM Coal	Calcium (Diss)	15	97	105.6	115	120.8	138
FY16_PZ_4	RCM Coal	Carbonate Alkalinity as CaCO3	16	1	1	1	1	15
FY16_PZ_4	RCM Coal	Chloride	16	5090	5380	5545	5670	5790
FY16_PZ_4	RCM Coal	Electrical Conductivity (Lab)	16	14200	15600	16000	16400	16600
FY16_PZ_4	RCM Coal	Hydroxide Alkalinity as CaCO3	16	1	1	1	1	1
FY16_PZ_4	RCM Coal	Iron (Diss)	13	0.4	0.454	0.54	1.068	1.21
FY16_PZ_4	RCM Coal	Iron (Total)	16	0.57	0.68	0.825	1.08	1.4
FY16_PZ_4	RCM Coal	Magnesium (Diss)	15	158	178.2	185	188	193
FY16_PZ_4	RCM Coal	Molybdenum (Diss)	17	0.001	0.001	0.001	0.003	0.004
FY16_PZ_4	RCM Coal	Molybdenum (Total)	16	0.001	0.001	0.001	0.004	0.005
FY16_PZ_4	RCM Coal	pH (Lab)	20	6.74	6.842	7.69	8.074	8.32
FY16_PZ_4	RCM Coal	Potassium (Diss)	15	9	10	10	10	11
FY16_PZ_4	RCM Coal	Selenium (Diss)	17	0.01	0.01	0.01	0.01	0.01
FY16_PZ_4	RCM Coal	Selenium (Total)	16	0.01	0.01	0.01	0.01	0.01
FY16_PZ_4	RCM Coal	Silver (Diss)	17	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	Silver (Total)	16	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	Sodium (Diss)	15	2920	3238	3300	3444	3490
FY16_PZ_4	RCM Coal	Sulphate as SO4 2-	17	4	4	5	14	16
FY16_PZ_4	RCM Coal	Total Alkalinity as CaCO3	16	882	990	1040	1070	1110
FY16_PZ_4	RCM Coal	Total Dissolved Solids (Lab)	15	9230	9638	10100	10620	10800
FY16_PZ_4	RCM Coal	Mercury (Diss)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_4	RCM Coal	Mercury (Total)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_4	RCM Coal	Ammonia as N	7	1.84	1.872	1.95	1.992	2.06
FY16_PZ_4	RCM Coal	Barium (Diss)	7	2.28	2.416	2.64	2.93	3.01
FY16_PZ_4	RCM Coal	Barium (Total)	7	2.61	2.624	2.75	2.856	3
FY16_PZ_4	RCM Coal	Beryllium (Diss)	7	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
FY16_PZ_4	RCM Coal	Beryllium (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	Lead (Diss)	16	0.001	0.001	0.001	0.001	0.001
FY16_PZ_4	RCM Coal	Lead (Total)	16	0.001	0.001	0.002	0.002	0.002
FY16_PZ_4	RCM Coal	Manganese (Diss)	16	0.042	0.044	0.047	0.048	0.055
FY16_PZ_4	RCM Coal	Manganese (Total)	16	0.042	0.047	0.05	0.055	0.058
FY16_PZ_4	RCM Coal	Nickel (Diss)	16	0.001	0.002	0.002	0.007	0.012
FY16_PZ_4	RCM Coal	Nickel (Total)	16	0.002	0.003	0.004	0.011	0.016
FY16_PZ_4	RCM Coal	Nitrate as N	6	0.01	0.01	0.01	0.01	0.01
FY16_PZ_4	RCM Coal	Zinc (Diss)	16	0.005	0.007	0.014	0.028	0.07
FY16_PZ_4	RCM Coal	Zinc (Total)	16	0.056	0.066	0.08	0.094	0.135
FY16_PZ_5	RCM Coal	EC (Field)	17	18352	21128.2	21243	21542.2	21783
FY16_PZ_5	RCM Coal	pH (Field)	14	6.49	6.526	6.62	6.822	7
FY16_PZ_5	RCM Coal	Aluminium (Diss)	15	0.01	0.01	0.01	0.01	0.01
FY16_PZ_5	RCM Coal	Aluminium (Total)	15	0.07	0.09	0.14	0.224	0.31
FY16_PZ_5	RCM Coal	Antimony (Diss)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Antimony (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Arsenic (Diss)	15	0.002	0.002	0.003	0.005	0.018
FY16_PZ_5	RCM Coal	Arsenic (Total)	15	0.002	0.0028	0.004	0.005	0.016
FY16_PZ_5	RCM Coal	Bicarbonate Alkalinity as CaCO3	15	694	752.2	790	803.2	822
FY16_PZ_5	RCM Coal	Calcium (Diss)	14	158	176.2	186	198.8	224
FY16_PZ_5	RCM Coal	Carbonate Alkalinity as CaCO3	15	1	1	1	1	1
FY16_PZ_5	RCM Coal	Chloride	15	6570	7366	7500	7578	7680
FY16_PZ_5	RCM Coal	Electrical Conductivity (Lab)	14	18100	20020	20400	20880	21600
FY16_PZ_5	RCM Coal	Hydroxide Alkalinity as CaCO3	15	1	1	1	1	1
FY16_PZ_5	RCM Coal	Iron (Diss)	11	0.22	0.47	0.7	1.23	2
FY16_PZ_5	RCM Coal	Iron (Total)	15	0.57	0.744	0.89	1.238	3
FY16_PZ_5	RCM Coal	Magnesium (Diss)	14	291	312.8	328	334.6	350
FY16_PZ_5	RCM Coal	Molybdenum (Diss)	15	0.001	0.002	0.002	0.003	0.015
FY16_PZ_5	RCM Coal	Molybdenum (Total)	15	0.002	0.003	0.004	0.004	0.024
FY16_PZ_5	RCM Coal	pH (Lab)	21	6.57	6.71	7.42	8	8.26

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
FY16_PZ_5	RCM Coal	Potassium (Diss)	14	11	11.6	12	12	12
FY16_PZ_5	RCM Coal	Selenium (Diss)	15	0.01	0.01	0.01	0.01	0.01
FY16_PZ_5	RCM Coal	Selenium (Total)	15	0.01	0.01	0.01	0.01	0.01
FY16_PZ_5	RCM Coal	Silver (Diss)	15	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Silver (Total)	15	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Sodium (Diss)	14	3740	3986	4095	4226	4350
FY16_PZ_5	RCM Coal	Sulphate as SO4 2-	15	2	2	3	5	137
FY16_PZ_5	RCM Coal	Total Alkalinity as CaCO3	15	694	752.2	790	803.2	822
FY16_PZ_5	RCM Coal	Total Dissolved Solids (Lab)	14	11800	13080	13500	13680	14800
FY16_PZ_5	RCM Coal	Mercury (Diss)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_5	RCM Coal	Mercury (Total)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
FY16_PZ_5	RCM Coal	Ammonia as N	7	1.98	2.08	2.43	2.484	2.58
FY16_PZ_5	RCM Coal	Barium (Diss)	7	4.42	18.74	19.1	19.9	21.5
FY16_PZ_5	RCM Coal	Barium (Total)	7	5.16	18.68	19.6	20.4	22.4
FY16_PZ_5	RCM Coal	Beryllium (Diss)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Beryllium (Total)	7	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Lead (Diss)	15	0.001	0.001	0.001	0.001	0.001
FY16_PZ_5	RCM Coal	Lead (Total)	15	0.001	0.002	0.002	0.003	0.004
FY16_PZ_5	RCM Coal	Manganese (Diss)	15	0.124	0.1298	0.144	0.1656	0.219
FY16_PZ_5	RCM Coal	Manganese (Total)	15	0.134	0.1368	0.149	0.1762	0.263
FY16_PZ_5	RCM Coal	Nickel (Diss)	15	0.004	0.008	0.012	0.0146	0.039
FY16_PZ_5	RCM Coal	Nickel (Total)	15	0.009	0.0156	0.02	0.0248	0.044
FY16_PZ_5	RCM Coal	Nitrate as N	6	0.01	0.01	0.01	0.01	0.01
FY16_PZ_5	RCM Coal	Zinc (Diss)	15	0.082	0.0902	0.154	0.2108	0.292
FY16_PZ_5	RCM Coal	Zinc (Total)	14	0.109	0.1386	0.1875	0.2882	0.354
MB1	RCM Coal	EC (Field)	38	10669	22964	35909.5	38109.4	40000
MB1	RCM Coal	pH (Field)	47	6.19	6.572	6.64	6.944	7.85
MB1	RCM Coal	Aluminium (Diss)	48	0.01	0.01	0.01	0.05	0.05
MB1	RCM Coal	Aluminium (Total)	48	0.01	0.164	0.585	1.292	5.11
MB1	RCM Coal	Antimony (Diss)	40	0.001	0.001	0.001	0.005	0.005
MB1	RCM Coal	Antimony (Total)	40	0.001	0.001	0.001	0.005	0.01

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB1	RCM Coal	Arsenic (Diss)	48	0.001	0.001	0.005	0.0056	0.008
MB1	RCM Coal	Arsenic (Total)	48	0.001	0.001	0.005	0.0066	0.375
MB1	RCM Coal	Bicarbonate Alkalinity as CaCO3	48	218	327.8	354.5	368	732
MB1	RCM Coal	Calcium (Diss)	47	76	619.2	670	773.4	962
MB1	RCM Coal	Carbonate Alkalinity as CaCO3	48	1	1	1	1	1
MB1	RCM Coal	Chloride	48	4610	11740	12400	13060	13900
MB1	RCM Coal	Electrical Conductivity (Lab)	48	14700	32180	34500	35660	36900
MB1	RCM Coal	Hydroxide Alkalinity as CaCO3	48	1	1	1	1	1
MB1	RCM Coal	Iron (Diss)	48	0.05	1.346	3.115	4.03	4.86
MB1	RCM Coal	Iron (Total)	48	0.65	3.168	4.74	6.274	14
MB1	RCM Coal	Magnesium (Diss)	47	95	644.2	673	719.6	769
MB1	RCM Coal	Molybdenum (Diss)	48	0.001	0.001	0.0035	0.005	0.006
MB1	RCM Coal	Molybdenum (Total)	48	0.001	0.001	0.005	0.005	0.016
MB1	RCM Coal	pH (Lab)	48	6.88	7.19	7.43	7.79	8.02
MB1	RCM Coal	Potassium (Diss)	47	9	23	24	29.8	42
MB1	RCM Coal	Selenium (Diss)	48	0.01	0.01	0.01	0.05	0.05
MB1	RCM Coal	Selenium (Total)	48	0.01	0.01	0.01	0.05	0.05
MB1	RCM Coal	Silver (Diss)	48	0.001	0.001	0.001	0.005	0.005
MB1	RCM Coal	Silver (Total)	48	0.001	0.001	0.001	0.005	0.02
MB1	RCM Coal	Sodium (Diss)	47	2400	6040	6670	6888	7800
MB1	RCM Coal	Sulphate as SO4 2-	48	34	326.8	351.5	364.6	980
MB1	RCM Coal	Total Alkalinity as CaCO3	48	218	327.8	354.5	368	732
MB1	RCM Coal	Total Dissolved Solids (Lab)	48	9080	22580	24900	26260	28900
MB1	RCM Coal	Mercury (Diss)	36	0.0001	0.0001	0.0001	0.0001	0.0005
MB1	RCM Coal	Mercury (Total)	39	0.0001	0.0001	0.0001	0.0001	0.0005
MB16	RCM Coal	EC (Field)	41	4000	11718	18218	20870	23000
MB16	RCM Coal	pH (Field)	45	6	6.486	6.67	7.156	7.78
MB16	RCM Coal	Aluminium (Diss)	44	0.01	0.01	0.01	0.01	0.09
MB16	RCM Coal	Aluminium (Total)	44	0.01	0.01	0.03	0.154	2.38
MB16	RCM Coal	Antimony (Diss)	37	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB16	RCM Coal	Antimony (Total)	37	0.001	0.001	0.001	0.001	0.001
MB16	RCM Coal	Arsenic (Diss)	44	0.001	0.001	0.001	0.002	0.005
MB16	RCM Coal	Arsenic (Total)	44	0.001	0.001	0.001	0.002	0.007
MB16	RCM Coal	Bicarbonate Alkalinity as CaCO3	44	263	375.4	419	440.4	480
MB16	RCM Coal	Calcium (Diss)	43	86	277.8	601	629	711
MB16	RCM Coal	Carbonate Alkalinity as CaCO3	44	1	1	1	1	1
MB16	RCM Coal	Chloride	44	1130	3624	7000	7424	7980
MB16	RCM Coal	Electrical Conductivity (Lab)	45	4190	10756	18700	20000	22800
MB16	RCM Coal	Hydroxide Alkalinity as CaCO3	44	1	1	1	1	1
MB16	RCM Coal	Iron (Diss)	44	0.05	1.264	6.16	11.78	18.3
MB16	RCM Coal	Iron (Total)	44	0.38	3.138	7.465	14.84	24.1
MB16	RCM Coal	Magnesium (Diss)	43	51	246.8	600	623.8	762
MB16	RCM Coal	Molybdenum (Diss)	44	0.001	0.001	0.001	0.001	0.007
MB16	RCM Coal	Molybdenum (Total)	44	0.001	0.001	0.001	0.001	0.009
MB16	RCM Coal	pH (Lab)	45	6.6	7.086	7.49	7.782	8.29
MB16	RCM Coal	Potassium (Diss)	43	9	16.4	23	26	32
MB16	RCM Coal	Selenium (Diss)	44	0.01	0.01	0.01	0.01	0.01
MB16	RCM Coal	Selenium (Total)	44	0.01	0.01	0.01	0.01	0.01
MB16	RCM Coal	Silver (Diss)	44	0.001	0.001	0.001	0.001	0.001
MB16	RCM Coal	Silver (Total)	44	0.001	0.001	0.001	0.001	0.01
MB16	RCM Coal	Sodium (Diss)	43	786	1542	2600	2836	3330
MB16	RCM Coal	Sulphate as SO4 2-	44	1	1.6	4	5.4	39
MB16	RCM Coal	Total Alkalinity as CaCO3	44	263	375.4	419	440.4	480
MB16	RCM Coal	Total Dissolved Solids (Lab)	44	2040	6798	12900	14400	16200
MB16	RCM Coal	Mercury (Diss)	33	0.0001	0.0001	0.0001	0.0001	0.001
MB16	RCM Coal	Mercury (Total)	37	0.0001	1.00E-04	0.0001	0.0001	0.0017
MB19BWM01P	RCM Coal	EC (Field)	18	21660	22787	24812.5	26206	26948
MB19BWM01P	RCM Coal	pH (Field)	24	6.75	6.998	7.19	9.222	10.2
MB19BWM01P	RCM Coal	Aluminium (Diss)	25	0.01	0.01	0.05	0.05	0.14
MB19BWM01P	RCM Coal	Aluminium (Total)	18	0.09	0.214	0.655	0.844	3.73

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM01P	RCM Coal	Antimony (Diss)	12	0.001	0.005	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Antimony (Total)	12	0.001	0.0018	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Arsenic (Diss)	25	0.001	0.002	0.005	0.005	0.022
MB19BWM01P	RCM Coal	Arsenic (Total)	18	0.001	0.003	0.005	0.005	0.023
MB19BWM01P	RCM Coal	Bicarbonate Alkalinity as CaCO3	18	1	462.4	645	659.4	687
MB19BWM01P	RCM Coal	Calcium (Diss)	18	1	62.6	205	262.6	307
MB19BWM01P	RCM Coal	Carbonate Alkalinity as CaCO3	18	1	1	1	67	774
MB19BWM01P	RCM Coal	Chloride	18	6460	8722	9060	9328	9570
MB19BWM01P	RCM Coal	Electrical Conductivity (Lab)	31	20400	22300	25400	26041	26364
MB19BWM01P	RCM Coal	Hydroxide Alkalinity as CaCO3	18	1	1	1	1	203
MB19BWM01P	RCM Coal	Iron (Diss)	24	0.05	0.05	0.37	1.544	2.21
MB19BWM01P	RCM Coal	Iron (Total)	18	0.15	1.646	2.475	4.508	9.14
MB19BWM01P	RCM Coal	Magnesium (Diss)	18	1	116.6	129	141.2	211
MB19BWM01P	RCM Coal	Molybdenum (Diss)	25	0.001	0.005	0.005	0.024	0.085
MB19BWM01P	RCM Coal	Molybdenum (Total)	18	0.001	0.005	0.005	0.0146	0.092
MB19BWM01P	RCM Coal	pH (Lab)	26	6.94	7.61	8.235	9.34	11.98
MB19BWM01P	RCM Coal	Potassium (Diss)	18	17	21	23.5	33.6	53
MB19BWM01P	RCM Coal	Selenium (Diss)	25	0.01	0.01	0.05	0.05	0.05
MB19BWM01P	RCM Coal	Selenium (Total)	18	0.01	0.01	0.05	0.05	0.05
MB19BWM01P	RCM Coal	Silver (Diss)	25	0.001	0.001	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Silver (Total)	18	0.001	0.001	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Sodium (Diss)	18	4780	5244	5600	5968	6520
MB19BWM01P	RCM Coal	Sulphate as SO4 2-	25	1	1	2	6.2	15
MB19BWM01P	RCM Coal	Total Alkalinity as CaCO3	18	505	565.4	648.5	667	977
MB19BWM01P	RCM Coal	Total Dissolved Solids (Lab)	17	11600	15620	16400	16880	17000
MB19BWM01P	RCM Coal	Mercury (Diss)	12	0.0001	1.00E-04	0.0001	0.0001	0.0001
MB19BWM01P	RCM Coal	Mercury (Total)	12	0.0001	1.00E-04	0.0001	0.0001	0.0001
MB19BWM01P	RCM Coal	Ammonia as N	12	4.5	4.712	4.735	5.054	5.8
MB19BWM01P	RCM Coal	Barium (Diss)	12	7.05	9.5	17.4	27.82	31.3
MB19BWM01P	RCM Coal	Barium (Total)	12	8	13.76	20.2	27.24	42.7

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM01P	RCM Coal	Beryllium (Diss)	12	0.001	0.005	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Beryllium (Total)	12	0.001	0.0018	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Lead (Diss)	18	0.001	0.0014	0.005	0.005	0.005
MB19BWM01P	RCM Coal	Lead (Total)	18	0.003	0.0044	0.005	0.007	0.012
MB19BWM01P	RCM Coal	Manganese (Diss)	18	0.001	0.007	0.101	0.1486	0.182
MB19BWM01P	RCM Coal	Manganese (Total)	18	0.003	0.0722	0.132	0.1798	0.264
MB19BWM01P	RCM Coal	Nickel (Diss)	18	0.001	0.0044	0.005	0.0056	0.007
MB19BWM01P	RCM Coal	Nickel (Total)	18	0.004	0.005	0.007	0.011	0.014
MB19BWM01P	RCM Coal	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB19BWM01P	RCM Coal	Zinc (Diss)	18	0.007	0.0208	0.0275	0.0868	0.164
MB19BWM01P	RCM Coal	Zinc (Total)	18	0.202	0.387	0.513	0.9972	1.7
MB19BWM03P	RCM Coal	EC (Field)	18	12283	12436.2	12672	12879.6	13140
MB19BWM03P	RCM Coal	pH (Field)	29	6.92	6.98	7.07	7.814	9.57
MB19BWM03P	RCM Coal	Aluminium (Diss)	29	0.01	0.01	0.01	0.01	0.56
MB19BWM03P	RCM Coal	Aluminium (Total)	23	0.11	0.632	1.37	1.752	3.75
MB19BWM03P	RCM Coal	Antimony (Diss)	13	0.001	0.001	0.001	0.001	0.005
MB19BWM03P	RCM Coal	Antimony (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM03P	RCM Coal	Arsenic (Diss)	29	0.001	0.001	0.001	0.002	0.005
MB19BWM03P	RCM Coal	Arsenic (Total)	23	0.001	0.002	0.003	0.003	0.005
MB19BWM03P	RCM Coal	Bicarbonate Alkalinity as CaCO3	23	280	1638	1700	1740	1800
MB19BWM03P	RCM Coal	Calcium (Diss)	23	1	35.8	45	54.2	73
MB19BWM03P	RCM Coal	Carbonate Alkalinity as CaCO3	22	1	1	1	7.4	640
MB19BWM03P	RCM Coal	Chloride	23	3230	3508	3620	3726	4130
MB19BWM03P	RCM Coal	Electrical Conductivity (Lab)	36	11400	11900	12550	12800	13200
MB19BWM03P	RCM Coal	Hydroxide Alkalinity as CaCO3	22	1	1	1	1	1
MB19BWM03P	RCM Coal	Iron (Diss)	25	0.05	0.05	0.26	0.938	2.19
MB19BWM03P	RCM Coal	Iron (Total)	23	0.18	1.27	2.84	3.644	4.99
MB19BWM03P	RCM Coal	Magnesium (Diss)	23	1	13	14	14	16
MB19BWM03P	RCM Coal	Molybdenum (Diss)	29	0.001	0.0046	0.006	0.009	0.079
MB19BWM03P	RCM Coal	Molybdenum (Total)	23	0.009	0.012	0.021	0.0374	0.094

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM03P	RCM Coal	pH (Lab)	29	6.97	7.306	7.81	8.21	9.81
MB19BWM03P	RCM Coal	Potassium (Diss)	23	29	31.6	40	53.6	71
MB19BWM03P	RCM Coal	Selenium (Diss)	29	0.01	0.01	0.01	0.01	0.05
MB19BWM03P	RCM Coal	Selenium (Total)	23	0.01	0.01	0.01	0.01	0.01
MB19BWM03P	RCM Coal	Silver (Diss)	29	0.001	0.001	0.001	0.001	0.005
MB19BWM03P	RCM Coal	Silver (Total)	23	0.001	0.001	0.001	0.001	0.001
MB19BWM03P	RCM Coal	Sodium (Diss)	23	2620	2724	2890	3016	3350
MB19BWM03P	RCM Coal	Sulphate as SO4 2-	29	4	11.8	37	118.6	210
MB19BWM03P	RCM Coal	Total Alkalinity as CaCO3	22	920	1634	1705	1748	1800
MB19BWM03P	RCM Coal	Total Dissolved Solids (Lab)	22	6990	7248	8060	8308	8580
MB19BWM03P	RCM Coal	Mercury (Diss)	13	0.0001	0.0001	0.0001	0.0001	0.0005
MB19BWM03P	RCM Coal	Mercury (Total)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM03P	RCM Coal	Ammonia as N	13	4.73	4.9	5.02	5.192	6.2
MB19BWM03P	RCM Coal	Barium (Diss)	13	0.154	0.524	0.82	1.18	1.65
MB19BWM03P	RCM Coal	Barium (Total)	13	0.235	0.782	1.4	1.636	2.17
MB19BWM03P	RCM Coal	Beryllium (Diss)	13	0.001	0.001	0.001	0.001	0.005
MB19BWM03P	RCM Coal	Beryllium (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM03P	RCM Coal	Lead (Diss)	23	0.001	0.001	0.001	0.001	0.005
MB19BWM03P	RCM Coal	Lead (Total)	23	0.002	0.008	0.012	0.017	0.021
MB19BWM03P	RCM Coal	Manganese (Diss)	23	0.005	0.0834	0.106	0.1126	0.134
MB19BWM03P	RCM Coal	Manganese (Total)	23	0.005	0.1094	0.156	0.1922	0.248
MB19BWM03P	RCM Coal	Nickel (Diss)	23	0.002	0.0024	0.005	0.0086	0.034
MB19BWM03P	RCM Coal	Nickel (Total)	23	0.002	0.0098	0.014	0.0222	0.044
MB19BWM03P	RCM Coal	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB19BWM03P	RCM Coal	Zinc (Diss)	23	0.005	0.0528	0.082	0.1424	0.234
MB19BWM03P	RCM Coal	Zinc (Total)	23	0.139	0.8024	0.994	1.312	1.91
MB19BWM08P	RCM Coal	EC (Field)	18	5255	5336.4	5388	5477.6	5513
MB19BWM08P	RCM Coal	pH (Field)	26	7.37	7.47	7.55	8.08	8.49
MB19BWM08P	RCM Coal	Aluminium (Diss)	26	0.01	0.01	0.01	0.01	0.02
MB19BWM08P	RCM Coal	Aluminium (Total)	19	0.04	0.706	1.79	6.334	32.8
MB19BWM08P	RCM Coal	Antimony (Diss)	13	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM08P	RCM Coal	Antimony (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM08P	RCM Coal	Arsenic (Diss)	26	0.001	0.001	0.001	0.001	0.002
MB19BWM08P	RCM Coal	Arsenic (Total)	19	0.001	0.001	0.001	0.0032	0.024
MB19BWM08P	RCM Coal	Bicarbonate Alkalinity as CaCO3	19	627	712.8	761	787.6	807
MB19BWM08P	RCM Coal	Calcium (Diss)	19	23	28	32	33	46
MB19BWM08P	RCM Coal	Carbonate Alkalinity as CaCO3	18	1	1	1	40.6	94
MB19BWM08P	RCM Coal	Chloride	19	1260	1320	1340	1370	1430
MB19BWM08P	RCM Coal	Electrical Conductivity (Lab)	33	4943	5194	5300	5380	5433
MB19BWM08P	RCM Coal	Hydroxide Alkalinity as CaCO3	18	1	1	1	1	1
MB19BWM08P	RCM Coal	Iron (Diss)	25	0.05	0.05	0.05	0.224	0.33
MB19BWM08P	RCM Coal	Iron (Total)	19	0.11	1.464	2.6	10.914	77.4
MB19BWM08P	RCM Coal	Magnesium (Diss)	19	6	6	6	6.4	7
MB19BWM08P	RCM Coal	Molybdenum (Diss)	26	0.001	0.002	0.002	0.003	0.003
MB19BWM08P	RCM Coal	Molybdenum (Total)	19	0.002	0.002	0.002	0.003	0.004
MB19BWM08P	RCM Coal	pH (Lab)	26	7.31	7.55	8.095	8.39	8.68
MB19BWM08P	RCM Coal	Potassium (Diss)	19	3	4	4	4	5
MB19BWM08P	RCM Coal	Selenium (Diss)	26	0.01	0.01	0.01	0.01	0.01
MB19BWM08P	RCM Coal	Selenium (Total)	19	0.01	0.01	0.01	0.01	0.01
MB19BWM08P	RCM Coal	Silver (Diss)	26	0.001	0.001	0.001	0.001	0.001
MB19BWM08P	RCM Coal	Silver (Total)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM08P	RCM Coal	Sodium (Diss)	19	1120	1146	1180	1200	1240
MB19BWM08P	RCM Coal	Sulphate as SO4 2-	26	1	1	1	2	6
MB19BWM08P	RCM Coal	Total Alkalinity as CaCO3	18	705	742.4	766.5	796.8	807
MB19BWM08P	RCM Coal	Total Dissolved Solids (Lab)	18	3030	3354	3425	3476	3520
MB19BWM08P	RCM Coal	Mercury (Diss)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM08P	RCM Coal	Mercury (Total)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM08P	RCM Coal	Ammonia as N	13	1.22	1.28	1.32	1.346	1.42
MB19BWM08P	RCM Coal	Barium (Diss)	13	3.41	4.188	4.38	4.586	4.79
MB19BWM08P	RCM Coal	Barium (Total)	13	3.98	4.162	4.57	5.836	7.02
MB19BWM08P	RCM Coal	Beryllium (Diss)	13	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM08P	RCM Coal	Beryllium (Total)	13	0.001	0.001	0.001	0.001	0.002
MB19BWM08P	RCM Coal	Lead (Diss)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM08P	RCM Coal	Lead (Total)	19	0.001	0.0026	0.004	0.01	0.054
MB19BWM08P	RCM Coal	Manganese (Diss)	19	0.027	0.038	0.045	0.0512	0.064
MB19BWM08P	RCM Coal	Manganese (Total)	19	0.03	0.0602	0.086	0.2236	1.32
MB19BWM08P	RCM Coal	Nickel (Diss)	19	0.001	0.001	0.002	0.0034	0.007
MB19BWM08P	RCM Coal	Nickel (Total)	19	0.002	0.0036	0.006	0.0148	0.093
MB19BWM08P	RCM Coal	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB19BWM08P	RCM Coal	Zinc (Diss)	19	0.005	0.0068	0.052	0.1232	0.203
MB19BWM08P	RCM Coal	Zinc (Total)	19	0.176	0.2772	0.317	0.4982	0.943
MB19BWM27P	RCM Coal	EC (Field)	17	14390	14639.4	14805	15133.2	15209
MB19BWM27P	RCM Coal	pH (Field)	26	6.56	6.63	6.75	7.53	8.1
MB19BWM27P	RCM Coal	Aluminium (Diss)	26	0.01	0.01	0.01	0.01	0.05
MB19BWM27P	RCM Coal	Aluminium (Total)	19	0.62	1.108	1.72	2.886	5.91
MB19BWM27P	RCM Coal	Antimony (Diss)	13	0.001	0.001	0.001	0.001	0.005
MB19BWM27P	RCM Coal	Antimony (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM27P	RCM Coal	Arsenic (Diss)	26	0.006	0.009	0.01	0.014	0.021
MB19BWM27P	RCM Coal	Arsenic (Total)	19	0.012	0.0136	0.017	0.022	0.039
MB19BWM27P	RCM Coal	Bicarbonate Alkalinity as CaCO3	19	1650	1780	1850	1894	1930
MB19BWM27P	RCM Coal	Calcium (Diss)	19	72	82	101	116	209
MB19BWM27P	RCM Coal	Carbonate Alkalinity as CaCO3	18	1	1	1	1	71
MB19BWM27P	RCM Coal	Chloride	19	3900	4124	4330	4440	4500
MB19BWM27P	RCM Coal	Electrical Conductivity (Lab)	33	12600	13740	14200	14496	14701
MB19BWM27P	RCM Coal	Hydroxide Alkalinity as CaCO3	18	1	1	1	1	1
MB19BWM27P	RCM Coal	Iron (Diss)	25	0.05	0.59	1.1	1.52	2.54
MB19BWM27P	RCM Coal	Iron (Total)	19	2.46	3.504	3.94	7.198	11.5
MB19BWM27P	RCM Coal	Magnesium (Diss)	19	45	51	52	53	56
MB19BWM27P	RCM Coal	Molybdenum (Diss)	26	0.002	0.003	0.003	0.004	0.006
MB19BWM27P	RCM Coal	Molybdenum (Total)	19	0.004	0.004	0.006	0.0064	0.009
MB19BWM27P	RCM Coal	pH (Lab)	26	6.49	6.74	7.36	7.99	8.43

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM27P	RCM Coal	Potassium (Diss)	19	12	13	14	14	15
MB19BWM27P	RCM Coal	Selenium (Diss)	26	0.01	0.01	0.01	0.01	0.05
MB19BWM27P	RCM Coal	Selenium (Total)	19	0.01	0.01	0.01	0.01	0.01
MB19BWM27P	RCM Coal	Silver (Diss)	26	0.001	0.001	0.001	0.001	0.005
MB19BWM27P	RCM Coal	Silver (Total)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM27P	RCM Coal	Sodium (Diss)	19	2730	3022	3190	3316	3480
MB19BWM27P	RCM Coal	Sulphate as SO4 2-	26	1	1	1	1	1
MB19BWM27P	RCM Coal	Total Alkalinity as CaCO3	18	1720	1780	1855	1896	1930
MB19BWM27P	RCM Coal	Total Dissolved Solids (Lab)	18	8190	8912	9160	9360	9560
MB19BWM27P	RCM Coal	Mercury (Diss)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM27P	RCM Coal	Mercury (Total)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM27P	RCM Coal	Ammonia as N	13	2.85	3.032	3.33	3.408	3.46
MB19BWM27P	RCM Coal	Barium (Diss)	13	10.5	12.12	13.9	14.86	16.5
MB19BWM27P	RCM Coal	Barium (Total)	13	13	13.72	14	15.46	16.6
MB19BWM27P	RCM Coal	Beryllium (Diss)	13	0.001	0.001	0.001	0.001	0.005
MB19BWM27P	RCM Coal	Beryllium (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM27P	RCM Coal	Lead (Diss)	19	0.001	0.001	0.001	0.001	0.005
MB19BWM27P	RCM Coal	Lead (Total)	19	0.005	0.007	0.008	0.0138	0.035
MB19BWM27P	RCM Coal	Manganese (Diss)	19	0.134	0.1666	0.229	0.3698	0.479
MB19BWM27P	RCM Coal	Manganese (Total)	19	0.187	0.215	0.29	0.4512	0.672
MB19BWM27P	RCM Coal	Nickel (Diss)	19	0.005	0.009	0.01	0.0128	0.055
MB19BWM27P	RCM Coal	Nickel (Total)	19	0.01	0.0136	0.018	0.0256	0.066
MB19BWM27P	RCM Coal	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB19BWM27P	RCM Coal	Zinc (Diss)	19	0.224	0.851	1.2	1.856	2.44
MB19BWM27P	RCM Coal	Zinc (Total)	19	0.819	1.098	1.36	2.25	3.31
MB20BWM02P2	RCM Coal	EC (Field)	20	17503	19021.8	19797.5	20491.4	21079
MB20BWM02P2	RCM Coal	pH (Field)	25	6.9	6.988	7.08	7.594	8.21
MB20BWM02P2	RCM Coal	Aluminium (Diss)	25	0.01	0.01	0.01	0.01	0.05
MB20BWM02P2	RCM Coal	Aluminium (Total)	18	0.2	2.326	13.35	35.26	76.3
MB20BWM02P2	RCM Coal	Antimony (Diss)	5	0.001	0.001	0.001	0.002	0.002
MB20BWM02P2	RCM Coal	Antimony (Total)	5	0.001	0.001	0.002	0.0022	0.003

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20BWM02P2	RCM Coal	Arsenic (Diss)	25	0.013	0.0214	0.033	0.0504	0.066
MB20BWM02P2	RCM Coal	Arsenic (Total)	18	0.039	0.0414	0.052	0.0656	0.073
MB20BWM02P2	RCM Coal	Bicarbonate Alkalinity as CaCO3	18	458	515	555	579.6	918
MB20BWM02P2	RCM Coal	Calcium (Diss)	18	150	160	180	191.4	252
MB20BWM02P2	RCM Coal	Carbonate Alkalinity as CaCO3	18	1	1	1	1	1
MB20BWM02P2	RCM Coal	Chloride	18	5860	6364	6830	7142	7480
MB20BWM02P2	RCM Coal	Electrical Conductivity (Lab)	26	16800	17800	18700	19700	20300
MB20BWM02P2	RCM Coal	Hydroxide Alkalinity as CaCO3	18	1	1	1	1	1
MB20BWM02P2	RCM Coal	Iron (Diss)	20	0.05	0.082	0.62	1.442	4.97
MB20BWM02P2	RCM Coal	Iron (Total)	18	0.13	3.18	13.95	60.54	90.1
MB20BWM02P2	RCM Coal	Magnesium (Diss)	18	150	165.8	199.5	213	233
MB20BWM02P2	RCM Coal	Molybdenum (Diss)	25	0.049	0.0594	0.068	0.089	0.098
MB20BWM02P2	RCM Coal	Molybdenum (Total)	18	0.022	0.0496	0.069	0.0798	0.092
MB20BWM02P2	RCM Coal	pH (Lab)	25	6.98	7.166	7.86	7.952	8.12
MB20BWM02P2	RCM Coal	Potassium (Diss)	18	14	15	16.5	18	22
MB20BWM02P2	RCM Coal	Selenium (Diss)	25	0.01	0.01	0.01	0.01	0.05
MB20BWM02P2	RCM Coal	Selenium (Total)	18	0.01	0.01	0.01	0.01	0.05
MB20BWM02P2	RCM Coal	Silver (Diss)	25	0.001	0.001	0.001	0.001	0.005
MB20BWM02P2	RCM Coal	Silver (Total)	18	0.001	0.001	0.001	0.001	0.005
MB20BWM02P2	RCM Coal	Sodium (Diss)	18	3390	3624	3950	4196	4640
MB20BWM02P2	RCM Coal	Sulphate as SO4 2-	25	9	40.8	73	217.2	358
MB20BWM02P2	RCM Coal	Total Alkalinity as CaCO3	18	458	515	555	579.6	918
MB20BWM02P2	RCM Coal	Total Dissolved Solids (Lab)	15	10900	11200	12200	12840	13400
MB20BWM02P2	RCM Coal	Mercury (Diss)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB20BWM02P2	RCM Coal	Mercury (Total)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB20BWM02P2	RCM Coal	Ammonia as N	5	1.57	1.586	1.65	1.968	2
MB20BWM02P2	RCM Coal	Barium (Diss)	5	1	1.064	1.33	1.426	1.77
MB20BWM02P2	RCM Coal	Barium (Total)	5	1	1.152	1.44	2.108	3.14
MB20BWM02P2	RCM Coal	Beryllium (Diss)	5	0.001	0.001	0.001	0.001	0.001
MB20BWM02P2	RCM Coal	Beryllium (Total)	5	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20BWM02P2	RCM Coal	Lead (Diss)	18	0.001	0.001	0.001	0.001	0.005
MB20BWM02P2	RCM Coal	Lead (Total)	18	0.001	0.0054	0.04	0.1626	0.376
MB20BWM02P2	RCM Coal	Manganese (Diss)	18	0.245	0.3128	0.4555	0.7446	1
MB20BWM02P2	RCM Coal	Manganese (Total)	18	0.388	0.4634	0.9325	2.23	2.99
MB20BWM02P2	RCM Coal	Nickel (Diss)	18	0.002	0.0034	0.0075	0.014	0.022
MB20BWM02P2	RCM Coal	Nickel (Total)	18	0.01	0.0154	0.0175	0.0508	0.083
MB20BWM02P2	RCM Coal	Nitrate as N	2	0.01	0.01	0.01	0.01	0.01
MB20BWM02P2	RCM Coal	Zinc (Diss)	18	0.005	0.0266	0.056	0.1176	0.363
MB20BWM02P2	RCM Coal	Zinc (Total)	18	0.005	0.0164	0.0835	0.3086	0.446
MB20BWM03P2	RCM Coal	EC (Field)	22	17300	19397.4	19746.5	19978.6	20391
MB20BWM03P2	RCM Coal	pH (Field)	27	6.79	6.86	6.96	7.776	8.25
MB20BWM03P2	RCM Coal	Aluminium (Diss)	27	0.01	0.01	0.01	0.01	0.05
MB20BWM03P2	RCM Coal	Aluminium (Total)	20	0.03	0.58	1.23	7.97	17
MB20BWM03P2	RCM Coal	Antimony (Diss)	7	0.001	0.001	0.001	0.001	0.001
MB20BWM03P2	RCM Coal	Antimony (Total)	7	0.001	0.001	0.001	0.001	0.002
MB20BWM03P2	RCM Coal	Arsenic (Diss)	27	0.001	0.001	0.002	0.003	0.005
MB20BWM03P2	RCM Coal	Arsenic (Total)	20	0.001	0.002	0.0035	0.007	0.011
MB20BWM03P2	RCM Coal	Bicarbonate Alkalinity as CaCO3	19	467	521.2	545	591	640
MB20BWM03P2	RCM Coal	Calcium (Diss)	20	107	125.6	138.5	156.4	316
MB20BWM03P2	RCM Coal	Carbonate Alkalinity as CaCO3	19	1	1	1	1	32
MB20BWM03P2	RCM Coal	Chloride	20	6370	6510	6695	6872	7740
MB20BWM03P2	RCM Coal	Electrical Conductivity (Lab)	28	17300	17840	18666	19260	19900
MB20BWM03P2	RCM Coal	Hydroxide Alkalinity as CaCO3	19	1	1	1	1	1
MB20BWM03P2	RCM Coal	Iron (Diss)	22	0.05	0.062	0.535	0.756	1.61
MB20BWM03P2	RCM Coal	Iron (Total)	20	0.34	1.39	2.475	14.18	29.8
MB20BWM03P2	RCM Coal	Magnesium (Diss)	20	84	91.8	100	104	113
MB20BWM03P2	RCM Coal	Molybdenum (Diss)	27	0.001	0.002	0.003	0.0068	0.018
MB20BWM03P2	RCM Coal	Molybdenum (Total)	20	0.001	0.002	0.004	0.0084	0.024
MB20BWM03P2	RCM Coal	pH (Lab)	27	6.78	6.944	7.82	7.98	8.41
MB20BWM03P2	RCM Coal	Potassium (Diss)	20	17	17	18	20.2	25

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20BWM03P2	RCM Coal	Selenium (Diss)	27	0.01	0.01	0.01	0.01	0.05
MB20BWM03P2	RCM Coal	Selenium (Total)	20	0.01	0.01	0.01	0.01	0.05
MB20BWM03P2	RCM Coal	Silver (Diss)	27	0.001	0.001	0.001	0.001	0.005
MB20BWM03P2	RCM Coal	Silver (Total)	20	0.001	0.001	0.001	0.001	0.005
MB20BWM03P2	RCM Coal	Sodium (Diss)	20	3700	3932	4040	4264	4620
MB20BWM03P2	RCM Coal	Sulphate as SO4 2-	27	1	1	1	2	15
MB20BWM03P2	RCM Coal	Total Alkalinity as CaCO3	19	499	521.2	545	591	640
MB20BWM03P2	RCM Coal	Total Dissolved Solids (Lab)	17	10600	11720	12100	12380	12700
MB20BWM03P2	RCM Coal	Mercury (Diss)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
MB20BWM03P2	RCM Coal	Mercury (Total)	7	0.0001	1.00E-04	0.0001	0.0001	0.0001
MB20BWM03P2	RCM Coal	Ammonia as N	7	4.21	4.252	4.58	4.7	5
MB20BWM03P2	RCM Coal	Barium (Diss)	7	18.2	18.48	25.6	29.38	35
MB20BWM03P2	RCM Coal	Barium (Total)	7	25.8	25.88	26.9	30.84	34
MB20BWM03P2	RCM Coal	Beryllium (Diss)	6	0.001	0.001	0.001	0.001	0.001
MB20BWM03P2	RCM Coal	Beryllium (Total)	6	0.001	0.001	0.001	0.001	0.001
MB20BWM03P2	RCM Coal	Lead (Diss)	20	0.001	0.001	0.001	0.001	0.005
MB20BWM03P2	RCM Coal	Lead (Total)	20	0.001	0.002	0.004	0.0152	0.024
MB20BWM03P2	RCM Coal	Manganese (Diss)	20	0.02	0.0348	0.067	0.1274	0.139
MB20BWM03P2	RCM Coal	Manganese (Total)	20	0.027	0.048	0.1165	0.293	0.568
MB20BWM03P2	RCM Coal	Nickel (Diss)	20	0.002	0.003	0.004	0.005	0.01
MB20BWM03P2	RCM Coal	Nickel (Total)	20	0.003	0.005	0.0085	0.036	0.053
MB20BWM03P2	RCM Coal	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB20BWM03P2	RCM Coal	Zinc (Diss)	20	0.057	0.1478	0.2365	1.152	1.3
MB20BWM03P2	RCM Coal	Zinc (Total)	20	0.081	0.2106	0.303	1.44	1.5
MB3	RCM Coal	EC (Field)	42	1203	10726	11908.5	12837.8	27571
MB3	RCM Coal	pH (Field)	50	6.39	6.824	7.135	7.696	8.14
MB3	RCM Coal	Aluminium (Diss)	50	0.01	0.01	0.01	0.01	0.05
MB3	RCM Coal	Aluminium (Total)	50	0.01	0.134	0.305	0.81	2.11
MB3	RCM Coal	Antimony (Diss)	42	0.001	0.001	0.001	0.001	0.001
MB3	RCM Coal	Antimony (Total)	42	0.001	0.001	0.001	0.001	0.005
MB3	RCM Coal	Arsenic (Diss)	50	0.001	0.001	0.001	0.001	0.004

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB3	RCM Coal	Arsenic (Total)	50	0.001	0.001	0.001	0.002	0.005
MB3	RCM Coal	Bicarbonate Alkalinity as CaCO3	50	143	170	186.5	208.4	276
MB3	RCM Coal	Calcium (Diss)	49	121	214	244	306	644
MB3	RCM Coal	Carbonate Alkalinity as CaCO3	50	1	1	1	1	1
MB3	RCM Coal	Chloride	50	1430	3970	4045	4314	10100
MB3	RCM Coal	Electrical Conductivity (Lab)	51	4690	11100	11600	12100	27000
MB3	RCM Coal	Hydroxide Alkalinity as CaCO3	50	1	1	1	1	1
MB3	RCM Coal	Iron (Diss)	50	0.05	0.898	1.65	2.244	3.15
MB3	RCM Coal	Iron (Total)	50	1.07	2.198	2.915	3.632	6.25
MB3	RCM Coal	Magnesium (Diss)	49	36	56.6	62	77.4	432
MB3	RCM Coal	Molybdenum (Diss)	50	0.001	0.001	0.002	0.0138	0.113
MB3	RCM Coal	Molybdenum (Total)	50	0.001	0.002	0.002	0.0184	0.136
MB3	RCM Coal	pH (Lab)	52	6.72	7.542	7.81	7.998	8.14
MB3	RCM Coal	Potassium (Diss)	49	5	9	10	12	22
MB3	RCM Coal	Selenium (Diss)	50	0.01	0.01	0.01	0.01	0.01
MB3	RCM Coal	Selenium (Total)	50	0.01	0.01	0.01	0.01	0.05
MB3	RCM Coal	Silver (Diss)	50	0.001	0.001	0.001	0.001	0.001
MB3	RCM Coal	Silver (Total)	50	0.001	0.001	0.001	0.001	0.01
MB3	RCM Coal	Sodium (Diss)	49	916	2080	2190	2294	4770
MB3	RCM Coal	Sulphate as SO4 2-	50	1	1	2	26.4	200
MB3	RCM Coal	Total Alkalinity as CaCO3	49	143	171.2	187	208.8	276
MB3	RCM Coal	Total Dissolved Solids (Lab)	51	2980	7140	7450	8010	19500
MB3	RCM Coal	Mercury (Diss)	38	0.0001	0.0001	0.0001	0.0001	0.0002
MB3	RCM Coal	Mercury (Total)	41	0.0001	0.0001	0.0001	0.0001	0.0004
MB5	RCM Coal	EC (Field)	21	3700	5320	6740	8630	13010
MB5	RCM Coal	pH (Field)	21	6.73	7.12	7.7	8.15	8.63
MB5	RCM Coal	Aluminium (Diss)	21	0.01	0.01	0.01	0.02	0.21
MB5	RCM Coal	Aluminium (Total)	20	0.001	0.33	0.85	1.236	3.88
MB5	RCM Coal	Antimony (Diss)	21	0.001	0.001	0.001	0.001	0.001
MB5	RCM Coal	Antimony (Total)	20	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB5	RCM Coal	Arsenic (Diss)	21	0.001	0.001	0.001	0.001	0.001
MB5	RCM Coal	Arsenic (Total)	20	0.001	0.001	0.001	0.002	0.004
MB5	RCM Coal	Bicarbonate Alkalinity as CaCO3	21	74	127	175	257	290
MB5	RCM Coal	Calcium (Diss)	21	33	52	127	170	491
MB5	RCM Coal	Carbonate Alkalinity as CaCO3	21	1	1	1	1	24
MB5	RCM Coal	Chloride	21	559	1280	1940	2740	7050
MB5	RCM Coal	Electrical Conductivity (Lab)	21	4010	5340	6540	7870	20400
MB5	RCM Coal	Hydroxide Alkalinity as CaCO3	21	1	1	1	1	1
MB5	RCM Coal	Iron (Diss)	21	0.05	0.05	0.1	0.14	2.06
MB5	RCM Coal	Iron (Total)	20	0.17	0.83	1.695	3.388	13.1
MB5	RCM Coal	Magnesium (Diss)	21	26	37	76	109	263
MB5	RCM Coal	Molybdenum (Diss)	21	0.001	0.003	0.015	0.018	0.03
MB5	RCM Coal	Molybdenum (Total)	20	0.001	0.0028	0.017	0.024	0.033
MB5	RCM Coal	pH (Lab)	21	7.8	7.88	7.98	8.27	8.5
MB5	RCM Coal	Potassium (Diss)	21	6	8	12	16	20
MB5	RCM Coal	Selenium (Diss)	21	0.01	0.01	0.01	0.01	0.01
MB5	RCM Coal	Selenium (Total)	20	0.001	0.001	0.001	0.001	0.001
MB5	RCM Coal	Silver (Diss)	21	0.01	0.01	0.01	0.01	0.01
MB5	RCM Coal	Silver (Total)	20	0.001	0.001	0.001	0.001	0.001
MB5	RCM Coal	Sodium (Diss)	21	651	873	1140	1320	3180
MB5	RCM Coal	Sulphate as SO4 2-	21	2	8	21	35	479
MB5	RCM Coal	Total Alkalinity as CaCO3	21	74	127	175	277	290
MB5	RCM Coal	Total Dissolved Solids (Lab)	21	2180	2790	4390	5780	11300
MB5	RCM Coal	Mercury (Diss)	20	0.0001	0.0001	0.0001	0.0001	0.0001
MB5	RCM Coal	Mercury (Total)	19	0.0001	0.0001	0.0001	0.0001	0.0001
MB15	RCM Over/Interburden	EC (Field)	38	2893	3970.8	4473	5761.4	16035
MB15	RCM Over/Interburden	pH (Field)	44	6.81	6.914	7.14	7.408	8.14
MB15	RCM Over/Interburden	Aluminium (Diss)	45	0.01	0.01	0.01	0.01	0.08
MB15	RCM Over/Interburden	Aluminium (Total)	45	0.02	0.078	0.21	0.45	2.62
MB15	RCM Over/Interburden	Antimony (Diss)	40	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB15	RCM Over/Interburden	Antimony (Total)	40	0.001	0.001	0.001	0.001	0.001
MB15	RCM Over/Interburden	Arsenic (Diss)	45	0.001	0.001	0.002	0.003	0.009
MB15	RCM Over/Interburden	Arsenic (Total)	45	0.001	0.001	0.003	0.003	0.01
MB15	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	45	263	379.8	415	448.4	482
MB15	RCM Over/Interburden	Calcium (Diss)	44	49	59.6	90	106.8	348
MB15	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	45	1	1	1	1	24
MB15	RCM Over/Interburden	Chloride	45	940	1066	1170	1506	4970
MB15	RCM Over/Interburden	Electrical Conductivity (Lab)	45	3790	4050	4270	5272	14300
MB15	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	45	1	1	1	1	1
MB15	RCM Over/Interburden	Iron (Diss)	45	0.05	0.05	0.23	1.72	7.58
MB15	RCM Over/Interburden	Iron (Total)	45	0.05	0.37	0.89	3.794	12.4
MB15	RCM Over/Interburden	Magnesium (Diss)	44	29	45.6	50	61.4	232
MB15	RCM Over/Interburden	Molybdenum (Diss)	45	0.001	0.001	0.001	0.002	0.007
MB15	RCM Over/Interburden	Molybdenum (Total)	45	0.001	0.001	0.001	0.003	0.006
MB15	RCM Over/Interburden	pH (Lab)	45	7.3	7.626	7.83	8.15	8.46
MB15	RCM Over/Interburden	Potassium (Diss)	44	7	9	10	12	16
MB15	RCM Over/Interburden	Selenium (Diss)	45	0.01	0.01	0.01	0.01	0.01
MB15	RCM Over/Interburden	Selenium (Total)	45	0.01	0.01	0.01	0.01	0.01
MB15	RCM Over/Interburden	Silver (Diss)	45	0.001	0.001	0.001	0.001	0.001
MB15	RCM Over/Interburden	Silver (Total)	45	0.001	0.001	0.001	0.001	0.01
MB15	RCM Over/Interburden	Sodium (Diss)	44	628	711.2	758.5	894	2490
MB15	RCM Over/Interburden	Sulphate as SO4 2-	45	1	2	3	5	106
MB15	RCM Over/Interburden	Total Alkalinity as CaCO3	44	283	379.6	415.5	448.8	482
MB15	RCM Over/Interburden	Total Dissolved Solids (Lab)	45	1970	2188	2340	2946	9340
MB15	RCM Over/Interburden	Mercury (Diss)	35	0.0001	0.0001	0.0001	0.0001	0.0011
MB15	RCM Over/Interburden	Mercury (Total)	39	0.0001	0.0001	0.0001	0.0001	0.0014
MB17	RCM Over/Interburden	EC (Field)	30	1283	2155.4	6374	12410.4	19480
MB17	RCM Over/Interburden	pH (Field)	37	6.33	6.782	7.18	7.702	8.36
MB17	RCM Over/Interburden	Aluminium (Diss)	37	0.01	0.01	0.01	0.01	0.05
MB17	RCM Over/Interburden	Aluminium (Total)	37	0.01	0.368	2.08	10.81	466

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB17	RCM Over/Interburden	Antimony (Diss)	37	0.001	0.001	0.001	0.001	0.004
MB17	RCM Over/Interburden	Antimony (Total)	37	0.001	0.001	0.001	0.001	0.001
MB17	RCM Over/Interburden	Arsenic (Diss)	37	0.001	0.002	0.004	0.006	0.014
MB17	RCM Over/Interburden	Arsenic (Total)	37	0.002	0.004	0.006	0.0098	0.083
MB17	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	37	92	190.2	272	327.8	421
MB17	RCM Over/Interburden	Calcium (Diss)	36	34	54	98	370	655
MB17	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	37	1	1	1	1	27
MB17	RCM Over/Interburden	Chloride	37	94	349.2	1270	3806	6160
MB17	RCM Over/Interburden	Electrical Conductivity (Lab)	37	890	1892	4350	11340	18100
MB17	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	37	1	1	1	1	1
MB17	RCM Over/Interburden	Iron (Diss)	36	0.05	0.05	0.255	0.43	2.73
MB17	RCM Over/Interburden	Iron (Total)	37	0.17	1.984	3.14	20.24	871
MB17	RCM Over/Interburden	Magnesium (Diss)	36	10	18	29.5	77	194
MB17	RCM Over/Interburden	Molybdenum (Diss)	37	0.001	0.009	0.016	0.0328	0.067
MB17	RCM Over/Interburden	Molybdenum (Total)	37	0.001	0.009	0.02	0.0408	0.078
MB17	RCM Over/Interburden	pH (Lab)	37	7.37	7.614	7.91	8.06	8.51
MB17	RCM Over/Interburden	Potassium (Diss)	36	2	3	5.5	9	13
MB17	RCM Over/Interburden	Selenium (Diss)	37	0.01	0.01	0.01	0.01	0.01
MB17	RCM Over/Interburden	Selenium (Total)	37	0.01	0.01	0.01	0.01	0.01
MB17	RCM Over/Interburden	Silver (Diss)	37	0.001	0.001	0.001	0.001	0.001
MB17	RCM Over/Interburden	Silver (Total)	37	0.001	0.001	0.001	0.001	0.001
MB17	RCM Over/Interburden	Sodium (Diss)	36	142	295	801	1960	2980
MB17	RCM Over/Interburden	Sulphate as SO4 2-	37	1	19	112	202.8	324
MB17	RCM Over/Interburden	Total Alkalinity as CaCO3	37	92	193.8	272	327.8	421
MB17	RCM Over/Interburden	Total Dissolved Solids (Lab)	37	552	1070	2760	7158	11600
MB17	RCM Over/Interburden	Mercury (Diss)	33	0.0001	0.0001	0.0001	0.0001	0.0002
MB17	RCM Over/Interburden	Mercury (Total)	36	0.0001	0.0001	0.0001	0.0001	0.0006
MB18	RCM Over/Interburden	EC (Field)	42	5436	14870	16430.5	17582.4	19780
MB18	RCM Over/Interburden	pH (Field)	49	6.05	6.632	6.86	7.262	7.94
MB18	RCM Over/Interburden	Aluminium (Diss)	50	0.01	0.01	0.01	0.01	0.07

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB18	RCM Over/Interburden	Aluminium (Total)	50	0.01	0.158	0.285	0.45	47.1
MB18	RCM Over/Interburden	Antimony (Diss)	42	0.001	0.001	0.001	0.001	0.004
MB18	RCM Over/Interburden	Antimony (Total)	42	0.001	0.001	0.001	0.001	0.002
MB18	RCM Over/Interburden	Arsenic (Diss)	50	0.001	0.001	0.005	0.007	0.01
MB18	RCM Over/Interburden	Arsenic (Total)	50	0.001	0.002	0.007	0.01	0.015
MB18	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	50	65	87.8	100	119.2	317
MB18	RCM Over/Interburden	Calcium (Diss)	49	165	565.6	611	649.4	782
MB18	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	50	1	1	1	1	1
MB18	RCM Over/Interburden	Chloride	50	1610	5816	6020	6372	7040
MB18	RCM Over/Interburden	Electrical Conductivity (Lab)	51	5320	16100	16800	17400	17800
MB18	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	50	1	1	1	1	1
MB18	RCM Over/Interburden	Iron (Diss)	50	0.05	0.624	1.495	1.986	4.51
MB18	RCM Over/Interburden	Iron (Total)	50	0.93	1.816	2.695	3.742	88.4
MB18	RCM Over/Interburden	Magnesium (Diss)	49	52	106	111	116.4	228
MB18	RCM Over/Interburden	Molybdenum (Diss)	50	0.001	0.001	0.001	0.00152	0.012
MB18	RCM Over/Interburden	Molybdenum (Total)	50	0.001	0.001	0.001	0.002	0.015
MB18	RCM Over/Interburden	pH (Lab)	51	6.98	7.3	7.52	7.75	7.98
MB18	RCM Over/Interburden	Potassium (Diss)	49	7	10	10	13	16
MB18	RCM Over/Interburden	Selenium (Diss)	50	0.01	0.01	0.01	0.01	0.01
MB18	RCM Over/Interburden	Selenium (Total)	50	0.01	0.01	0.01	0.01	0.01
MB18	RCM Over/Interburden	Silver (Diss)	50	0.001	0.001	0.001	0.001	0.005
MB18	RCM Over/Interburden	Silver (Total)	50	0.001	0.001	0.001	0.001	0.001
MB18	RCM Over/Interburden	Sodium (Diss)	49	861	2740	2860	2948	3200
MB18	RCM Over/Interburden	Sulphate as SO4 2-	50	1	1	1	3.2	190
MB18	RCM Over/Interburden	Total Alkalinity as CaCO3	50	65	87.8	100	119.2	317
MB18	RCM Over/Interburden	Total Dissolved Solids (Lab)	49	3250	10160	11400	12040	14500
MB18	RCM Over/Interburden	Mercury (Diss)	37	0.0001	1.00E-04	0.0001	0.0001	0.0004
MB18	RCM Over/Interburden	Mercury (Total)	41	0.0001	0.0001	0.0001	0.0001	0.0006
MB20BWM03P1	RCM Over/Interburden	EC (Field)	20	22893	25598.8	27189.5	28718.6	29463
MB20BWM03P1	RCM Over/Interburden	pH (Field)	25	6.61	6.728	6.8	7.388	7.98

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20BWM03P1	RCM Over/Interburden	Aluminium (Diss)	25	0.01	0.01	0.05	0.05	0.05
MB20BWM03P1	RCM Over/Interburden	Aluminium (Total)	18	0.14	0.248	1.005	2.56	10.9
MB20BWM03P1	RCM Over/Interburden	Antimony (Diss)	5	0.001	0.001	0.001	0.002	0.002
MB20BWM03P1	RCM Over/Interburden	Antimony (Total)	5	0.001	0.001	0.001	0.0052	0.006
MB20BWM03P1	RCM Over/Interburden	Arsenic (Diss)	25	0.003	0.006	0.007	0.0082	0.009
MB20BWM03P1	RCM Over/Interburden	Arsenic (Total)	18	0.004	0.008	0.009	0.012	0.02
MB20BWM03P1	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	17	270	295	303	319.6	342
MB20BWM03P1	RCM Over/Interburden	Calcium (Diss)	18	358	383	474	537.2	887
MB20BWM03P1	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	17	1	1	1	1	1
MB20BWM03P1	RCM Over/Interburden	Chloride	18	7730	8652	9295	10200	10800
MB20BWM03P1	RCM Over/Interburden	Electrical Conductivity (Lab)	25	20600	23700	25700	26760	29000
MB20BWM03P1	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	17	1	1	1	1	1
MB20BWM03P1	RCM Over/Interburden	Iron (Diss)	20	0.05	1.366	2.125	3.348	4.39
MB20BWM03P1	RCM Over/Interburden	Iron (Total)	18	2.98	3.784	5.91	10.1	47.3
MB20BWM03P1	RCM Over/Interburden	Magnesium (Diss)	18	238	280.6	309.5	359	401
MB20BWM03P1	RCM Over/Interburden	Molybdenum (Diss)	25	0.004	0.005	0.005	0.0082	0.016
MB20BWM03P1	RCM Over/Interburden	Molybdenum (Total)	18	0.005	0.005	0.0055	0.0136	0.024
MB20BWM03P1	RCM Over/Interburden	pH (Lab)	26	6.59	6.77	7.595	7.74	8.07
MB20BWM03P1	RCM Over/Interburden	Potassium (Diss)	18	19	22	23	24.6	26
MB20BWM03P1	RCM Over/Interburden	Selenium (Diss)	25	0.01	0.01	0.05	0.05	0.05
MB20BWM03P1	RCM Over/Interburden	Selenium (Total)	18	0.01	0.01	0.05	0.05	0.05
MB20BWM03P1	RCM Over/Interburden	Silver (Diss)	25	0.001	0.001	0.005	0.005	0.005
MB20BWM03P1	RCM Over/Interburden	Silver (Total)	18	0.001	0.001	0.005	0.005	0.005
MB20BWM03P1	RCM Over/Interburden	Sodium (Diss)	18	3970	4644	5285	5846	6320
MB20BWM03P1	RCM Over/Interburden	Sulphate as SO4 2-	25	1	1	1	4.2	16
MB20BWM03P1	RCM Over/Interburden	Total Alkalinity as CaCO3	17	270	295	303	319.6	342
MB20BWM03P1	RCM Over/Interburden	Total Dissolved Solids (Lab)	15	14000	15420	16600	20960	23400
MB20BWM03P1	RCM Over/Interburden	Mercury (Diss)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB20BWM03P1	RCM Over/Interburden	Mercury (Total)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB20BWM03P1	RCM Over/Interburden	Ammonia as N	5	3.72	3.784	3.86	4.504	5

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20BWM03P1	RCM Over/Interburden	Barium (Diss)	5	20.6	24.04	34.2	36.96	44
MB20BWM03P1	RCM Over/Interburden	Barium (Total)	5	24.2	24.84	31.9	39.4	41
MB20BWM03P1	RCM Over/Interburden	Beryllium (Diss)	4	0.001	0.001	0.001	0.001	0.001
MB20BWM03P1	RCM Over/Interburden	Beryllium (Total)	4	0.001	0.001	0.001	0.0026	0.005
MB20BWM03P1	RCM Over/Interburden	Lead (Diss)	18	0.001	0.001	0.005	0.005	0.005
MB20BWM03P1	RCM Over/Interburden	Lead (Total)	18	0.002	0.005	0.005	0.0096	0.027
MB20BWM03P1	RCM Over/Interburden	Manganese (Diss)	18	0.432	0.5478	0.613	0.677	1
MB20BWM03P1	RCM Over/Interburden	Manganese (Total)	18	0.532	0.6274	0.697	0.815	1.62
MB20BWM03P1	RCM Over/Interburden	Nickel (Diss)	18	0.003	0.005	0.007	0.0132	0.043
MB20BWM03P1	RCM Over/Interburden	Nickel (Total)	18	0.004	0.0054	0.0105	0.0268	0.054
MB20BWM03P1	RCM Over/Interburden	Nitrate as N	3	0.01	0.01	0.01	0.01	0.01
MB20BWM03P1	RCM Over/Interburden	Zinc (Diss)	18	0.033	0.086	0.1615	0.2704	0.306
MB20BWM03P1	RCM Over/Interburden	Zinc (Total)	18	0.137	0.193	0.2755	0.36	0.428
MB4	RCM Over/Interburden	EC (Field)	26	10010	16570	18432	19950	34872
MB4	RCM Over/Interburden	pH (Field)	33	4.45	6.608	6.9	7.312	7.95
MB4	RCM Over/Interburden	Aluminium (Diss)	32	0.01	0.01	0.01	0.01	0.01
MB4	RCM Over/Interburden	Aluminium (Total)	33	0.02	0.526	0.96	2.192	19.5
MB4	RCM Over/Interburden	Antimony (Diss)	33	0.001	0.001	0.001	0.001	0.001
MB4	RCM Over/Interburden	Antimony (Total)	33	0.001	0.001	0.001	0.001	0.001
MB4	RCM Over/Interburden	Arsenic (Diss)	33	0.001	0.001	0.001	0.001	0.003
MB4	RCM Over/Interburden	Arsenic (Total)	33	0.001	0.001	0.001	0.001	0.009
MB4	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	33	6	139.6	156	172.2	756
MB4	RCM Over/Interburden	Calcium (Diss)	32	159	475	507.5	539.6	815
MB4	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	33	1	1	1	1	1
MB4	RCM Over/Interburden	Chloride	33	1910	6406	6800	7178	8800
MB4	RCM Over/Interburden	Electrical Conductivity (Lab)	33	6950	17400	18600	19100	22100
MB4	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	33	1	1	1	1	1
MB4	RCM Over/Interburden	Iron (Diss)	33	0.05	0.258	1.08	2.352	4.14
MB4	RCM Over/Interburden	Iron (Total)	33	0.68	2.36	3.96	6.844	27.2
MB4	RCM Over/Interburden	Magnesium (Diss)	32	125	251.2	262	279.8	368

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB4	RCM Over/Interburden	Molybdenum (Diss)	33	0.001	0.001	0.001	0.0016	0.01
MB4	RCM Over/Interburden	Molybdenum (Total)	33	0.001	0.001	0.001	0.002	0.01
MB4	RCM Over/Interburden	pH (Lab)	33	5.41	7.312	7.45	7.72	8.22
MB4	RCM Over/Interburden	Potassium (Diss)	32	5	14	16	18.8	22
MB4	RCM Over/Interburden	Selenium (Diss)	33	0.01	0.01	0.01	0.01	0.01
MB4	RCM Over/Interburden	Selenium (Total)	33	0.01	0.01	0.01	0.01	0.01
MB4	RCM Over/Interburden	Silver (Diss)	33	0.001	0.001	0.001	0.001	0.001
MB4	RCM Over/Interburden	Silver (Total)	33	0.001	0.001	0.001	0.001	0.01
MB4	RCM Over/Interburden	Sodium (Diss)	32	1040	3080	3175	3334	4360
MB4	RCM Over/Interburden	Sulphate as SO4 2-	33	1	3	5	7.6	1950
MB4	RCM Over/Interburden	Total Alkalinity as CaCO3	33	6	139.6	156	172.2	756
MB4	RCM Over/Interburden	Total Dissolved Solids (Lab)	33	4260	11440	12900	13880	15800
MB4	RCM Over/Interburden	Mercury (Diss)	29	0.0001	0.0001	0.0001	0.0001	0.001
MB4	RCM Over/Interburden	Mercury (Total)	32	0.0001	1.00E-04	0.0001	0.0001	0.0012
MB6	RCM Over/Interburden	EC (Field)	36	2181	2540	3578	8278	17900
MB6	RCM Over/Interburden	pH (Field)	42	4.66	5.512	5.935	6.604	7.19
MB6	RCM Over/Interburden	Aluminium (Diss)	42	0.01	0.05	0.2	0.29	0.69
MB6	RCM Over/Interburden	Aluminium (Total)	42	0.06	0.384	0.845	1.434	6.65
MB6	RCM Over/Interburden	Antimony (Diss)	42	0.001	0.001	0.001	0.001	0.001
MB6	RCM Over/Interburden	Antimony (Total)	42	0.001	0.001	0.001	0.001	0.001
MB6	RCM Over/Interburden	Arsenic (Diss)	42	0.001	0.001	0.001	0.001	0.003
MB6	RCM Over/Interburden	Arsenic (Total)	42	0.001	0.001	0.001	0.001	0.005
MB6	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	42	15	48.4	63.5	120.8	394
MB6	RCM Over/Interburden	Calcium (Diss)	41	13	25	34	69	637
MB6	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	42	1	1	1	1	1
MB6	RCM Over/Interburden	Chloride	42	533	641.8	1020	1516	6820
MB6	RCM Over/Interburden	Electrical Conductivity (Lab)	42	1890	2222	3350	5532	19900
MB6	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	42	1	1	1	1	1
MB6	RCM Over/Interburden	Iron (Diss)	42	0.05	0.05	0.055	0.498	11.3
MB6	RCM Over/Interburden	Iron (Total)	42	0.07	0.516	1.105	3.676	14.8

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB6	RCM Over/Interburden	Magnesium (Diss)	41	34	44	88	127	623
MB6	RCM Over/Interburden	Molybdenum (Diss)	42	0.001	0.001	0.001	0.001	0.002
MB6	RCM Over/Interburden	Molybdenum (Total)	42	0.001	0.001	0.001	0.001	0.002
MB6	RCM Over/Interburden	pH (Lab)	42	5.45	6.072	6.47	6.842	7.98
MB6	RCM Over/Interburden	Potassium (Diss)	41	1	2	3	6	28
MB6	RCM Over/Interburden	Selenium (Diss)	42	0.01	0.01	0.01	0.01	0.01
MB6	RCM Over/Interburden	Selenium (Total)	42	0.01	0.01	0.01	0.01	0.01
MB6	RCM Over/Interburden	Silver (Diss)	42	0.001	0.001	0.001	0.001	0.001
MB6	RCM Over/Interburden	Silver (Total)	42	0.001	0.001	0.001	0.001	0.001
MB6	RCM Over/Interburden	Sodium (Diss)	41	315	380	479	626	2620
MB6	RCM Over/Interburden	Sulphate as SO4 2-	42	1	35.2	48.5	114.8	761
MB6	RCM Over/Interburden	Total Alkalinity as CaCO3	42	15	48.4	63.5	120.8	394
MB6	RCM Over/Interburden	Total Dissolved Solids (Lab)	42	1140	1382	2045	3302	21600
MB6	RCM Over/Interburden	Mercury (Diss)	39	0.0001	0.0001	0.0001	0.0001	0.0008
MB6	RCM Over/Interburden	Mercury (Total)	42	0.0001	0.0001	0.0001	0.0001	0.0015
MB8	RCM Over/Interburden	EC (Field)	38	4880	12081	15474.5	18620	28048
MB8	RCM Over/Interburden	pH (Field)	45	5.58	6.248	6.65	7.148	7.95
MB8	RCM Over/Interburden	Aluminium (Diss)	46	0.01	0.01	0.01	0.01	0.09
MB8	RCM Over/Interburden	Aluminium (Total)	46	0.04	0.16	0.445	1.19	19.9
MB8	RCM Over/Interburden	Antimony (Diss)	38	0.001	0.001	0.001	0.001	0.001
MB8	RCM Over/Interburden	Antimony (Total)	38	0.001	0.001	0.001	0.001	0.001
MB8	RCM Over/Interburden	Arsenic (Diss)	46	0.001	0.001	0.001	0.002	0.011
MB8	RCM Over/Interburden	Arsenic (Total)	46	0.001	0.001	0.001	0.003	0.011
MB8	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	45	209	233.6	293	640	790
MB8	RCM Over/Interburden	Calcium (Diss)	45	71	262	332	518.6	701
MB8	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	45	1	1	1	1	30
MB8	RCM Over/Interburden	Chloride	45	3010	4030	4710	6196	12800
MB8	RCM Over/Interburden	Electrical Conductivity (Lab)	45	11500	12300	13700	17680	26400
MB8	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	45	1	1	1	1	1
MB8	RCM Over/Interburden	Iron (Diss)	46	0.05	0.05	0.09	0.31	6.21

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB8	RCM Over/Interburden	Iron (Total)	46	0.07	0.49	1.115	3.14	42.9
MB8	RCM Over/Interburden	Magnesium (Diss)	45	52	301.6	382	679.8	759
MB8	RCM Over/Interburden	Molybdenum (Diss)	46	0.001	0.001	0.001	0.003	0.013
MB8	RCM Over/Interburden	Molybdenum (Total)	46	0.001	0.001	0.001	0.004	0.01
MB8	RCM Over/Interburden	pH (Lab)	46	6.02	7.09	7.39	7.62	8.45
MB8	RCM Over/Interburden	Potassium (Diss)	45	9	14	39	45	48
MB8	RCM Over/Interburden	Selenium (Diss)	46	0.01	0.01	0.01	0.01	0.02
MB8	RCM Over/Interburden	Selenium (Total)	46	0.001	0.01	0.01	0.01	0.02
MB8	RCM Over/Interburden	Silver (Diss)	46	0.001	0.001	0.001	0.001	0.007
MB8	RCM Over/Interburden	Silver (Total)	46	0.001	0.001	0.001	0.001	0.001
MB8	RCM Over/Interburden	Sodium (Diss)	45	813	2148	2230	2402	5580
MB8	RCM Over/Interburden	Sulphate as SO4 2-	45	353	541.4	690	1078.4	1790
MB8	RCM Over/Interburden	Total Alkalinity as CaCO3	45	209	233.6	293	640	790
MB8	RCM Over/Interburden	Total Dissolved Solids (Lab)	44	7410	8360	9575	12640	17200
MB8	RCM Over/Interburden	Mercury (Diss)	34	0.0001	0.0001	0.0001	0.0001	0.0006
MB8	RCM Over/Interburden	Mercury (Total)	37	0.0001	1.00E-04	0.0001	0.0002	0.0045
MB9	RCM Over/Interburden	EC (Field)	40	8860	11488	12353	15098.2	21920
MB9	RCM Over/Interburden	pH (Field)	46	6.07	6.51	6.71	7.08	8.86
MB9	RCM Over/Interburden	Aluminium (Diss)	47	0.01	0.01	0.01	0.01	0.09
MB9	RCM Over/Interburden	Aluminium (Total)	47	0.01	0.126	0.46	2.254	20.8
MB9	RCM Over/Interburden	Antimony (Diss)	39	0.001	0.001	0.001	0.001	0.001
MB9	RCM Over/Interburden	Antimony (Total)	39	0.001	0.001	0.001	0.001	0.001
MB9	RCM Over/Interburden	Arsenic (Diss)	47	0.001	0.001	0.001	0.002	0.012
MB9	RCM Over/Interburden	Arsenic (Total)	47	0.001	0.001	0.002	0.003	0.012
MB9	RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	47	240	528.8	742	787.6	890
MB9	RCM Over/Interburden	Calcium (Diss)	46	222	302	360.5	434	647
MB9	RCM Over/Interburden	Carbonate Alkalinity as CaCO3	47	1	1	1	1	1
MB9	RCM Over/Interburden	Chloride	47	2720	3020	3720	4418	12800
MB9	RCM Over/Interburden	Electrical Conductivity (Lab)	46	11100	12000	12400	13600	19500
MB9	RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	47	1	1	1	1	1

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB9	RCM Over/Interburden	Iron (Diss)	47	0.05	0.082	0.37	1.248	5.91
MB9	RCM Over/Interburden	Iron (Total)	47	0.11	0.946	1.75	5.93	35.3
MB9	RCM Over/Interburden	Magnesium (Diss)	46	186	274	319.5	384	838
MB9	RCM Over/Interburden	Molybdenum (Diss)	47	0.001	0.0012	0.005	0.007	0.017
MB9	RCM Over/Interburden	Molybdenum (Total)	47	0.001	0.002	0.006	0.009	0.018
MB9	RCM Over/Interburden	pH (Lab)	48	6.59	7.174	7.47	7.77	8.08
MB9	RCM Over/Interburden	Potassium (Diss)	46	8	9	12	26	51
MB9	RCM Over/Interburden	Selenium (Diss)	47	0.01	0.01	0.01	0.01	0.02
MB9	RCM Over/Interburden	Selenium (Total)	47	0.01	0.01	0.01	0.01	0.02
MB9	RCM Over/Interburden	Silver (Diss)	47	0.001	0.001	0.001	0.001	0.002
MB9	RCM Over/Interburden	Silver (Total)	47	0.001	0.001	0.001	0.001	0.001
MB9	RCM Over/Interburden	Sodium (Diss)	46	1930	2060	2185	2420	6700
MB9	RCM Over/Interburden	Sulphate as SO4 2-	47	416	912	1650	1760	2010
MB9	RCM Over/Interburden	Total Alkalinity as CaCO3	47	240	528.8	742	787.6	890
MB9	RCM Over/Interburden	Total Dissolved Solids (Lab)	45	7530	8156	8480	9652	13600
MB9	RCM Over/Interburden	Mercury (Diss)	35	0.0001	0.0001	0.0001	0.0001	0.0039
MB9	RCM Over/Interburden	Mercury (Total)	38	0.0001	0.0001	0.0001	0.0001	0.0041
MB19BWM_25P	Rewan	EC (Field)	13	4679	4813	5046	5704.8	5791
MB19BWM_25P	Rewan	pH (Field)	7	7.68	7.75	7.94	7.948	8.07
MB19BWM_25P	Rewan	Aluminium (Diss)	12	0.01	0.01	0.01	0.01	0.01
MB19BWM_25P	Rewan	Arsenic (Diss)	12	0.004	0.008	0.011	0.0128	0.015
MB19BWM_25P	Rewan	Electrical Conductivity (Lab)	12	4450	4548	4910	5528	5680
MB19BWM_25P	Rewan	Iron (Diss)	12	0.06	0.096	0.245	0.372	0.56
MB19BWM_25P	Rewan	Molybdenum (Diss)	12	0.001	0.0012	0.002	0.002	0.002
MB19BWM_25P	Rewan	pH (Lab)	7	7.13	7.172	7.2	7.252	7.41
MB19BWM_25P	Rewan	Selenium (Diss)	12	0.01	0.01	0.01	0.01	0.01
MB19BWM_25P	Rewan	Silver (Diss)	12	0.001	0.001	0.001	0.001	0.001
MB19BWM_25P	Rewan	Sulphate as SO4 2-	12	11	25.2	87.5	97.2	111
MB19BWM02A	Rewan	EC (Field)	6	36873	36904	37178	37441	37915
MB19BWM02A	Rewan	pH (Field)	14	5.93	6.15	6.235	6.342	7.49
MB19BWM02A	Rewan	Aluminium (Diss)	14	0.05	0.05	0.05	0.05	0.05

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM02A	Rewan	Aluminium (Total)	13	0.05	0.066	0.14	0.424	1.25
MB19BWM02A	Rewan	Antimony (Diss)	9	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Antimony (Total)	9	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Arsenic (Diss)	14	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Arsenic (Total)	13	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Bicarbonate Alkalinity as CaCO3	13	401	425.2	438	454	467
MB19BWM02A	Rewan	Calcium (Diss)	13	852	906	960	994.6	1060
MB19BWM02A	Rewan	Carbonate Alkalinity as CaCO3	13	1	1	1	1	1
MB19BWM02A	Rewan	Chloride	13	12400	13240	13400	13500	14300
MB19BWM02A	Rewan	Electrical Conductivity (Lab)	20	30200	34960	36945.5	37461.8	38000
MB19BWM02A	Rewan	Hydroxide Alkalinity as CaCO3	13	1	1	1	1	1
MB19BWM02A	Rewan	Iron (Diss)	11	0.05	0.14	0.23	0.4	0.78
MB19BWM02A	Rewan	Iron (Total)	13	0.09	0.206	0.46	0.75	2.38
MB19BWM02A	Rewan	Magnesium (Diss)	13	939	959.4	1030	1066	1150
MB19BWM02A	Rewan	Molybdenum (Diss)	14	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Molybdenum (Total)	13	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	pH (Lab)	14	6.21	6.954	7.145	7.57	7.8
MB19BWM02A	Rewan	Potassium (Diss)	13	9	9	10	10	10
MB19BWM02A	Rewan	Selenium (Diss)	14	0.05	0.05	0.05	0.05	0.05
MB19BWM02A	Rewan	Selenium (Total)	13	0.05	0.05	0.05	0.05	0.05
MB19BWM02A	Rewan	Silver (Diss)	14	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Silver (Total)	13	0.005	0.005	0.005	0.005	0.01
MB19BWM02A	Rewan	Sodium (Diss)	13	6420	6588	6830	7110	7560
MB19BWM02A	Rewan	Sulphate as SO4 2-	14	454	485.2	504.5	509.6	527
MB19BWM02A	Rewan	Total Alkalinity as CaCO3	13	401	425.2	438	454	467
MB19BWM02A	Rewan	Total Dissolved Solids (Lab)	13	19800	23200	24000	27200	30800
MB19BWM02A	Rewan	Mercury (Diss)	9	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM02A	Rewan	Mercury (Total)	9	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM02A	Rewan	Ammonia as N	9	0.03	0.04	0.05	0.084	0.09
MB19BWM02A	Rewan	Barium (Diss)	9	0.141	0.1484	0.164	0.215	0.286

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM02A	Rewan	Barium (Total)	9	0.142	0.1514	0.161	0.2604	0.384
MB19BWM02A	Rewan	Beryllium (Diss)	9	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Beryllium (Total)	9	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Lead (Diss)	13	0.005	0.005	0.005	0.005	0.005
MB19BWM02A	Rewan	Lead (Total)	13	0.005	0.005	0.005	0.005	0.007
MB19BWM02A	Rewan	Manganese (Diss)	13	0.068	0.081	0.094	0.1132	0.304
MB19BWM02A	Rewan	Manganese (Total)	13	0.069	0.087	0.101	0.1194	0.365
MB19BWM02A	Rewan	Nickel (Diss)	13	0.005	0.005	0.005	0.0094	0.043
MB19BWM02A	Rewan	Nickel (Total)	13	0.005	0.005	0.005	0.0128	0.139
MB19BWM02A	Rewan	Nitrate as N	2	0.01	0.01	0.01	0.01	0.01
MB19BWM02A	Rewan	Zinc (Diss)	13	0.025	0.1586	0.182	0.3904	1.4
MB19BWM02A	Rewan	Zinc (Total)	13	0.124	0.1824	0.208	0.492	1.47
MB19BWM04R	Rewan	EC (Field)	18	33503	33939.2	34232.5	34601	34883
MB19BWM04R	Rewan	pH (Field)	29	6.4	6.624	6.76	7.154	7.69
MB19BWM04R	Rewan	Aluminium (Diss)	29	0.05	0.05	0.05	0.05	0.06
MB19BWM04R	Rewan	Aluminium (Total)	23	0.34	0.412	0.91	3.136	7.54
MB19BWM04R	Rewan	Antimony (Diss)	13	0.005	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Antimony (Total)	13	0.001	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Arsenic (Diss)	29	0.005	0.005	0.008	0.0124	0.019
MB19BWM04R	Rewan	Arsenic (Total)	23	0.005	0.0064	0.01	0.0172	0.023
MB19BWM04R	Rewan	Bicarbonate Alkalinity as CaCO3	23	100	105.4	111	117.8	144
MB19BWM04R	Rewan	Calcium (Diss)	23	1280	1390	1490	1556	1790
MB19BWM04R	Rewan	Carbonate Alkalinity as CaCO3	22	1	1	1	1	1
MB19BWM04R	Rewan	Chloride	23	10900	11920	12300	12500	13000
MB19BWM04R	Rewan	Electrical Conductivity (Lab)	36	28300	31800	33300	33900	34800
MB19BWM04R	Rewan	Hydroxide Alkalinity as CaCO3	22	1	1	1	1	1
MB19BWM04R	Rewan	Iron (Diss)	25	0.05	1.284	1.86	2.274	2.9
MB19BWM04R	Rewan	Iron (Total)	23	1.4	3.064	3.68	5.394	16.9
MB19BWM04R	Rewan	Magnesium (Diss)	23	186	198.2	206	214.4	235
MB19BWM04R	Rewan	Molybdenum (Diss)	29	0.005	0.006	0.007	0.009	0.017

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM04R	Rewan	Molybdenum (Total)	23	0.005	0.0074	0.01	0.0106	0.016
MB19BWM04R	Rewan	pH (Lab)	29	6.62	6.88	7.27	7.542	7.76
MB19BWM04R	Rewan	Potassium (Diss)	23	19	21	22	23	25
MB19BWM04R	Rewan	Selenium (Diss)	29	0.05	0.05	0.05	0.05	0.05
MB19BWM04R	Rewan	Selenium (Total)	23	0.01	0.05	0.05	0.05	0.05
MB19BWM04R	Rewan	Silver (Diss)	29	0.005	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Silver (Total)	23	0.001	0.005	0.005	0.005	0.009
MB19BWM04R	Rewan	Sodium (Diss)	23	5580	6228	6420	6620	7160
MB19BWM04R	Rewan	Sulphate as SO4 2-	29	1	1	2	23	126
MB19BWM04R	Rewan	Total Alkalinity as CaCO3	22	100	105.2	111.5	118.4	144
MB19BWM04R	Rewan	Total Dissolved Solids (Lab)	22	18600	21220	21900	25560	30000
MB19BWM04R	Rewan	Mercury (Diss)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM04R	Rewan	Mercury (Total)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM04R	Rewan	Ammonia as N	13	4.67	5.102	5.22	5.304	5.37
MB19BWM04R	Rewan	Barium (Diss)	13	1.61	2.808	7.94	22.7	36
MB19BWM04R	Rewan	Barium (Total)	13	2	3.448	9.94	22.32	36.7
MB19BWM04R	Rewan	Beryllium (Diss)	13	0.005	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Beryllium (Total)	13	0.001	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Lead (Diss)	23	0.005	0.005	0.005	0.005	0.005
MB19BWM04R	Rewan	Lead (Total)	23	0.005	0.005	0.005	0.0066	0.01
MB19BWM04R	Rewan	Manganese (Diss)	23	2.38	2.622	2.71	2.882	3.43
MB19BWM04R	Rewan	Manganese (Total)	23	2.5	2.646	2.79	2.974	3.29
MB19BWM04R	Rewan	Nickel (Diss)	23	0.005	0.005	0.013	0.018	0.04
MB19BWM04R	Rewan	Nickel (Total)	23	0.005	0.0086	0.016	0.026	0.054
MB19BWM04R	Rewan	Nitrate as N	4	0.01	0.01	0.01	0.01	0.01
MB19BWM04R	Rewan	Zinc (Diss)	23	0.056	0.0704	0.134	0.1714	2.45
MB19BWM04R	Rewan	Zinc (Total)	23	0.06	0.1456	0.186	0.2598	1.76
MB19BWM25P	Rewan	EC (Field)	5	4253	4456.2	4671	5029	5309
MB19BWM25P	Rewan	pH (Field)	19	7.07	7.156	7.21	7.342	7.49
MB19BWM25P	Rewan	Aluminium (Diss)	19	0.01	0.01	0.01	0.01	0.01
MB19BWM25P	Rewan	Aluminium (Total)	19	0.08	0.168	0.37	0.67	5.5

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM25P	Rewan	Antimony (Diss)	13	0.001	0.001	0.001	0.001	0.002
MB19BWM25P	Rewan	Antimony (Total)	13	0.001	0.001	0.001	0.001	0.002
MB19BWM25P	Rewan	Arsenic (Diss)	19	0.003	0.004	0.005	0.008	0.013
MB19BWM25P	Rewan	Arsenic (Total)	19	0.002	0.004	0.005	0.008	0.014
MB19BWM25P	Rewan	Bicarbonate Alkalinity as CaCO3	19	508	593.4	690	803.4	845
MB19BWM25P	Rewan	Calcium (Diss)	19	33	39.6	45	48	58
MB19BWM25P	Rewan	Carbonate Alkalinity as CaCO3	18	1	1	1	5.2	33
MB19BWM25P	Rewan	Chloride	19	771	828.6	1110	1398	1600
MB19BWM25P	Rewan	Electrical Conductivity (Lab)	22	3880	4131.4	4358.5	4948	5680
MB19BWM25P	Rewan	Hydroxide Alkalinity as CaCO3	18	1	1	1	1	1
MB19BWM25P	Rewan	Iron (Diss)	18	0.05	0.05	0.05	0.086	0.44
MB19BWM25P	Rewan	Iron (Total)	19	0.18	0.312	0.54	0.97	6.24
MB19BWM25P	Rewan	Magnesium (Diss)	19	17	18	21	22	26
MB19BWM25P	Rewan	Molybdenum (Diss)	19	0.001	0.002	0.005	0.006	0.011
MB19BWM25P	Rewan	Molybdenum (Total)	19	0.001	0.0026	0.006	0.008	0.011
MB19BWM25P	Rewan	pH (Lab)	19	7.61	7.852	7.93	8.284	8.47
MB19BWM25P	Rewan	Potassium (Diss)	19	3	3	3	3	4
MB19BWM25P	Rewan	Selenium (Diss)	19	0.01	0.01	0.01	0.01	0.01
MB19BWM25P	Rewan	Selenium (Total)	19	0.01	0.01	0.01	0.01	0.01
MB19BWM25P	Rewan	Silver (Diss)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM25P	Rewan	Silver (Total)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM25P	Rewan	Sodium (Diss)	19	860	911.6	1020	1076	1170
MB19BWM25P	Rewan	Sulphate as SO4 2-	19	17	63.4	110	179	242
MB19BWM25P	Rewan	Total Alkalinity as CaCO3	18	515	600.4	683.5	806.6	845
MB19BWM25P	Rewan	Total Dissolved Solids (Lab)	18	2520	2626	2915	3236	3620
MB19BWM25P	Rewan	Mercury (Diss)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM25P	Rewan	Mercury (Total)	13	0.0001	0.0001	0.0001	0.0001	0.0001
MB19BWM25P	Rewan	Ammonia as N	13	0.06	0.108	0.18	0.288	0.45
MB19BWM25P	Rewan	Barium (Diss)	13	0.203	0.232	0.364	0.517	0.699
MB19BWM25P	Rewan	Barium (Total)	13	0.193	0.249	0.448	0.5206	0.831

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19BWM25P	Rewan	Beryllium (Diss)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM25P	Rewan	Beryllium (Total)	13	0.001	0.001	0.001	0.001	0.001
MB19BWM25P	Rewan	Lead (Diss)	19	0.001	0.001	0.001	0.001	0.001
MB19BWM25P	Rewan	Lead (Total)	19	0.001	0.001	0.001	0.001	0.012
MB19BWM25P	Rewan	Manganese (Diss)	19	0.032	0.0512	0.132	0.2582	0.357
MB19BWM25P	Rewan	Manganese (Total)	19	0.042	0.0792	0.16	0.267	0.394
MB19BWM25P	Rewan	Nickel (Diss)	19	0.001	0.001	0.001	0.002	0.012
MB19BWM25P	Rewan	Nickel (Total)	19	0.002	0.002	0.003	0.0052	0.019
MB19BWM25P	Rewan	Nitrate as N	4	0.01	0.01	0.03	0.05	0.05
MB19BWM25P	Rewan	Zinc (Diss)	19	0.005	0.005	0.006	0.008	0.11
MB19BWM25P	Rewan	Zinc (Total)	19	0.005	0.006	0.008	0.0182	0.477
MB11	Tertiary	EC (Field)	5	745	5245	6680	6880	7280
MB11	Tertiary	pH (Field)	5	4.82	4.844	5.18	5.462	5.51
MB11	Tertiary	Aluminium (Diss)	6	0.00047	0.00237	0.01975	0.0472	0.0744
MB11	Tertiary	Antimony (Diss)	6	0.001	0.001	0.001	0.001	0.001
MB11	Tertiary	Arsenic (Diss)	6	0.001	0.001	0.0115	0.021	0.023
MB11	Tertiary	Bicarbonate Alkalinity as CaCO3	6	1	1	1	22	29
MB11	Tertiary	Calcium (Diss)	6	113	113	122	125	132
MB11	Tertiary	Carbonate Alkalinity as CaCO3	6	1	1	1	1	1
MB11	Tertiary	Chloride	6	1510	1570	1630	1670	1880
MB11	Tertiary	Electrical Conductivity (Lab)	6	6290	6300	6385	6680	6790
MB11	Tertiary	Hydroxide Alkalinity as CaCO3	6	1	1	1	1	1
MB11	Tertiary	Iron (Diss)	6	0.247	0.369	0.3895	0.562	0.59
MB11	Tertiary	Magnesium (Diss)	6	289	294	311	335	339
MB11	Tertiary	Molybdenum (Diss)	6	0.001	0.001	0.001	0.002	0.002
MB11	Tertiary	pH (Lab)	6	3.21	3.34	4.665	5	5.08
MB11	Tertiary	Potassium (Diss)	6	10	10	12	17	18
MB11	Tertiary	Selenium (Diss)	6	0.01	0.01	0.01	0.01	0.02
MB11	Tertiary	Sodium (Diss)	6	709	794	800.5	857	888
MB11	Tertiary	Sulphate as SO4 2-	6	1080	1090	1315	1380	1390

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB11	Tertiary	Total Alkalinity as CaCO3	6	1	1	1.5	22	29
MB11	Tertiary	Total Dissolved Solids (Lab)	6	4340	4670	4905	5140	5190
MB11	Tertiary	Mercury (Diss)	6	0.0001	0.0001	0.0001	0.0001	0.0001
MB11	Tertiary	Lead (Diss)	6	0.001	0.001	0.015	0.05	0.05
MB11	Tertiary	Manganese (Diss)	6	0.00669	0.00696	0.008835	0.00971	0.0102
MB11	Tertiary	Nickel (Diss)	6	0.176	0.178	0.254	0.288	0.314
MB11	Tertiary	Zinc (Diss)	6	0.382	0.392	0.6245	0.805	1.99
MB12	Tertiary	EC (Field)	31	1728	4450	9250	14630	16670
MB12	Tertiary	pH (Field)	31	5.4	6.03	6.28	6.45	6.69
MB12	Tertiary	Aluminium (Diss)	47	0.00548	0.01	0.01	0.04	30.3
MB12	Tertiary	Aluminium (Total)	19	0.001	2.944	9.01	13.02	33.3
MB12	Tertiary	Antimony (Diss)	47	0.001	0.001	0.001	0.001	0.001
MB12	Tertiary	Antimony (Total)	19	0.001	0.001	0.001	0.001	0.001
MB12	Tertiary	Arsenic (Diss)	47	0.001	0.001	0.001	0.0028	0.034
MB12	Tertiary	Arsenic (Total)	19	0.001	0.001	0.003	0.004	0.008
MB12	Tertiary	Bicarbonate Alkalinity as CaCO3	47	1	96	165	203.6	244
MB12	Tertiary	Calcium (Diss)	47	14	71.2	159	308	323
MB12	Tertiary	Carbonate Alkalinity as CaCO3	47	1	1	1	1	151
MB12	Tertiary	Chloride	47	226	1260	2970	5158	5650
MB12	Tertiary	Electrical Conductivity (Lab)	47	962	4840	9380	14540	16200
MB12	Tertiary	Hydroxide Alkalinity as CaCO3	47	1	1	1	1	1
MB12	Tertiary	Iron (Diss)	46	0.0181	0.05	0.09	0.3	24.1
MB12	Tertiary	Iron (Total)	19	0.005	4.63	7.96	14.92	21.8
MB12	Tertiary	Magnesium (Diss)	47	20	127.6	297	677.6	708
MB12	Tertiary	Molybdenum (Diss)	47	0.001	0.001	0.001	0.001	0.001
MB12	Tertiary	Molybdenum (Total)	19	0.001	0.001	0.001	0.001	0.001
MB12	Tertiary	pH (Lab)	47	6.19	6.326	6.66	6.926	7.47
MB12	Tertiary	Potassium (Diss)	47	10	35.6	61	103.2	119
MB12	Tertiary	Selenium (Diss)	47	0.01	0.01	0.01	0.01	0.05
MB12	Tertiary	Selenium (Total)	19	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB12	Tertiary	Silver (Diss)	33	0.01	0.01	0.01	0.01	0.01
MB12	Tertiary	Silver (Total)	19	0.001	0.001	0.001	0.001	0.001
MB12	Tertiary	Sodium (Diss)	47	138	705.2	1430	2568	2870
MB12	Tertiary	Sulphate as SO4 2-	47	79	205.2	422	1796	3000
MB12	Tertiary	Total Alkalinity as CaCO3	47	47	111	165	203.6	244
MB12	Tertiary	Total Dissolved Solids (Lab)	47	562	3050	6510	11100	12800
MB12	Tertiary	Mercury (Diss)	43	0.0001	0.0001	0.0001	0.0001	0.0002
MB12	Tertiary	Mercury (Total)	18	0.0001	0.0001	0.0001	0.0001	0.0001
MB12	Tertiary	Lead (Diss)	10	0.001	0.0042	0.007	0.0138	0.073
MB12	Tertiary	Manganese (Diss)	10	0.00181	0.007582	0.010185	0.04532	3.35
MB12	Tertiary	Nickel (Diss)	10	0.048	0.0704	0.0855	0.1892	0.542
MB12	Tertiary	Zinc (Diss)	10	0.022	0.0514	0.073	0.1912	0.726
MB13	Tertiary	EC (Field)	27	623	2090.4	4790	5029	14000
MB13	Tertiary	pH (Field)	36	2.85	3.63	3.835	4.36	6.72
MB13	Tertiary	Aluminium (Diss)	36	0.01	3.2	5.095	6.78	34
MB13	Tertiary	Aluminium (Total)	36	0.08	6.44	7.35	15	40.9
MB13	Tertiary	Antimony (Diss)	28	0.001	0.001	0.001	0.001	0.001
MB13	Tertiary	Antimony (Total)	28	0.001	0.001	0.001	0.001	0.001
MB13	Tertiary	Arsenic (Diss)	36	0.001	0.001	0.001	0.001	0.002
MB13	Tertiary	Arsenic (Total)	36	0.001	0.001	0.002	0.004	0.048
MB13	Tertiary	Bicarbonate Alkalinity as CaCO3	36	1	1	1	1	591
MB13	Tertiary	Calcium (Diss)	36	34	49	54	68	284
MB13	Tertiary	Carbonate Alkalinity as CaCO3	36	1	1	1	1	1
MB13	Tertiary	Chloride	36	27	150	256	458	4260
MB13	Tertiary	Electrical Conductivity (Lab)	36	623	2870	4770	4990	14700
MB13	Tertiary	Hydroxide Alkalinity as CaCO3	36	1	1	1	1	1
MB13	Tertiary	Iron (Diss)	36	0.05	2.93	6.18	9.9	31.8
MB13	Tertiary	Iron (Total)	36	1.76	7.16	13.7	26.9	276
MB13	Tertiary	Magnesium (Diss)	36	18	84	146	169	660
MB13	Tertiary	Molybdenum (Diss)	36	0.001	0.001	0.001	0.001	0.001

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB13	Tertiary	Molybdenum (Total)	36	0.001	0.001	0.001	0.001	0.002
MB13	Tertiary	pH (Lab)	36	2.85	3.72	3.85	4.14	7.58
MB13	Tertiary	Potassium (Diss)	36	1	1	2	4	17
MB13	Tertiary	Selenium (Diss)	36	0.01	0.01	0.01	0.01	0.01
MB13	Tertiary	Selenium (Total)	36	0.01	0.01	0.01	0.01	0.01
MB13	Tertiary	Silver (Diss)	36	0.001	0.001	0.001	0.001	0.001
MB13	Tertiary	Silver (Total)	36	0.001	0.001	0.001	0.001	0.001
MB13	Tertiary	Sodium (Diss)	36	23	210	777	970	2280
MB13	Tertiary	Sulphate as SO4 2-	36	227	900	1930	2420	2600
MB13	Tertiary	Total Alkalinity as CaCO3	36	1	1	1	1	591
MB13	Tertiary	Total Dissolved Solids (Lab)	36	519	2200	3725	4170	10500
MB13	Tertiary	Mercury (Diss)	27	0.0001	1.00E-04	0.0001	0.0001	0.0005
MB13	Tertiary	Mercury (Total)	27	0.0001	1.00E-04	0.0001	0.0001	0.001
MB14	Tertiary	EC (Field)	5	303	359	466	563.4	601
MB14	Tertiary	pH (Field)	5	5.6	5.864	6.31	6.456	7
MB14	Tertiary	Aluminium (Diss)	6	0.24	0.28	0.725	0.86	1.11
MB14	Tertiary	Aluminium (Total)	5	0.0208	8.16416	21.2	48.14	93.5
MB14	Tertiary	Antimony (Diss)	6	0.001	0.001	0.001	0.001	0.001
MB14	Tertiary	Antimony (Total)	5	0.001	0.001	0.001	0.001	0.001
MB14	Tertiary	Arsenic (Diss)	6	0.001	0.001	0.001	0.001	0.002
MB14	Tertiary	Arsenic (Total)	5	0.003	0.0038	0.006	0.0078	0.011
MB14	Tertiary	Bicarbonate Alkalinity as CaCO3	6	98	121	141.5	159	192
MB14	Tertiary	Calcium (Diss)	6	1	1	1	2	7
MB14	Tertiary	Carbonate Alkalinity as CaCO3	6	1	1	1	1	1
MB14	Tertiary	Chloride	6	4	10	19.5	24	28
MB14	Tertiary	Electrical Conductivity (Lab)	6	299	309	380.5	441	652
MB14	Tertiary	Hydroxide Alkalinity as CaCO3	6	1	1	1	1	1
MB14	Tertiary	Iron (Diss)	6	0.35	0.37	0.485	0.71	0.72
MB14	Tertiary	Iron (Total)	5	14.6	23.88	31.7	56.52	141
MB14	Tertiary	Magnesium (Diss)	6	1	1	1	3	4

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB14	Tertiary	Molybdenum (Diss)	6	0.001	0.001	0.001	0.001	0.002
MB14	Tertiary	Molybdenum (Total)	5	0.001	0.001	0.001	0.0012	0.002
MB14	Tertiary	pH (Lab)	6	6.62	6.7	6.755	6.86	7.59
MB14	Tertiary	Potassium (Diss)	6	1	1	1.5	2	4
MB14	Tertiary	Selenium (Diss)	6	0.01	0.01	0.01	0.01	0.01
MB14	Tertiary	Selenium (Total)	5	0.001	0.001	0.001	0.001	0.001
MB14	Tertiary	Silver (Diss)	6	0.01	0.01	0.01	0.01	0.01
MB14	Tertiary	Silver (Total)	5	0.001	0.001	0.001	0.0014	0.003
MB14	Tertiary	Sodium (Diss)	6	66	70	76	80	105
MB14	Tertiary	Sulphate as SO4 2-	6	10	11	18	26	34
MB14	Tertiary	Total Alkalinity as CaCO3	6	98	121	141.5	159	192
MB14	Tertiary	Total Dissolved Solids (Lab)	6	248	631	873	1930	2480
MB14	Tertiary	Mercury (Diss)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB14	Tertiary	Mercury (Total)	5	0.0001	0.0001	0.0001	1.00E-04	0.0001
MB19	Tertiary	EC (Field)	1	5930	5930	5930	5930	5930
MB19	Tertiary	pH (Field)	1	4.68	4.68	4.68	4.68	4.68
MB19	Tertiary	Aluminium (Diss)	1	0.0263	0.0263	0.0263	0.0263	0.0263
MB19	Tertiary	Antimony (Diss)	1	0.001	0.001	0.001	0.001	0.001
MB19	Tertiary	Arsenic (Diss)	1	0.008	0.008	0.008	0.008	0.008
MB19	Tertiary	Bicarbonate Alkalinity as CaCO3	1	23	23	23	23	23
MB19	Tertiary	Calcium (Diss)	1	65	65	65	65	65
MB19	Tertiary	Carbonate Alkalinity as CaCO3	1	1	1	1	1	1
MB19	Tertiary	Chloride	1	1680	1680	1680	1680	1680
MB19	Tertiary	Electrical Conductivity (Lab)	1	5890	5890	5890	5890	5890
MB19	Tertiary	Hydroxide Alkalinity as CaCO3	1	1	1	1	1	1
MB19	Tertiary	Iron (Diss)	1	0.0315	0.0315	0.0315	0.0315	0.0315
MB19	Tertiary	Magnesium (Diss)	1	171	171	171	171	171
MB19	Tertiary	Molybdenum (Diss)	1	0.011	0.011	0.011	0.011	0.011
MB19	Tertiary	pH (Lab)	1	5.31	5.31	5.31	5.31	5.31
MB19	Tertiary	Potassium (Diss)	1	26	26	26	26	26

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB19	Tertiary	Selenium (Diss)	1	0.01	0.01	0.01	0.01	0.01
MB19	Tertiary	Sodium (Diss)	1	920	920	920	920	920
MB19	Tertiary	Sulphate as SO4 2-	1	304	304	304	304	304
MB19	Tertiary	Total Alkalinity as CaCO3	1	23	23	23	23	23
MB19	Tertiary	Total Dissolved Solids (Lab)	1	3700	3700	3700	3700	3700
MB19	Tertiary	Mercury (Diss)	1	0.0001	0.0001	0.0001	0.0001	0.0001
MB19	Tertiary	Lead (Diss)	1	0.027	0.027	0.027	0.027	0.027
MB19	Tertiary	Manganese (Diss)	1	0.00158	0.00158	0.00158	0.00158	0.00158
MB19	Tertiary	Nickel (Diss)	1	0.234	0.234	0.234	0.234	0.234
MB19	Tertiary	Zinc (Diss)	1	0.716	0.716	0.716	0.716	0.716
MB20	Tertiary	EC (Field)	12	5950	6102	6519	6920	7710
MB20	Tertiary	pH (Field)	12	4.86	5.078	5.15	5.308	5.6
MB20	Tertiary	Aluminium (Diss)	23	0.00021	0.010262	0.35	0.64	6.79
MB20	Tertiary	Aluminium (Total)	3	4.19	4.494	4.95	5.142	5.27
MB20	Tertiary	Antimony (Diss)	23	0.001	0.001	0.001	0.001	0.001
MB20	Tertiary	Antimony (Total)	3	0.001	0.001	0.001	0.001	0.001
MB20	Tertiary	Arsenic (Diss)	23	0.001	0.001	0.001	0.005	0.011
MB20	Tertiary	Arsenic (Total)	3	0.002	0.002	0.002	0.002	0.002
MB20	Tertiary	Bicarbonate Alkalinity as CaCO3	23	1	12.8	14	39	60
MB20	Tertiary	Calcium (Diss)	23	31	60.4	64	96	119
MB20	Tertiary	Carbonate Alkalinity as CaCO3	23	1	1	1	1	31
MB20	Tertiary	Chloride	23	1610	1766	1890	2264	2670
MB20	Tertiary	Electrical Conductivity (Lab)	23	5390	5764	6200	6958	7270
MB20	Tertiary	Hydroxide Alkalinity as CaCO3	23	1	1	1	1	1
MB20	Tertiary	Iron (Diss)	22	0.00022	0.03234	0.08	0.13	24.1
MB20	Tertiary	Iron (Total)	3	5.14	5.232	5.37	6.36	7.02
MB20	Tertiary	Magnesium (Diss)	23	165	174	176	204.8	218
MB20	Tertiary	Molybdenum (Diss)	23	0.001	0.001	0.001	0.005	0.016
MB20	Tertiary	Molybdenum (Total)	3	0.002	0.002	0.002	0.002	0.002
MB20	Tertiary	pH (Lab)	23	5.37	5.44	5.64	6.012	6.42

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB20	Tertiary	Potassium (Diss)	23	25	28	31	33.2	35
MB20	Tertiary	Selenium (Diss)	23	0.01	0.01	0.01	0.01	0.01
MB20	Tertiary	Selenium (Total)	3	0.001	0.001	0.001	0.001	0.001
MB20	Tertiary	Silver (Diss)	11	0.01	0.01	0.01	0.01	0.01
MB20	Tertiary	Silver (Total)	3	0.001	0.001	0.001	0.001	0.001
MB20	Tertiary	Sodium (Diss)	23	874	957.4	1040	1202	1370
MB20	Tertiary	Sulphate as SO4 2-	23	228	296	315	488.6	663
MB20	Tertiary	Total Alkalinity as CaCO3	23	8	12.8	15	40.2	60
MB20	Tertiary	Total Dissolved Solids (Lab)	22	3460	3600	4100	4838	5240
MB20	Tertiary	Mercury (Diss)	22	0.0001	1.00E-04	0.0001	0.0002	0.0002
MB20	Tertiary	Mercury (Total)	3	0.0002	0.00024	0.0003	0.0003	0.0003
MB20	Tertiary	Lead (Diss)	9	0.001	0.0112	0.018	0.021	0.047
MB20	Tertiary	Manganese (Diss)	9	0.775	0.9046	1.13	1.418	1.67
MB20	Tertiary	Nickel (Diss)	9	0.129	0.14	0.148	0.1788	0.233
MB20	Tertiary	Zinc (Diss)	9	0.491	0.5156	0.567	0.667	0.828
MB21	Tertiary	EC (Field)	40	4204	12258.2	14090	15131	18932
MB21	Tertiary	pH (Field)	48	6.05	6.36	6.535	7.108	8.12
MB21	Tertiary	Aluminium (Diss)	48	0.01	0.01	0.01	0.01	0.07
MB21	Tertiary	Aluminium (Total)	48	0.01	0.264	0.49	5.51	62.7
MB21	Tertiary	Antimony (Diss)	41	0.001	0.001	0.001	0.001	0.001
MB21	Tertiary	Antimony (Total)	41	0.001	0.001	0.001	0.001	0.001
MB21	Tertiary	Arsenic (Diss)	48	0.001	0.001	0.001	0.002	0.016
MB21	Tertiary	Arsenic (Total)	48	0.001	0.001	0.002	0.012	0.32
MB21	Tertiary	Bicarbonate Alkalinity as CaCO3	48	416	523.6	542	574.4	642
MB21	Tertiary	Calcium (Diss)	47	218	240.4	261	511.4	577
MB21	Tertiary	Carbonate Alkalinity as CaCO3	48	1	1	1	1	35
MB21	Tertiary	Chloride	48	2850	3654	4270	4824	5430
MB21	Tertiary	Electrical Conductivity (Lab)	49	10500	12860	13500	14800	16800
MB21	Tertiary	Hydroxide Alkalinity as CaCO3	48	1	1	1	1	1
MB21	Tertiary	Iron (Diss)	47	0.05	0.05	0.72	2.548	11.5

Bore ID	Formation	Parameter	Count	Minimum	20th Percentile	50th Percentile	80th Percentile	Maximum
MB21	Tertiary	Iron (Total)	48	0.48	1.684	4.055	17.7	305
MB21	Tertiary	Magnesium (Diss)	47	425	513.2	553	591.2	660
MB21	Tertiary	Molybdenum (Diss)	48	0.001	0.001	0.001	0.001	0.004
MB21	Tertiary	Molybdenum (Total)	48	0.001	0.001	0.001	0.002	0.007
MB21	Tertiary	pH (Lab)	48	6.58	7.092	7.39	7.758	8.4
MB21	Tertiary	Potassium (Diss)	47	12	14	16	27.6	30
MB21	Tertiary	Selenium (Diss)	48	0.01	0.01	0.01	0.01	0.01
MB21	Tertiary	Selenium (Total)	48	0.01	0.01	0.01	0.01	0.01
MB21	Tertiary	Silver (Diss)	48	0.001	0.001	0.001	0.001	0.001
MB21	Tertiary	Silver (Total)	48	0.001	0.001	0.001	0.001	0.002
MB21	Tertiary	Sodium (Diss)	47	1660	1824	2040	2270	2410
MB21	Tertiary	Sulphate as SO4 2-	48	352	519.8	1720	2014	2250
MB21	Tertiary	Total Alkalinity as CaCO3	48	416	523.6	542.5	574.4	642
MB21	Tertiary	Total Dissolved Solids (Lab)	47	7360	9052	9770	10280	11700
MB21	Tertiary	Mercury (Diss)	36	0.0001	0.0001	0.0001	0.0001	0.0001

Blackwater Groundwater Monitoring Statistics by Formation

Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
Burngrove	EC (Field)	68	5390	6551.2	11045	15821	19317
Burngrove	pH (Field)	75	6.31	6.712	7.21	7.772	8.35
Burngrove	Aluminium (Diss)	79	0.01	0.01	0.01	0.01	0.18
Burngrove	Aluminium (Total)	79	0.01	0.07	0.23	0.644	4.44
Burngrove	Antimony (Diss)	79	0.001	0.001	0.001	0.001	0.001
Burngrove	Antimony (Total)	79	0.001	0.001	0.001	0.001	0.002
Burngrove	Arsenic (Diss)	79	0.001	0.001	0.001	0.001	0.002
Burngrove	Arsenic (Total)	79	0.001	0.001	0.001	0.001	0.003
Burngrove	Bicarbonate Alkalinity as CaCO3	79	516	628.6	699	825.4	919
Burngrove	Calcium (Diss)	77	16	19	128	260.4	477
Burngrove	Carbonate Alkalinity as CaCO3	79	1	1	1	18.6	130
Burngrove	Chloride	79	1440	1730	3680	4902	7150
Burngrove	Electrical Conductivity (Lab)	79	6190	6512	11600	15680	21500
Burngrove	Hydroxide Alkalinity as CaCO3	79	1	1	1	1	1
Burngrove	Iron (Diss)	79	0.05	0.05	0.08	0.298	0.8
Burngrove	Iron (Total)	79	0.09	0.28	0.75	2.022	14
Burngrove	Magnesium (Diss)	77	6	7	246	402.6	506
Burngrove	Molybdenum (Diss)	79	0.001	0.001	0.001	0.001	0.007
Burngrove	Molybdenum (Total)	79	0.001	0.001	0.001	0.001	0.007
Burngrove	pH (Lab)	79	7.06	7.508	7.9	8.39	8.9
Burngrove	Potassium (Diss)	77	5	6	10	14	38
Burngrove	Selenium (Diss)	79	0.01	0.01	0.01	0.01	0.01
Burngrove	Selenium (Total)	79	0.01	0.01	0.01	0.01	0.01
Burngrove	Silver (Diss)	79	0.001	0.001	0.001	0.001	0.001
Burngrove	Silver (Total)	79	0.001	0.001	0.001	0.001	0.001
Burngrove	Sodium (Diss)	77	1230	1382	2240	2736	3870
Burngrove	Sulphate as SO4 2-	79	1	2	585	1202	1720
Burngrove	Total Alkalinity as CaCO3	79	516	655.2	704	825.4	919
Burngrove	Total Dissolved Solids (Lab)	78	3250	3704	7270	10460	14400
Burngrove	Mercury (Diss)	69	0.0001	0.0001	0.0001	0.0001	0.0005
Burngrove	Mercury (Total)	76	0.0001	0.0001	0.0001	0.0001	0.001
RCM Coal	EC (Field)	310	1203	11601	18034	21388	40000

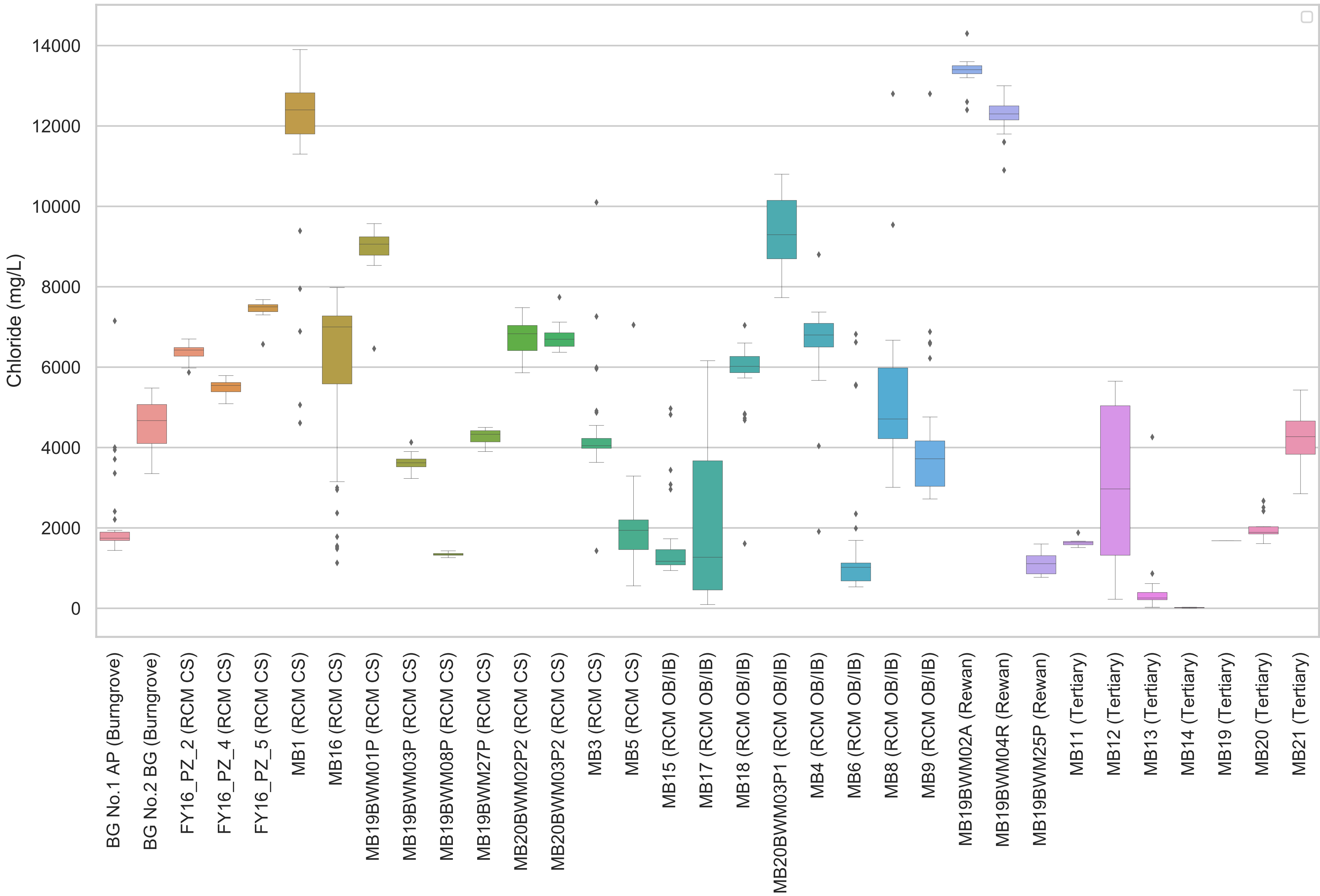
Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
RCM Coal	pH (Field)	367	6	6.672	7	7.63	10.2
RCM Coal	Aluminium (Diss)	374	0.01	0.01	0.01	0.01	0.56
RCM Coal	Aluminium (Total)	328	0.001	0.09	0.52	1.646	76.3
RCM Coal	Antimony (Diss)	224	0.001	0.001	0.001	0.001	0.005
RCM Coal	Antimony (Total)	223	0.001	0.001	0.001	0.001	0.01
RCM Coal	Arsenic (Diss)	374	0.001	0.001	0.001	0.005	0.066
RCM Coal	Arsenic (Total)	328	0.001	0.001	0.002	0.006	0.375
RCM Coal	Bicarbonate Alkalinity as CaCO3	327	1	237.8	450	792.8	1930
RCM Coal	Calcium (Diss)	323	1	93.8	184	592.6	962
RCM Coal	Carbonate Alkalinity as CaCO3	324	1	1	1	1	774
RCM Coal	Chloride	329	559	3696	6210	7768	13900
RCM Coal	Electrical Conductivity (Lab)	398	4010	11300	16400	21400	36900
RCM Coal	Hydroxide Alkalinity as CaCO3	324	1	1	1	1	203
RCM Coal	Iron (Diss)	345	0.05	0.07	0.88	2.682	18.3
RCM Coal	Iron (Total)	328	0.11	1.328	3.165	6.858	90.1
RCM Coal	Magnesium (Diss)	323	1	52	106	585.2	769
RCM Coal	Molybdenum (Diss)	374	0.001	0.001	0.003	0.009	0.113
RCM Coal	Molybdenum (Total)	328	0.001	0.001	0.004	0.0146	0.136
RCM Coal	pH (Lab)	391	6.49	7.22	7.72	8.05	11.98
RCM Coal	Potassium (Diss)	323	3	10	17	25	71
RCM Coal	Selenium (Diss)	374	0.01	0.01	0.01	0.01	0.05
RCM Coal	Selenium (Total)	328	0.001	0.01	0.01	0.01	0.05
RCM Coal	Silver (Diss)	374	0.001	0.001	0.001	0.001	0.01
RCM Coal	Silver (Total)	328	0.001	0.001	0.001	0.001	0.02
RCM Coal	Sodium (Diss)	323	651	2124	3160	4362	7800
RCM Coal	Sulphate as SO4 2-	371	1	1	4	74	980
RCM Coal	Total Alkalinity as CaCO3	324	74	250.6	481.5	798.4	1930
RCM Coal	Total Dissolved Solids (Lab)	316	2040	7170	10850	15500	28900
RCM Coal	Mercury (Diss)	211	0.0001	0.0001	0.0001	0.0001	0.001
RCM Coal	Mercury (Total)	220	0.0001	0.0001	0.0001	0.0001	0.0017
RCM Coal	Ammonia as N	84	1.22	1.858	3.405	4.83	6.2
RCM Coal	Barium (Diss)	84	0.154	1.722	9.5	20.6	39.6
RCM Coal	Barium (Total)	84	0.235	2.434	13.1	25.8	42.7
RCM Coal	Beryllium (Diss)	83	0.001	0.001	0.001	0.001	0.005
RCM Coal	Beryllium (Total)	83	0.001	0.001	0.001	0.001	0.005

Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
RCM Coal	Lead (Diss)	166	0.001	0.001	0.001	0.001	0.005
RCM Coal	Lead (Total)	166	0.001	0.002	0.005	0.014	0.376
RCM Coal	Manganese (Diss)	166	0.001	0.038	0.0965	0.177	1
RCM Coal	Manganese (Total)	166	0.003	0.048	0.1375	0.337	2.99
RCM Coal	Nickel (Diss)	166	0.001	0.003	0.005	0.01	0.055
RCM Coal	Nickel (Total)	166	0.002	0.005	0.012	0.023	0.093
RCM Coal	Nitrate as N	40	0.01	0.01	0.01	0.01	0.01
RCM Coal	Zinc (Diss)	166	0.005	0.025	0.1145	0.753	2.44
RCM Coal	Zinc (Total)	165	0.005	0.1388	0.388	1.112	3.31
RCM Over/Interburden	EC (Field)	270	1283	4529	12884	18392	34872
RCM Over/Interburden	pH (Field)	321	4.45	6.49	6.85	7.34	8.86
RCM Over/Interburden	Aluminium (Diss)	324	0.01	0.01	0.01	0.034	0.69
RCM Over/Interburden	Aluminium (Total)	318	0.01	0.17	0.46	1.72	466
RCM Over/Interburden	Antimony (Diss)	276	0.001	0.001	0.001	0.001	0.004
RCM Over/Interburden	Antimony (Total)	276	0.001	0.001	0.001	0.001	0.006
RCM Over/Interburden	Arsenic (Diss)	325	0.001	0.001	0.001	0.005	0.014
RCM Over/Interburden	Arsenic (Total)	318	0.001	0.001	0.002	0.007	0.083
RCM Over/Interburden	Bicarbonate Alkalinity as CaCO3	316	6	109	261	454	890
RCM Over/Interburden	Calcium (Diss)	311	13	72	351	555	887
RCM Over/Interburden	Carbonate Alkalinity as CaCO3	316	1	1	1	1	30
RCM Over/Interburden	Chloride	317	94	1110	4130	6416	12800
RCM Over/Interburden	Electrical Conductivity (Lab)	324	890	4156	12900	17900	29000
RCM Over/Interburden	Hydroxide Alkalinity as CaCO3	316	1	1	1	1	1
RCM Over/Interburden	Iron (Diss)	319	0.05	0.05	0.35	1.72	11.3
RCM Over/Interburden	Iron (Total)	318	0.05	0.784	2.21	5.58	871
RCM Over/Interburden	Magnesium (Diss)	311	10	53	120	334	838
RCM Over/Interburden	Molybdenum (Diss)	325	0.001	0.001	0.001	0.006	0.067
RCM Over/Interburden	Molybdenum (Total)	318	0.001	0.001	0.001	0.0076	0.078
RCM Over/Interburden	pH (Lab)	328	5.41	7.134	7.525	7.86	8.51
RCM Over/Interburden	Potassium (Diss)	311	1	7	11	22	51
RCM Over/Interburden	Selenium (Diss)	325	0.01	0.01	0.01	0.01	0.05
RCM Over/Interburden	Selenium (Total)	318	0.001	0.01	0.01	0.01	0.05
RCM Over/Interburden	Silver (Diss)	325	0.001	0.001	0.001	0.001	0.007
RCM Over/Interburden	Silver (Total)	318	0.001	0.001	0.001	0.001	0.01
RCM Over/Interburden	Sodium (Diss)	311	142	720	2200	2940	6700

Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
RCM Over/Interburden	Sulphate as SO4 2-	324	1	2	34.5	690.4	2010
RCM Over/Interburden	Total Alkalinity as CaCO3	315	6	108.4	264	454.4	890
RCM Over/Interburden	Total Dissolved Solids (Lab)	310	552	2264	8655	12400	23400
RCM Over/Interburden	Mercury (Diss)	247	0.0001	0.0001	0.0001	0.0001	0.0039
RCM Over/Interburden	Mercury (Total)	270	0.0001	0.0001	0.0001	0.0001	0.0045
RCM Over/Interburden	Ammonia as N	5	3.72	3.784	3.86	4.504	5
RCM Over/Interburden	Barium (Diss)	5	20.6	24.04	34.2	36.96	44
RCM Over/Interburden	Barium (Total)	5	24.2	24.84	31.9	39.4	41
RCM Over/Interburden	Beryllium (Diss)	4	0.001	0.001	0.001	0.001	0.001
RCM Over/Interburden	Beryllium (Total)	4	0.001	0.001	0.001	0.0026	0.005
RCM Over/Interburden	Lead (Diss)	18	0.001	0.001	0.005	0.005	0.005
RCM Over/Interburden	Lead (Total)	18	0.002	0.005	0.005	0.0096	0.027
RCM Over/Interburden	Manganese (Diss)	18	0.432	0.5478	0.613	0.677	1
RCM Over/Interburden	Manganese (Total)	18	0.532	0.6274	0.697	0.815	1.62
RCM Over/Interburden	Nickel (Diss)	18	0.003	0.005	0.007	0.0132	0.043
RCM Over/Interburden	Nickel (Total)	18	0.004	0.0054	0.0105	0.0268	0.054
RCM Over/Interburden	Nitrate as N	3	0.01	0.01	0.01	0.01	0.01
RCM Over/Interburden	Zinc (Diss)	18	0.033	0.086	0.1615	0.2704	0.306
RCM Over/Interburden	Zinc (Total)	18	0.137	0.193	0.2755	0.36	0.428
Rewan	EC (Field)	42	4253	4976	33864	34724	37915
Rewan	pH (Field)	69	5.93	6.51	6.98	7.364	8.07
Rewan	Aluminium (Diss)	74	0.01	0.01	0.05	0.05	0.06
Rewan	Aluminium (Total)	55	0.05	0.174	0.43	1.258	7.54
Rewan	Antimony (Diss)	35	0.001	0.001	0.005	0.005	0.005
Rewan	Antimony (Total)	35	0.001	0.001	0.005	0.005	0.005
Rewan	Arsenic (Diss)	74	0.003	0.005	0.006	0.012	0.019
Rewan	Arsenic (Total)	55	0.002	0.005	0.006	0.012	0.023
Rewan	Bicarbonate Alkalinity as CaCO3	55	100	110.8	435	663.4	845
Rewan	Calcium (Diss)	55	33	46.8	987	1490	1790
Rewan	Carbonate Alkalinity as CaCO3	53	1	1	1	1	33
Rewan	Chloride	55	771	1188	12200	13040	14300
Rewan	Electrical Conductivity (Lab)	90	3880	4700	32200	34628	38000
Rewan	Hydroxide Alkalinity as CaCO3	53	1	1	1	1	1
Rewan	Iron (Diss)	66	0.05	0.06	0.315	1.84	2.9
Rewan	Iron (Total)	55	0.09	0.394	1.23	3.856	16.9

Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
Rewan	Magnesium (Diss)	55	17	21	202	955.4	1150
Rewan	Molybdenum (Diss)	74	0.001	0.002	0.005	0.008	0.017
Rewan	Molybdenum (Total)	55	0.001	0.005	0.007	0.01	0.016
Rewan	pH (Lab)	69	6.21	7.114	7.36	7.868	8.47
Rewan	Potassium (Diss)	55	3	3	10	22.2	25
Rewan	Selenium (Diss)	74	0.01	0.01	0.05	0.05	0.05
Rewan	Selenium (Total)	55	0.01	0.01	0.05	0.05	0.05
Rewan	Silver (Diss)	74	0.001	0.001	0.005	0.005	0.005
Rewan	Silver (Total)	55	0.001	0.001	0.005	0.005	0.01
Rewan	Sodium (Diss)	55	860	1028	6360	6752	7560
Rewan	Sulphate as SO4 2-	74	1	2	76.5	230	527
Rewan	Total Alkalinity as CaCO3	53	100	111.4	435	655.6	845
Rewan	Total Dissolved Solids (Lab)	53	2520	3062	21500	24160	30800
Rewan	Mercury (Diss)	35	0.0001	0.0001	0.0001	0.0001	0.0001
Rewan	Mercury (Total)	35	0.0001	0.0001	0.0001	0.0001	0.0001
Rewan	Ammonia as N	35	0.03	0.07	0.22	5.148	5.37
Rewan	Barium (Diss)	35	0.141	0.2046	0.471	5.516	36
Rewan	Barium (Total)	35	0.142	0.2114	0.473	6.508	36.7
Rewan	Beryllium (Diss)	35	0.001	0.001	0.005	0.005	0.005
Rewan	Beryllium (Total)	35	0.001	0.001	0.005	0.005	0.005
Rewan	Lead (Diss)	55	0.001	0.001	0.005	0.005	0.005
Rewan	Lead (Total)	55	0.001	0.001	0.005	0.005	0.012
Rewan	Manganese (Diss)	55	0.032	0.0898	0.26	2.716	3.43
Rewan	Manganese (Total)	55	0.042	0.1006	0.27	2.79	3.29
Rewan	Nickel (Diss)	55	0.001	0.001	0.005	0.013	0.043
Rewan	Nickel (Total)	55	0.002	0.003	0.007	0.0182	0.139
Rewan	Nitrate as N	10	0.01	0.01	0.01	0.018	0.05
Rewan	Zinc (Diss)	55	0.005	0.006	0.102	0.178	2.45
Rewan	Zinc (Total)	55	0.005	0.0118	0.16	0.2618	1.76
Tertiary	EC (Field)	121	303	4538	7280	14400	18932
Tertiary	pH (Field)	138	2.85	4.21	6.18	6.576	8.12
Tertiary	Aluminium (Diss)	167	0.0002	0.01	0.02	2.956	34
Tertiary	Aluminium (Total)	111	0.001	0.41	5.34	11.9	93.5
Tertiary	Antimony (Diss)	152	0.001	0.001	0.001	0.001	0.001
Tertiary	Antimony (Total)	96	0.001	0.001	0.001	0.001	0.001
Tertiary	Arsenic (Diss)	167	0.001	0.001	0.001	0.002	0.034
Tertiary	Arsenic (Total)	111	0.001	0.001	0.002	0.006	0.32
Tertiary	Bicarbonate Alkalinity as CaCO3	167	1	1	144	528	642

Formation	Parameter	Count	Mini-mum	20th %ile	Median	80th %ile	Maxi-mum
Tertiary	Calcium (Diss)	166	1	54	120	286	577
Tertiary	Carbonate Alkalinity as CaCO3	167	1	1	1	1	151
Tertiary	Chloride	167	4	359.6	2000	4514	5650
Tertiary	Electrical Conductivity (Lab)	168	299	4770	6865	13820	16800
Tertiary	Hydroxide Alkalinity as CaCO3	167	1	1	1	1	1
Tertiary	Iron (Diss)	164	0.0002	0.05	0.3695	4.098	31.8
Tertiary	Iron (Total)	111	0.005	2.94	8.66	24.9	305
Tertiary	Magnesium (Diss)	166	1	143	218	573	708
Tertiary	Molybdenum (Diss)	167	0.001	0.001	0.001	0.001	0.016
Tertiary	Molybdenum (Total)	111	0.001	0.001	0.001	0.001	0.007
Tertiary	pH (Lab)	167	2.85	4.476	6.55	7.244	8.4
Tertiary	Potassium (Diss)	166	1	4	20.5	44	119
Tertiary	Selenium (Diss)	167	0.01	0.01	0.01	0.01	0.05
Tertiary	Selenium (Total)	111	0.001	0.001	0.01	0.01	0.01
Tertiary	Silver (Diss)	134	0.001	0.001	0.001	0.01	0.01
Tertiary	Silver (Total)	111	0.001	0.001	0.001	0.001	0.003
Tertiary	Sodium (Diss)	166	23	748	1065	2150	2870
Tertiary	Sulphate as SO4 2-	167	10	301.6	1090	2032	3000
Tertiary	Total Alkalinity as CaCO3	167	1	1.2	150	532.8	642
Tertiary	Total Dissolved Solids (Lab)	165	248	3452	4950	10000	12800
Tertiary	Mercury (Diss)	140	0.0001	0.0001	0.0001	0.0001	0.0005
Tertiary	Mercury (Total)	93	0.0001	0.0001	0.0001	0.0001	0.001
Tertiary	Lead (Diss)	26	0.001	0.001	0.015	0.021	0.073
Tertiary	Manganese (Diss)	26	0.0015	0.0083	0.0105	1.13	3.35
Tertiary	Nickel (Diss)	26	0.048	0.086	0.1735	0.233	0.542
Tertiary	Zinc (Diss)	26	0.022	0.073	0.513	0.667	1.99


Chloride (mg/L)
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12000
10000
8000
6000
4000
2000
0
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BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
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MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
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MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
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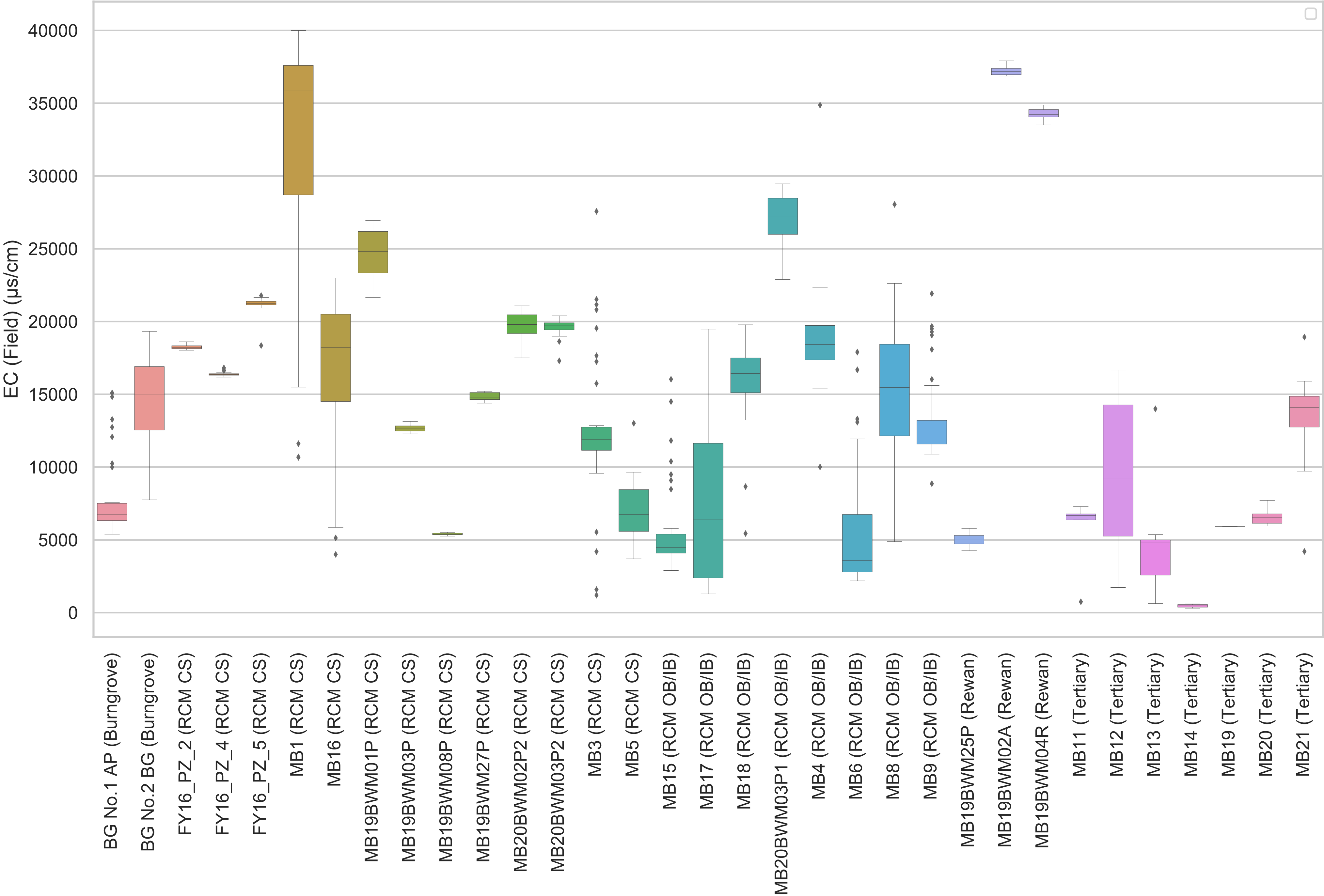
EC (Field) (μs/cm)
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30000
25000
20000
15000
10000
5000
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
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MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
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MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
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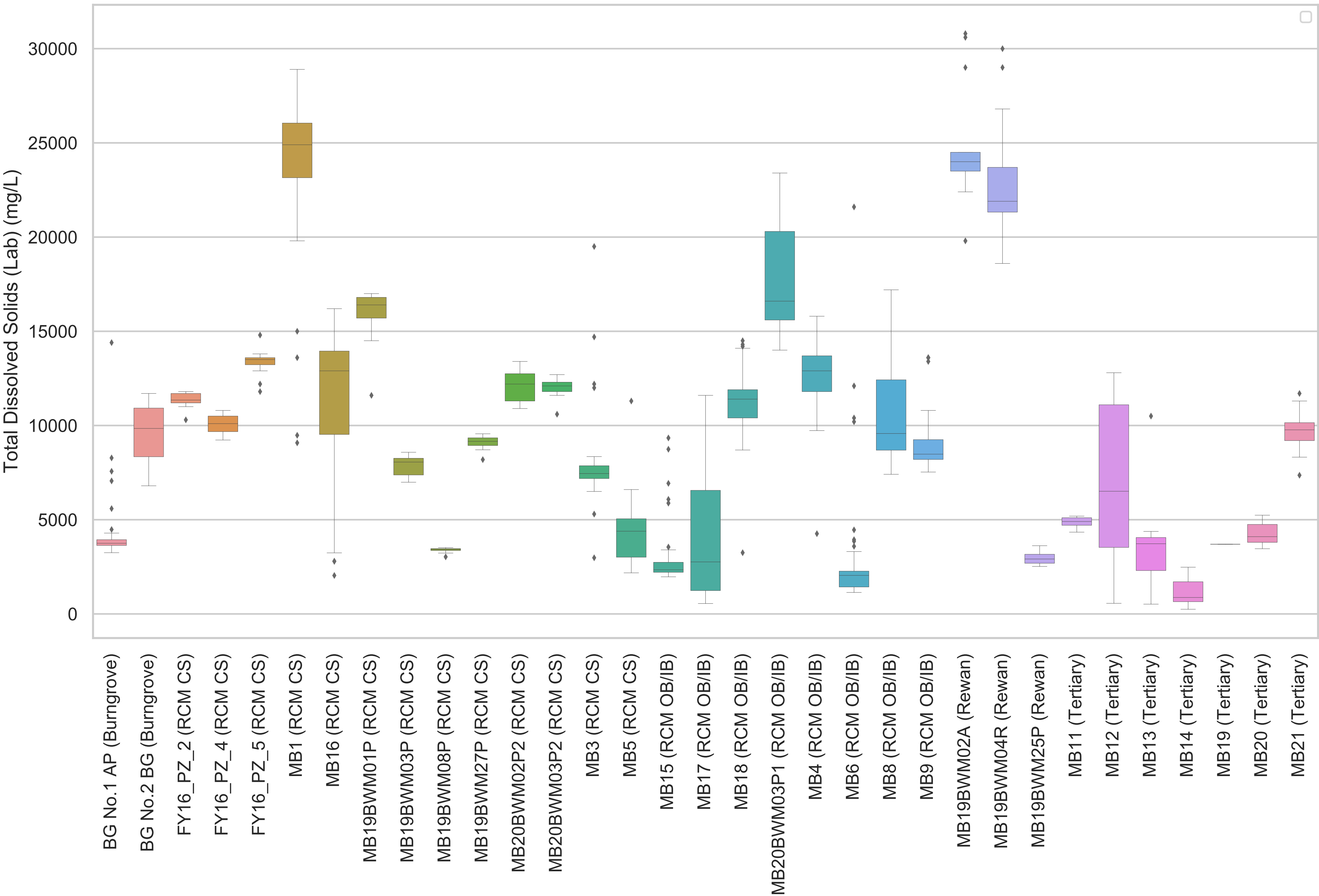
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25000
20000
15000
10000
5000
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
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MB8 (RCM OB/IB)
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MB19BWM25P (Rewan)
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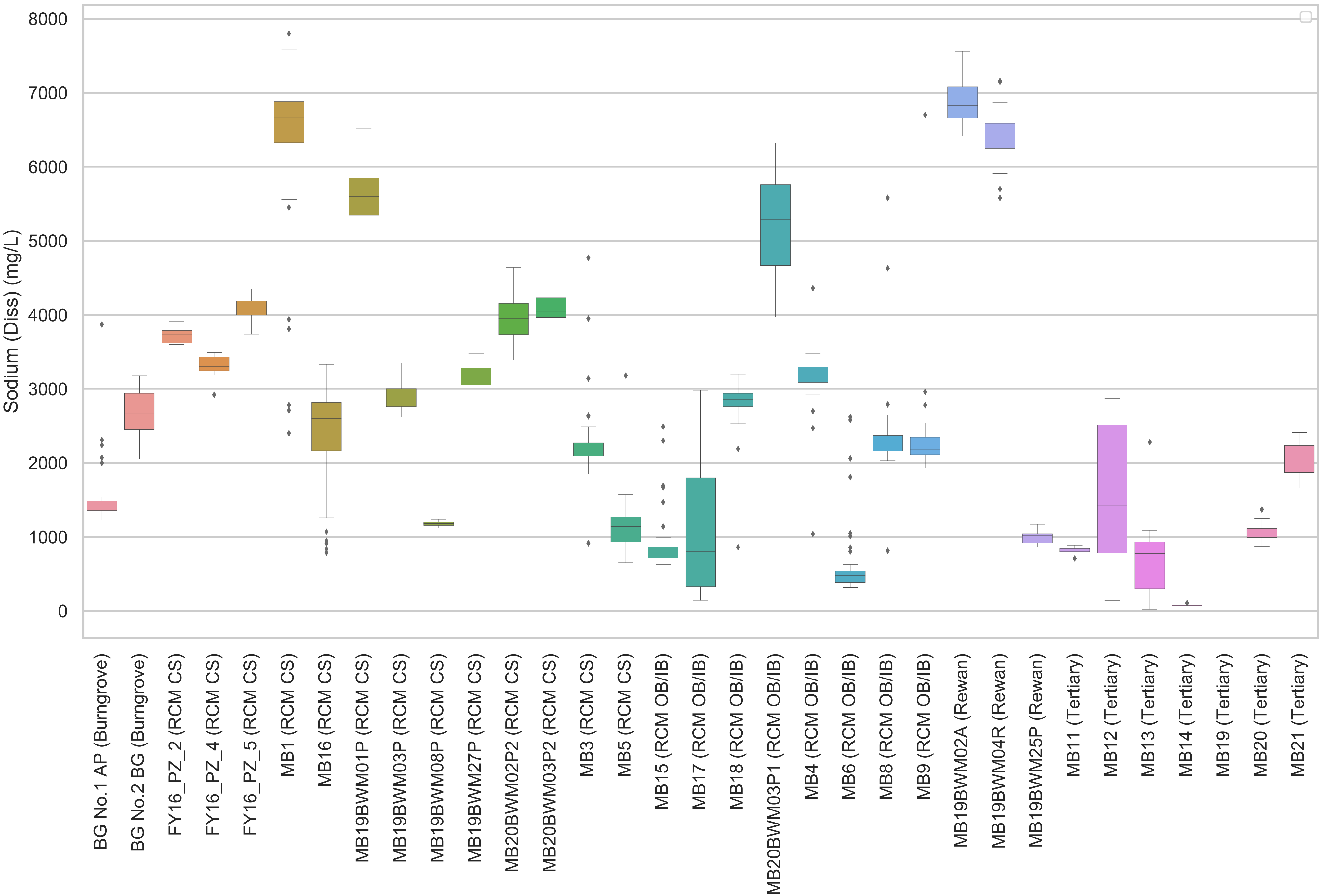
MB21 (Tertiary)


Sodium (Diss) (mg/L)
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1000
2000
3000
4000
5000
6000
7000
8000
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
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MB6 (RCM OB/IB)
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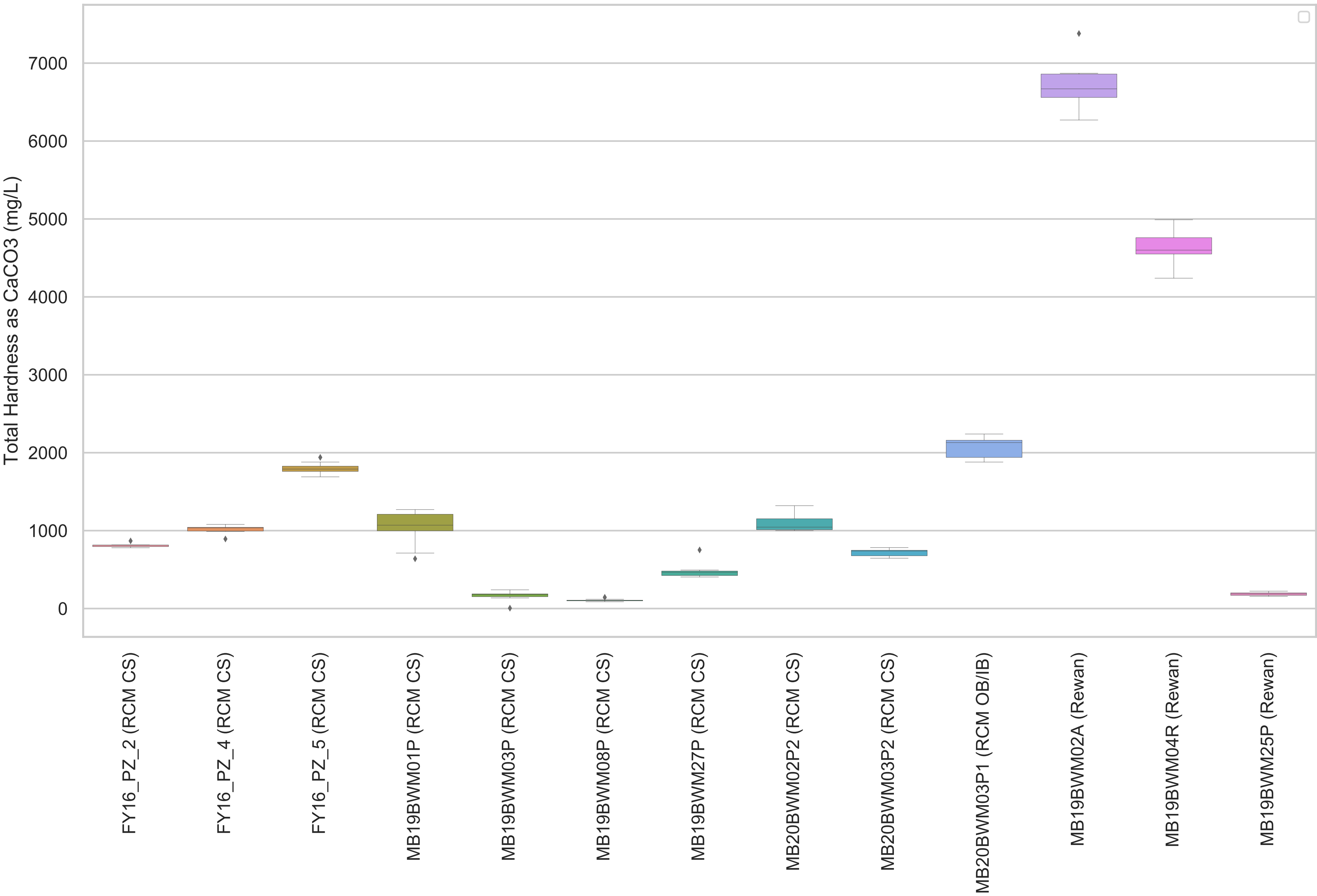
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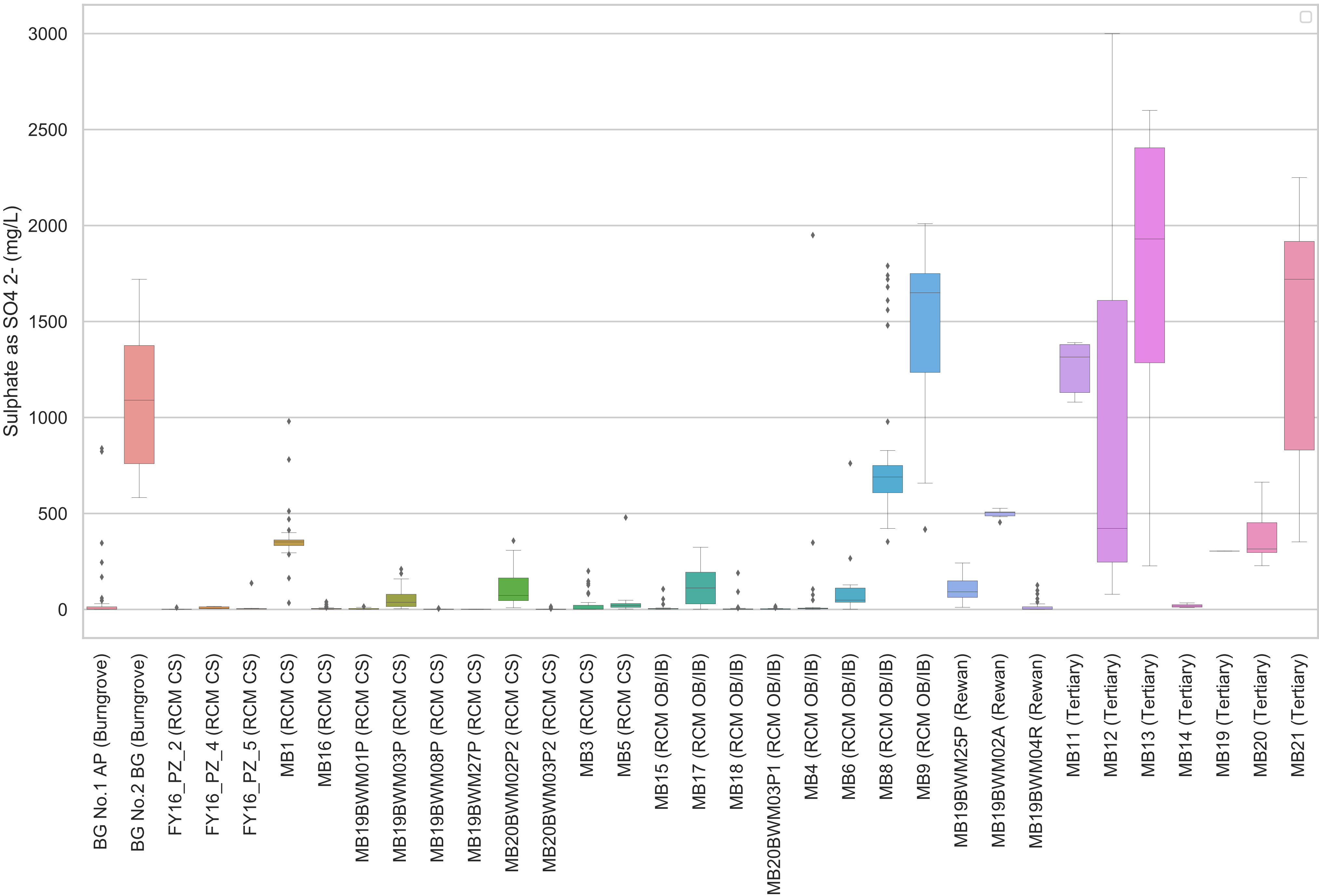
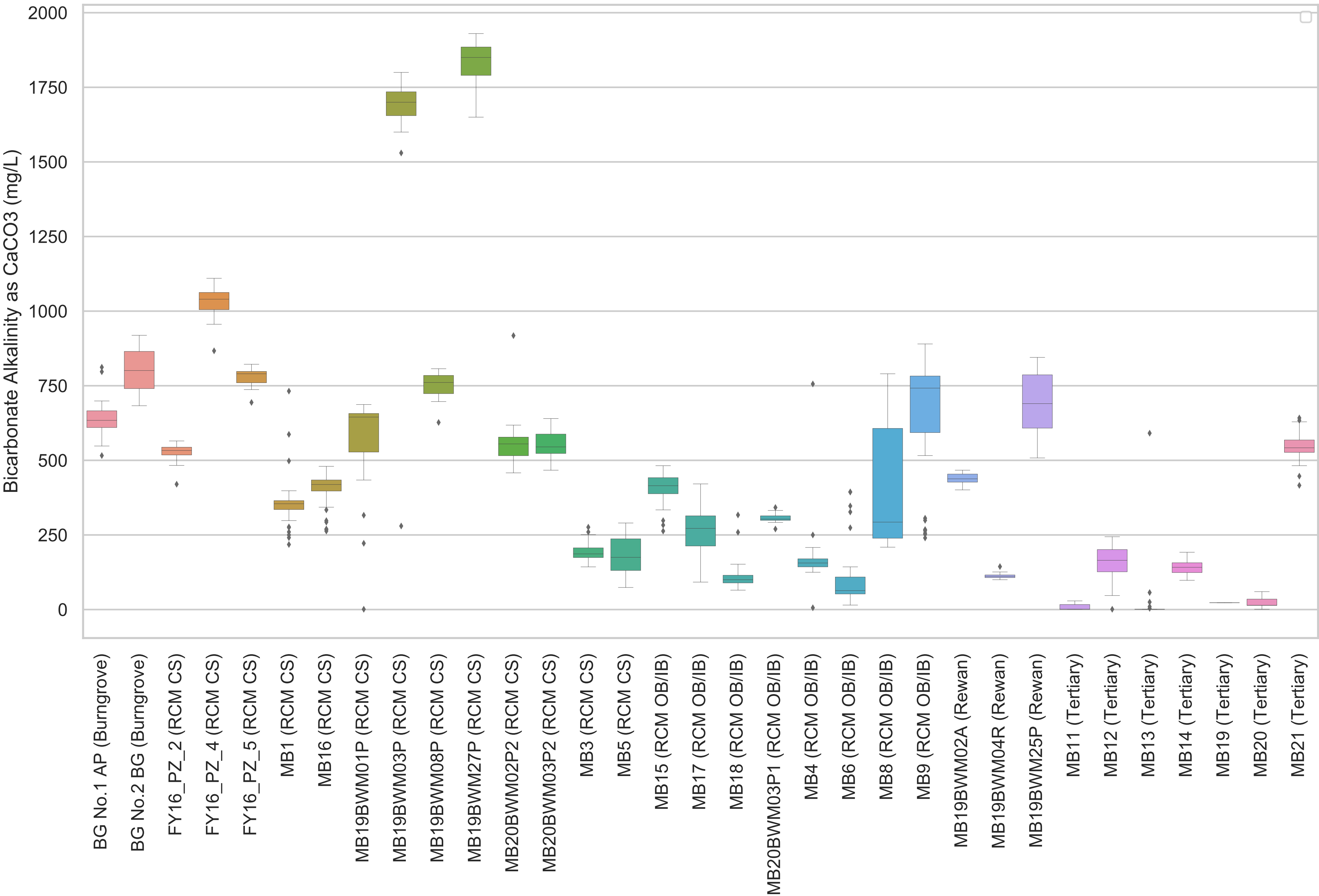
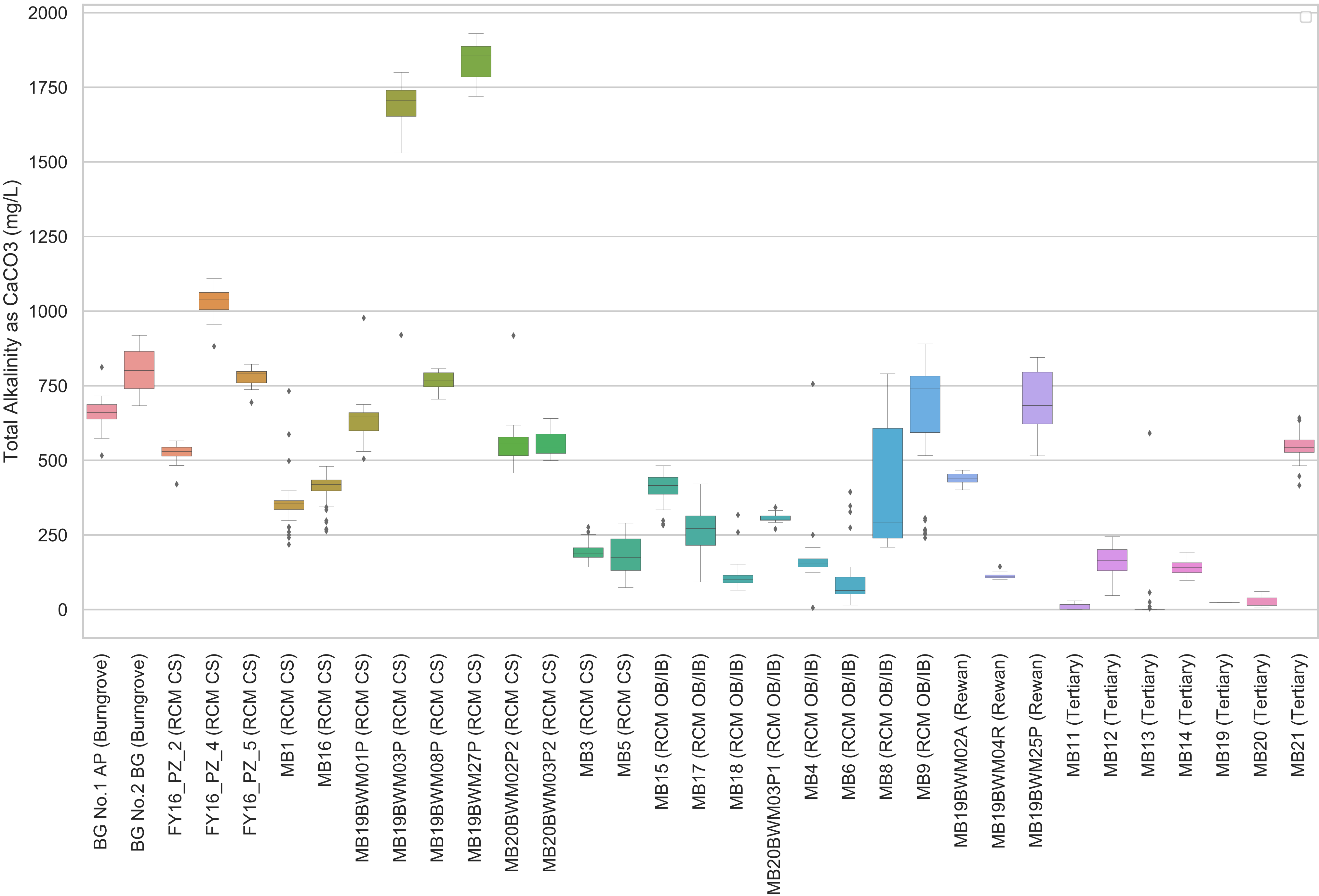
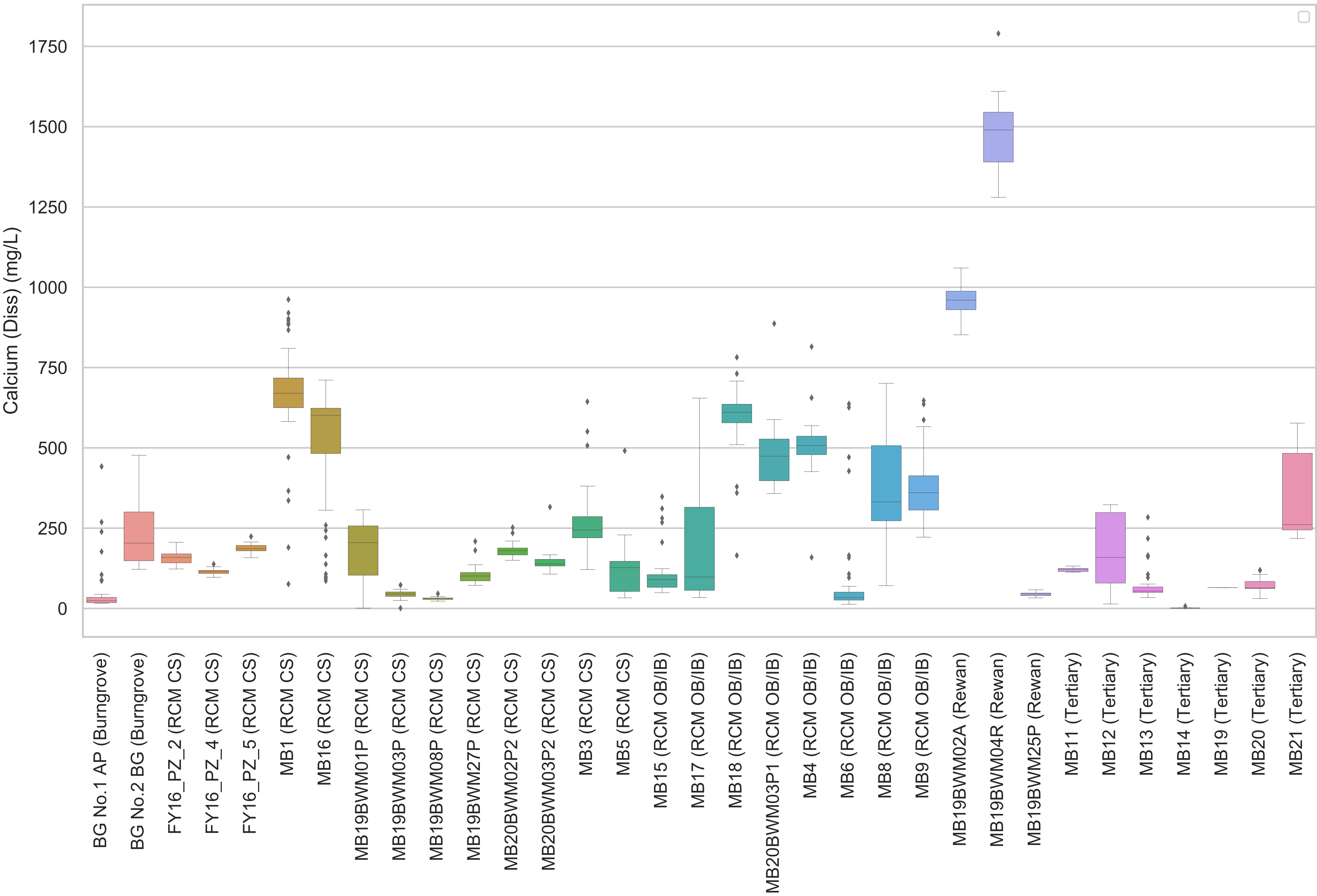
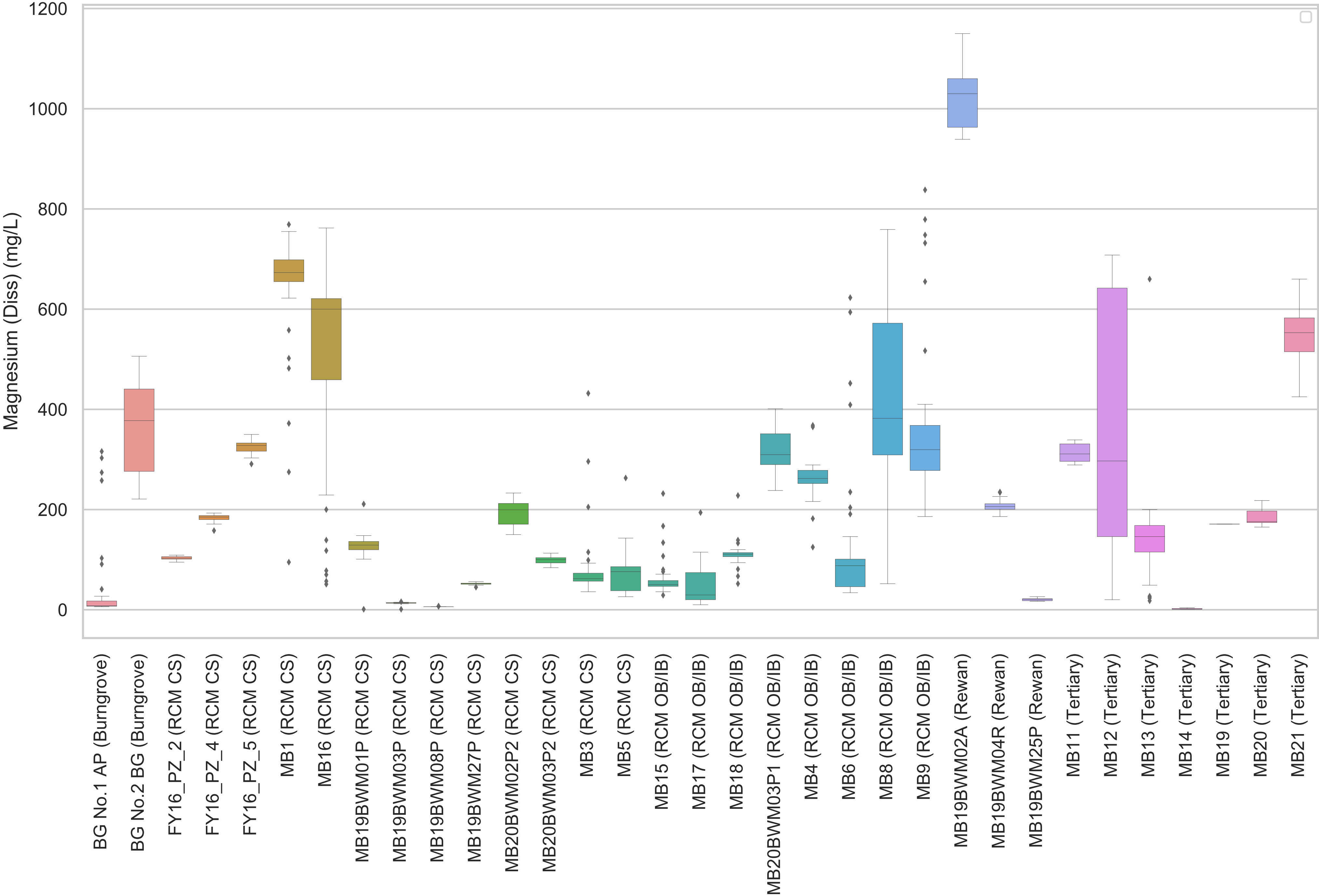
6000
5000
4000
3000
2000
1000
0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

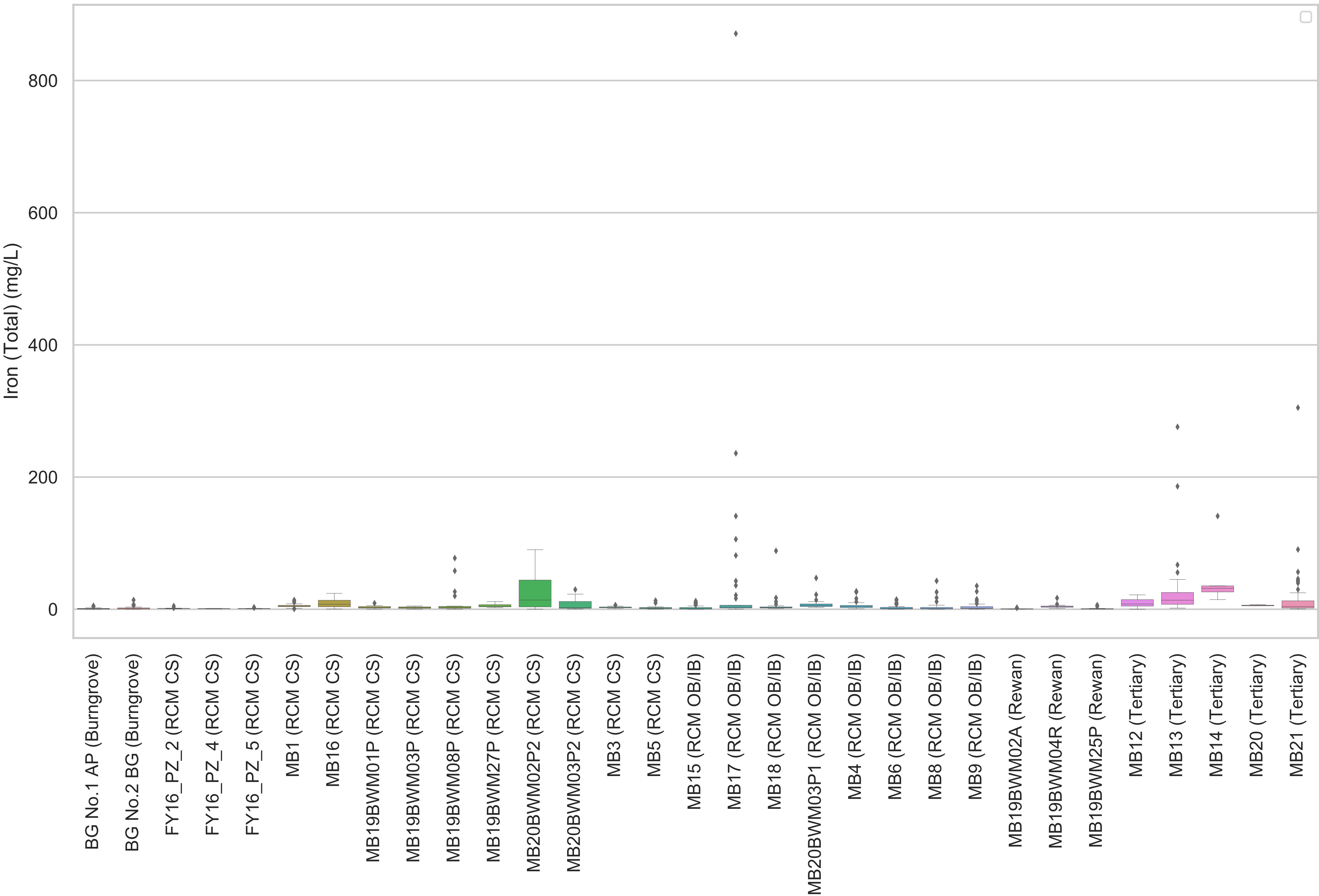

Sulphate as SO4 2- (mg/L)
3000
2500
2000
1500
1000
500
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

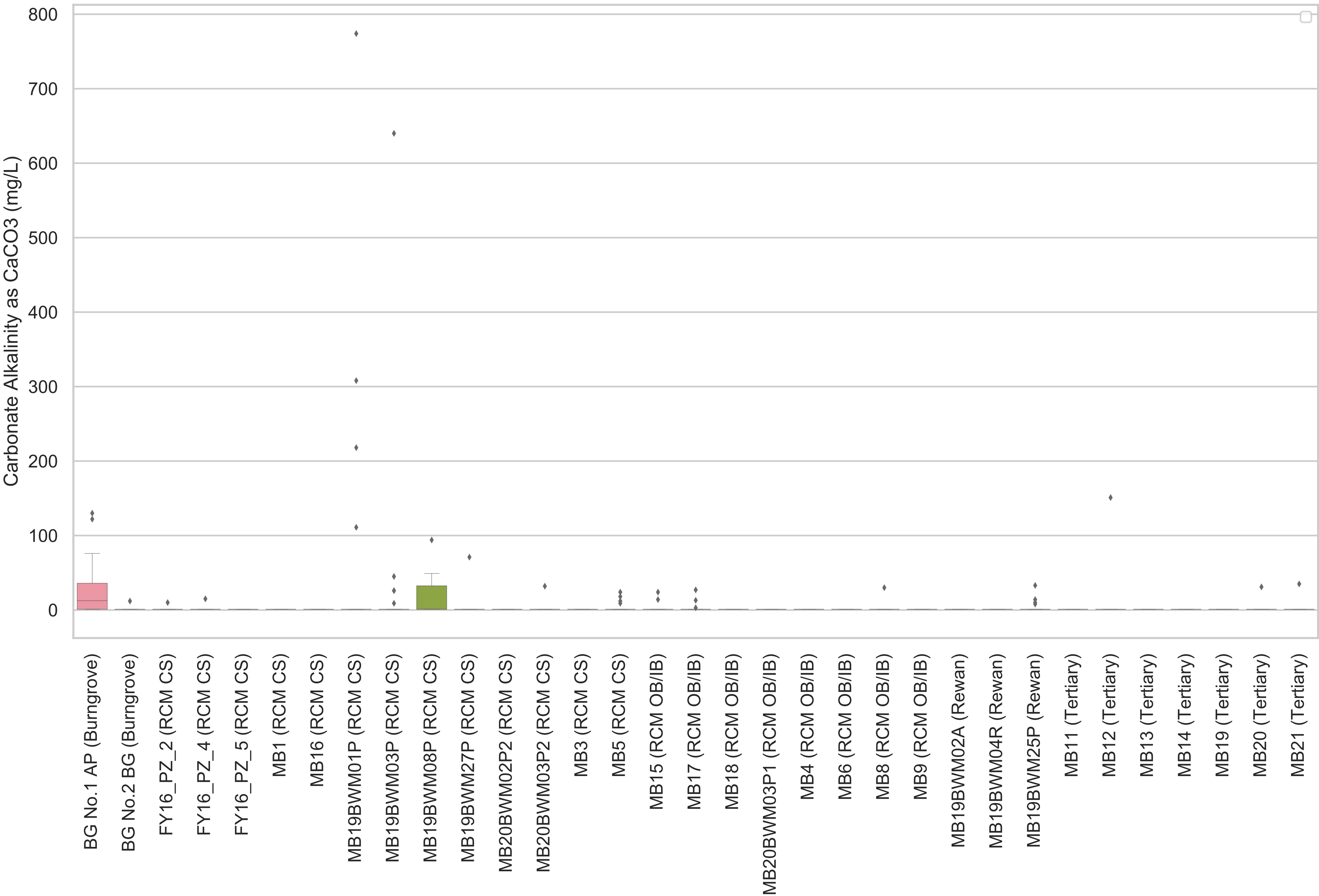

Bicarbonate Alkalinity as CaCO3 (mg/L)
2000
1750
1500
1250
1000
750
500
250
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)


Total Alkalinity as CaCO3 (mg/L)
2000
1750
1500
1250
1000
750
500
250
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

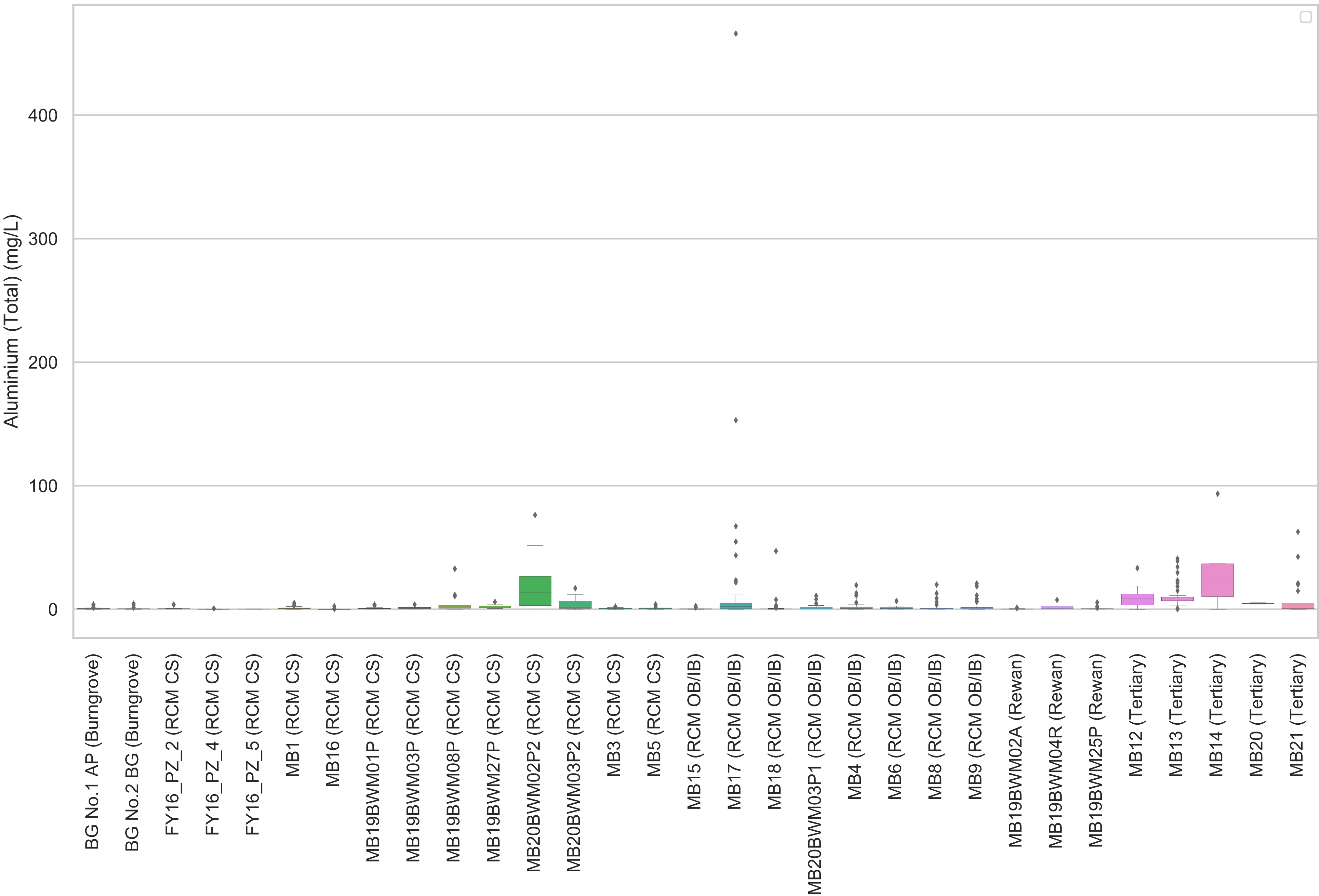

Calcium (Diss) (mg/L)
1750
1500
1250
1000
750
500
250
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

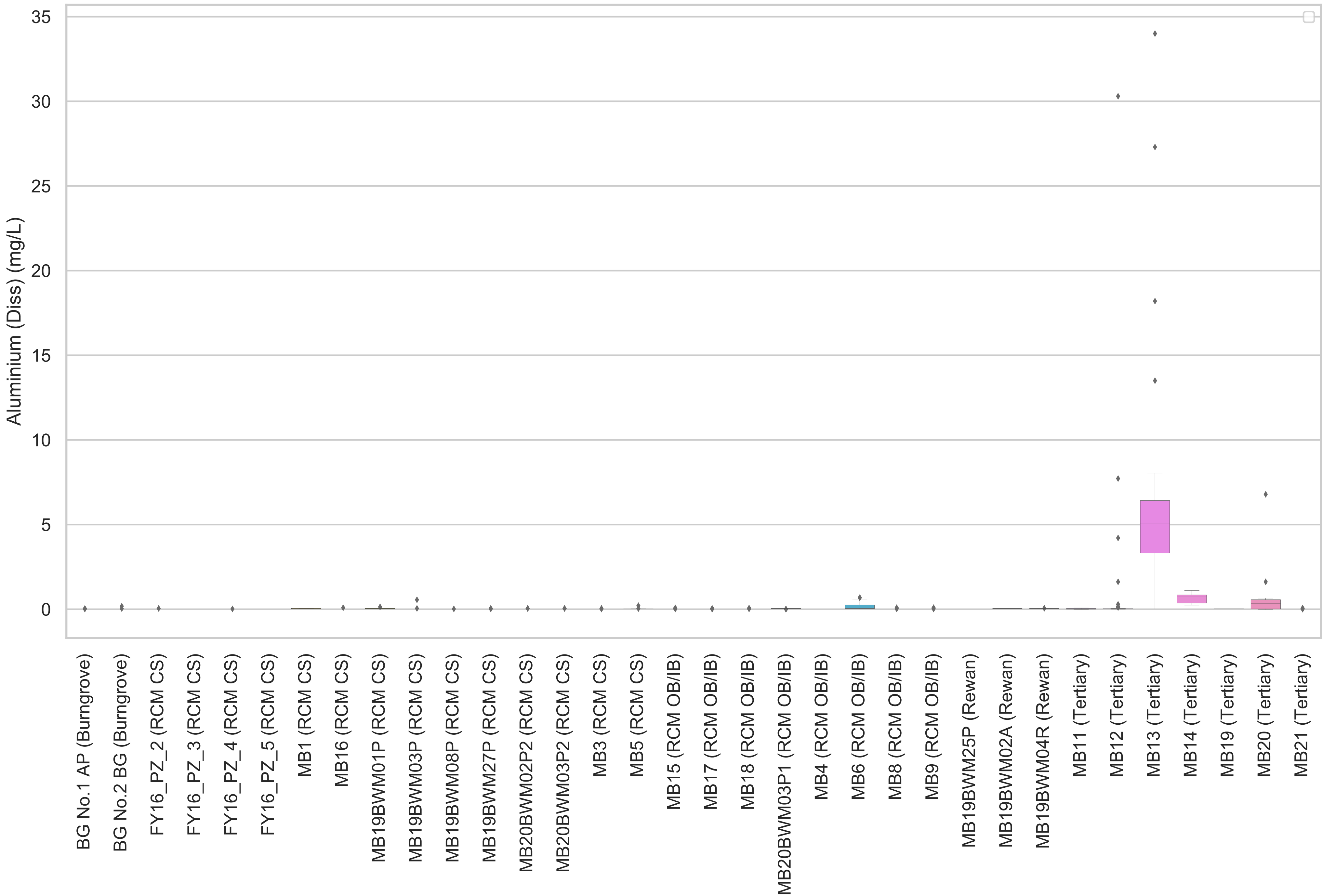

Magnesium (Diss) (mg/L)
1200
1000
800
600
400
200
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

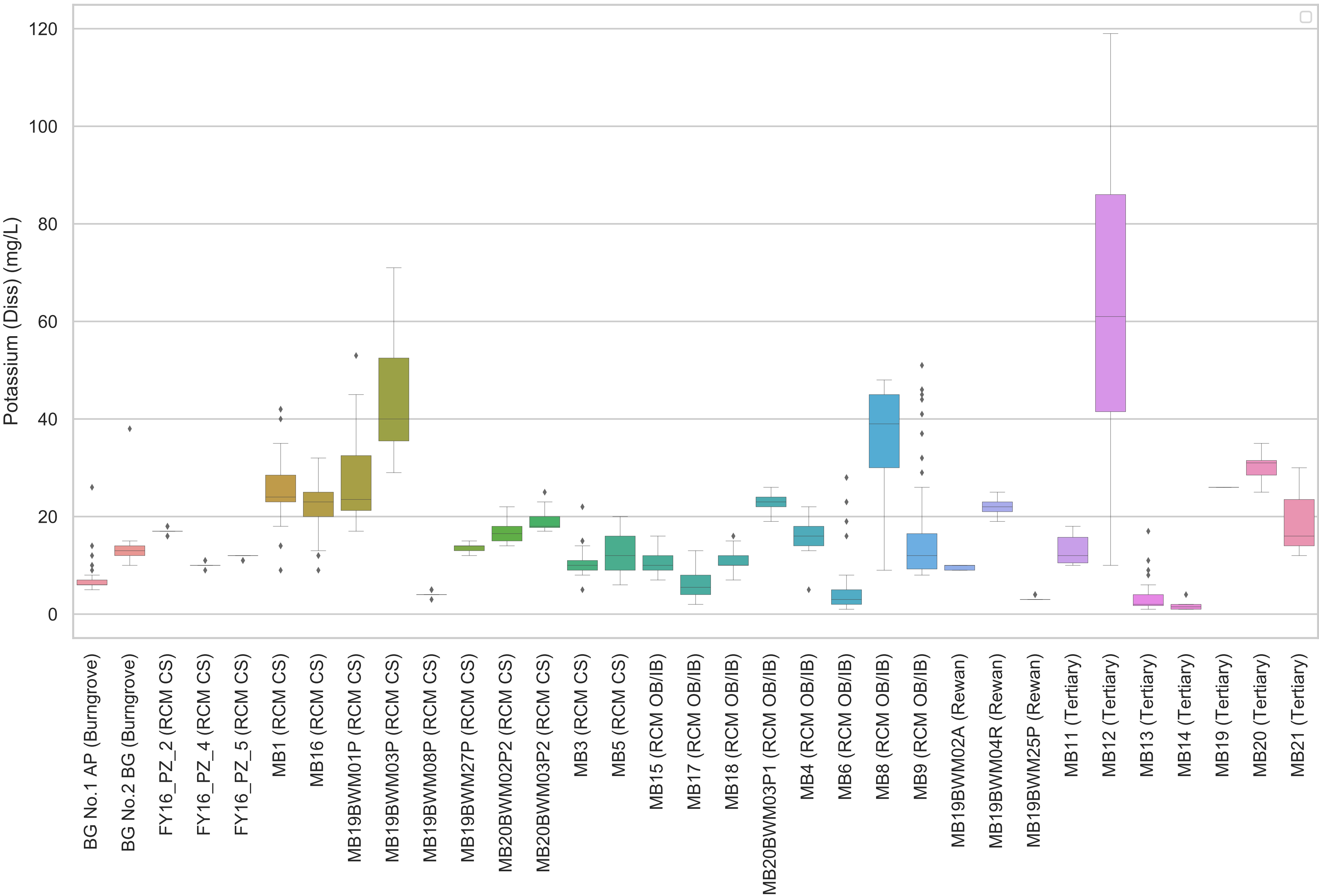

Iron (Total) (mg/L)
800
600
400
200
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

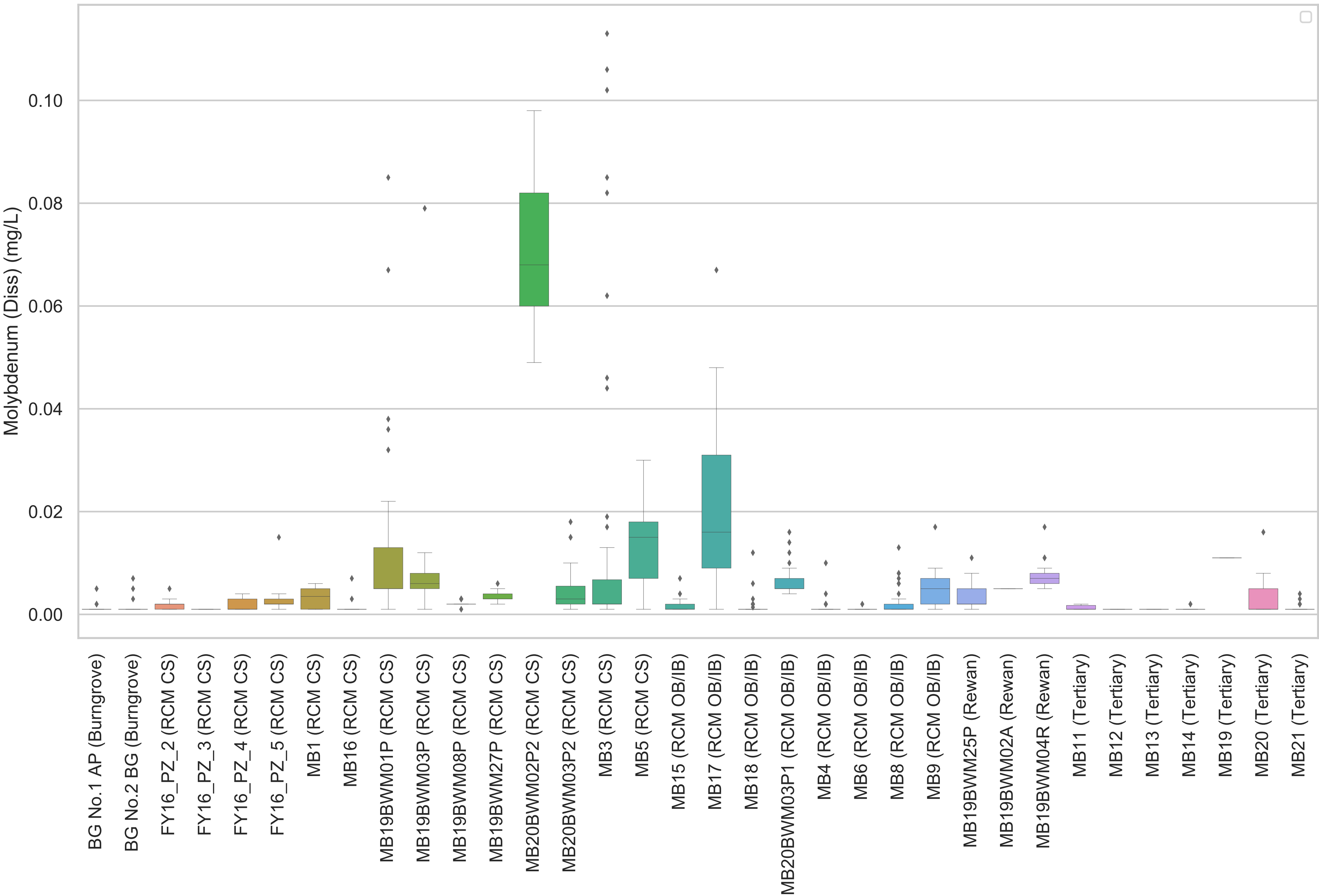


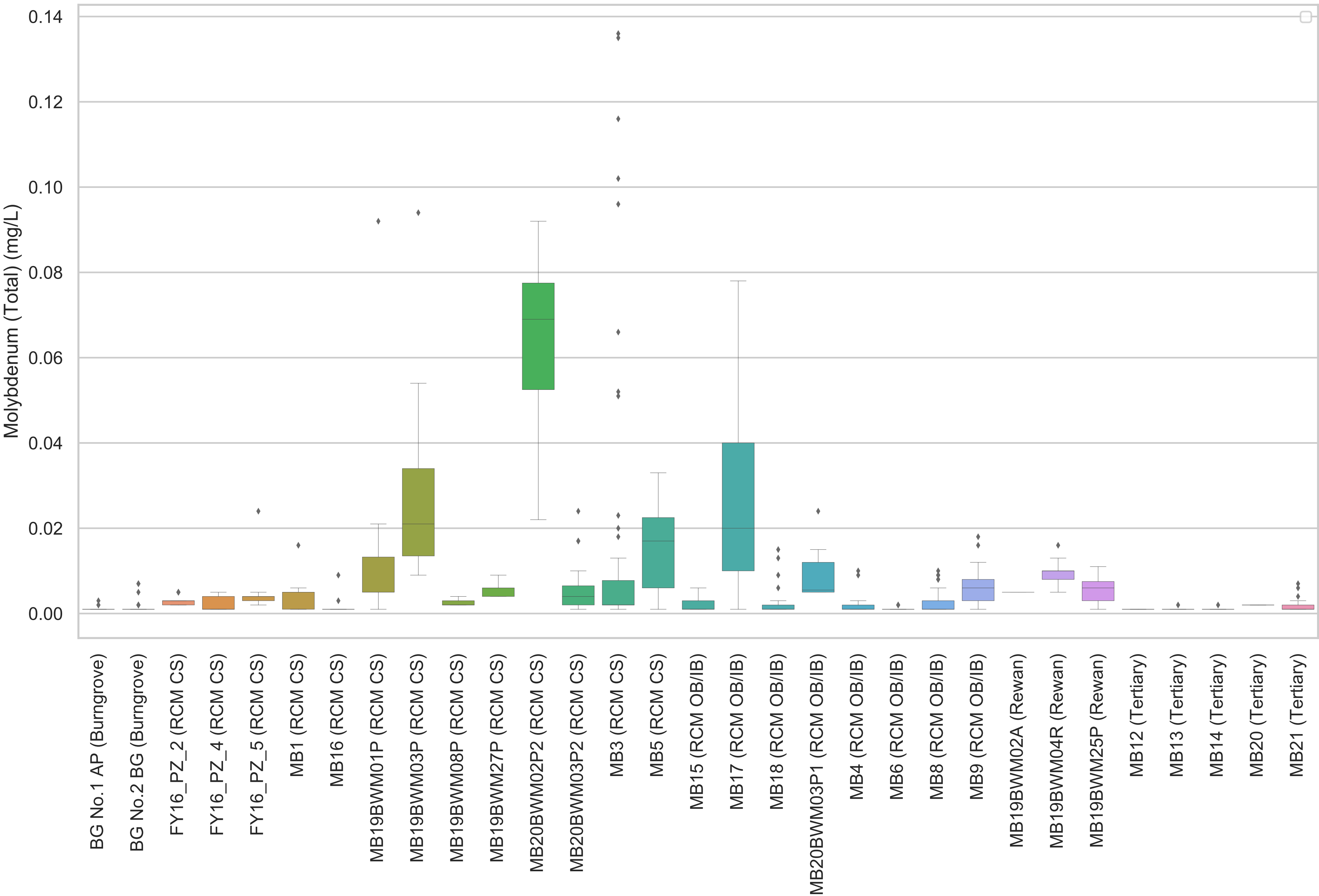
Carbonate Alkalinity as CaCO3 (mg/L)
800
700
600
500
400
300
200
100
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)


Aluminium (Total) (mg/L)
400
300
200
100
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

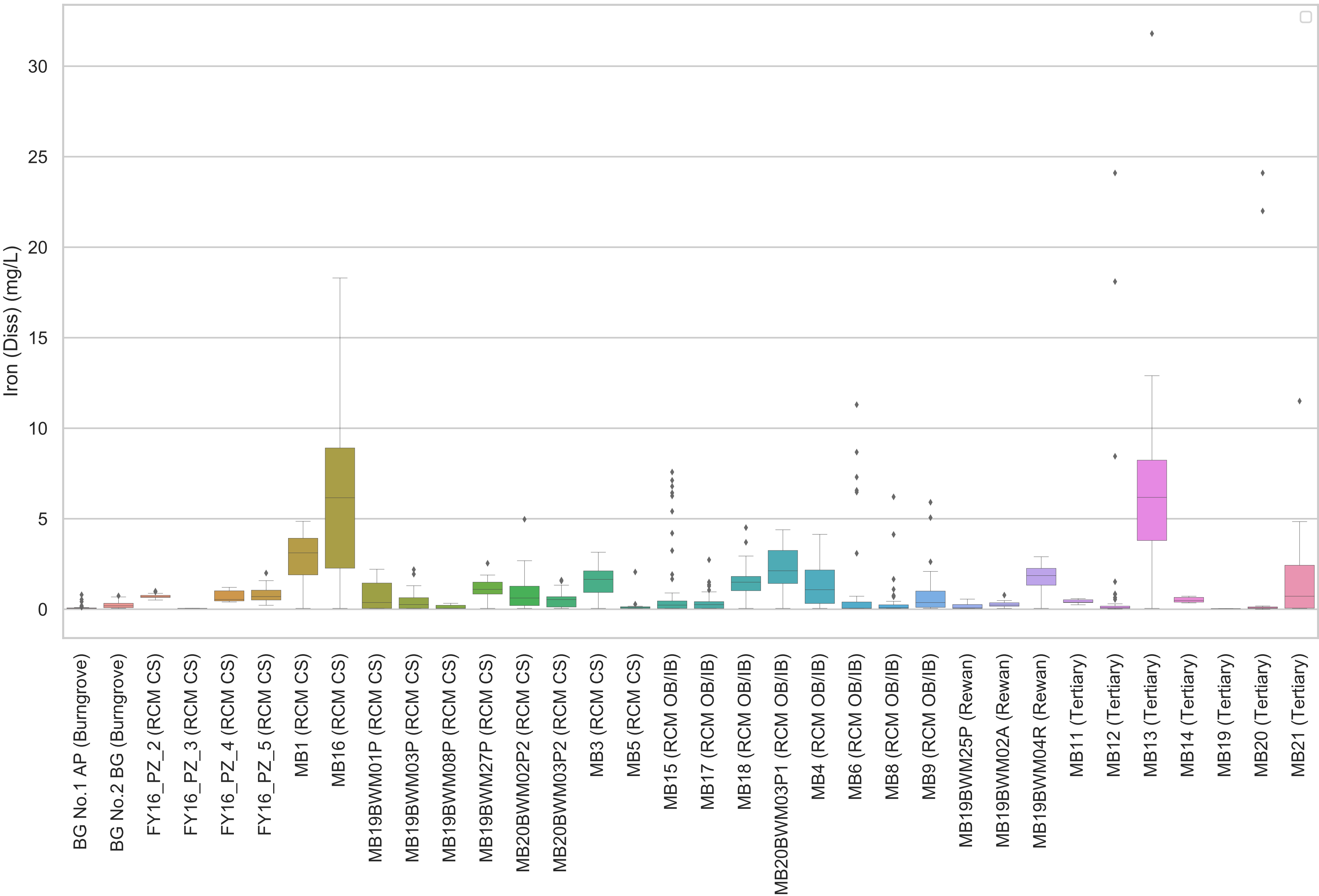

Aluminium (Diss) (mg/L)
0
5
10
15
20
25
30
35
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

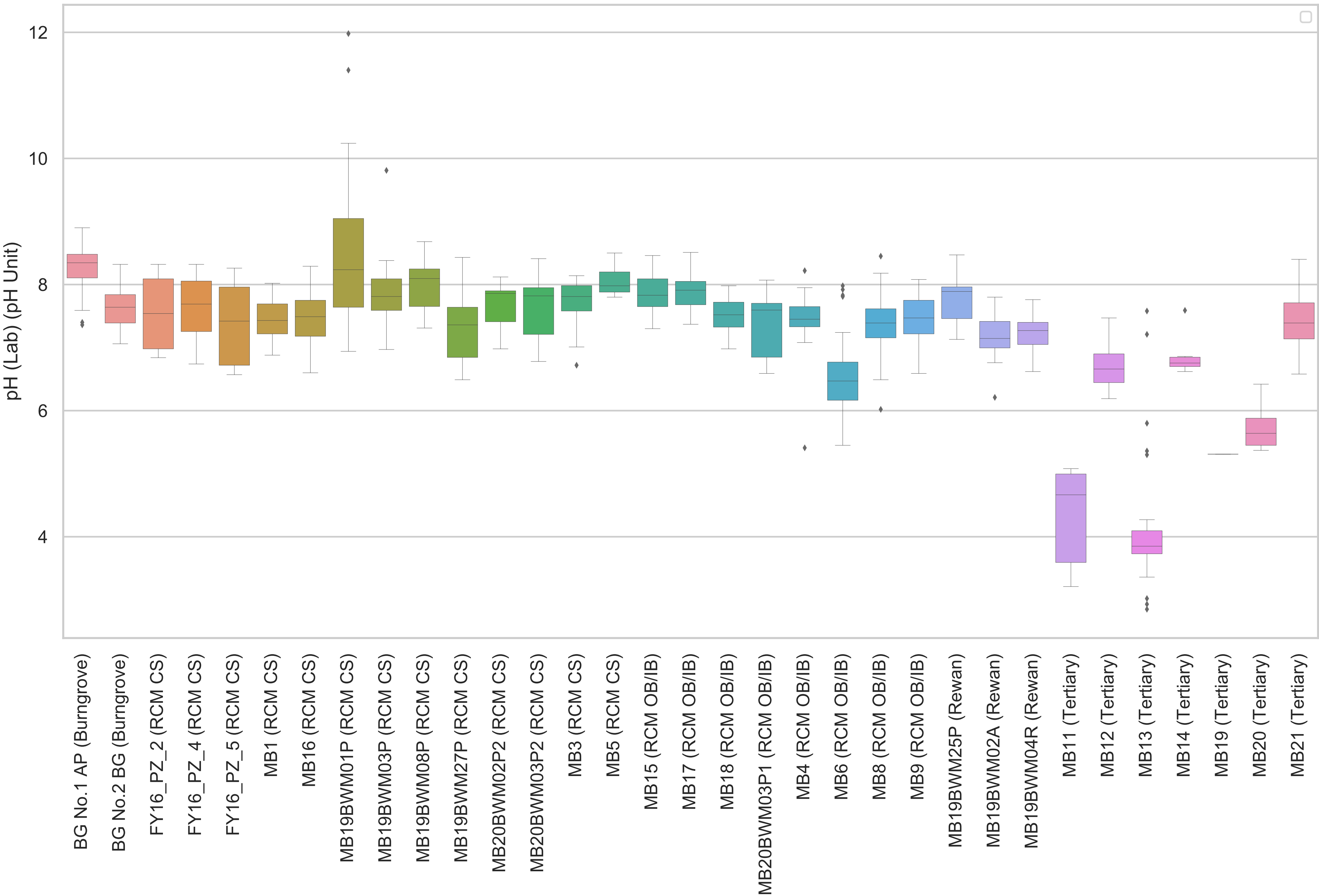

Potassium (Diss) (mg/L)
0
20
40
60
80
100
120
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

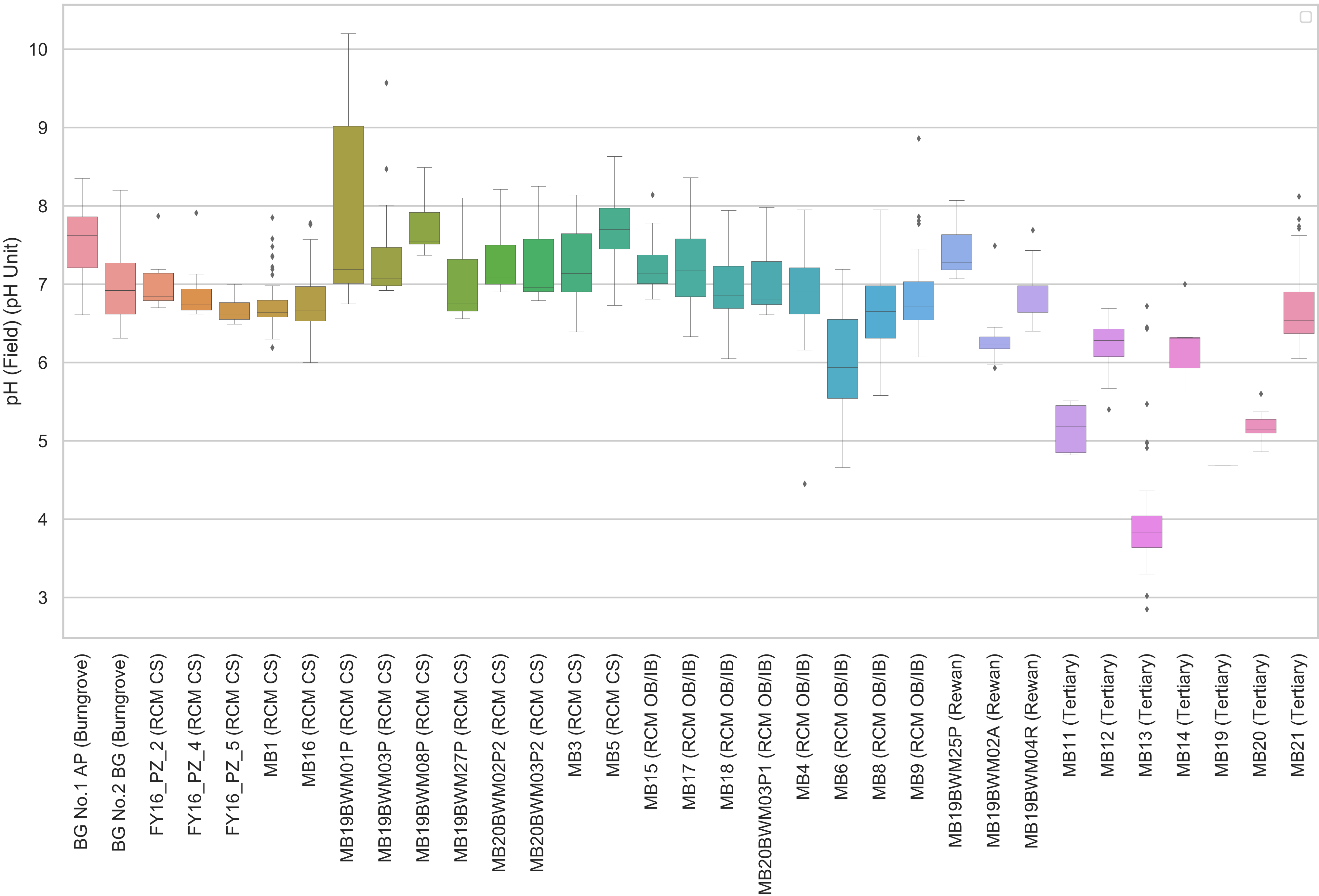

Molybdenum (Diss) (mg/L)
0.10
0.08
0.06
0.04
0.02
0.00
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

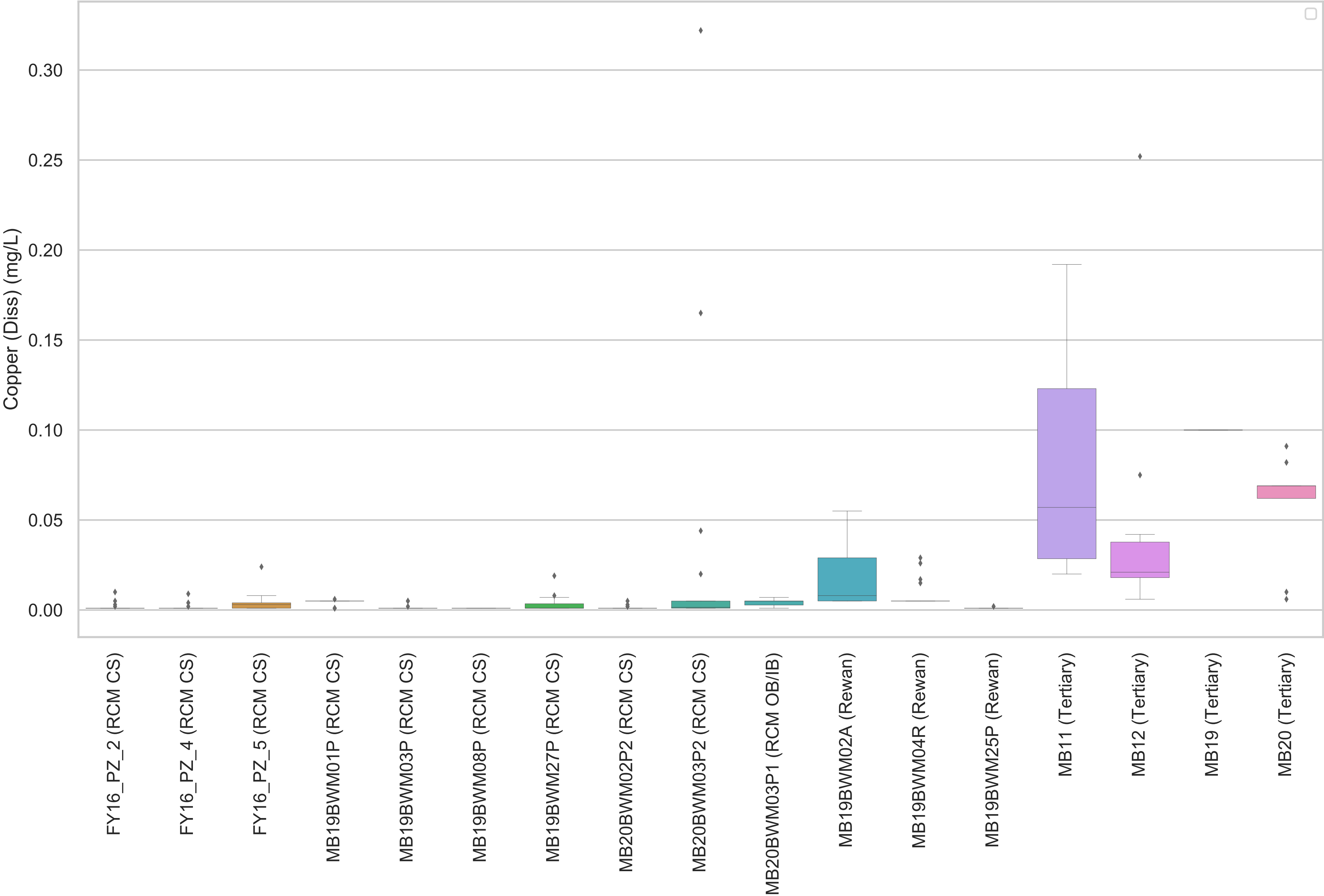


Molybdenum (Total) (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

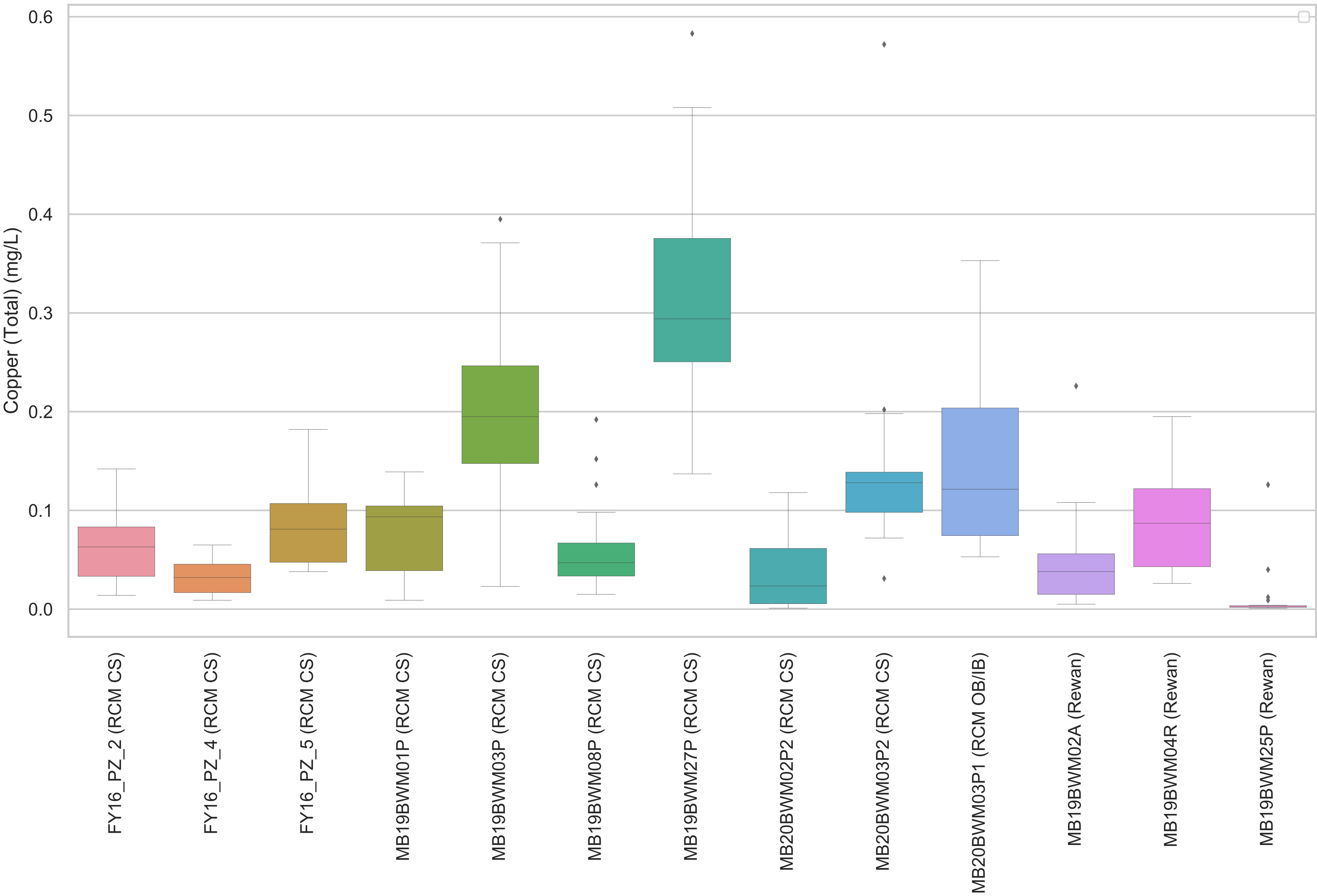

Iron (Diss) (mg/L)
0
5
10
15
20
25
30
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

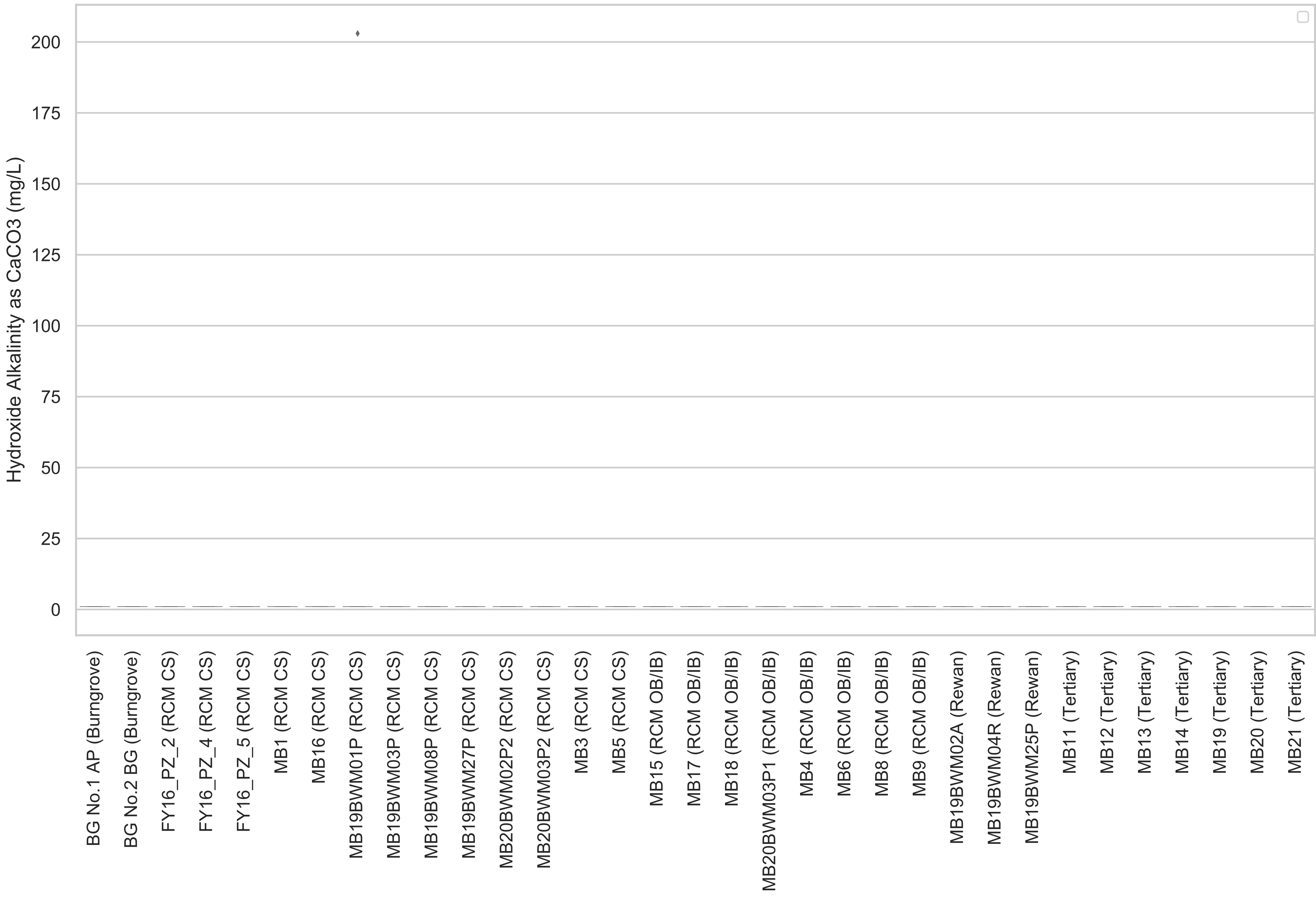

pH (Lab) (pH Unit)
12
10
8
6
4
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

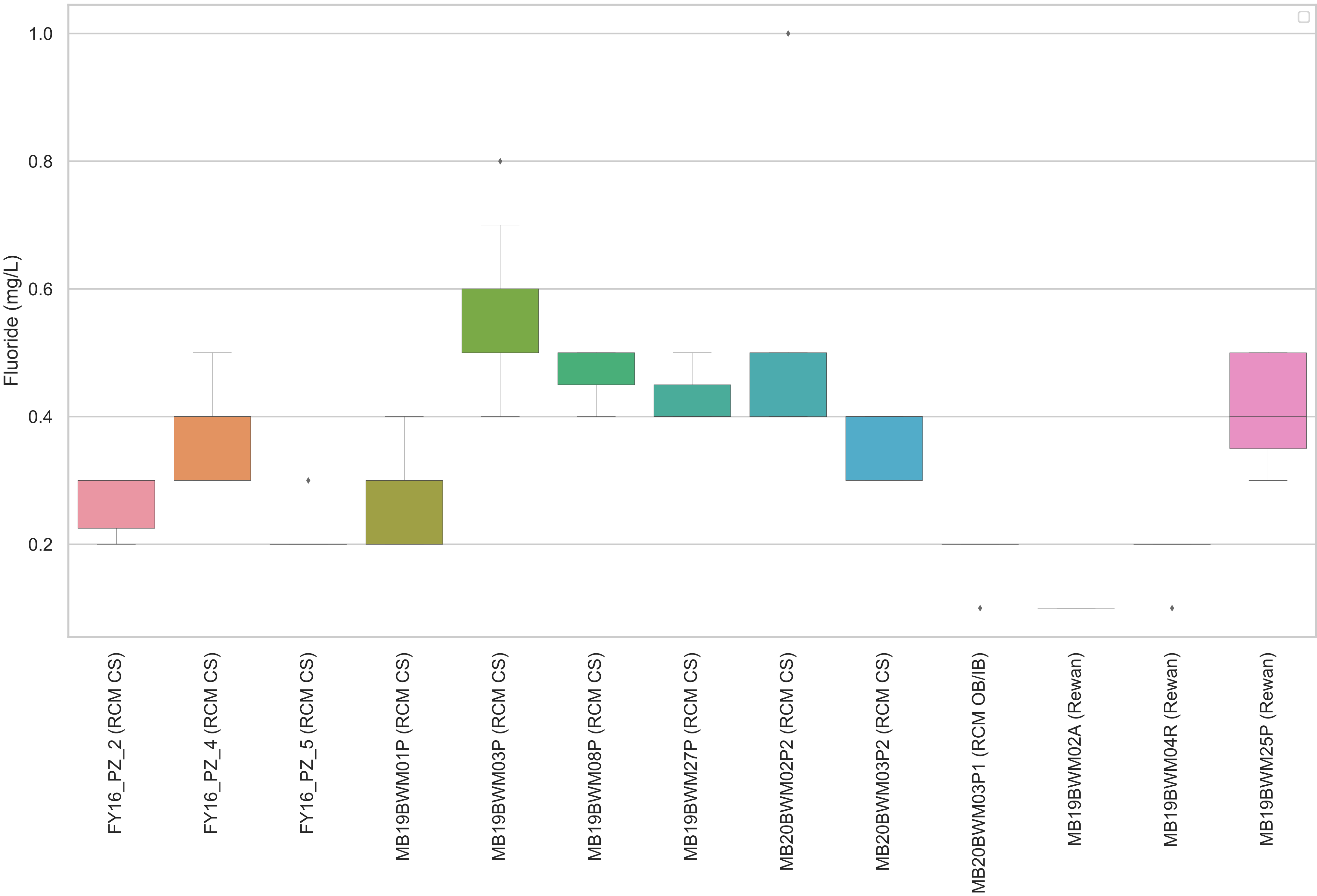

pH (Field) (pH Unit)
10
9
8
7
6
5
4
3
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

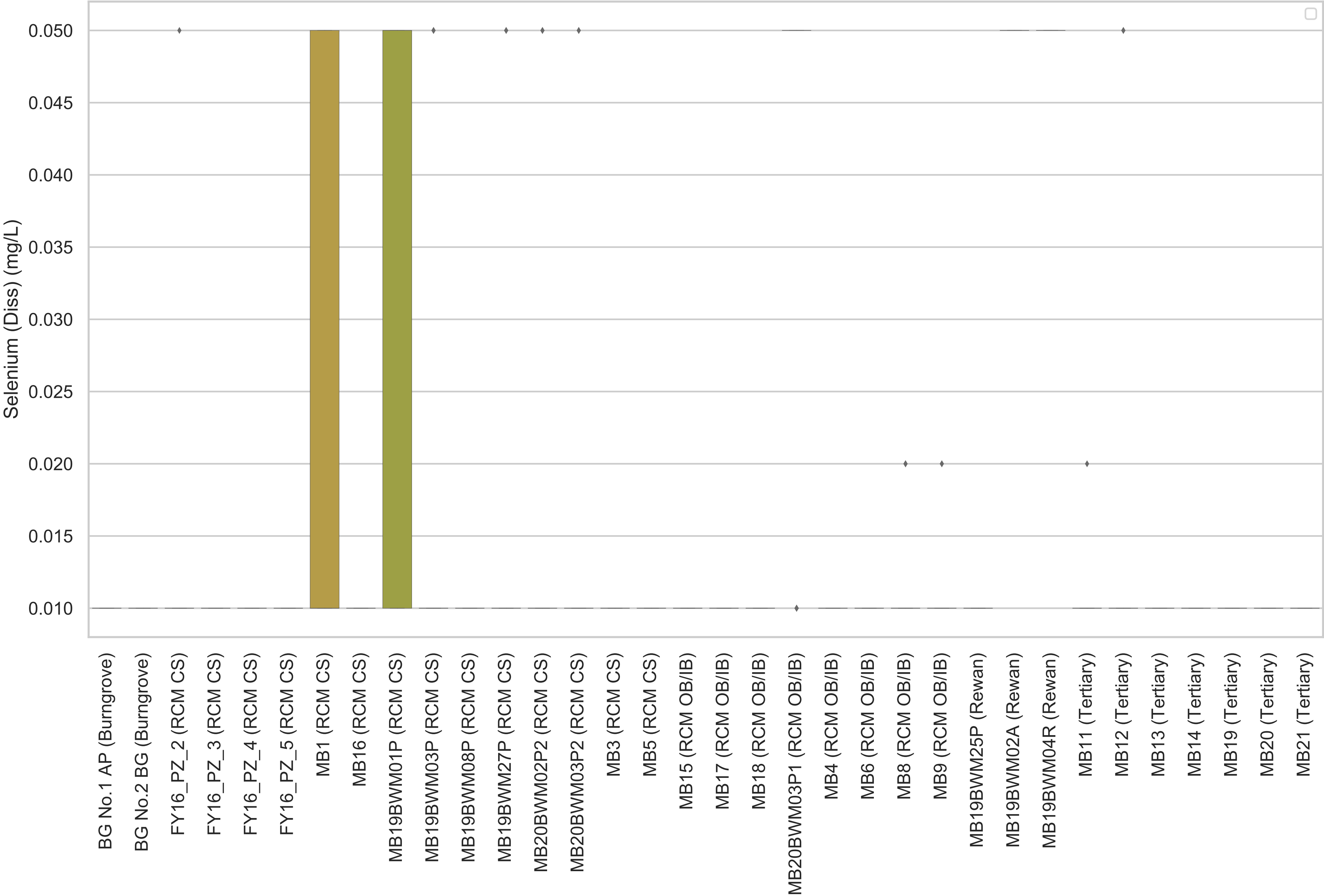


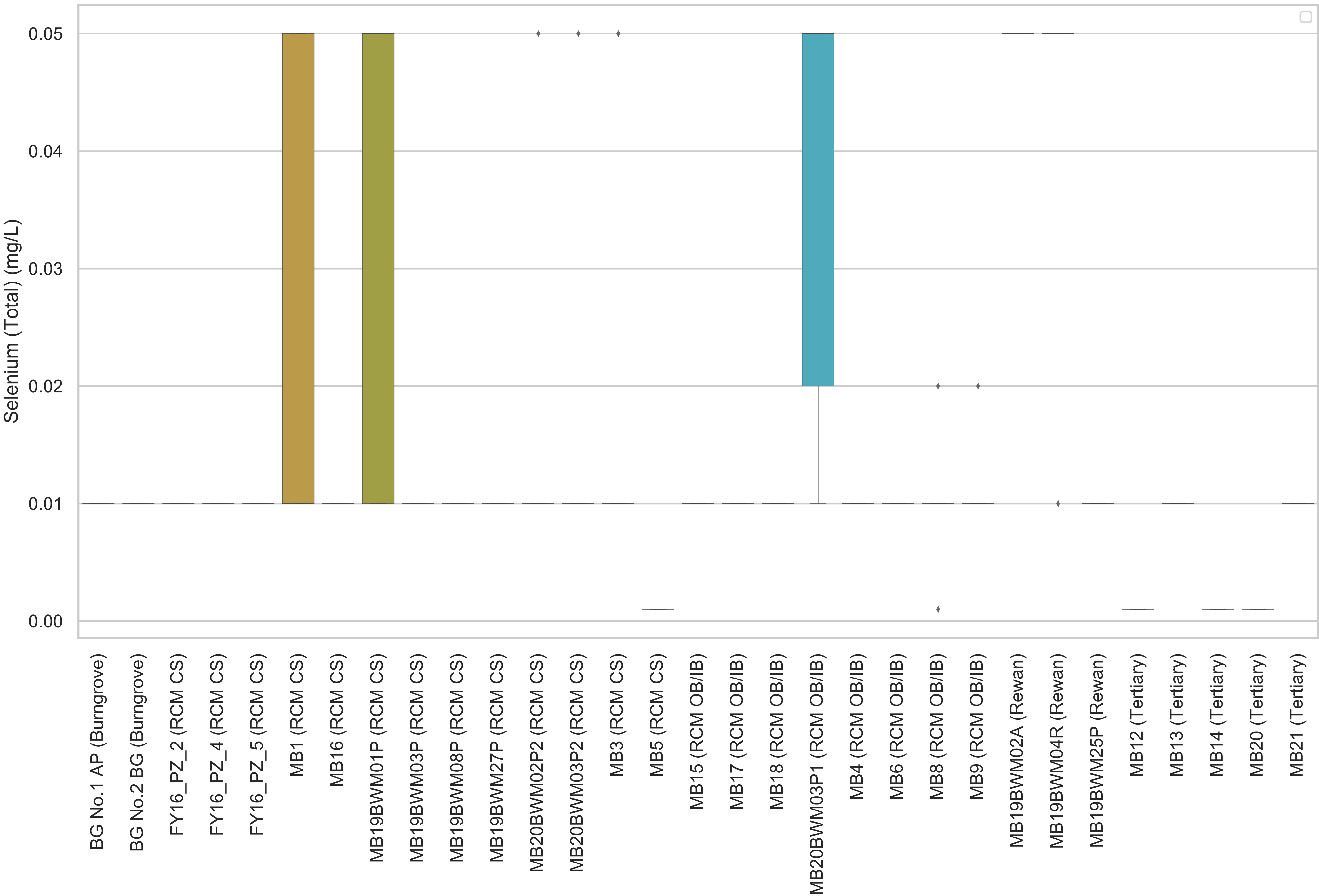
Copper (Diss) (mg/L)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)

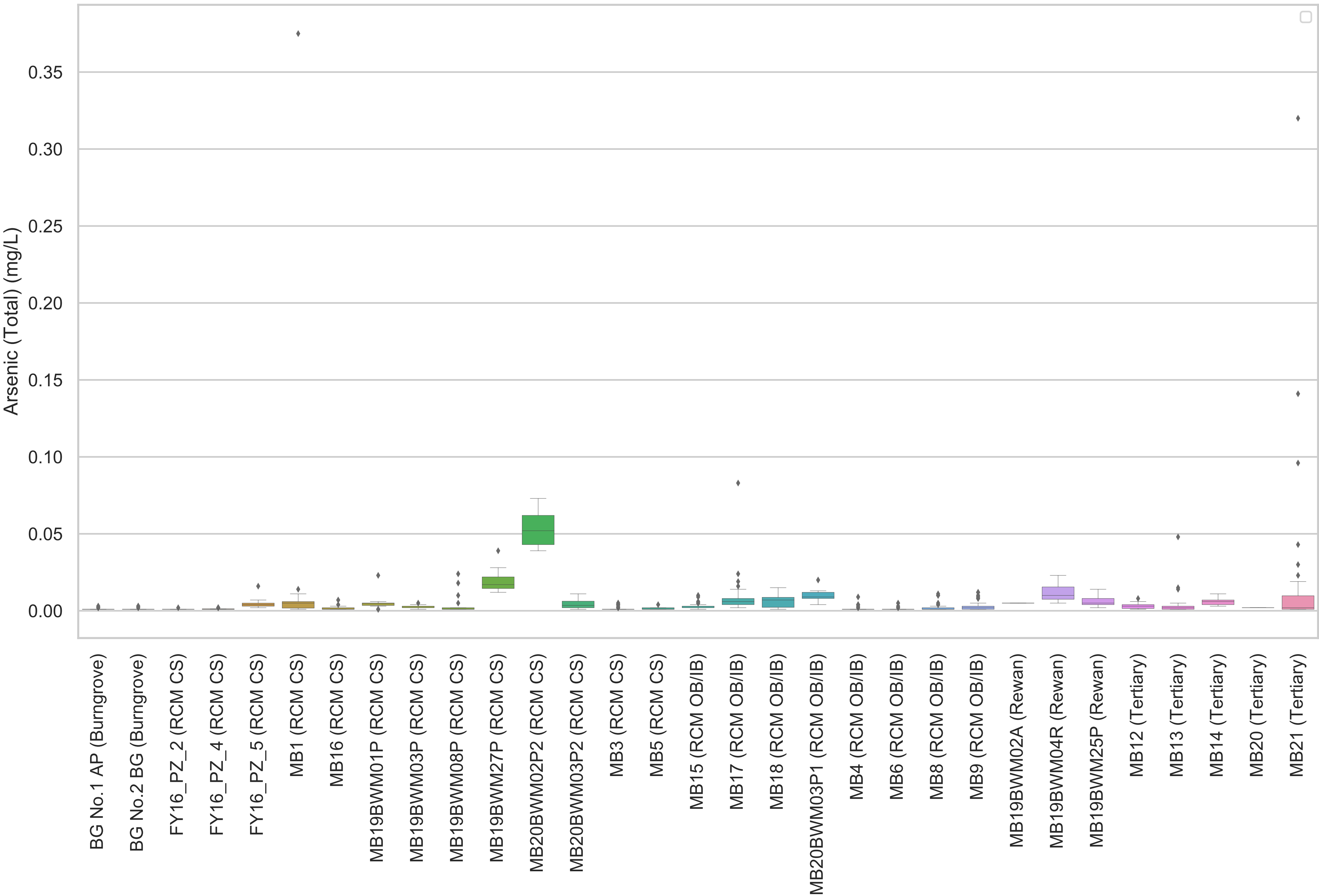

Copper (Total) (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

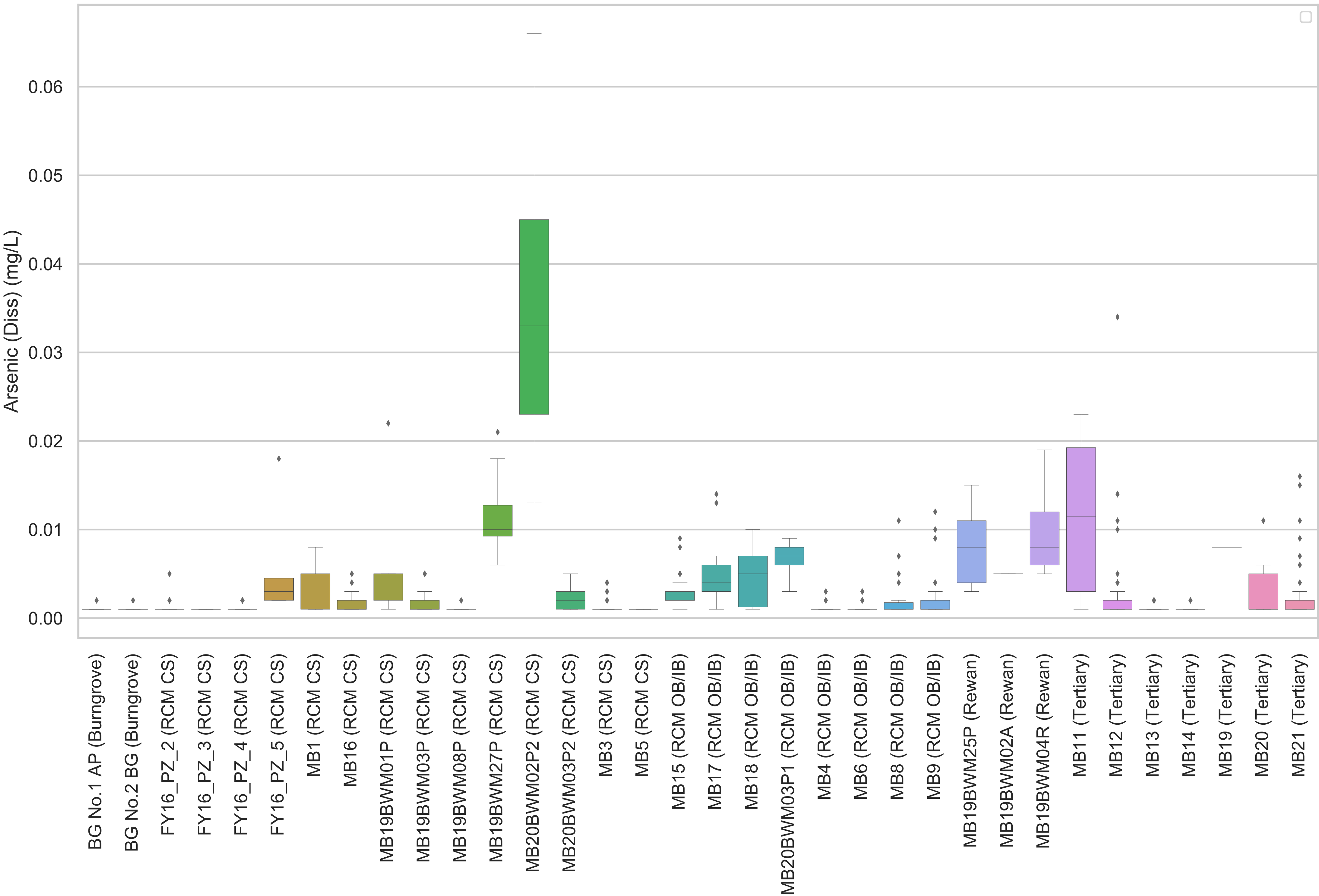

Hydroxide Alkalinity as CaCO3 (mg/L)
200
175
150
125
100
75
50
25
0
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

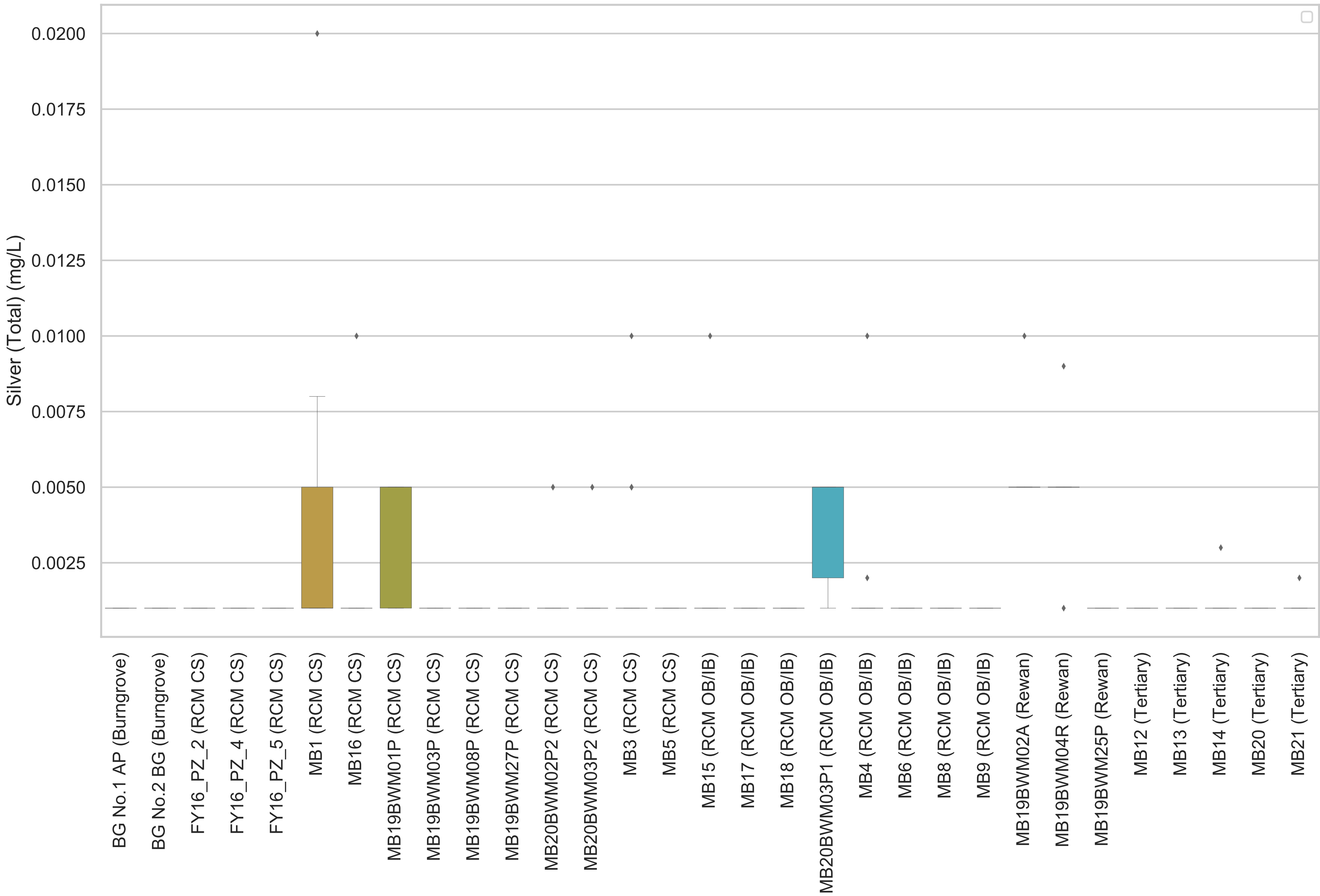

1.0
0.8
0.6
0.4
0.2
Fluoride (mg/L)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

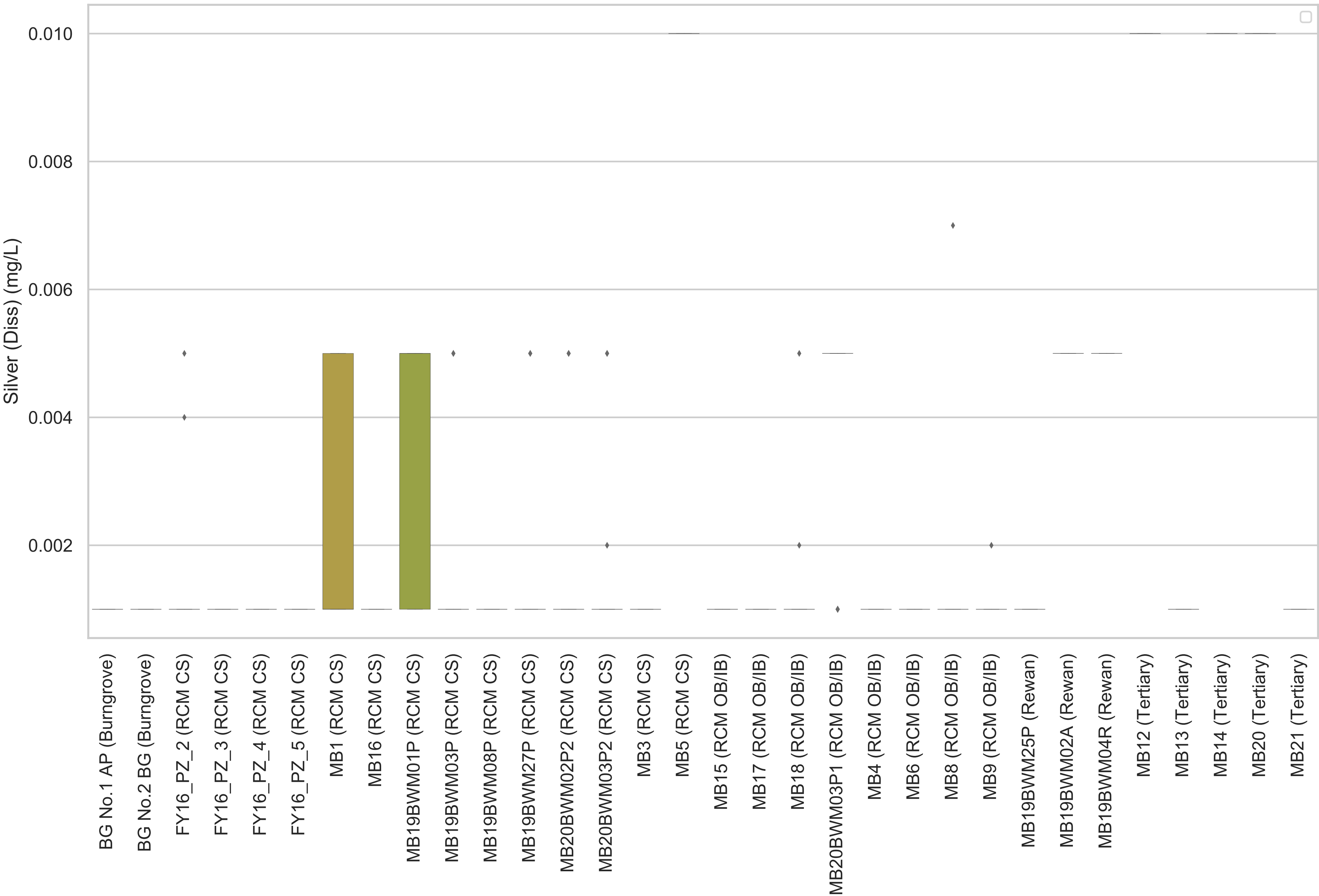

0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
Selenium (Diss) (mg/L)
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

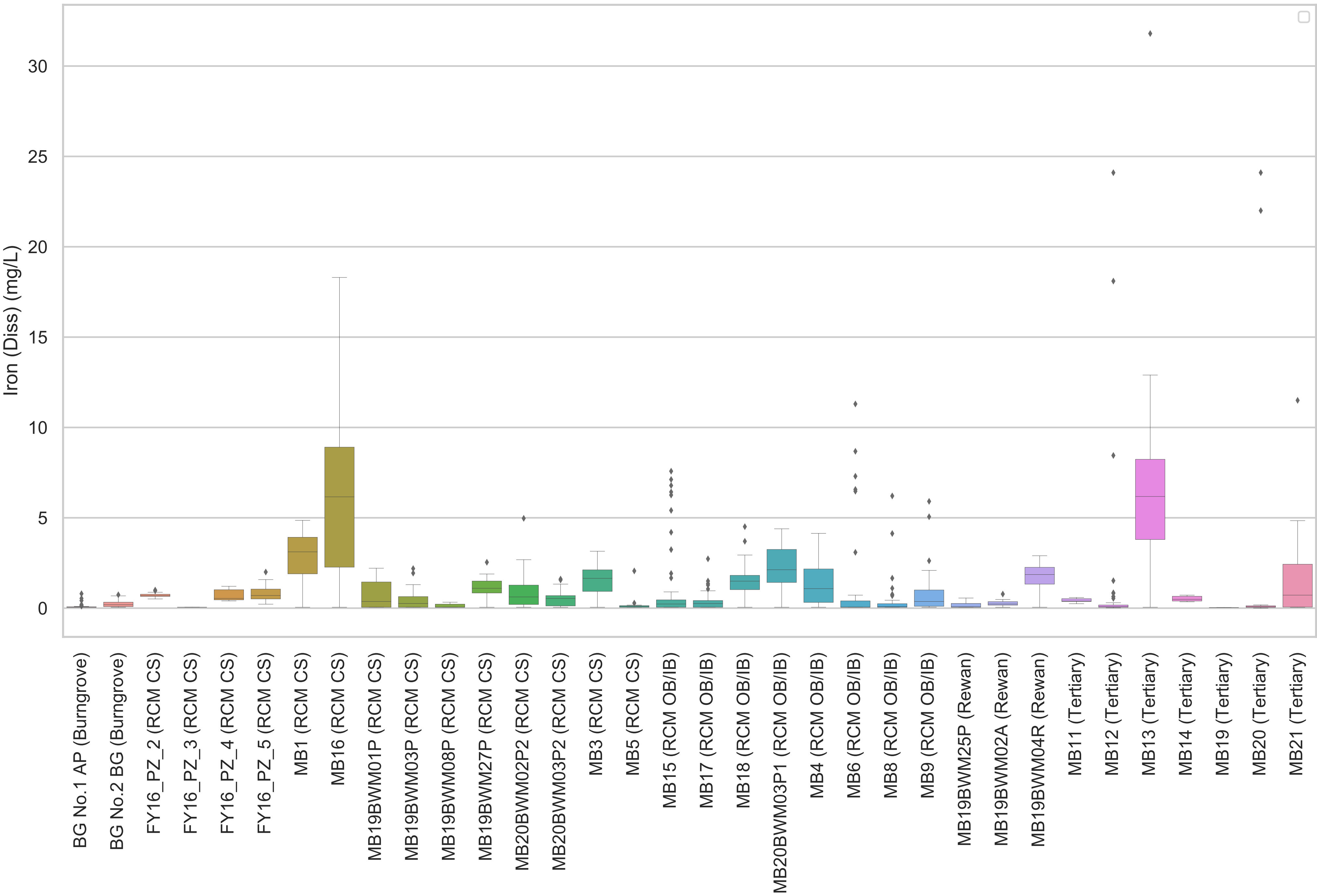

Selenium (Total) (mg/L)
0.05
0.04
0.03
0.02
0.01
0.00
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

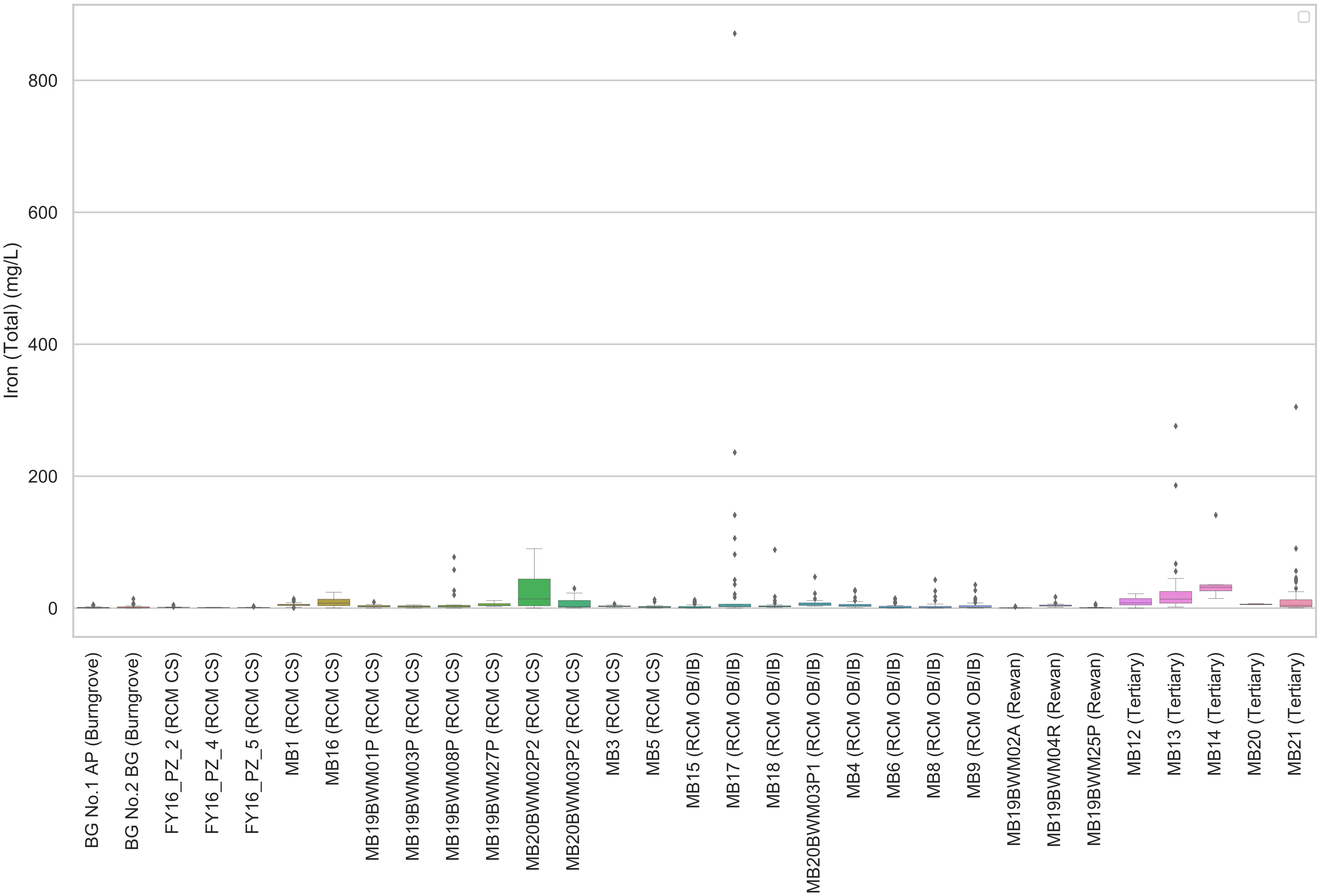

Arsenic (Total) (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

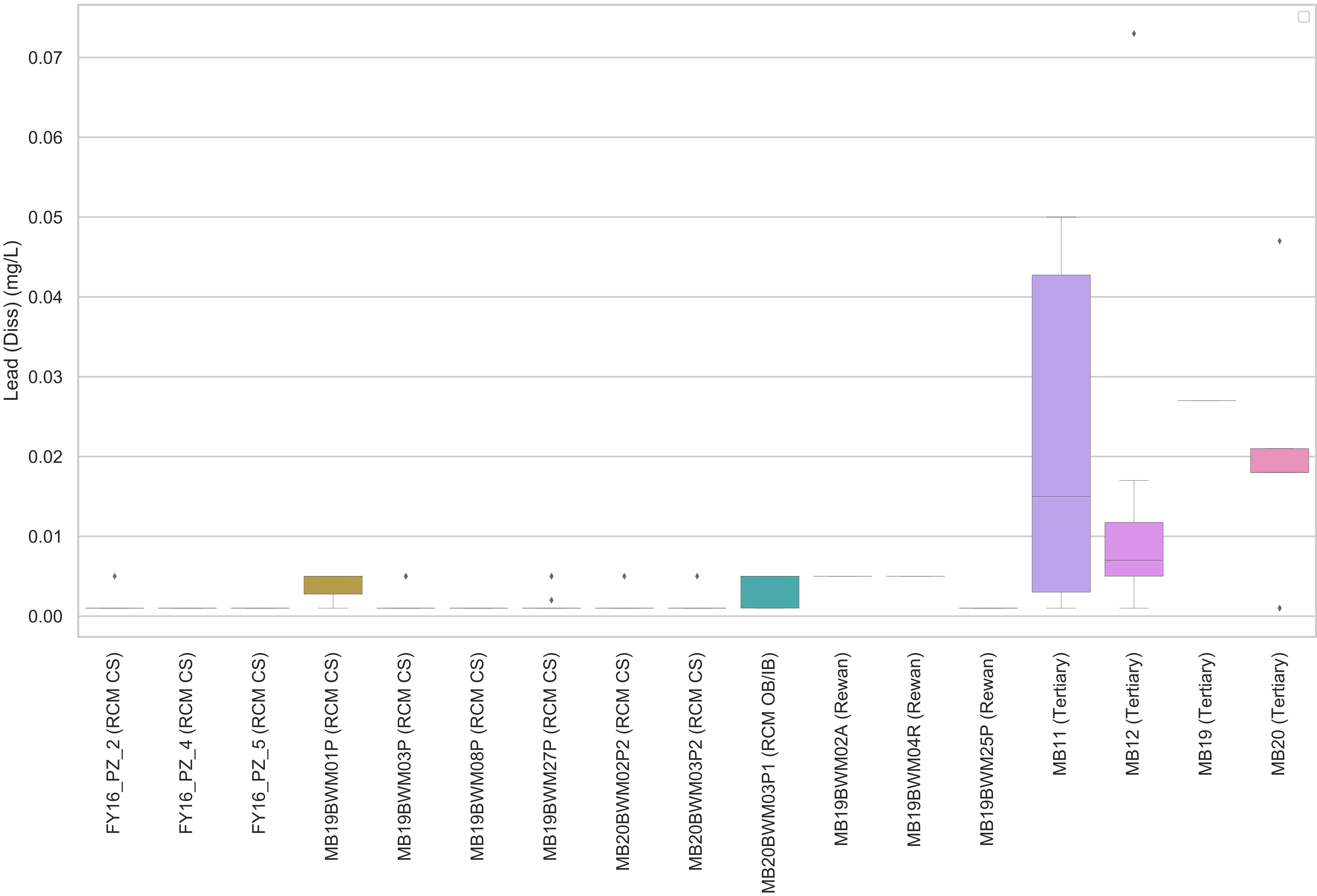

Arsenic (Diss) (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

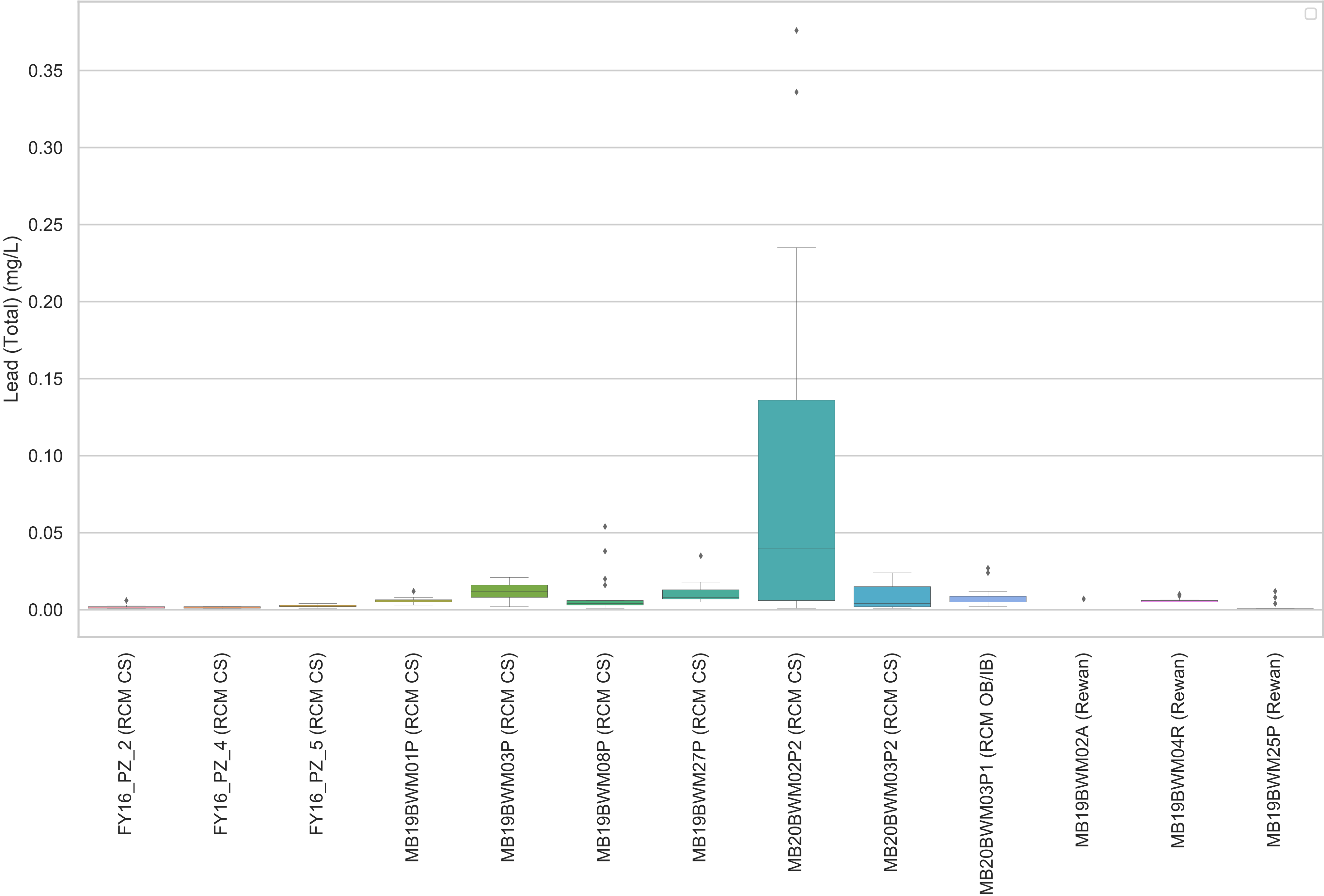

Silver (Total) (mg/L)
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

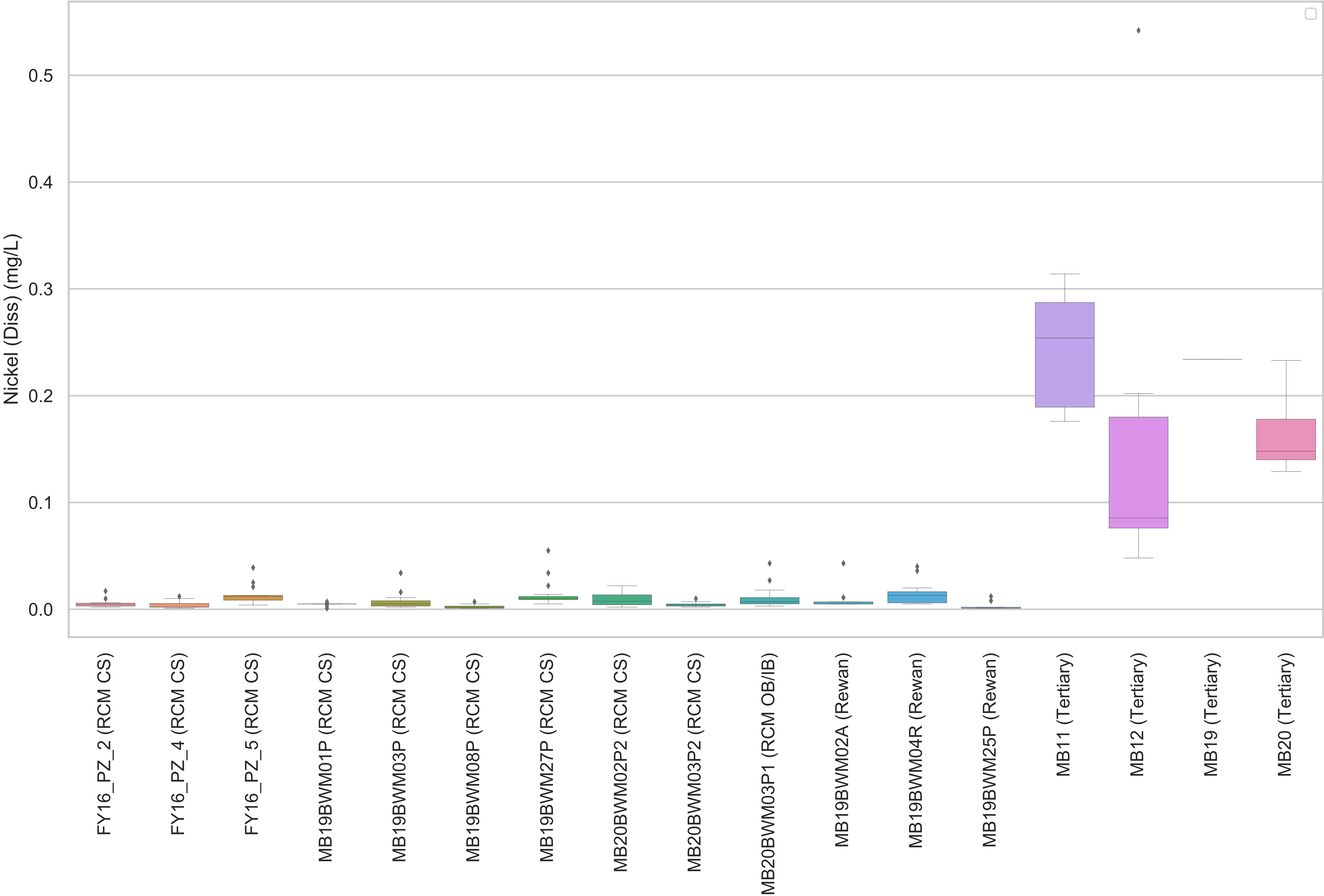

Silver (Diss) (mg/L)
0.010
0.008
0.006
0.004
0.002
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

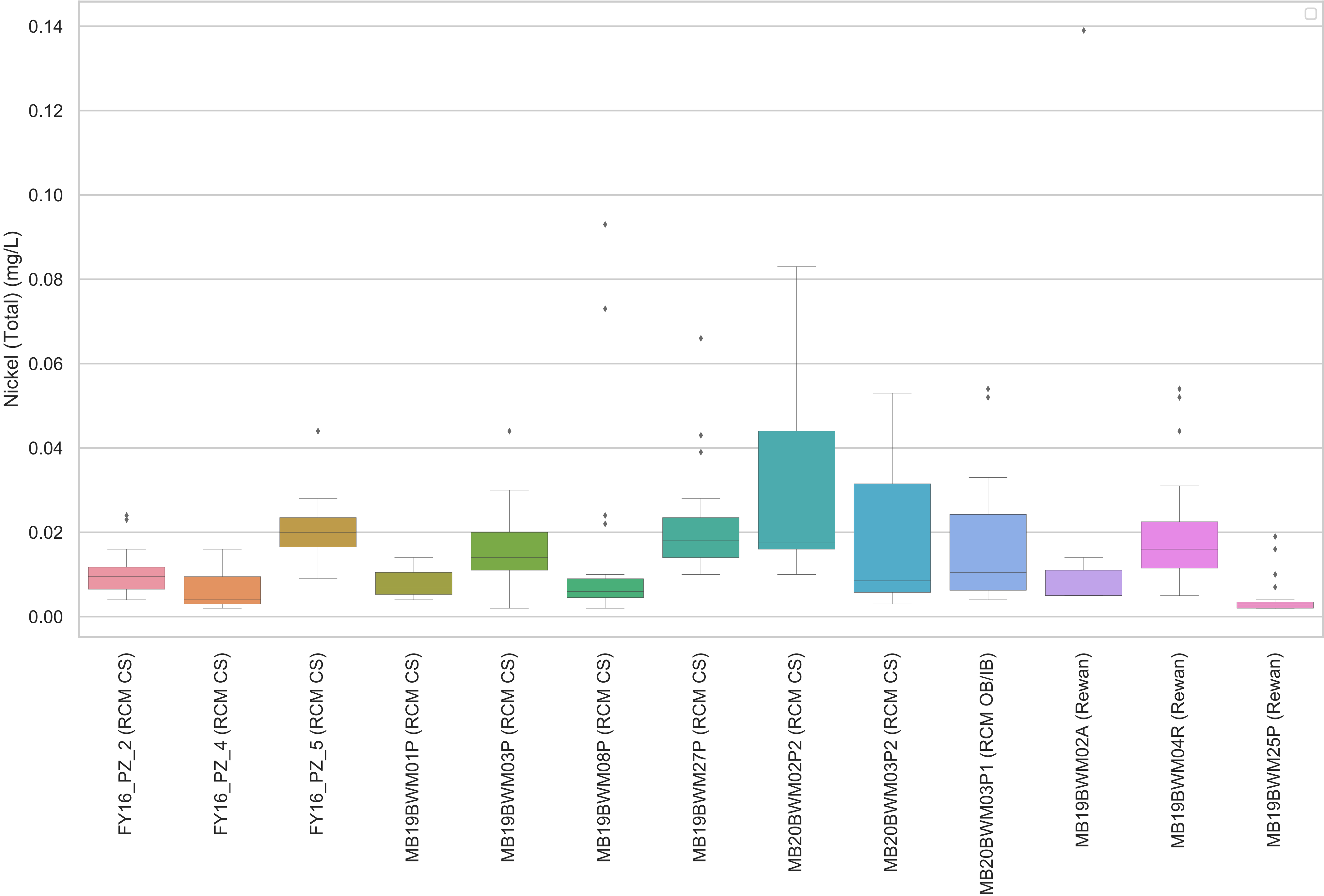

Iron (Diss) (mg/L)
0
5
10
15
20
25
30
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_3 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM25P (Rewan)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

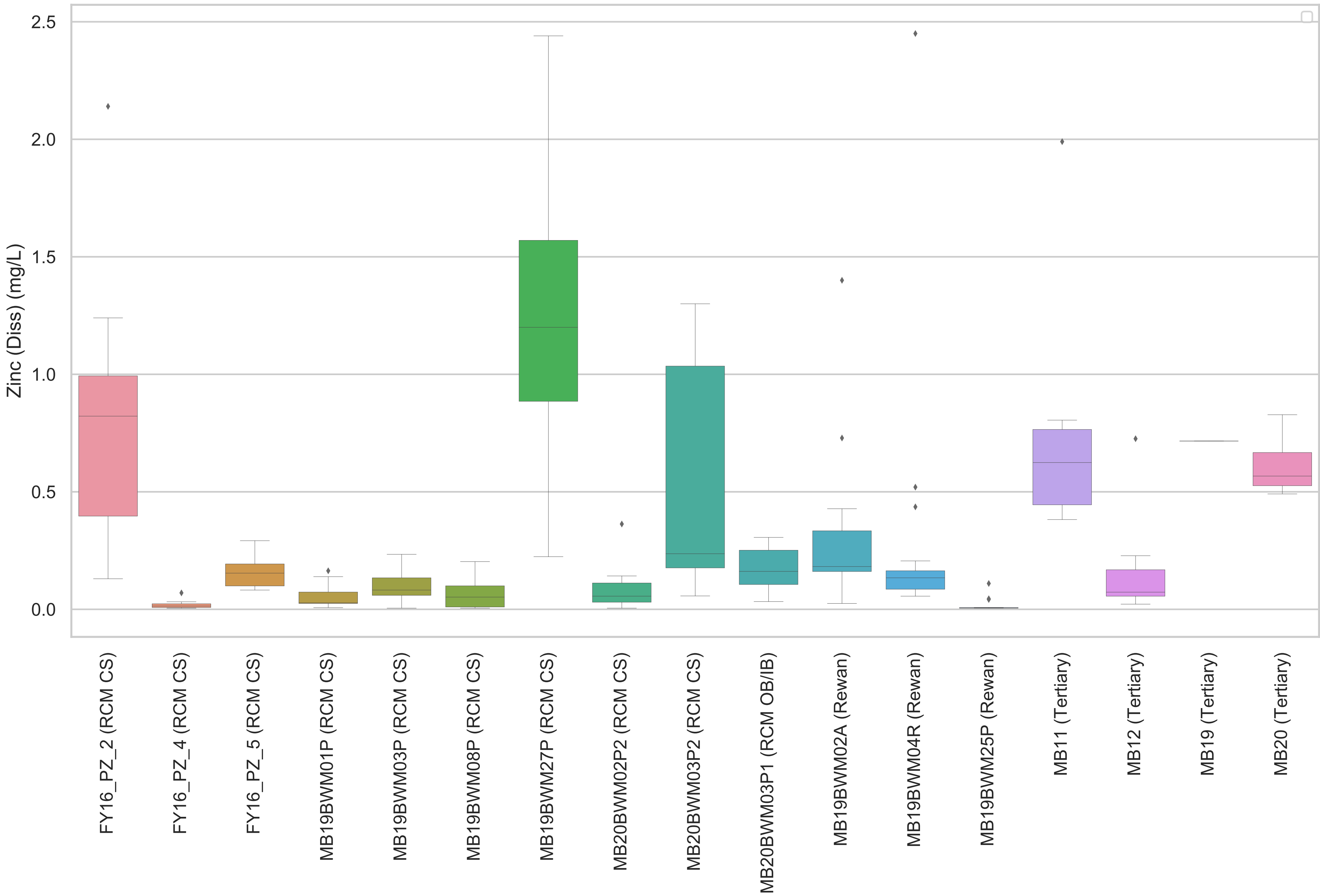

Iron (Total) (mg/L)
0
200
400
600
800
BG No.1 AP (Burngrove)
BG No.2 BG (Burngrove)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB1 (RCM CS)
MB16 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB3 (RCM CS)
MB5 (RCM CS)
MB15 (RCM OB/IB)
MB17 (RCM OB/IB)
MB18 (RCM OB/IB)
MB20BWM03P1 (RCM OB/IB)
MB4 (RCM OB/IB)
MB6 (RCM OB/IB)
MB8 (RCM OB/IB)
MB9 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB12 (Tertiary)
MB13 (Tertiary)
MB14 (Tertiary)
MB20 (Tertiary)
MB21 (Tertiary)

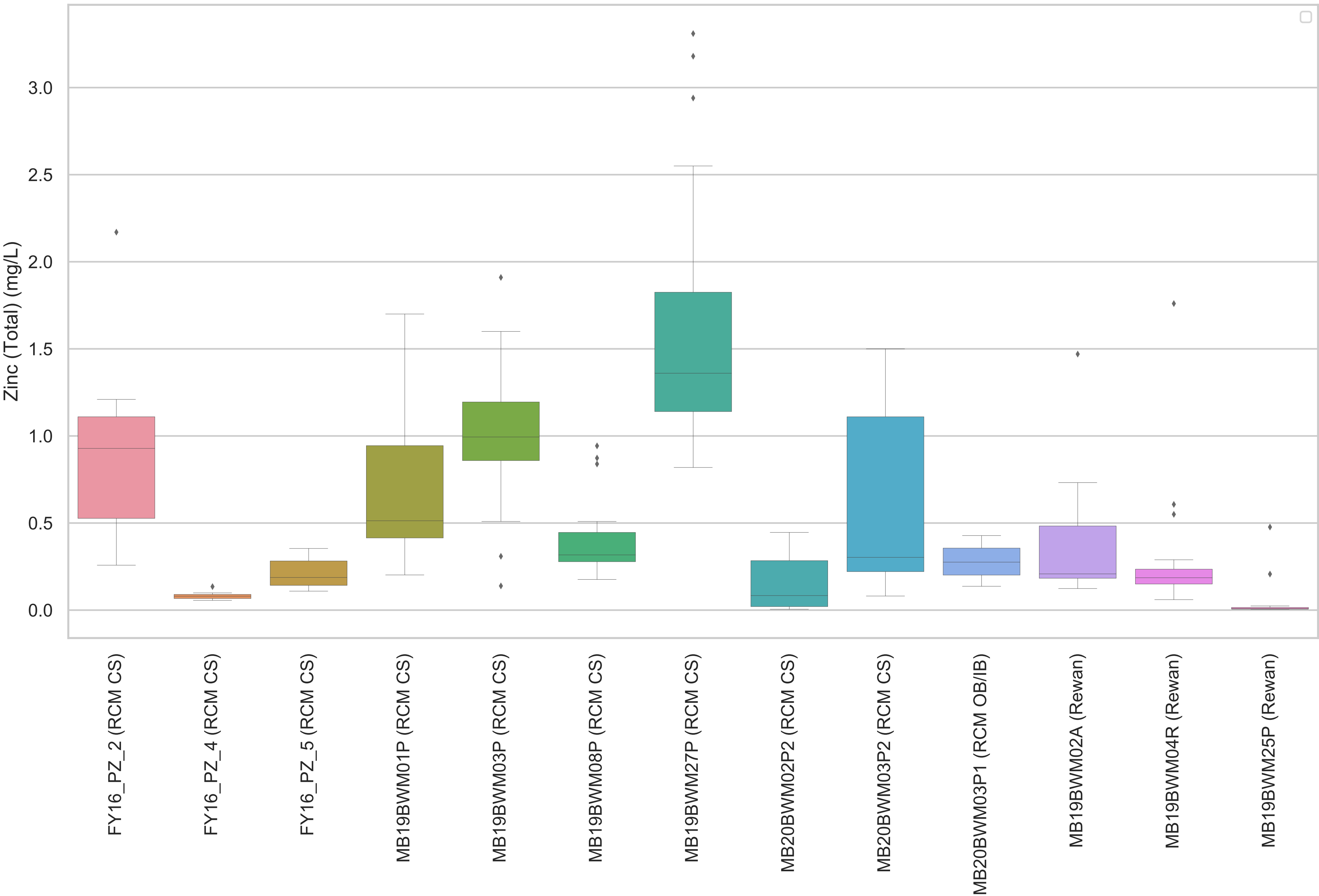

Lead (Diss) (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)

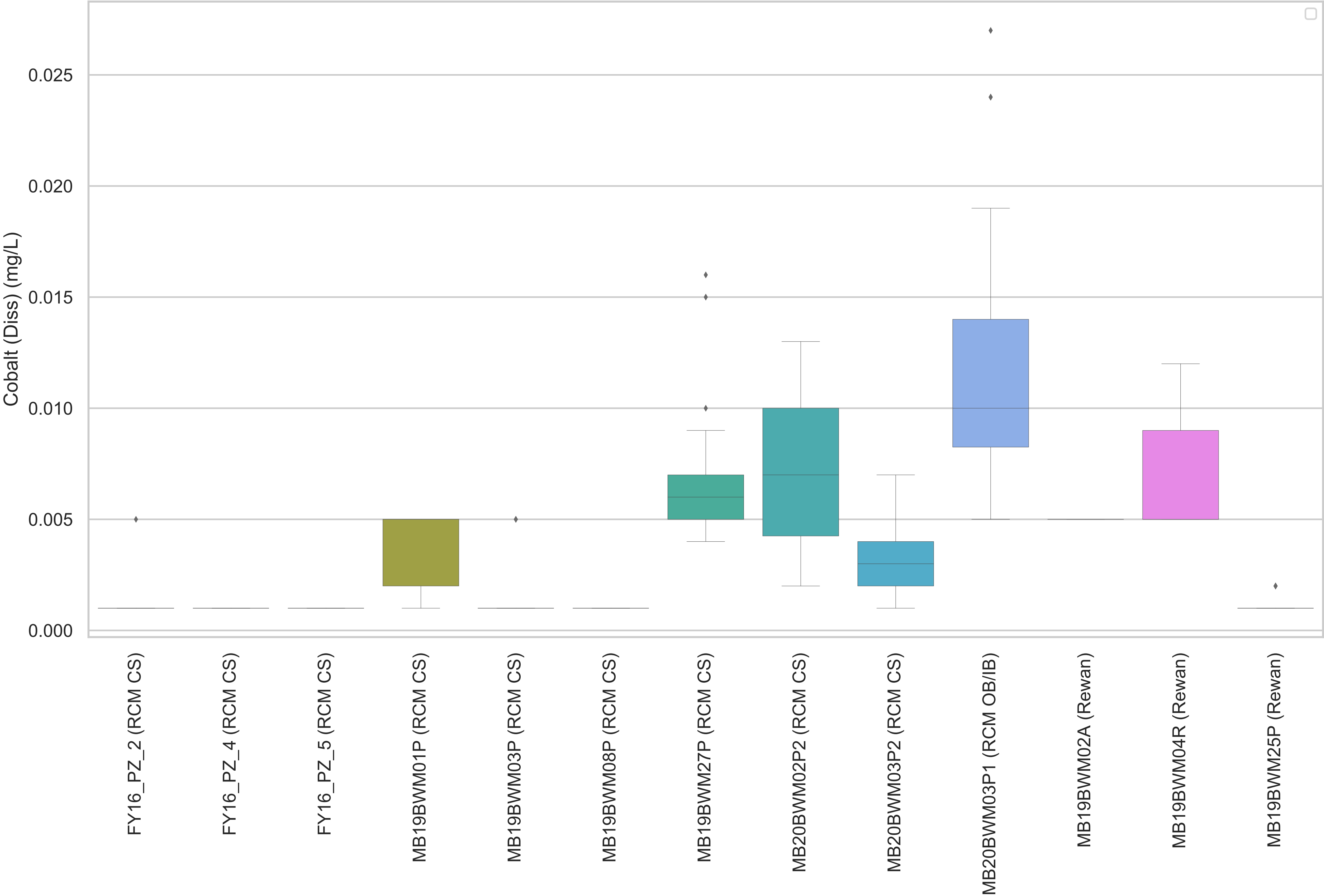

Lead (Total) (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)


Nickel (Diss) (mg/L)
0.5
0.4
0.3
0.2
0.1
0.0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)

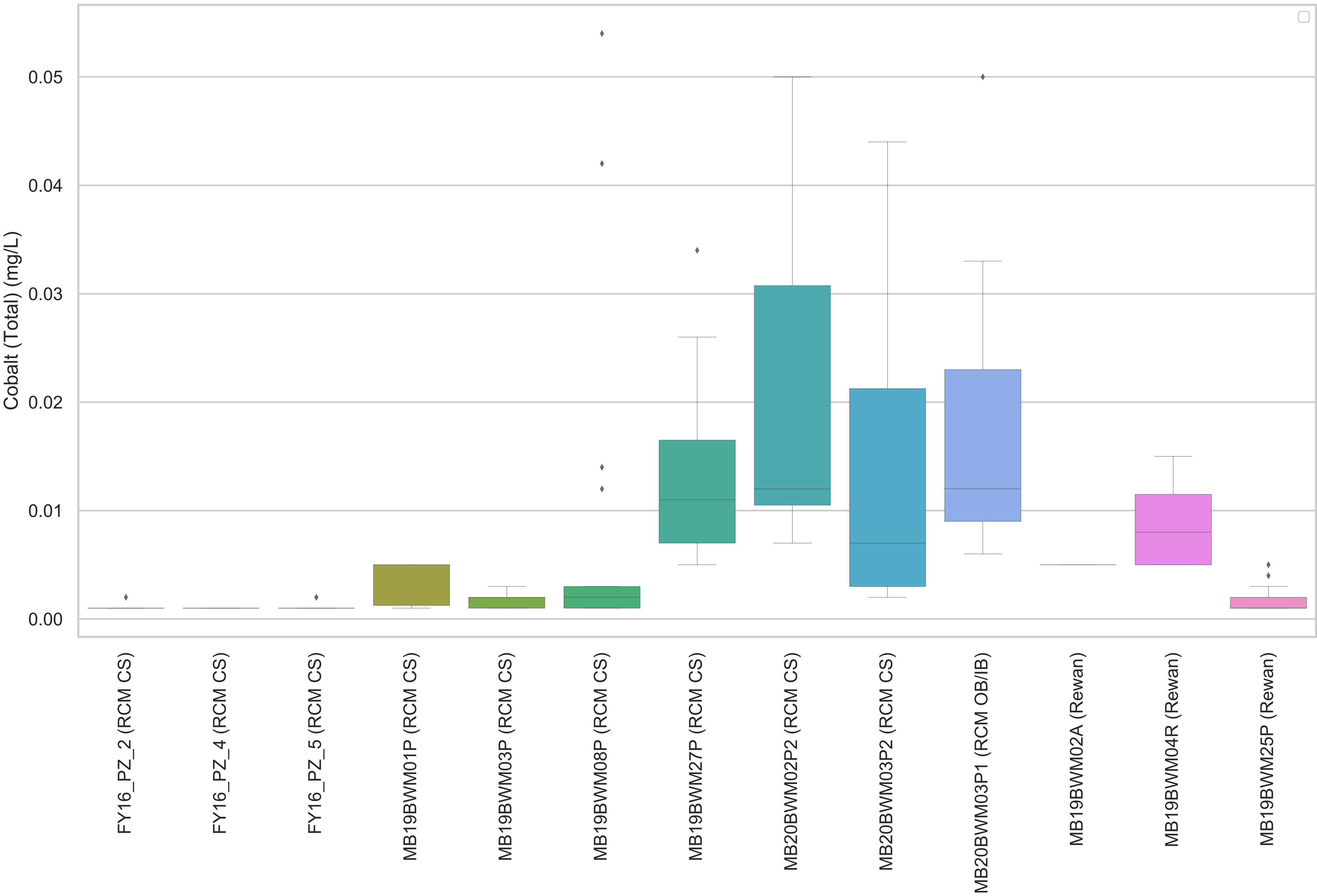

Nickel (Total) (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

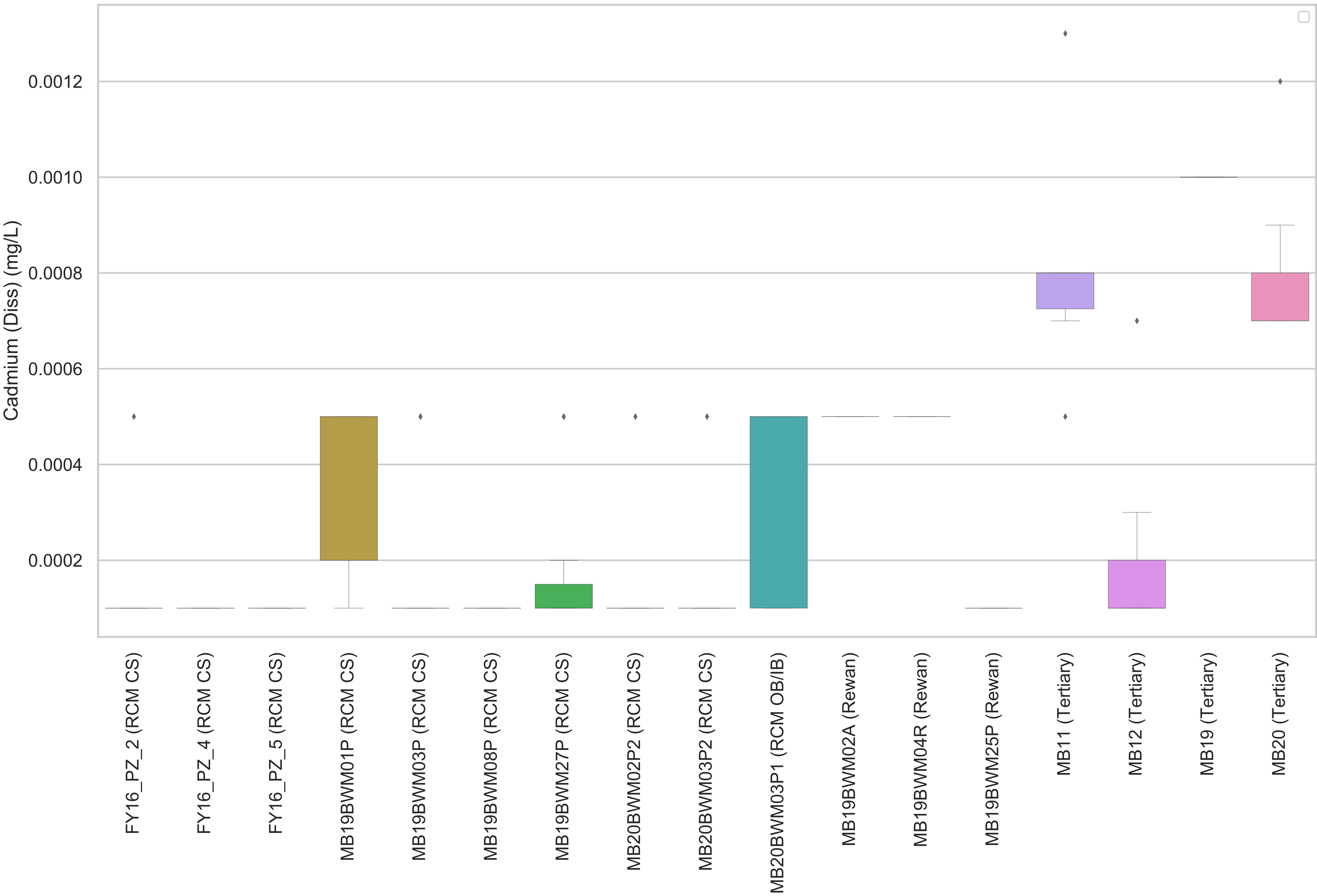

Zinc (Diss) (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)

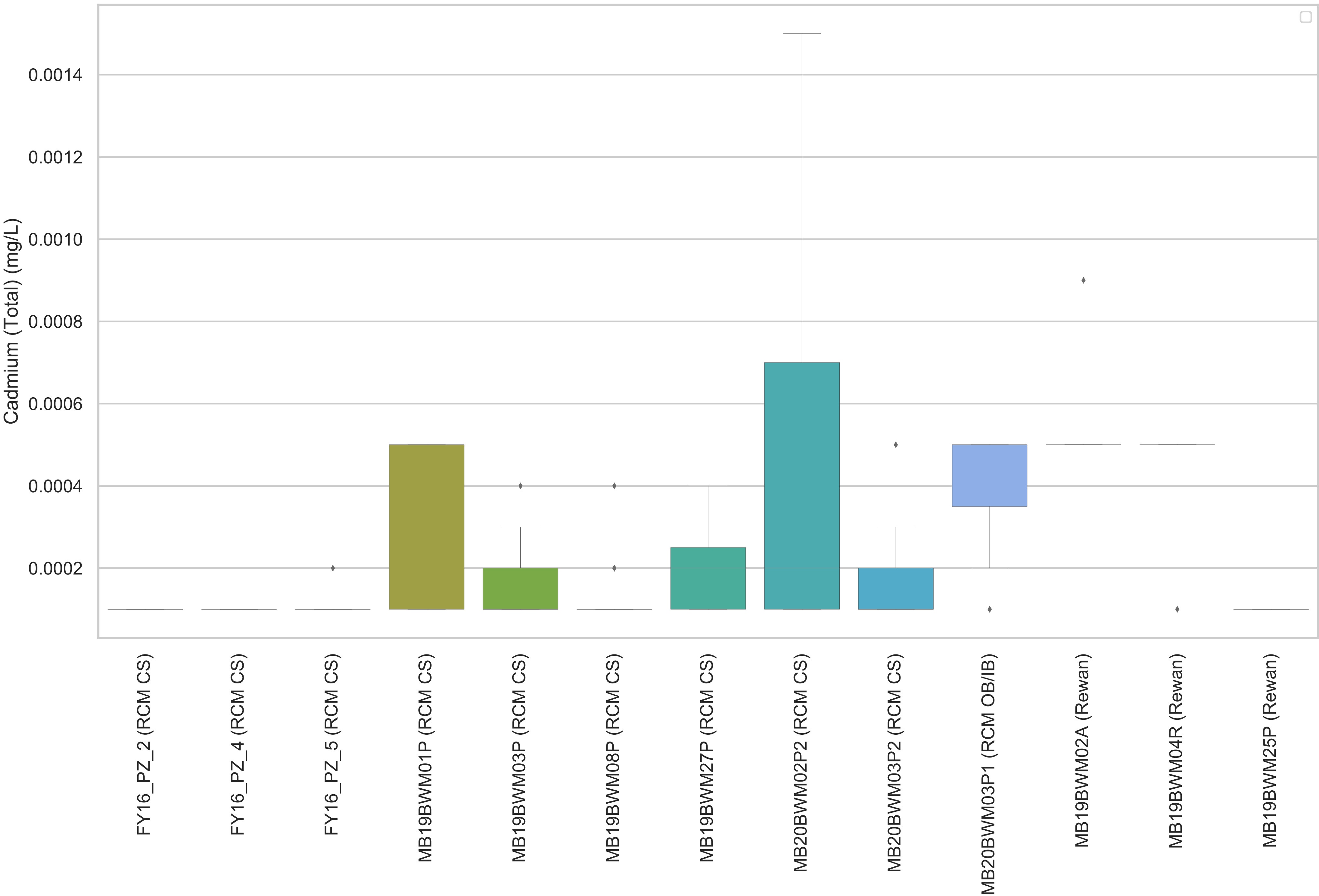

Zinc (Total) (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

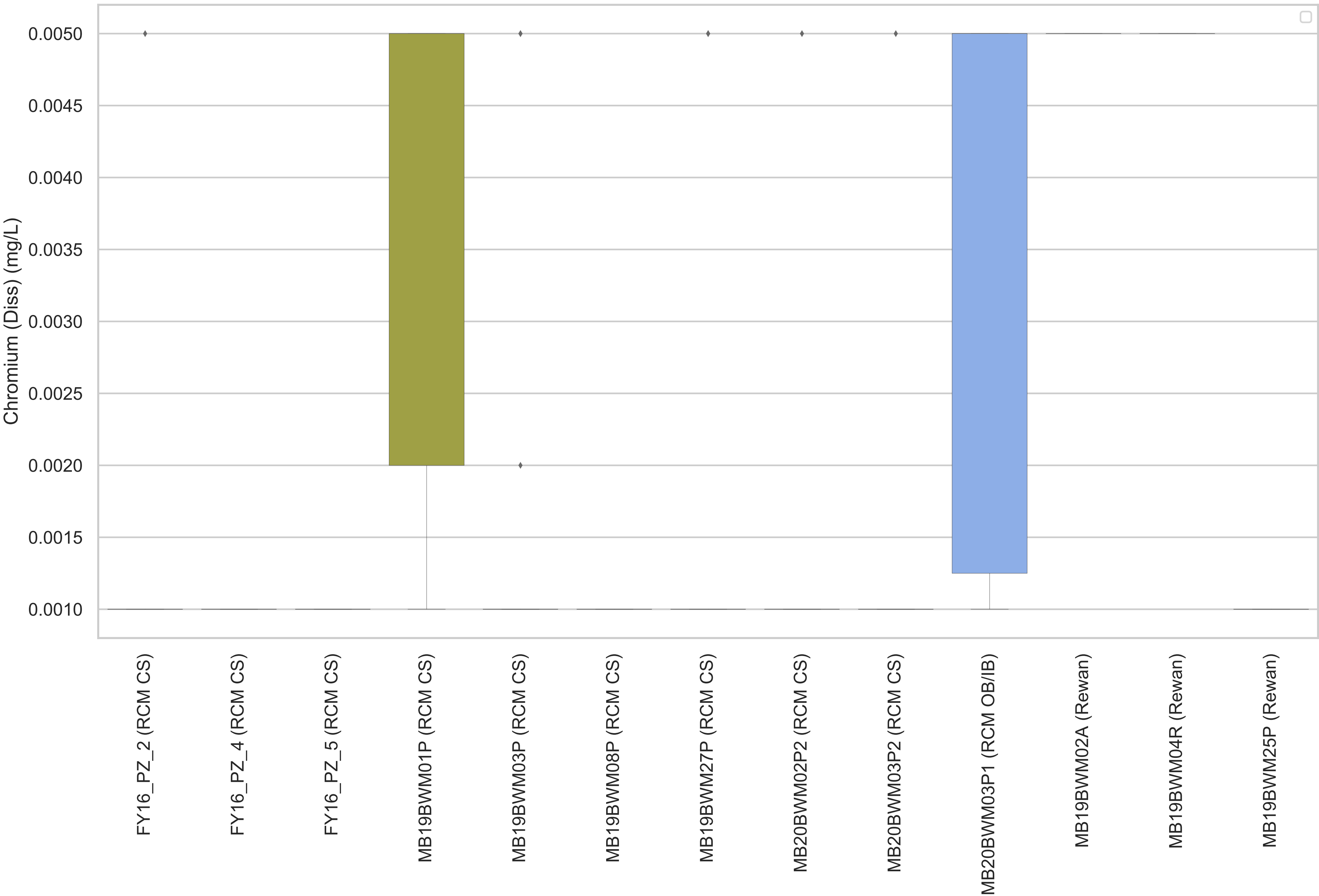


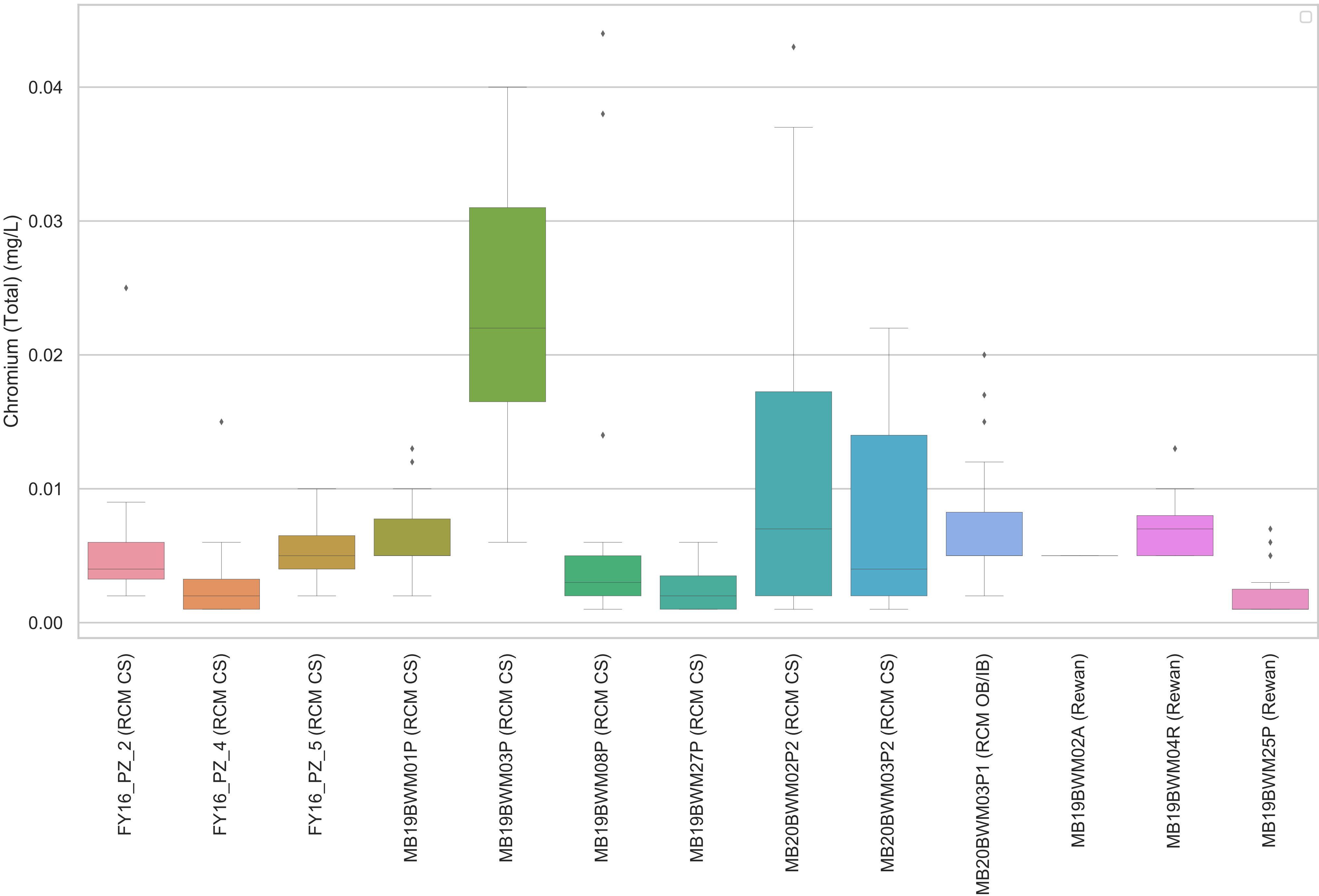
Cobalt (Diss) (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

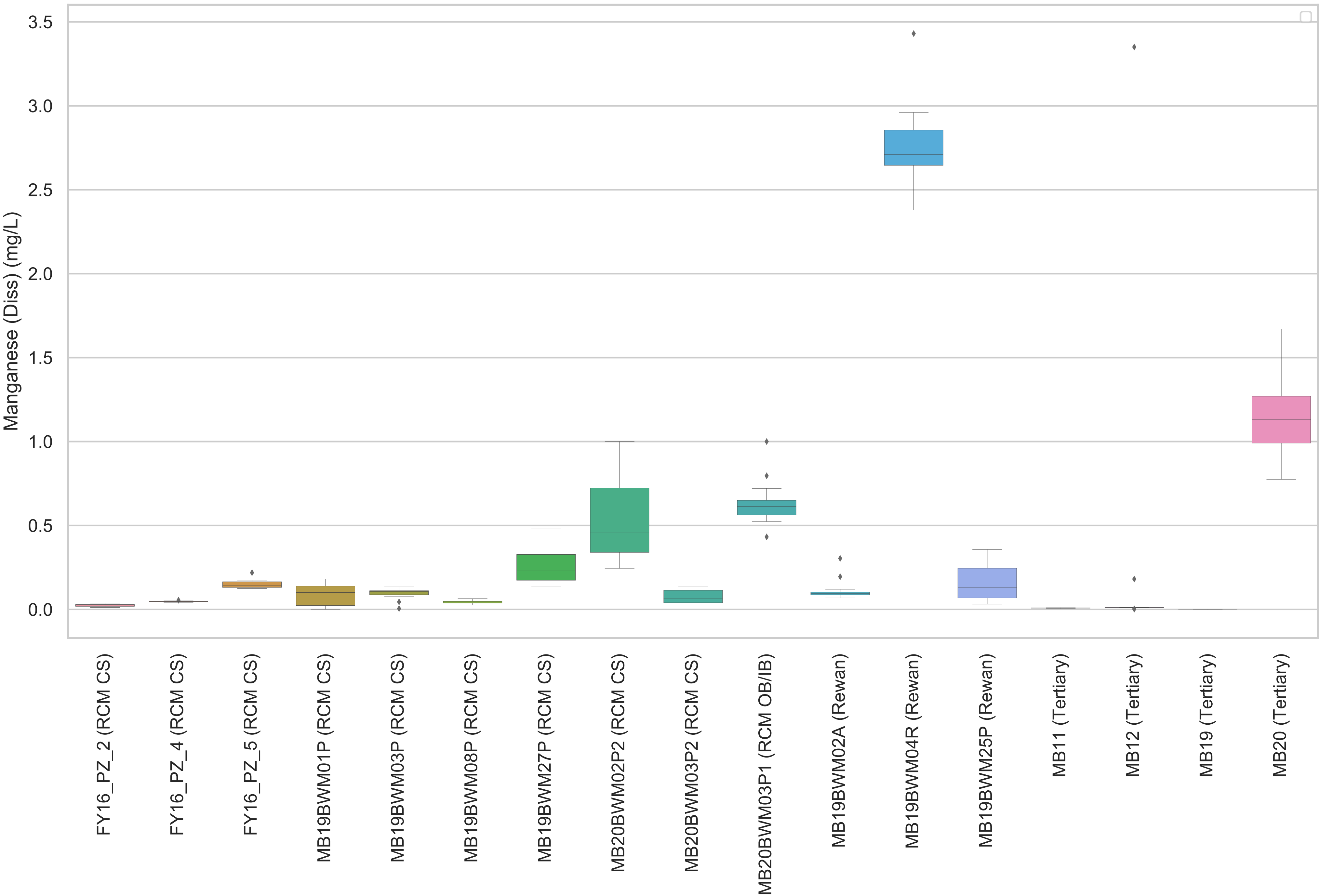

Cobalt (Total) (mg/L)
0.00
0.01
0.02
0.03
0.04
0.05
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

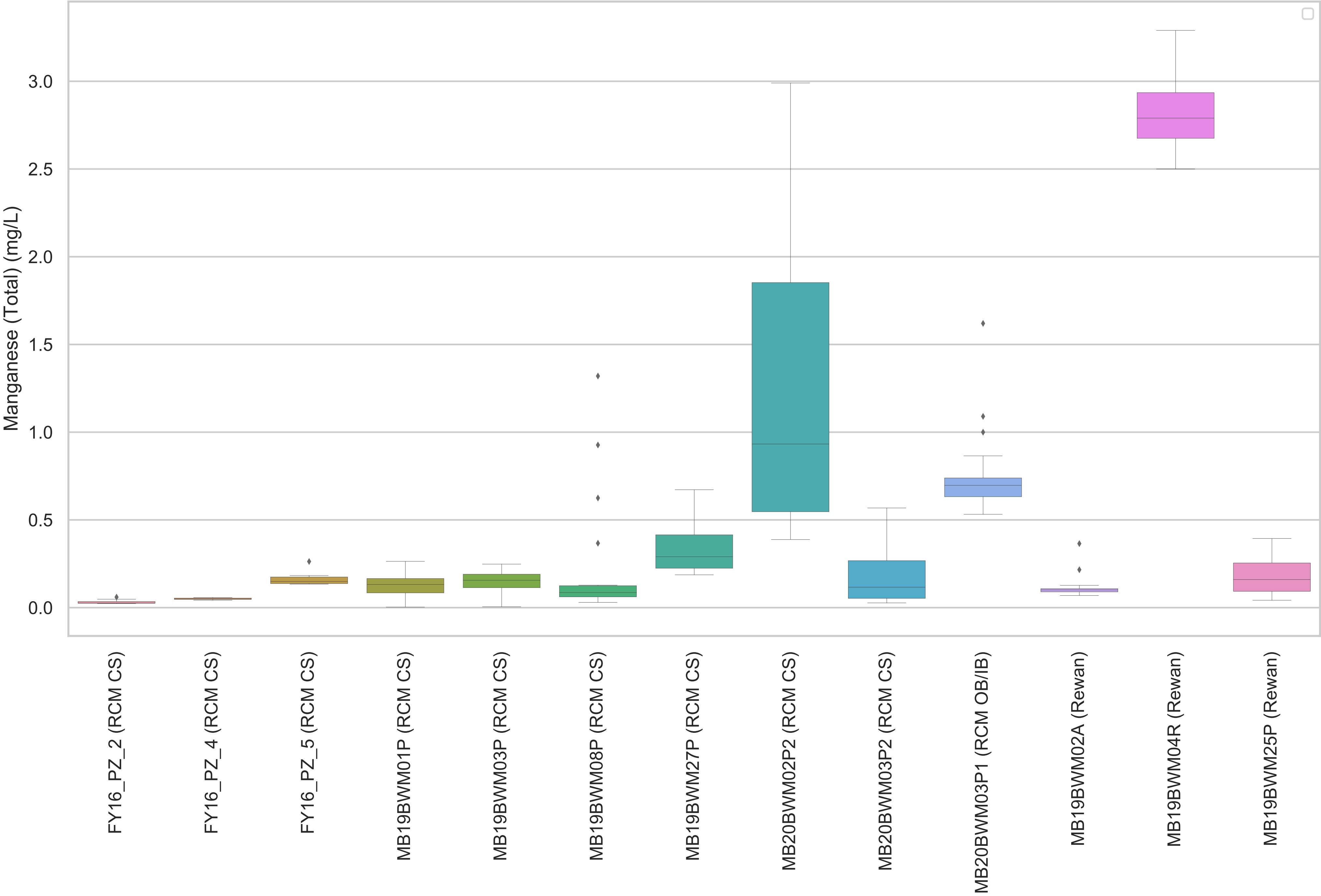

Cadmium (Diss) (mg/L)
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)


Cadmium (Total) (mg/L)
0.0014
0.0012
0.0010
0.0008
0.0006
0.0004
0.0002
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)


Chromium (Diss) (mg/L)
0.0050
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)


Chromium (Total) (mg/L)
0.00
0.01
0.02
0.03
0.04
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)


3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Manganese (Diss) (mg/L)
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)
MB11 (Tertiary)
MB12 (Tertiary)
MB19 (Tertiary)
MB20 (Tertiary)


Manganese (Total) (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
FY16_PZ_2 (RCM CS)
FY16_PZ_4 (RCM CS)
FY16_PZ_5 (RCM CS)
MB19BWM01P (RCM CS)
MB19BWM03P (RCM CS)
MB19BWM08P (RCM CS)
MB19BWM27P (RCM CS)
MB20BWM02P2 (RCM CS)
MB20BWM03P2 (RCM CS)
MB20BWM03P1 (RCM OB/IB)
MB19BWM02A (Rewan)
MB19BWM04R (Rewan)
MB19BWM25P (Rewan)

Appendix A-3 Exisiting Water Supply Bores in the Study area / Bore Census

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd
SLR Project No.: 620.014601.00006 R01

11 December 2023

Bore ID 57404

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Top bore
Latitude	-23.978
Longitude	148.725

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	18
Water strike (m BGL)	15.5
Airlift yield during drilling (L/s)	1
Geological formation screened	Undivided Permian Upper
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Old windmill
Pump depth (m BGL)	15
Power supply	None
Frequency of use	Never
Typical pumping rate	-
Stocking rate	-
Site storage & capacity	Old tank, not used

Groundwater level

Depth to water (m BRP)	12.37
Water level status	Resting
Height of reference (m AGL)	0.08

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

A newer bore 50 m away has replaced this bore. Bore is likely screened within Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 57405

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Middle bore
Latitude	-23.921
Longitude	148.701

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	36.6
Water strike (m BGL)	21
Airlift yield during drilling (L/s)	1
Geological formation screened	Basalt
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	250 cows
Site storage & capacity (L)	1 x 10,000 & 2 x 75,000

Groundwater level

Depth to water (m BRP)	22.69
Water level status	Resting
Height of reference (m AGL)	0.34

Groundwater quality parameters

pH	6.71
EC (µS/cm)	1646
TDS (mg/L)	1069
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 57406

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Sirius bore
Latitude	-23.948
Longitude	148.732

Bore construction

Drilling records available	Yes
Date drilled/constructed	1965
Bore depth (m)	54.9
Water strike (m BGL)	18.3
Airlift yield during drilling (L/s)	0.5
Geological formation screened	Undivided Permian Upper
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Windmill
Pump depth (m BGL)	-
Power supply	-
Frequency of use	Not in use
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	None

Groundwater level

Depth to water (m BRP)	16.64
Water level status	Resting
Height of reference (m AGL)	0.13

Groundwater quality parameters

pH	6.47
EC (µS/cm)	6870
TDS (mg/L)	4467
Colour	Clear

Comments

Groundwater reported to be highly corrosive, riser frequently replaced.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 57407

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	3/SP162568		

Bore identification & use

Bore status	Yes
Primary use of bore	Stock
Landholder bore name	Twelve mile
Latitude	-23.946
Longitude	148.697

Bore construction

Drilling records available	Yes
Date drilled/constructed	1979
Bore depth (m)	36.6
Water strike (m BGL)	12.2
Airlift yield during drilling (L/s)	1
Geological formation screened	Basalt
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	190 cows
Site storage & capacity (L)	2 x 75,000

Groundwater level

Depth to water (m BRP)	12.93
Water level status	Resting
Height of reference (m AGL)	Ground level

Groundwater quality parameters

pH	7.17
EC (µS/cm)	1403
TDS (mg/L)	912
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

BLACKWATER MINE GROUNDWATER BORE CENSUS

Bore ID 57410

Landholder	Hutton	Census date	04/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	9/SP187935		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Home bore
Latitude	-23.996
Longitude	148.717

Bore construction

Drilling records available	Yes
Date drilled/constructed	1913?
Bore depth (m)	24.4
Water strike (m BGL)	12.2
Airlift yield during drilling (L/s)	0.1
Geological formation screened	Undivided Permian Upper
Casing material	Open hole
Casing diameter (mm)	Unknown

Bore pump

Pumping equipment	Windmill
Pump depth (m BGL)	15 (estimate)
Power supply	Windmill
Frequency of use	Not in use
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	7.4
Water level status	Resting
Height of reference (m AGL)	0.3

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Bore can be used if needed, alternative bore preferable due to location. Likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 62662

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	3/SP162568		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Cecils bore
Latitude	-23.980
Longitude	148.672

Bore construction

Drilling records available	Yes
Date drilled/constructed	1982
Bore depth (m)	52
Water strike (m BGL)	30
Airlift yield during drilling (L/s)	2.3
Geological formation screened	Undivided Permian Upper
Casing material	Unknown
Casing diameter (mm)	Unknown

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	280 cows
Site storage & capacity (L)	10,000

Groundwater level

Depth to water (m BRP)	36.6
Water level status	Pumping
Height of reference (m AGL)	0.1

Groundwater quality parameters

pH	7.5
EC (µS/cm)	4091
TDS (mg/L)	2260
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 57408

Landholder	Hutton	Census date	04/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	9/SP187935		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Struans bore
Latitude	-24.037
Longitude	148.659

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	46.9
Water strike (m BGL)	42.7
Airlift yield during drilling (L/s)	0.5
Geological formation screened	Bandanna Formation
Casing material	Unknown
Casing diameter (mm)	Unknown

Bore pump

Pumping equipment	Windmill
Pump depth (m BGL)	Unknown
Power supply	Windmill
Frequency of use	Not in use
Typical pumping rate	Low
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	-
Water level status	-
Height of reference (m AGL)	-

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Bore is screened across Bandanna Formation which is equivalent to Rangal Coal Measures.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 62660

Landholder	Hutton	Census date	05/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	9/SP187935		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Thomas bore
Latitude	-24.05
Longitude	148.70

Bore construction

Drilling records available	Yes
Date drilled/constructed	1983
Bore depth (m)	100
Water strike (m BGL)	45
Airlift yield during drilling (L/s)	1.5
Geological formation screened	Bandanna Formation
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Absent
Pump depth (m BGL)	-
Power supply	-
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	-
Water level status	-
Height of reference (m AGL)	-

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Bore is screened across Bandanna Formation which is equivalent to Rangal Coal Measures. Obstruction in bore at 29 m.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 132658

Landholder	Hutton	Census date	05/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	8/WNA107		

Bore identification & use	
Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Drought bore
Latitude	-24.026
Longitude	148.641

Bore construction	
Drilling records available	Yes
Date drilled/constructed	2009
Bore depth (m)	75
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Bandanna Formation
Casing material	PVC
Casing diameter (mm)	125

Bore pump	
Pumping equipment	None
Pump depth (m BGL)	-
Power supply	-
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level		Groundwater quality parameters	
Depth to water (m BRP)	28.75	pH	-
Water level status	Resting	EC (µS/cm)	-
Height of reference (m AGL)	0.44	TDS (mg/L)	-
		Colour	-

Comments

Bore is screened across Bandanna Formation which is equivalent to Rangal Coal Measures.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 62661

Landholder	Hutton	Census date	05/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	8/WNA107		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Half share bore
Latitude	-23.975
Longitude	148.639

Bore construction

Drilling records available	Yes
Date drilled/constructed	1982
Bore depth (m)	73.5
Water strike (m BGL)	35
Airlift yield during drilling (L/s)	1
Geological formation screened	Undivided Permian Upper
Casing material	PVC
Casing diameter (mm)	140

Bore pump

Pumping equipment	Windmill
Pump depth (m BGL)	Unknown
Power supply	Windmill
Frequency of use	Not in use
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	32.1
Water level status	Resting
Height of reference (m AGL)	0

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Intending to equip with solar pump in future and commence use. Bore likely screened across Rangal Coal Measures.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 1

Landholder	Hutton	Census date	04/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	9/SP187935		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Scotts bore
Latitude	-24.007
Longitude	148.691

Bore construction

Drilling records available	No
Date drilled/constructed	1999
Bore depth (m)	Unknown
Water strike (m BGL)	33
Airlift yield during drilling (L/s)	2
Geological formation screened	Basalt
Casing material	PVC
Casing diameter (mm)	150

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	170
Site storage & capacity (L)	7,000; 10,000 & 2 x 7,000

Groundwater level

Depth to water (m BRP)	29.86
Water level status	Pumping
Height of reference (m AGL)	0.3

Groundwater quality parameters

pH	8.0
EC (µS/cm)	3,913
TDS (mg/L)	2,546
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 2

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	3/SP162568		

Bore identification & use

Bore status	In use
Primary use of bore	Stock & domestic
Landholder bore name	Council camp bore
Latitude	-23.979
Longitude	148.716

Bore construction

Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Basalt
Casing material	PVC
Casing diameter (mm)	150

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Power
Frequency of use	Daily
Typical pumping rate (L/s)	4 (landholder estimate)
Stocking rate	260
Site storage & capacity (L)	2 x 26,000

Groundwater level

Depth to water (m BRP)	> 26*
Water level status	Pumping
Height of reference (m AGL)	0.3

Groundwater quality parameters

pH	7.38
EC (µS/cm)	2,550
TDS (mg/L)	1,655
Colour	Clear

Comments

* Dipper obstructed at 26 m BGL (top of pump?)

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 3

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	In use
Primary use of bore	Stock & domestic
Landholder bore name	Kenmare House bore
Latitude	-23.980
Longitude	148.722

Bore construction

Drilling records available	No
Date drilled/constructed	1980s (?)
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	Steel
Casing diameter (mm)	150

Bore pump

Pumping equipment	Grundfos electric submersible
Pump depth (m BGL)	Unknown
Power supply	Power
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	240
Site storage & capacity (L)	3 x 7,000

Groundwater level

Depth to water (m BRP)	27.17
Water level status	Pumping
Height of reference (m AGL)	0.2

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Water quality samples not collected as nearest sampling point was located approximately 2 km from bore.+

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 4

Landholder	Hutton	Census date	04/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	In use
Primary use of bore	stock
Landholder bore name	Ten mile bore
Latitude	-23.918
Longitude	148.725

Bore construction

Drilling records available	No
Date drilled/constructed	2006-2010
Bore depth (m)	15-18
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible pump
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	240
Site storage & capacity (L)	2 x 10,000

Groundwater level

Depth to water (m BRP)	14.12
Water level status	Resting
Height of reference (m AGL)	0.47

Groundwater quality parameters

pH	7.12
EC (µS/cm)	858
TDS (mg/L)	558
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 6

Landholder	Hutton	Census date	05/12/2018
Property name	Kenmare	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	1/SP185527		

Bore identification & use

Bore status	In use
Primary use of bore	stock
Landholder bore name	Aquila bore
Latitude	-23.923
Longitude	148.694

Bore construction

Drilling records available	No
Date drilled/constructed	2008-2010
Bore depth (m)	60-65
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	35
Power supply	Solar
Frequency of use	Daily
Typical pumping rate (L/s)	5 (landholder estimate)
Stocking rate	120 cows
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	>23*
Water level status	Resting
68Height of reference (m AGL)	0.45

Groundwater quality parameters

pH	6.53
EC (µS/cm)	2,068
TDS (mg/L)	1,340
Colour	Clear

Comments

* Dipper obstructed at 23 m BGL (top of pump?)

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 7

Landholder	Hutton	Census date	05/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	9/SP187935		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Thomas bore new
Latitude	-24.040
Longitude	148.696

Bore construction

Drilling records available	No
Date drilled/constructed	1970-1980s
Bore depth (m)	Unknowns
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	70 (?)
Power supply	Solar
Frequency of use	Daily
Typical pumping rate (L/s)	1
Stocking rate	220 cows
Site storage & capacity (L)	2 x 7,000

Groundwater level

Depth to water (m BRP)	> 38*
Water level status	Resting
Height of reference (m AGL)	0

Groundwater quality parameters

pH	7.43
EC (µS/cm)	7,358
TDS (mg/L)	4,786
Colour	Clear

Comments

* Dipper obstructed at 38 m BGL (top of pump?)

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 9

Landholder	Hutton	Census date	05/12/2018
Property name	Togara	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	8/WNA107		

Bore identification & use

Bore status	In use
Primary use of bore	
Landholder bore name	Bottom Paddock Bore
Latitude	-24.000
Longitude	148.648

Bore construction

Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	75
Water strike (m BGL)	Unknown
Airlift yield during drilling	unknown
Geological formation screened	COAL
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible pump
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	180
Site storage & capacity (L)	250,000

Groundwater level

Depth to water (m BRP)	40
Water level status	Pumping
Height of reference (m AGL)	0.16

Groundwater quality parameters

pH	7.92
EC (µS/cm)	2,712
TDS (mg/L)	1,762
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 10

Landholder	Neilsen	Census date	06/12/2018
Property name	Tolmie Creek	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	13/HT602		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	Aquila bore, paddock 1
Latitude	-23.674
Longitude	148.778

Bore construction

Drilling records available	No
Date drilled/constructed	2012-2013
Bore depth (m)	49
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	No pump
Pump depth (m BGL)	-
Power supply	solar
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	9.77
Water level status	Resting
Height of reference (m AGL)	0.91

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Strong sulfur smell from dipper when retrieved. Likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 11

Landholder	Neilsen	Census date	06/12/2018
Property name	Tolmie Creek	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	13/HT602		

Bore identification & use	
Bore status	In use
Primary use of bore	Stock
Landholder bore name	No. 4 bore
Latitude	-23.698
Longitude	148.770

Bore construction	
Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	Steel
Casing diameter (mm)	125

Bore pump	
Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	
Stocking rate	180
Site storage & capacity (L)	20,000

Groundwater level		Groundwater quality parameters	
Depth to water (m BRP)	17.62	pH	7.02
Water level status	Resting	EC (µS/cm)	7,719
Height of reference (m AGL)	0.05	TDS (mg/L)	5,018
		Colour	Clear

Comments

Likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 90483

Landholder	McCamley (leased from BHP)	Census date	06/12/2018
Property name	Memooloo	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	7/SP187934		

Bore identification & use	
Bore status	In use
Primary use of bore	Stock
Landholder bore name	Top cures
Latitude	-24.069
Longitude	148.765

Bore construction	
Drilling records available	Yes
Date drilled/constructed	1994
Bore depth (m)	104
Water strike (m BGL)	Unknown
Airlift yield during drilling (L/s)	3.8
Geological formation screened	Bandanna Formation
Casing material	PVC
Casing diameter (mm)	125

Bore pump	
Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Power
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	2,200 cows
Site storage & capacity (L)	2 x 25,000

Groundwater level	
Depth to water (m BRP)	27.76
Water level status	Resting
Height of reference (m AGL)	0.4

Groundwater quality parameters	
pH	7.79
EC (µS/cm)	3,162
TDS (mg/L)	2,055
Colour	clear

Comments

Screened across Bandanna Formation which is equivalent to Rangal Coal Measures. Bore is gassy.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

BLACKWATER MINE GROUNDWATER BORE CENSUS

Bore ID 103006

Landholder	McCamley (leased from BHP)	Census date	05/12/2018
Property name	Memooloo	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	7/SP187934		

Bore identification & use

Bore status	In use
Primary use of bore	stock
Landholder bore name	Espresso
Latitude	-24.034
Longitude	148.754

Bore construction

Drilling records available	Yes
Date drilled/constructed	1987
Bore depth (m)	104
Water strike (m BGL)	
Airlift yield during drilling	
Geological formation screened	Undivided Permian Upper
Casing material	Steel
Casing diameter (mm)	150

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Power
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	1600 cows
Site storage & capacity (L)	2 x 25,000

Groundwater level

Depth to water (m BRP)	>18*
Water level status	Pumping
Height of reference (m AGL)	0.5

Groundwater quality parameters

pH	7.77
EC (µS/cm)	2,260
TDS (mg/L)	1,469
Colour	Clear

Comments

* Bore obstructed at 18 m BGL (top of pump?). Bore likely screened across Burngrove Formation or Rangal Coal Measures.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

BLACKWATER MINE GROUNDWATER BORE CENSUS

Bore ID 57421

Landholder	McCamley (leased from BHP)	Census date	06/12/2018
Property name	Memooloo	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	7/SP187934		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	The well
Latitude	-24.002
Longitude	148.728

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	30.5
Water strike (m BGL)	18.3
Airlift yield during drilling (L/s)	1
Geological formation screened	Basalt
Casing material	Concrete
Casing diameter (mm)	8500

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Power
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	500 cows
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	21.12
Water level status	Pumping
Height of reference (m AGL)	0.34

Groundwater quality parameters

pH	7.14
EC (µS/cm)	2,229
TDS (mg/L)	1,449
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 14

Landholder	McCamley (leased from BHP)	Census date	06/12/2018
Property name	Memooloo	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	13/WNA75		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Red bore
Latitude	-24.035
Longitude	148.797

Bore construction

Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Basalt (?)
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	500 cows
Site storage & capacity (L)	2 x 25,000

Groundwater level

Depth to water (m BRP)	41.35
Water level status	Resting
Height of reference (m AGL)	0.26

Groundwater quality parameters

pH	7.34
EC (µS/cm)	1,285
TDS (mg/L)	843
Colour	clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 103349

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	-
Latitude	-23.991
Longitude	148.757

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	43
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Undivided Permian Upper
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Windmill (not operational)
Pump depth (m BGL)	-
Power supply	-
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	-
Water level status	-
Height of reference (m AGL)	-

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

BLACKWATER MINE GROUNDWATER BORE CENSUS

Bore ID 103348

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	House bore
Latitude	-23.968
Longitude	148.757

Bore construction

Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	38
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Undivided Permian Upper
Casing material	PVC
Casing diameter (mm)	125

Bore pump

Pumping equipment	Submersible pump (not operational)
Pump depth (m BGL)	Unknown
Power supply	-
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	24
Water level status	Resting
Height of reference (m AGL)	0.46

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Likely screened across Burngrove Formation. Has not been used for over 20 years.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 103347

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use	
Bore status	In use
Primary use of bore	stock
Landholder bore name	Squintys bore
Latitude	-23.980
Longitude	148.760

Bore construction	
Drilling records available	Yes
Date drilled/constructed	Unknown
Bore depth (m)	35
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Undivided Permian Upper
Casing material	Unknown
Casing diameter (mm)	Unknown

Bore pump	
Pumping equipment	Electric submersible
Pump depth (m BGL)	Unknown
Power supply	Unknown
Frequency of use	Regularly
Typical pumping rate	Unknown
Stocking rate	100 cows
Site storage & capacity (L)	Turkeys nest

Groundwater level		**Groundwater quality parameters**	
Depth to water (m BRP)	18.62	pH	6.51
Water level status	Pumping	EC (µS/cm)	5,466
Height of reference (m AGL)	0.1	TDS (mg/L)	3,556
		Colour	Clear

Comments
Bore is likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 17

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use

Bore status	Not in use
Primary use of bore	Not in use
Landholder bore name	-
Latitude	-23.982
Longitude	148.801

Bore construction

Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Windmill (not operational)
Pump depth (m BGL)	Unknown
Power supply	-
Frequency of use	-
Typical pumping rate	-
Stocking rate	-
Site storage & capacity (L)	-

Groundwater level

Depth to water (m BRP)	-
Water level status	-
Height of reference (m AGL)	-

Groundwater quality parameters

pH	-
EC (µS/cm)	-
TDS (mg/L)	-
Colour	-

Comments

Bore not used for 40 years. Bore is blocked approximately 1 m from surface.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID Unregistered 18

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use

Bore status	In use
Primary use of bore	Stock
Landholder bore name	Gorge bore
Latitude	-23.840
Longitude	148.807

Bore construction

Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Unknown
Casing material	Steel
Casing diameter (mm)	125

Bore pump

Pumping equipment	Electric submersible
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	low
Stocking rate	50 cows
Site storage & capacity (L)	2 tanks

Groundwater level

Depth to water (m BRP)	49.38
Water level status	Pumping
Height of reference (m AGL)	0.15

Groundwater quality parameters

pH	6.73
EC (µS/cm)	1,715
TDS (mg/L)	1,115
Colour	Clear

Comments

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

BLACKWATER MINE GROUNDWATER BORE CENSUS

Bore ID 57504

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use	
Bore status	In use
Primary use of bore	Stock
Landholder bore name	18 mile
Latitude	-23.809
Longitude	148.784

Bore construction	
Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Undivided Permian Upper
Casing material	Steel
Casing diameter (mm)	Unknown

Bore pump	
Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	50
Site storage & capacity (L)	2 tanks

Groundwater level		**Groundwater quality parameters**	
Depth to water (m BRP)	19.82	pH	7.65
Water level status	Pumping	EC (µS/cm)	1,613
Height of reference (m AGL)	0.12	TDS (mg/L)	1,049
		Colour	Clear

Comments

Landholder commented that this is a good yielding bore. Bore is likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Bore ID 57503

Landholder	Stewart (leased from BHP)	Census date	07/12/2018
Property name	Terang	EMM personnel	Craig Vincent / Dan Condon
Lot/Plan	12/SP185512		

Bore identification & use	
Bore status	In use
Primary use of bore	Stock
Landholder bore name	Stake bore
Latitude	-23.852
Longitude	148.755

Bore construction	
Drilling records available	No
Date drilled/constructed	Unknown
Bore depth (m)	Unknown
Water strike (m BGL)	Unknown
Airlift yield during drilling	Unknown
Geological formation screened	Undivided Permian Upper
Casing material	Steel
Casing diameter (mm)	125/150

Bore pump	
Pumping equipment	Electric submersible Grundfos
Pump depth (m BGL)	Unknown
Power supply	Solar
Frequency of use	Daily
Typical pumping rate	Unknown
Stocking rate	150 cows
Site storage & capacity (L)	3 tanks

Groundwater level	
Depth to water (m BRP)	>36*
Water level status	Pumping
Height of reference (m AGL)	0.1

Groundwater quality parameters	
pH	6.12
EC (µS/cm)	1,929
TDS (mg/L)	1,254
Colour	Clear

Comments

* Dipper obstructed at 36 m BGL (top of pump?). Bore is likely screened across Burngrove Formation.

m BGL = meters below ground, m AGL = meters above ground, m BRP = meters below reference point, L/s = litres per second, µS/cm = micro Siemens per centimetre

Appendix A-4 Groundwater Bore Installation Report

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd

SLR Project No.: 620.014601.00006 R01

11 December 2023

Australasian Groundwater and Environmental Consultants Pty Ltd

Report on

Blackwater Mine Monitoring Bore Installation Report Northern Lease Area ML1759 and ML 1762

Prepared for
BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd

Project No. G1679C May 2020
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Report on

Blackwater Mine Monitoring Bore Installation Report Northern Lease Area ML1759 and ML1762

1 Introduction

BHP Billiton Mitsubishi Alliance Coal Operations Pty Ltd (BMA) owns and operates the Blackwater Mine (BWM) which is located approximately 25 km south of the township of Blackwater in Central Queensland. The coal seams mined at the Blackwater Mine are coal seams within the Rangal Coal Measures which produce approximately 14 million tonnes of coal per year. BMA intend to expand the Blackwater mine by developing the northern and southern areas on their existing mining leases; ML1759 (SA10) and ML1762 including ML1762 (SA7). To enable future State and Federal approvals for mining activity to commence in these areas, an assessment of the hydrogeological regime and the installation of a groundwater monitoring network is required.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were commissioned by BMA to supervise the installation of ten groundwater monitoring bores and two vibrating wire piezometers (VWP) in the northern lease area and collect groundwater data during the installation process. This report presents results of the bore installation program and includes bore construction details, bore logs, groundwater levels/quality data and hydraulic conductivity data from permeability testing in the screened formations.

2 Planned monitoring network for northern lease area

The target formations for bores within the monitoring network were the alluvium along creek drainage, the Permian overburden (sandstone/siltstone), and the coal measures with the Permian Group. The rationale for selection of bore locations and target formations were provided by EMM Consulting within a GAP analysis of the Project area (2019a) and specifications for drilling and bore construction were also developed by EMM Consulting (EMM, 2019b). The planned locations are provided in Table 2-1.

Table 2-1 Planned groundwater monitoring network in northern lease area

Bore ID	Latitude	Longitude	Estimated depth (m)	Construction type	Target Unit
MB19BWM01P	-23.5869	148.8621	170	Single standpipe	Aries Coal Seam
MB19BWM02A			15	Single standpipe	Quaternary alluvium
MB19BWM03P	-23.6485	148.8474	200	Single standpipe	Aries Coal Seam
MB19BWM04R			50	Single standpipe	Rewan Group
MB19BWM05A			15	Single standpipe	Quaternary alluvium
MB19BWM06P	-23.6847	148.8408	165	Single standpipe	Aries Coal Seam
VWP19BWM01	-23.7089	148.856	260	Vibrating wire piezometer	Multiple coal seams (Aries, Castor, Pollux), overburden, & Rewan Group
MB19BWM07A			15	Single standpipe	Quaternary alluvium
MB19BWM08P	-23.7629	148.8792	185	Single standpipe	Aries Coal Seam
VWP19BWM02	-23.8019	148.8853	160	Vibrating wire piezometer	Multiple coal seams (Aries, Castor, Pollux), overburden, & Rewan Group
MB19BWM09A	-23.7385	148.8801	15		Quaternary alluvium
PB19BWM01P	-23.7089	148.8546	205	Single standpipe	Aries Coal Seam

Note: *These planned bores are provided in bore specification report by EMM Consulting (EMM, 2019b).*

The site works was modified from the above planned program by EMM and this was due to geological and hydrogeological conditions encountered during drilling onsite. These modifications to the program included changes of screened target formations and screened depths, exclusion of monitoring bores installed at specific sites and not proceeding with installing test production bores. Specifically, the reasons for the changes to the program are as follows:

- an absence of alluvium during drilling at specific locations provided merit for no monitoring bore to be installed at these sites;
- dry conditions of alluvium provided merit for the screened interval to be placed deeper within underlying weathered Tertiary or Rewan formations that are below the water table;
- insufficient yield occurred within target Aries Coal Seam to merit the installation of a test production bore;
- deviations from the geological model for the target depths of coal seams encountered during drilling; and
- opportunistically installing monitoring bores where groundwater was observed, such as at the base of weathering.

These changes from the intended planned program are discussed further in Section 3 below.

3 Drilling and monitoring bore/VWP construction

3.1 Introduction

Ten groundwater monitoring bores and two multilevel VWPs were installed at BWM between September 2019 and May 2020. A plan showing the location of the northern lease area, monitoring bores and multilevel VWPs is presented in Figure 3-1. A table summarising bore location, depth, groundwater occurrence and drilling method is provided in Table 3-1. The oversight for construction of bores and collection of groundwater data was conducted by AGE hydrogeologists.

Drilling and bore construction were undertaken by J & S Drilling Pty Ltd. The construction of the bores was completed to meet minimum construction requirements for water bores in Australia (National Uniform Drillers Licensing Committee, 2012) under a Queensland licensed Class 2 water bore driller (Ryan Sainsbury, license number #3489) from J & S Drilling Pty Ltd.

Field program delays were experienced due to wet weather conditions leading to restriction of site access (January 2019 to March 2020), redrilling of boreholes due to poor formation stability conditions, extended well development time due to poor yield and the COVID-19 outbreak (March 2020 to May 2020). These delays extended the timeframe for completing the field program.

3.2 Drilling

The boreholes were drilled using conventional rotary air drilling methods, with foam or muds being used where the formation required support.

Drilling was largely undertaken by conventional rotary air drilling methods using a 170 mm PCD hammer bit and a 170 mm PCD bit, however some boreholes required drilling by mud/foam to avoid borehole collapse. The drilling method of each borehole is provided in Table 3-1. The drilling muds consisted of natural bio-degradable polymers and were mixed and recycled through mud pits. The drilling muds were removed either prior to construction or during development.

During drilling the borehole chip samples were laid out in one metre intervals for geological logging. Hydrogeological information such as water strikes, yields, and water chemistry were also recorded by the AGE hydrogeologist. The water quality parameters recorded during drilling consisted of electrical conductivity (EC), pH, temperature, and oxidation reduction potential (ORP).

Downhole geophysical logging by MPC Kinetic was conducted in boreholes which intersected the coal seams to assist in updating the geological model with the location of coal seams and other stratigraphic boundaries. The geophysical logs also assisted with identifying coal seam depths to position the bore screened section or VWP sensors. The downhole geophysics included density, calliper and gamma logs. These boreholes were; MB19BWM01P, MB19BWM03P, MB19BWM06P, MB19BWM08P, MB19BWM27P, VWP19BWM01 and VWP19BWM02. The total depths of these bores were extended to penetrate the full thickness of the coal seams with an additional sump drilled below the coal seams so as to conduct the geophysical logging of the borehole.

Geophysical interpreted logs by MPC Kinetic are included in this report in Appendix A.

LEGEND

Proposed bores
Mining Lease

Drainage
Major drainage

Road
Major road

Inset
Blackwater Mine
Populated_places

Monitoring bore locations (northern lease)_v01
Aries Coal Seam
Aries, Castor, Pollux coal seams, overburden, and Rewan Group
Quaternary alluvium
Rewan Group

Blackwater Mine Monitoring Bore Installation Report (G1679C)

Monitoring bore and VWP locations (northern lease area)

AGE

DATE 20/05/2020

FIGURE No: **3-1**

Table 3-1 Monitoring bore details

Hole ID	Easting (GDA94, z55)	Northing (GDA94, z55)	Surface Elevation (mAHD)#	Target Lithology	Drilling Method	Groundwater Strikes (mbGL)	Total borehole depth (mbGL)
MB19BWM01P	690037	7390281	169	Aries Coal Seam	Air/mud	15	171
MB19BWM02A	690127	7390182	168	Weathered Rewan	Air	13	15
MB19BWM03P	688454	7383473	202	Aries Coal Seam	Air	149^	231.5
MB19BWM04R	688315	7383604	203	Rewan Group	Air	N/A	80
MB19BWM05A	688501	7383611	203	Weathered Rewan	Air	N/A	15
MB19BWM06P	687698	7379464	214	Aries Coal Seam	Air	98^	186
MB19BWM07A	689279	7376877	198	Quaternary alluvium	Air	Dry	7
MB19BWM08P	691542	7370739	224	Aries Coal Seam	Air	181^	198
MB19BWM09A*	691621	7373456	205	Quaternary alluvium	Air	Dry	15
MB19BWM09Ar*	691621	7373456	205	Quaternary alluvium	Air	Dry	15
MB19BWM25P	689259	7376879	192	Weathered Rewan	Air	17	20
MB19BWM27P	688958	7376559	198	Aries Coal Seam	Air/mud	30	189
VWP19BWM01	689178	7376893	198	Multiple coal seams (Aries, Castor, Pollux), coal overburden, & Rewan Group	Air	12.5	271.5
VWP19BWM02	691839	7365920	249	Multiple coal seams (Aries, Castor, Pollux), coal overburden, & Rewan Group	Air	99	174

Notes: *RL surface (mAHD) – elevation on top of cement plinth (meters Australian height datum).*
na = not available.
** Borehole abandoned – target lithology not intercepted.*
mbGL – metres below ground level.
^ Data affected by water injection.
 # Recorded with a hand-held GPS (3 m accuracy).

3.3 Monitoring bores

3.3.1 Construction details

Ten groundwater monitoring bores were installed in the northern lease area at Blackwater Mine and their locations are presented in Figure 3-1. The construction logs for each groundwater monitoring bore are provided in Appendix A.

Monitoring bores were constructed using 50 mm internal diameter uPVC casing (PN18) with 1 mm machine slotted screens. The casing had threaded joins with rubber O-ring seals that were screwed together tightly during installation. A sand filter pack consisting of 3 mm to 5 mm washed quartz sand was installed to at least 1 m above the top of each screen. The bores were sealed from overlying formations by bentonite and grout (bentonite and cement) seals. The bores were completed with a 100 mm steel monument and a concrete pad around the monument. Where required, monitoring bores had surface casing installed to prevent collapsing of unstable weathered sediments with 200 mm diameter Class 9 uPVC casing grouted in place. Grout was mixed with an agitator and then pumped into the annulus between the casing and the hole using a flexi-drive pump. A HDPE tremie pipe was used to pump grout to the target depth.

Bores planned to be installed in the alluvium for groundwater monitoring were not successful due to dry conditions of the alluvium or there was no alluvium intersected at the planned locations. The following is a summary of outcomes for the planned alluvium bore sites:

- MB19BWM09A: No monitoring bore was installed. Two boreholes were drilled (MB19BWM09A and MB19BWM09Ar) and the target lithology of alluvium was not intercepted. The boreholes were grouted up.
- MB19BWM05A was installed in slightly weathered claystone (Rewan Formation) beneath soil and silty clay which is possibly alluvium or a product of the weathering of the claystone. No water was intersected during drilling, and it was completed as a dry bore.
- MB19BWM07A, was installed in alluvial gravels, no water was intersected during drilling, and it was completed as a dry bore.
- Monitoring bore MB19BWM02A was installed at 15 m below ground level (m bgl) in weathered claystone/siltstone/sandstone (Tertiary sediments?) as the alluvium was dry and water was intersected at 17 m bgl. The water level rose to approximately 7 m bgl after development within weathered claystone.

The site of PB19BWM01P was intended to be a test production bore. However, there was insufficient yield in the Aries seam during drilling of the borehole to merit the installation of a test production bore for conducting a pumping test. At this location a monitoring bore (MB19BWM27P) was installed into the Aries seam. There were two initial attempts at drilling and installing the bore casing, but they failed due to unstable borehole conditions. The two unsuccessful holes were grouted up. No pumping bores were installed in the northern lease.

Monitoring bore MB19BWM25P was opportunistically added to the network because water was intersected at the base of weathering in this location, which will provide useful data for future analysis.

Table 3-2 Bore construction details

Borehole ID	Lithology screened	Top of gravel pack (mbgl)	Top of screen (mbgl)	Base of screen (mbgl)	Stick-up	Date of water level	Water level (mbgl)	Water level (mAHD)
MB19BWM01P	Aries Coal Seam	166	168	171	0.60	17/12/2019	13.05	155.95
MB19BWM02A	Siltstone (Weathered Rewan)	10	12	15	0.50	17/12/2019	7.17	160.82
MB19BWM03P	Aries Coal Seam	220.5	222.5	231.5	0.65	15/12/2019	22.33	179.67
MB19BWM04R	Sandstone (Rewan)	69	71	80	0.6	15/12/2019	36.09	166.91
MB19BWM05A	Claystone (Weathered Rewan)	7	9	15	0.60	18/12/2019	Dry	Dry
MB19BWM06P	Aries Coal Seam	178	180	186	0.55	16/12/2019	12.02	201.98
MB19BWM07A	Alluvium	3.5	4	7	0.60	18/12/2019	Dry	Dry
MB19BWM08P	Aries Coal Seam	182	184	190	0.60	19/12/2019	12.23	211.77
MB19BWM09A	Hole abandoned – no alluvium intercepted during drilling							
MB19BWM09Ar	Hole abandoned – no alluvium intercepted during drilling							
MB19BWM25P	Sandstone (Weathered Rewan)	15	17	20	0.55	16/12/2019	11.47	180.53
MB19BWM27P	Aries Coal Seam	178	180	189	0.50	19/12/2019	5.38	192.62

Notes: *mAHD – meters Australian height datum.*
mbgl – meters below ground level.

3.3.2 Monitoring bore development

The monitoring bores were developed following their installation to improve near well permeability by removing fines (sand/silt/clay) from disturbance during drilling, drilling fluids and settling the filter pack. The bores were either directly developed by air compressor or flushed with fresh water, where applicable. Airlift yields, fines content and water quality parameters were monitored during development. A summary of bore development results is provided in Table 3-3.

The bores were developed until they returned relatively clear water in most instances. Three monitoring bores (MB19BWM03P, MB19BWM04R and MB19BWM06P) had incomplete development due to low yields. In these instances, development was attempted multiple times to remove as much sediment and drilling fluids as possible and for the water quality parameters to stabilise. Monitoring bores MB19BWM01P, MB19BWM03P, MB19BWM04R, MB19BWM06P, and MB19BWM25P were developed multiple times. Flow rates during development were measured by recording the time to fill a 1-litre container or estimated where applicable. Monitoring bores MB19BWM05A and MB19BWM07A remained dry and were unable to be developed. These bores were blown with air to remove fine sediments from the gravel pack that may have entered the screen during installation.

Water quality parameters of pH, and EC were monitored regularly during development using a Myron water quality meter. Monitoring bores are considered developed when the EC and pH values had stabilised over three consecutive readings and there are no visible fines in the sample.

Table 3-3 Bore development details

Borehole ID	Pre-development SWL (mTOC)	Duration (mins)	Flow rate (L/s)	EC (µS/cm)	pH	Development method	Development complete#
MB19BWM01P	13.39	366	0.02	27,070	7.85	Air compressor	Yes
MB19BWM02A	10.43	69	0.05	36,630	7.86	Air compressor	Yes
MB19BWM03P	>100	438	~0.001	16,560	9.59	Air compressor*	No
MB19BWM04R	36.73	346	~0.001	51,850	7.60	Air compressor*	No
MB19BWM05A	Dry	-	-	-	-	-	-
MB19BWM06P	11.54	358	~0.001	19,330	8.27	Air compressor*	No
MB19BWM07A	Dry	-	-	-	-	-	-
MB19BWM08P	12.83	116	0.05	5,614	8.69	Air compressor	Yes
MB19BWM25P	11.03	479	~0.001	5,236	8.93	Air compressor	Yes
MB19BWM27P	6.40	143	0.05	14,740	8.76	Air compressor	Yes

Notes: ** Incomplete – due to low flow.*
 # Development is considered incomplete when pH and EC have not stabilised.
mTOC is metres to top of casing.

3.3.3 Data logger installation

In-Situ Level Troll pressure transducers (data loggers) were deployed in each monitoring bore. The data loggers were set to take a reading every six hours. Bores equipped with data loggers are presented in Table 3-4 and includes logger serial number, details of the depth to which the logger was installed, and date/time logging commenced.

Data loggers record absolute pressure, which is a combination of water head pressure and atmospheric pressure. Therefore, the data requires correction, obtained from a barometric logger, to remove the influence of atmospheric pressure to achieve a true measurement of groundwater level elevation.

A barometric pressure logger (In-Situ BaroTroll) was installed inside MB19BWM01P (above the water table) and set to record concurrently with the data loggers.

On 29 of April, the datalogger cable at MB19BWM03P was extended from 55.65 m to 102.5 m to accommodate for the low permeability and slow recovery time. The datalogger cable at MB19BWM06P was also extended from 60.6 m to 115.6 m for the same reason.

Table 3-4 Bores equipped with dataloggers

Bore ID	Logger depth (mbgl)	Logger serial number	Install date	Water level at time of install (mbgl)	Frequency of measurement
MB19BWM01P	50	697238	17/12/2019	13.05	6 hours
MB19BWM01P_baro	1.5	701419	17/12/2019	13.05	6 hours
MB19BWM02A	15	676461	17/12/2019	7.17	6 hours
MB19BWM03P	101.8*	697227	17/12/2019	22.33	6 hours
MB19BWM04R	75.15	699203	18/12/2019	36.09	6 hours
MB19BWM05A	15	676641	18/12/2019	Dry	6 hours
MB19BWM06P	115*	617792	18/12/2019	12.02	6 hours
MB19BWM07A	7	677565	18/12/2019	Dry	6 hours
MB19BWM08P	60	697242	19/12/2019	12.23	6 hours
MB19BWM25P	20	699385	19/12/2019	11.47	6 hours
MB19BWM27P	50	697264	19/12/2019	5.38	6 hours

Note: ** Extended the length of the original cable length.*

3.3.4 *Permeability testing*

In-situ permeability tests (falling head and rising head tests) were conducted in monitoring bores to estimate the hydraulic conductivity of geological formations screened in the bores. The results are summarised in Table 3-5. There are no test results for the alluvium as the bores were dry during the site investigations.

The falling head tests 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. The rising head tests were undertaken using a similar technique, where a solid slug was removed from the bore, resulting in a displaced lowered water level and the water level recovery was recorded.

The water level data were analysed using standard methods by Bouwer and Rice (1976) and Hvorslev (1951). The analysis was completed using the Aquifer Test 2011.1 software. The alluvium was not tested because there was no water in the alluvium bores. Five hydraulic tests performed within the Aries coal seam provided hydraulic conductivity estimates ranging from 3.3 x 10^{-2} m/d to 3 x 10^{-5} m/d. Permeability tests were conducted in three bores screened in the weathered Rewan Formation, they ranged between 3.9 x 10^{-1} m/d to 5 x 10^{-4} m/d. A permeability test was also performed in the Rewan Group at MB19BWM04R which recorded an average value of 8.0 x 10^{-4} m/d.

The rising head test analyses were performed on the post-development recovery data at MB19BWM03P and MB19BWM06P. This is due to the difficulties in performing the rising and falling head tests using the slug method due to rate of recovery. The recovery of MB19BWM03P and MB19BWM06P post-development took between one to two months. The coal seams intersected at MB19BWM03P and MB19BWM06P are considered aquitards, based on the permeability results. Once these bores have recovered to static regional water level, the falling head test and rising head test should be performed again using a solid slug.

The graphical analyses for each monitoring bore are presented in Appendix D. The falling head tests for MB19BWM03P and MB19BWM06P have also been included in Appendix D, however they are only considered indicative of the permeability in the Aries coal seam at those locations because the falling head tests didn't fully recover to a static water level.

Table 3-5 Hydraulic conductivity results

Bore ID	Formation	Falling head test (m/day)	Rising head test (m/day)	Mean hydraulic conductivity (m/day)	Analysis method
MB19BWM01P	Aries Coal Seam	0.037	0.028	0.033	Bouwer & Rice
MB19BWM02A	Siltstone (Weathered Rewan)	0.37	0.41	0.39	Bouwer & Rice
MB19BWM03P	Aries Coal Seam	N/A	0.00003	0.00003	Hvorslev
MB19BWM04R	Sandstone (Rewan)	0.0013	0.0004	0.0008	Bouwer & Rice
MB19BWM05A	Claystone (Weathered Rewan)	Dry	-	-	-
MB19BWM06P	Aries Coal Seam	N/A	0.00007	0.00007	Bouwer & Rice
MB19BWM07A	Alluvium	Dry	-	-	-
MB19BWM08P	Aries Coal Seam	0.023	0.024	0.024	Hvorslev
MB19BWM25P	Sandstone (Weathered Rewan)	0.003	0.0005	0.002	Hvorslev
MB19BWM27P	Aries Coal Seam	0.024	0.03	0.027	Hvorslev

Note: m/day = metres per day.

3.4 Multilevel Vibrating Wire Piezometers

The multilevel VWPs, (VWP19BWM01 and VWP19BWM02) were installed and grouted by J & S Drilling under the guidance of the AGE Hydrogeologist. The location of the VWPs are presented on Figure 3-1and the installation details are presented in Table 3-6. The construction logs are provided in Appendix B and the piezometer sensor calibration certificates are presented in Appendix E.

Prior to installation, the depth of the borehole was measured to ensure the hole was open to the required depth and flushed to remove any obstructions. Each VWP sensor was checked and prepared as per the manufacture's specification and the surface calibration factors for each piezometer recorded. The sensor depths were measured and marked on 32 mm blue line poly pipe. Two lengths of poly pipe were used, one extended to the full depth of the sensors, and the other poly extended part way downhole in order to act and assist as a secondary grout line.

A weighted length of steel was attached to the base of the poly pipe to keep the poly pipe straight and assist with the VWP sensors being positioned at the targeted depths.

The array was lowered down into the drill hole and suspended at the specified depth with a clamp. Prior to grouting, the sensors were checked to confirm none had been damaged during installation. A 2.5% bentonite/cement grout mix was used to grout the VWP array in the borehole.

Table 3-6 Vibrating wire piezometer details

VWP ID	Surface elevation	Sensor number	Serial number	Target unit	Sensor depth / elevation	
					Depth (mbgl)	(mAHD)
VWP19BWM01	198.0	VWP1	S2178	Overburden	46.0	152.0
		VWP2	S2179	Overburden	104.0	94.0
		VWP3	S2125	Aries Seam	125.0	73.0
		VWP4	S2126	Interburden	154.0	44.0
		VWP5	S2127	Pollux Seam	186.0	12.0
VWP19BWM02	249.0	VWP1	S2352	Overburden	87.5	161.5
		VWP2	S2353	Aries Coal Seam	101.0	148.0
		VWP3	S2180	Castor Coal Seam	112.0	132.0
		VWP4	S2181	Pollux Coal Seam	127.0	122.0
		VWP5	S2182	Rewan Group	149.0	100.0

Notes: *mAHD - metres Australian Height Datum.*
mbgl - metres below ground level.

4 References

Bouwer, H. and. Rice, R.C (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.

Hvorslev, M., (1951), *Time Lag and Soil Permeability in Ground-Water Observations*, Waterways Exper. Sta. Corps of Engrs, U.S. Army, Vicksburg.

EMM Consulting (EMM) (2019a), *Blackwater Mine - Groundwater GAP analysis and monitoring recommendations, prepared for BHP Billiton Mitsubishi Alliance, February 2019, B180329RP#1.*

EMM Consulting (EMM) (2019b), *Blackwater Mine Groundwater Monitoring Program – Drilling Specification*, prepared for BHP Billiton Mitsubishi Alliance March 2019, B180329RP#2.

National Uniform Drillers Licensing Committee, (2012), *Minimum construction requirements for water bores in Australia*, Third edition, February 2012.

Appendix A Geophysical logs

QUICKLOOK LITHOLOGY LOG

MB19BWM01P

MPC KINETIC

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	MB19BWM01P	**LOCATION**	MB19BWM01P	**COUNTRY**	AUSTRALIA

LOCATION: MB19BWM01P
FIELD: BLW
STATE: QLD
WELL: MB19BWM01P
COMPANY: BMA

	ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM		
DRILLING MEASURED FROM	KB	1.
PERMANENT DATUM	DF	2.
PERMANENT DATUM ELEVATION	GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	16-11-2019			RECORDED BY	KAR		
TIME	13-07			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	192m			RIG NUMBER			
DEPTH-LOGGER	177.99m			TOOL TYPE	9239C		
BIT SIZE	171mm			TOOL SERIAL NO.	2807		
CASING TYPE	PVC			EASTING	690029		
CASING ID	200mm			NORTHING	7390275		
CASING BOTTOM	15m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	7.2m			SOURCE TYPE	CS137	SOURCE ID	CZ3498

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

- **CO - Coal**
- **CF - Inferior Coal**
- **ST - SILTSTONE**
- **S1 - Sandstone - very fine grained**
- **S2 - Sandstone - fine grained**
- **S3 - Sandstone - fine to medium grained**
- **S4 - Sandstone - medium grained**

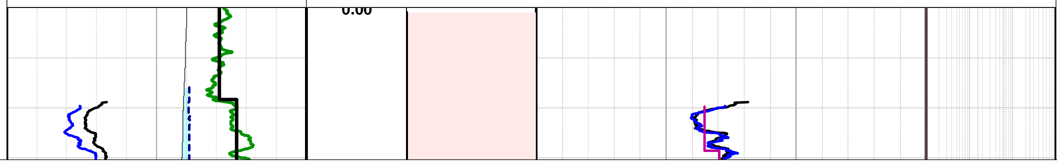
MNEMONICS

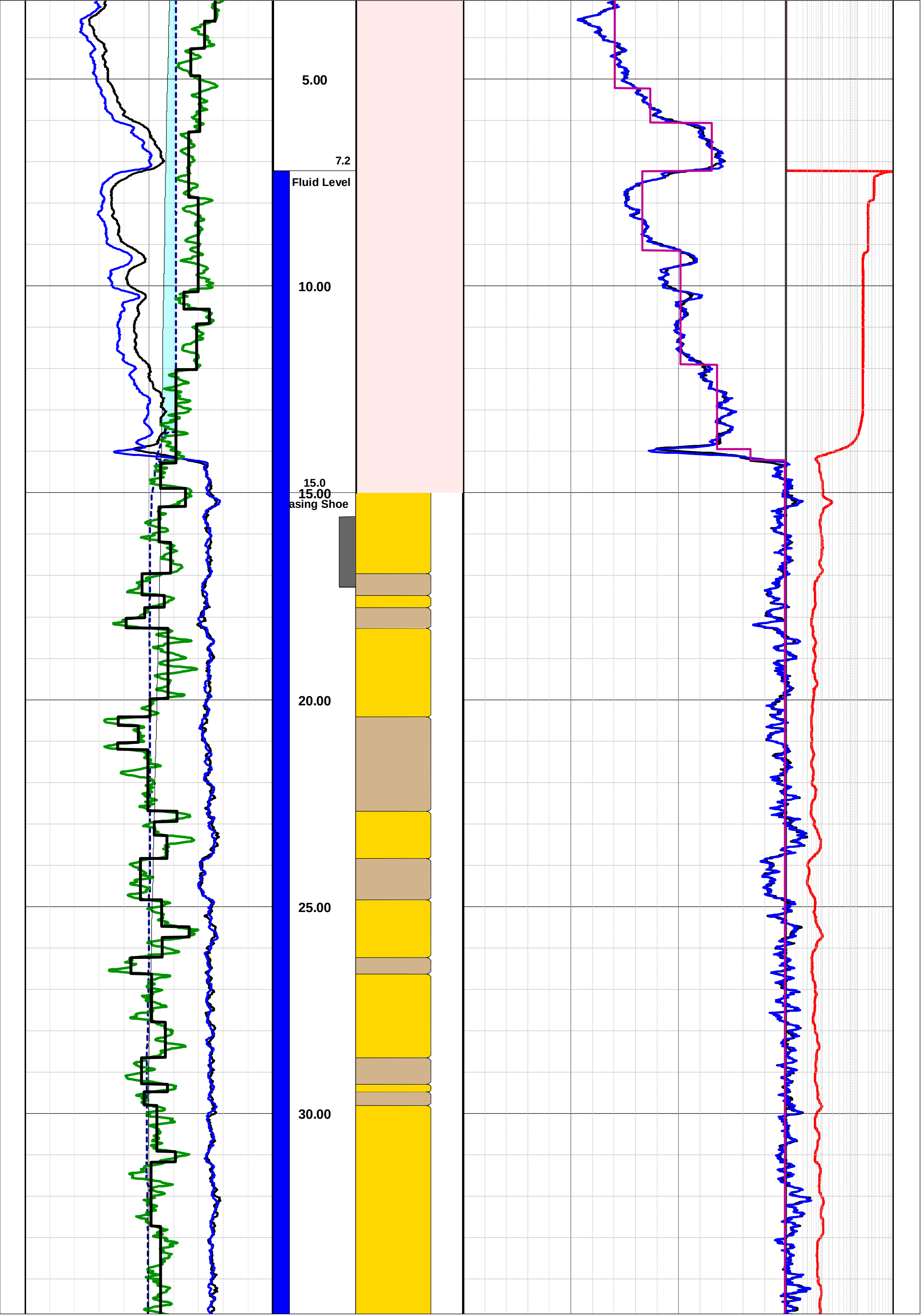
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

IMPORTANT NOTE	The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

Track	Left	Unit	Right
DEN(LS)	1	g/cc	3
DEN(SS)	1	g/cc	3
CALIPER	50	mm	300
GAM(NAT)	200	API	0
NOM_BIT	50	mm	300
SANG	0	DEG	20
Depth		1m:100m	
DATA_FLAG			
WT_FLAG			
COKED_COAL			
LITHOLOGY			
CASING			
RES(SG)	1	OHM-M	1000
DEN(COD)	1	g/cc	3
DEN(ER)	1	g/cc	3

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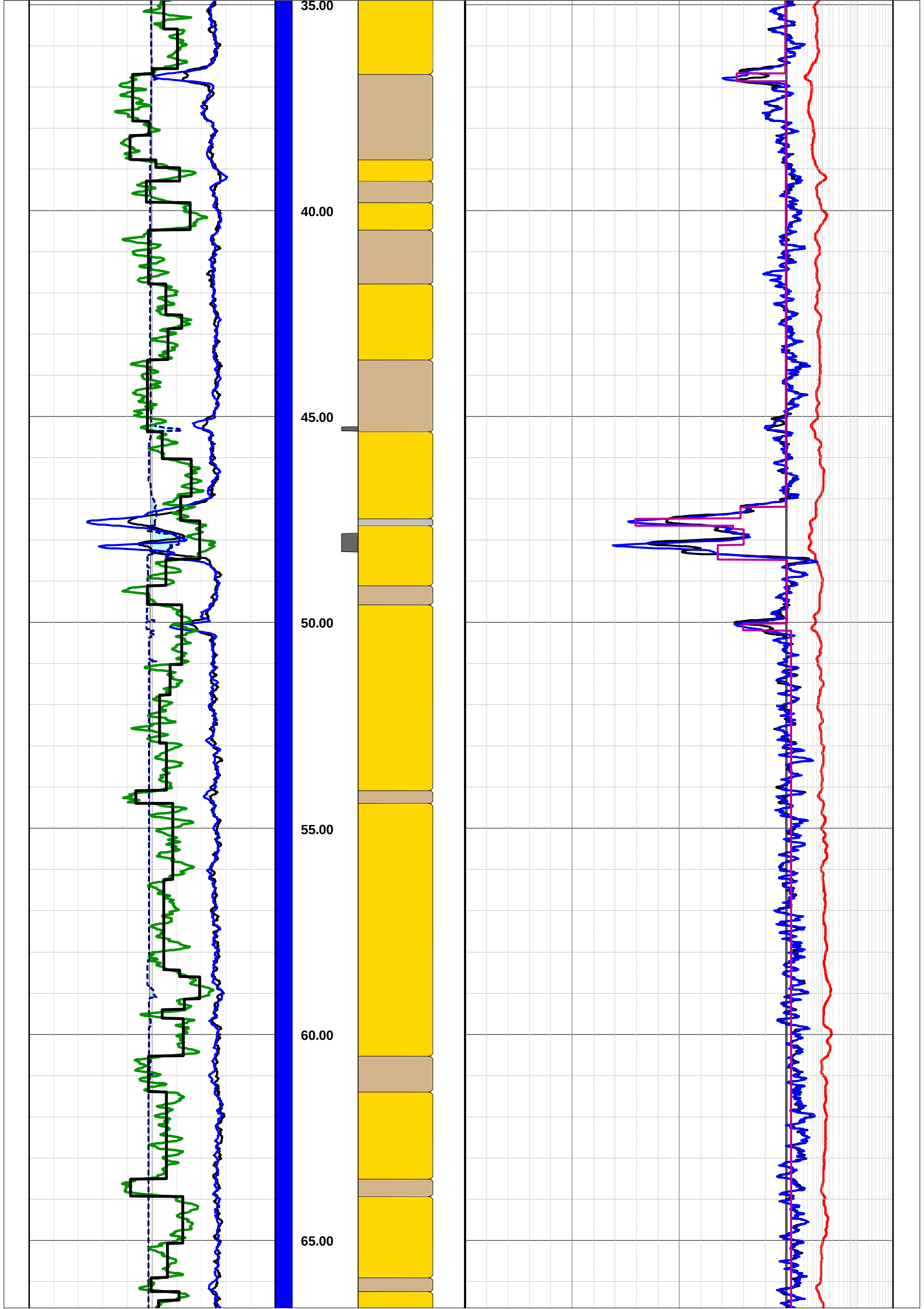
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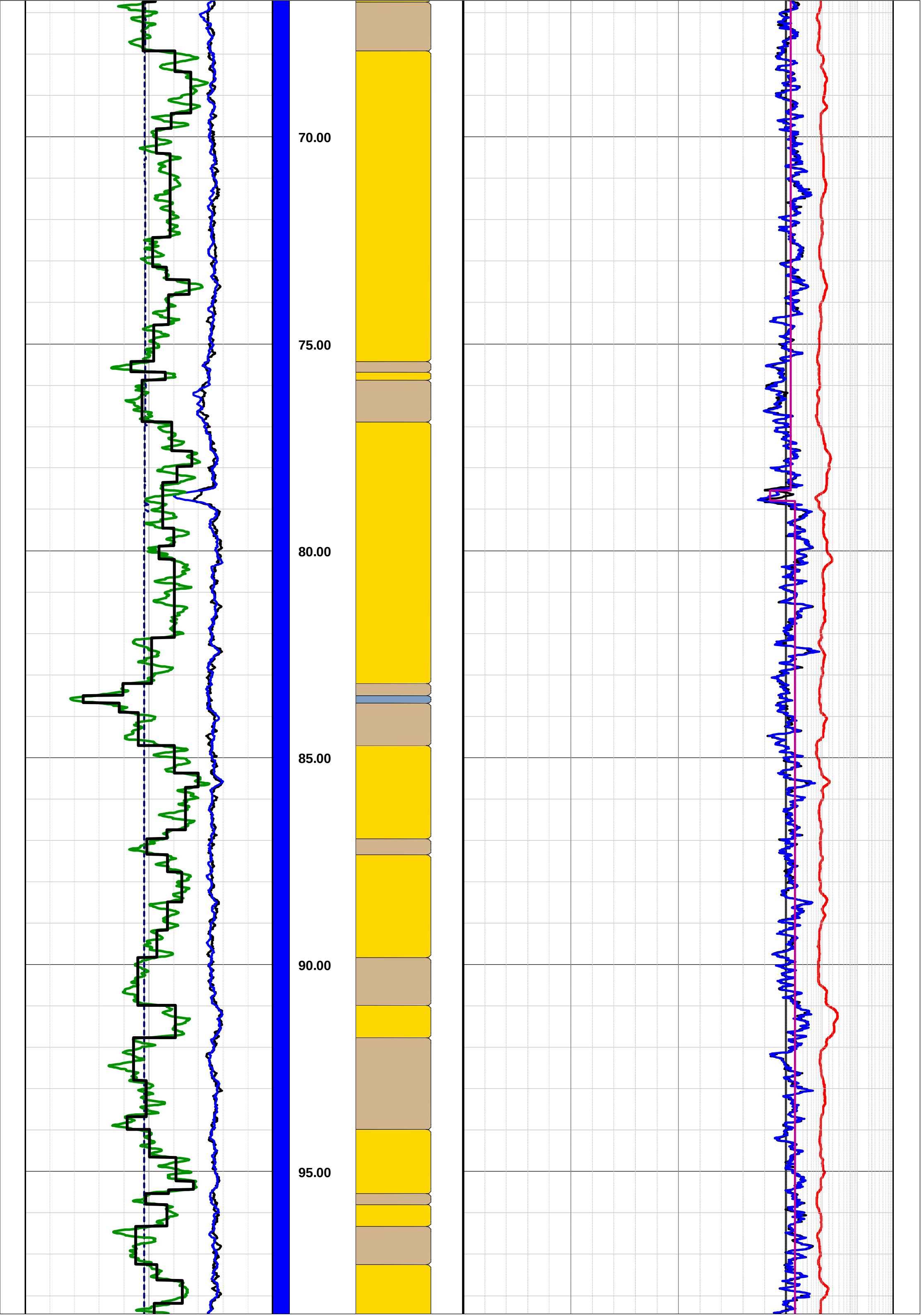
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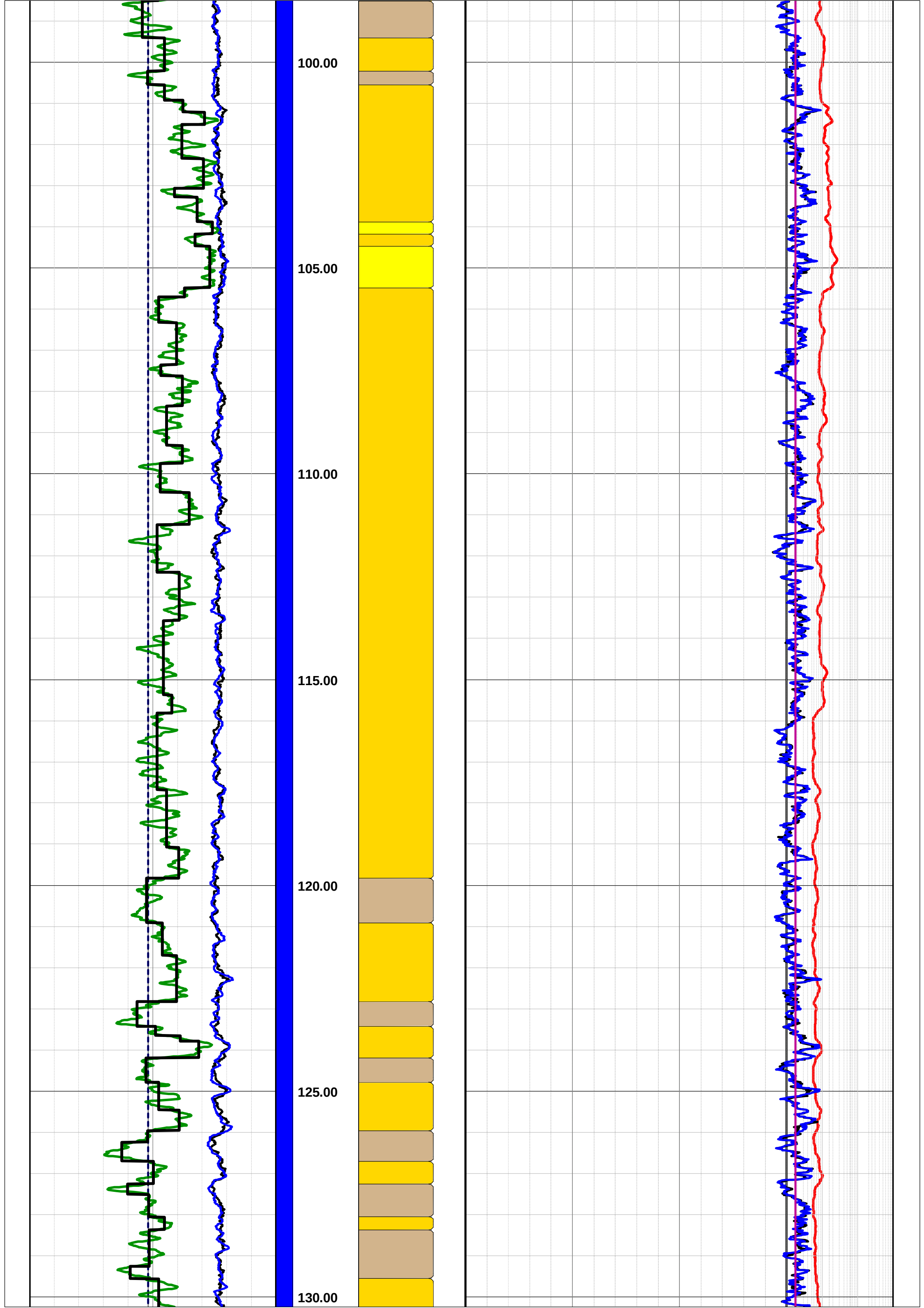
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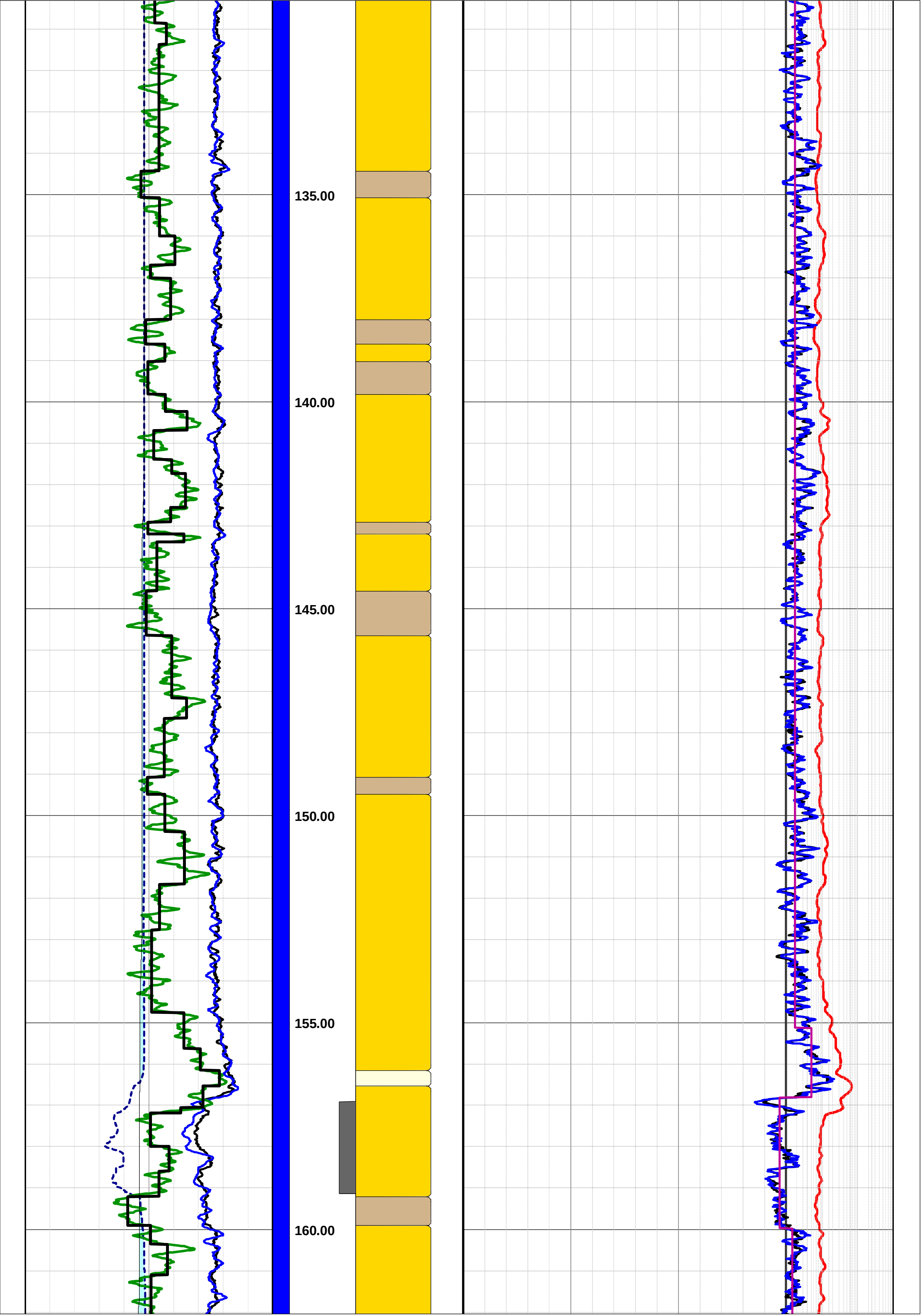
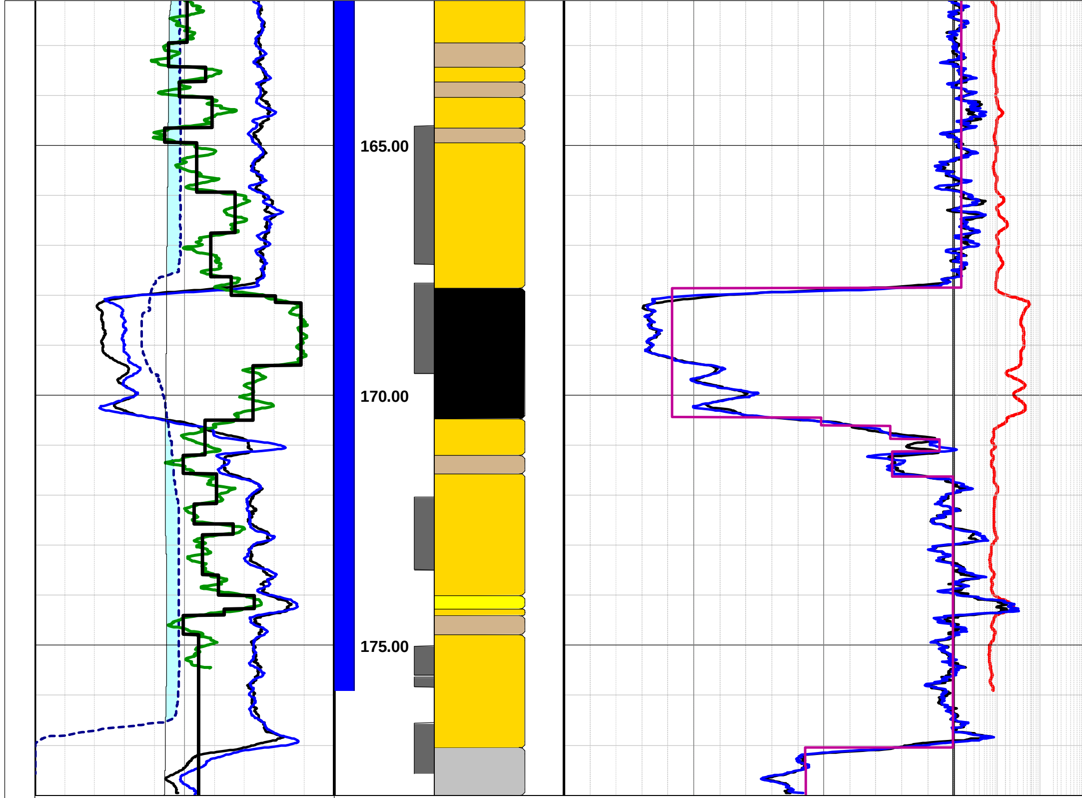


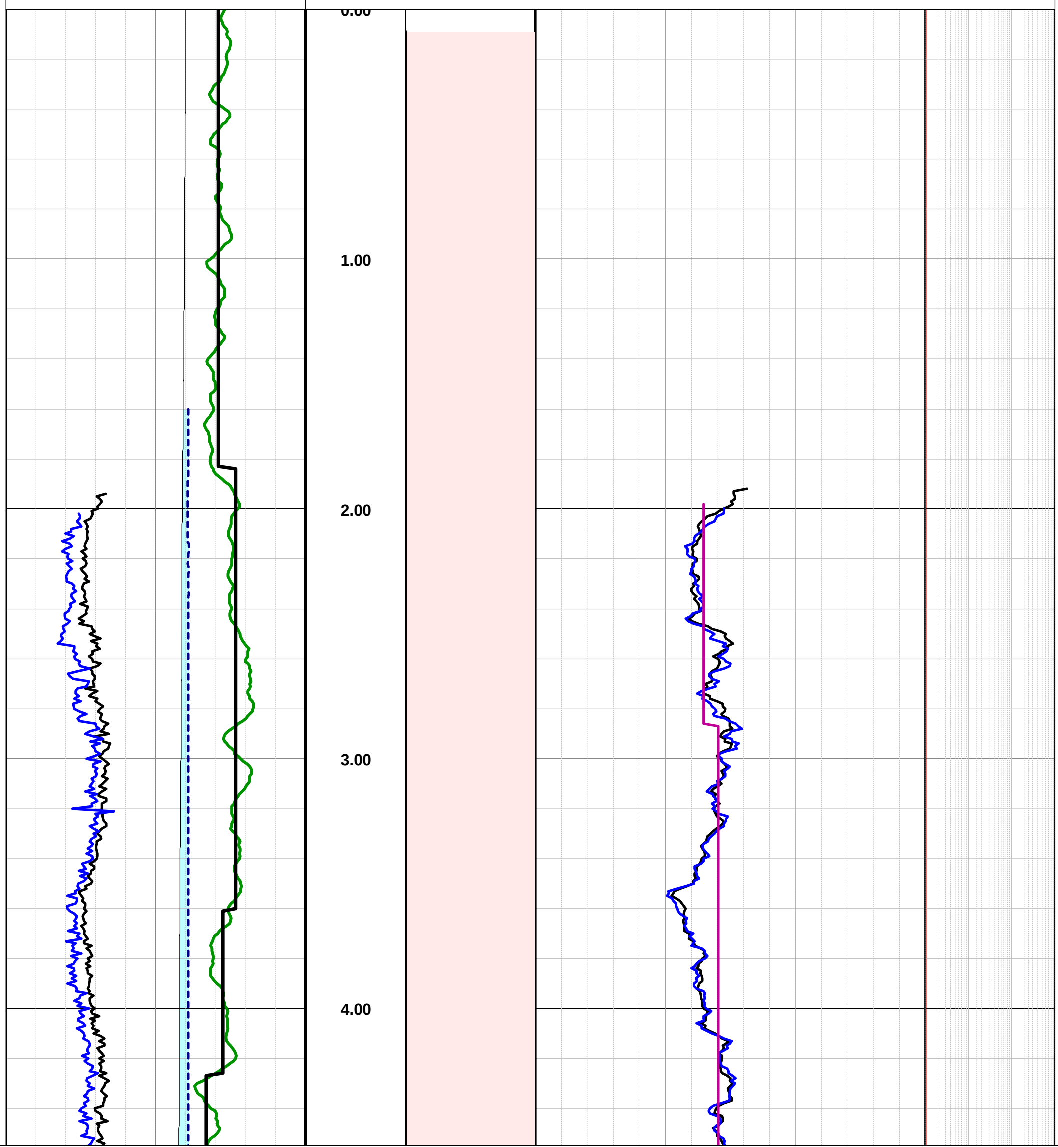


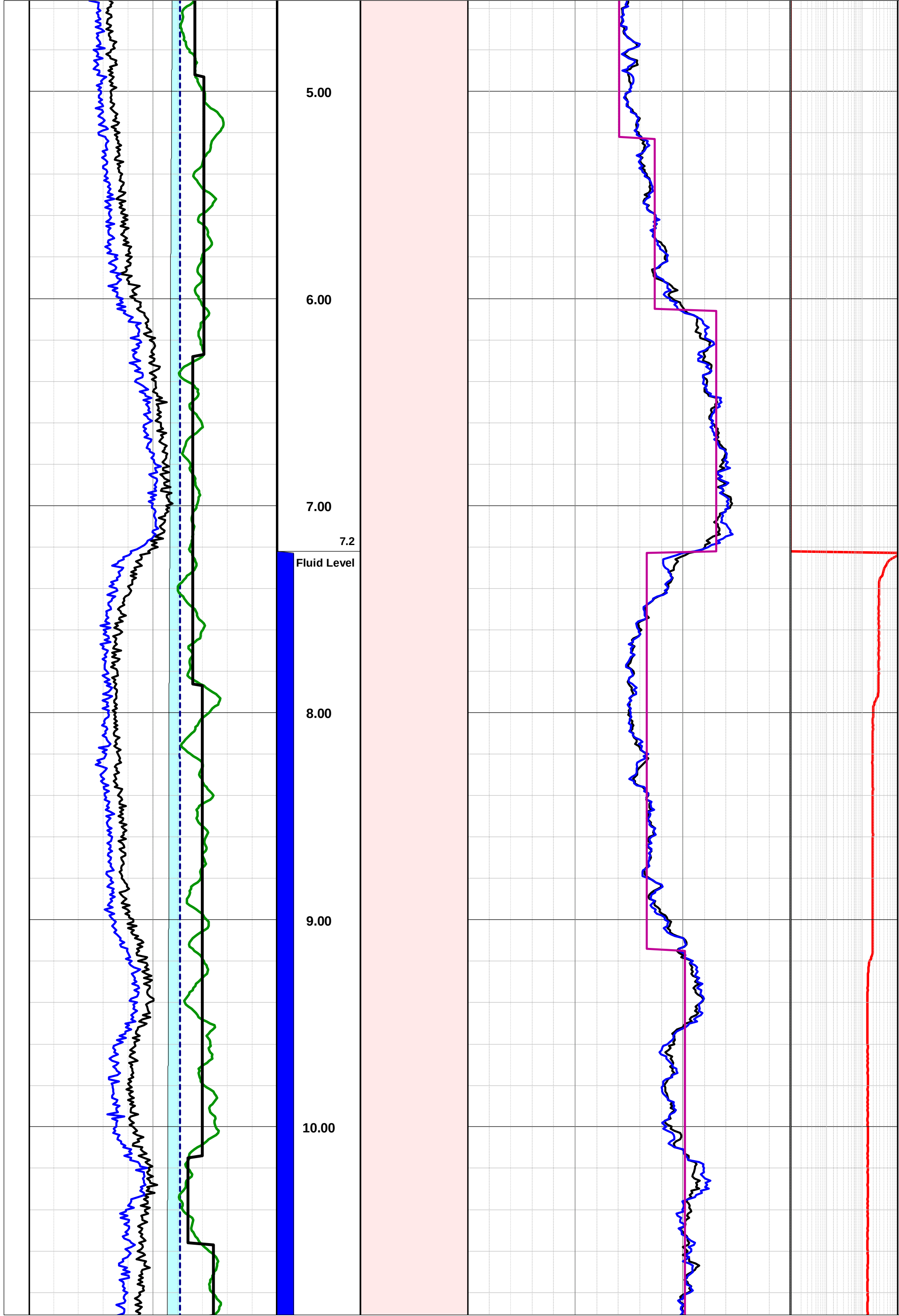
Scale	Curve
0 DEG 20	SANG
50 mm 300	NOM_BIT
200 API 0	GAM(NAT)
50 mm 300	CALIPER
1 g/cc 3	DEN(SS)
1 g/cc 3	DEN(LS)
	WT_FLAG
	DATA_FLAG
1m:100m	Depth
	CASING
	LITHOLOGY
	COKED_COAL
1 g/cc 3	DEN(ER)
1 g/cc 3	DEN(COD)
1 OHM-M 1000	RES(SG)

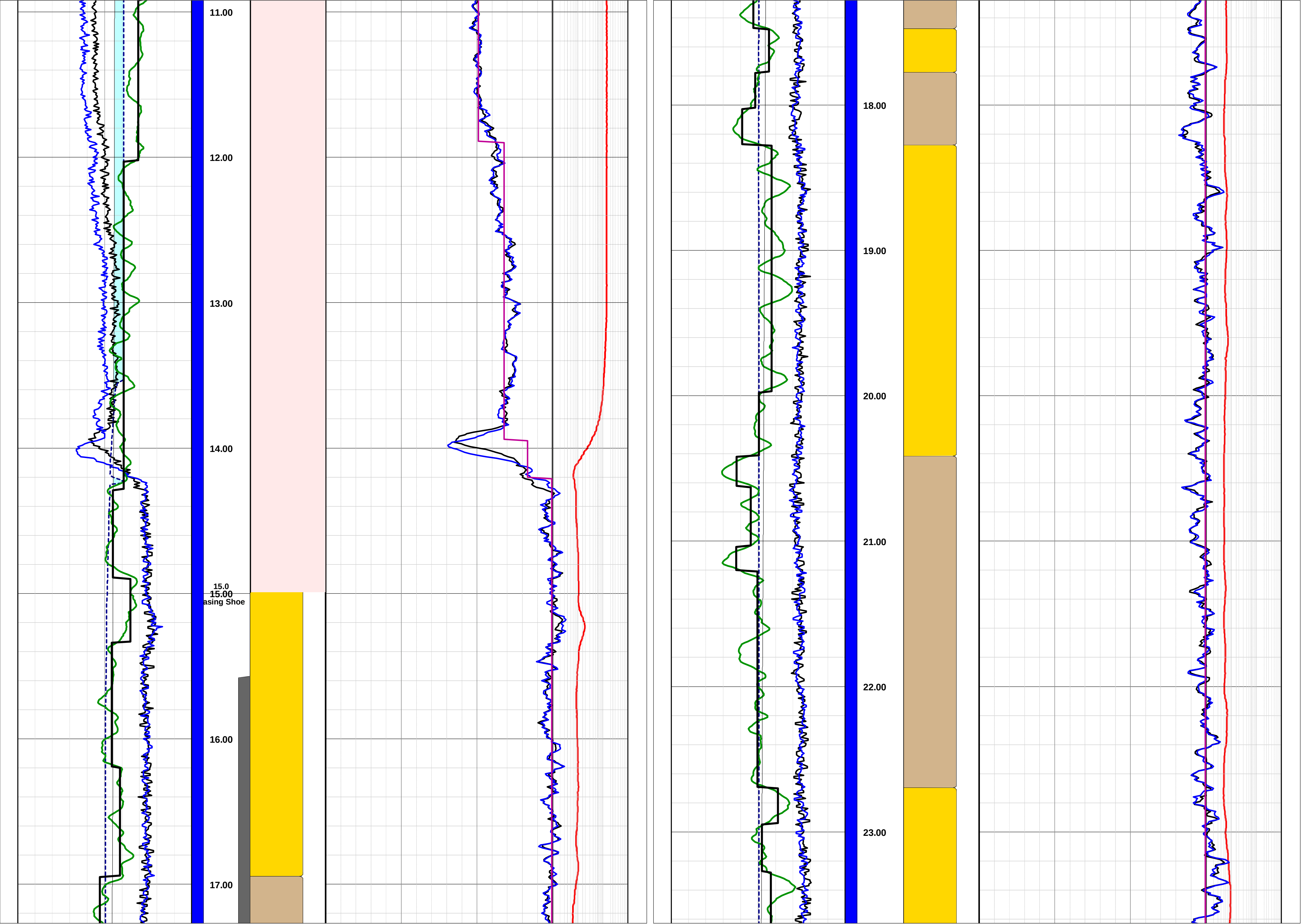
DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) 1 g/cc 3	Depth 1m:20m	COKED_COAL		RES(SG) 1 OHM-M 1000
DEN(SS) 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) 1 g/cc 3	
CALIPER 50 mm 300	WT_FLAG 0 5	CASING	DEN(ER) 1 g/cc 3	
GAM(NAT) 200 API 0				
SANG 0 DEG 20				







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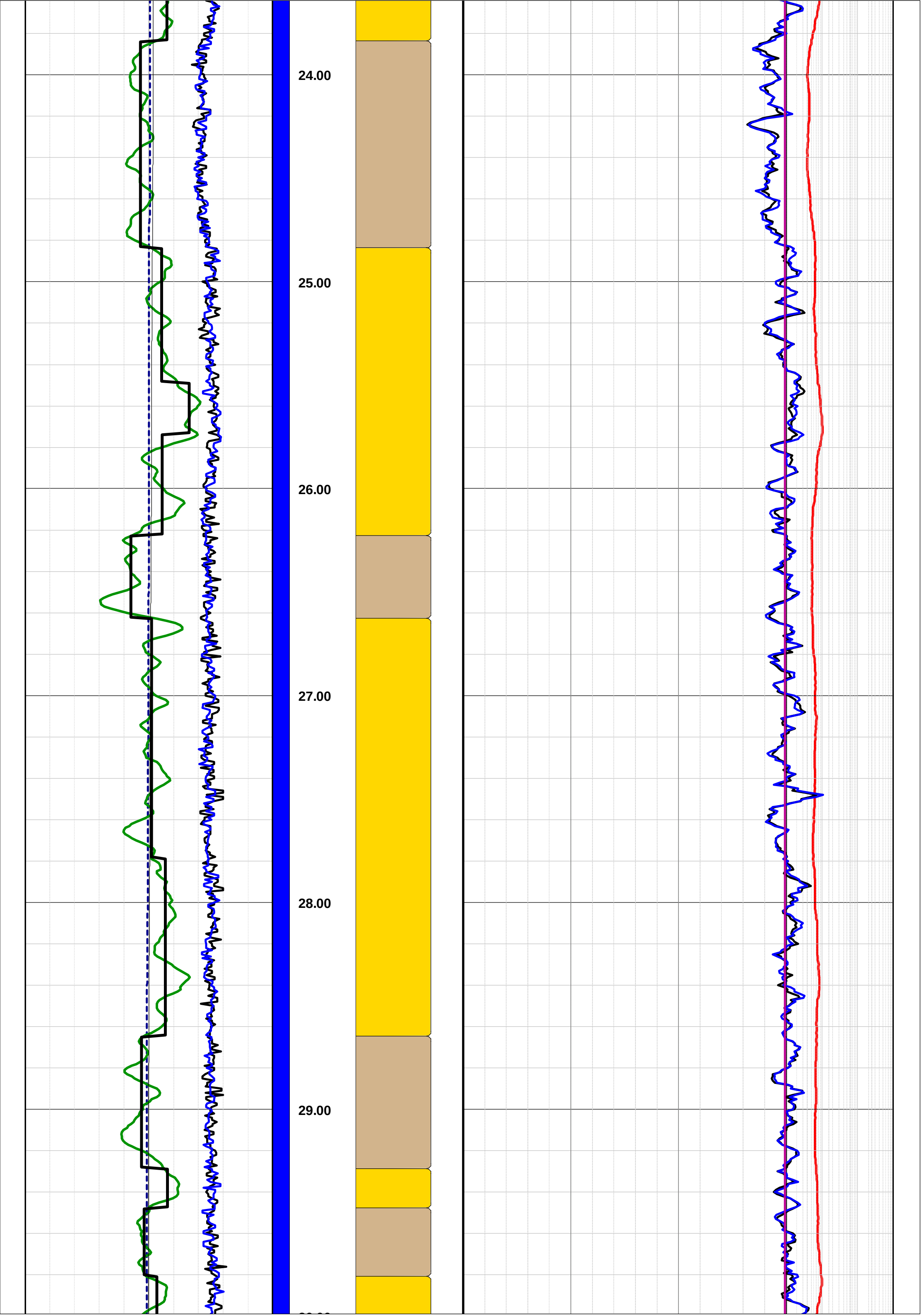
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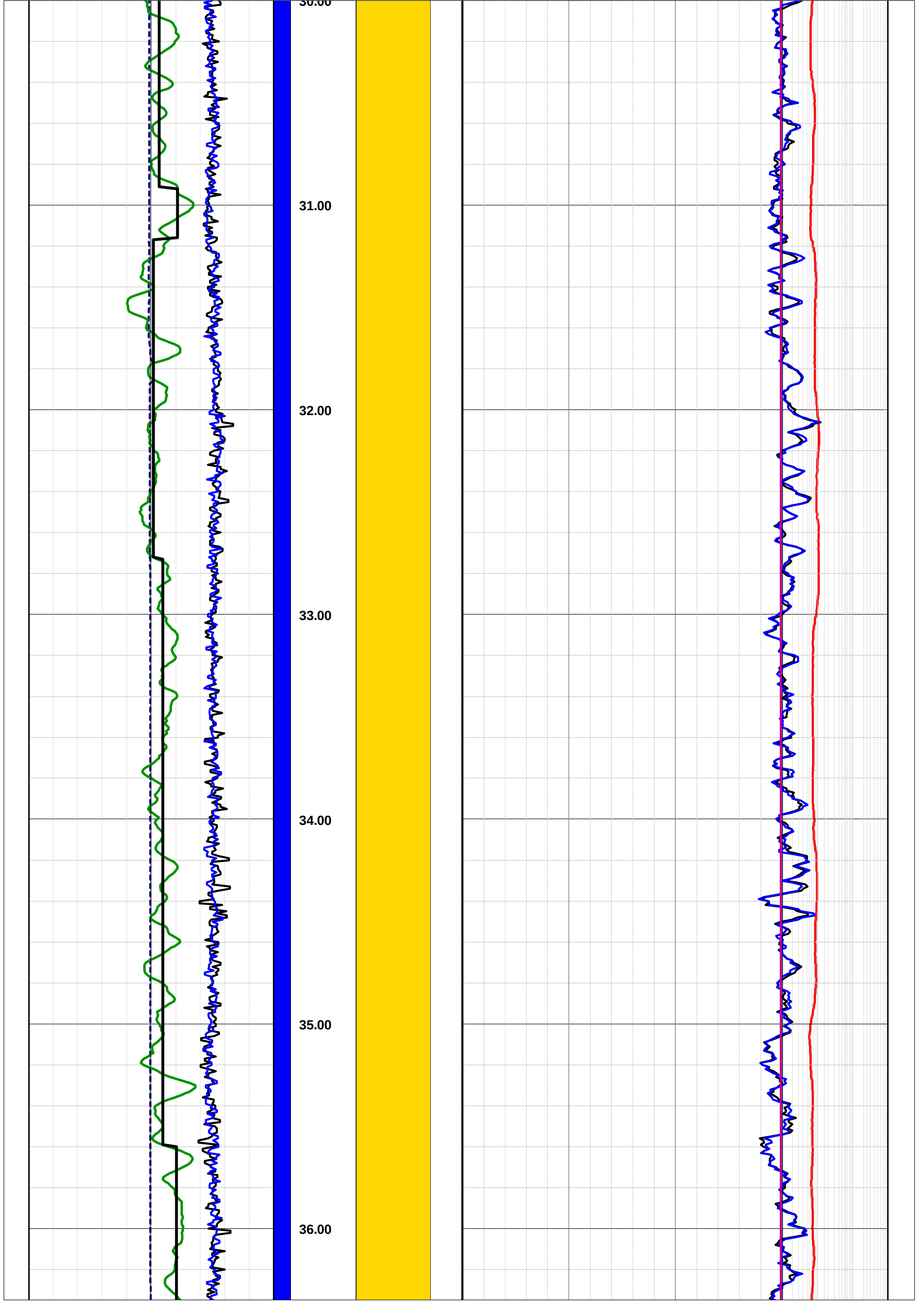
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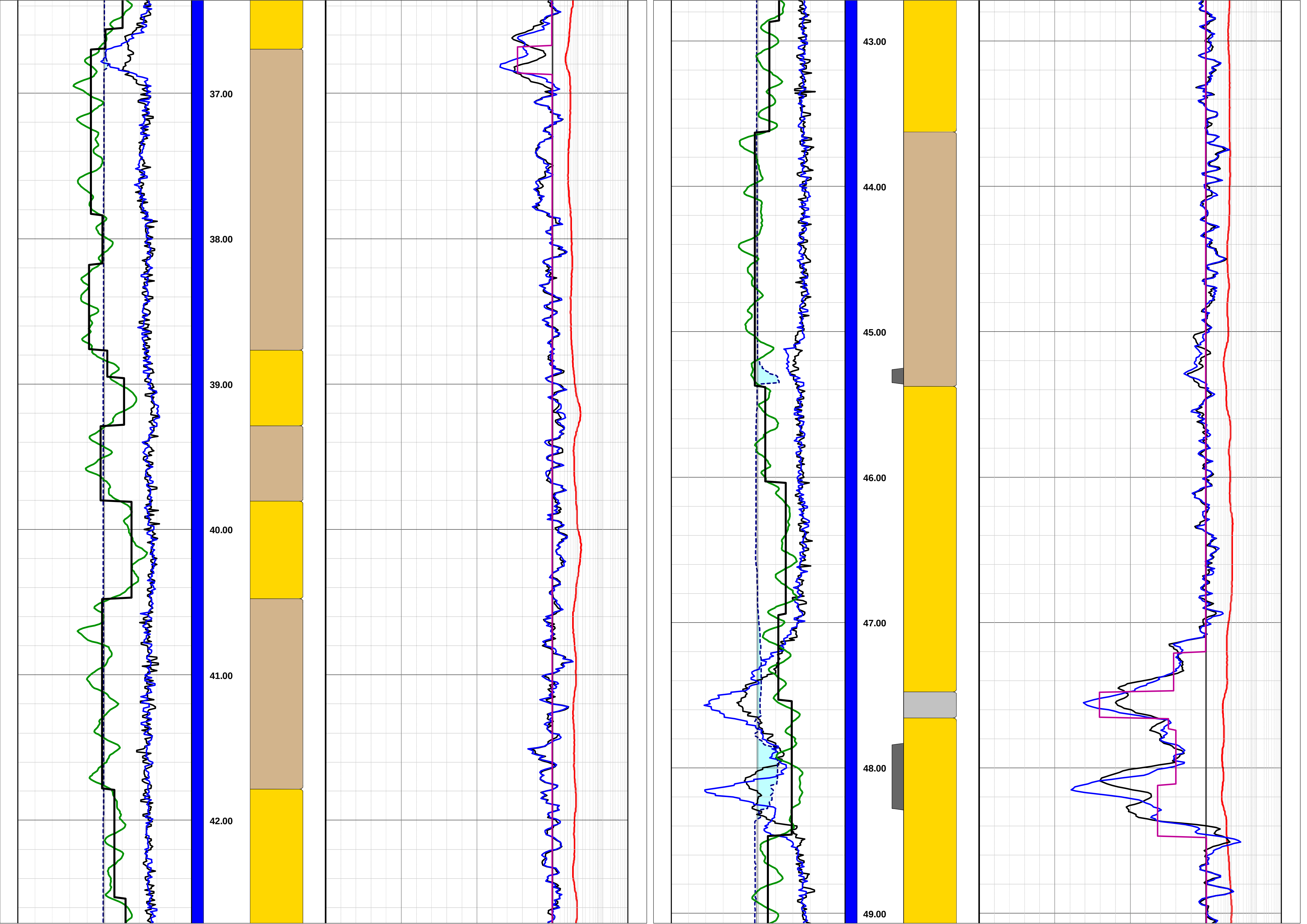
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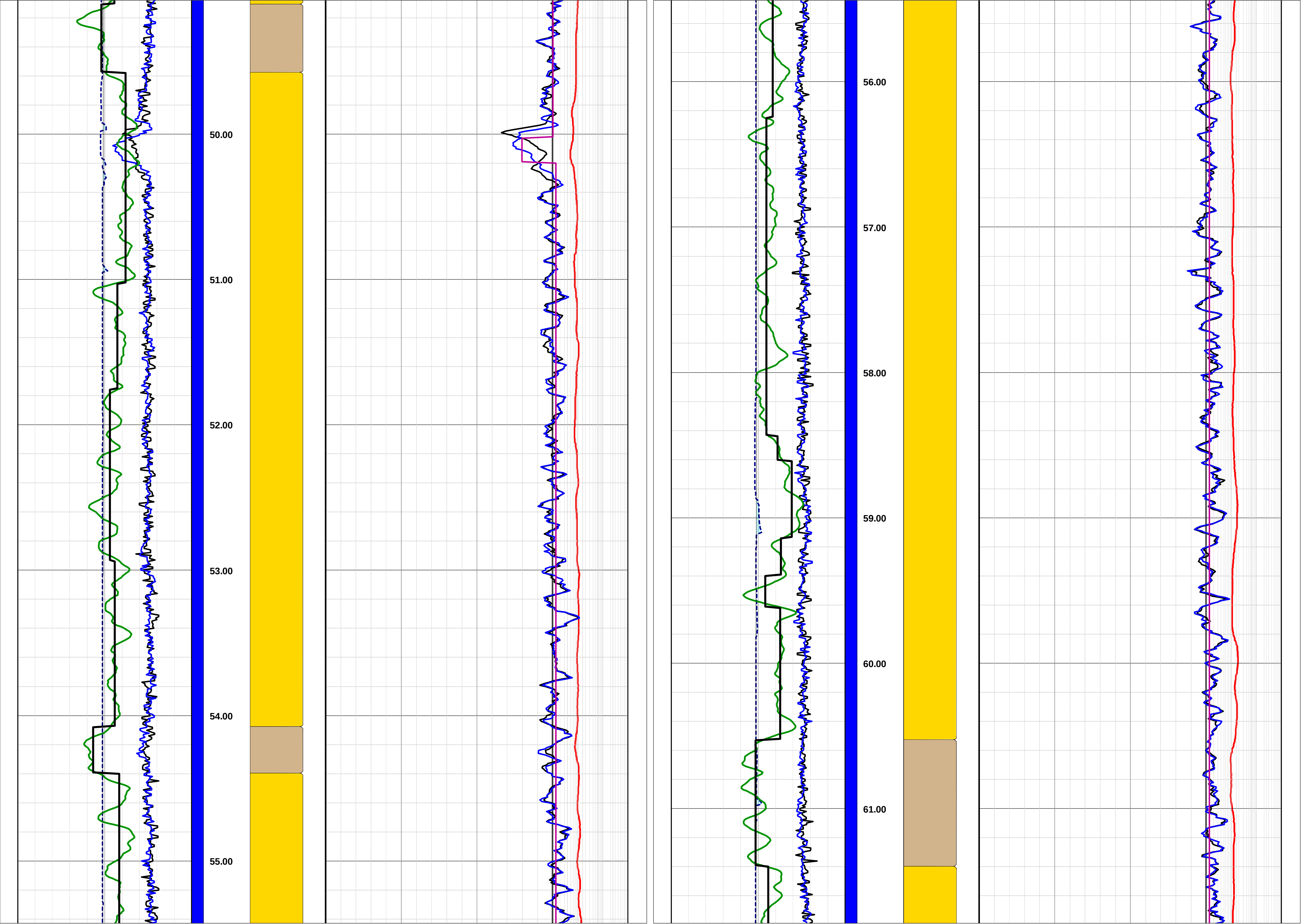
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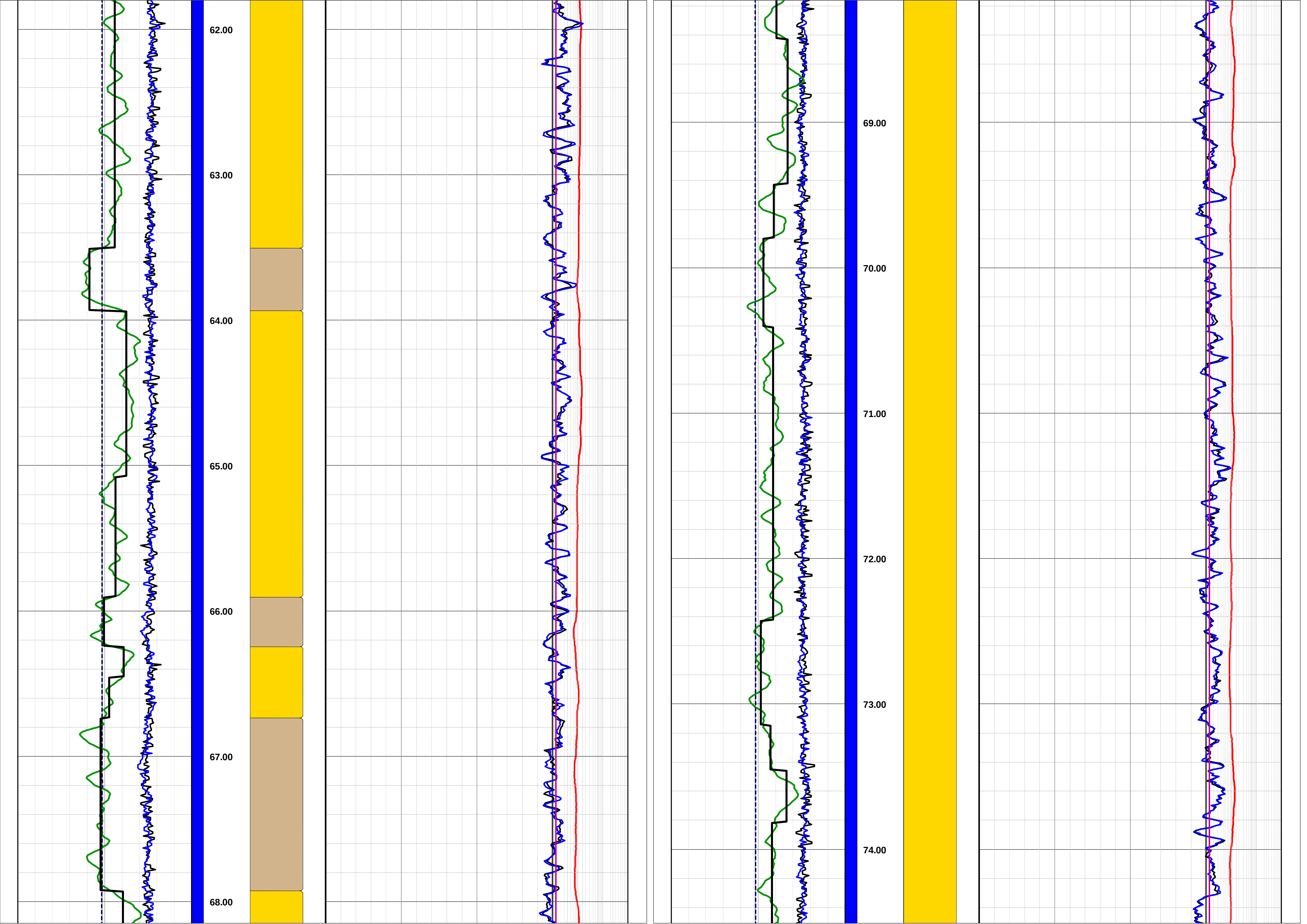
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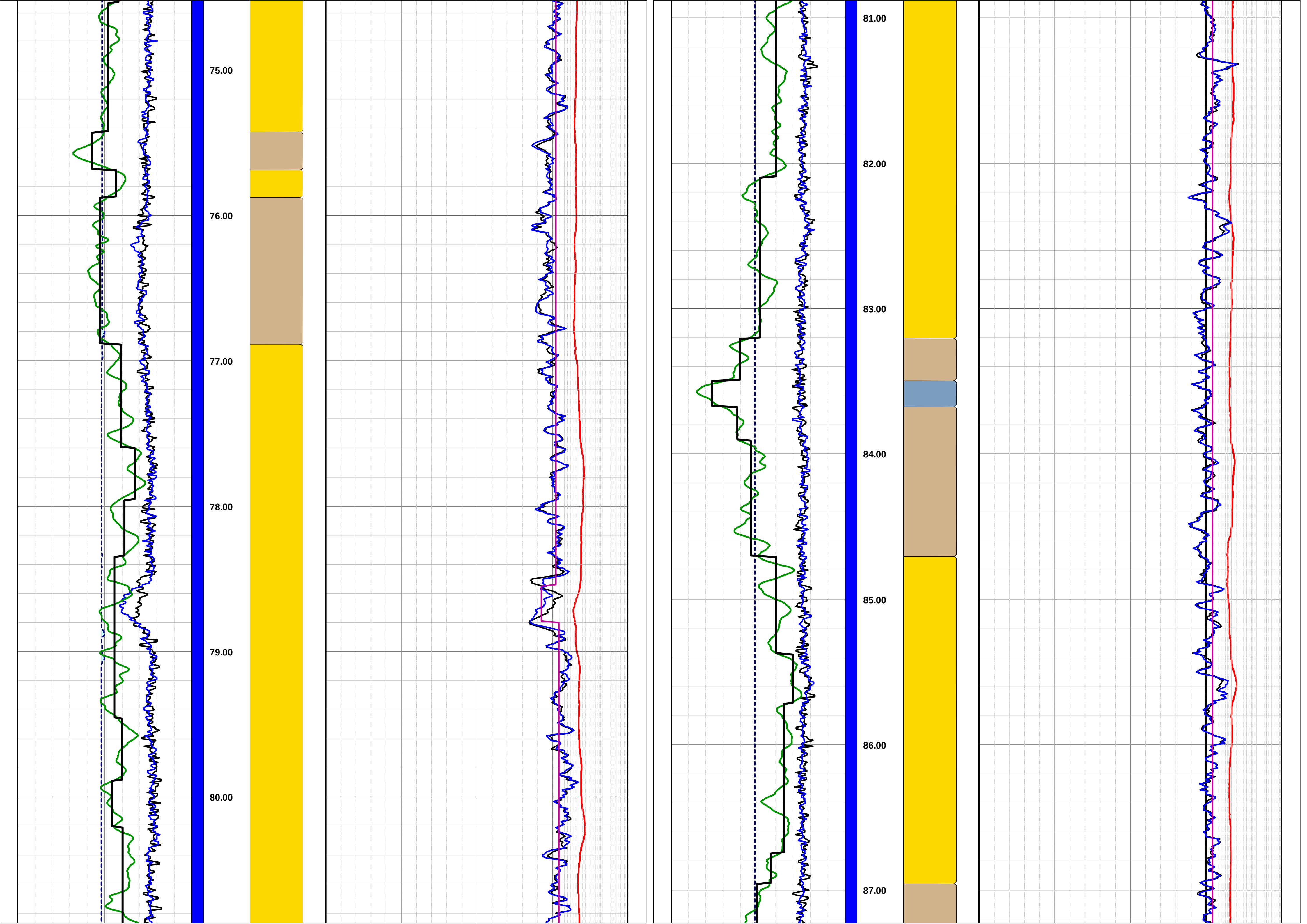
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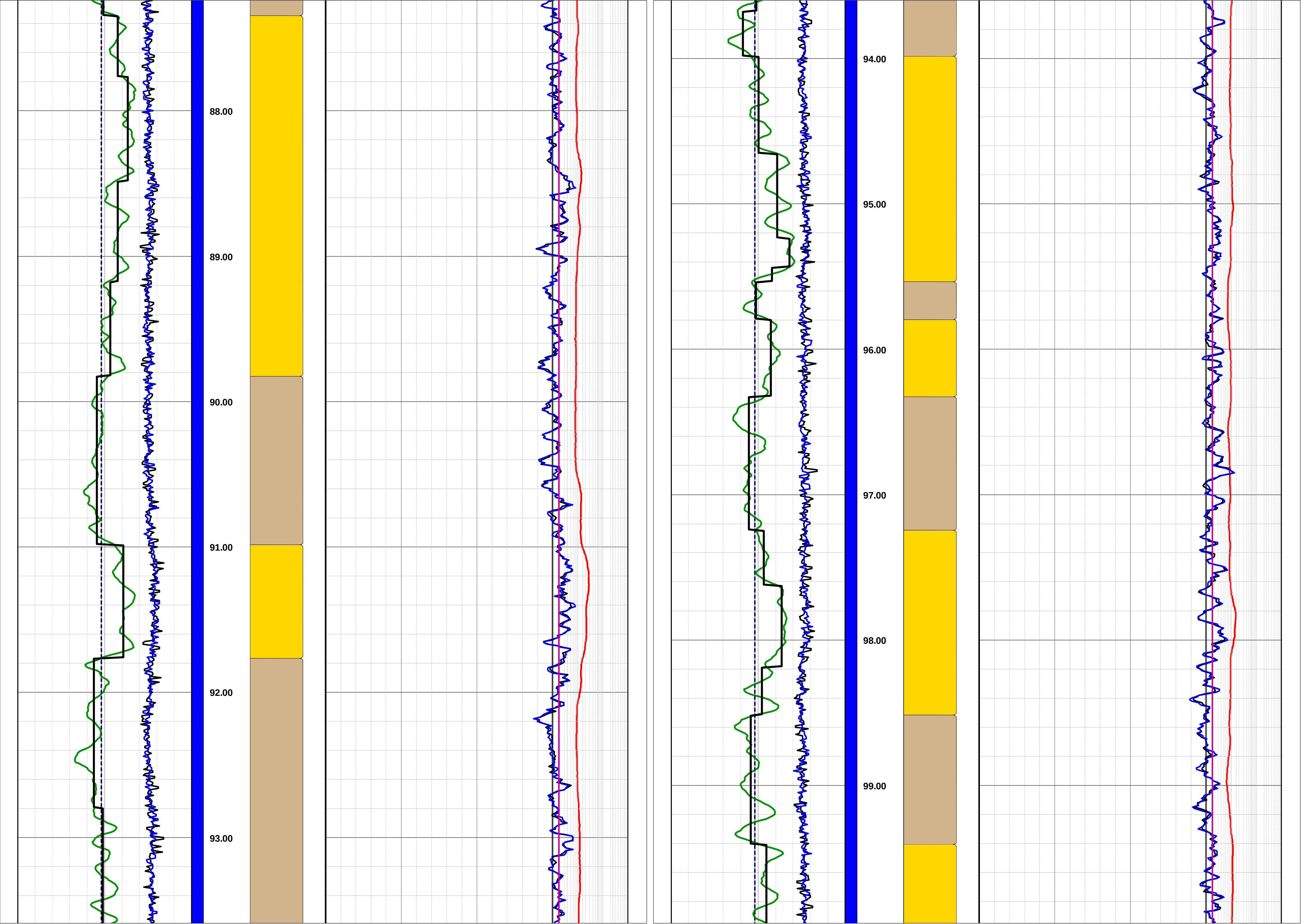
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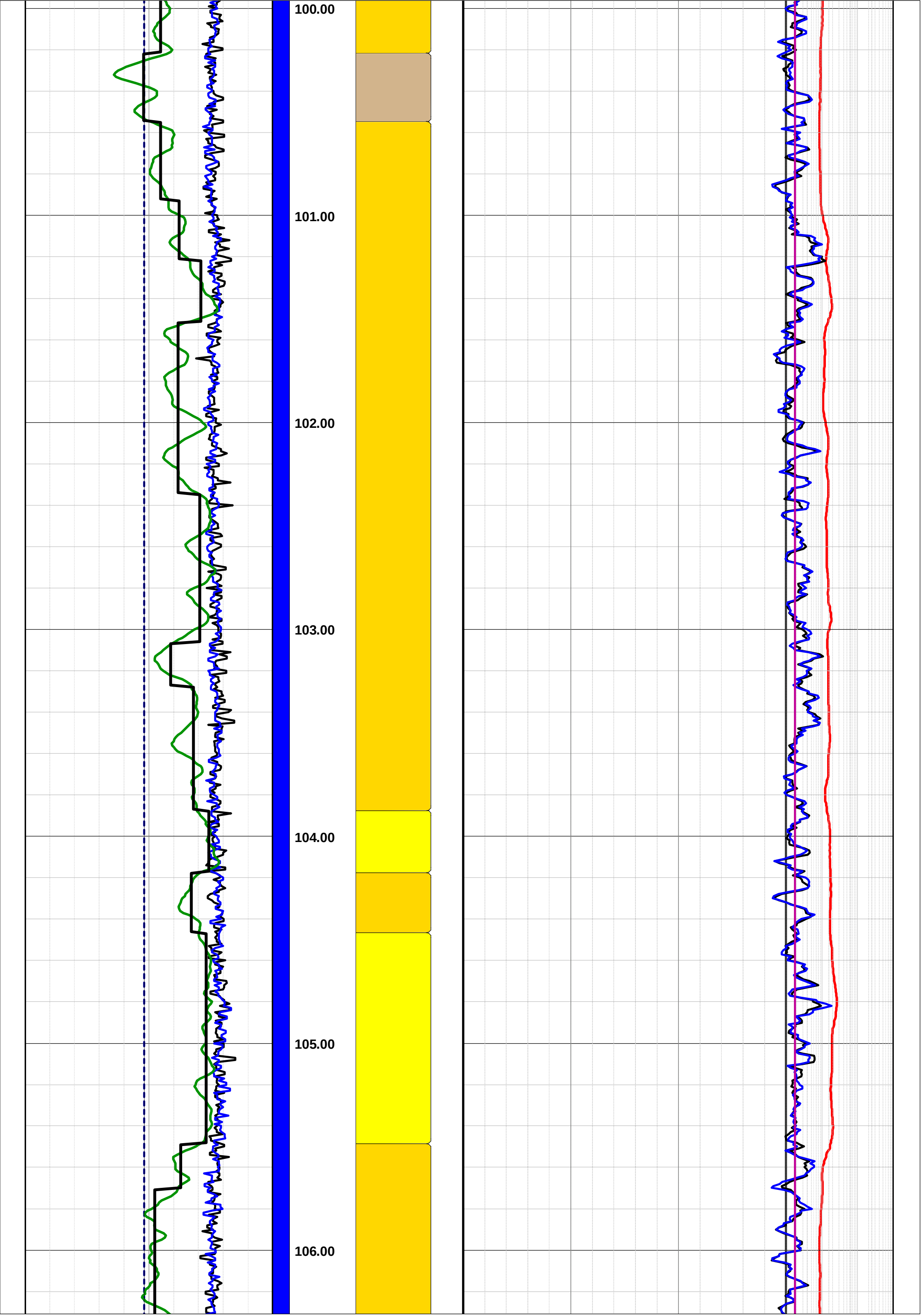
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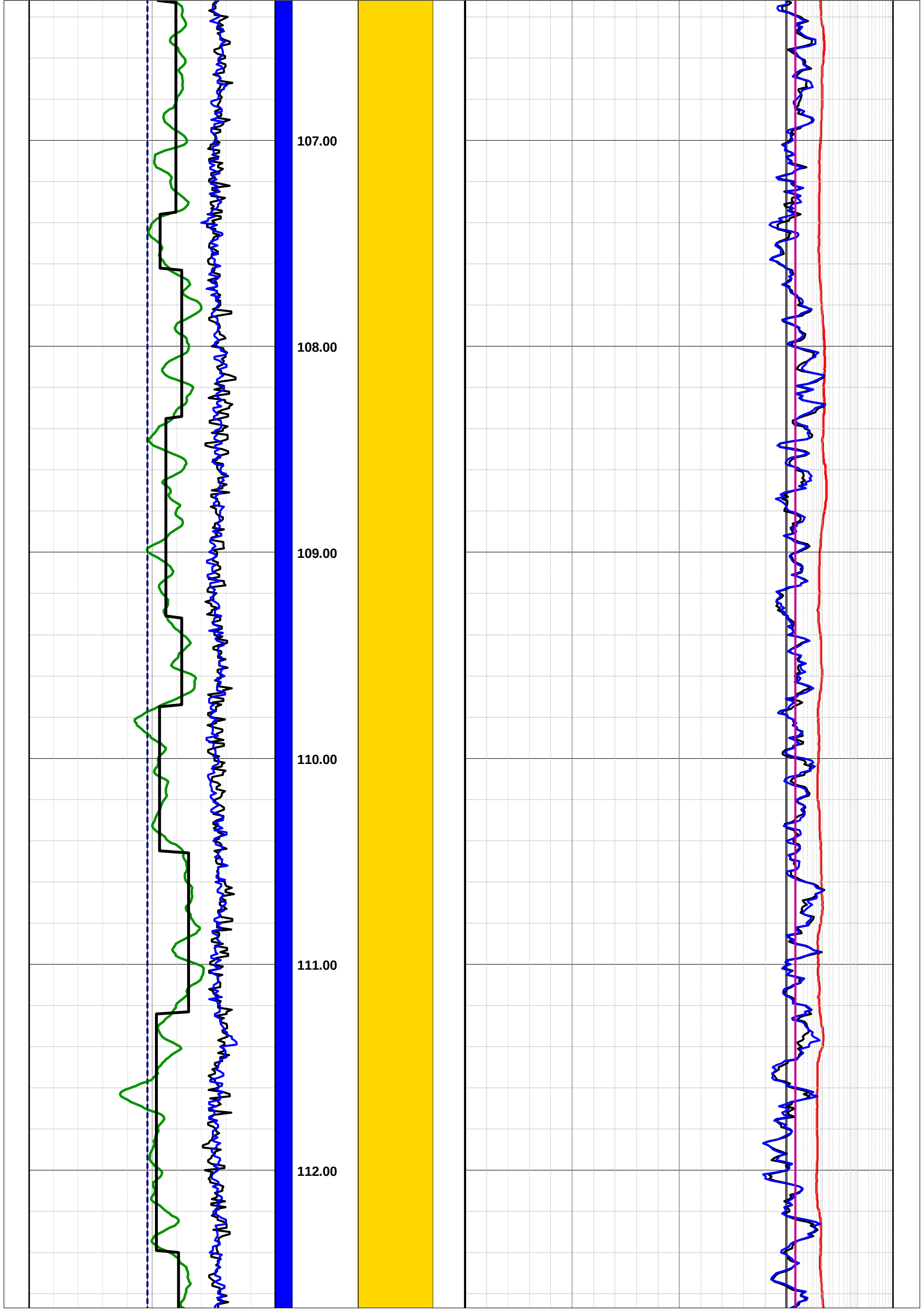
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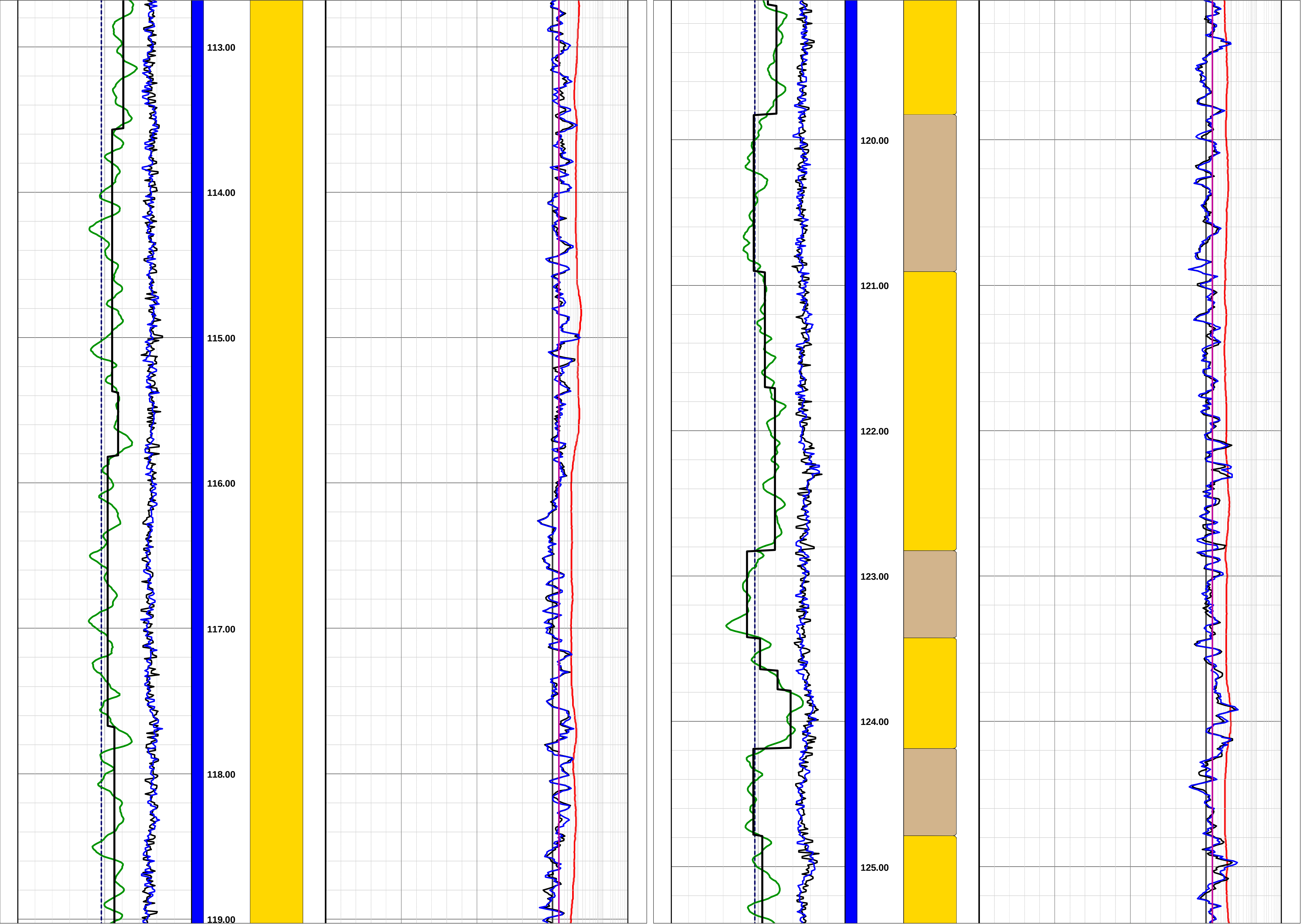
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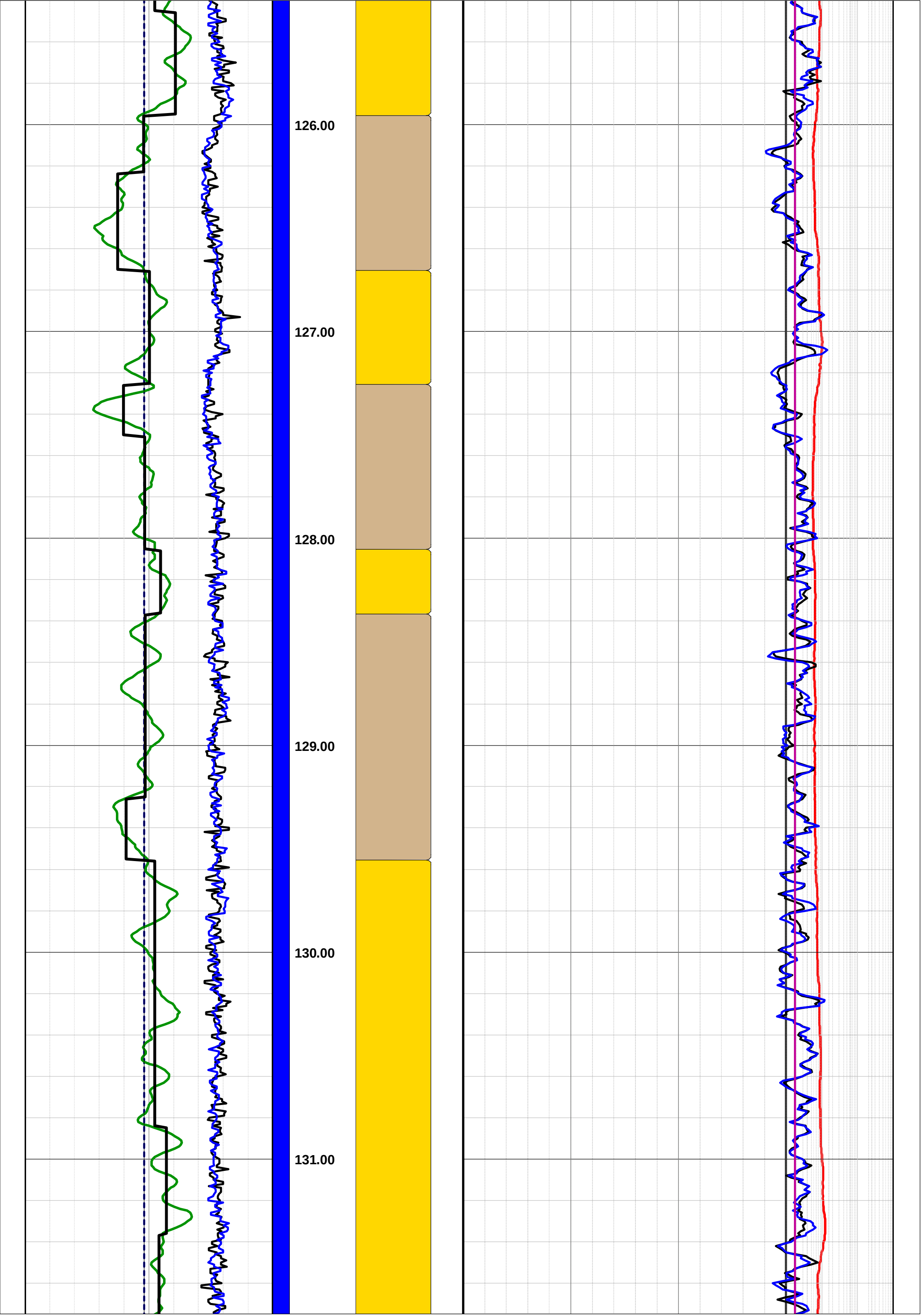
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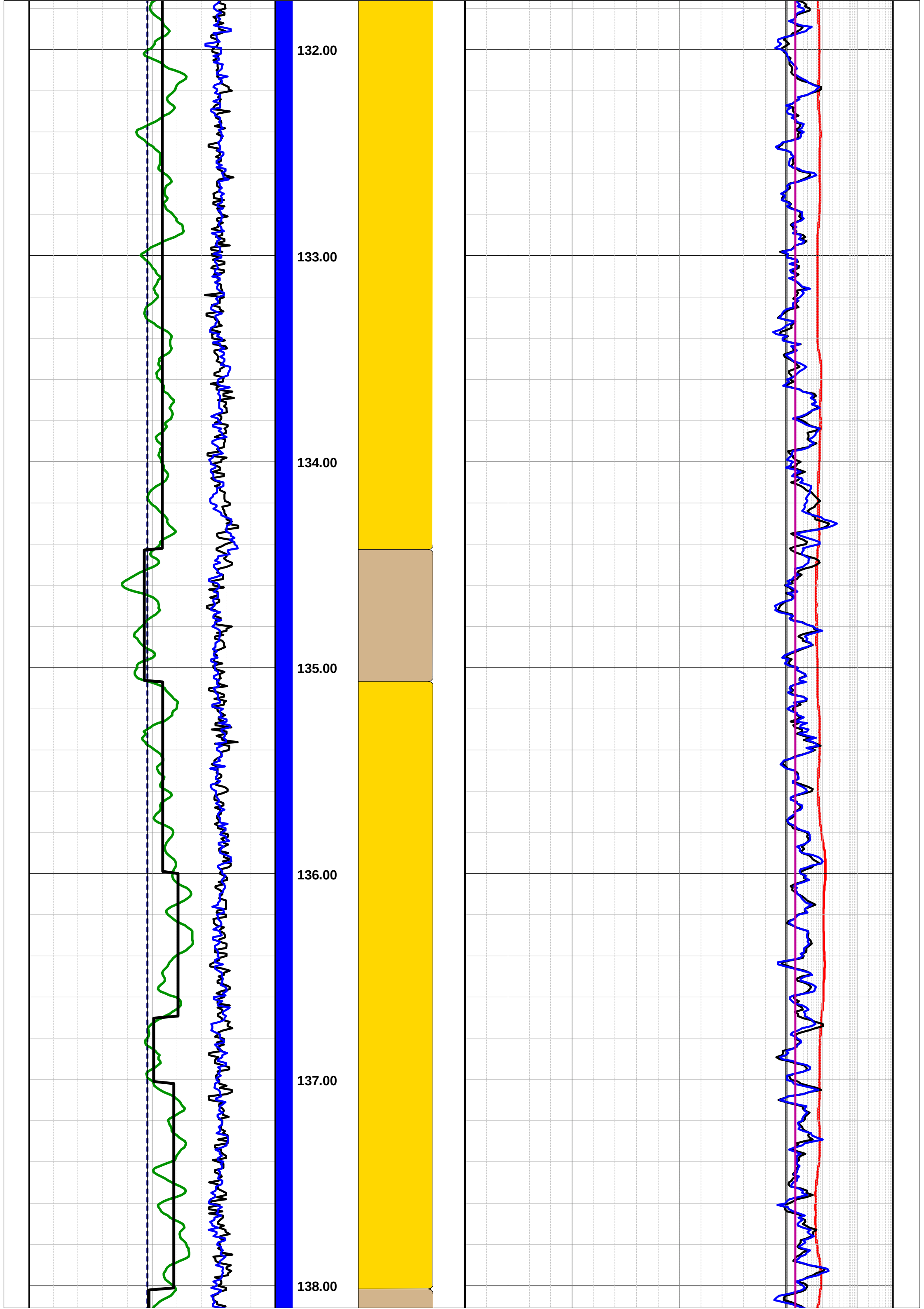
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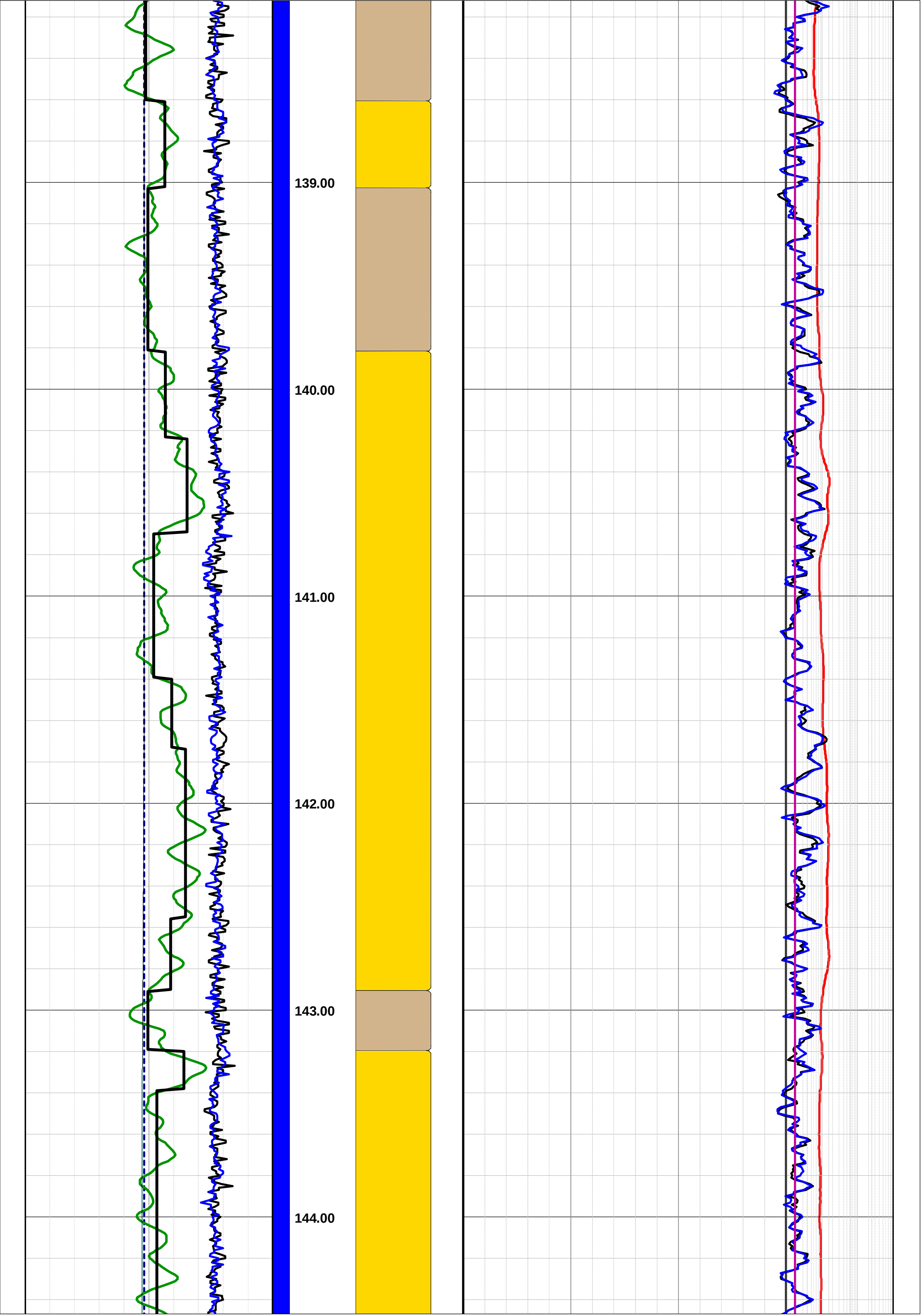
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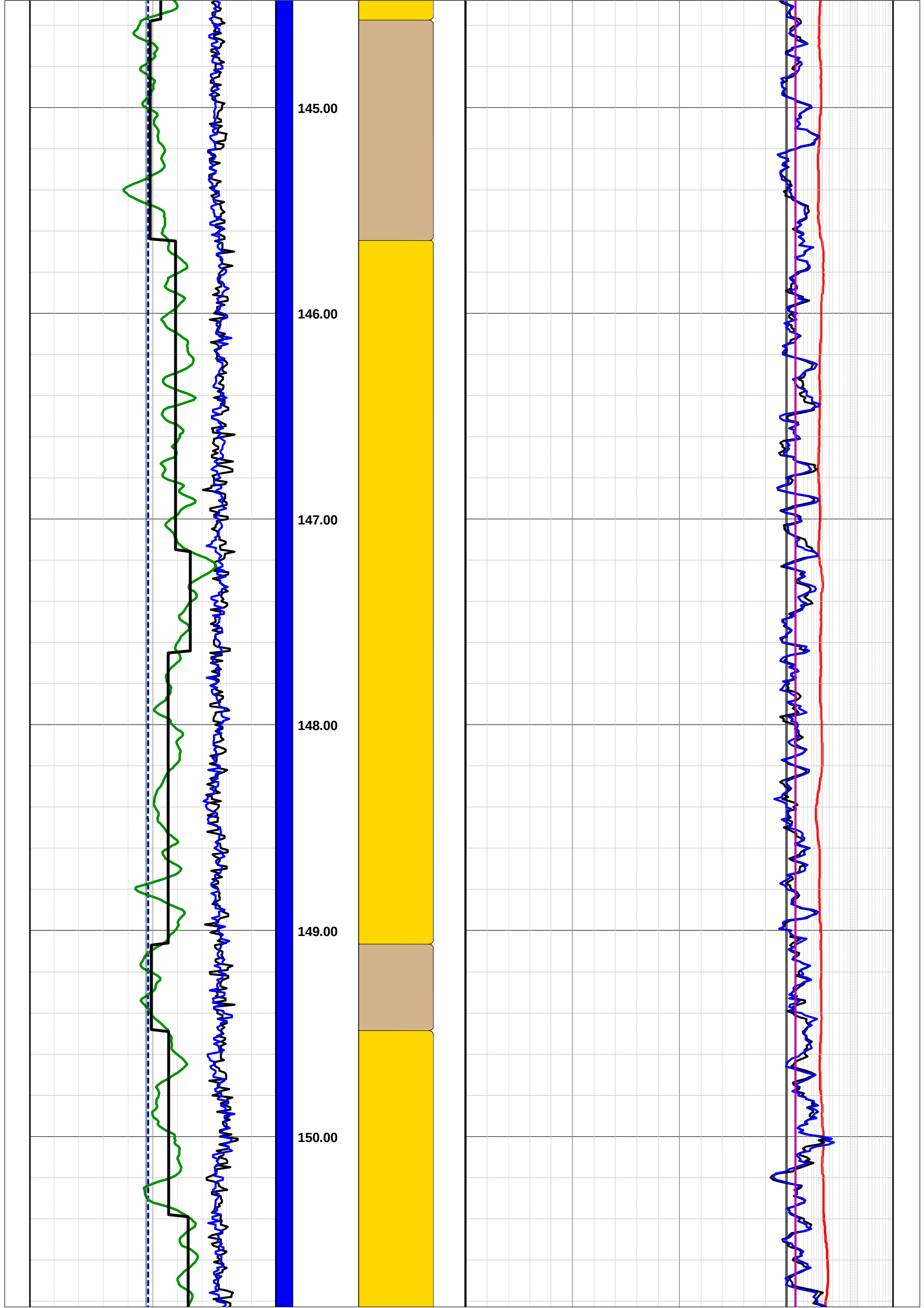
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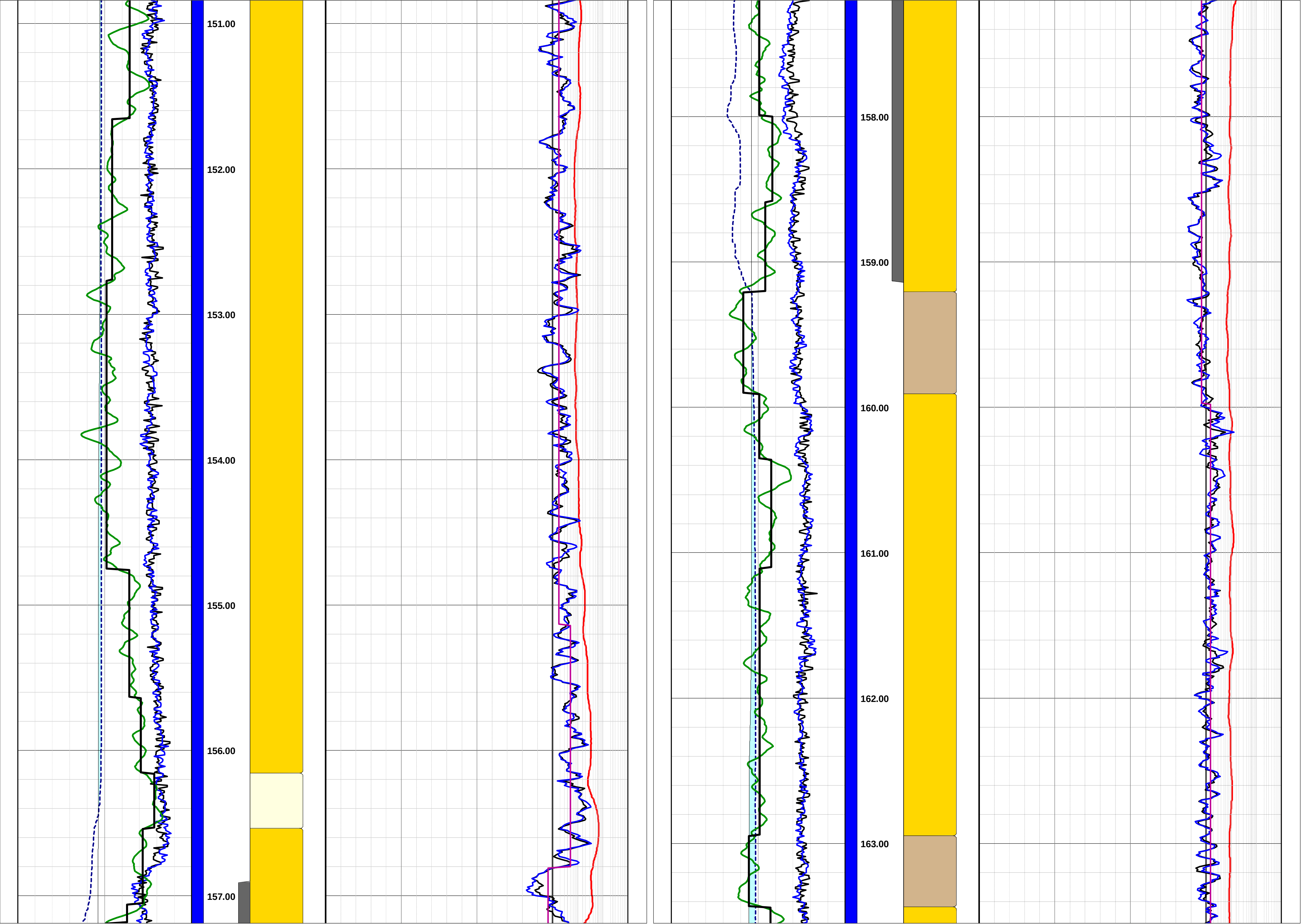
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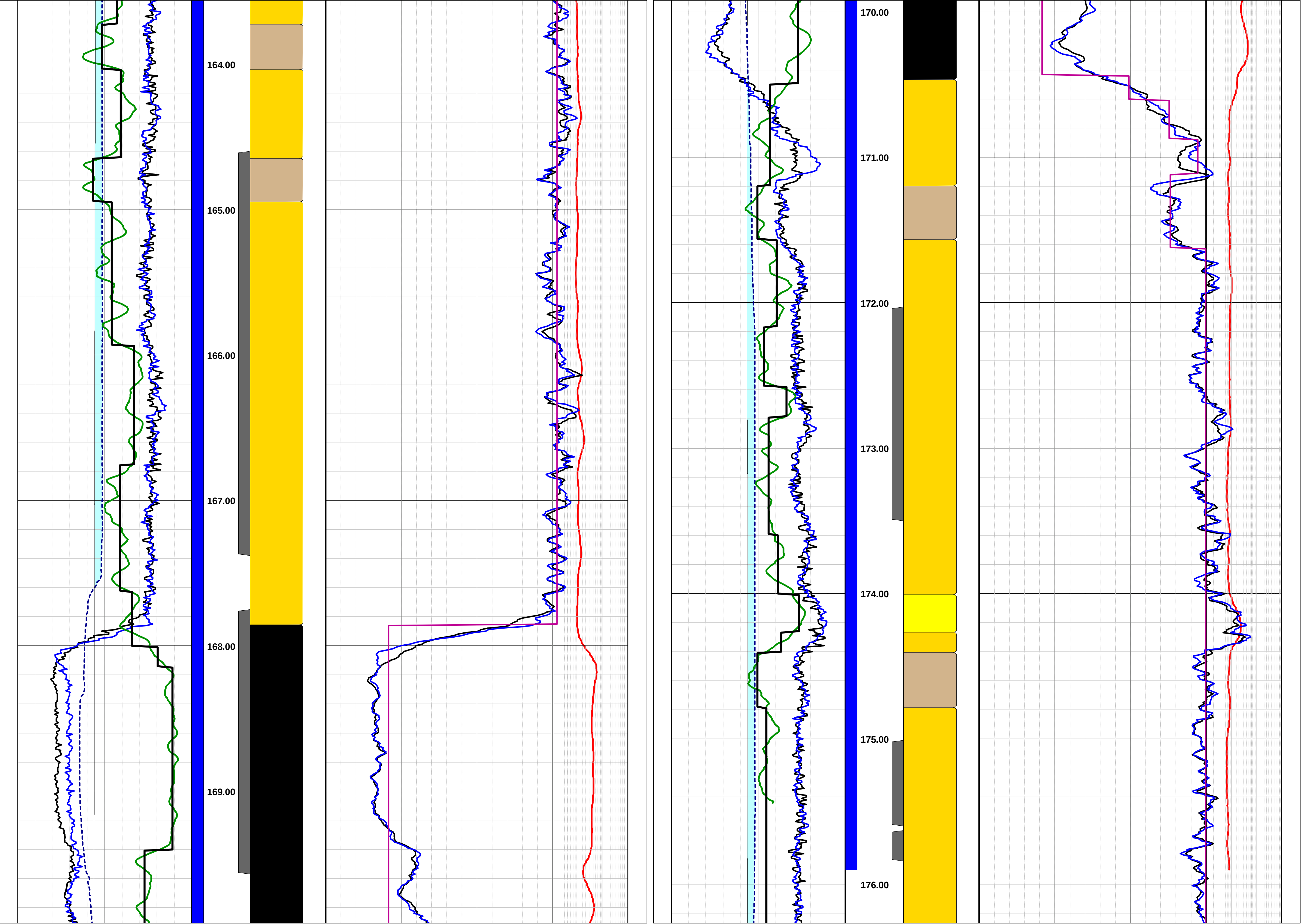

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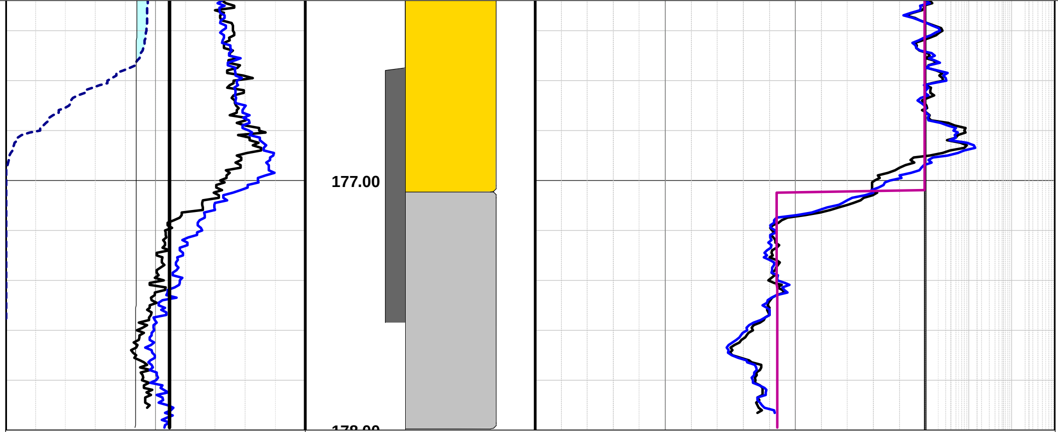


0 DEG 20 SANG			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND	
CO - Coal	S2 - Sandstone - fine grained
CF - Inferior Coal	S3 - Sandstone - fine to medium grained
ST - SILTSTONE	S4 - Sandstone - medium grained
S1 - Sandstone - very fine grained	

COMPANY	BMA	**LOCATION**	MB19BWM01P
WELL	MB19BWM01P	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

MB19BWM01P

QUICKLOOK LITHOLOGY LOG

MB19BWM03P

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	MB19BWM03P	**LOCATION**	MB19BWM03P	**COUNTRY**	AUSTRALIA

LOCATION: MB19BWM03P
FIELD: BLW
STATE: QLD
WELL: MB19BWM03P
COMPANY: BMA

	ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM		
DRILLING MEASURED FROM	KB	1.
PERMANENT DATUM	DF	2.
PERMANENT DATUM ELEVATION	GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	07-11-2019			RECORDED BY	GRM		
TIME	16-11			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	234m			RIG NUMBER			
DEPTH-LOGGER	233.85m			TOOL TYPE	9239C		
BIT SIZE	171mm			TOOL SERIAL NO.	2727		
CASING TYPE	PVC			EASTING	688322		
CASING ID	200mm			NORTHING	7383292		
CASING BOTTOM	14m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	178.5 m			SOURCE TYPE	CS137	SOURCE ID	CZ3498

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

⬛	**CO - Coal**	🟫	**S1 - Sandstone - very fine grained**
⬜	**CF - Inferior Coal**	🟨	**S2 - Sandstone - fine grained**
🟦	**ST - SILTSTONE**	🟥	**TF - TUFF**

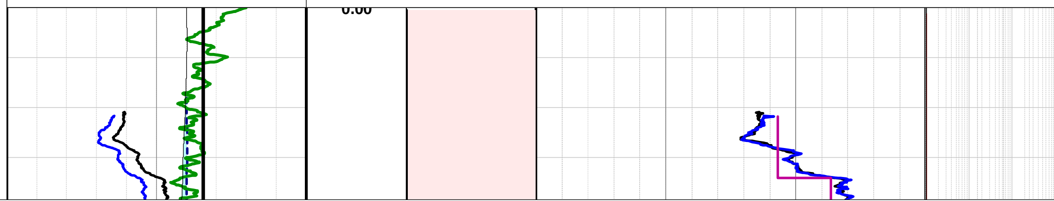
MNEMONICS

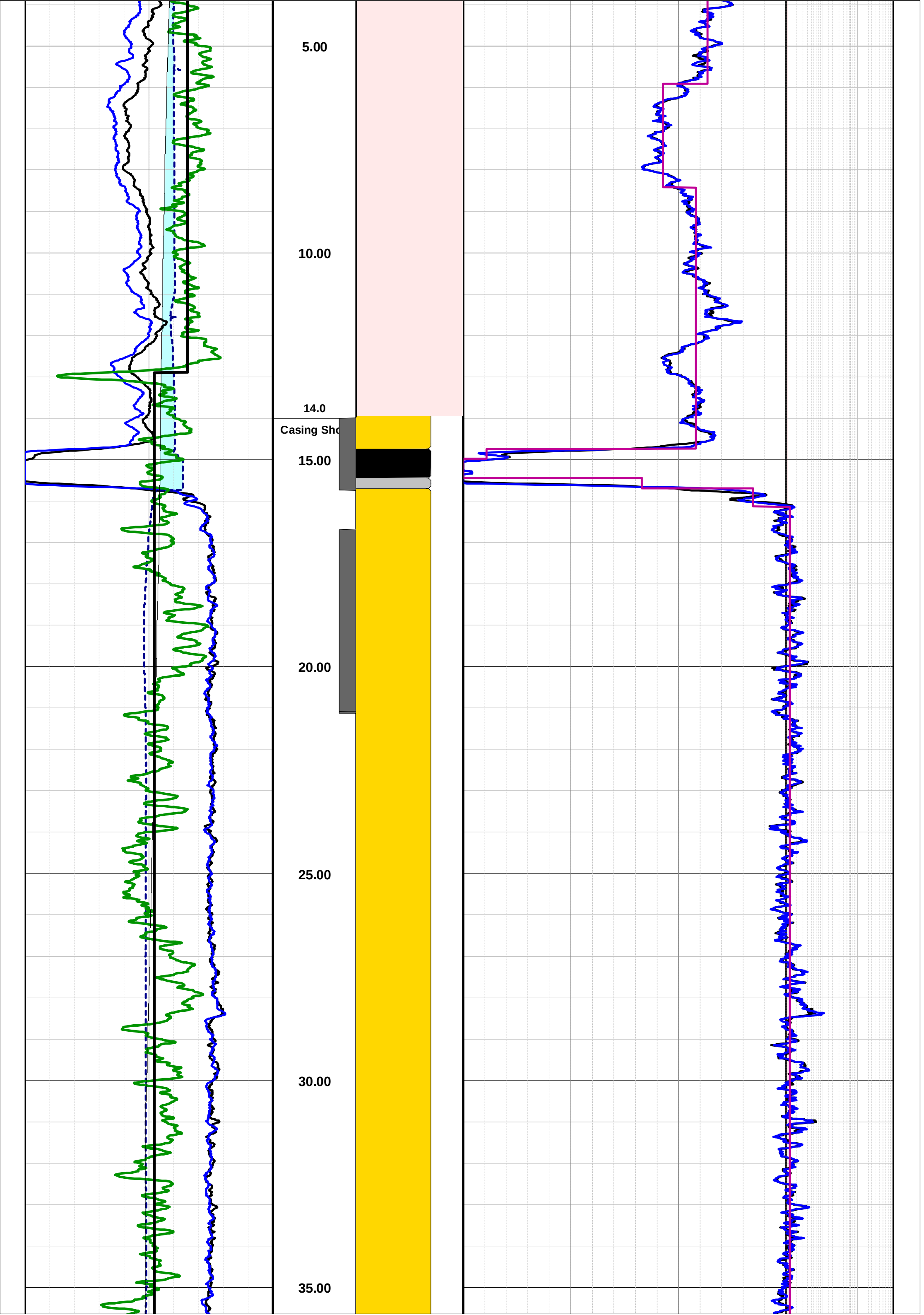
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

IMPORTANT NOTE	The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

DEN(LS) 1 g/cc 3	**Depth** 1m:100m	**COKED_COAL**		**RES(SG)** 1 OHM-M 1000
DEN(SS) 1 g/cc 3	**DATA_FLAG**	**LITHOLOGY**	**DEN(COD)** 1 g/cc 3	
CALIPER 50 mm 300	**WT_FLAG**	**CASING**	**DEN(ER)** 1 g/cc 3	
GAM(NAT) 200 API 0				
NOM_BIT 50 mm 300				
SANG 0 DEG 20				

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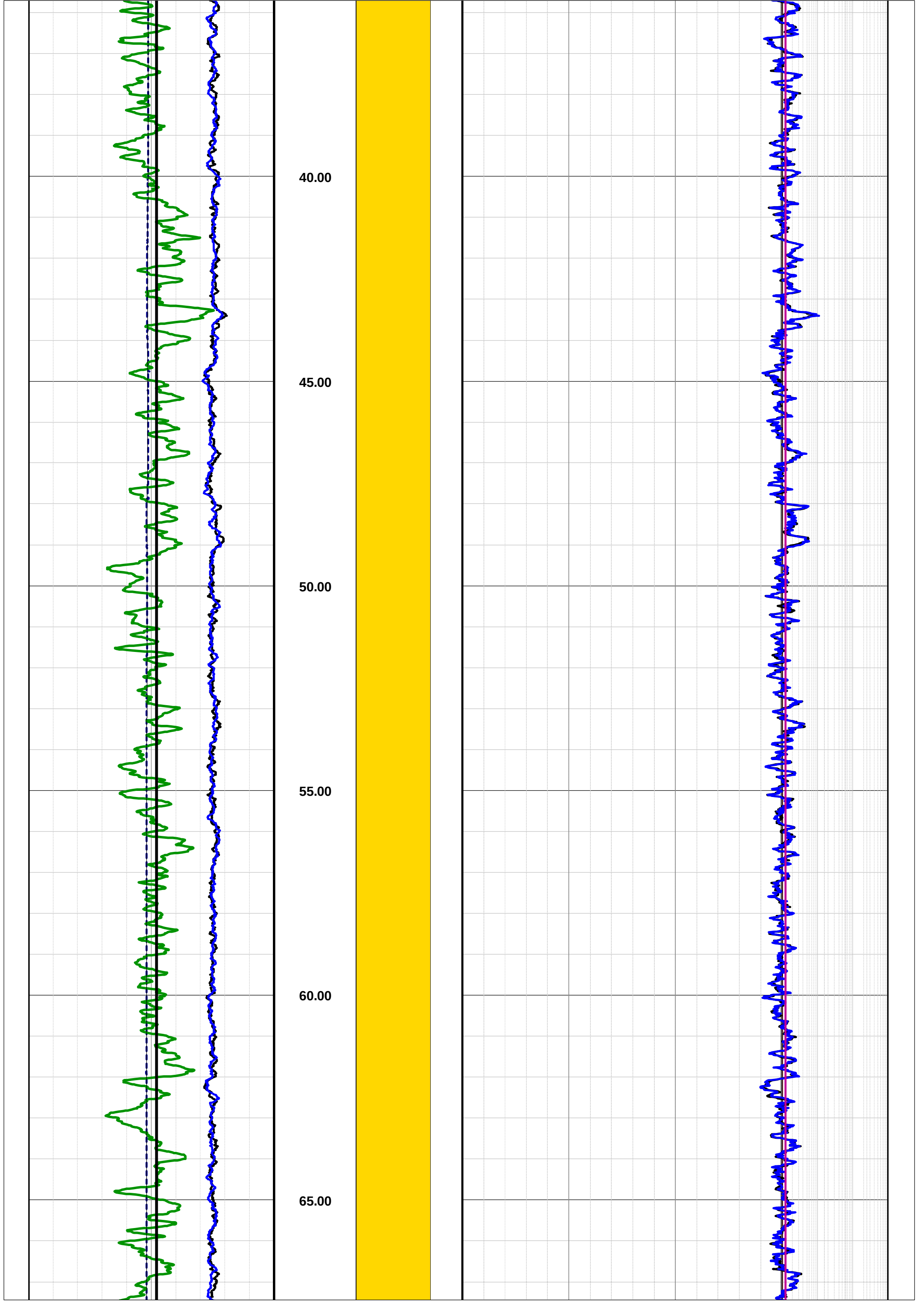
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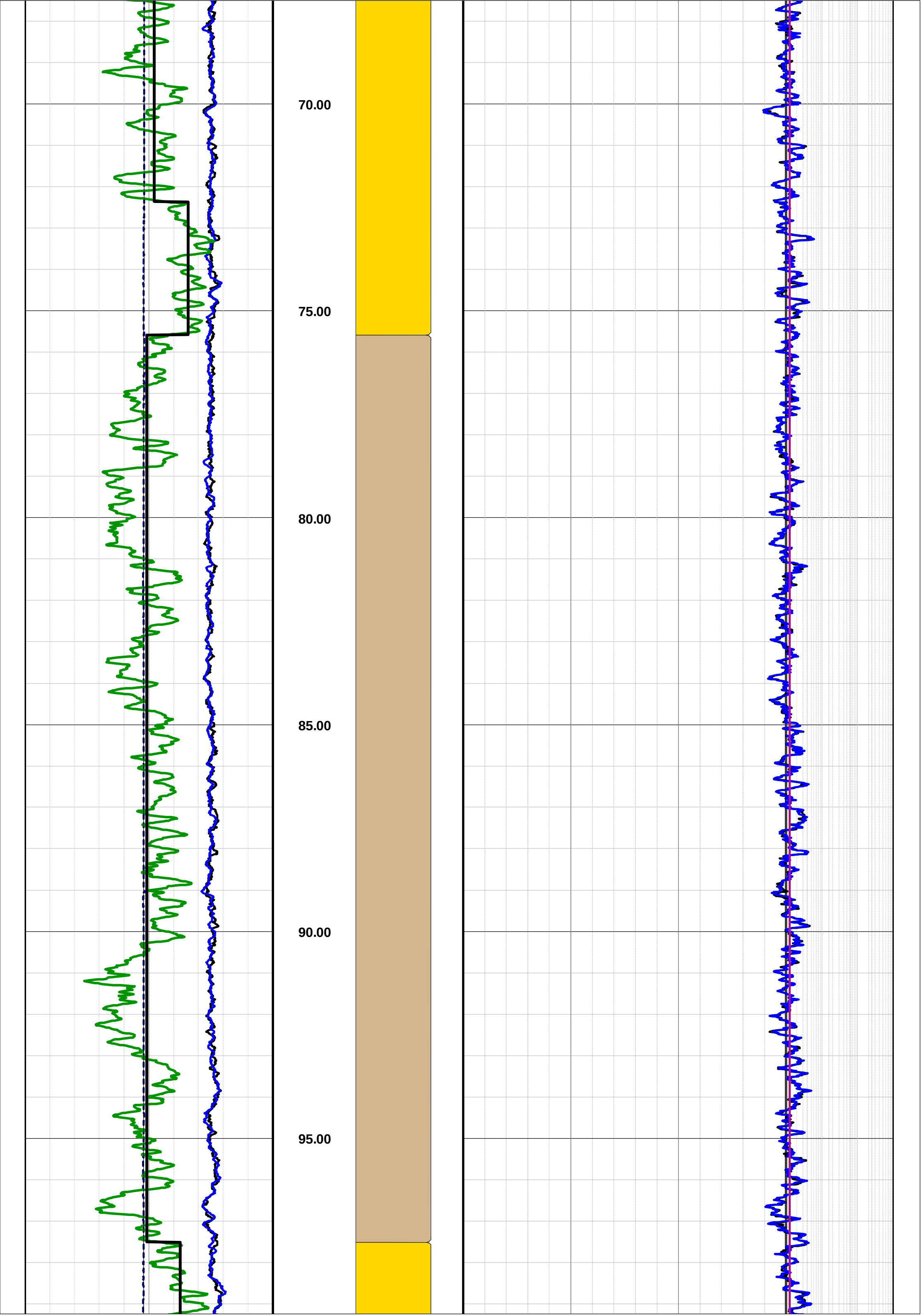
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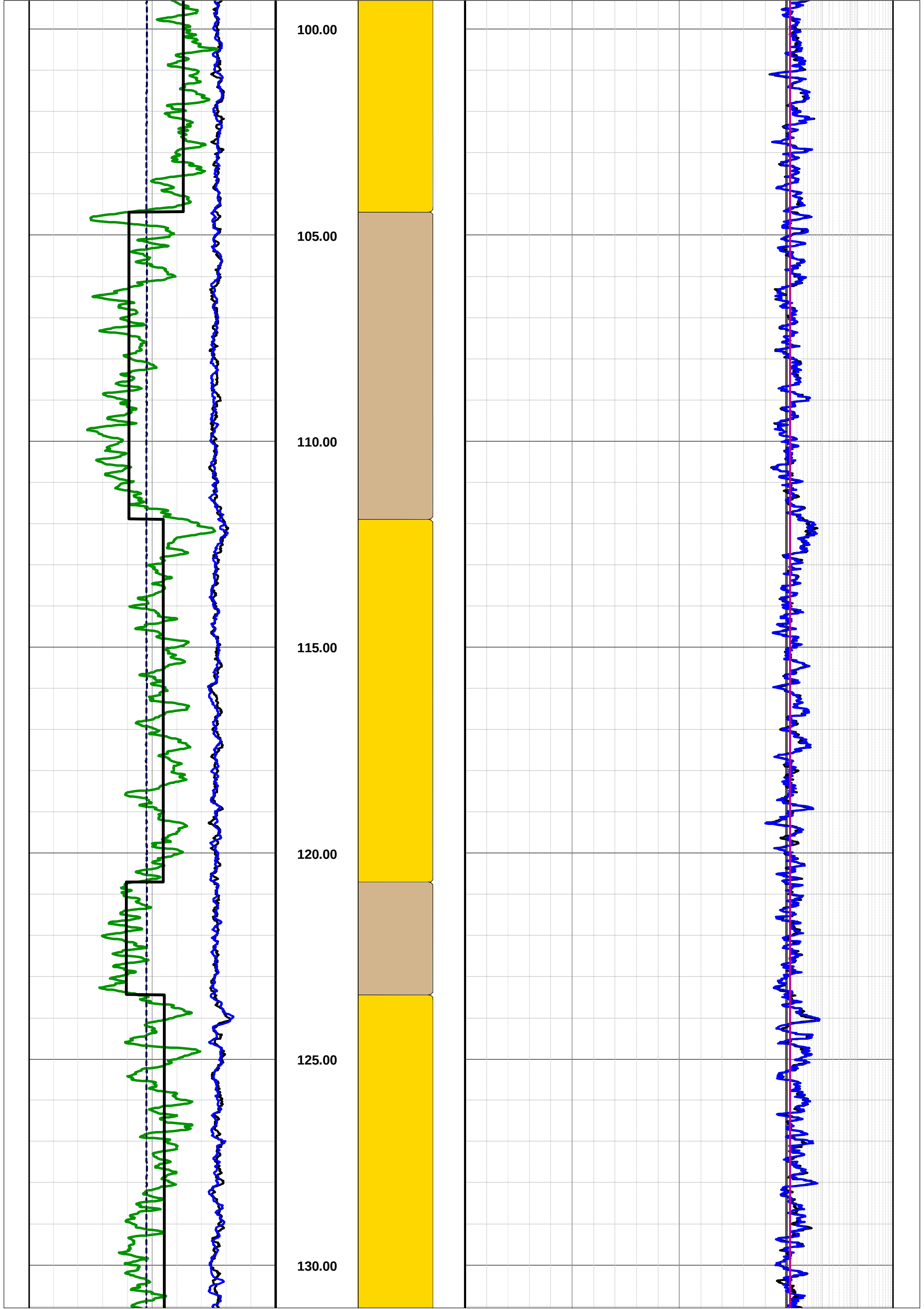
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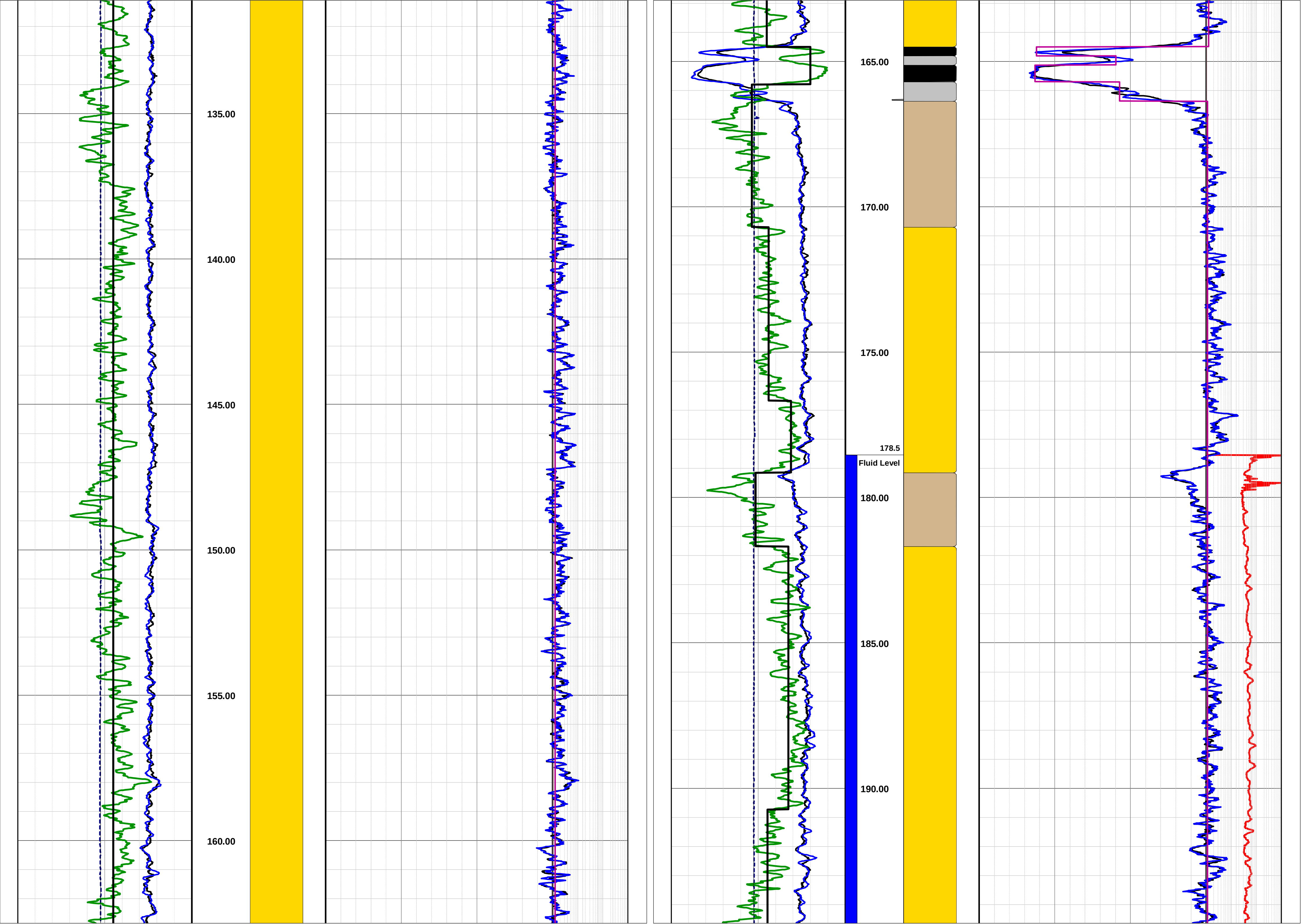
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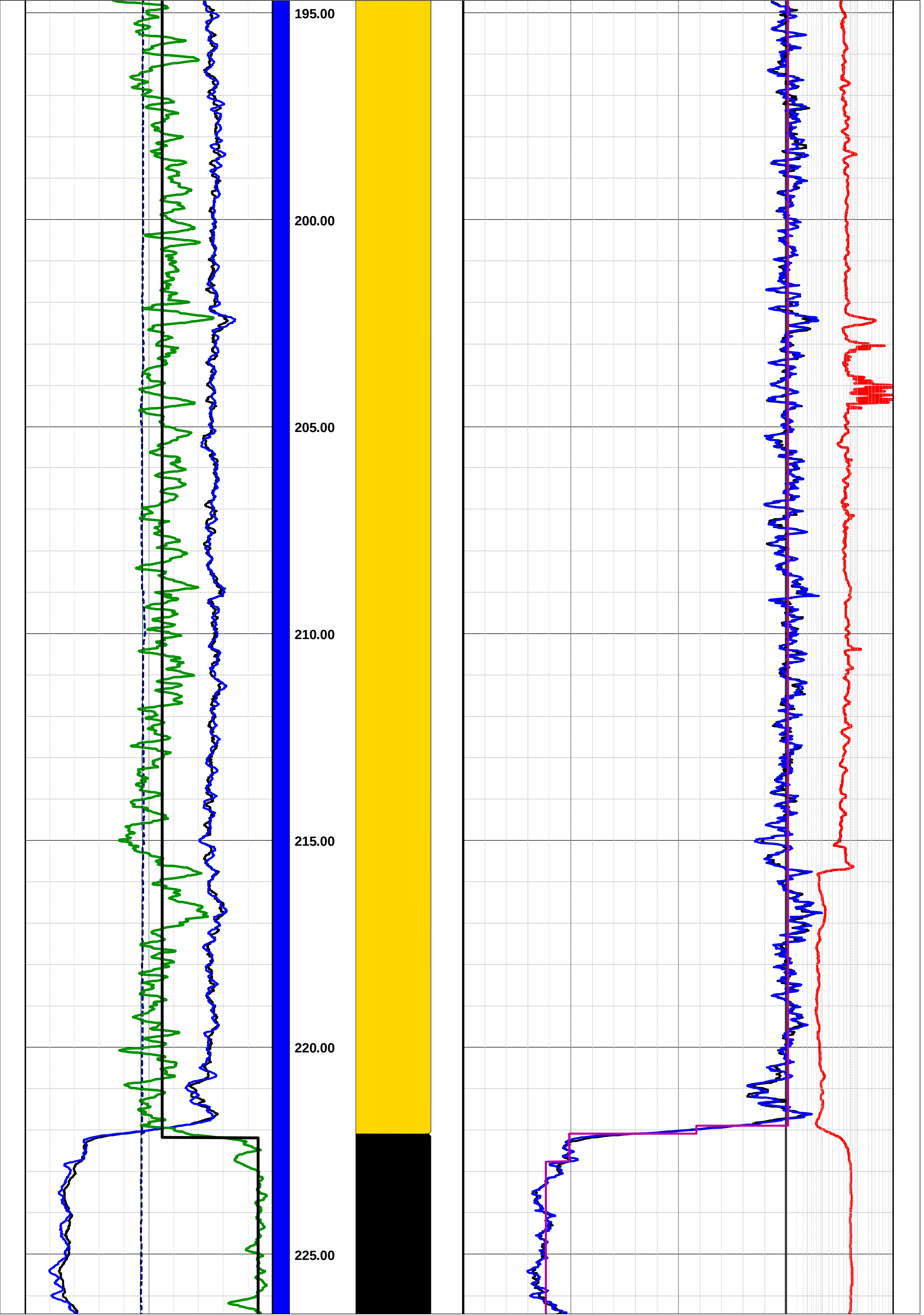
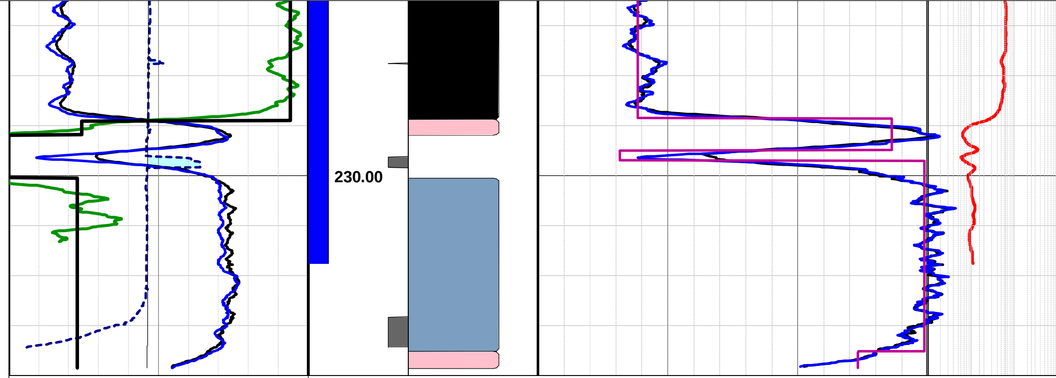


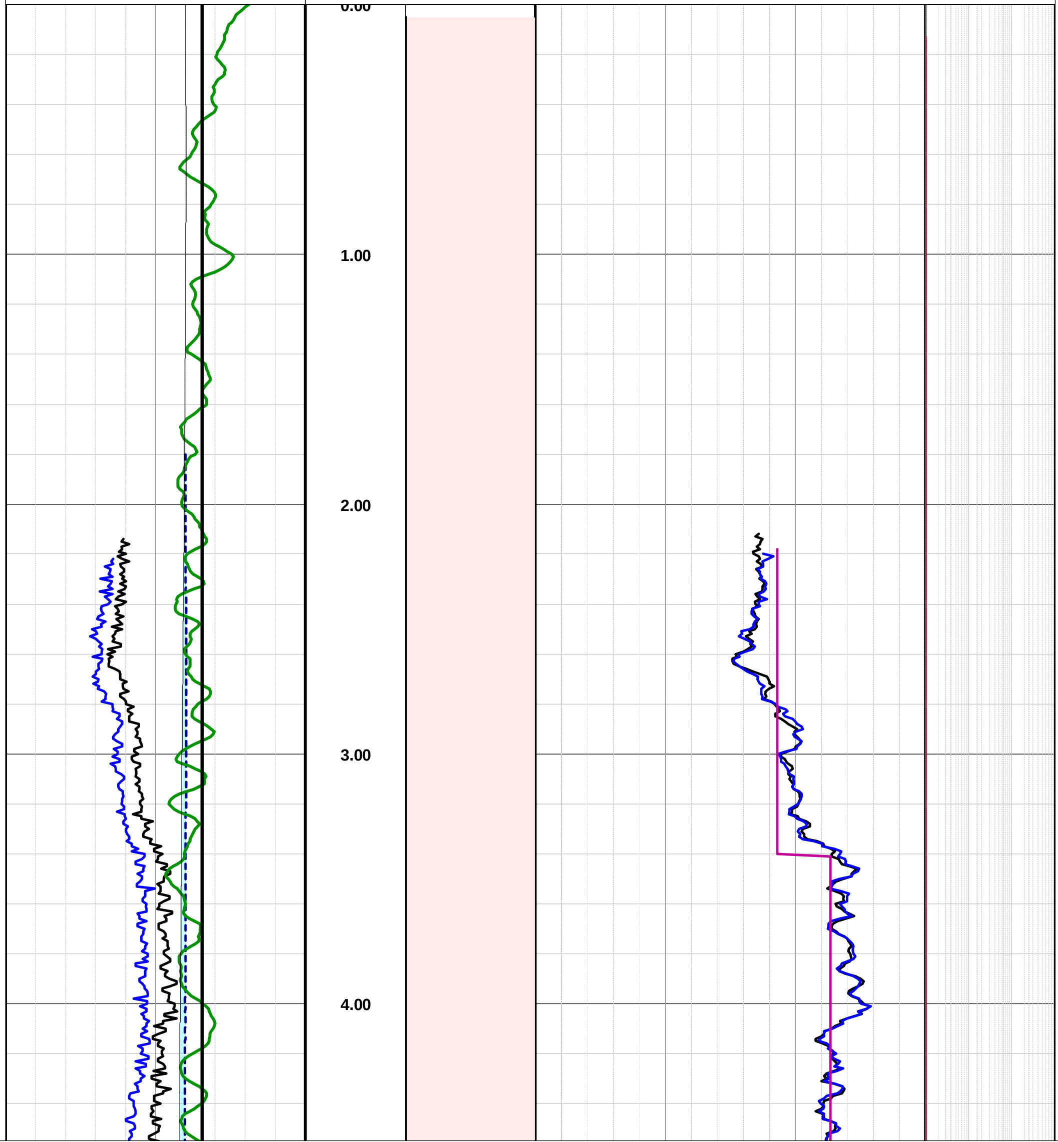


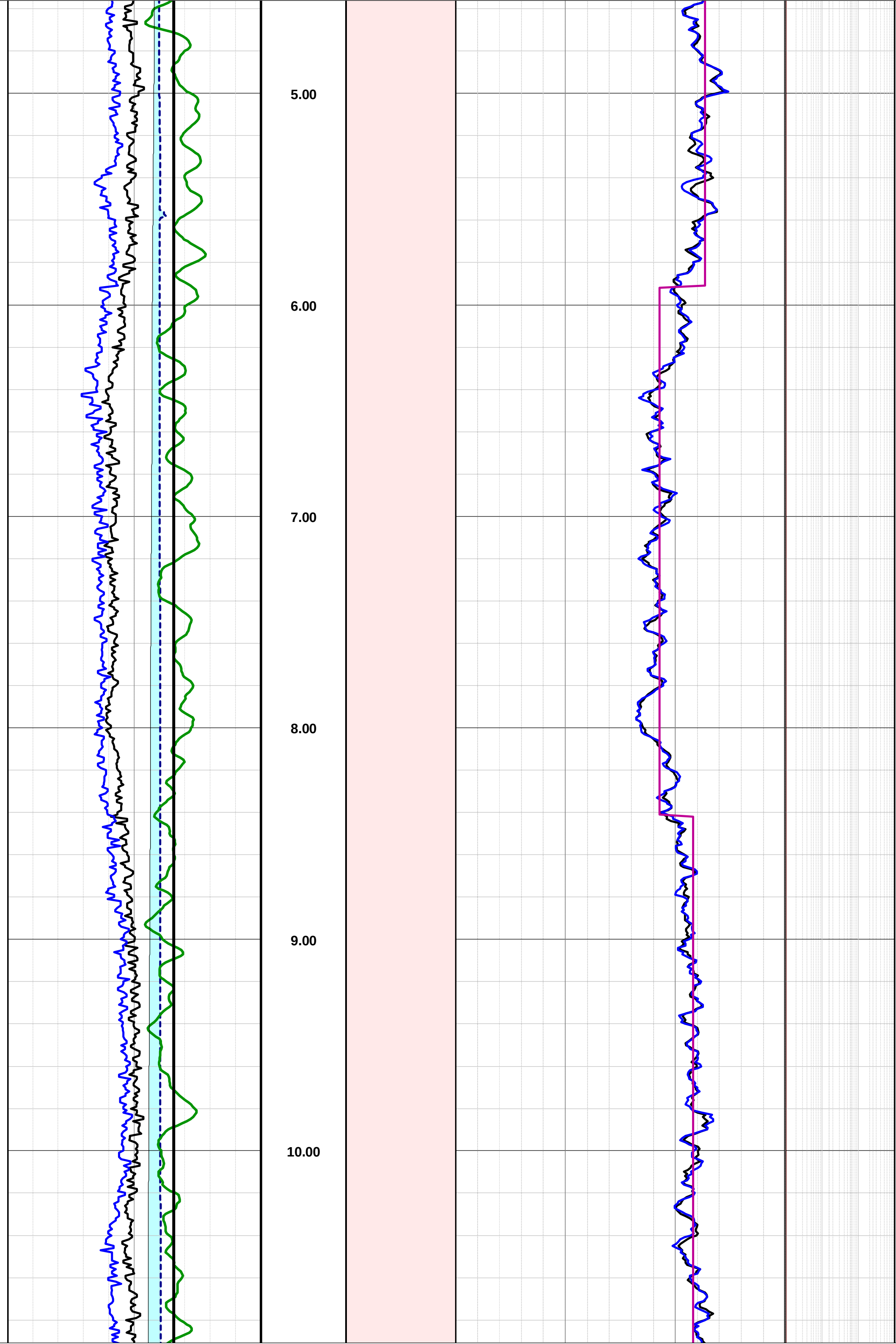
0 DEG 20 SANG			
50 mm 300 NOM_BIT			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:100m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

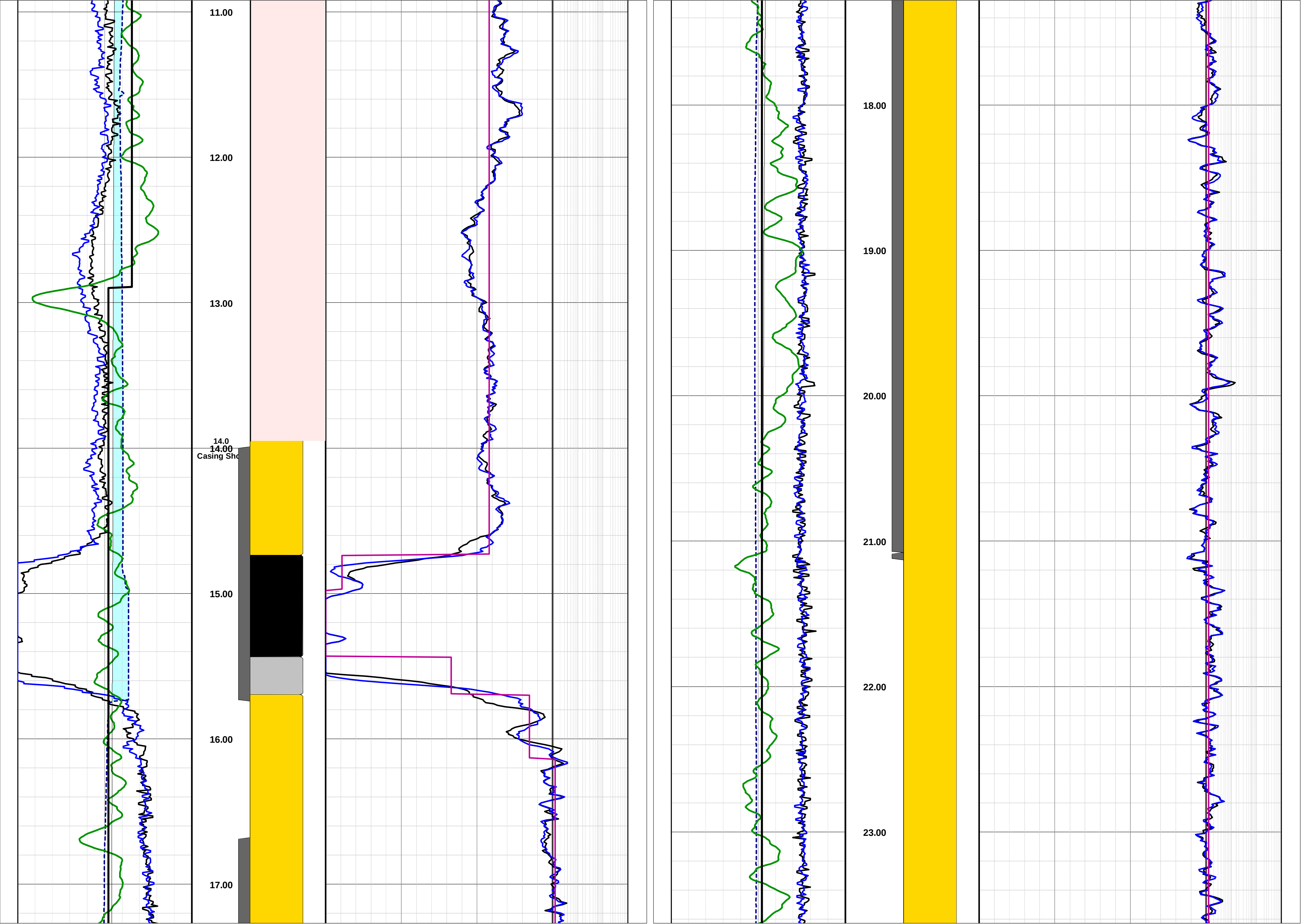
DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) 1 g/cc 3	Depth 1m:20m	COKED_COAL		RES(SG) 1 OHM-M 1000
DEN(SS) 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) 1 g/cc 3	
CALIPER 50 mm 300	WT_FLAG 0 5	CASING	DEN(ER) 1 g/cc 3	
GAM(NAT) 200 API 0				
SANG 0 DEG 20				



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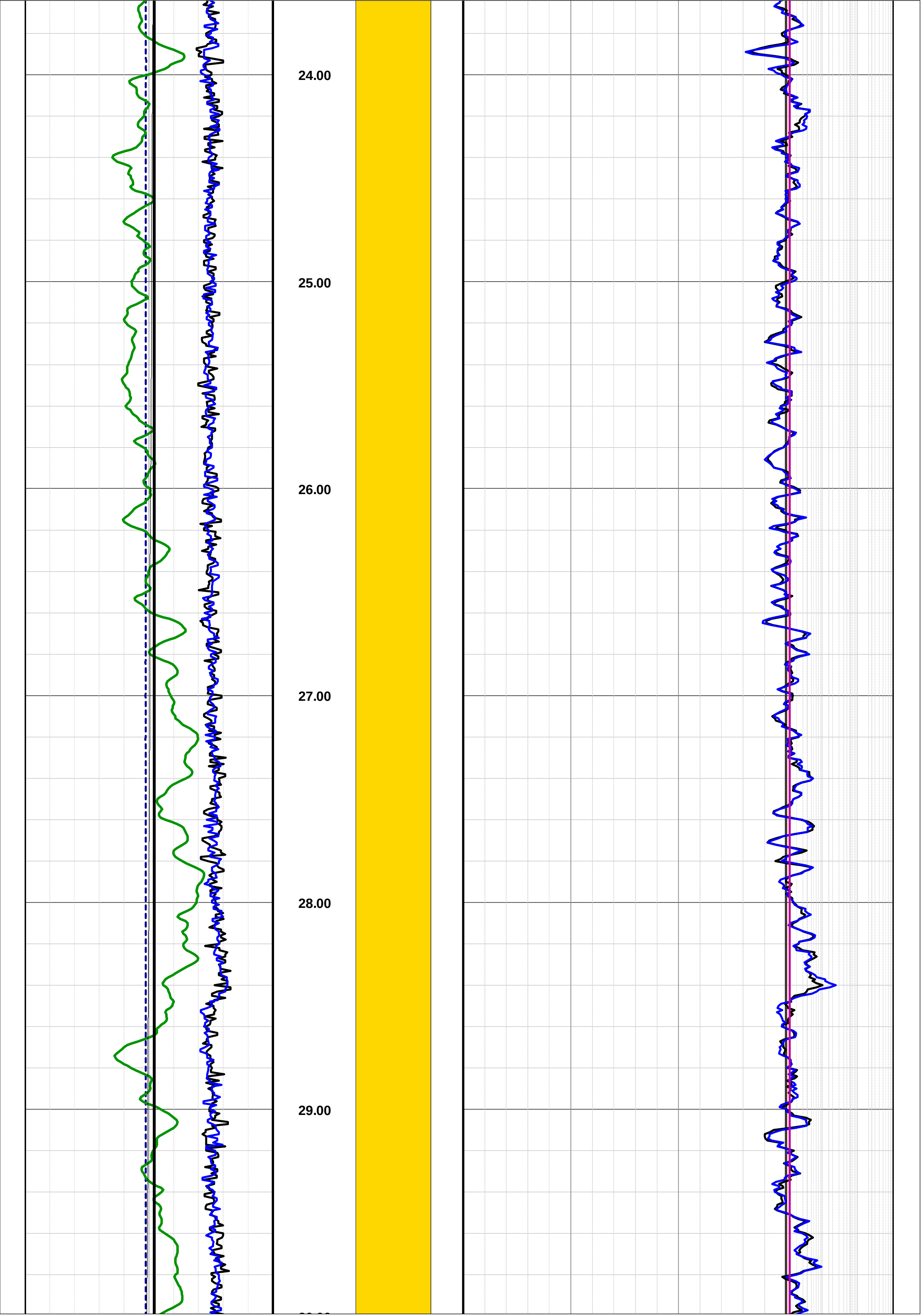
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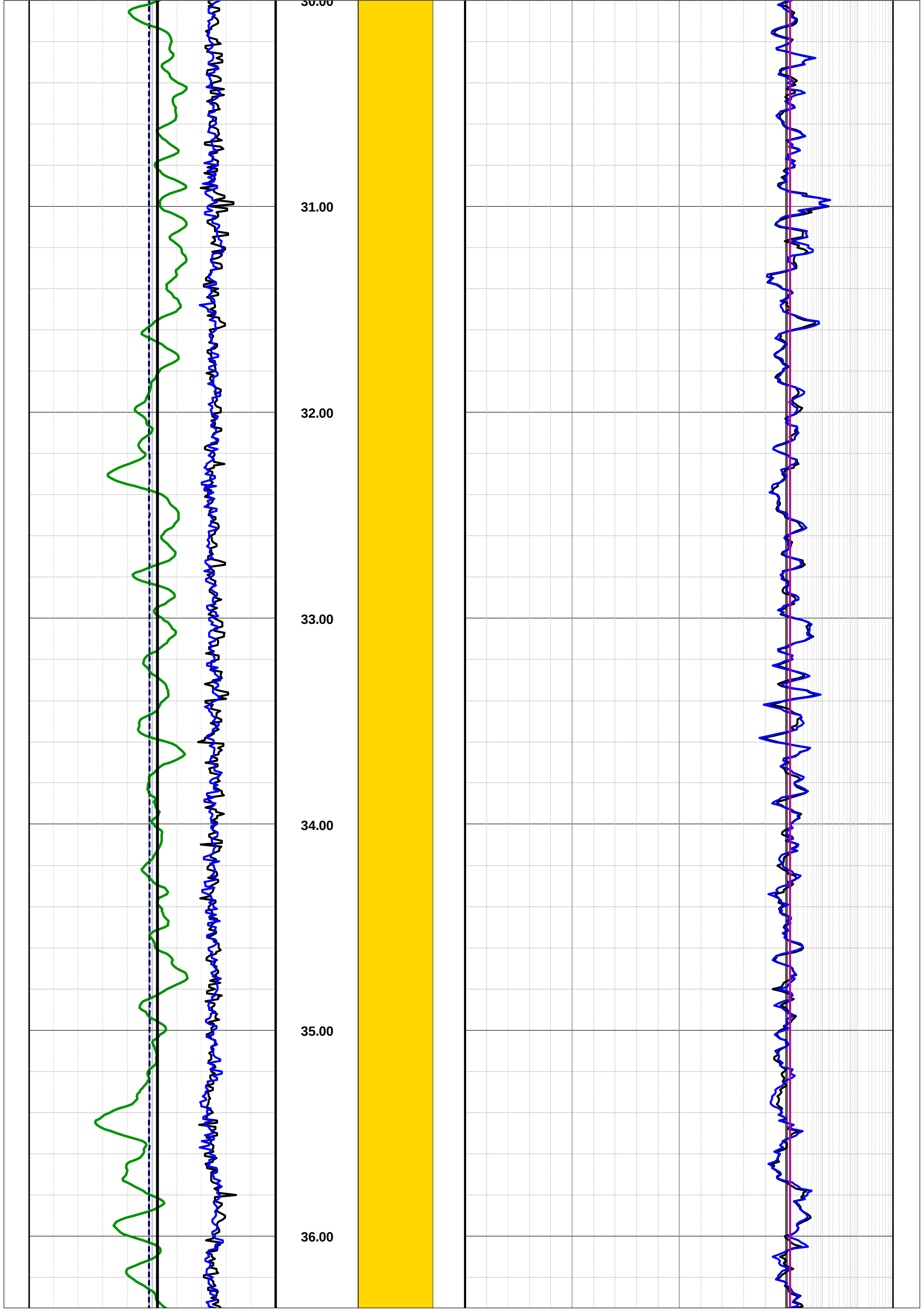
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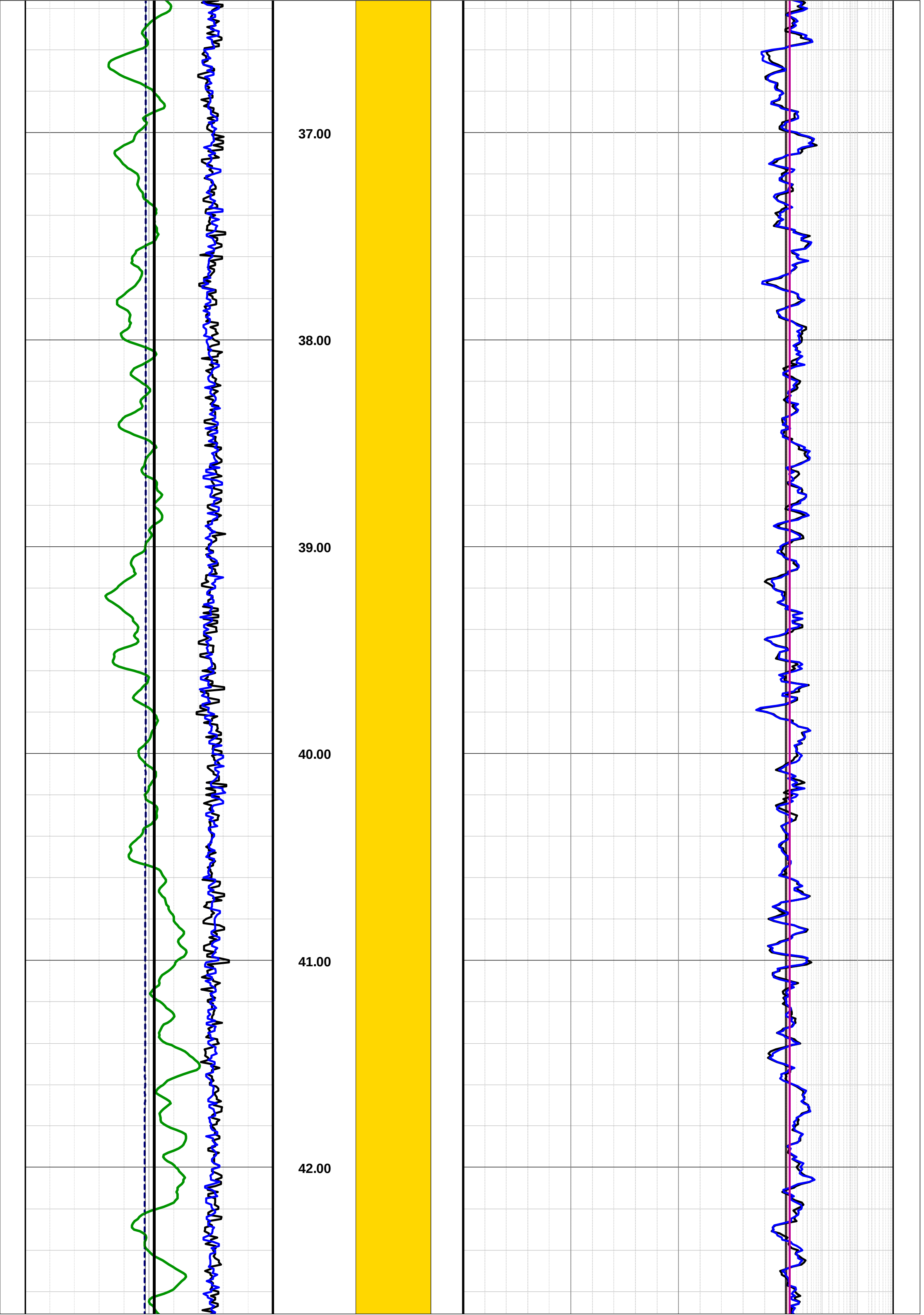
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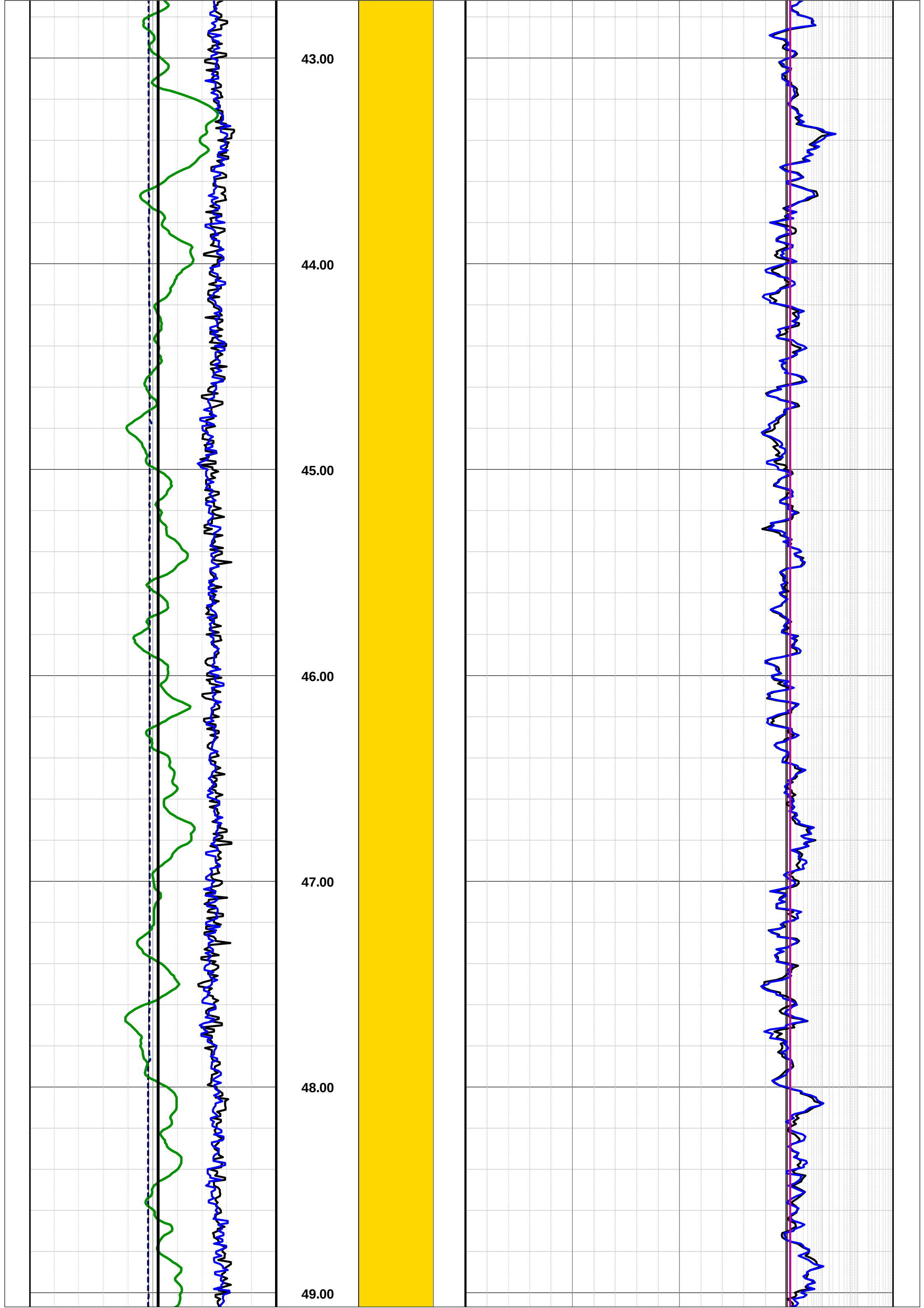
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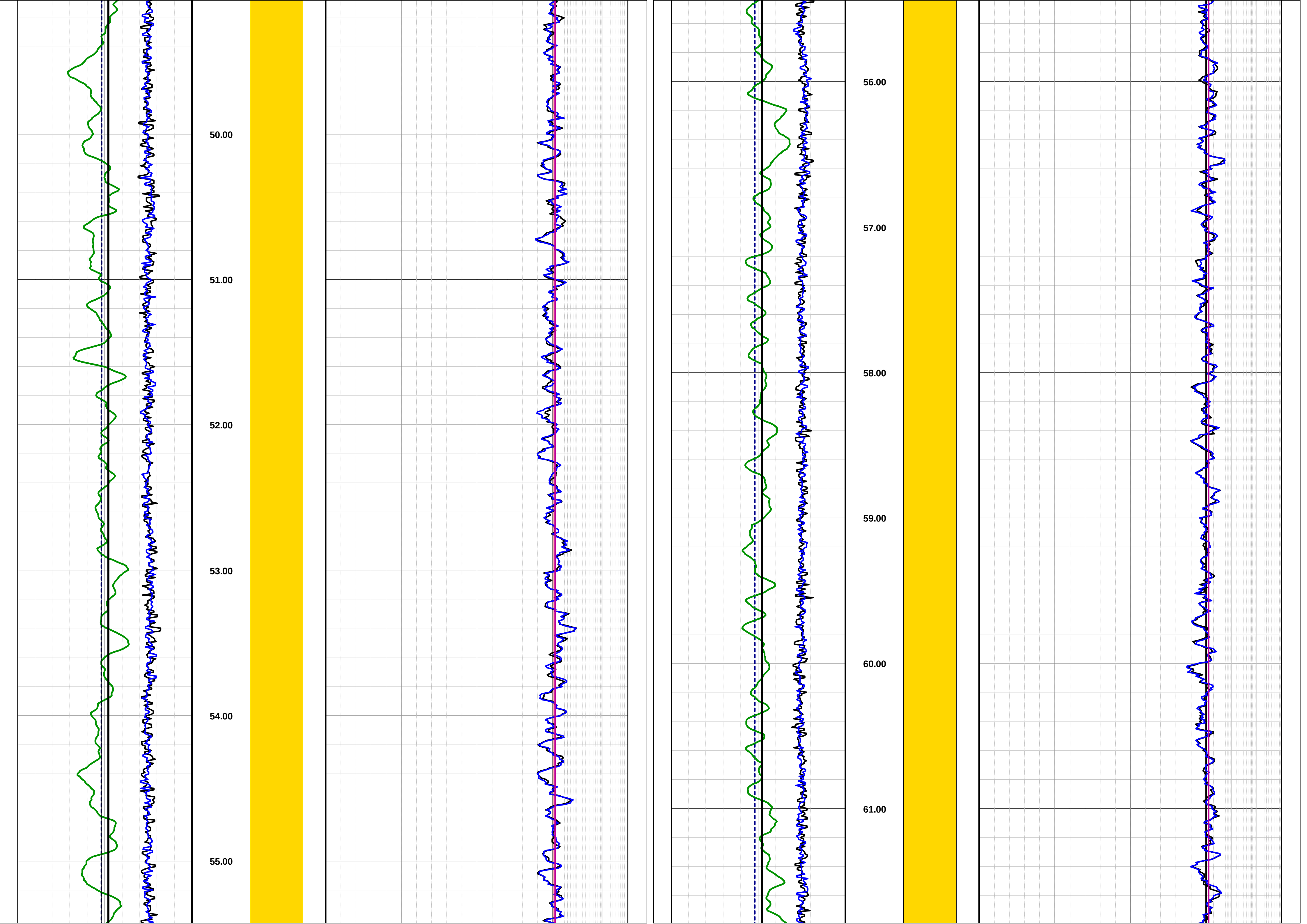

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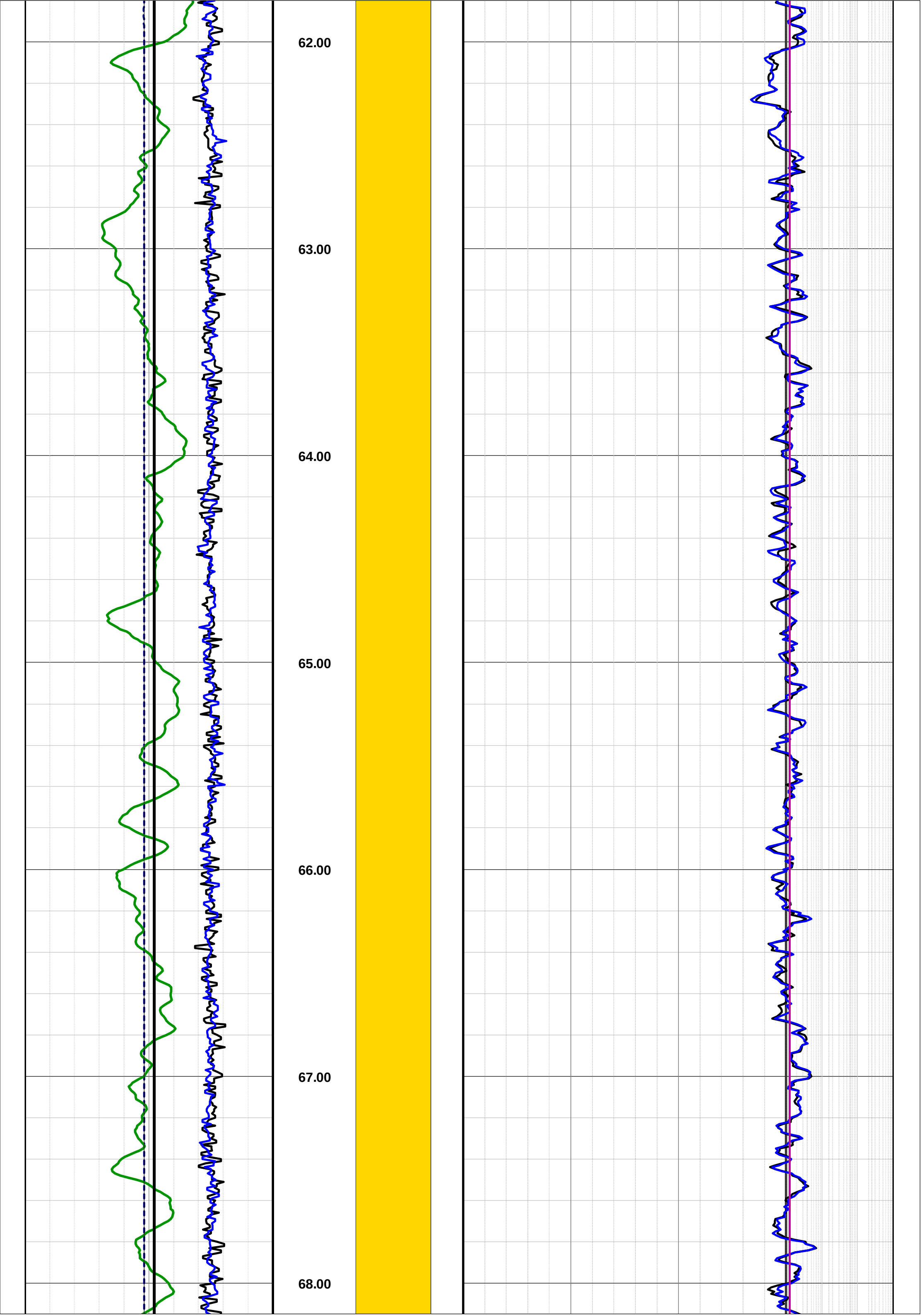
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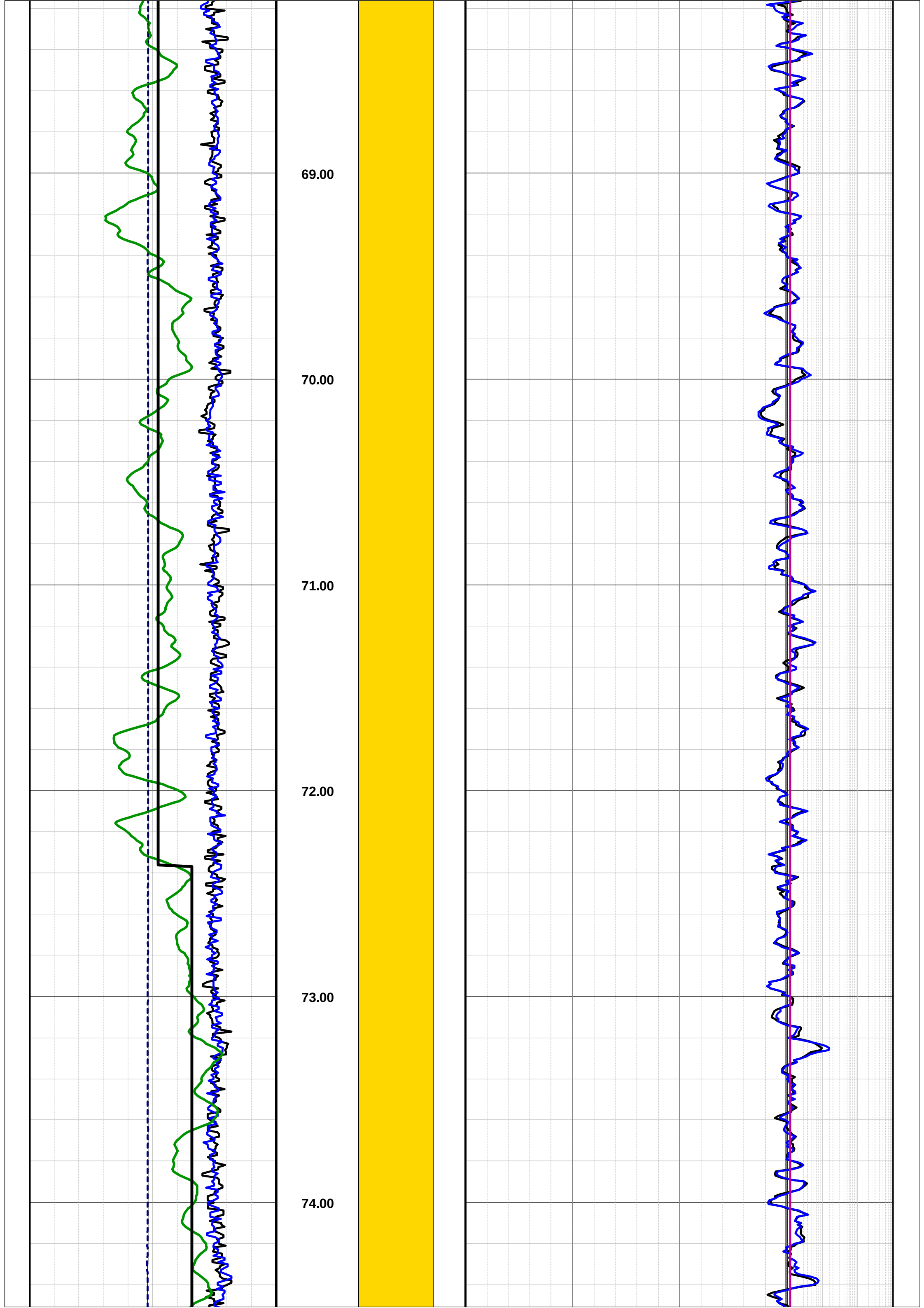
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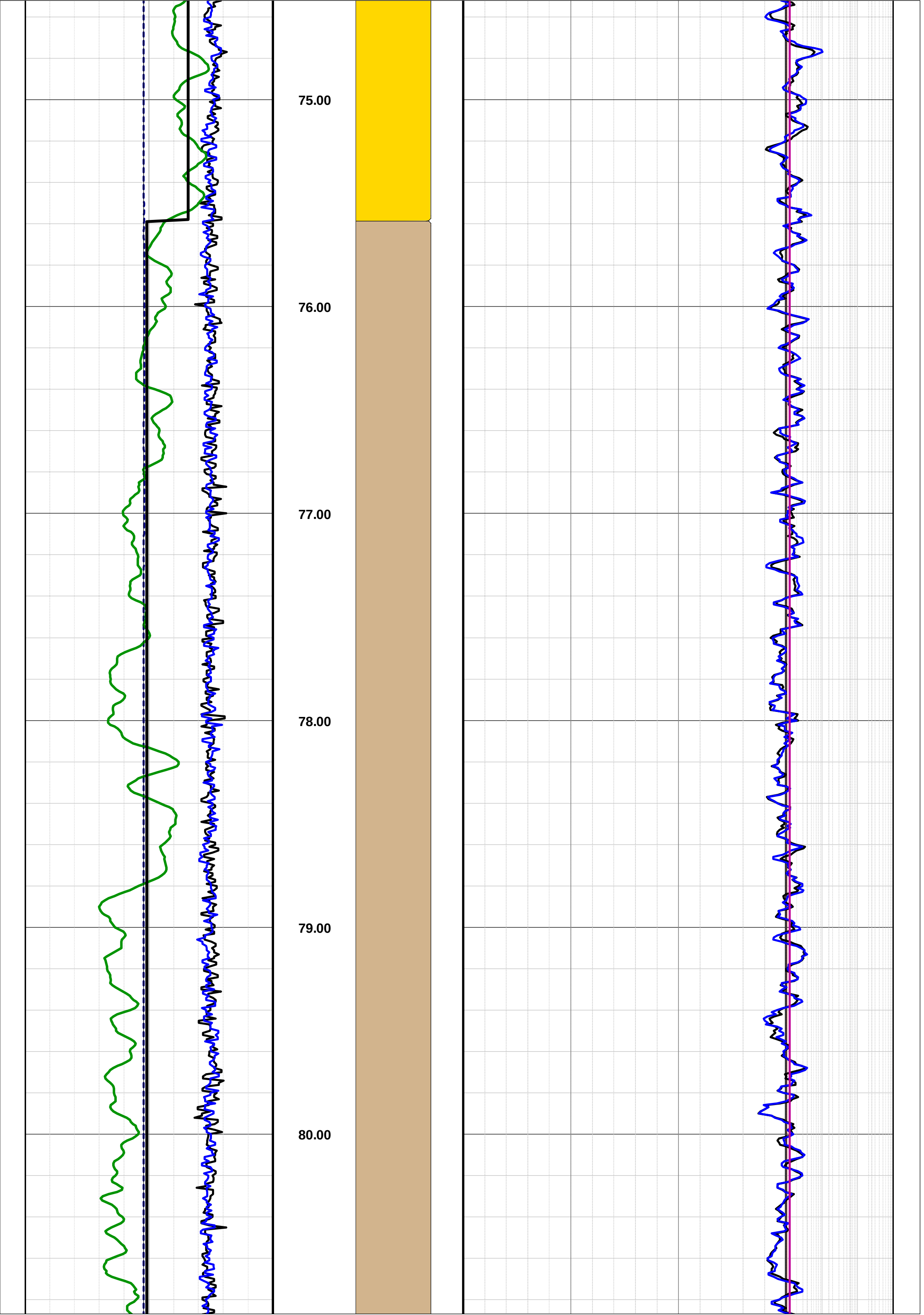
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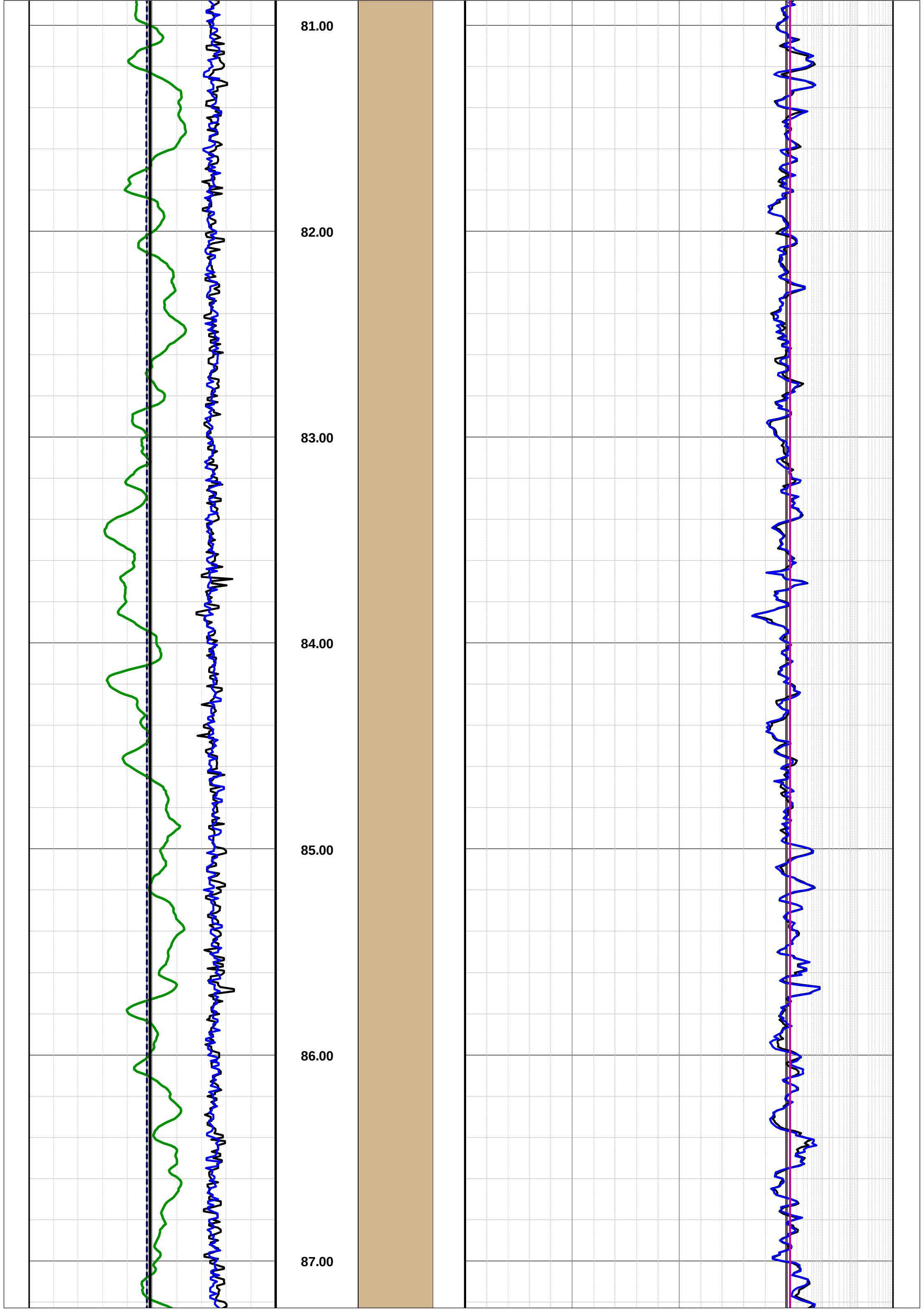
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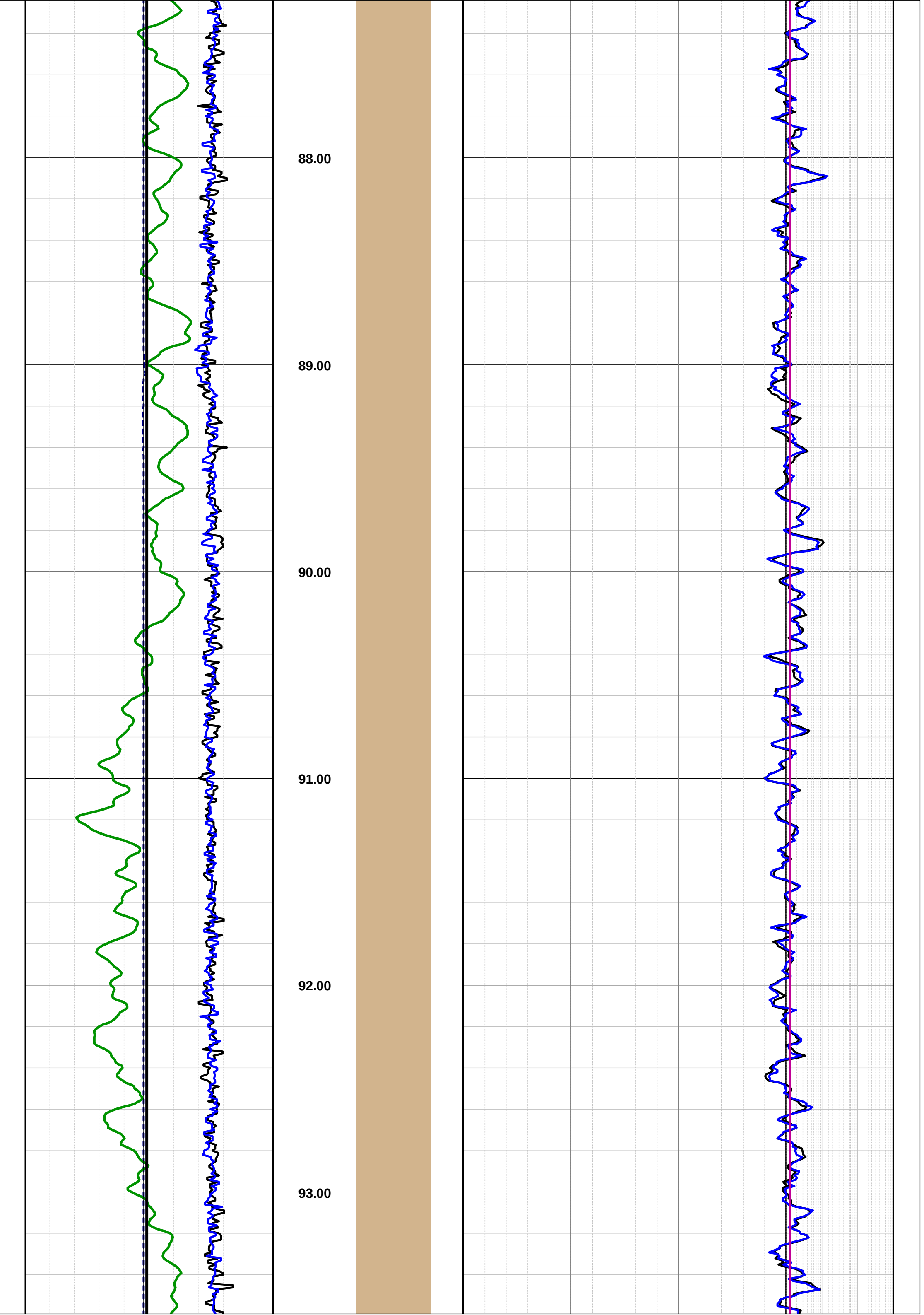
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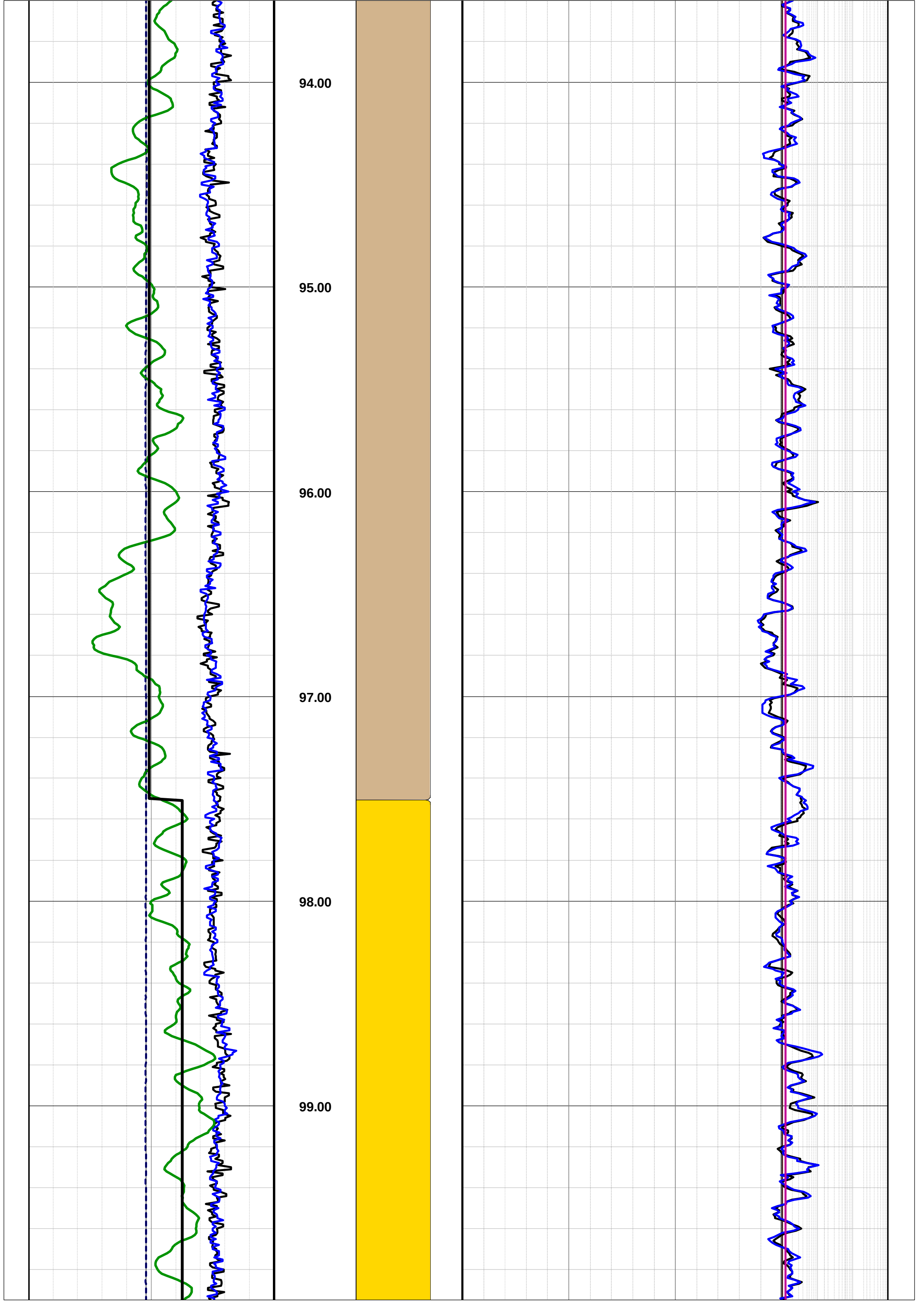
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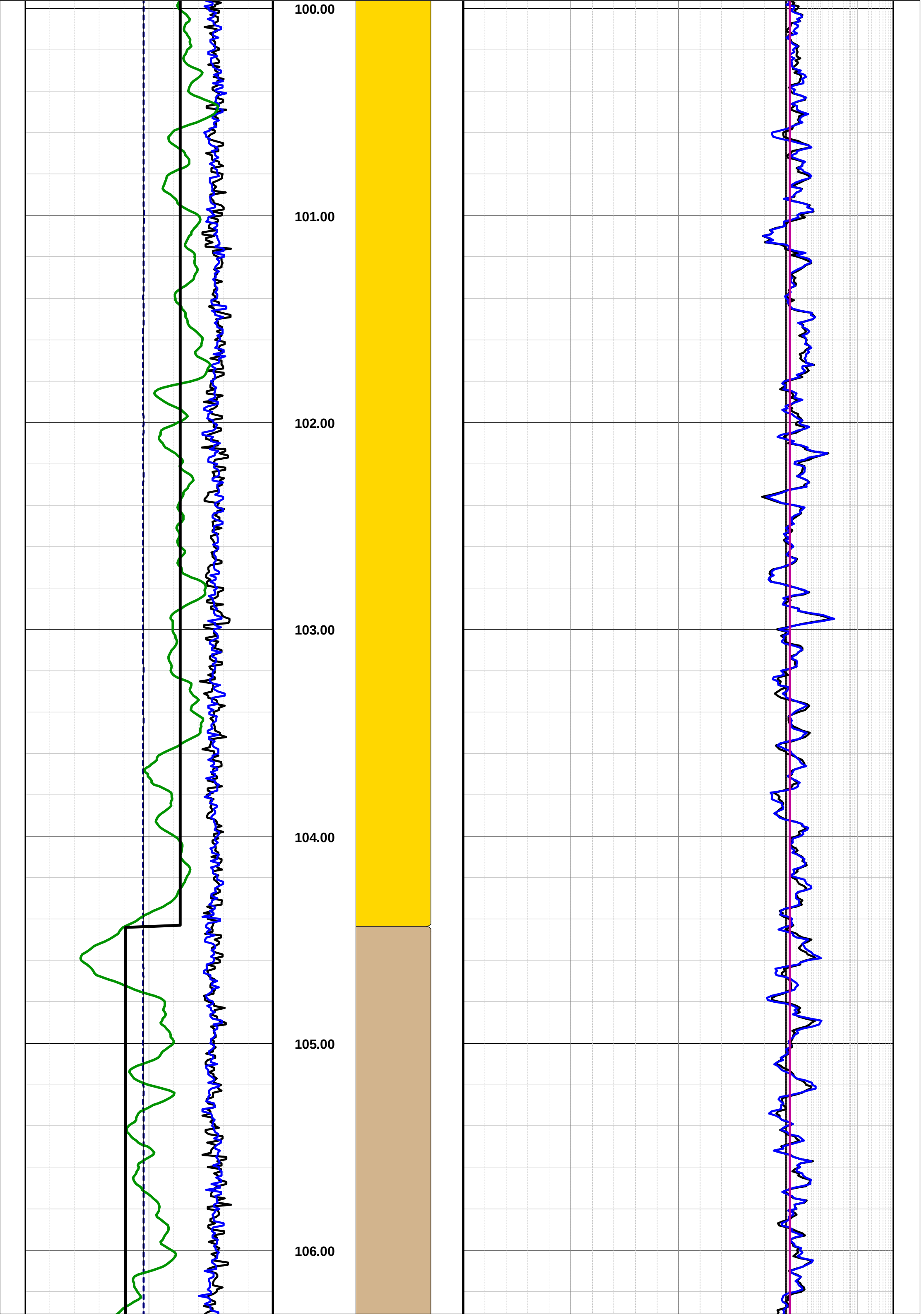
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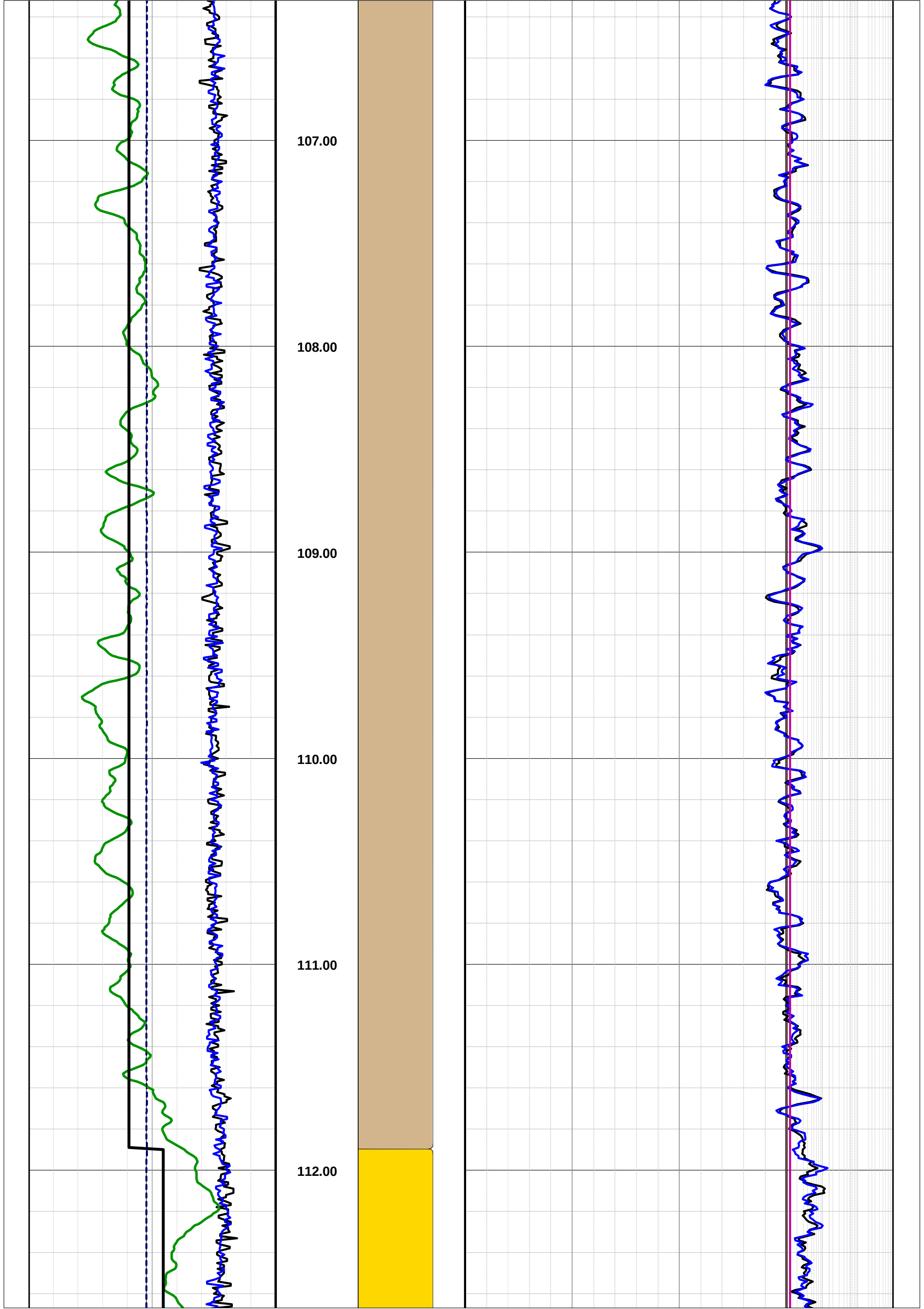
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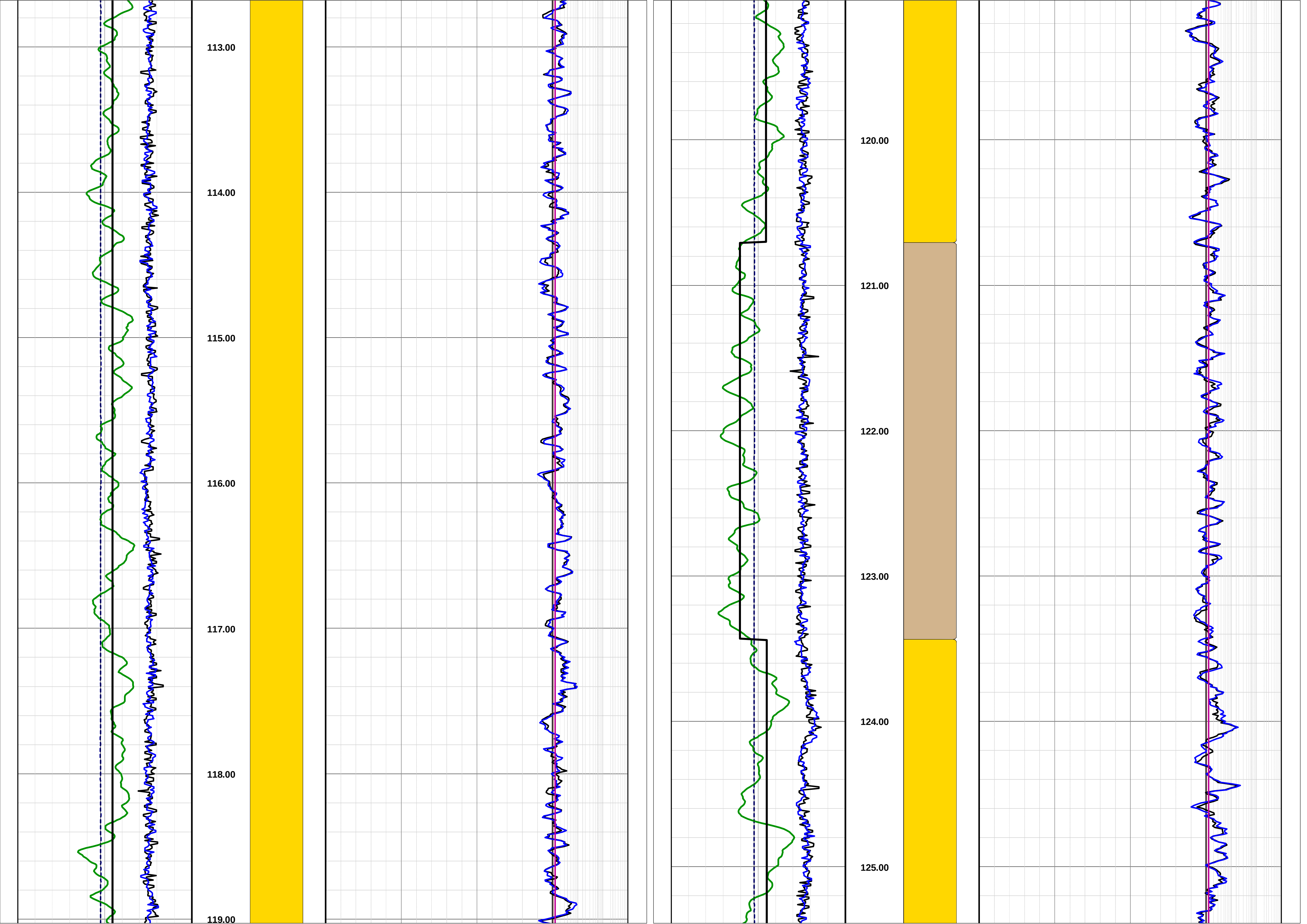
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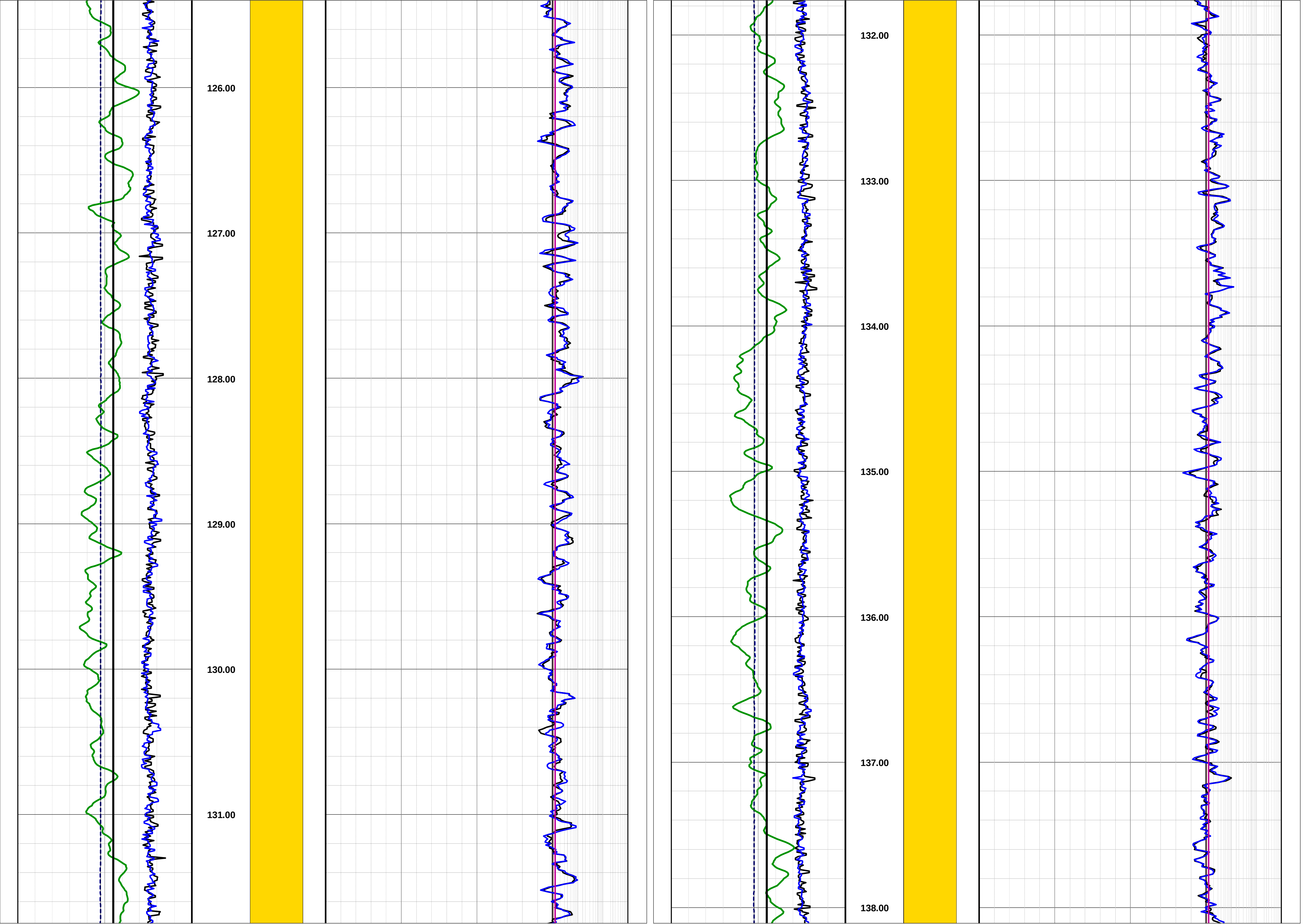
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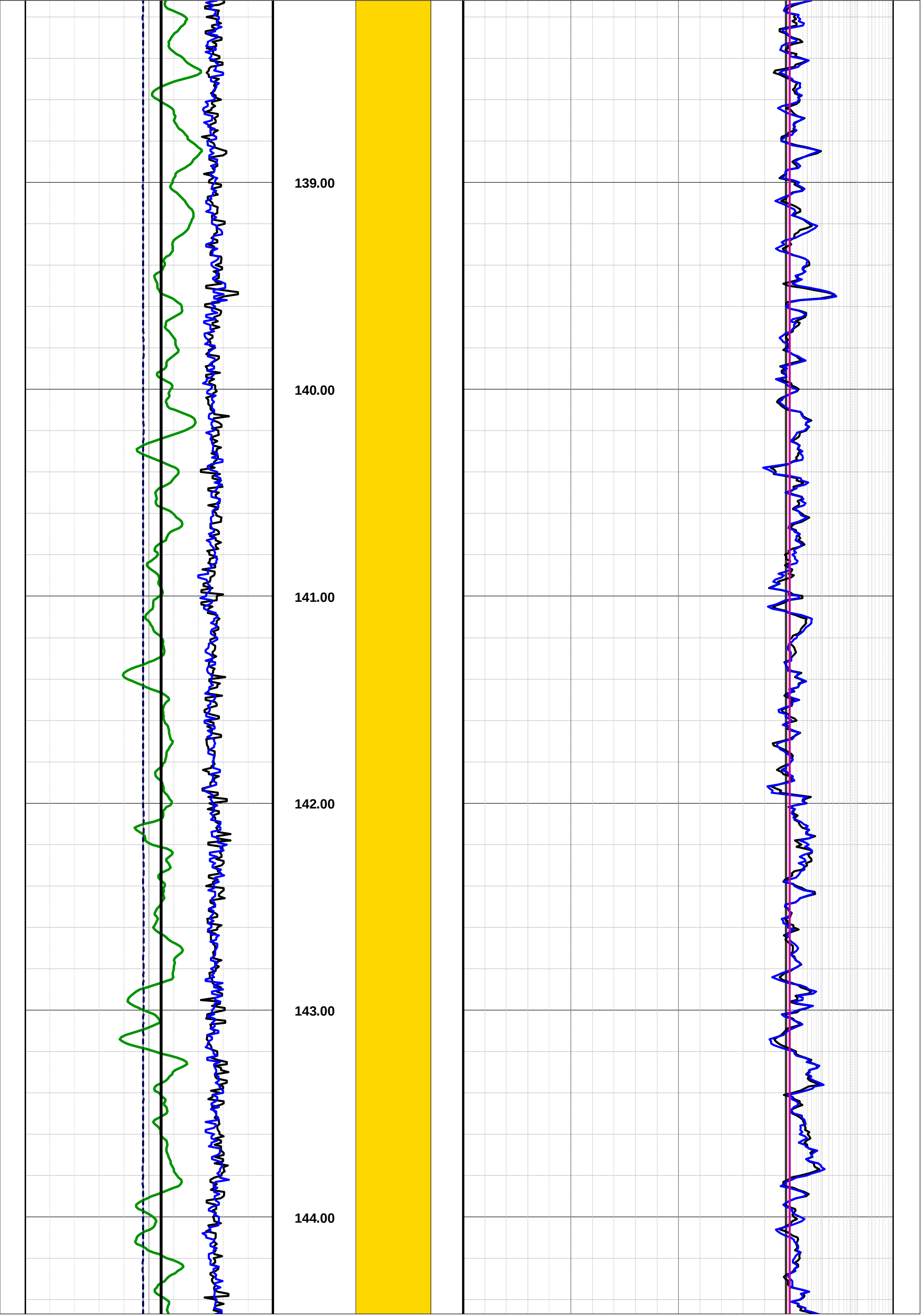
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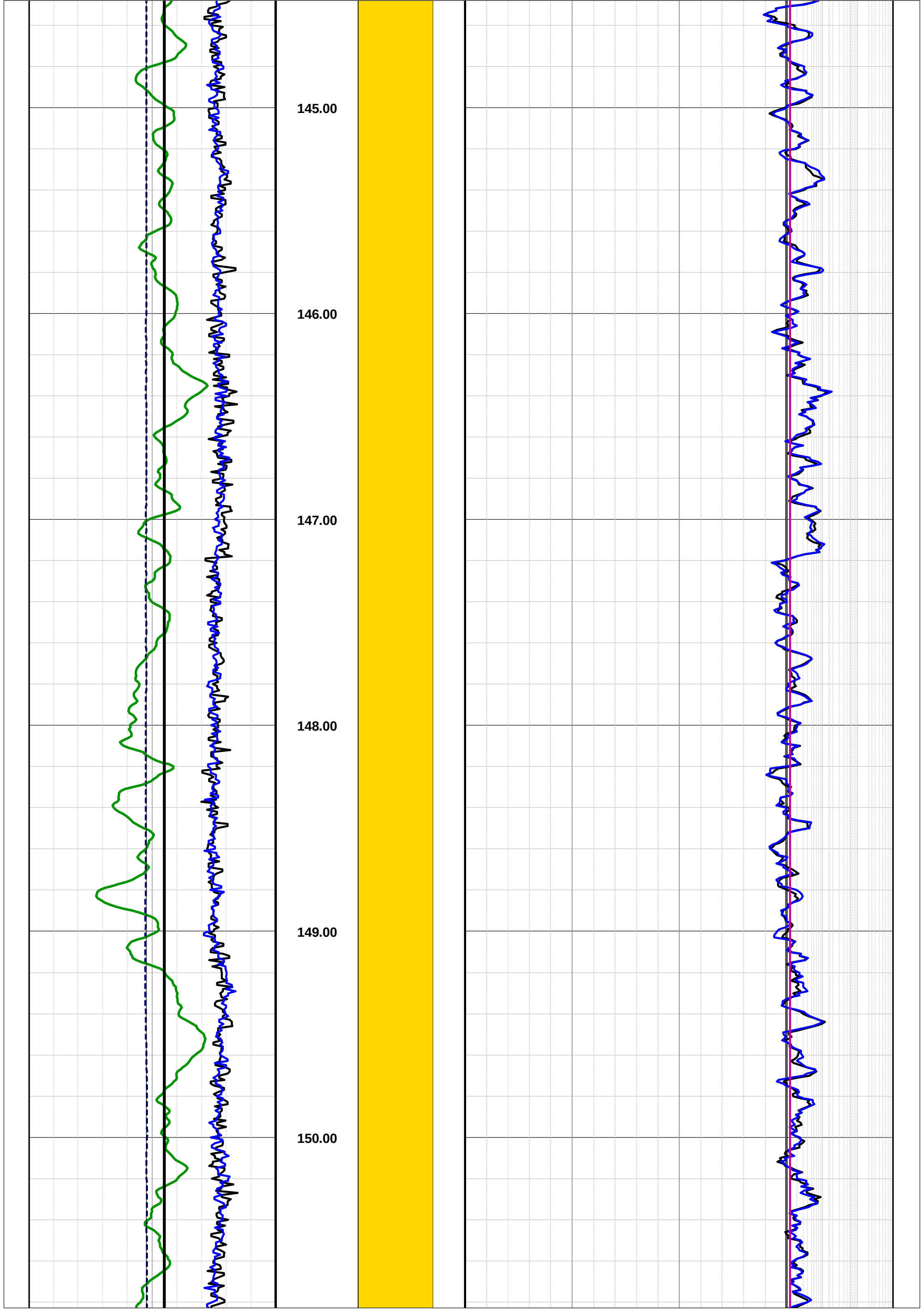
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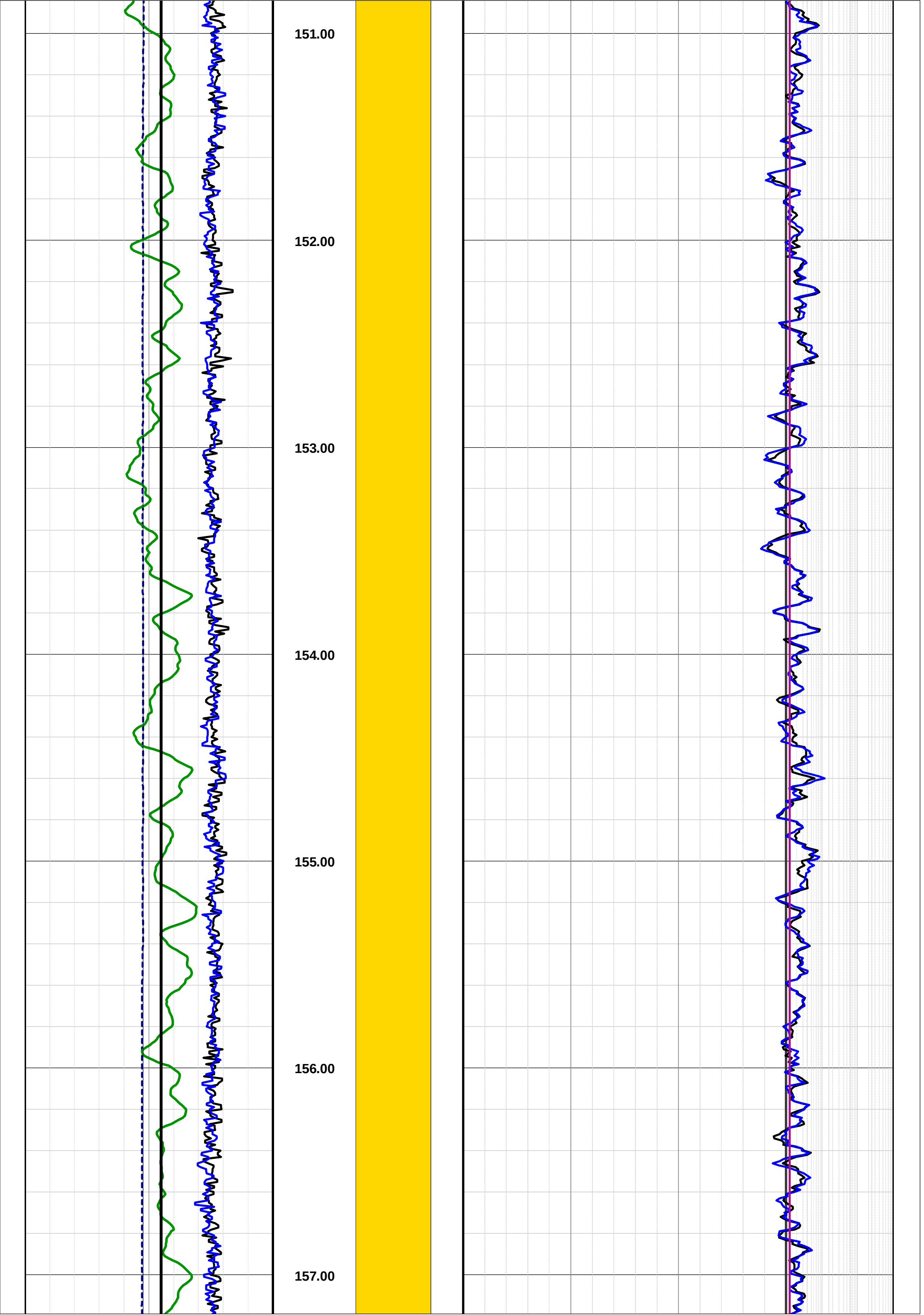
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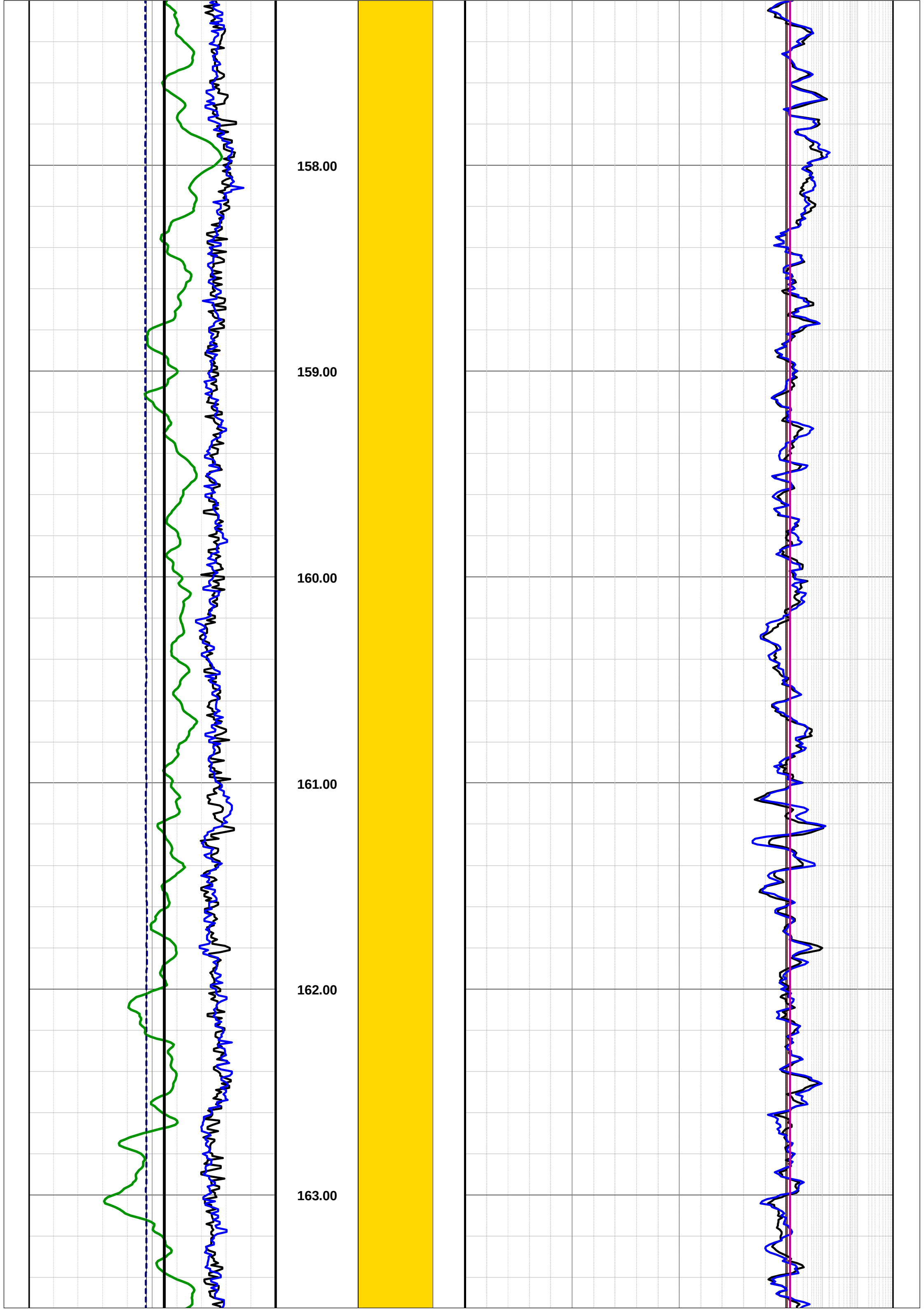
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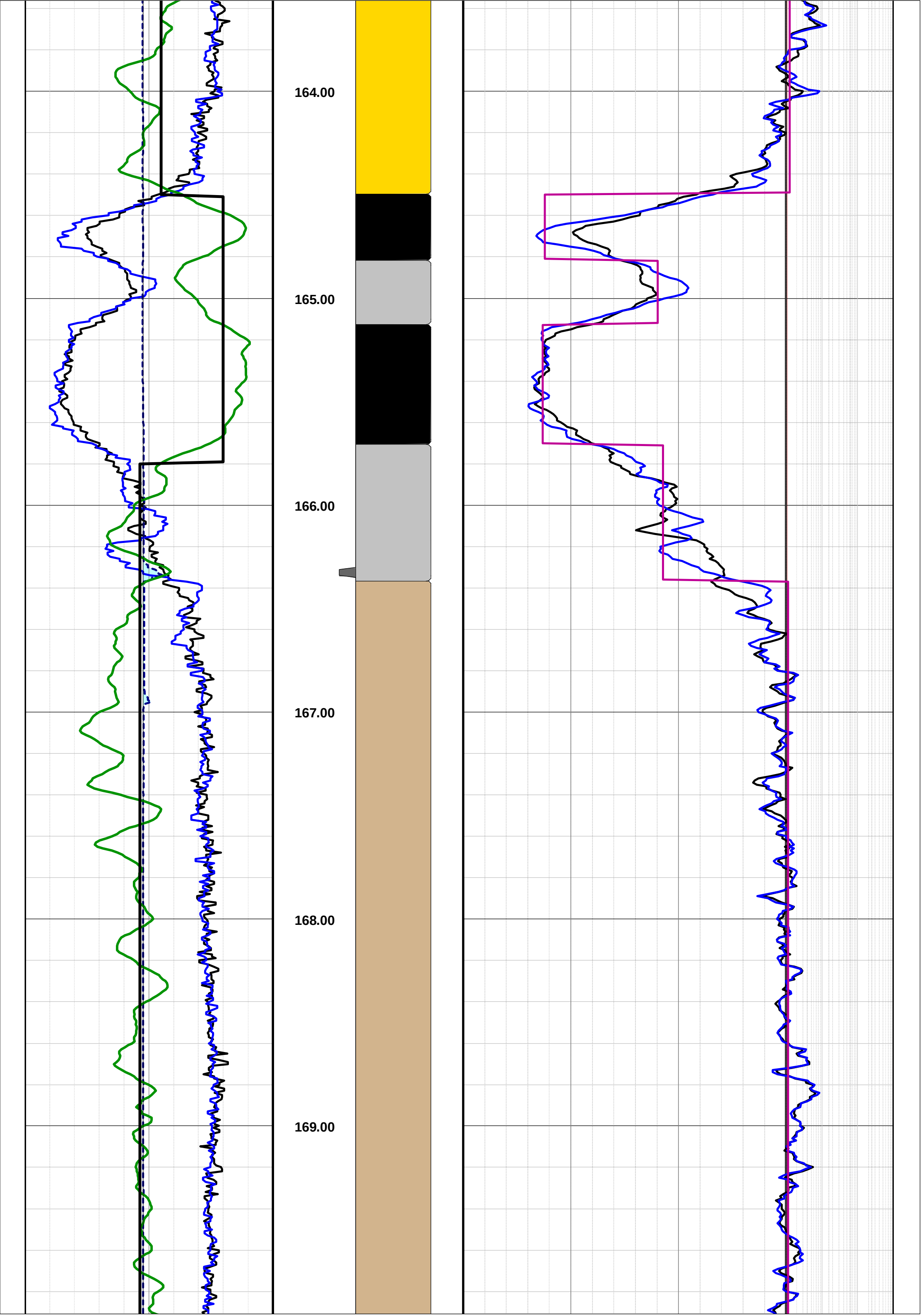
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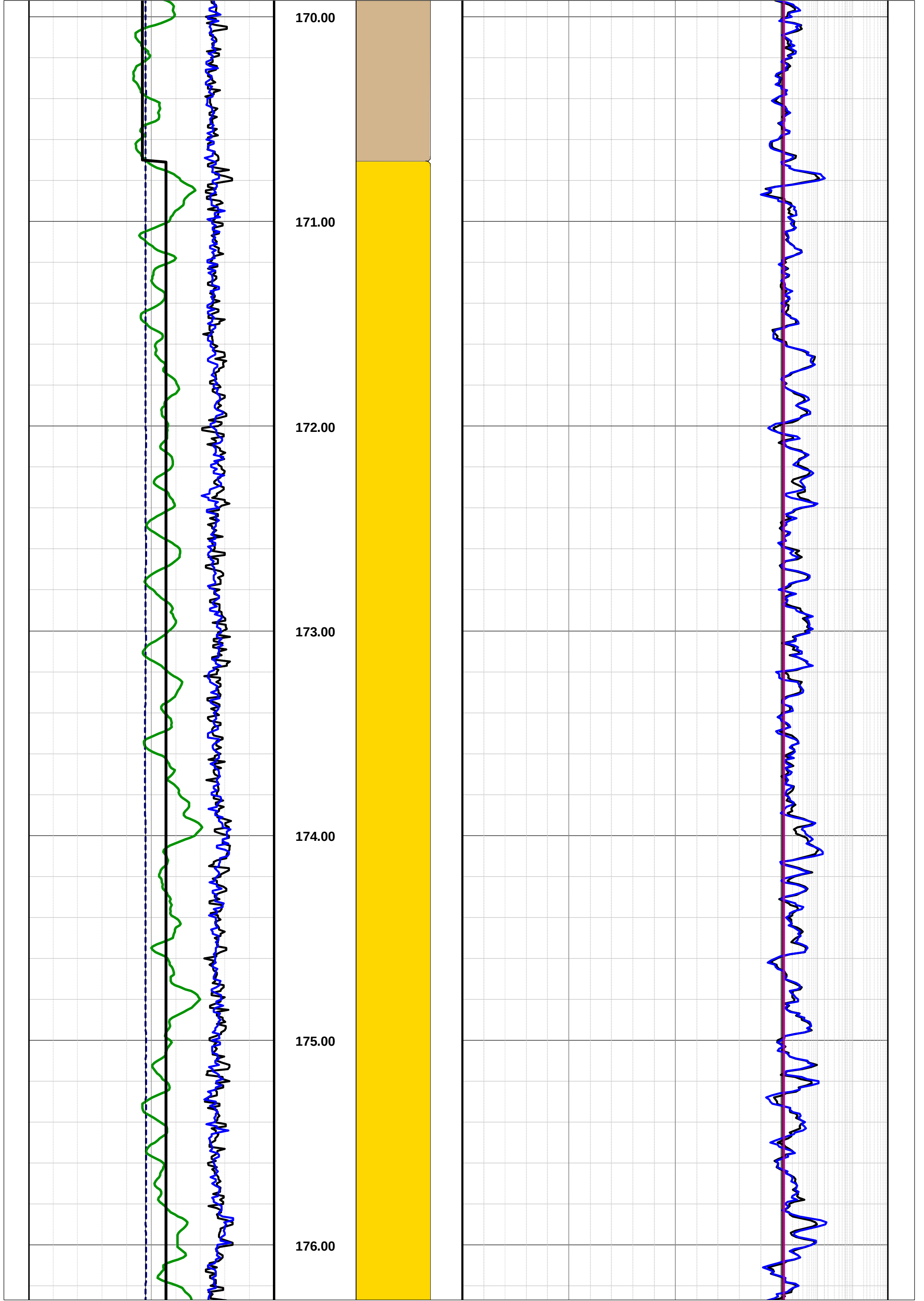
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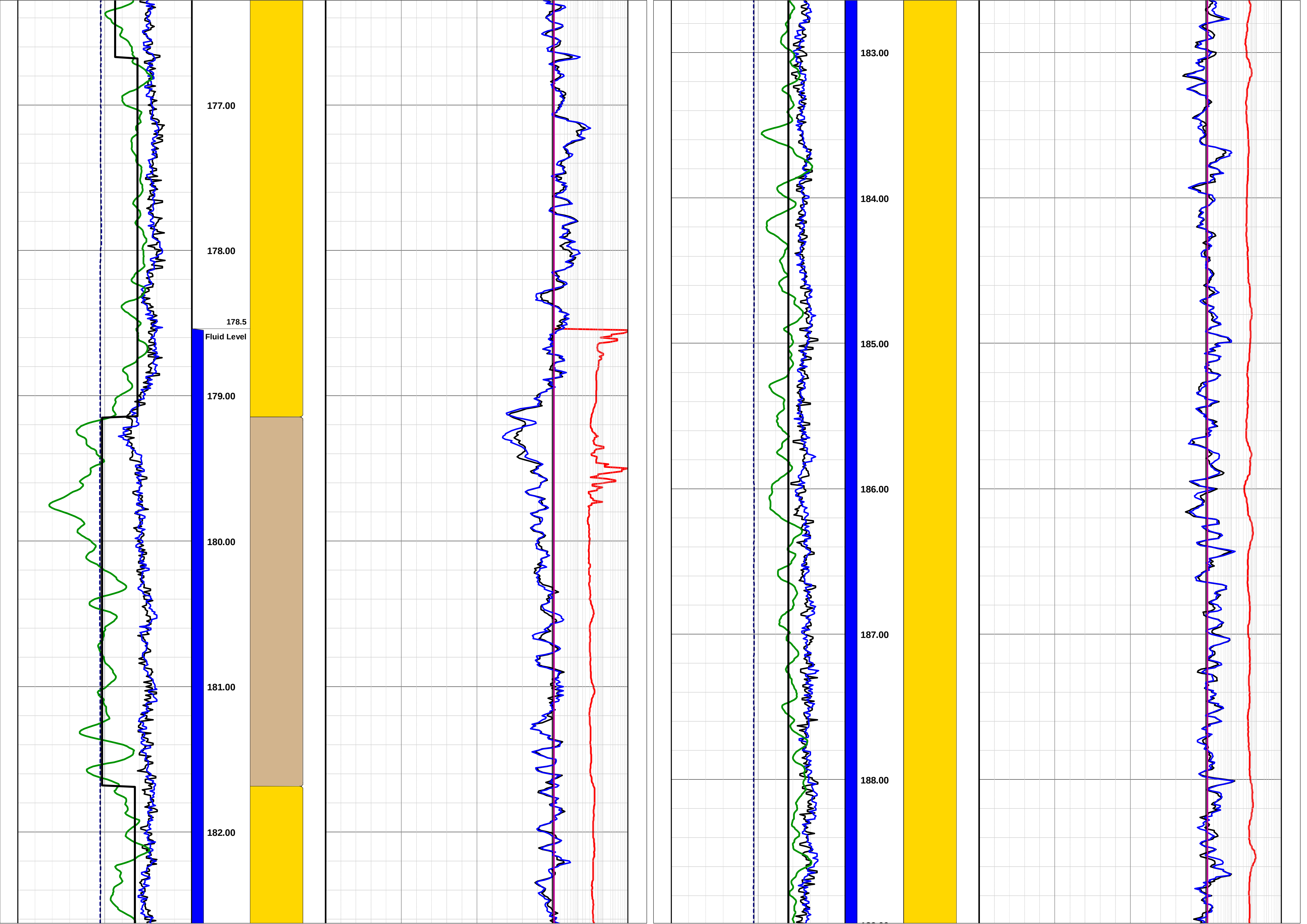
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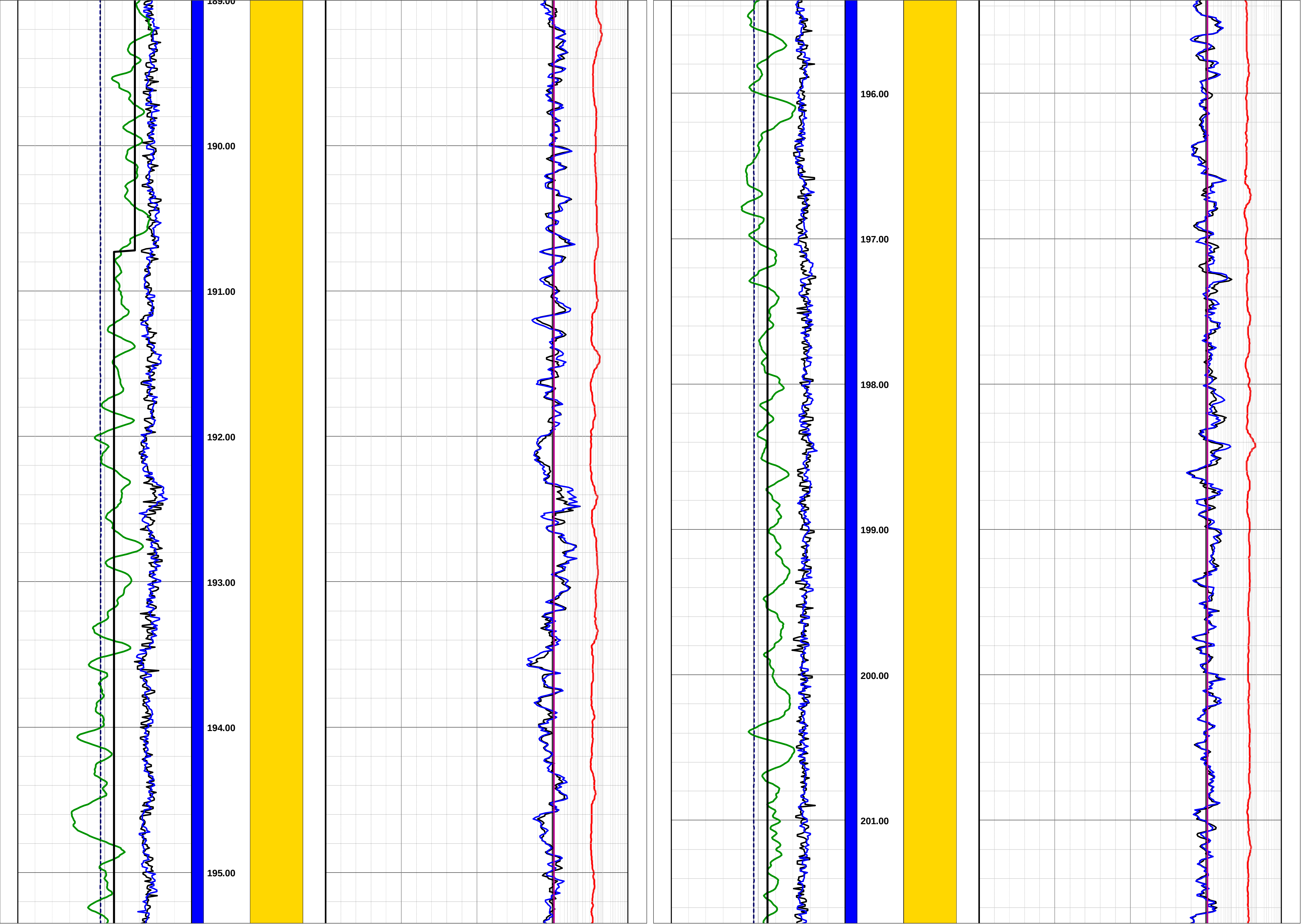
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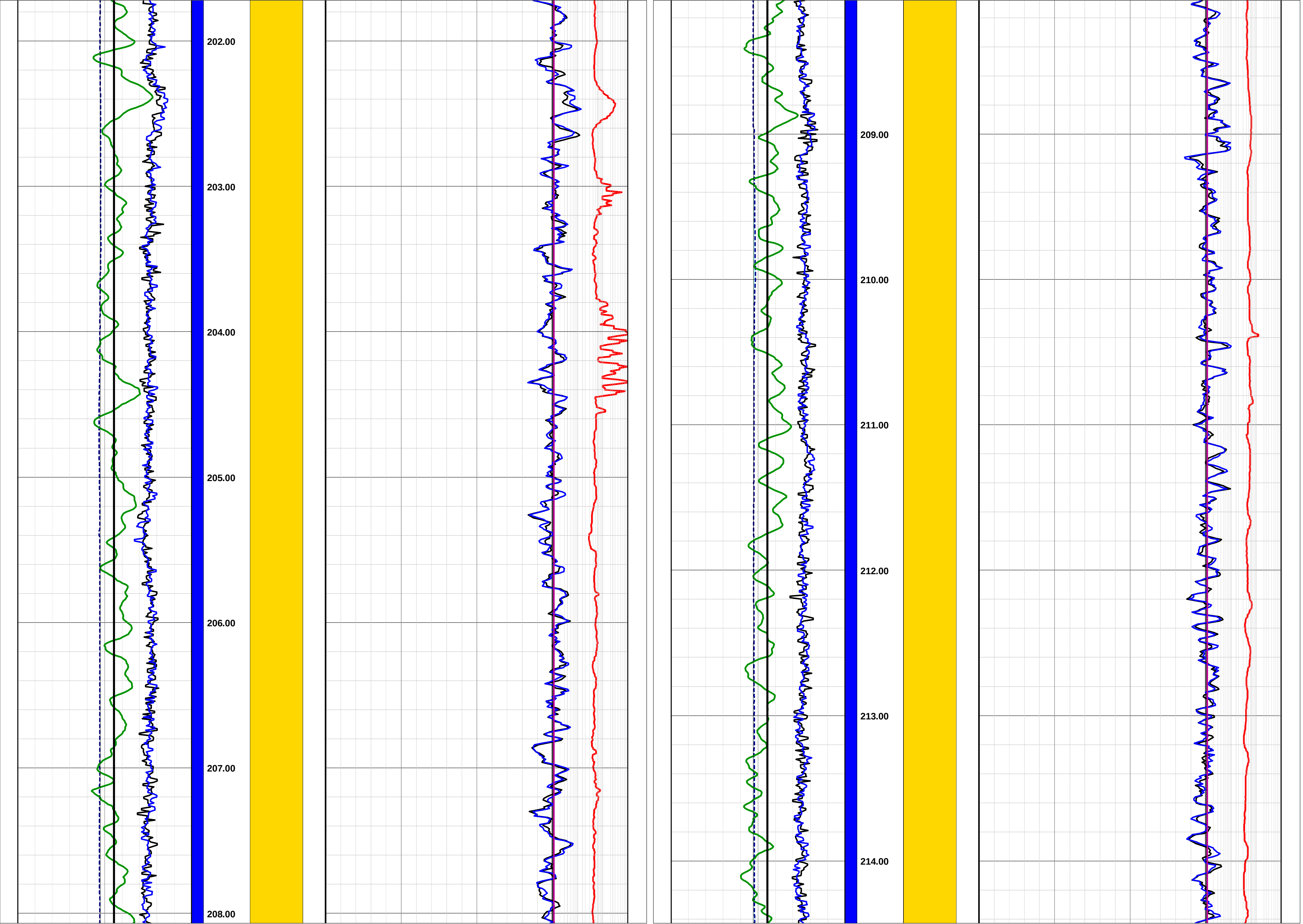
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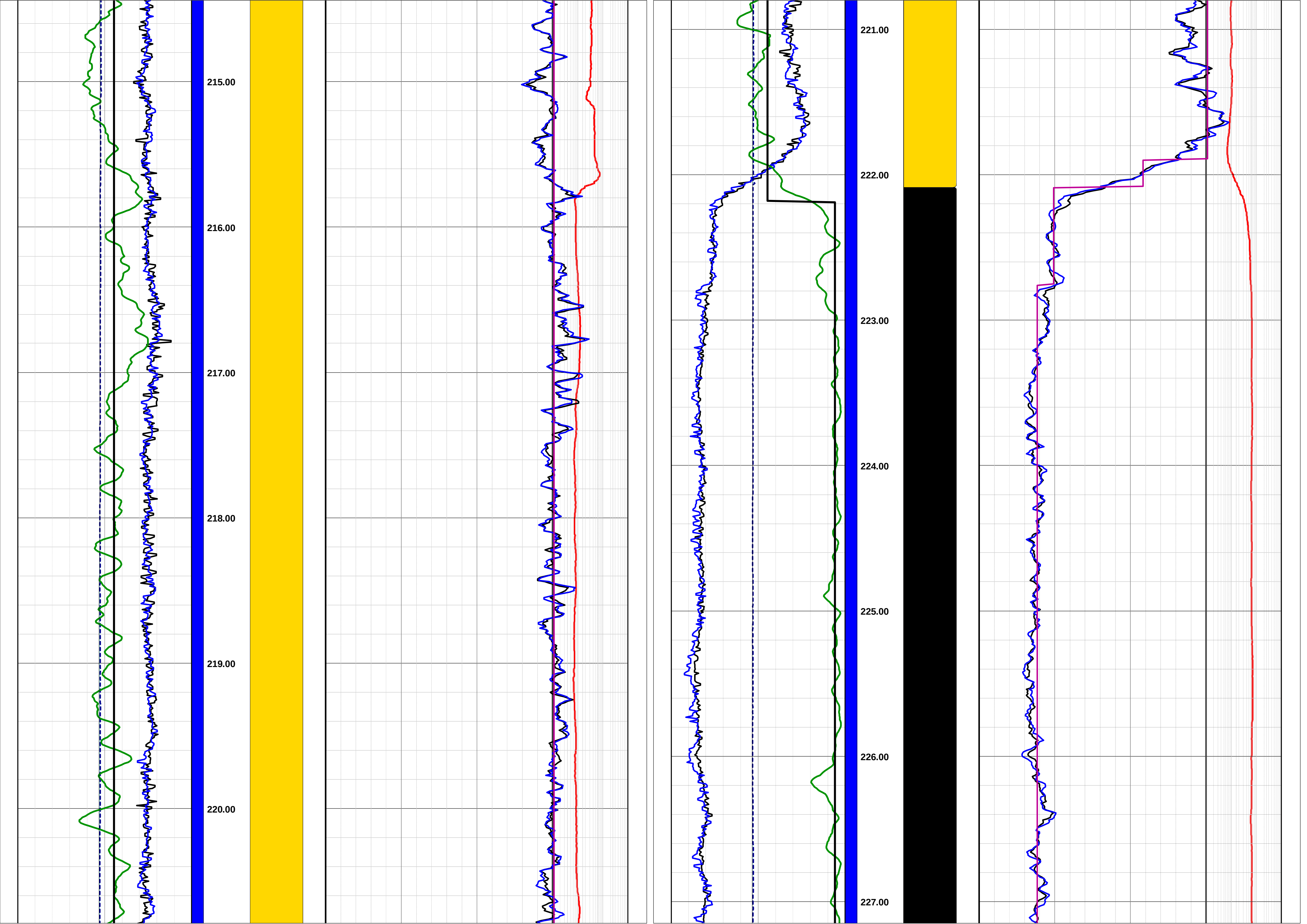
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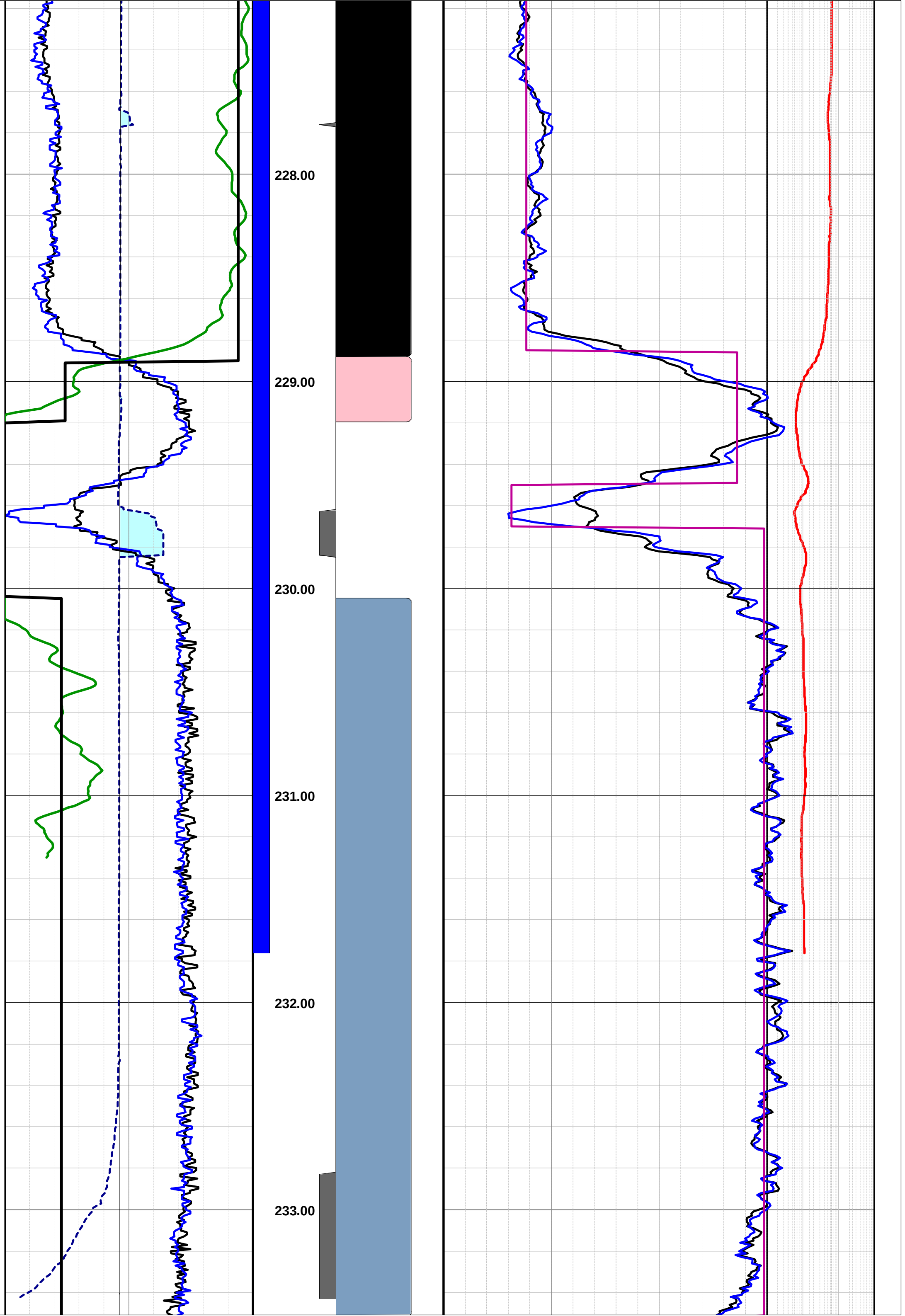
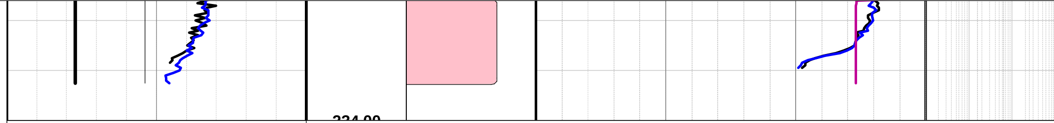




0 DEG 20 SANG			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND

CO - Coal	S1 - Sandstone - very fine grained
CF - Inferior Coal	S2 - Sandstone - fine grained
ST - SILTSTONE	TF - TUFF

COMPANY	BMA	**LOCATION**	MB19BWM03P
WELL	MB19BWM03P	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

MB19BWM03P

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

MB19BWM06P

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	MB19BWM06P	**LOCATION**	MB19BWM06P	**COUNTRY**	AUSTRALIA

LOCATION: MB19BWM06P
FIELD: BLW
STATE: QLD
WELL: MB19BWM06P
COMPANY: BMA

	ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM		
DRILLING MEASURED FROM	KB	1.
PERMANENT DATUM	DF	2.
PERMANENT DATUM ELEVATION	GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	07-11-2019			RECORDED BY	GRM		
TIME	11-14			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	192m			RIG NUMBER			
DEPTH-LOGGER	191.90m			TOOL TYPE	9239C		
BIT SIZE	171mm			TOOL SERIAL NO.	2727		
CASING TYPE	PVC			EASTING	687588		
CASING ID	200mm			NORTHING	7379287		
CASING BOTTOM	15m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	32.2 m			SOURCE TYPE	CS137	SOURCE ID	CZ3498

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

CO - Coal	**S2 - Sandstone - fine grained**
CF - Inferior Coal	**S3 - Sandstone - fine to medium grained**

S1 - SILTSTONE | S4 - Sandstone - medium grained

S1 - Sandstone - very fine grained

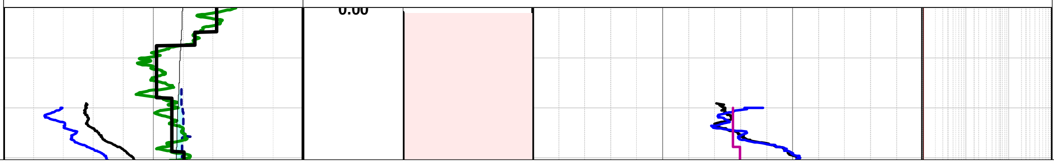
MNEMONICS

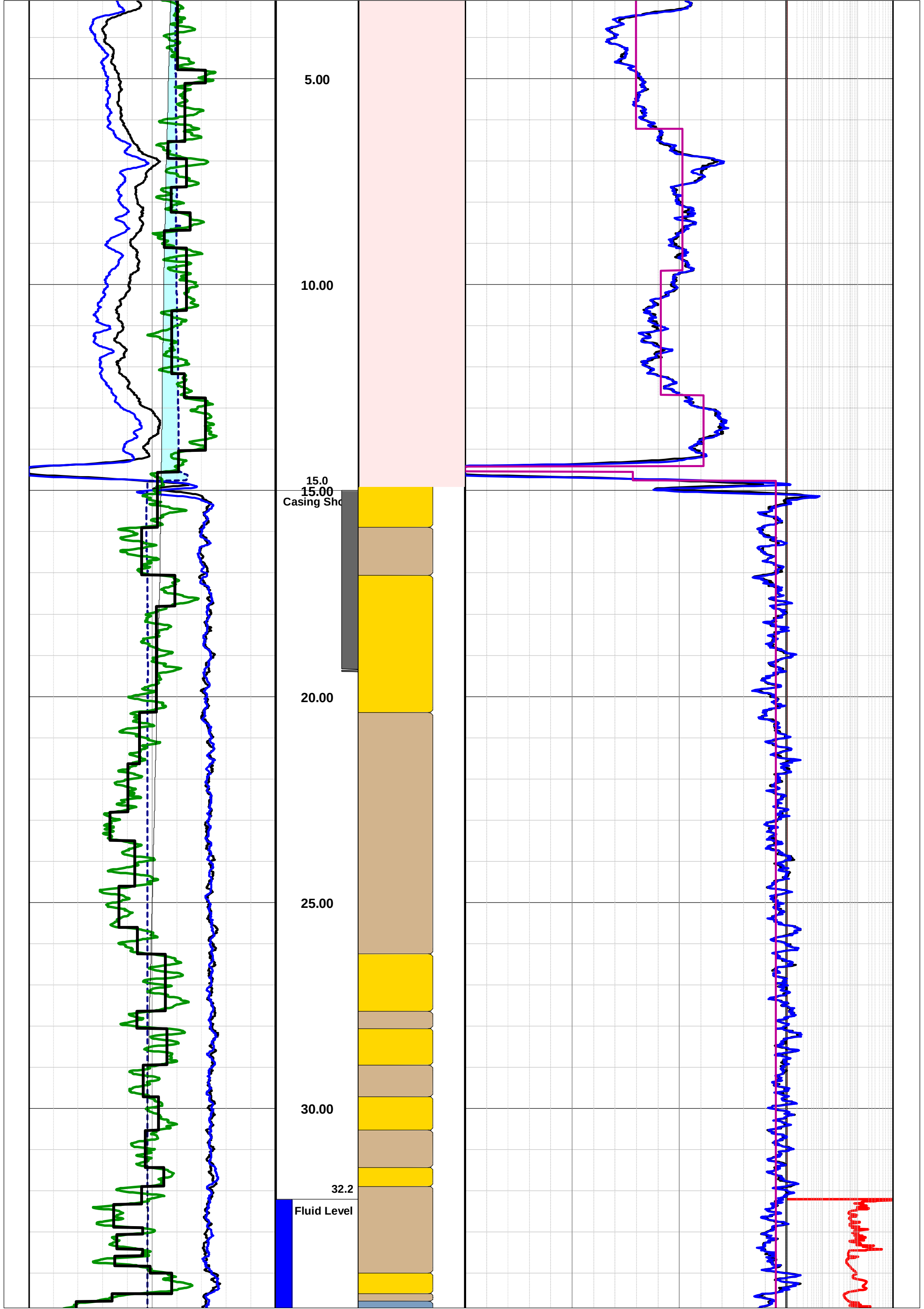
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

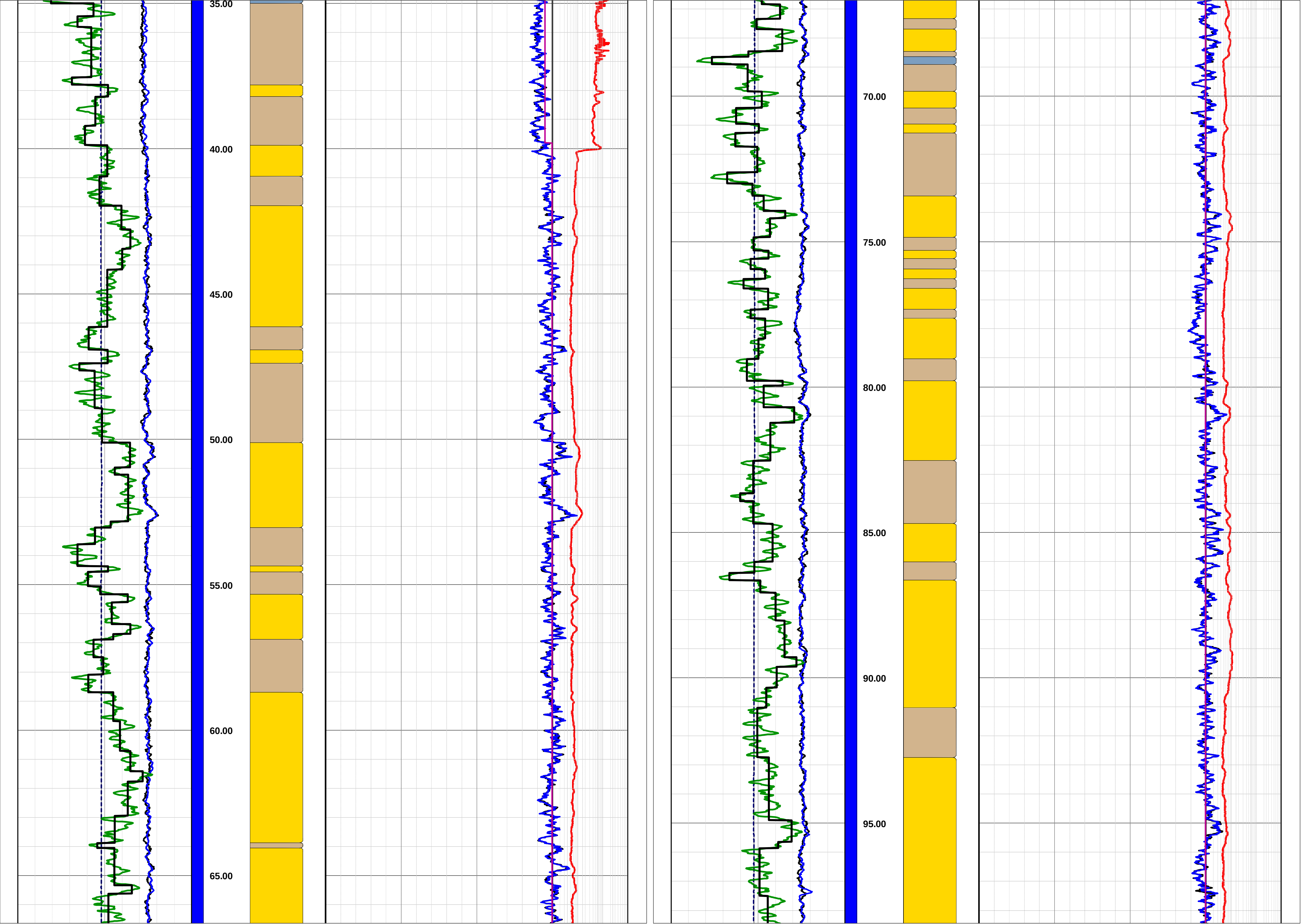
IMPORTANT NOTE	The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

Curve	Left	Unit	Right
DEN(LS)	1	g/cc	3
DEN(SS)	1	g/cc	3
CALIPER	50	mm	300
GAM(NAT)	200	API	0
NOM_BIT	50	mm	300
SANG	0	DEG	20
Depth		1m:100m	
DATA_FLAG			
WT_FLAG			
COKED_COAL			
LITHOLOGY			
CASING			
RES(SG)	1	OHM-M	1000
DEN(COD)	1	g/cc	3
DEN(ER)	1	g/cc	3



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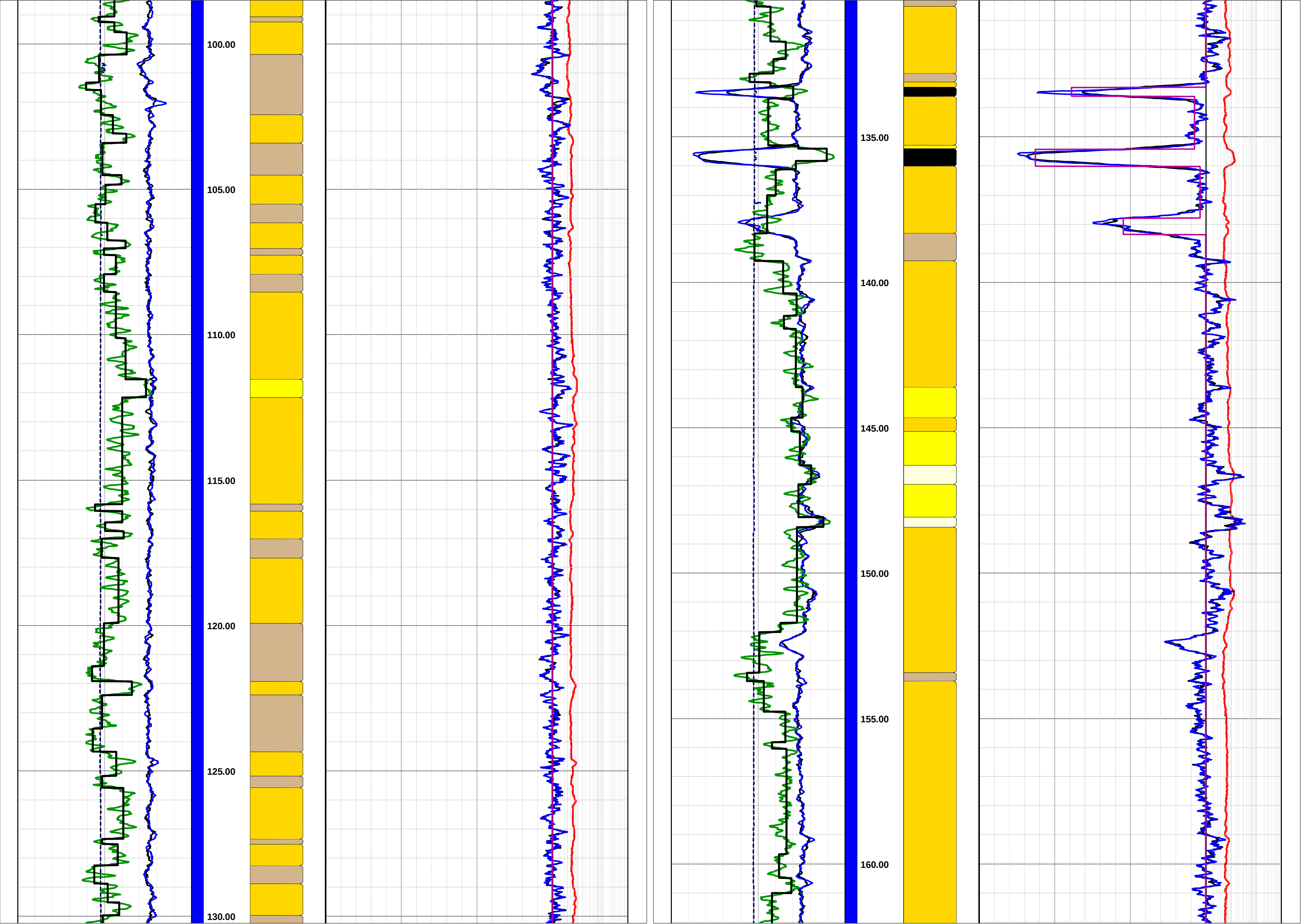
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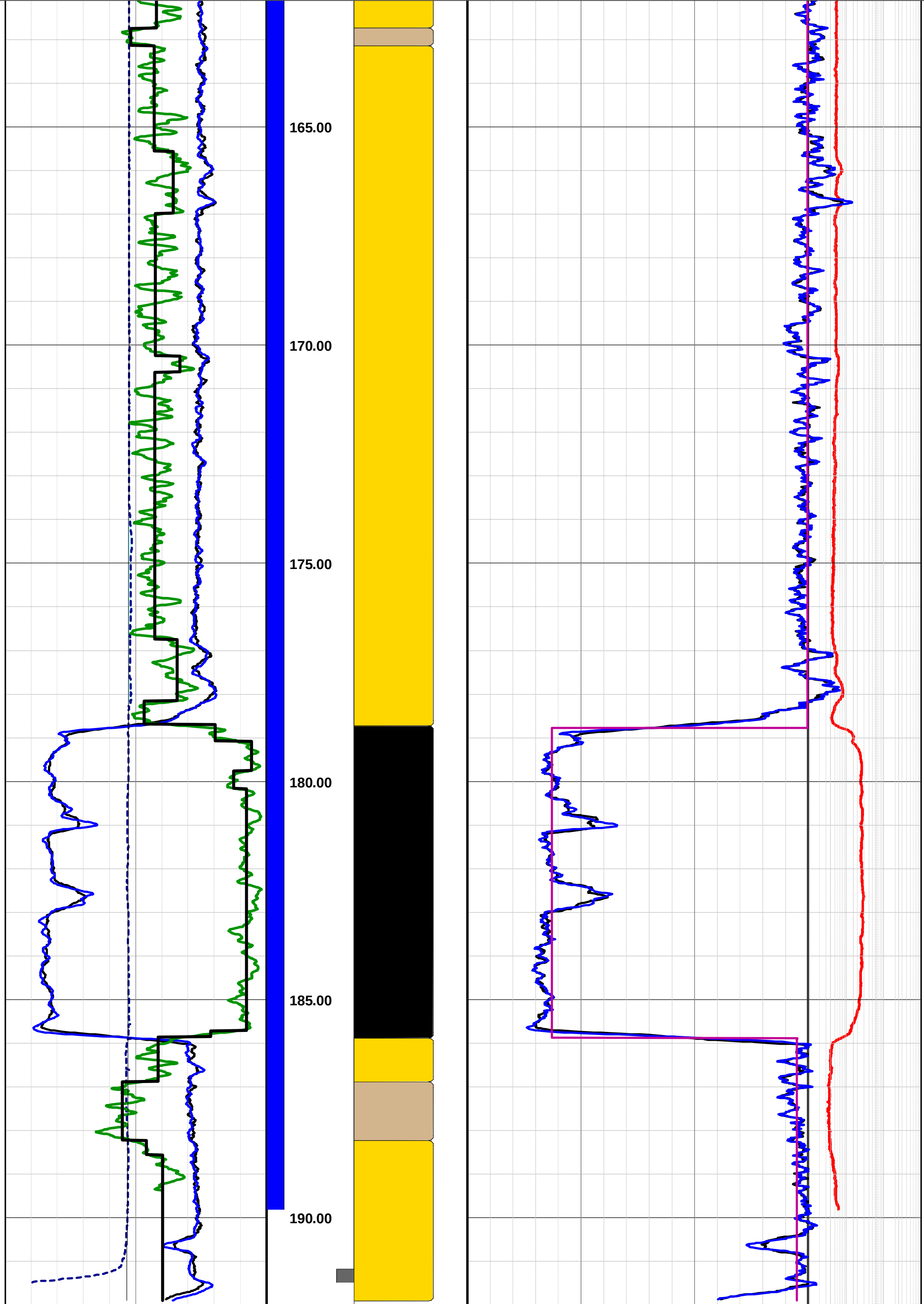


0 DEG 20
SANG
50 mm 300

NOM_BIT

200 API 0
GAM(NAT)

50 mm 300
CALIPER

WT_FLAG

CASING

1 g/cc 3
DEN(ER)

1 g/cc 3
DEN(SS)

DATA_FLAG

LITHOLOGY

1 g/cc 3
DEN(COD)

1 g/cc 3
DEN(LS)

1m:100m
Depth

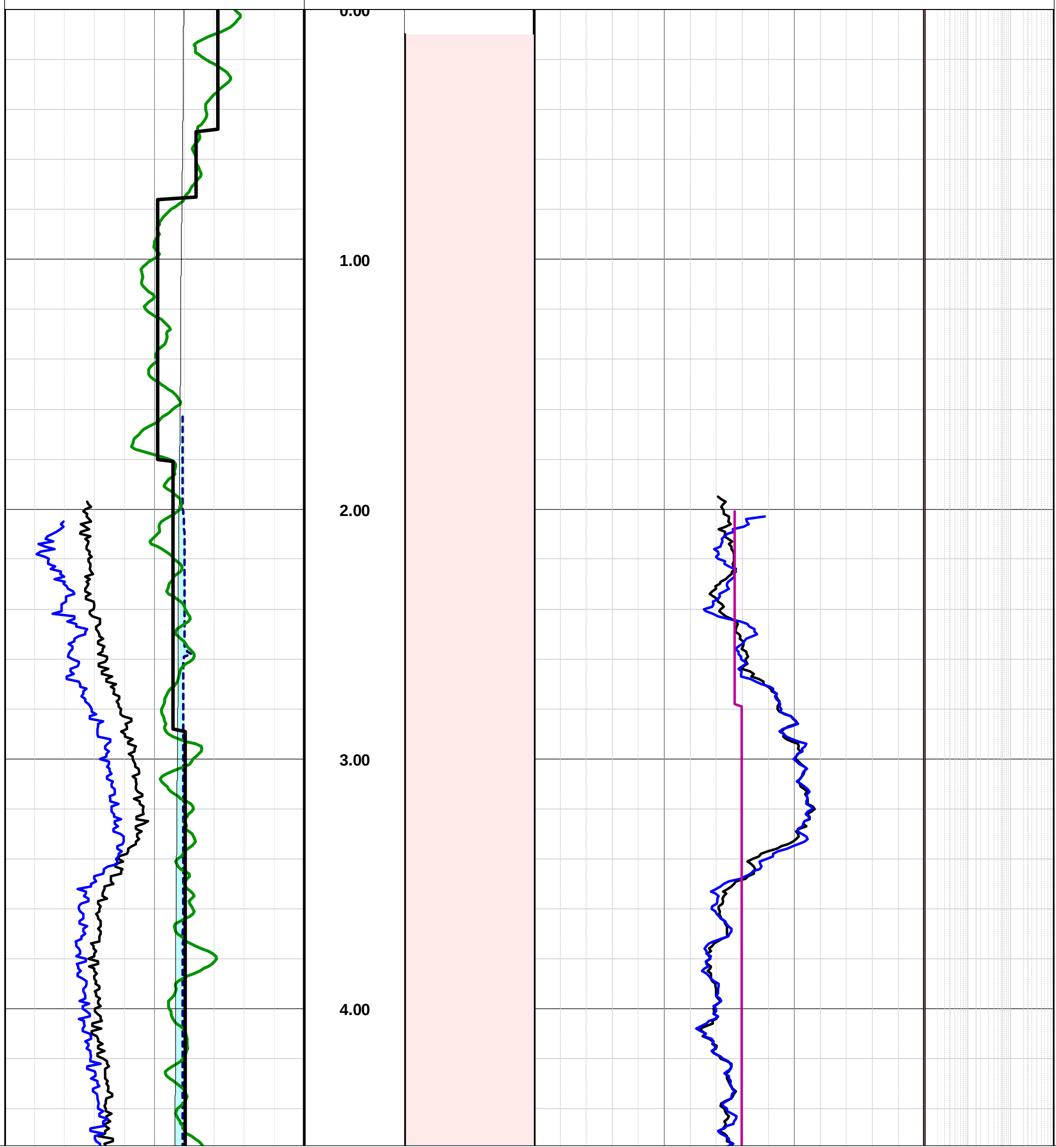
COKED_COAL

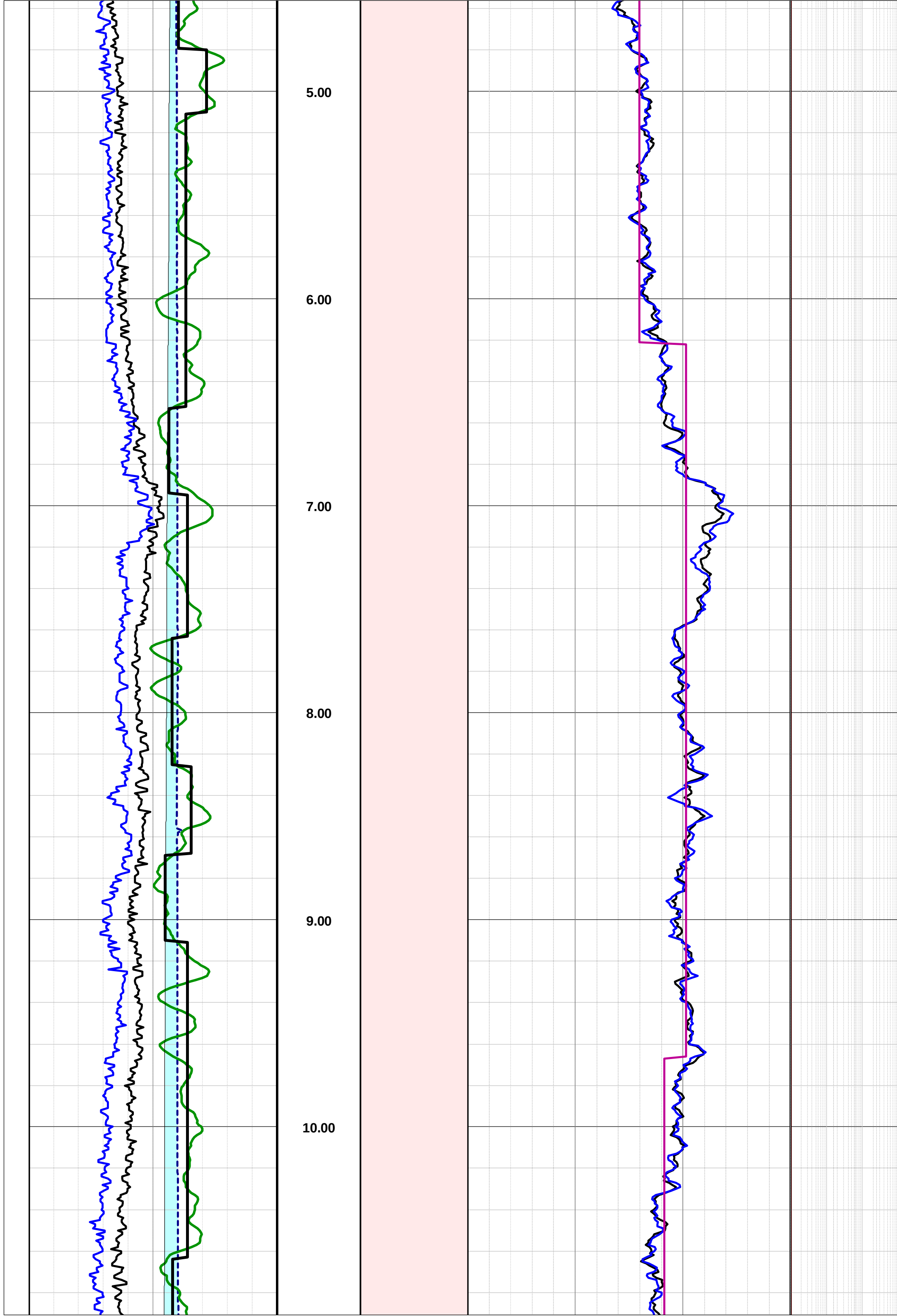
1 OHM-M 1000
RES(SG)

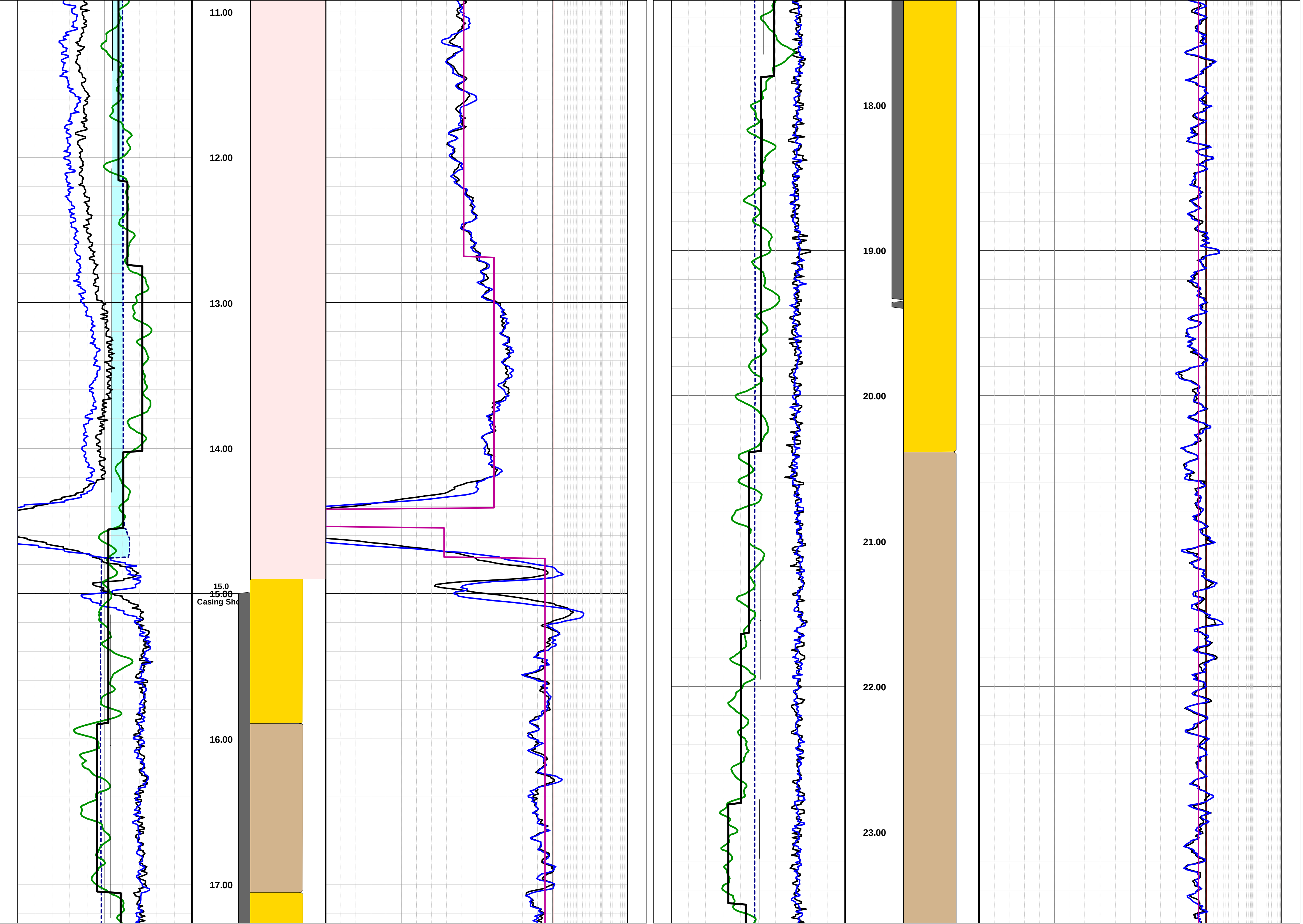
DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) 1 g/cc 3	Depth 1m:20m	COKED_COAL		RES(SG) 1 OHM-M 1000
DEN(SS) 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) 1 g/cc 3	
CALIPER 50 mm 300	WT_FLAG 0 5	CASING	DEN(ER) 1 g/cc 3	
GAM(NAT) 200 API 0				
SANG 0 DEG 20				



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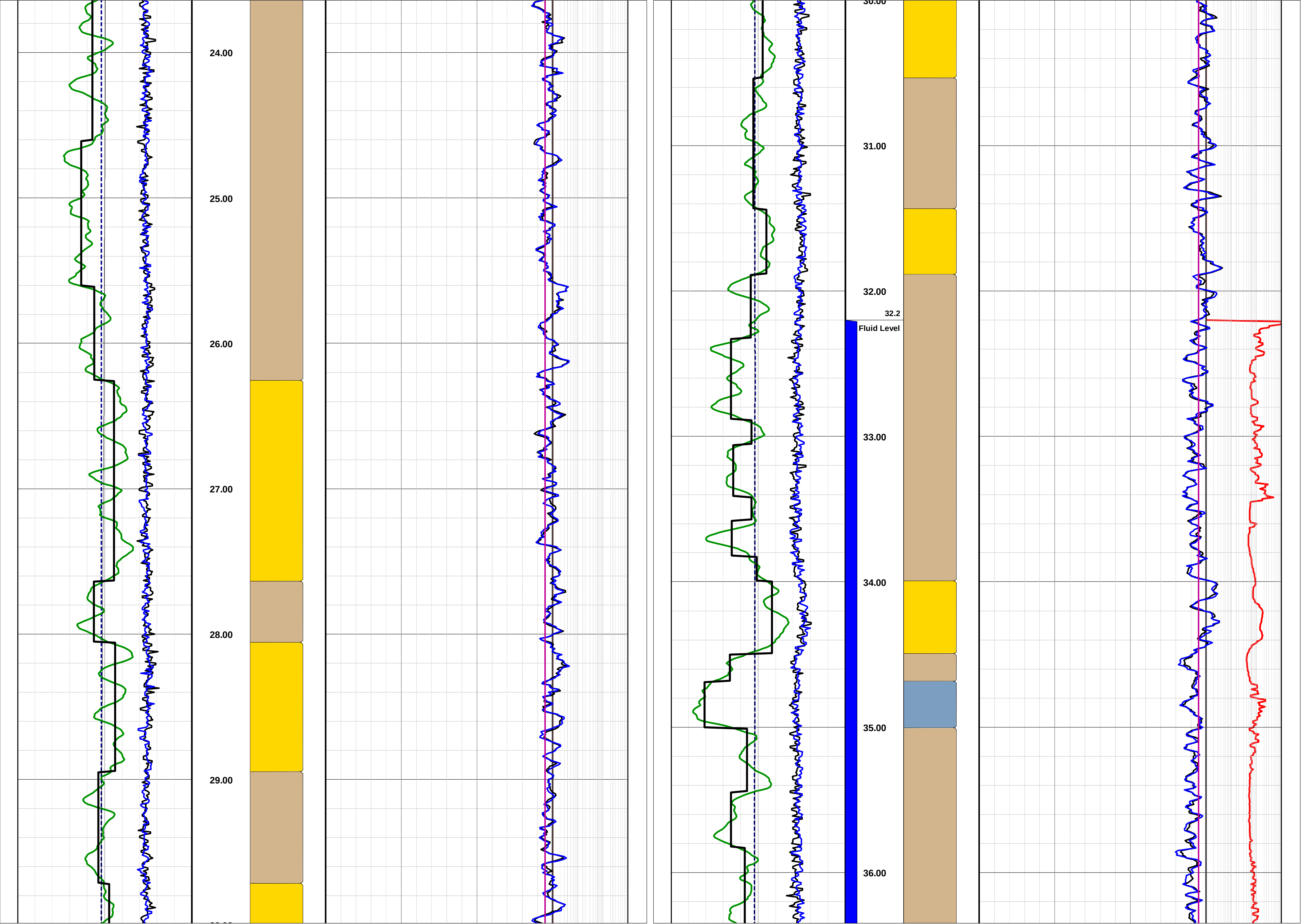
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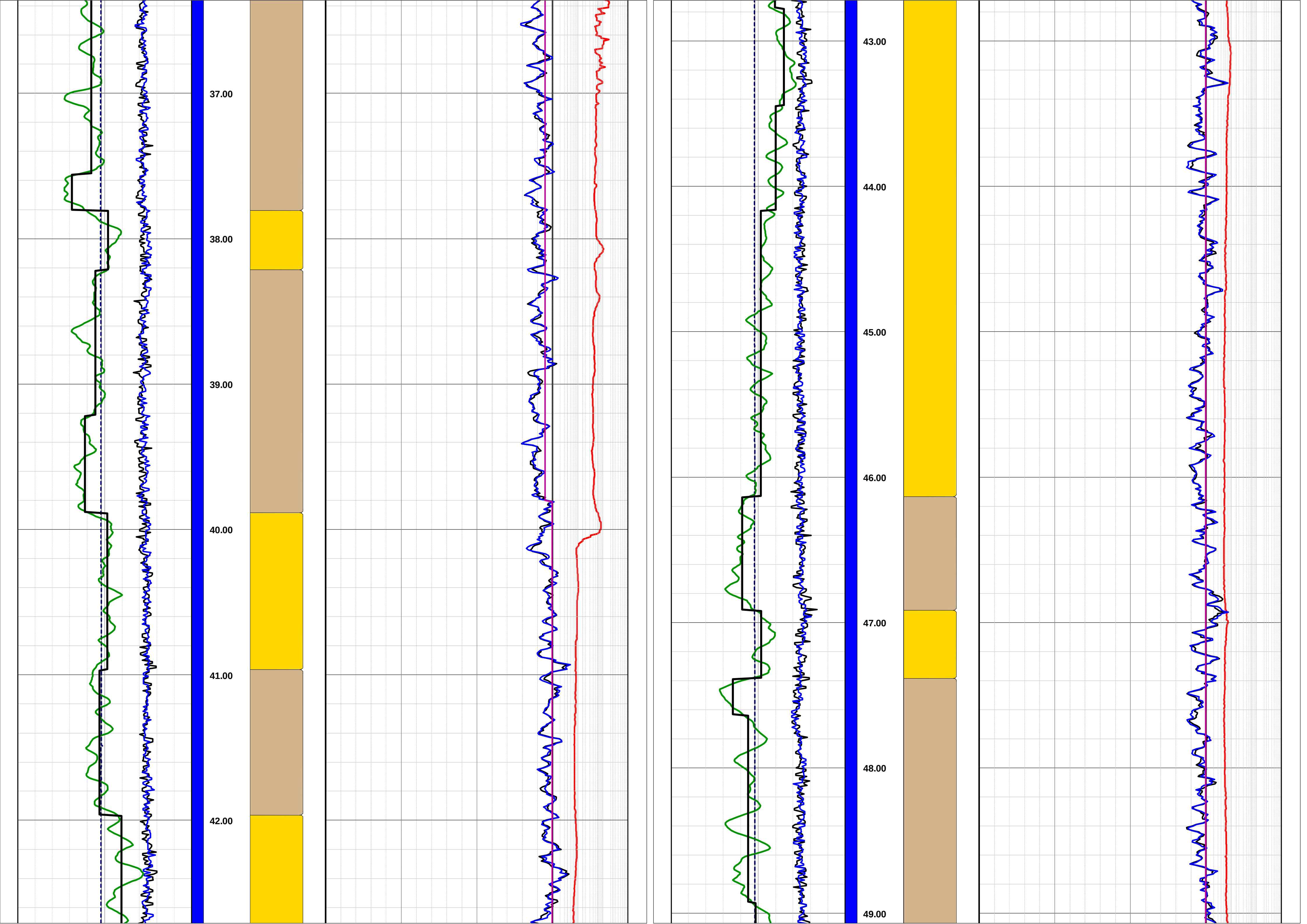
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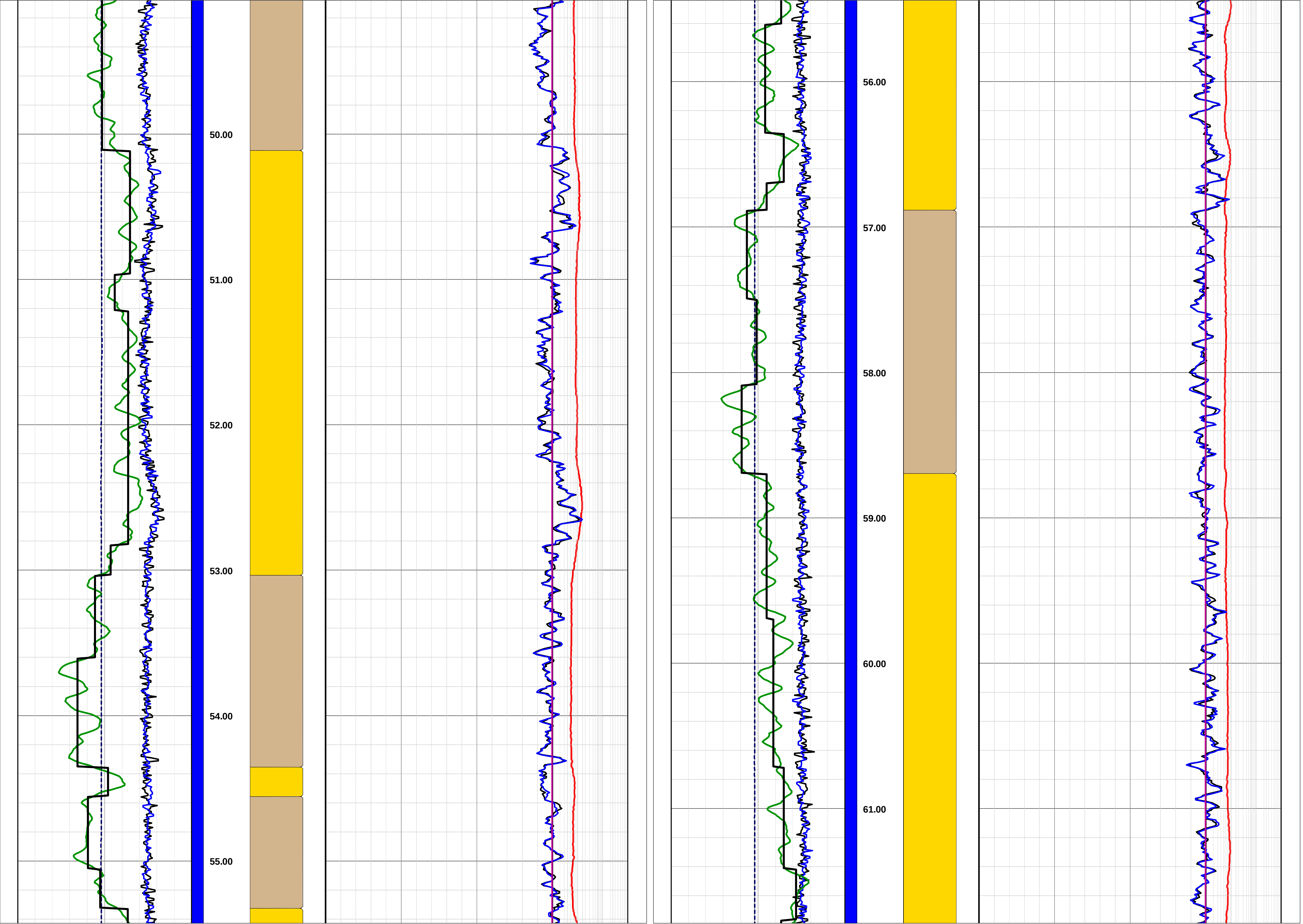
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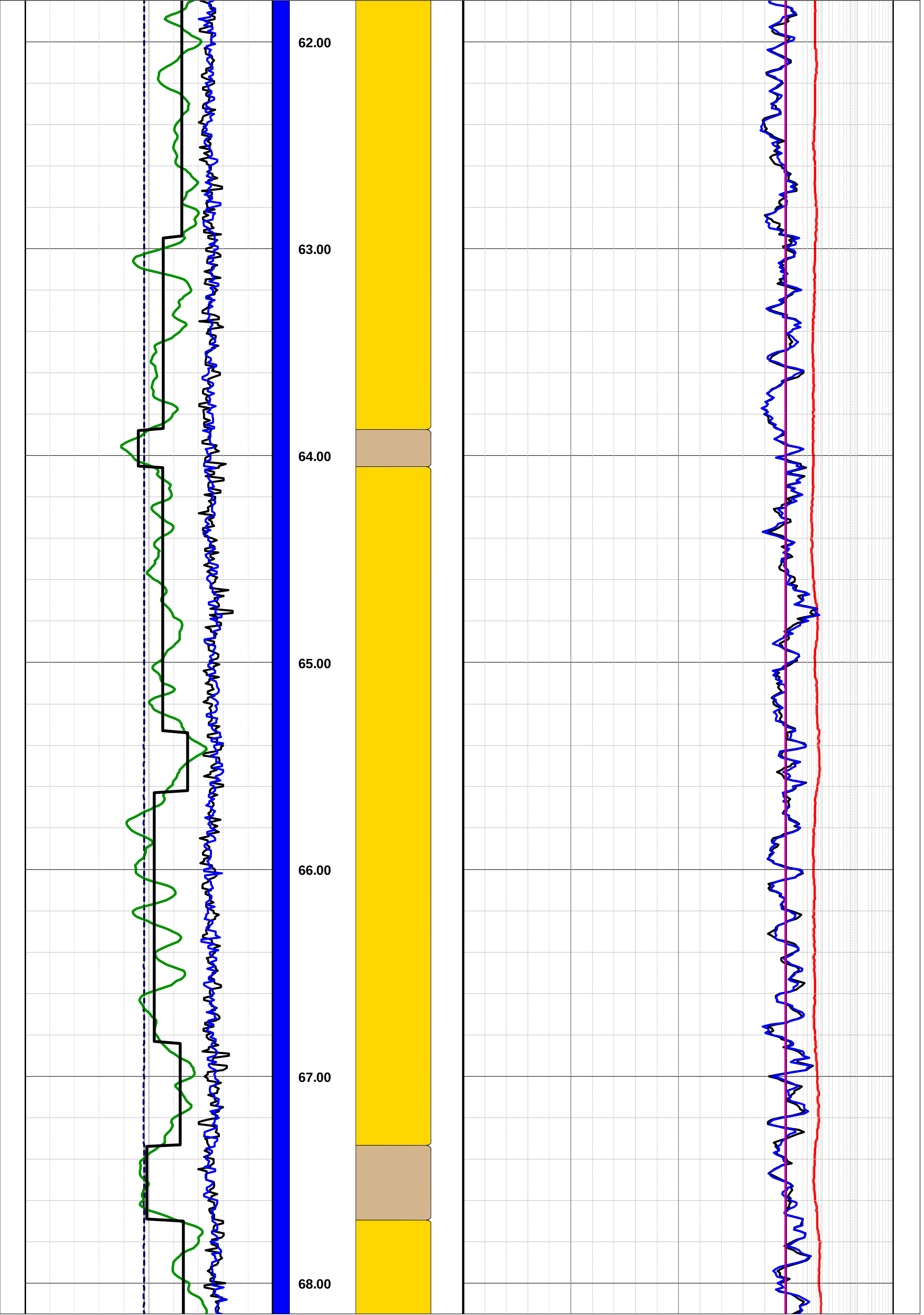
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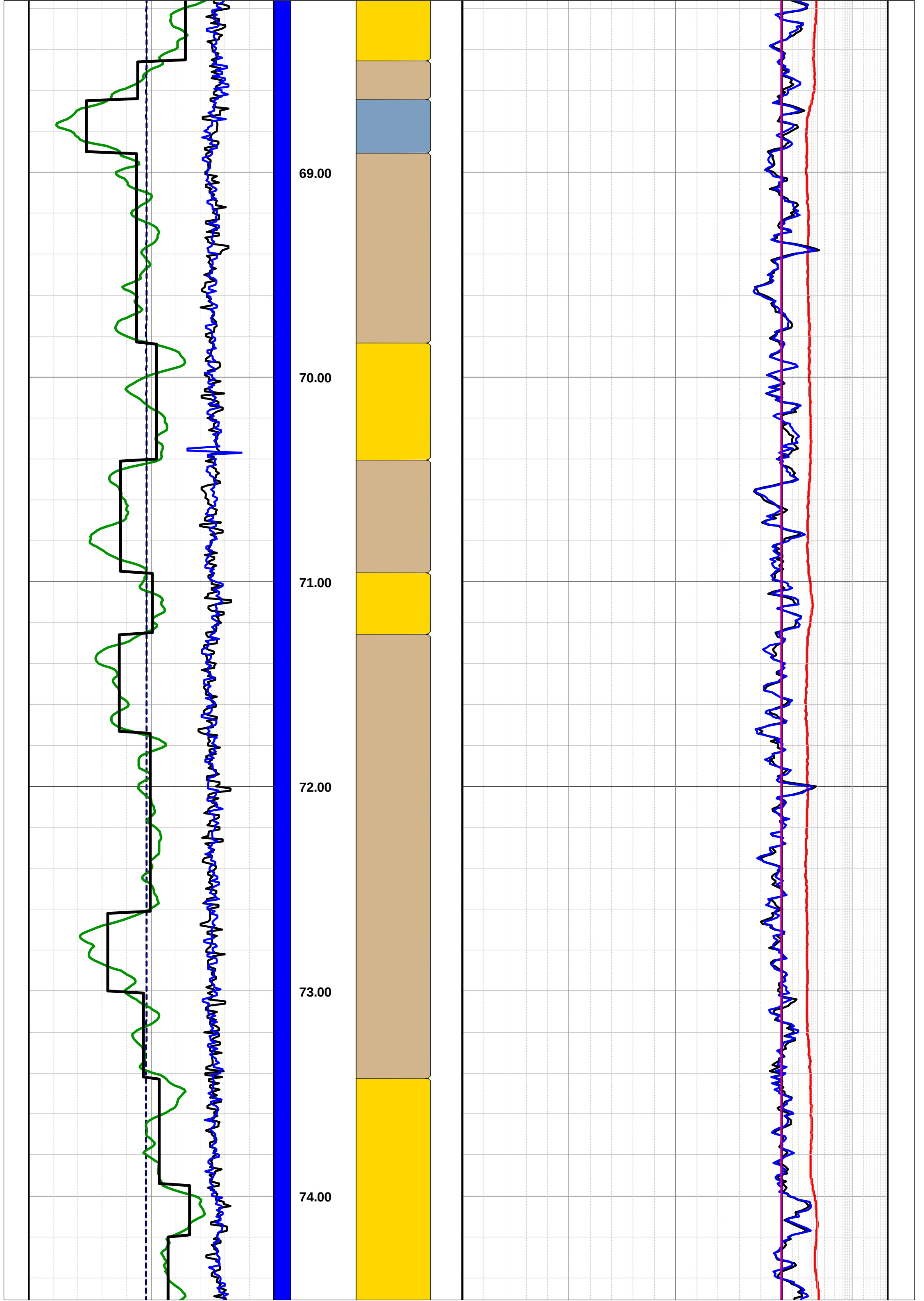
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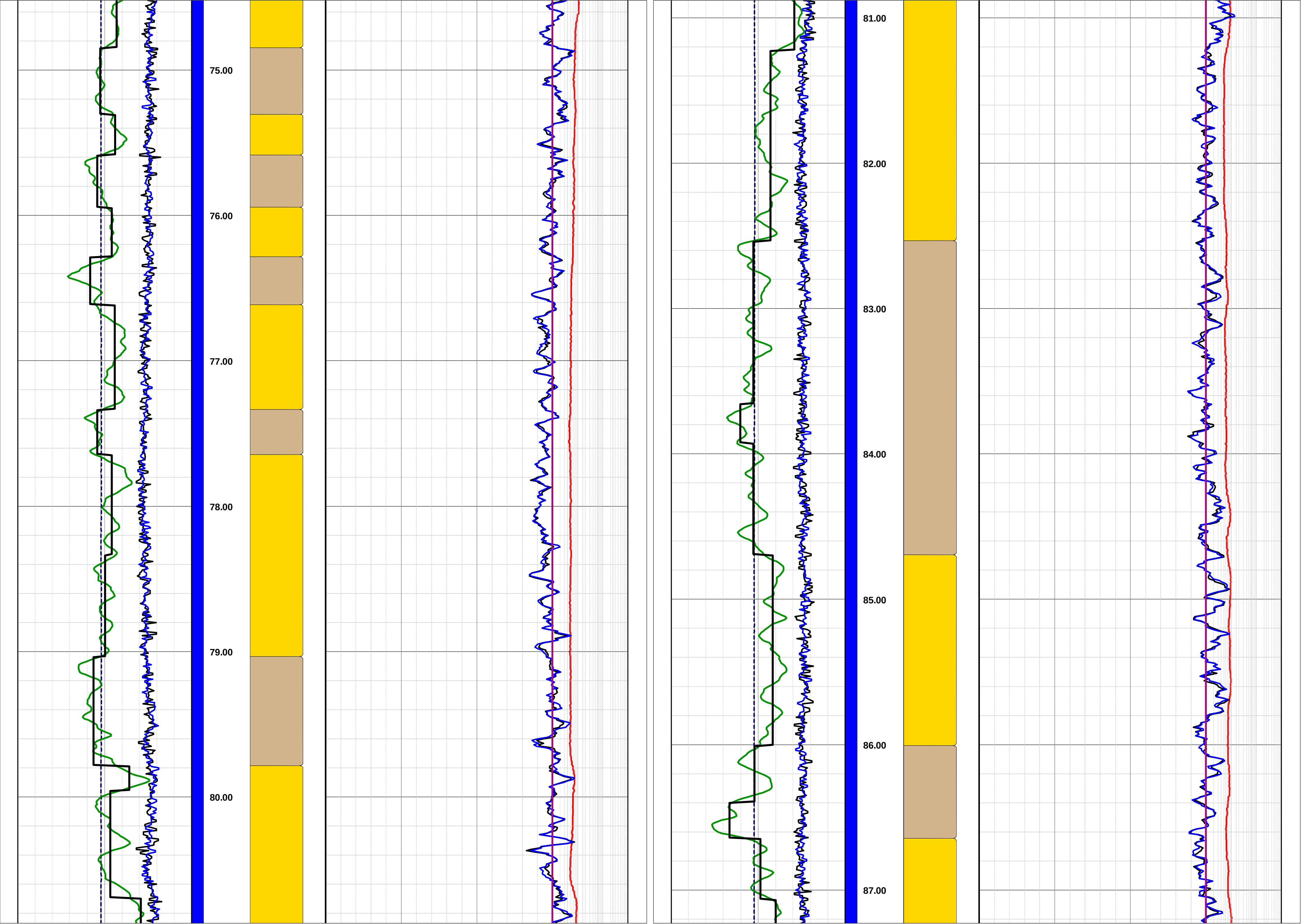
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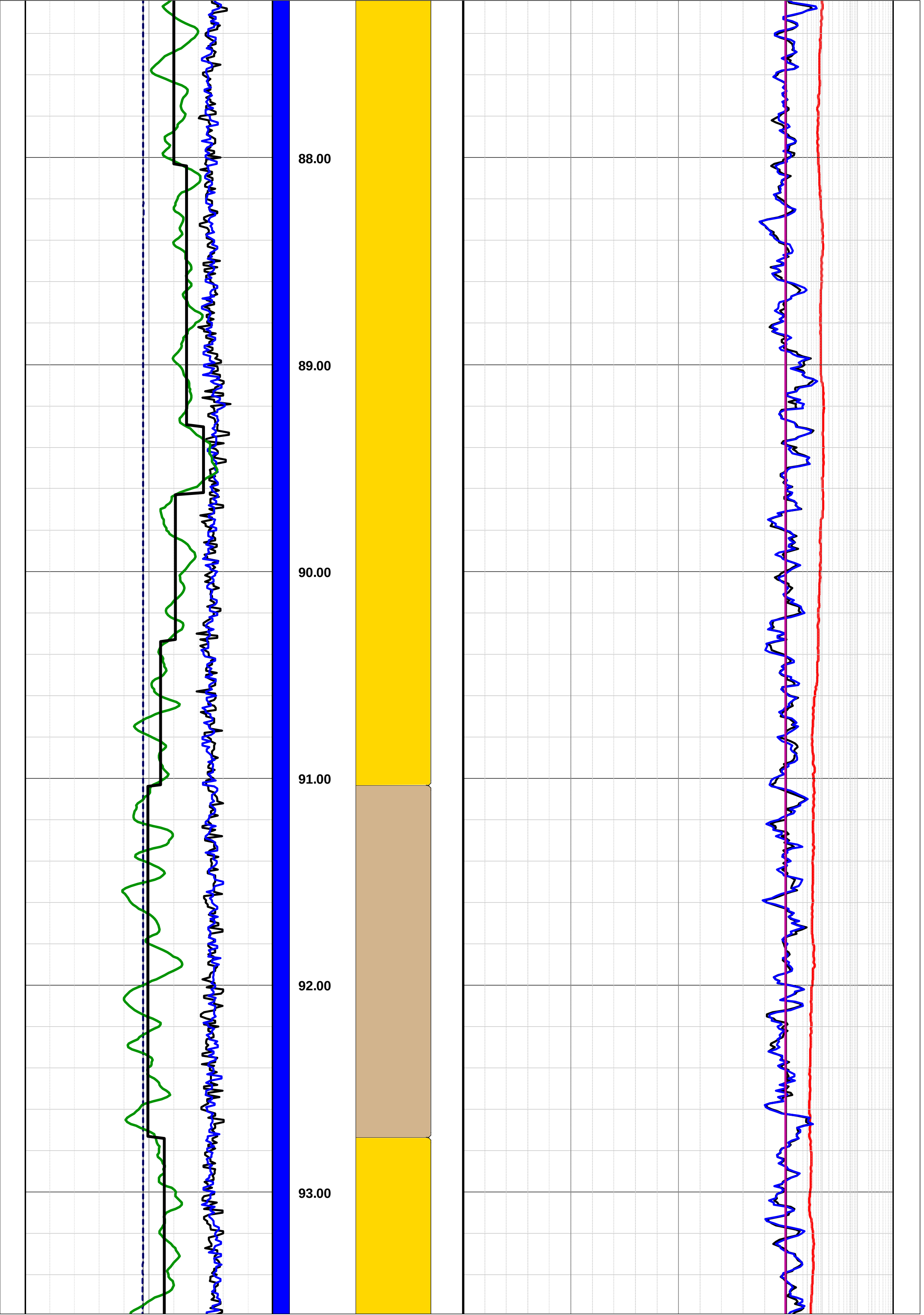
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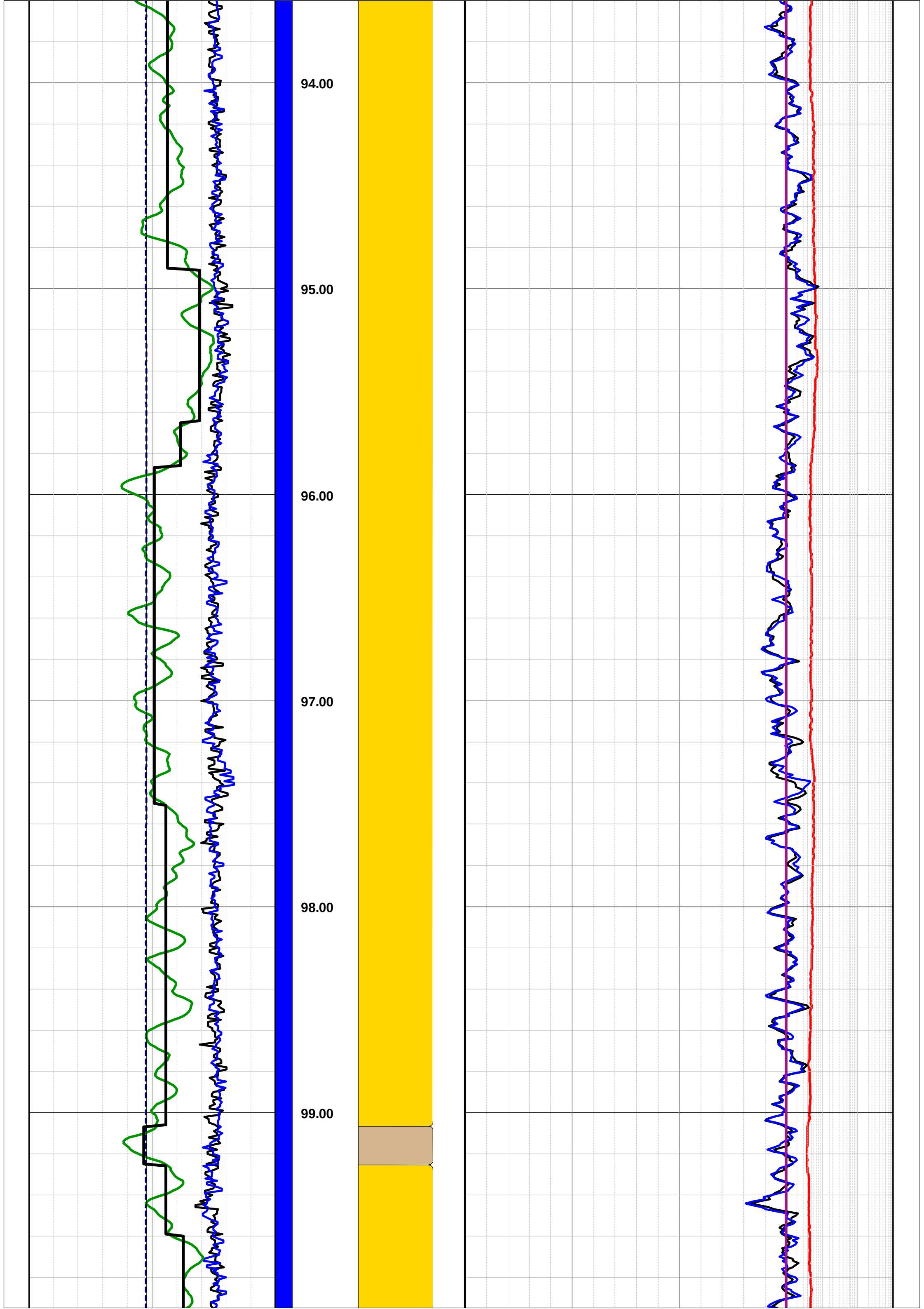
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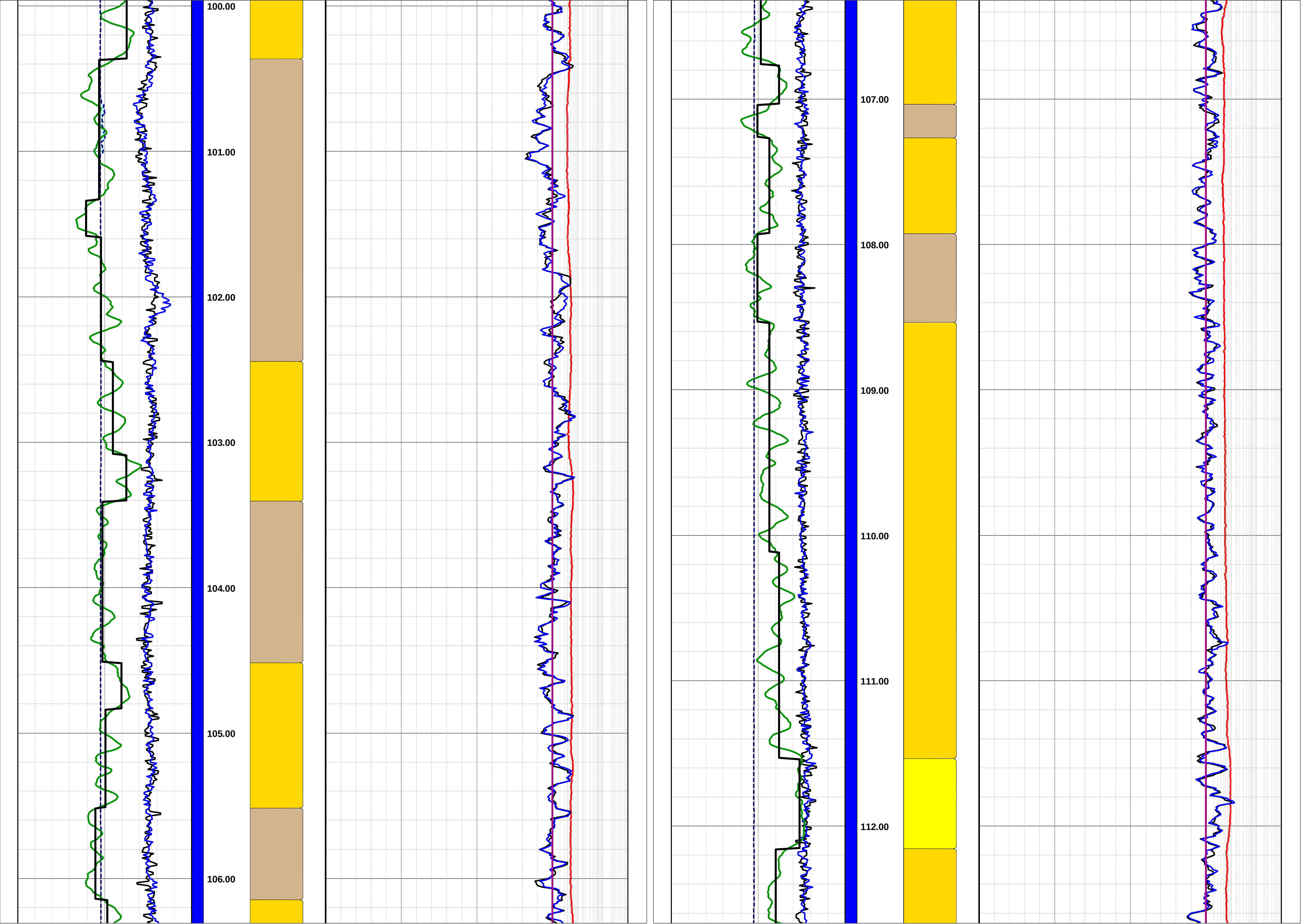
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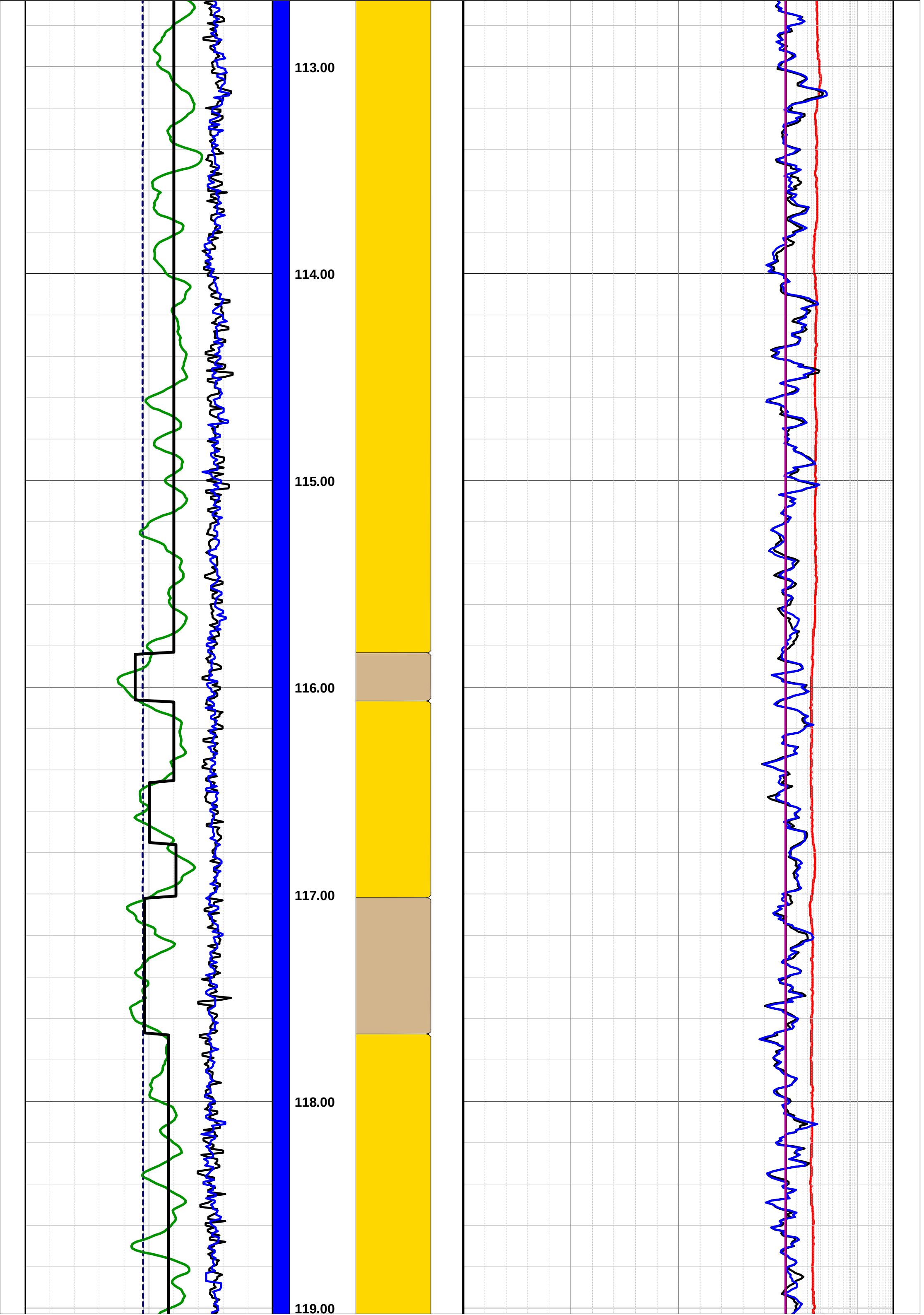
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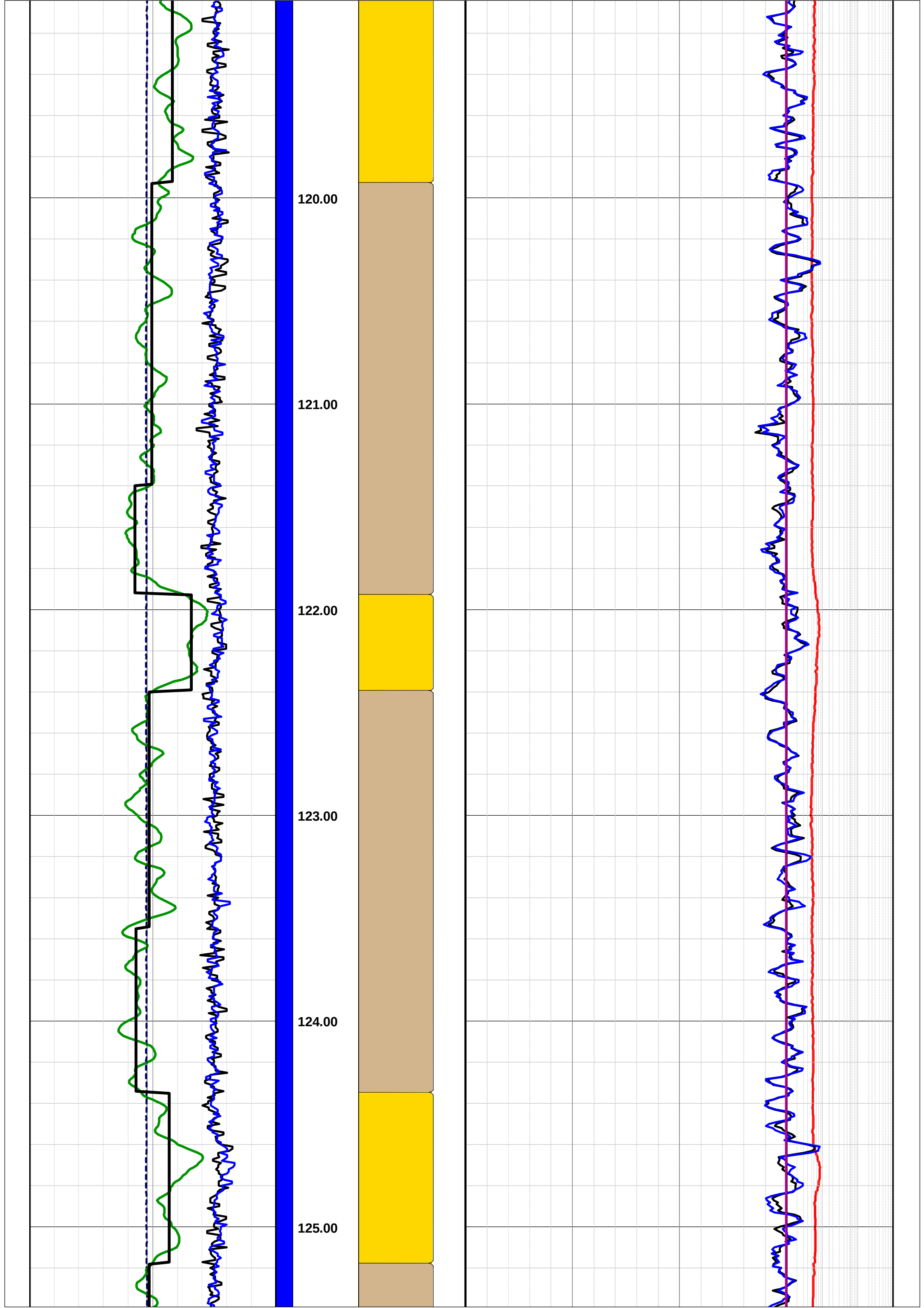
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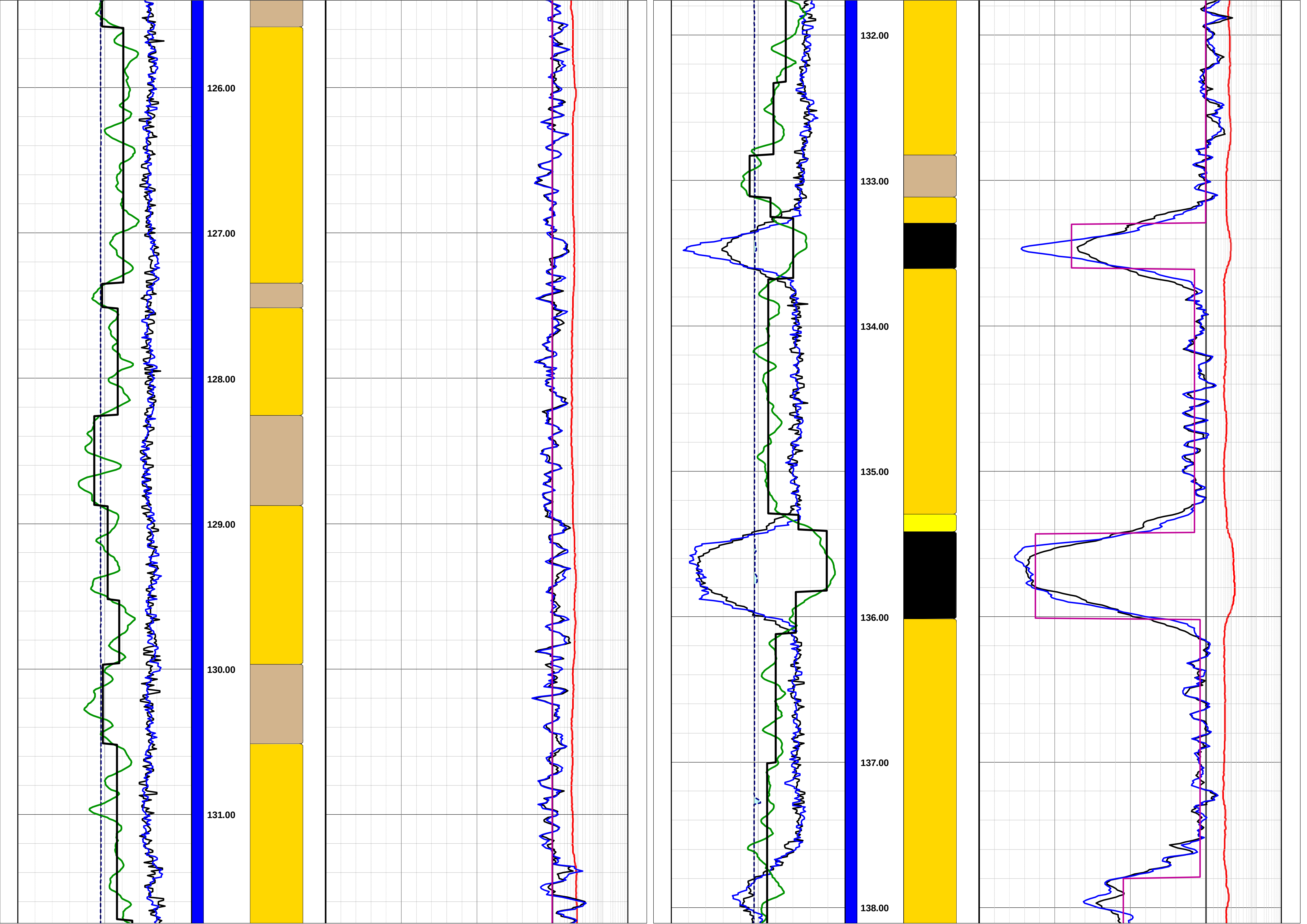
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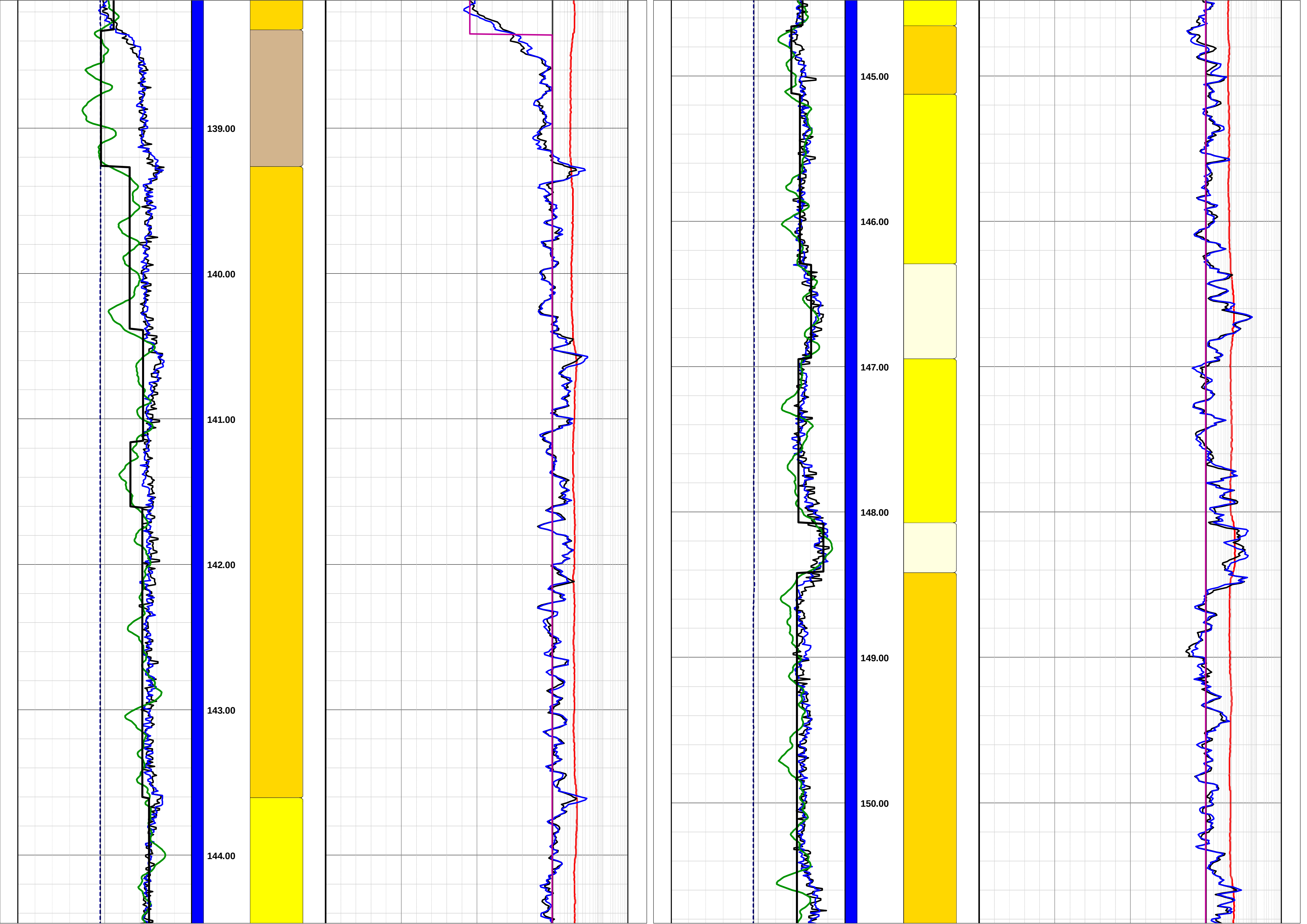
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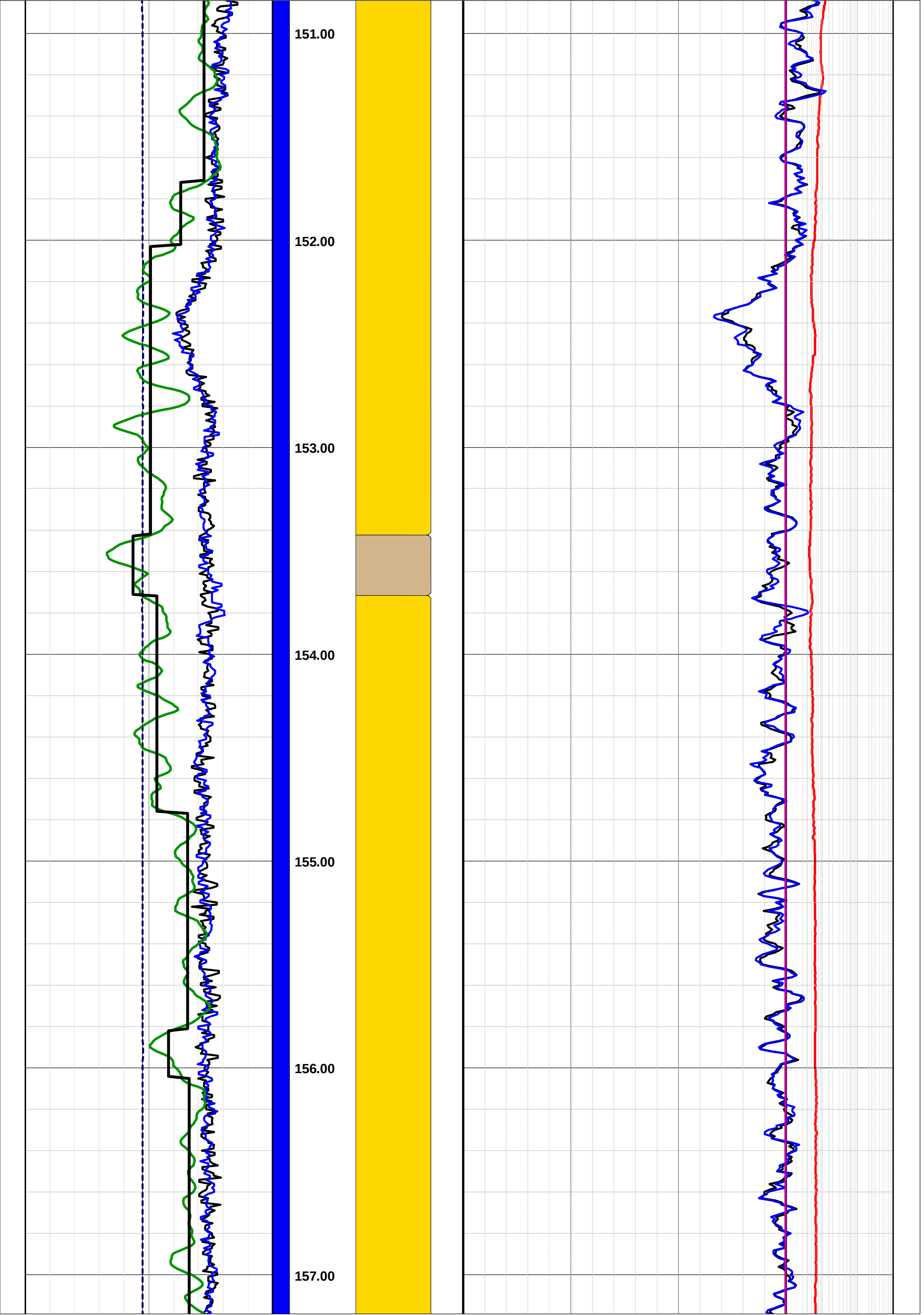
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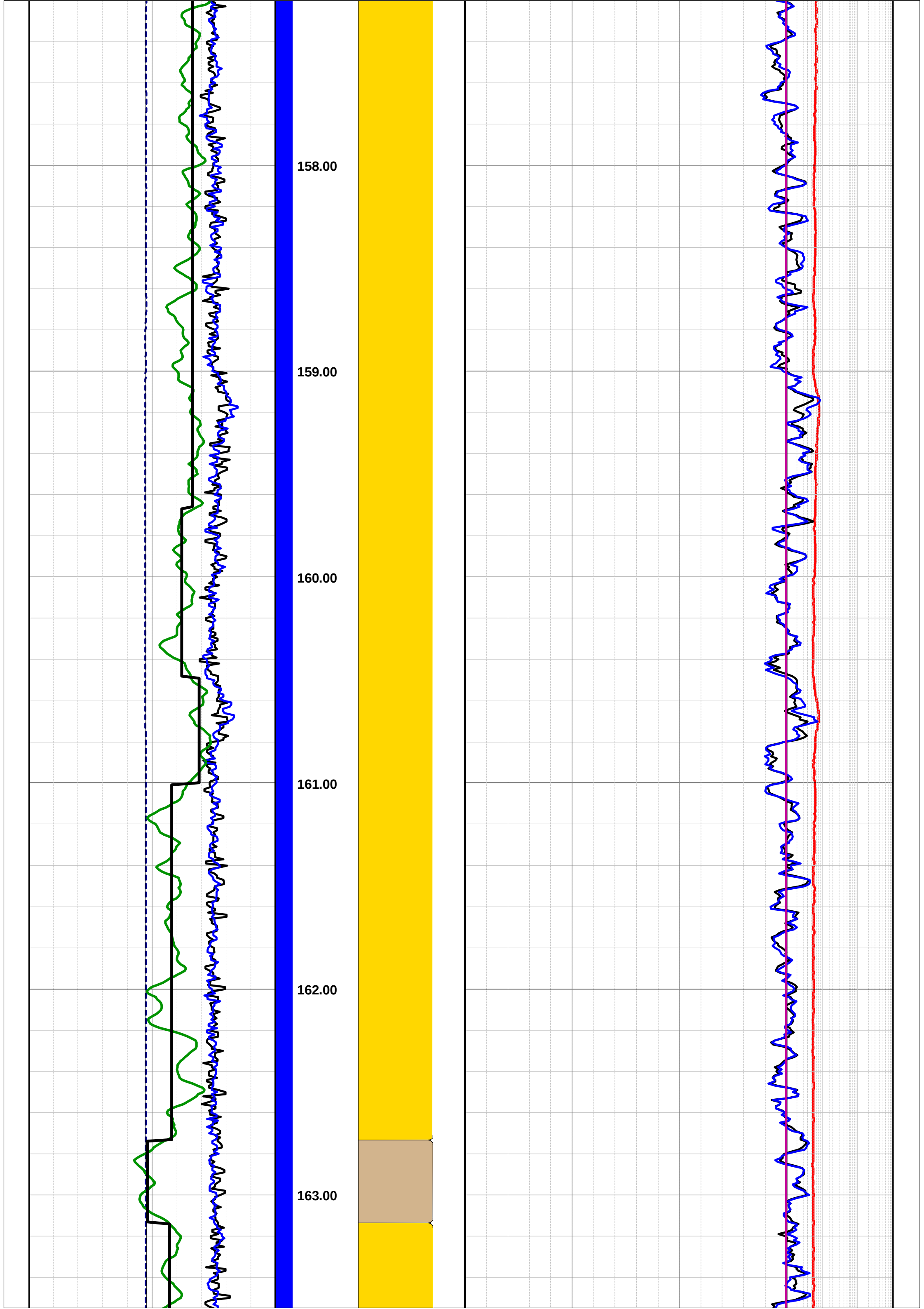
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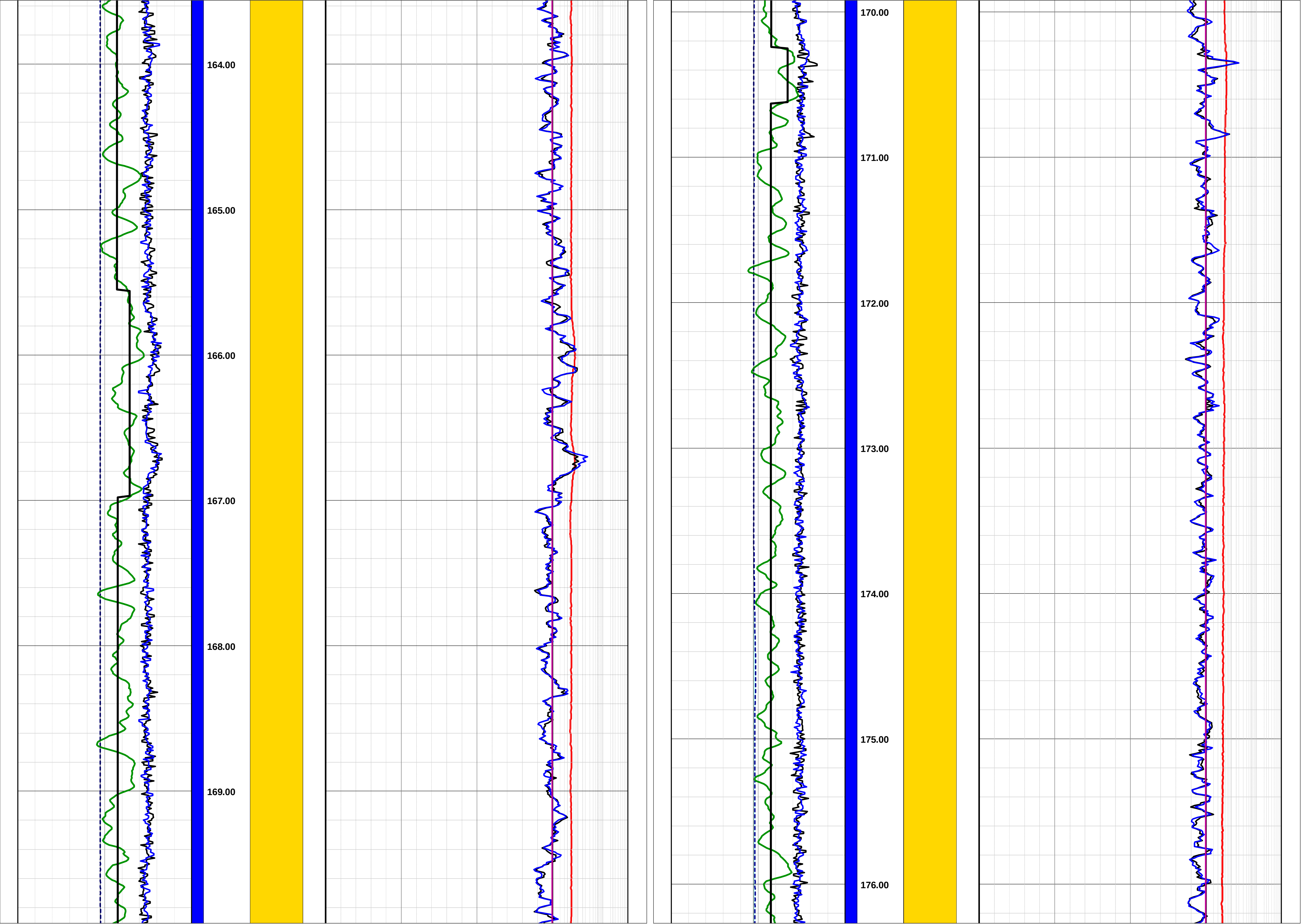
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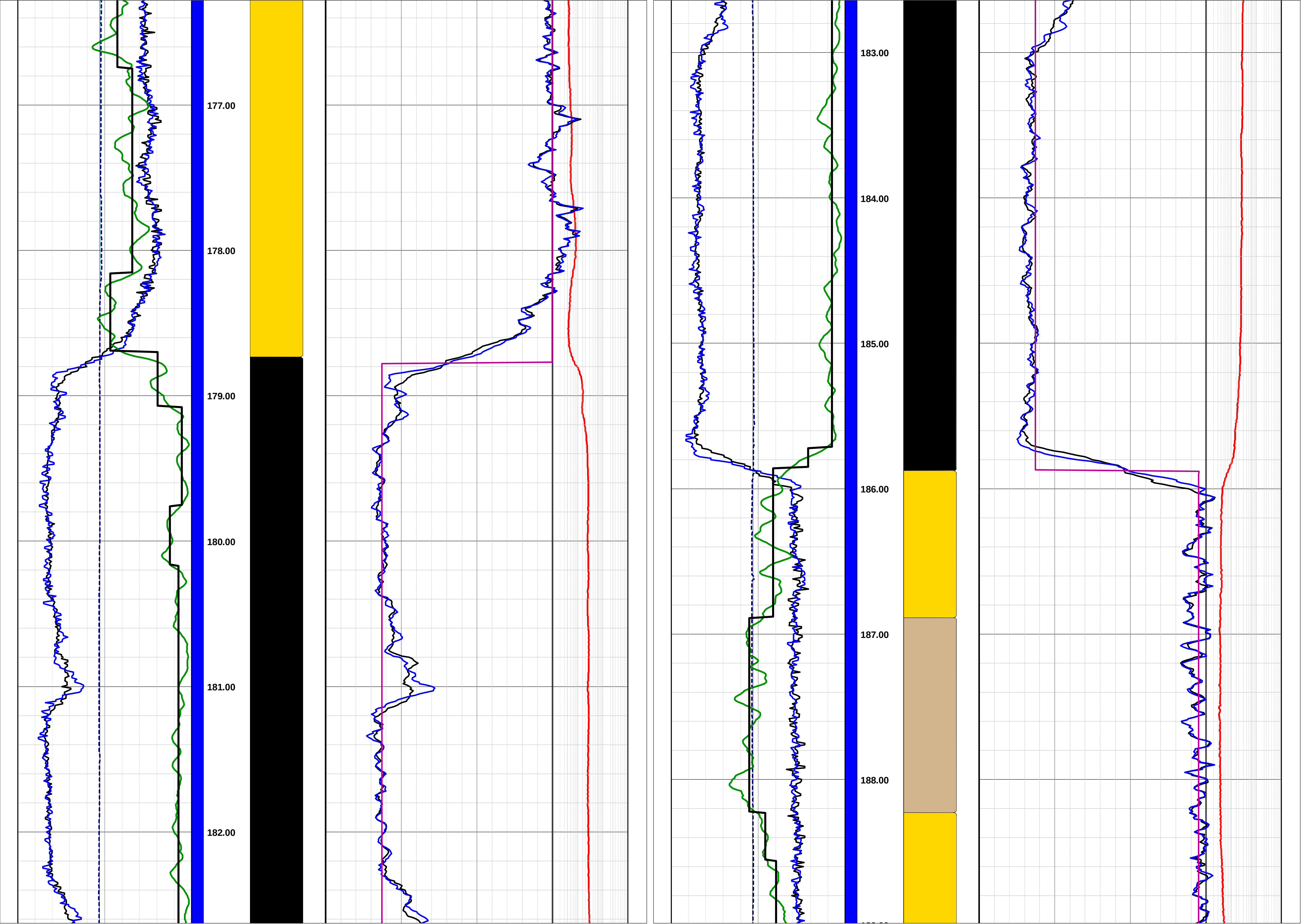
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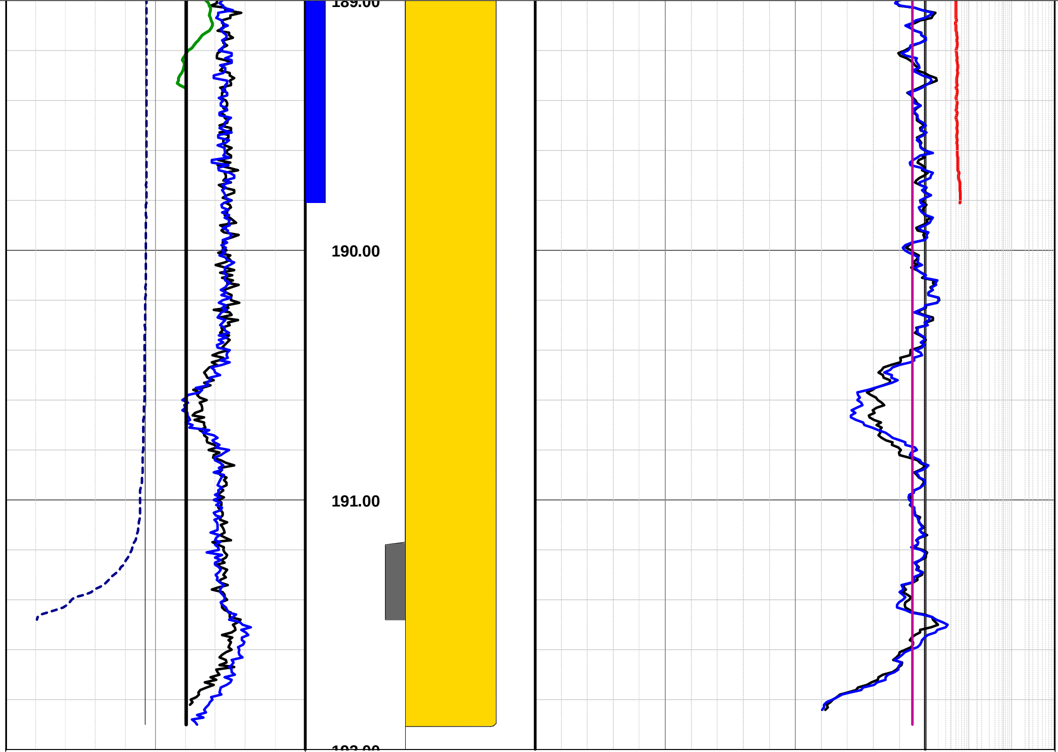


0 DEG 20 SANG		
200 API 0 GAM(NAT)		
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND	
CO - Coal	S2 - Sandstone - fine grained
CF - Inferior Coal	S3 - Sandstone - fine to medium grained
ST - SILTSTONE	S4 - Sandstone - medium grained
S1 - Sandstone - very fine grained	

COMPANY	BMA	**LOCATION**	MB19BWM06P
WELL	MB19BWM06P	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

MB19BWM06P

QUICKLOOK LITHOLOGY LOG

MB19BWM08P

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	MB19BWM08P	**LOCATION**	MB19BWM08P	**COUNTRY**	AUSTRALIA

LOCATION: MB19BWM08P
FIELD: BLW
STATE: QLD
WELL: MB19BWM08P
COMPANY: BMA

		ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM	GL	KB	1.
DRILLING MEASURED FROM	GL	DF	2.
PERMANENT DATUM		GL	3.
PERMANENT DATUM ELEVATION			

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	19-10-2019			RECORDED BY	KAR		
TIME	14-11			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	198m			RIG NUMBER			
DEPTH-LOGGER	195.53m			TOOL TYPE	9239C		
BIT SIZE	165mm			TOOL SERIAL NO.	2745		
CASING TYPE	PVC			EASTING	691542		
CASING ID	200mm			NORTHING	7370742		
CASING BOTTOM	12m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	19.9m			SOURCE TYPE	CS137	SOURCE ID	CZ3498

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

- **CO - Coal**
- **S2 - Sandstone - fine grained**
- **CF - Inferior Coal**
- **S3 - Sandstone - fine to medium grained**
- **ST - SILTSTONE**
- **CY - Claystone**
- **S1 - Sandstone - very fine grained**

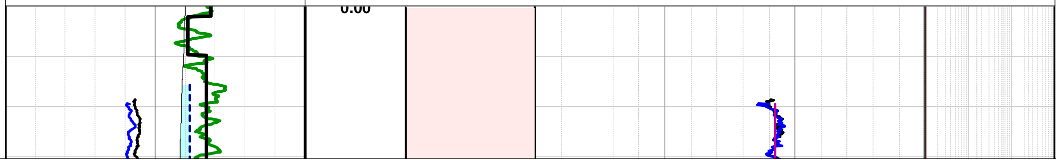
MNEMONICS

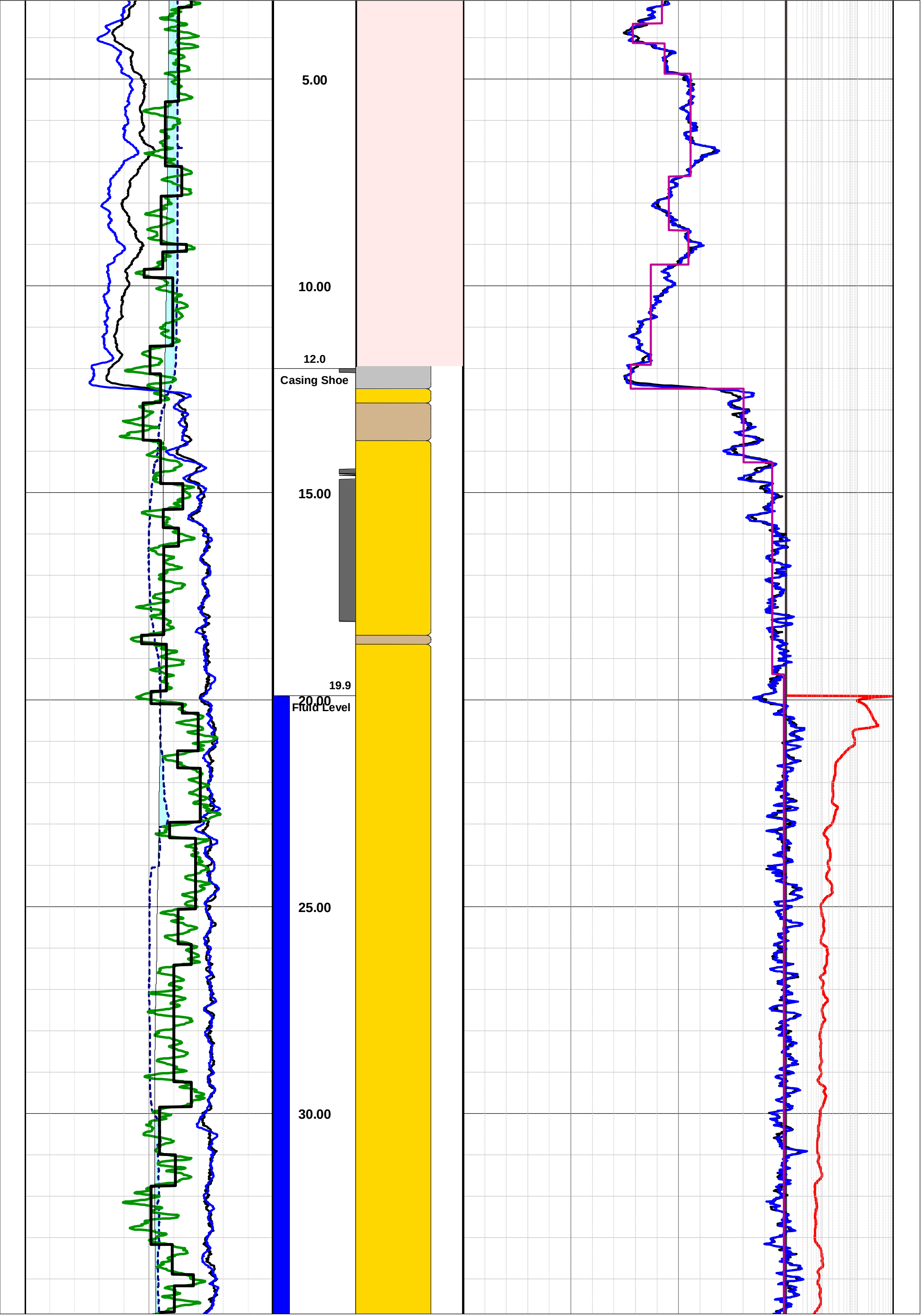
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

IMPORTANT NOTE	The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

Track	Scale
DEN(LS)	1 g/cc 3
DEN(SS)	1 g/cc 3
CALIPER	50 mm 300
GAM(NAT)	200 API 0
NOM_BIT	50 mm 300
SANG	0 DEG 20
Depth	1m:100m
DATA_FLAG	
WT_FLAG	
COKED_COAL	
LITHOLOGY	
CASING	
RES(SG)	1 OHM-M 1000
DEN(COD)	1 g/cc 3
DEN(ER)	1 g/cc 3

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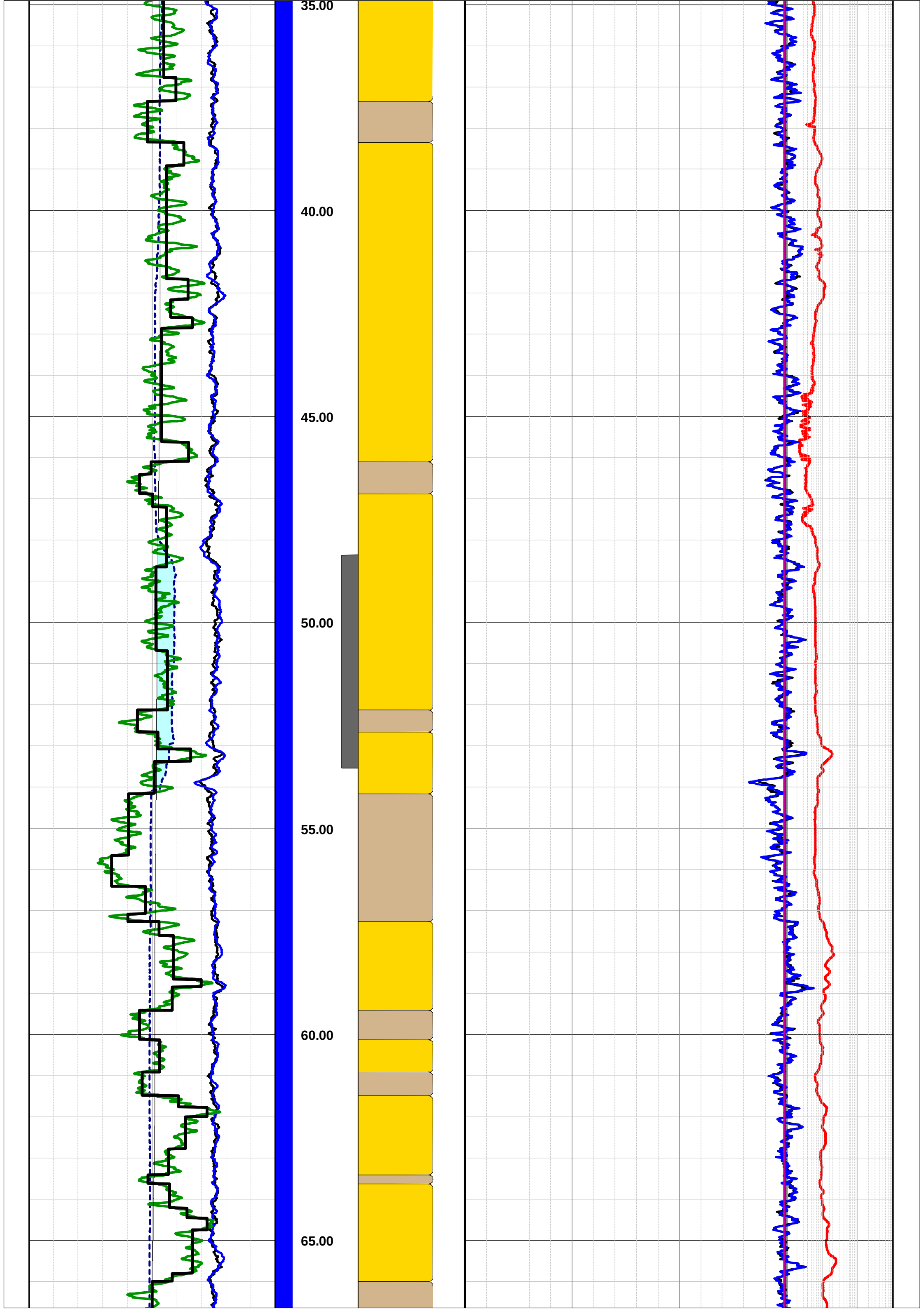
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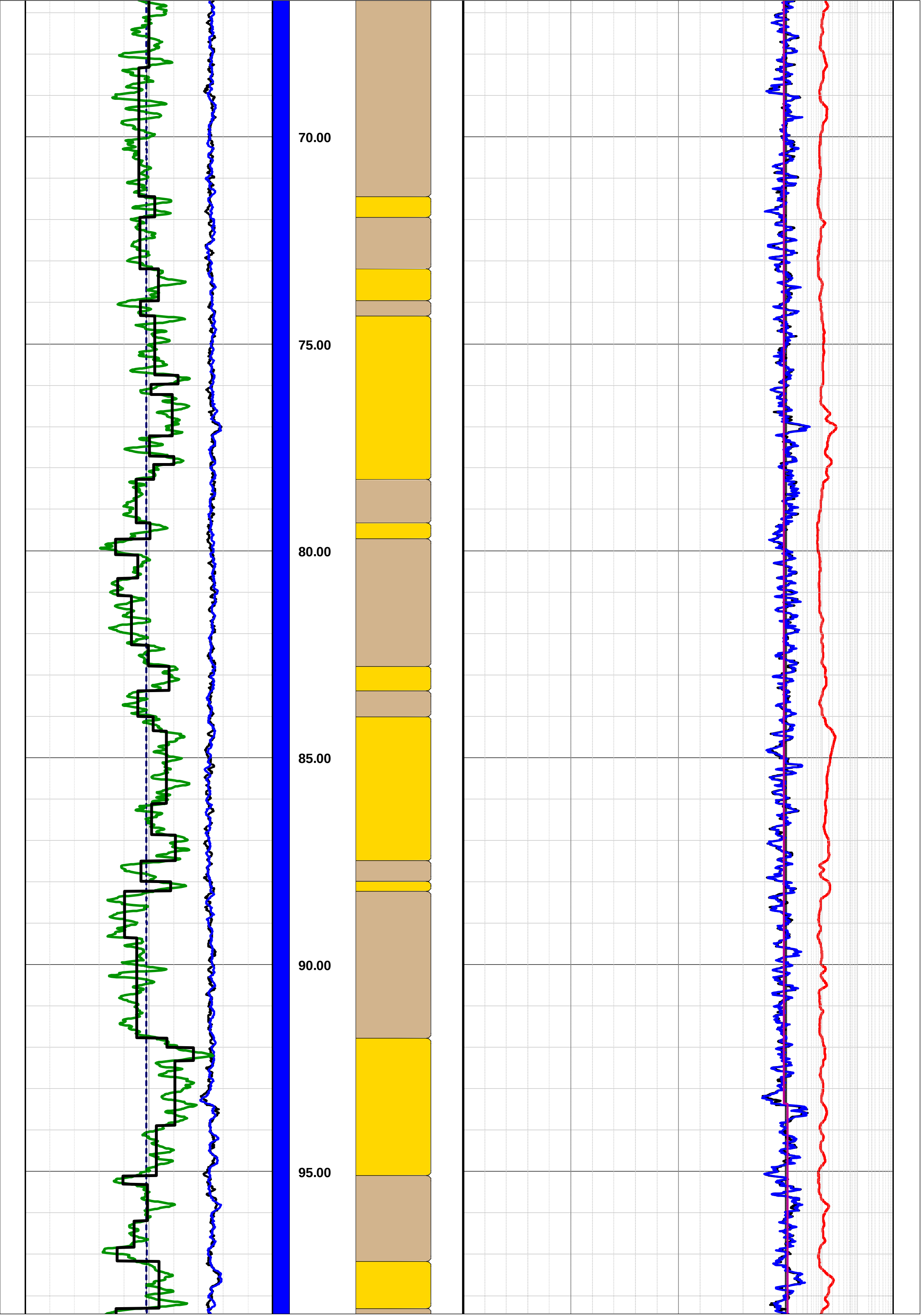
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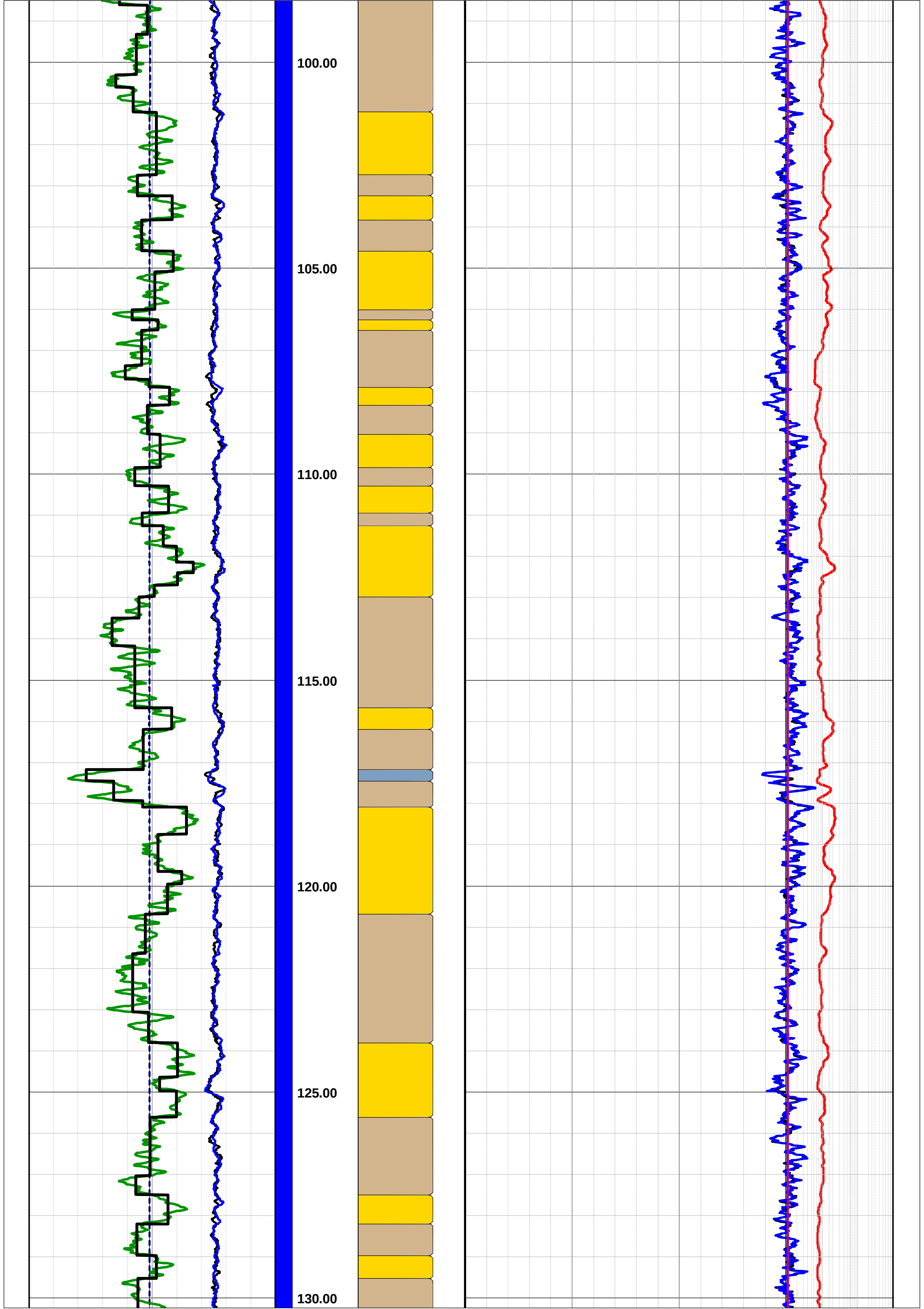
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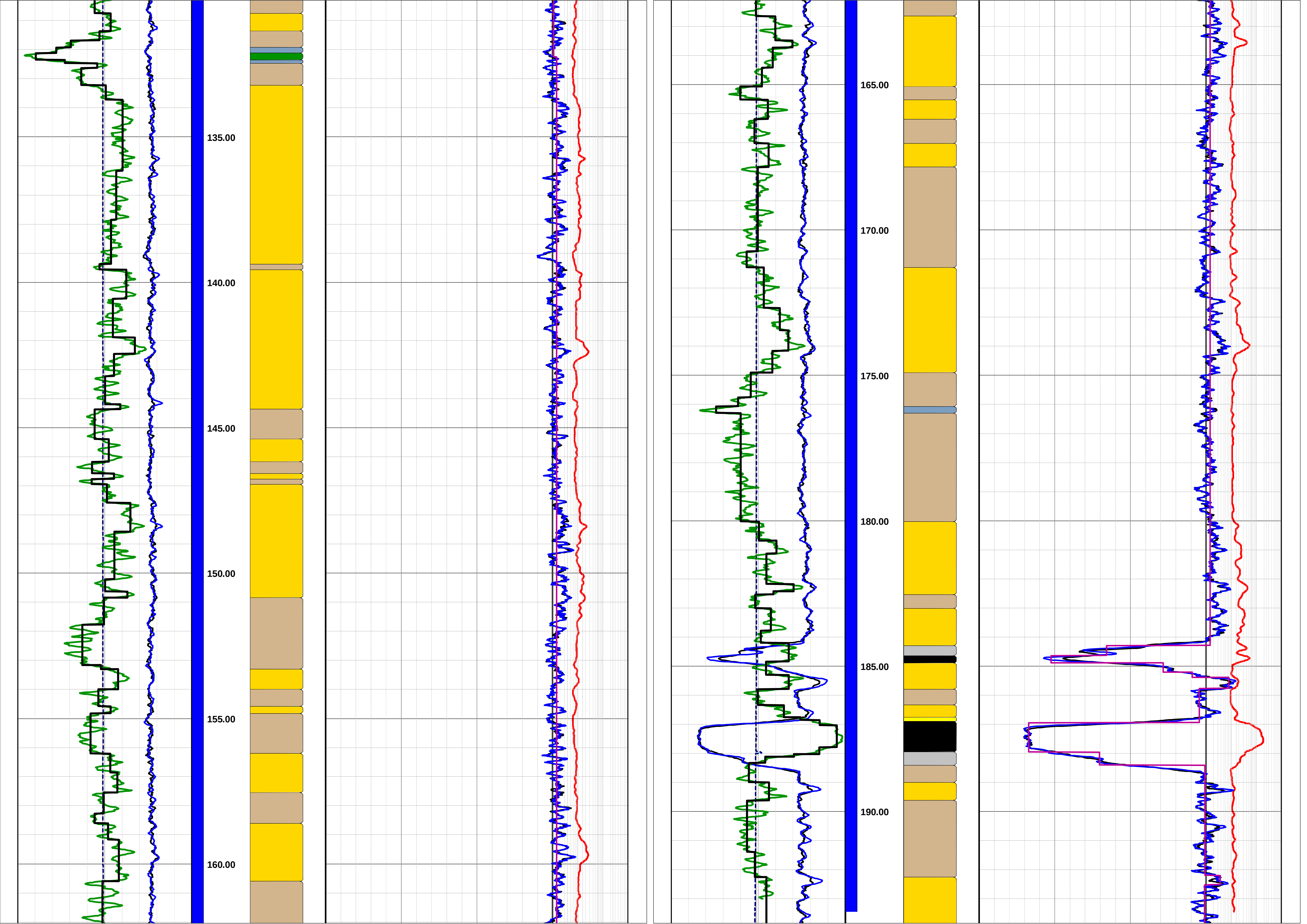
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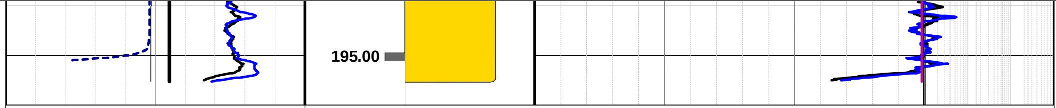
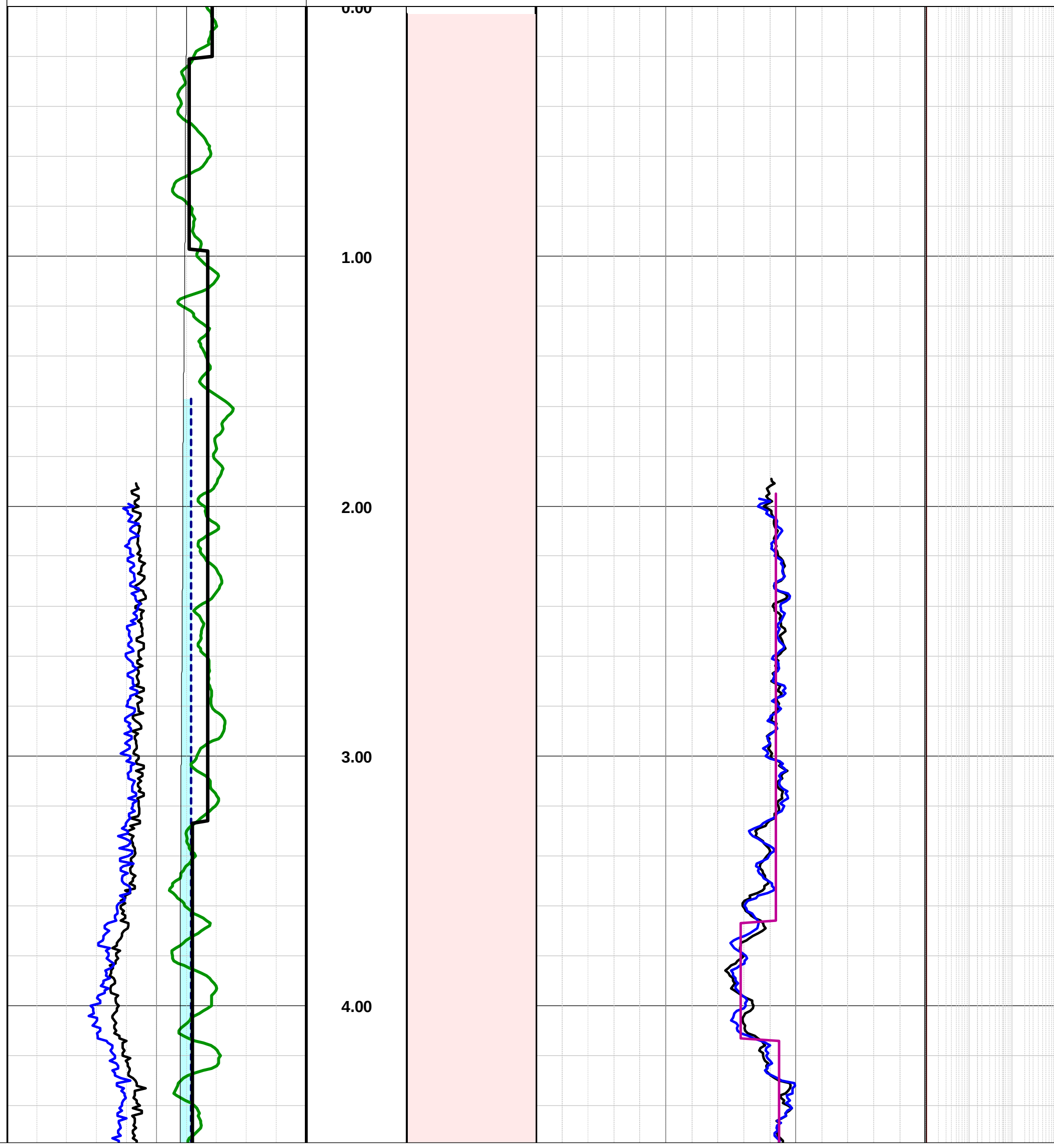


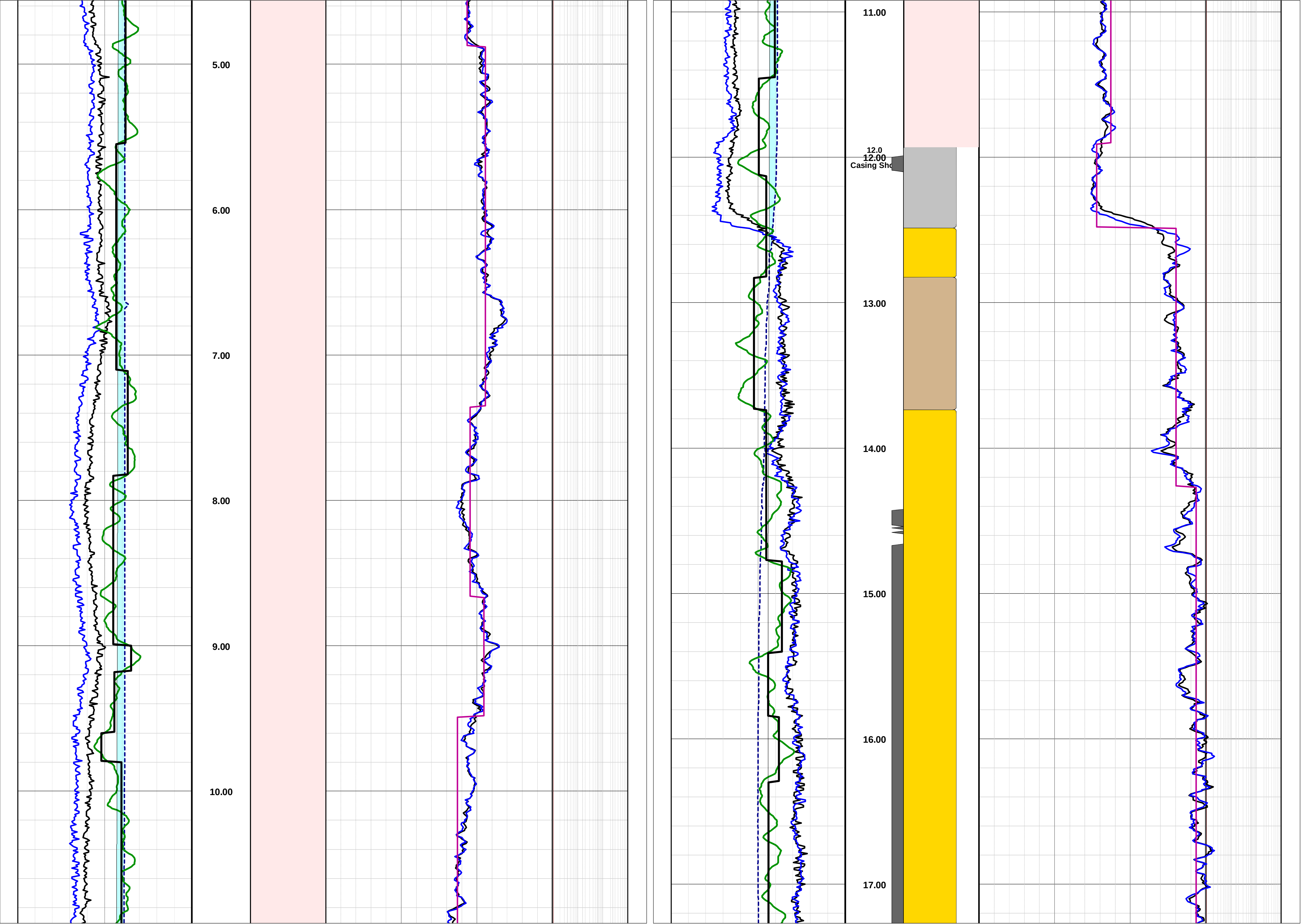
SANG: 0 DEG 20			
NOM_BIT: 50 mm 300			
GAM(NAT): 200 API 0			
CALIPER: 50 mm 300	WT_FLAG	CASING	DEN(ER): 1 g/cc 3
DEN(SS): 1 g/cc 3	DATA_FLAG	LITHOLOGY	DEN(COD): 1 g/cc 3
DEN(LS): 1 g/cc 3	Depth 1m:100m	COKED_COAL	RES(SG): 1 OHM-M 1000

DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS): 1 g/cc 3	Depth 1m:20m	COKED_COAL	RES(SG): 1 OHM-M 1000
DEN(SS): 1 g/cc 3	DATA_FLAG: 5 0	LITHOLOGY	DEN(COD): 1 g/cc 3
CALIPER: 50 mm 300	WT_FLAG: 0 5	CASING	DEN(ER): 1 g/cc 3
GAM(NAT): 200 API 0			
SANG: 0 DEG 20			

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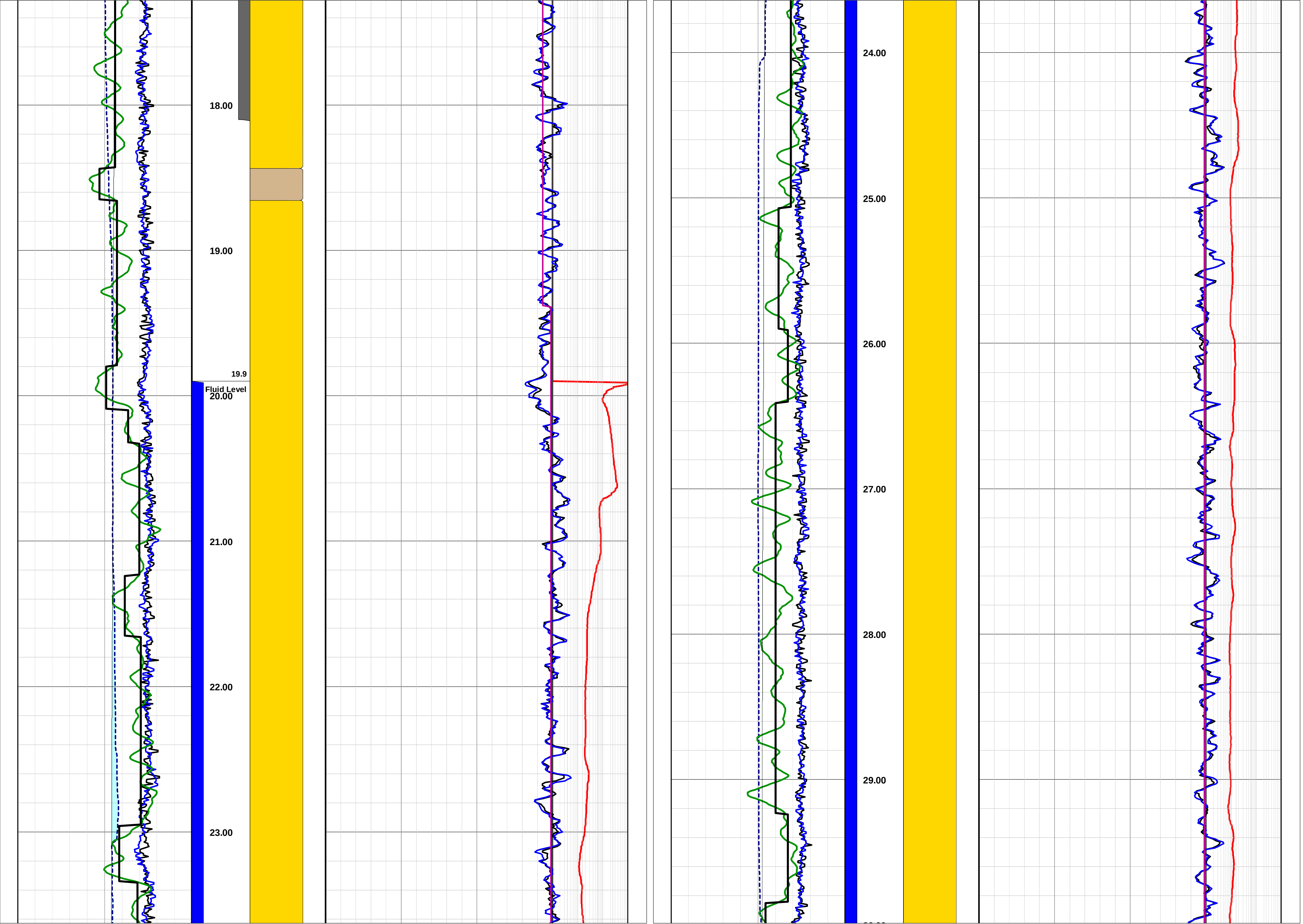
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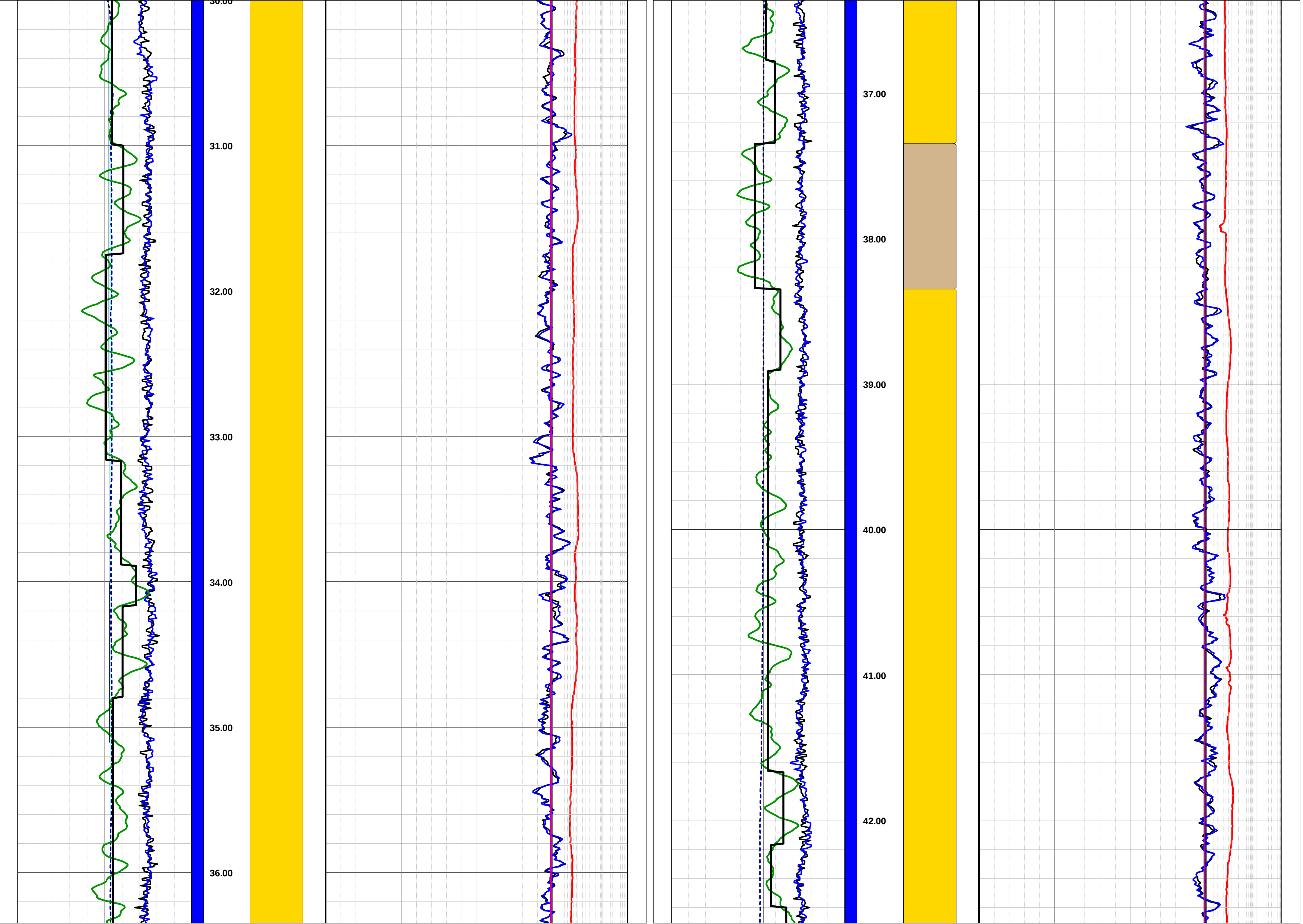

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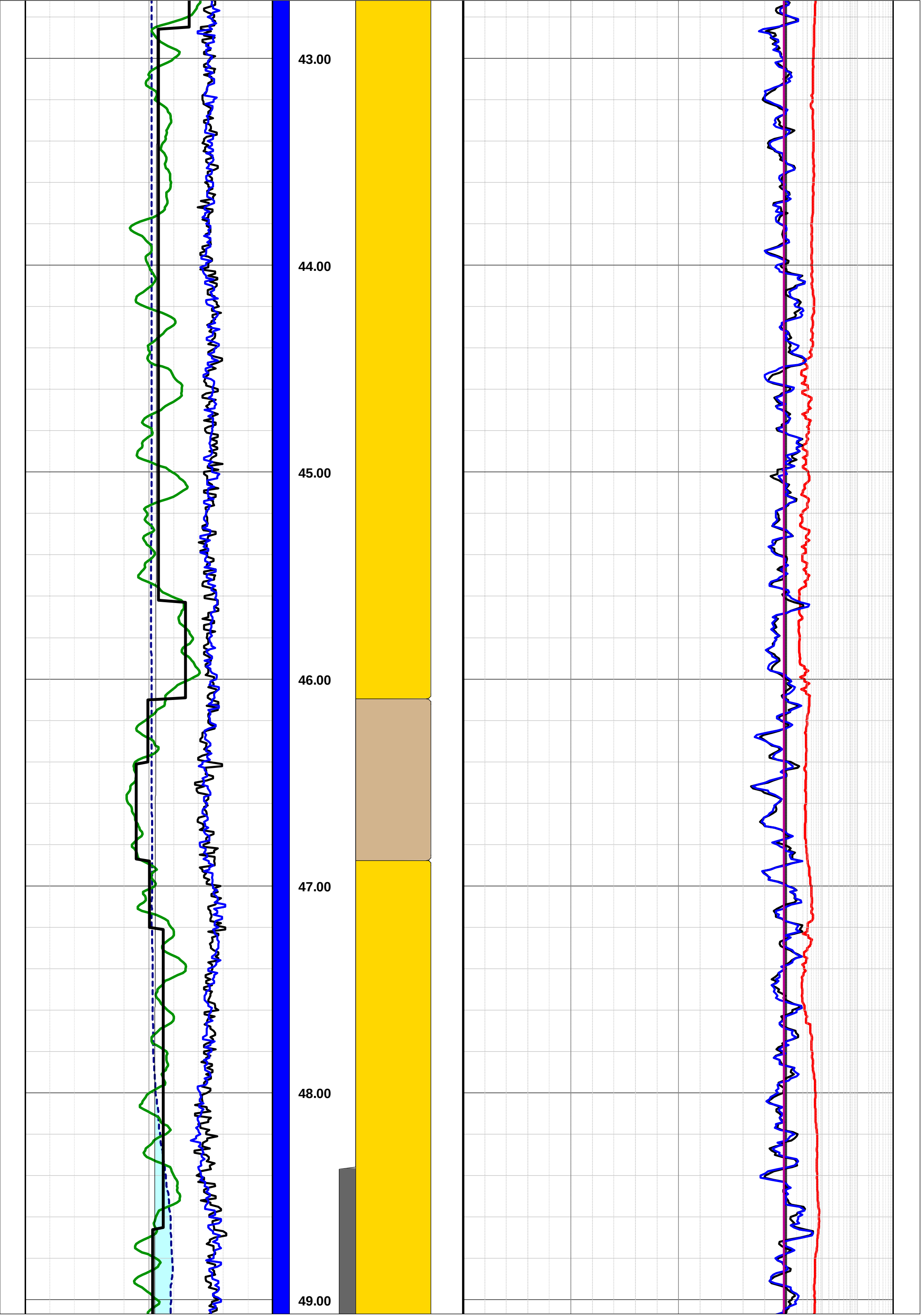
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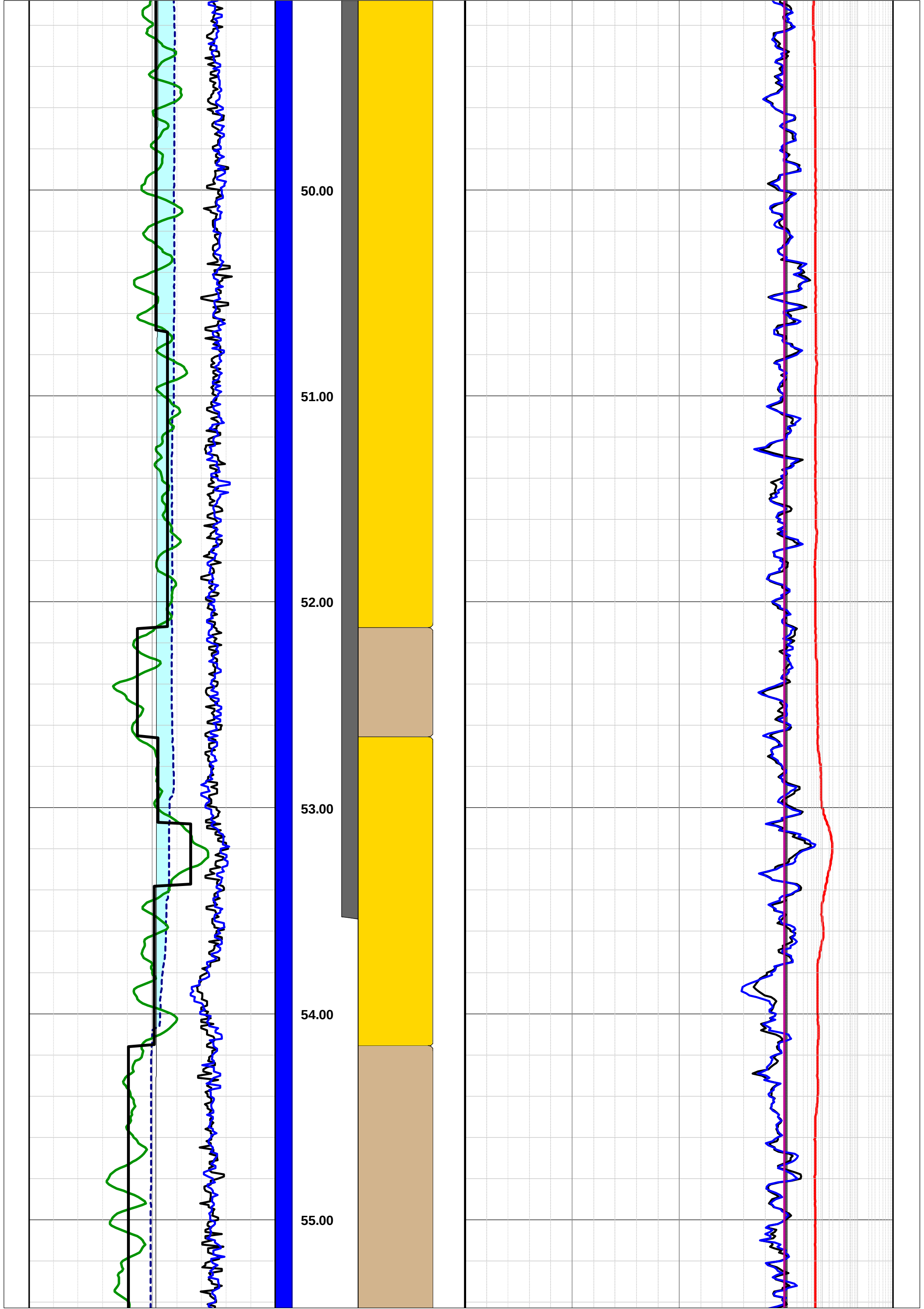
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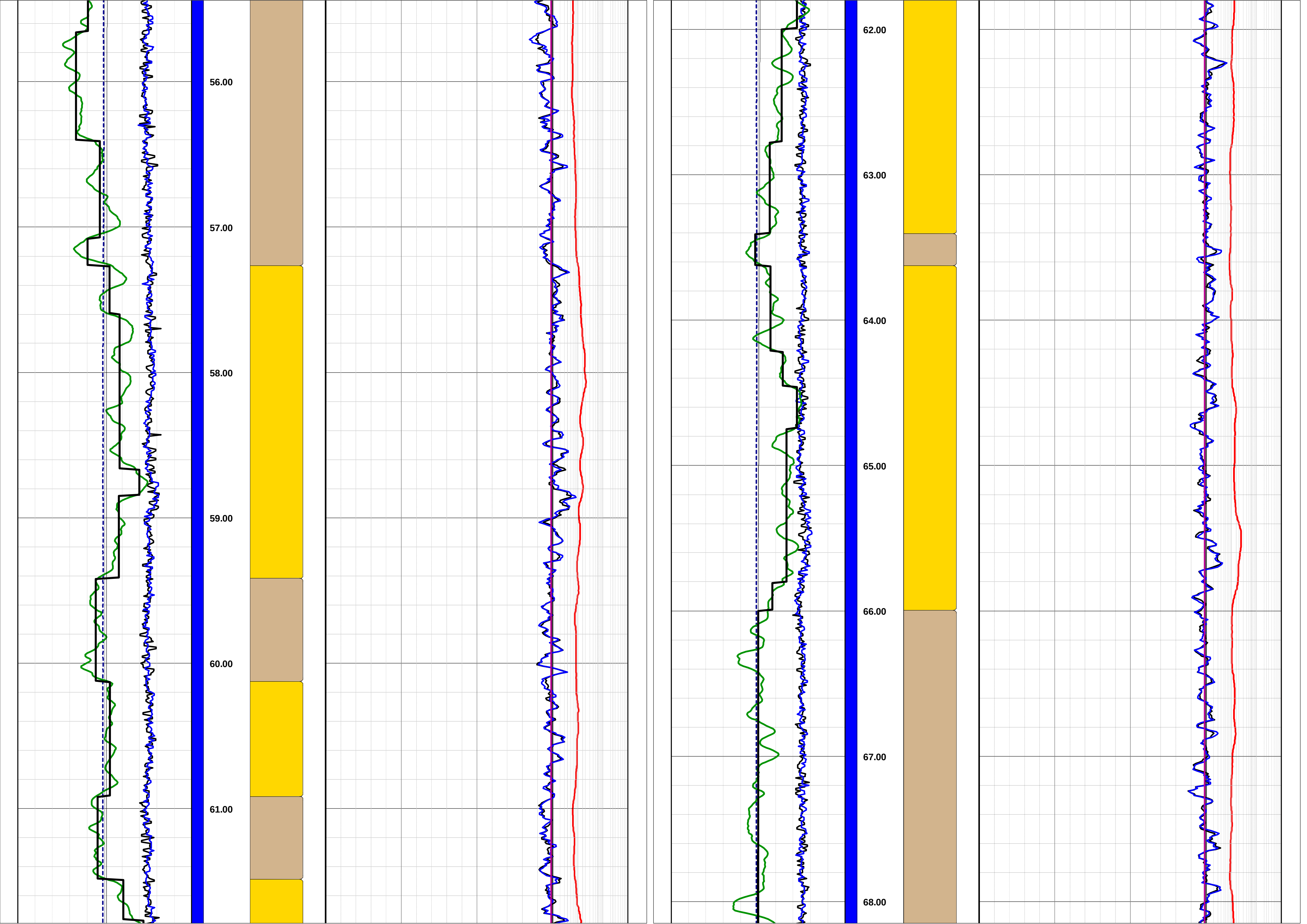
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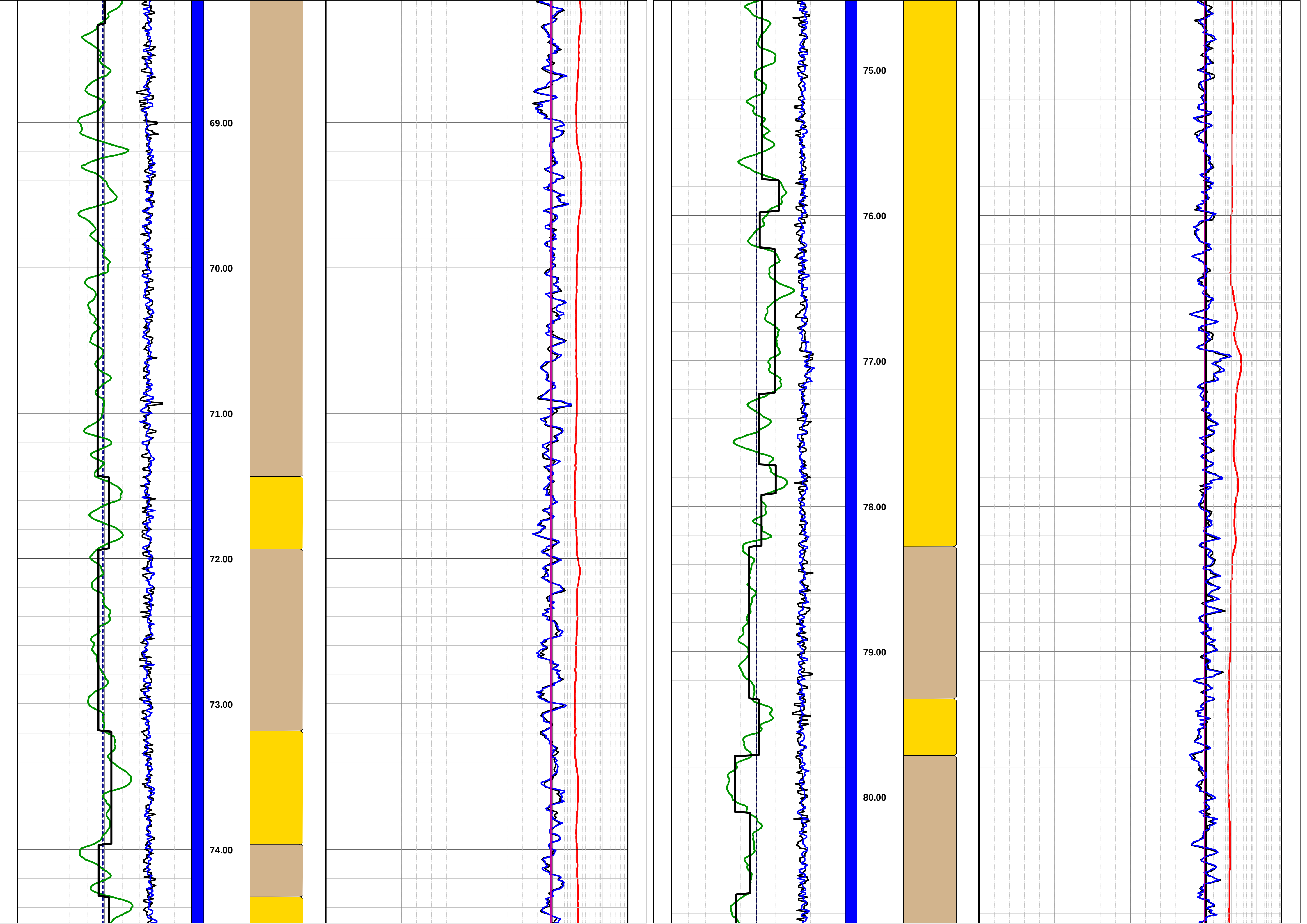
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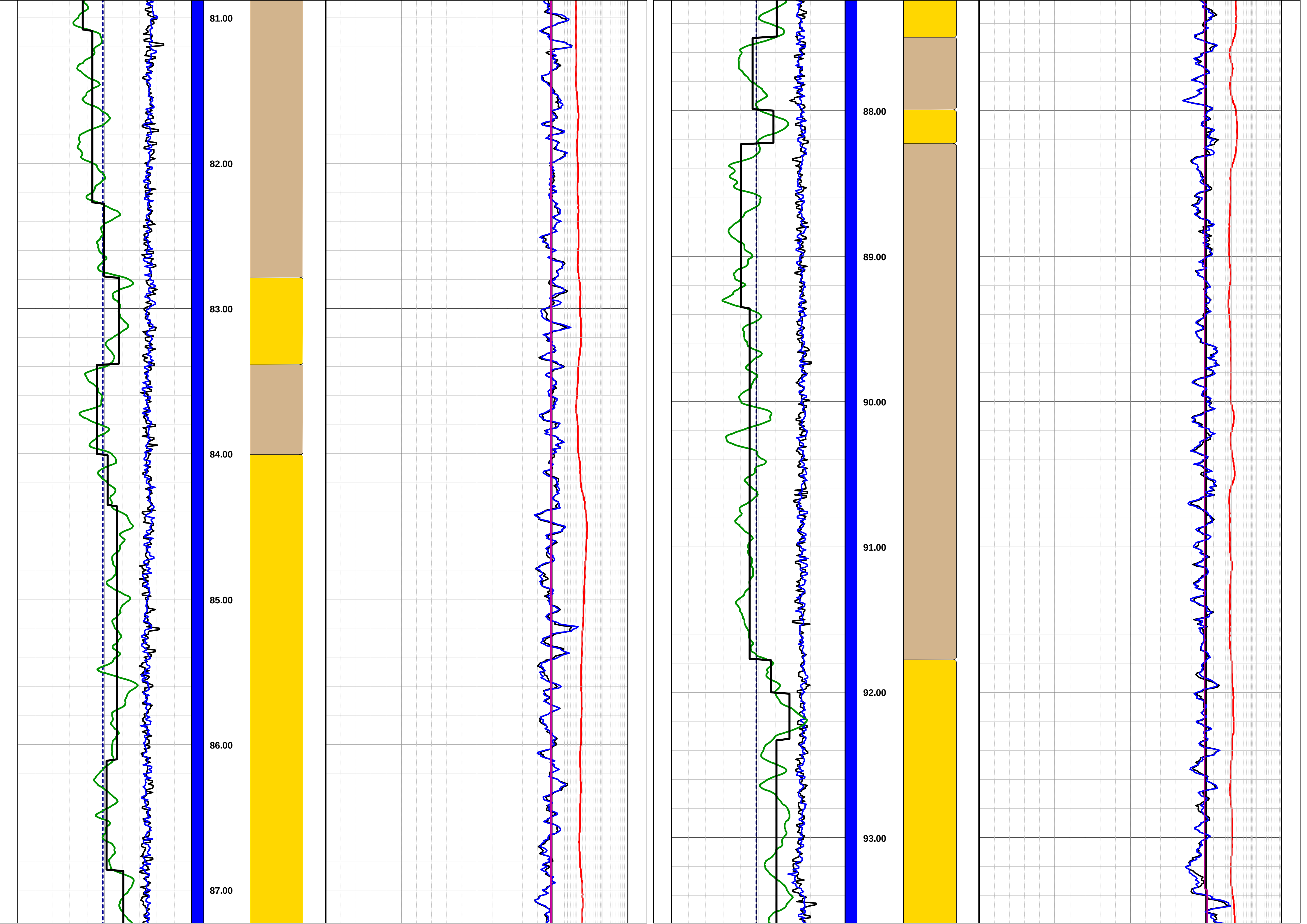
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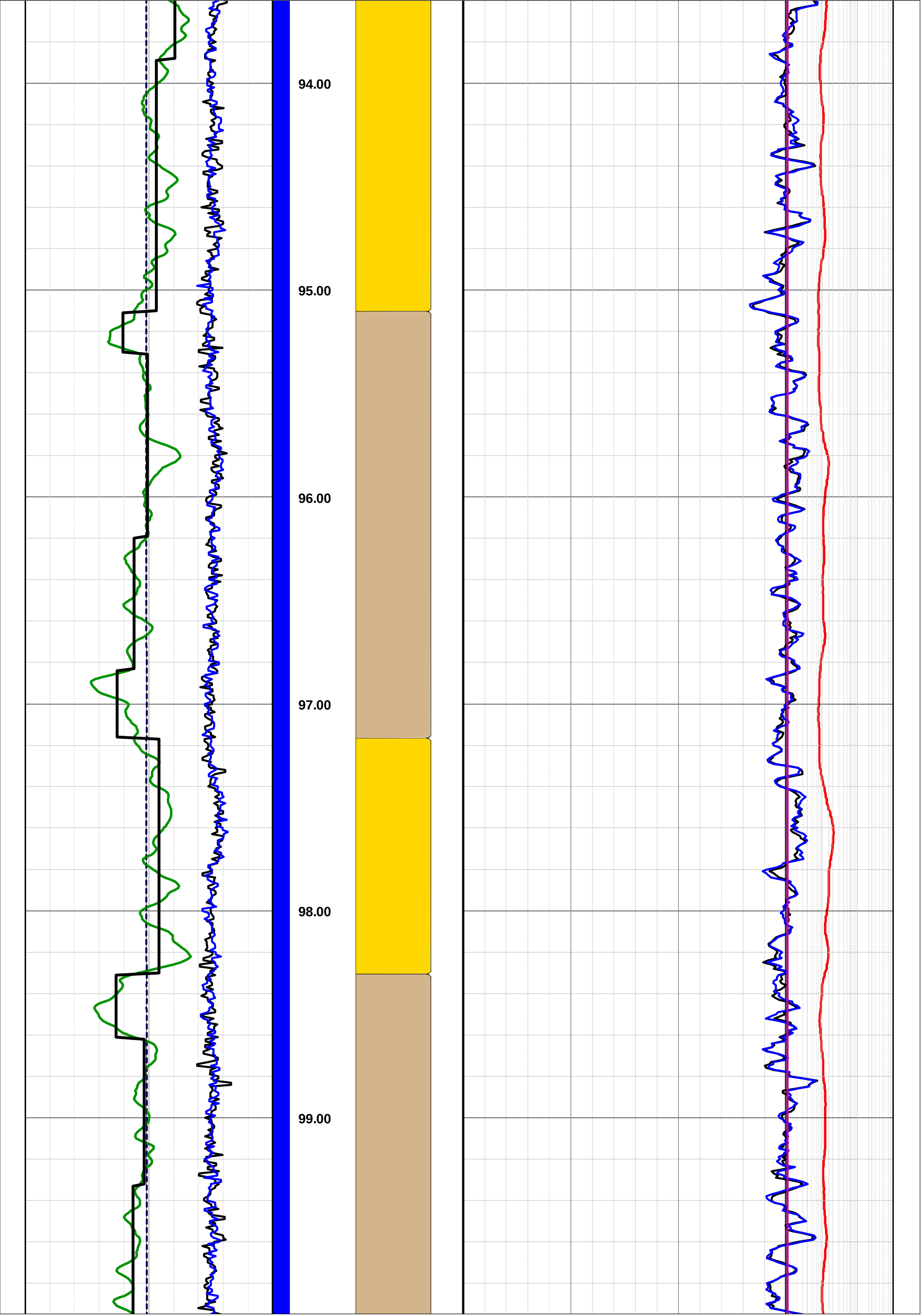
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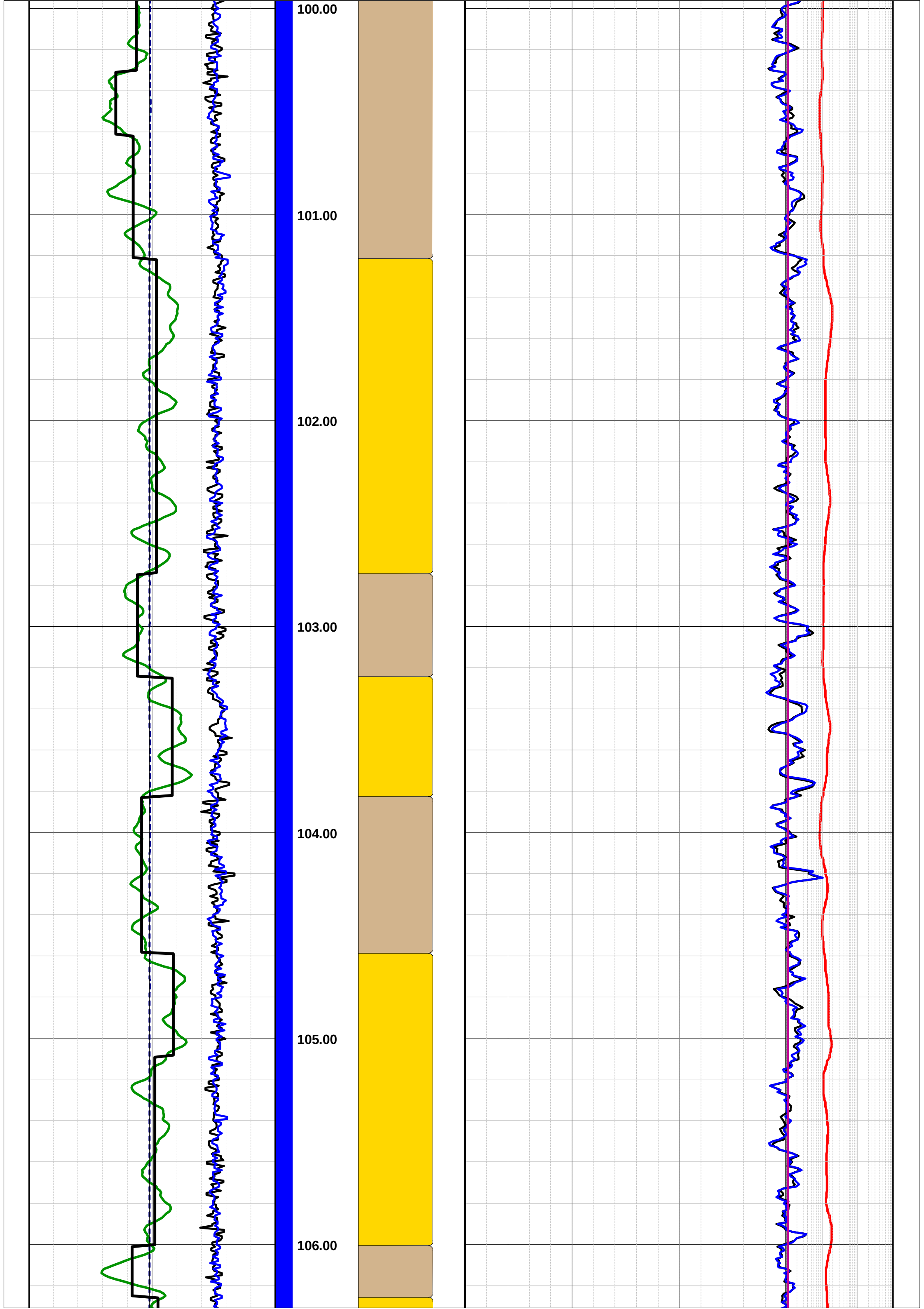
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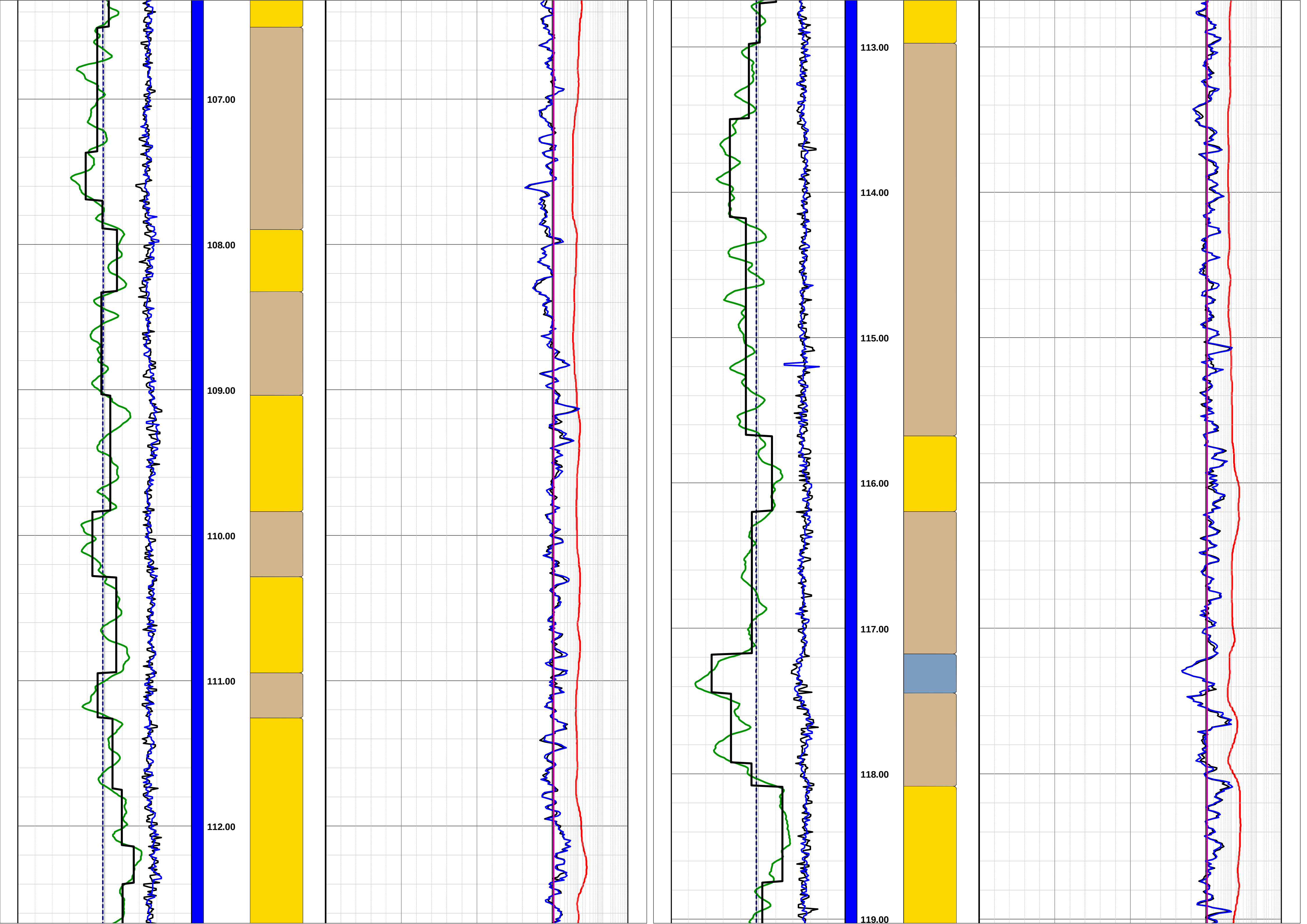

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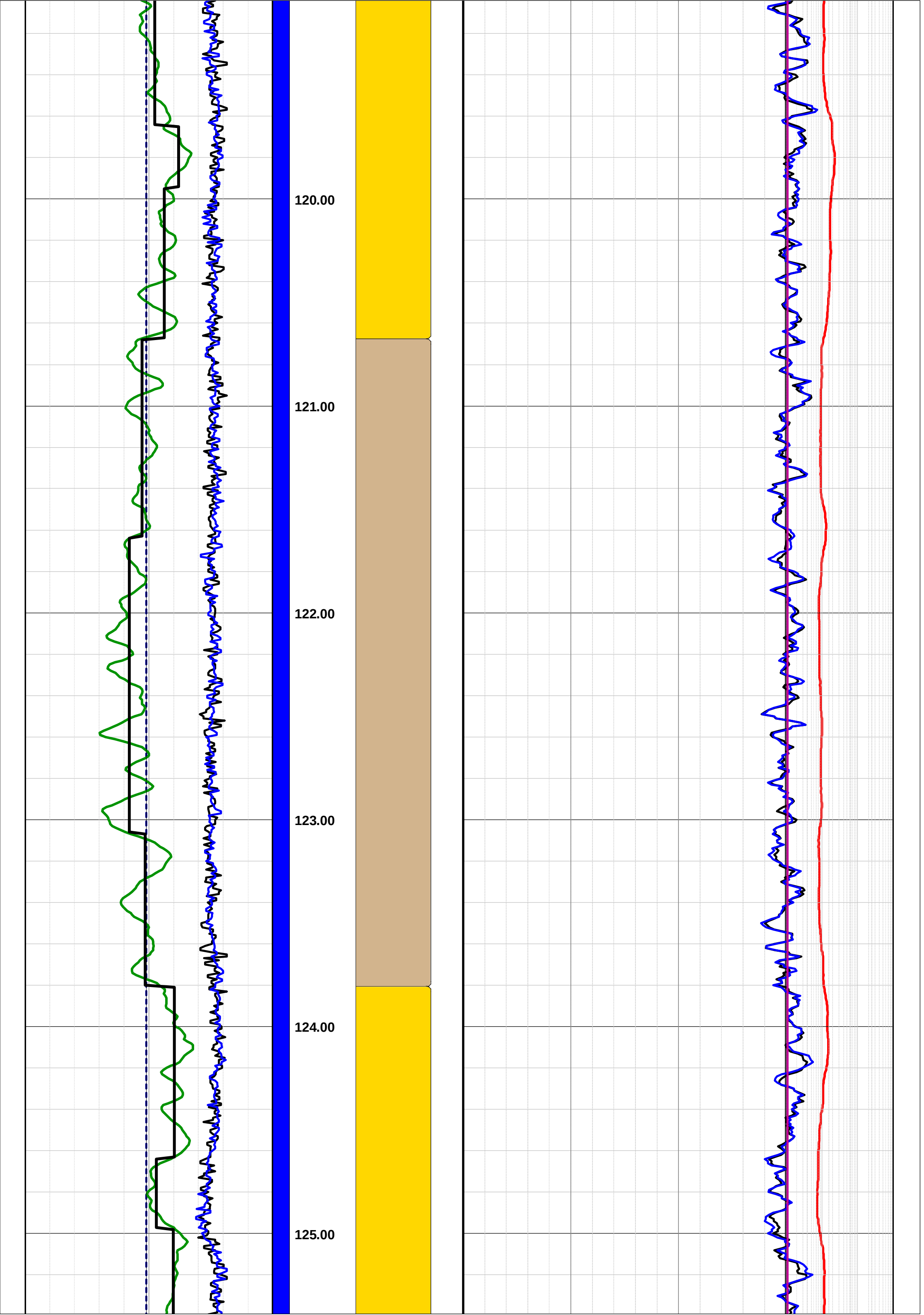
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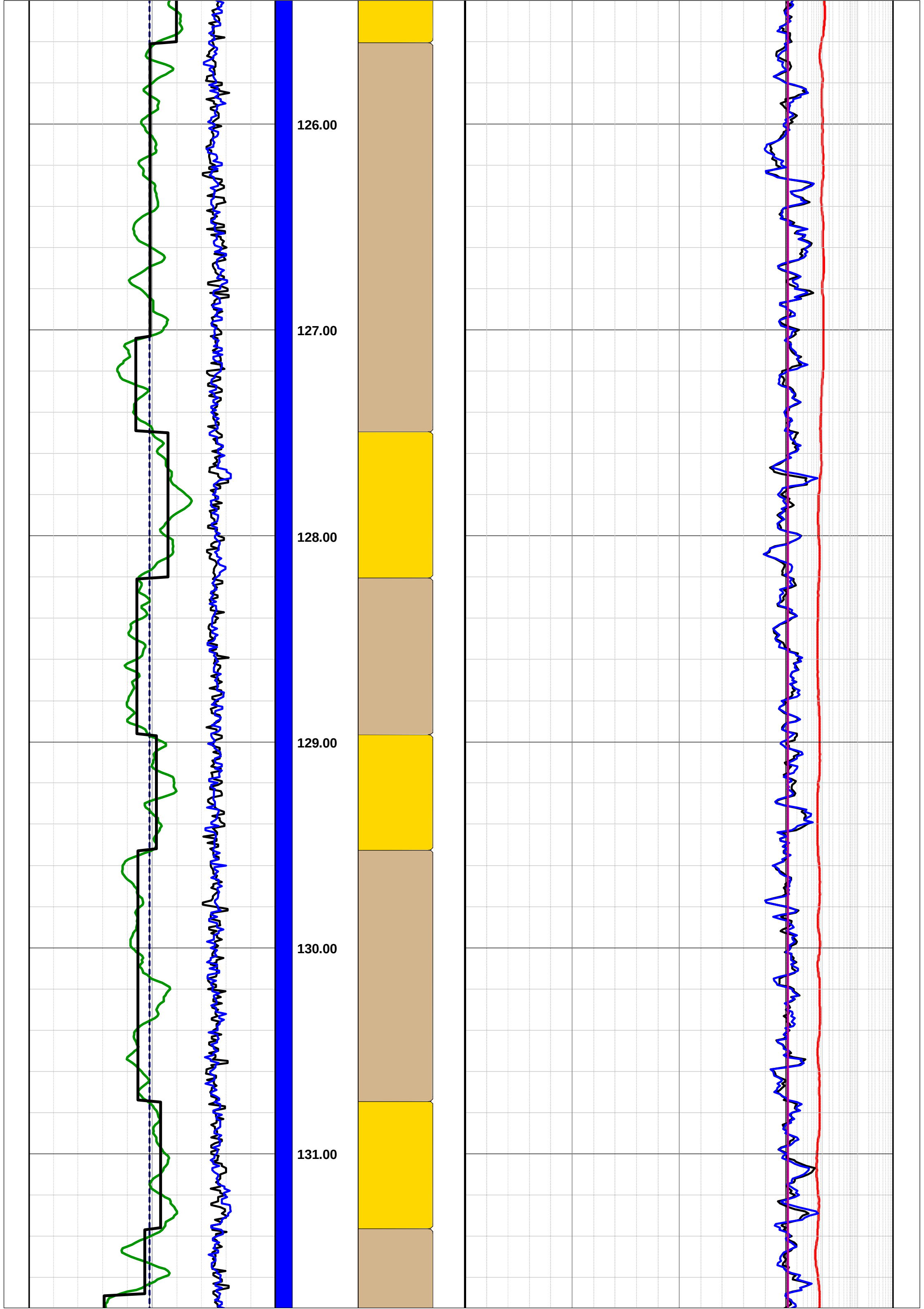
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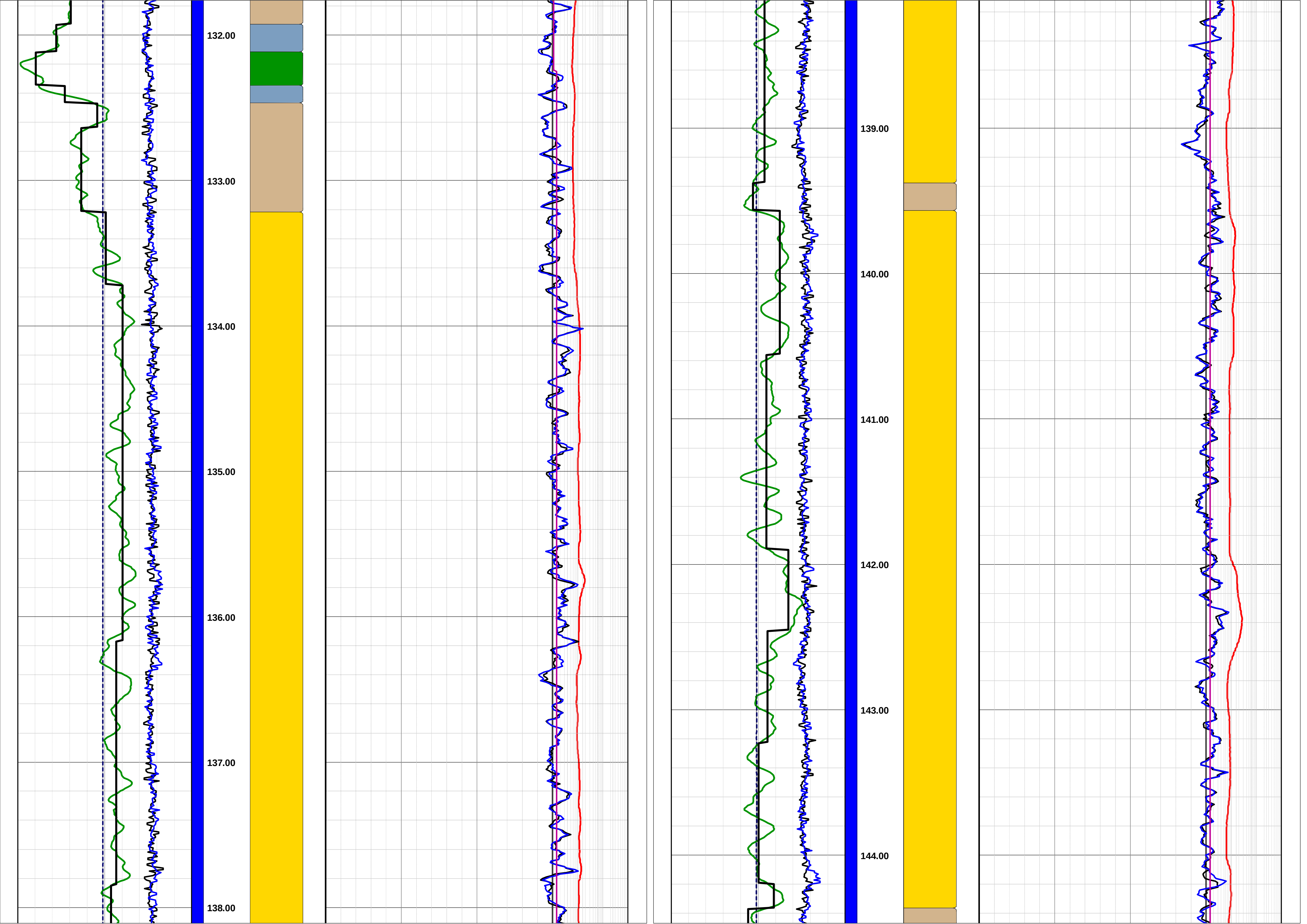
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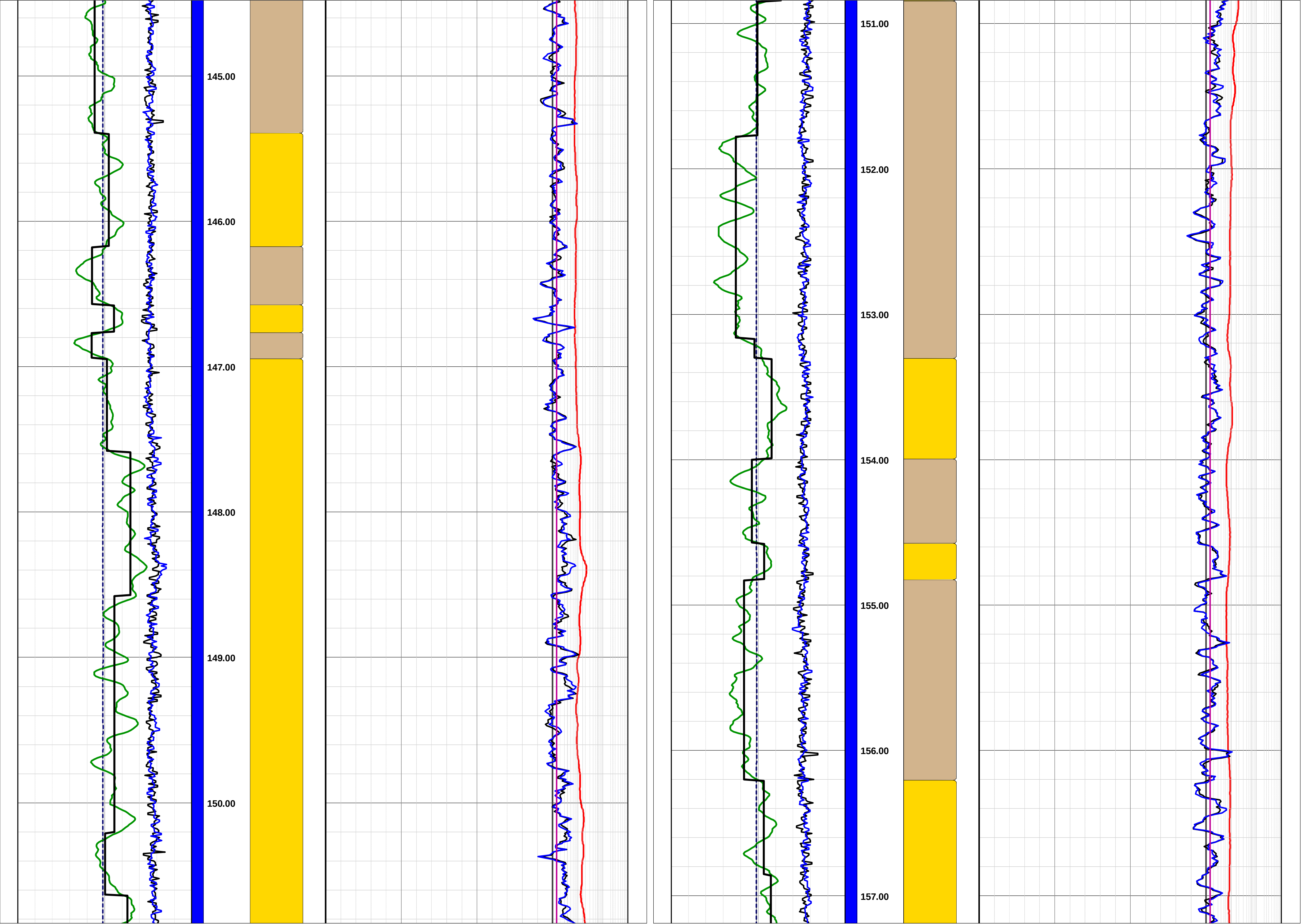

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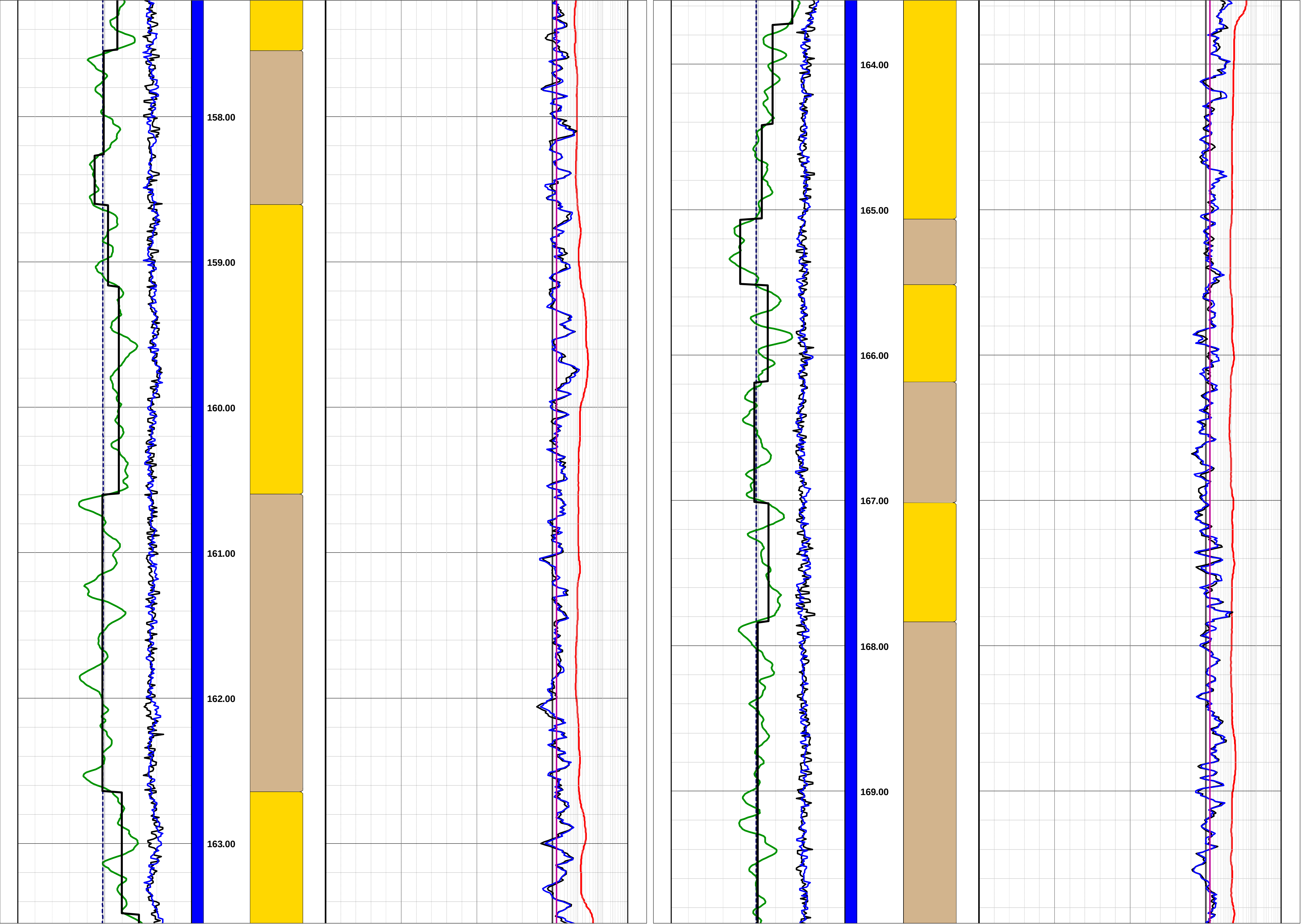
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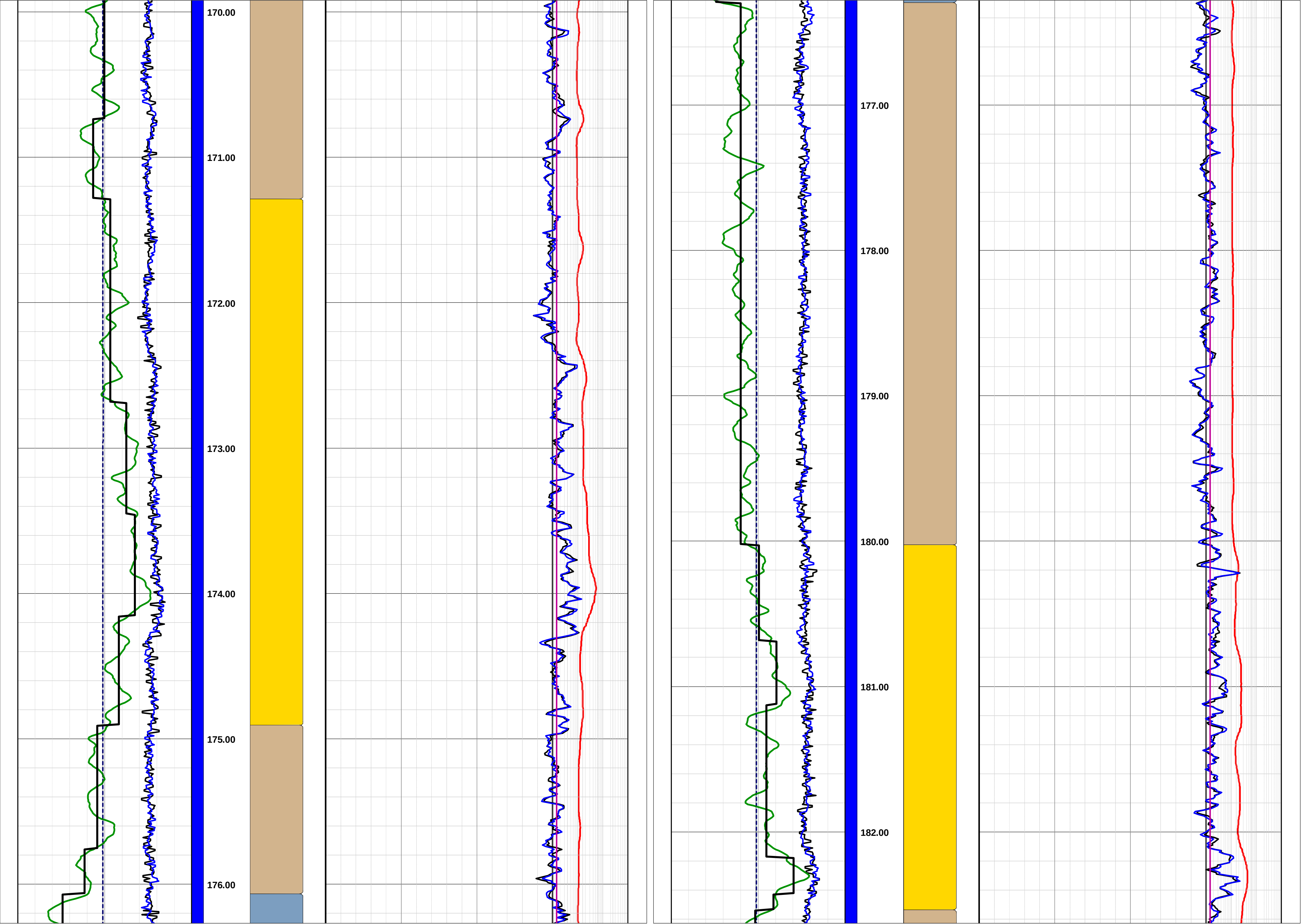
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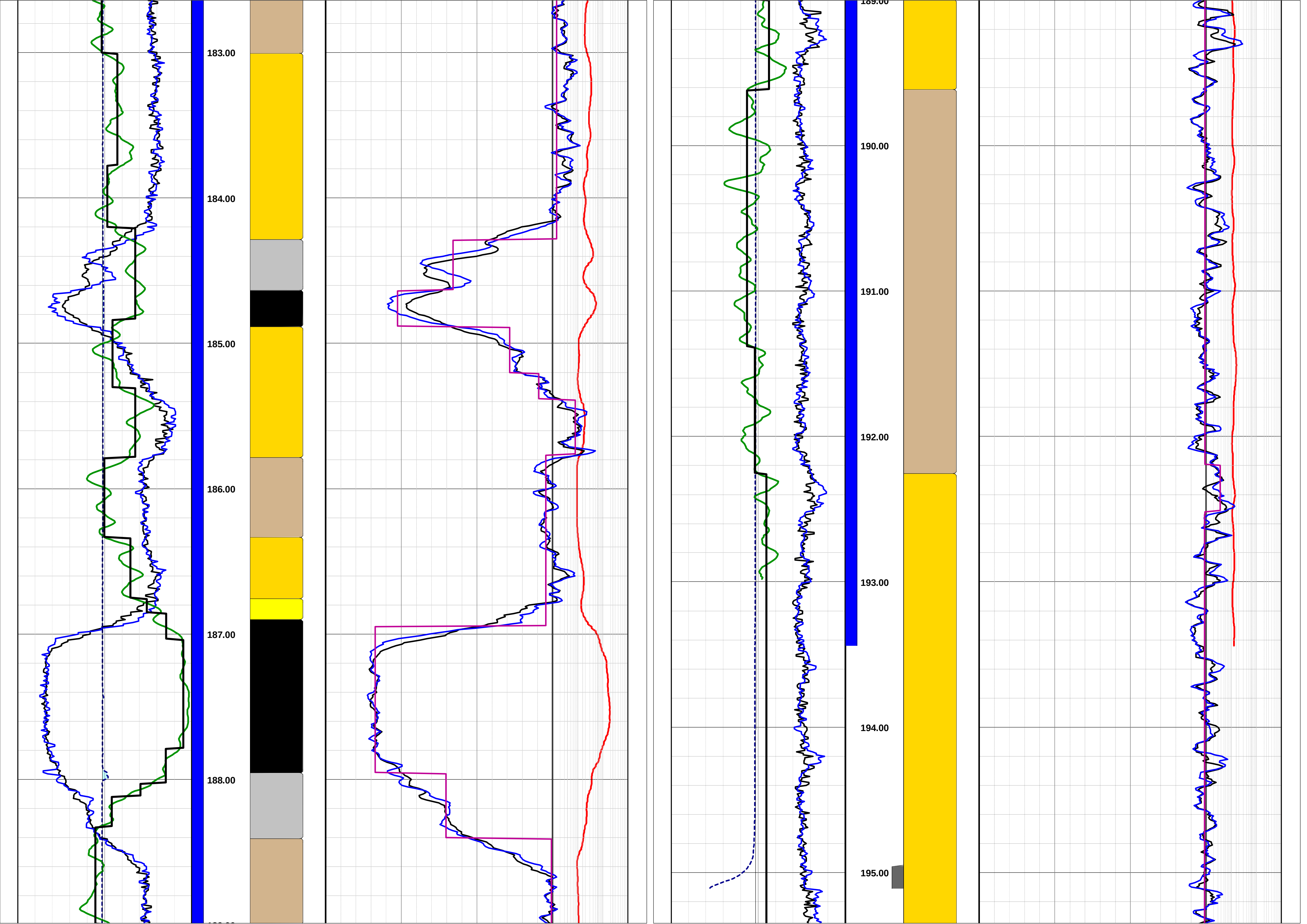

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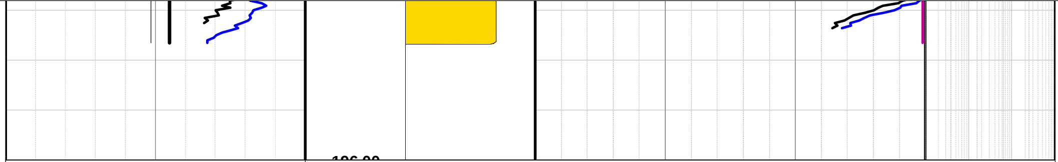

0 DEG 20 SANG			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND

- CO - Coal
- CF - Inferior Coal
- ST - SILTSTONE
- S1 - Sandstone - very fine grained
- S2 - Sandstone - fine grained
- S3 - Sandstone - fine to medium grained
- CY - Claystone

COMPANY	BMA	**LOCATION**	MB19BWM08P
WELL	MB19BWM08P	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

MB19BWM08P

QUICKLOOK LITHOLOGY LOG

PB19BWM01P

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	PB19BWM01P	**LOCATION**	PB19BWM01P	**COUNTRY**	AUSTRALIA

LOCATION: PB19BWM01P
FIELD: BLW
STATE: QLD
WELL: PB19BWM01P
COMPANY: BMA

LOG MEASURED FROM	GL	ELEVATIONS:	OTHER SERVICES:
DRILLING MEASURED FROM	GL	KB	1.
PERMANENT DATUM		DF	2.
PERMANENT DATUM ELEVATION		GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	23-10-2019			RECORDED BY	DMB		
TIME	15-27			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	198m			RIG NUMBER			
DEPTH-LOGGER	195.52m			TOOL TYPE	9239C1		
BIT SIZE	269mm			TOOL SERIAL NO.	2745		
CASING TYPE				EASTING	688963		
CASING ID	320mm			NORTHING	7376586		
CASING BOTTOM	17m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	10.6 m			SOURCE TYPE	CS137	SOURCE ID	CZ3948

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

CO - Coal	S3 - Sandstone - fine to medium grained
CF - Inferior Coal	S4 - Sandstone - medium grained
S1 - Sandstone - very fine grained	TF - TUFF
S2 - Sandstone - fine grained	CY - Claystone

MNEMONICS

DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

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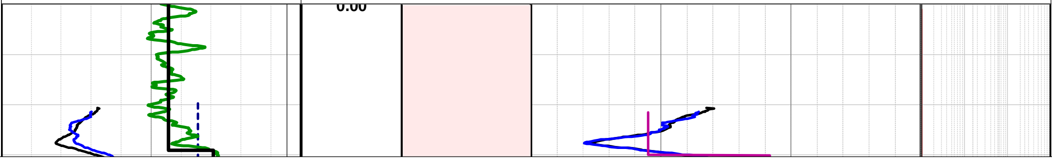
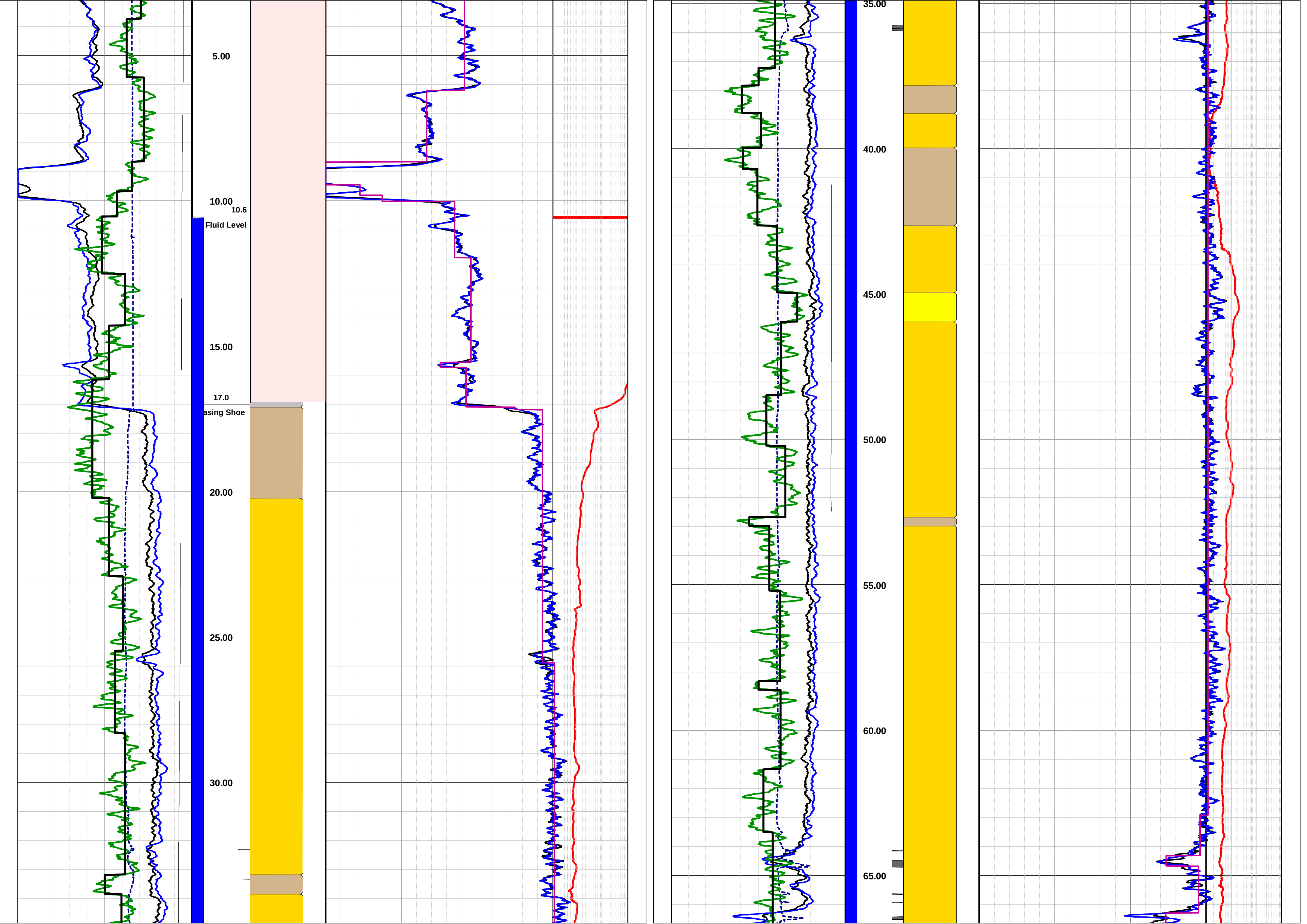
DEPTH SCALE 1:100

Track	Left	Unit	Right
DEN(LS)	1	g/cc	3
DEN(SS)	1	g/cc	3
CALIPER	150	mm	360
GAM(NAT)	200	API	0
NOM_BIT	50	mm	300
SANG	0	DEG	20
Depth		1m:100m	
DATA_FLAG			
WT_FLAG			
COKED_COAL			
LITHOLOGY			
CASING			
RES(SG)	1	OHM-M	1000
DEN(COD)	1	g/cc	3
DEN(ER)	1	g/cc	3

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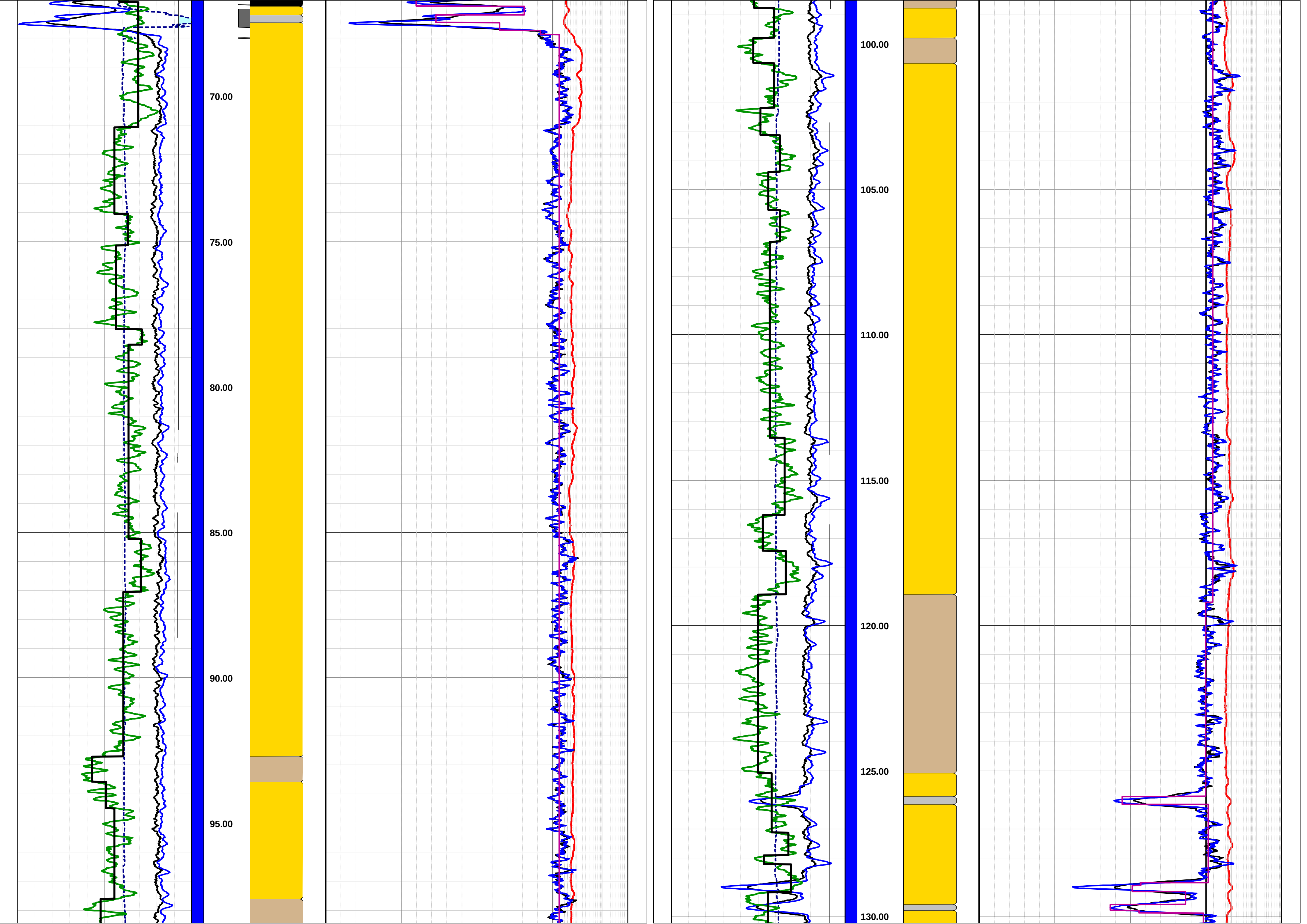
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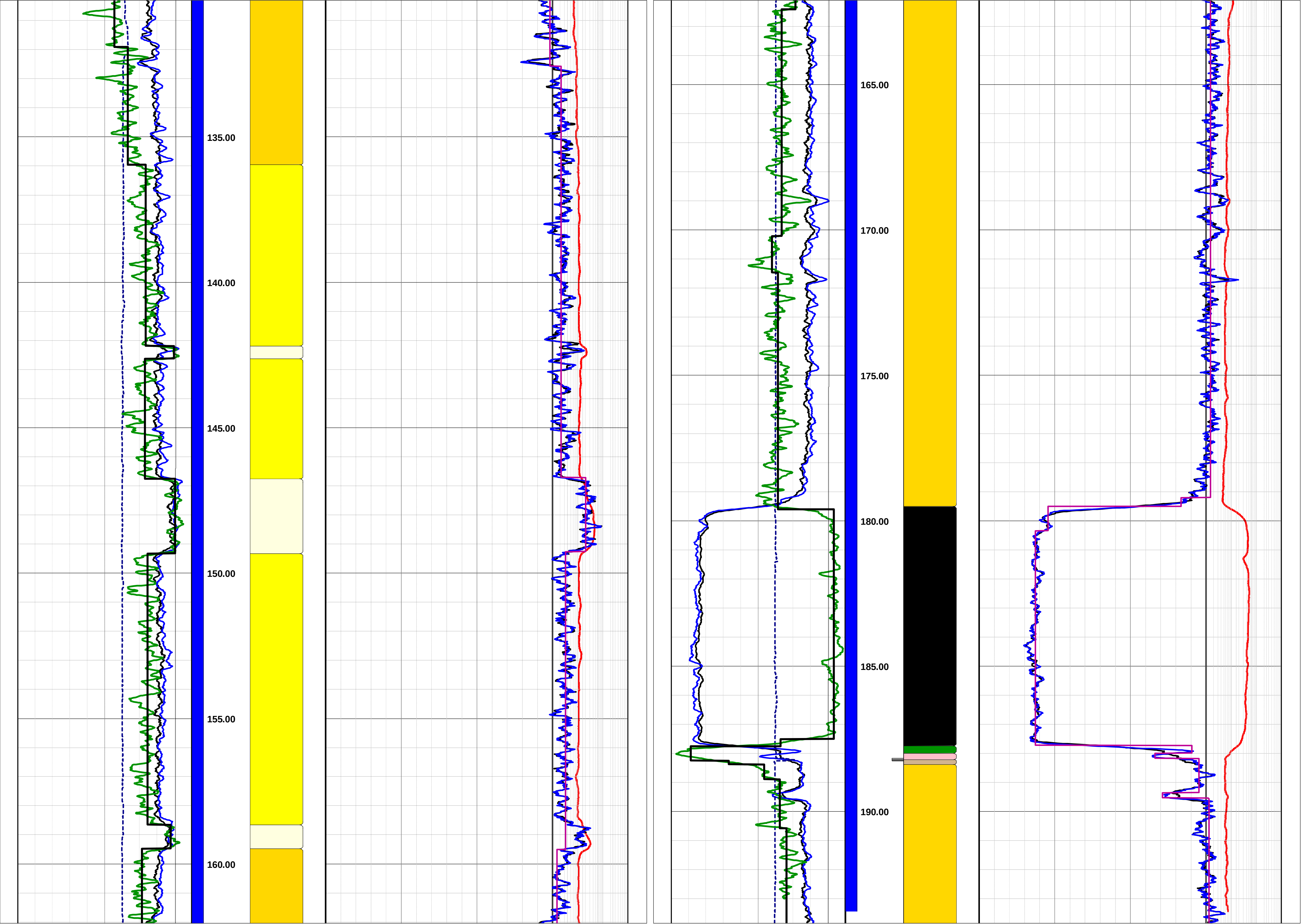
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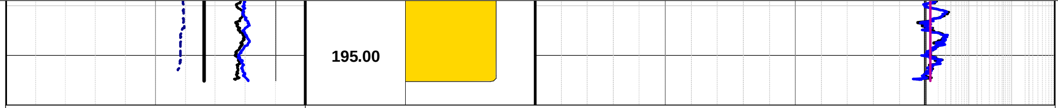
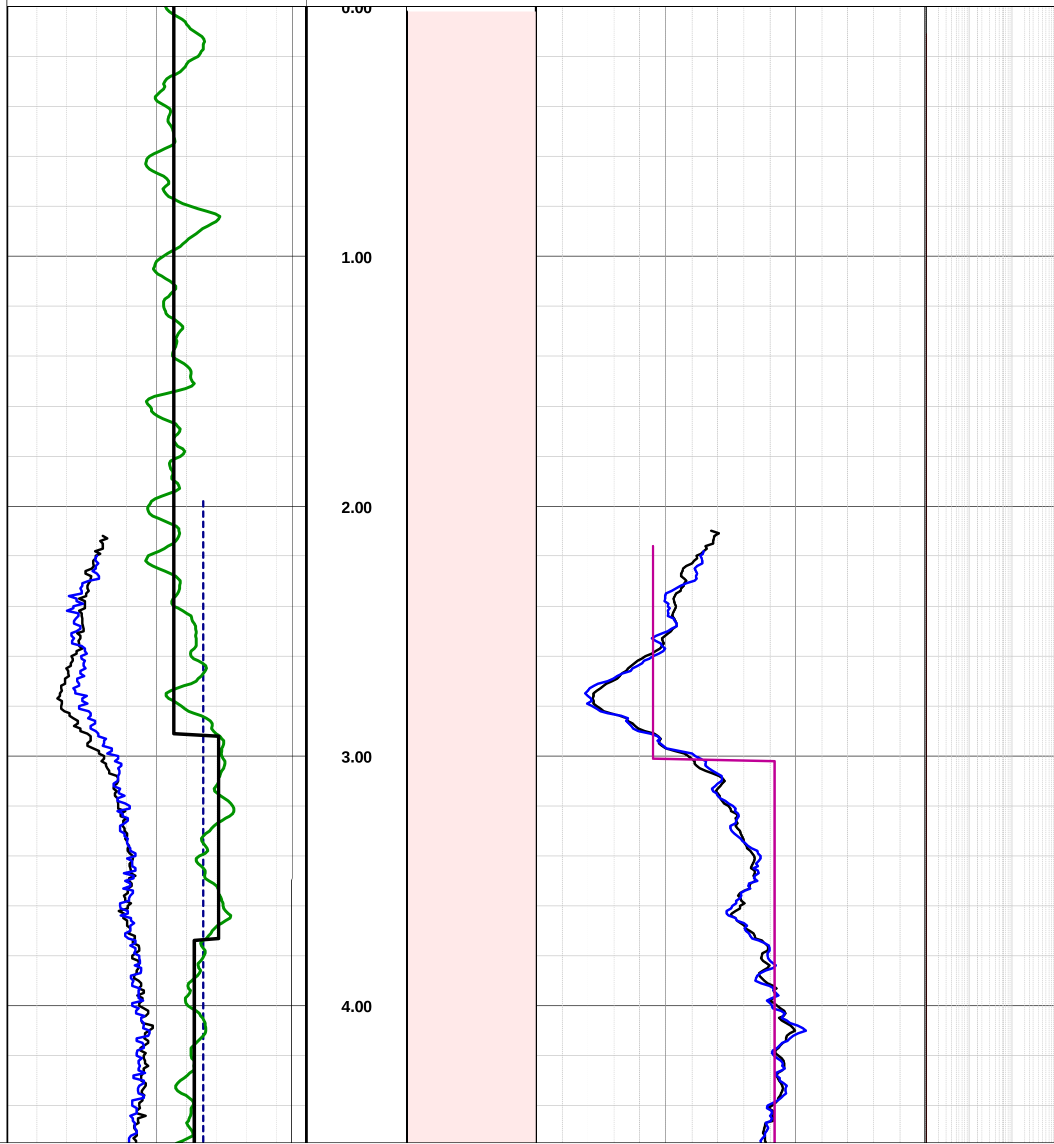


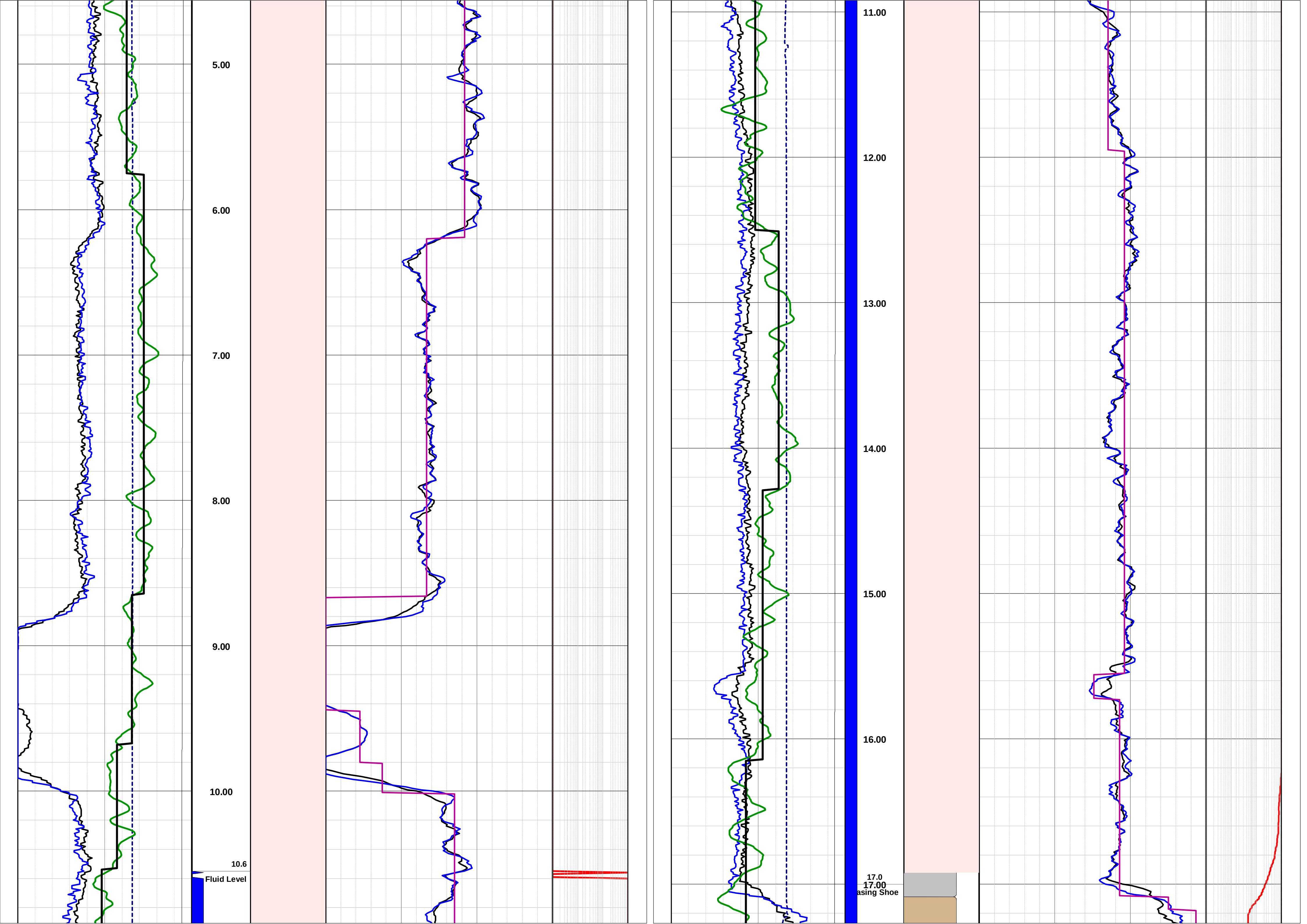
0 DEG 20 SANG				
50 mm 300 NOM_BIT				
200 API 0 GAM(NAT)				
150 mm 360 CALIPER	WT_FLAG	CASING	1 g/cc 3 DEN(ER)	
1 g/cc 3 DEN(SS)	DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)	
1 g/cc 3 DEN(LS)	1m:100m Depth	COKED_COAL		1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) 1 g/cc 3	Depth 1m:20m	COKED_COAL		RES(SG) 1 OHM-M 1000
DEN(SS) 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) 1 g/cc 3	
CALIPER 150 mm 360	WT_FLAG 0 5	CASING	DEN(ER) 1 g/cc 3	
GAM(NAT) 200 API 0				
SANG 0 DEG 20				





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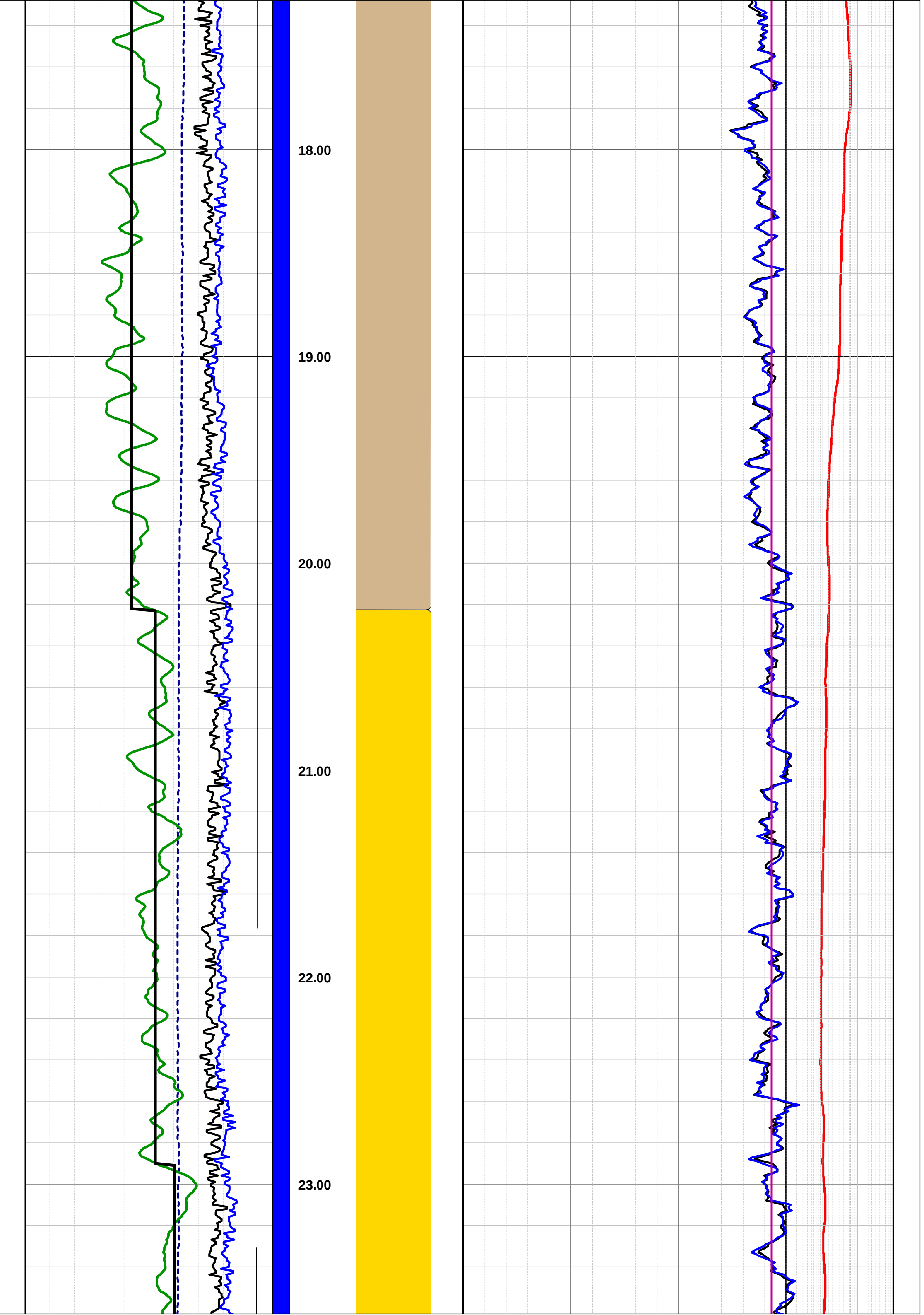
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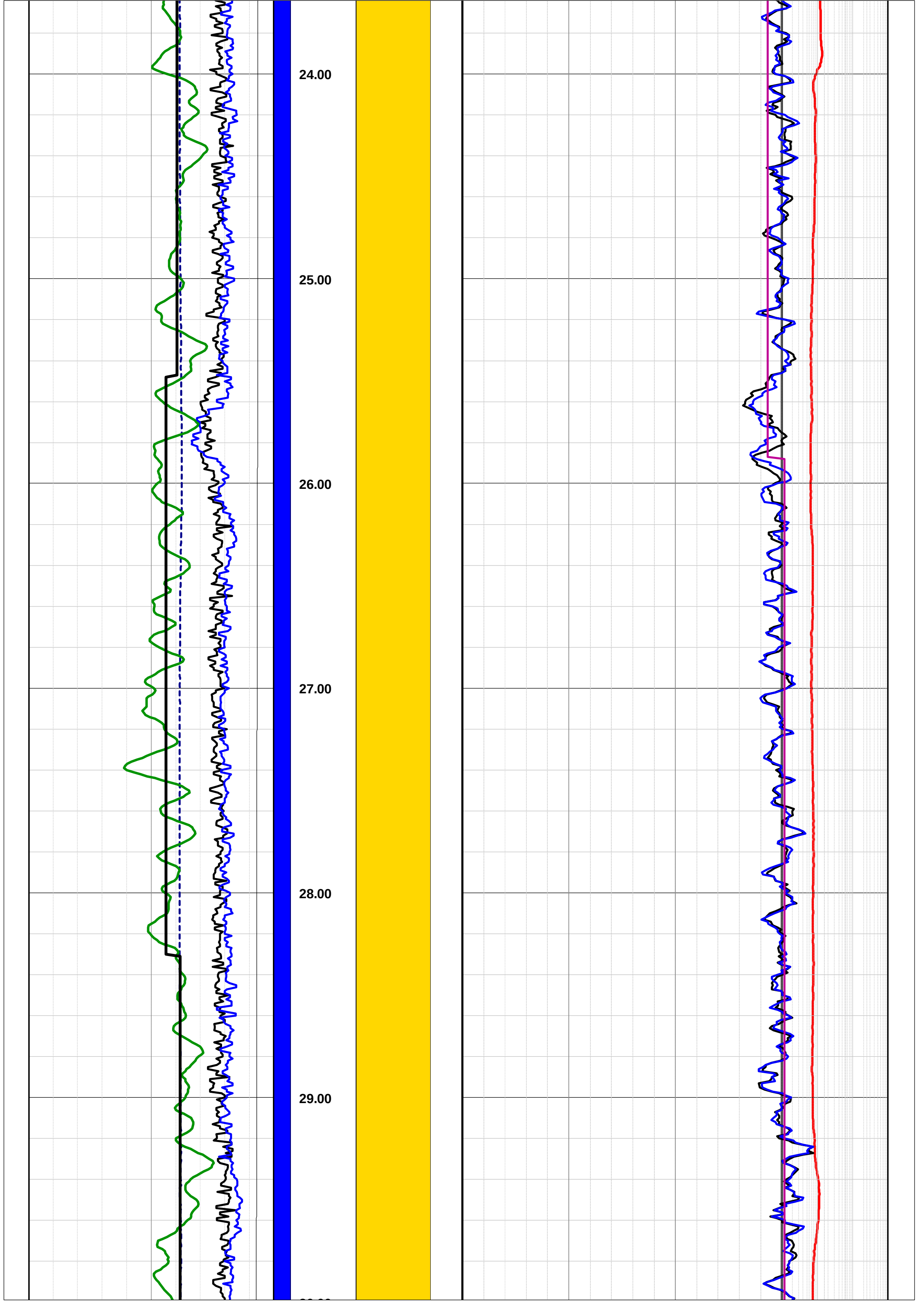
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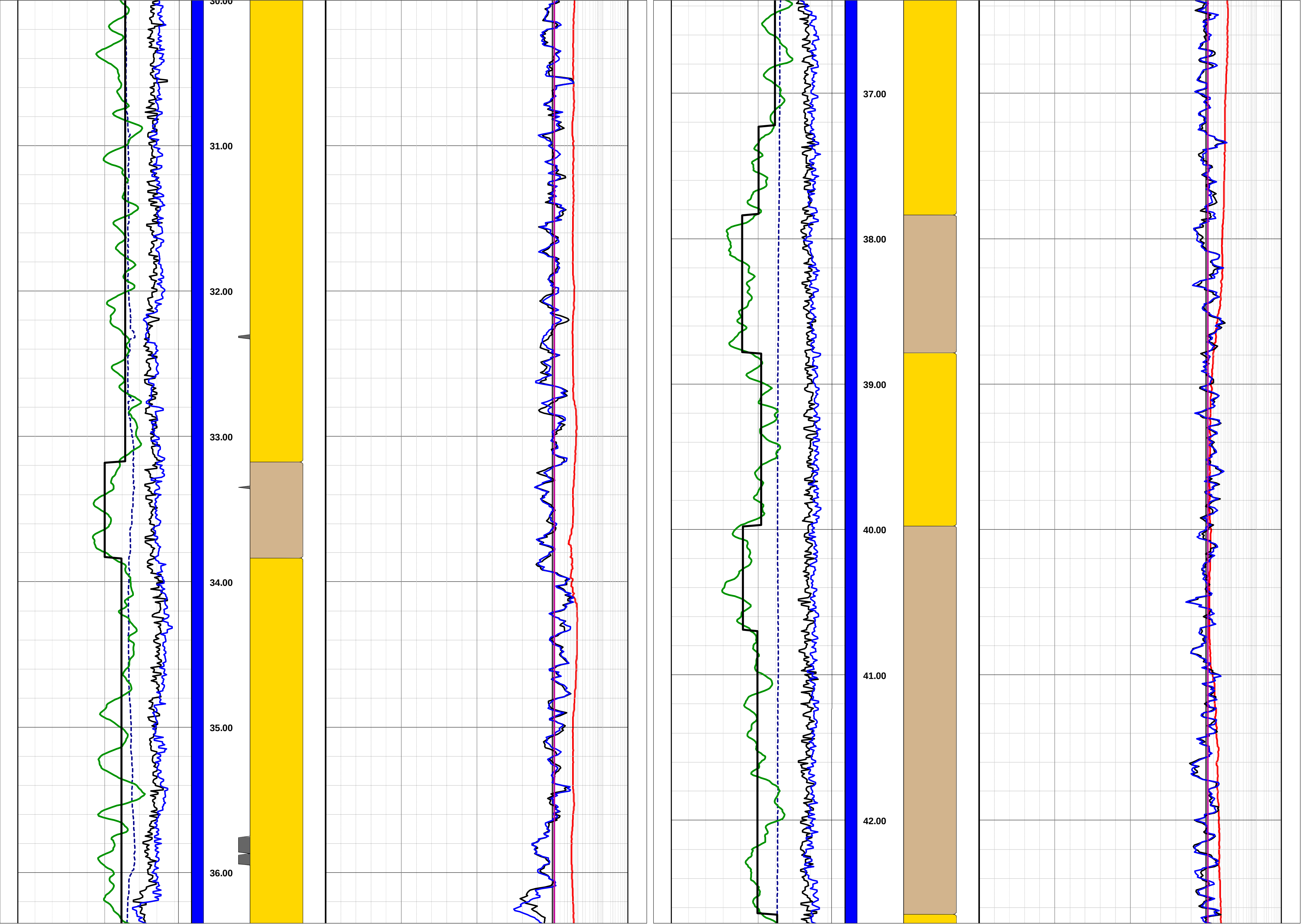

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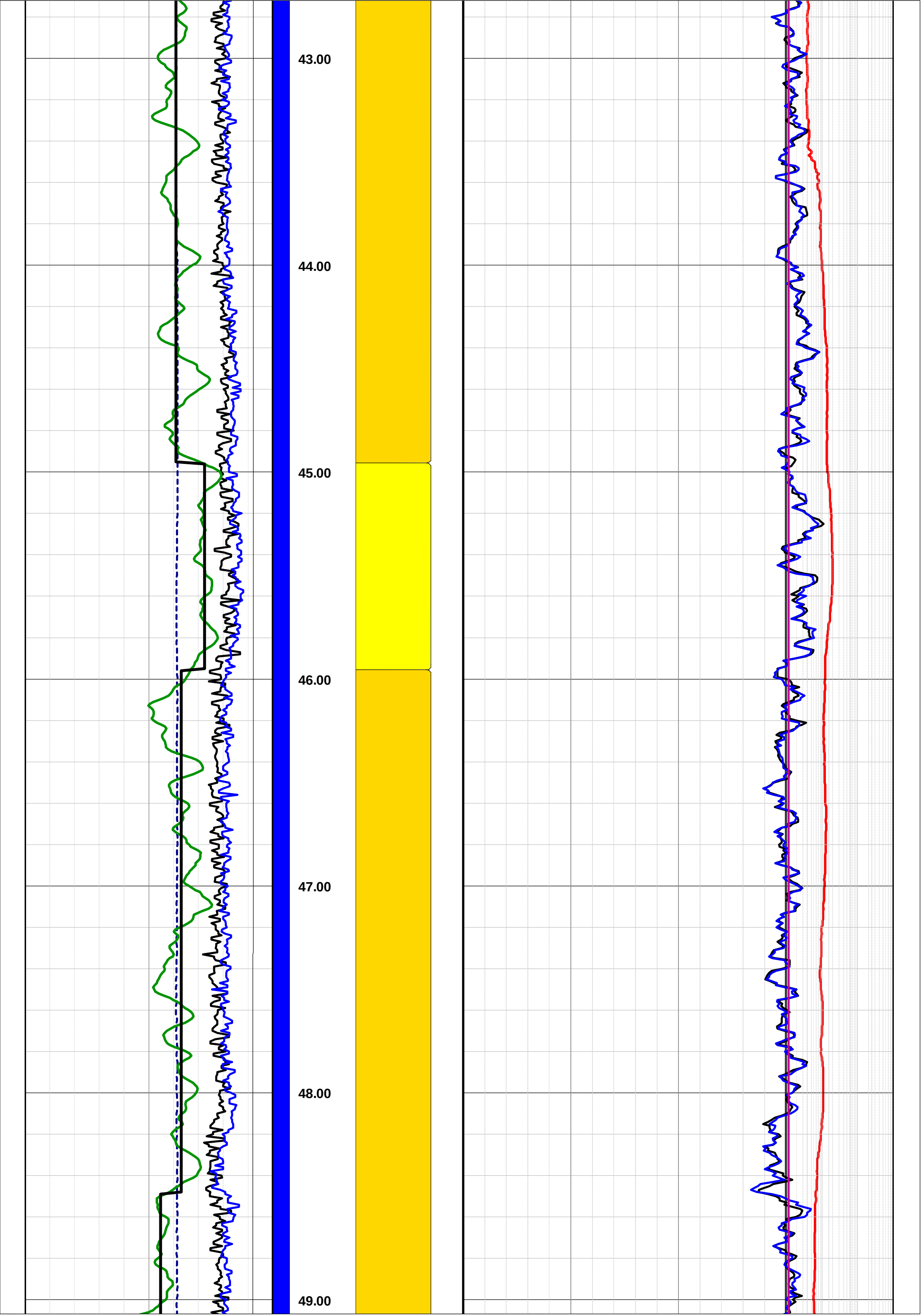
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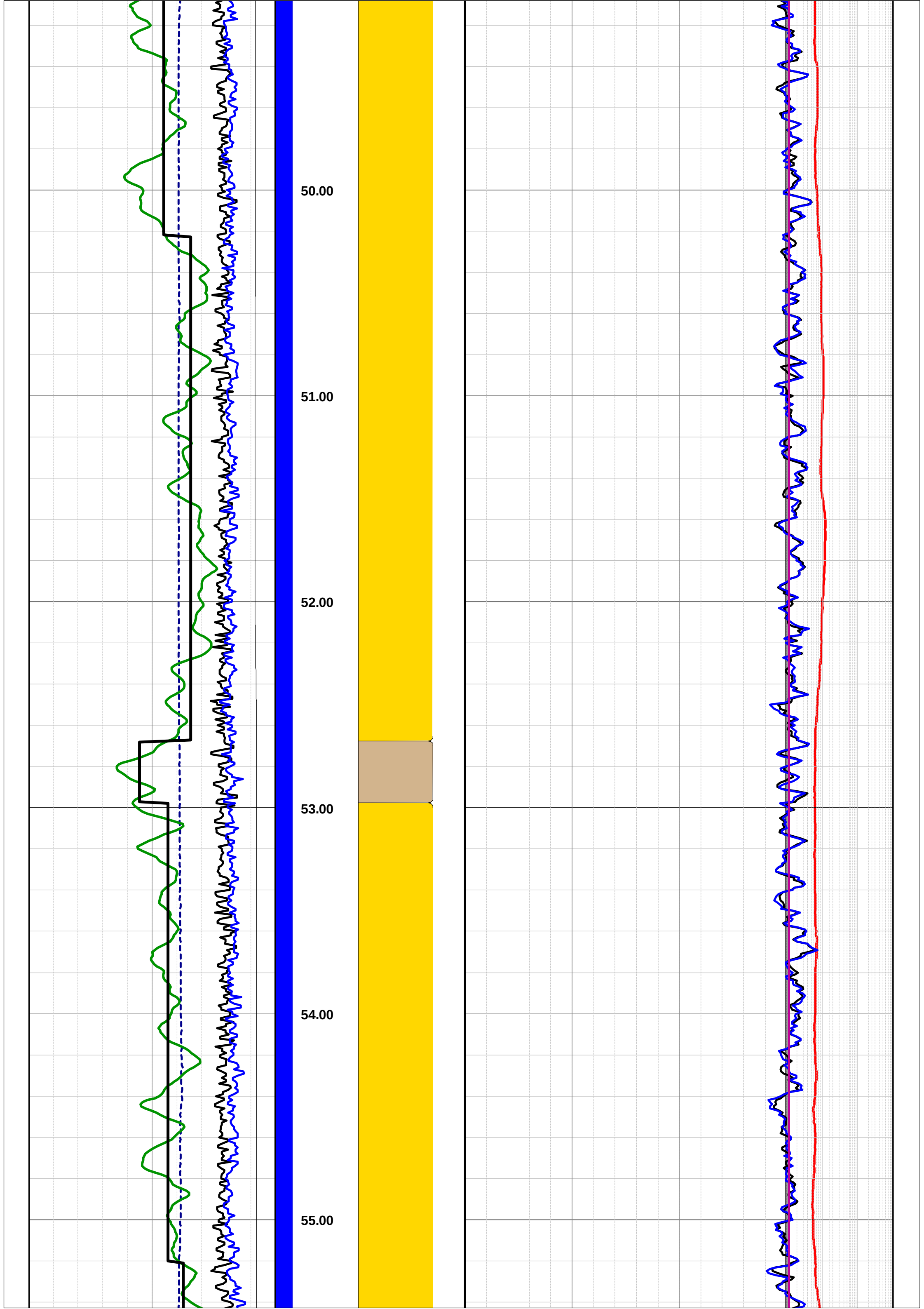
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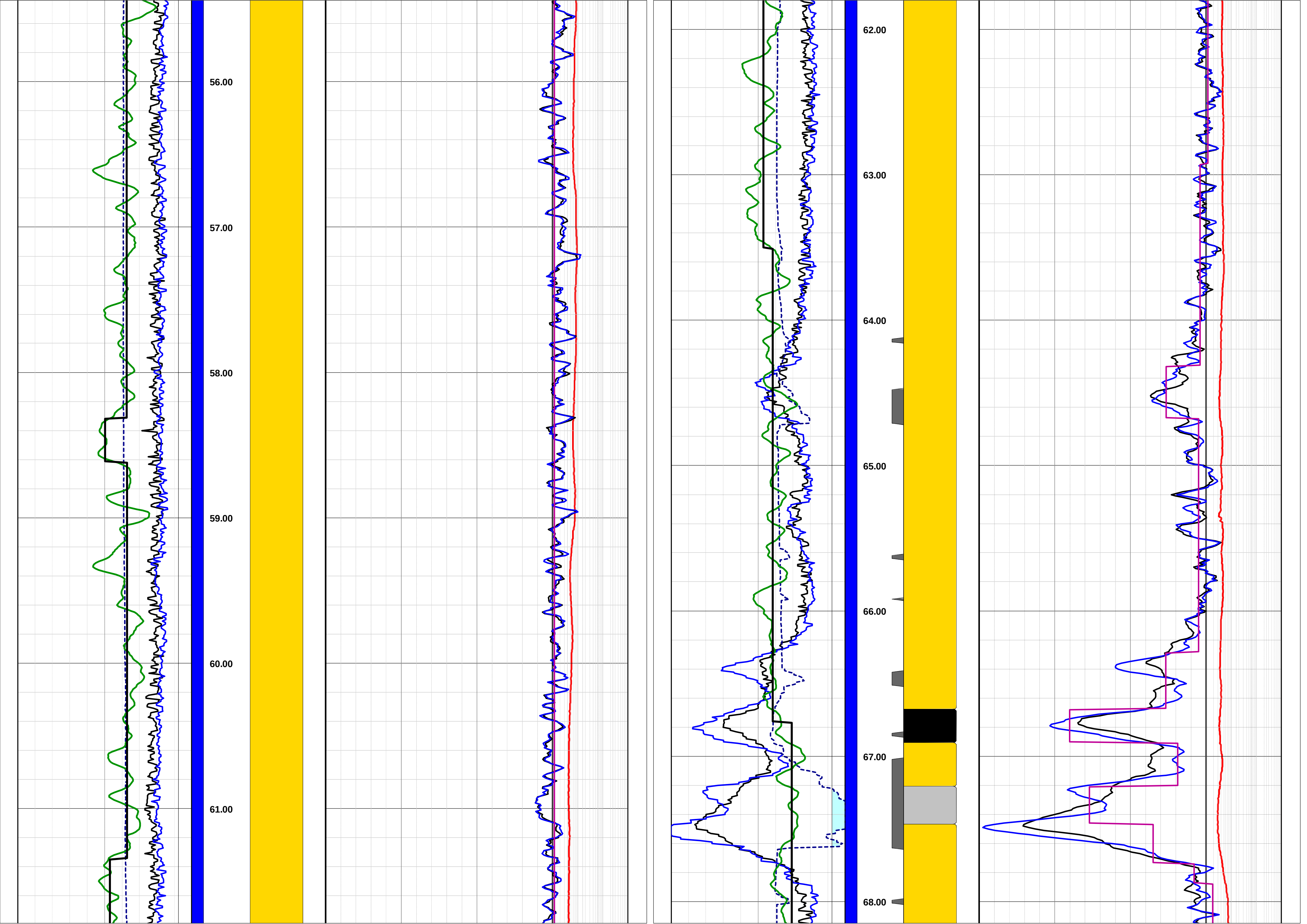
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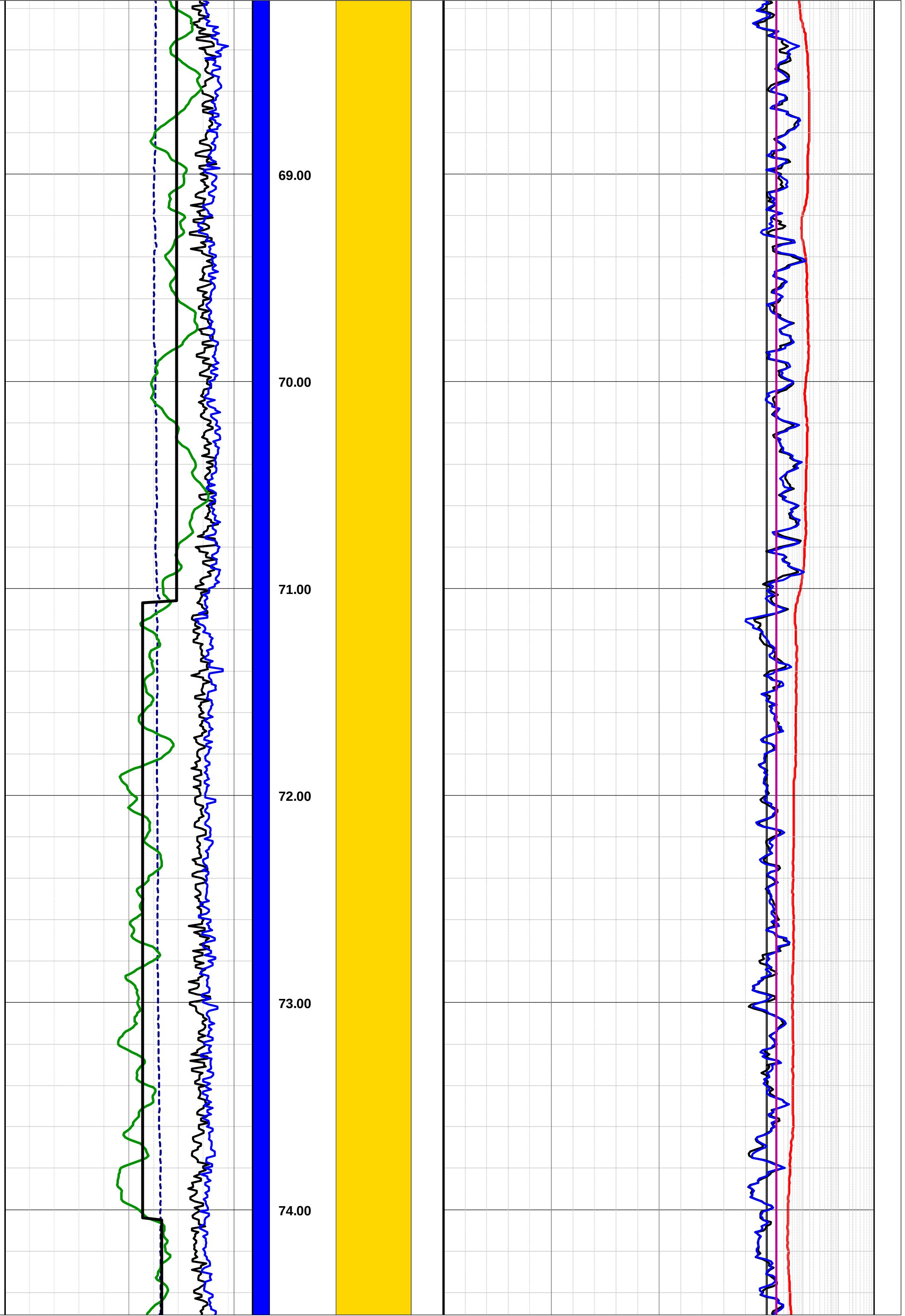

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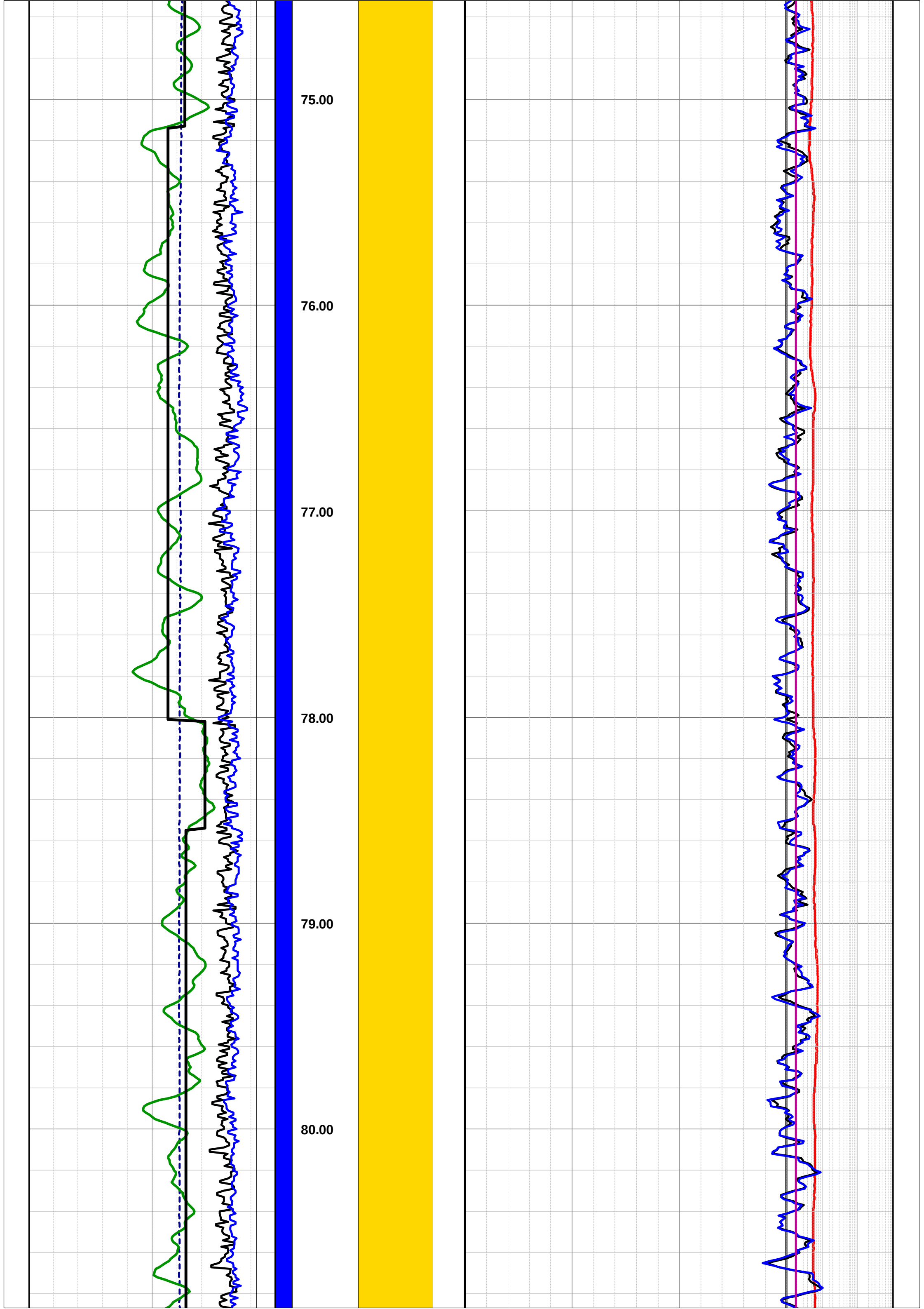

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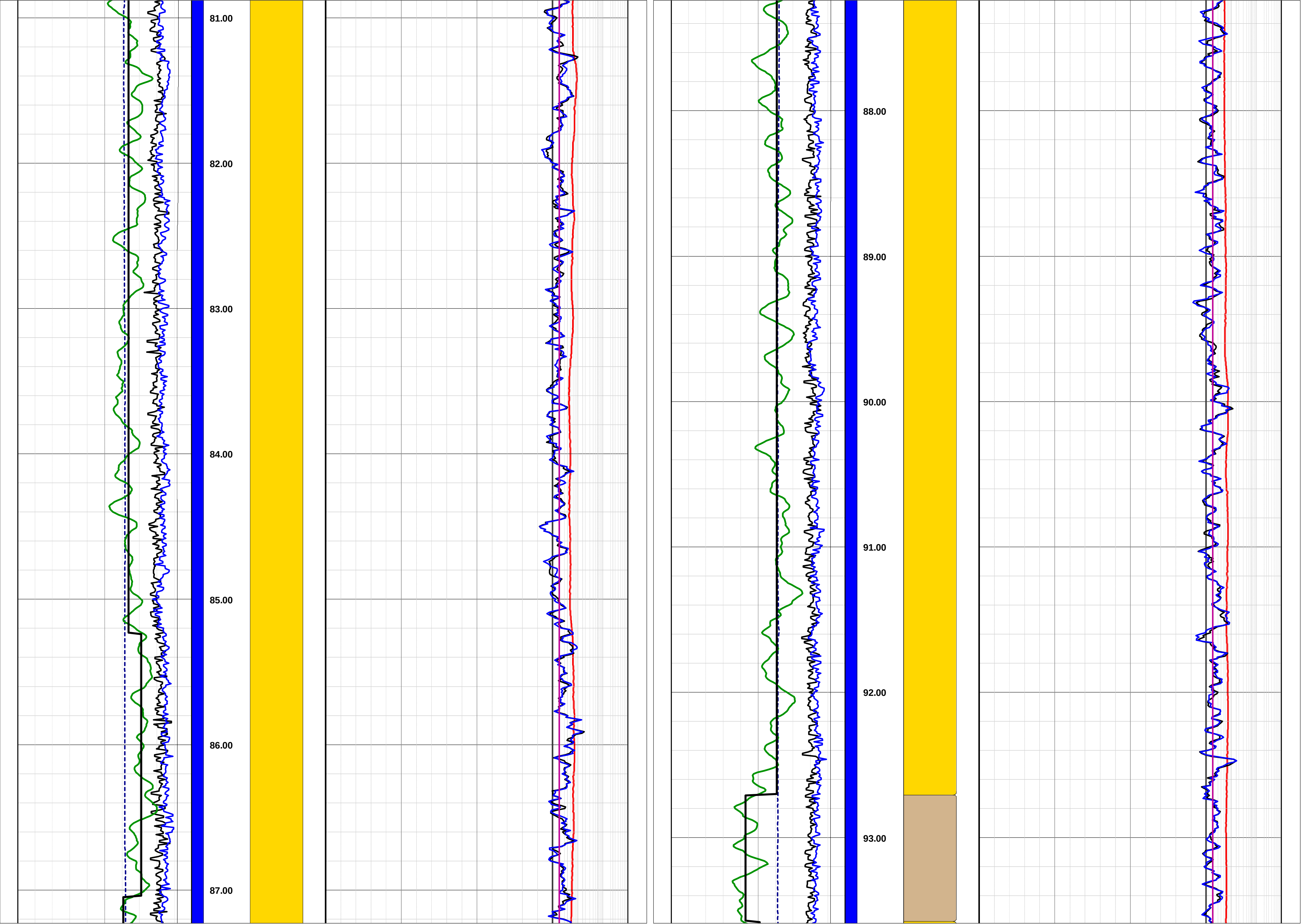
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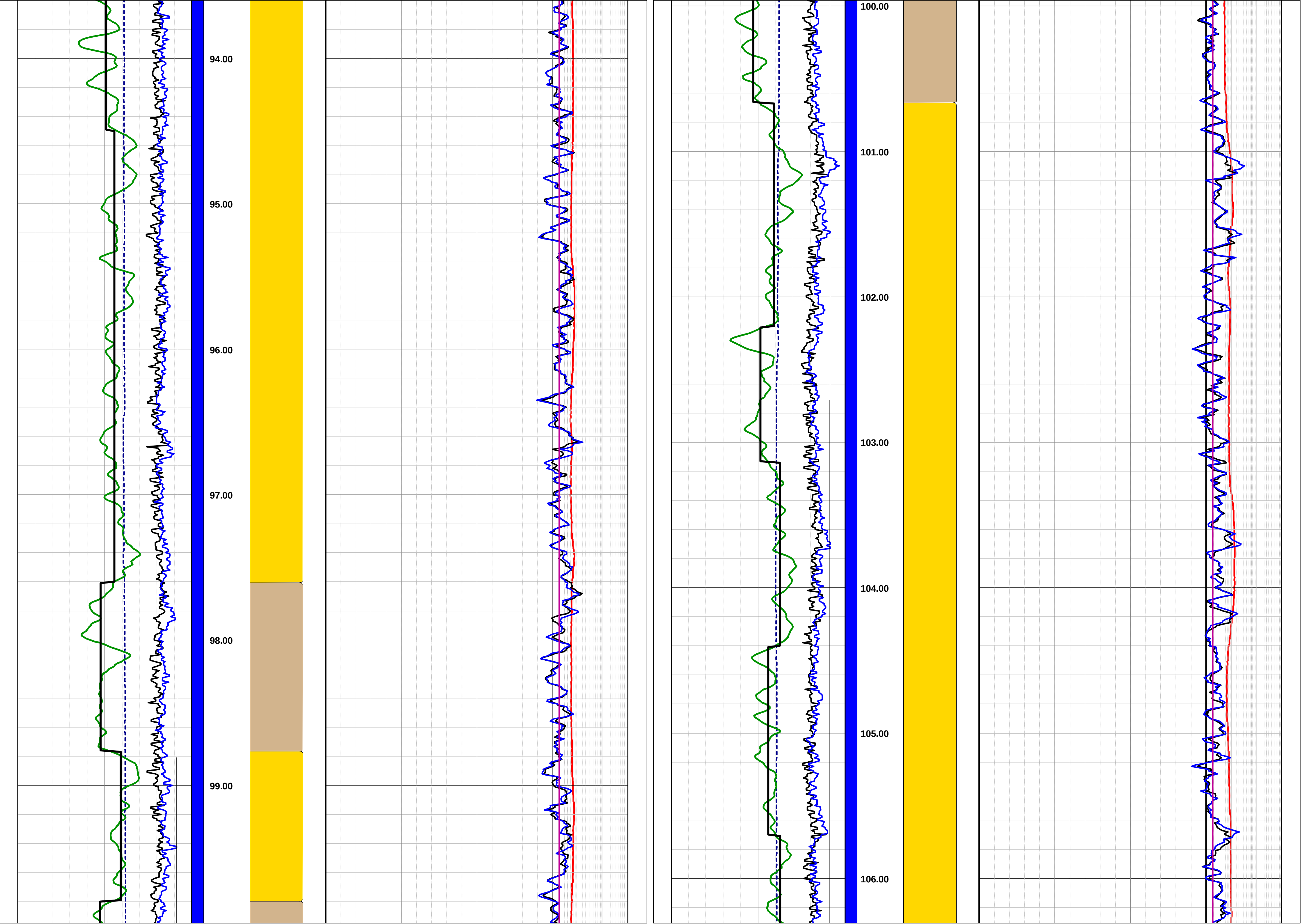
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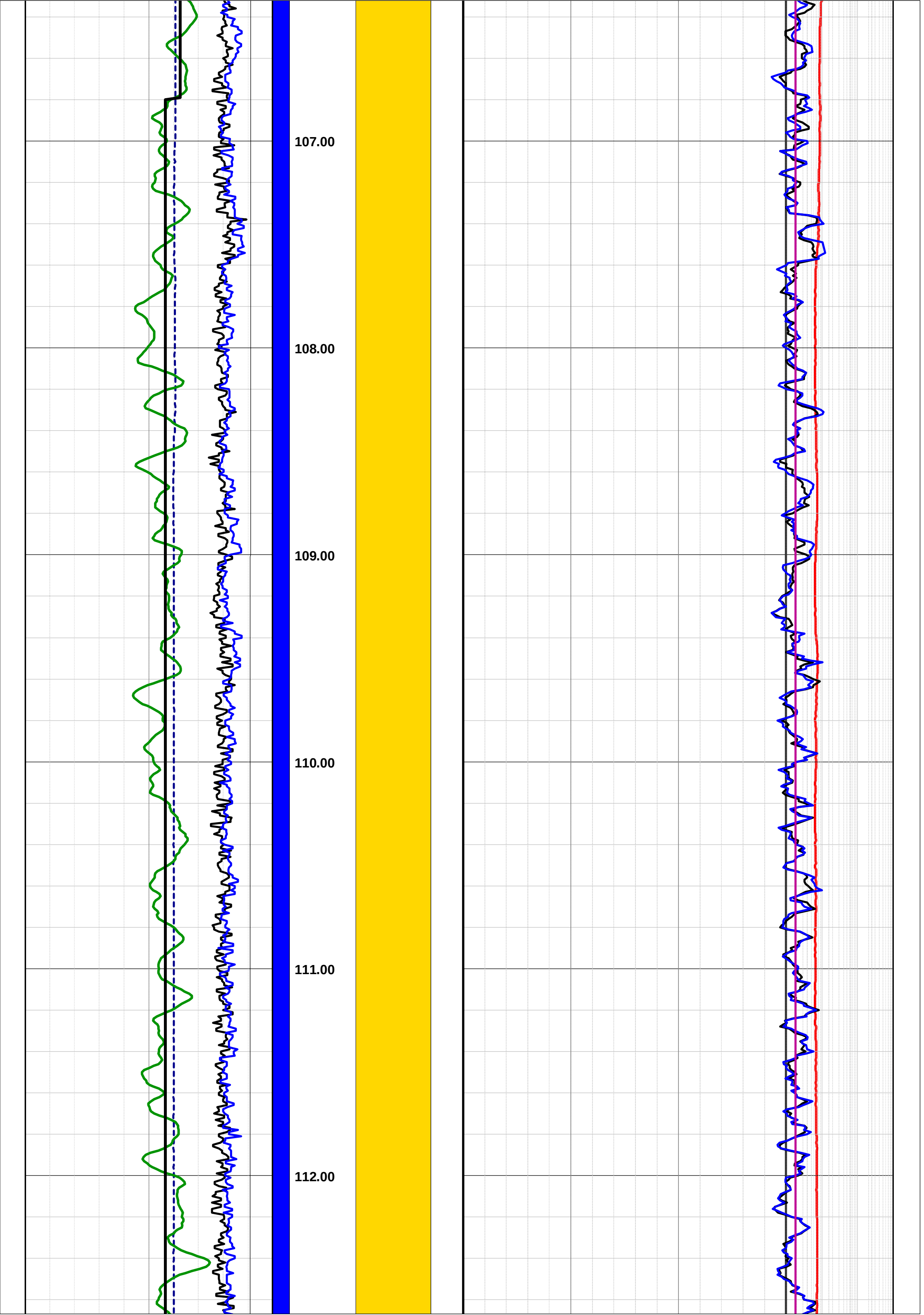
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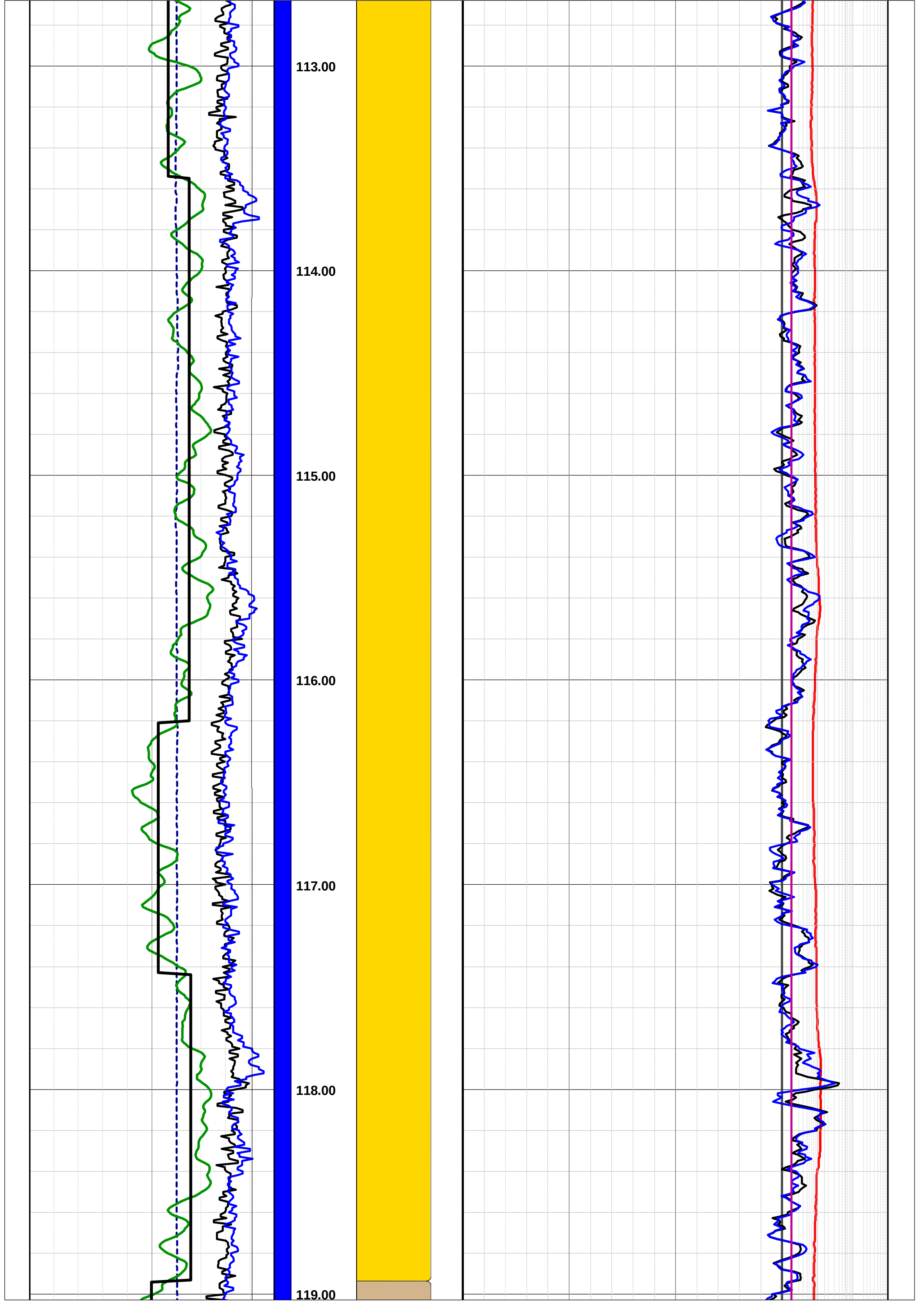
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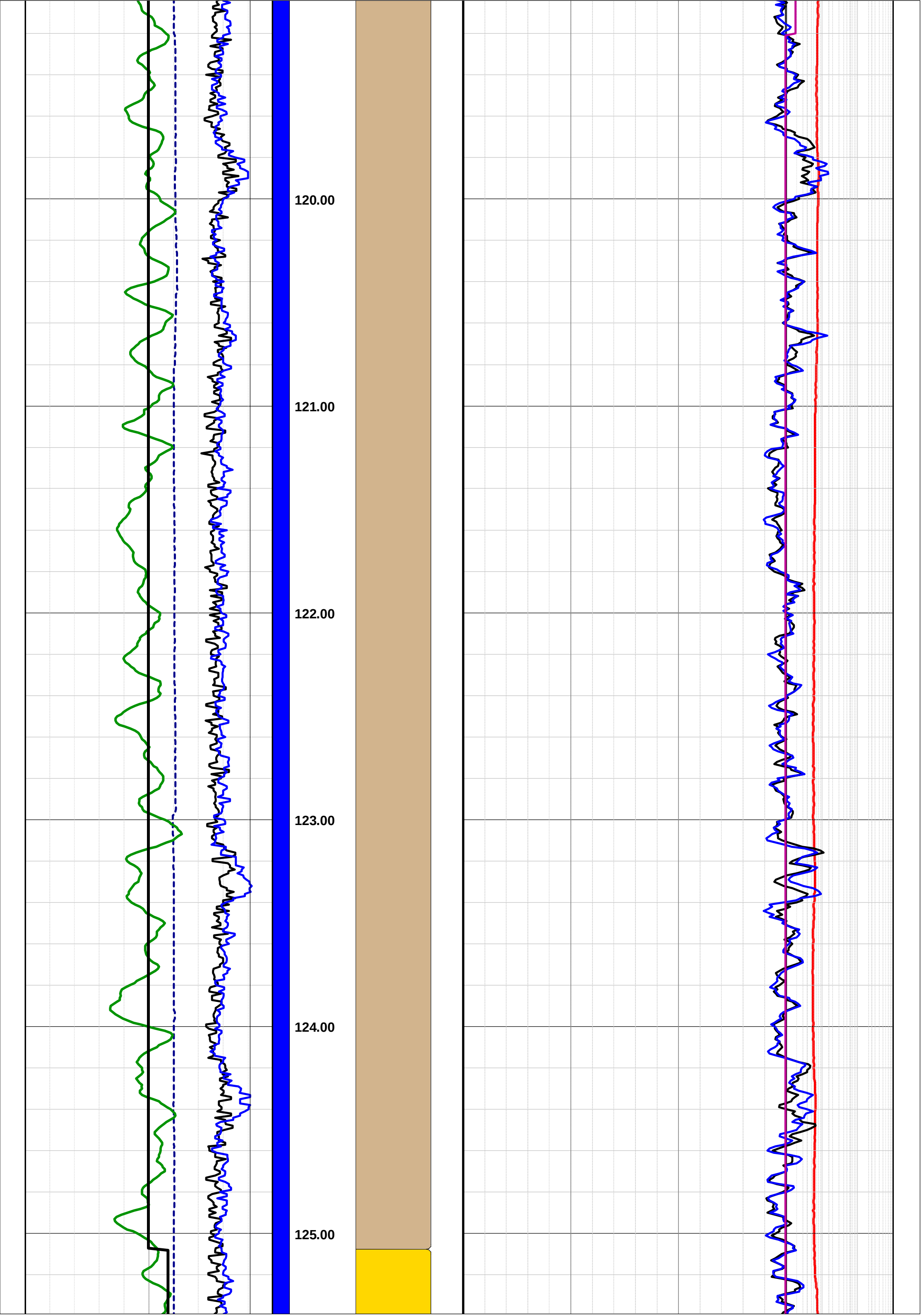
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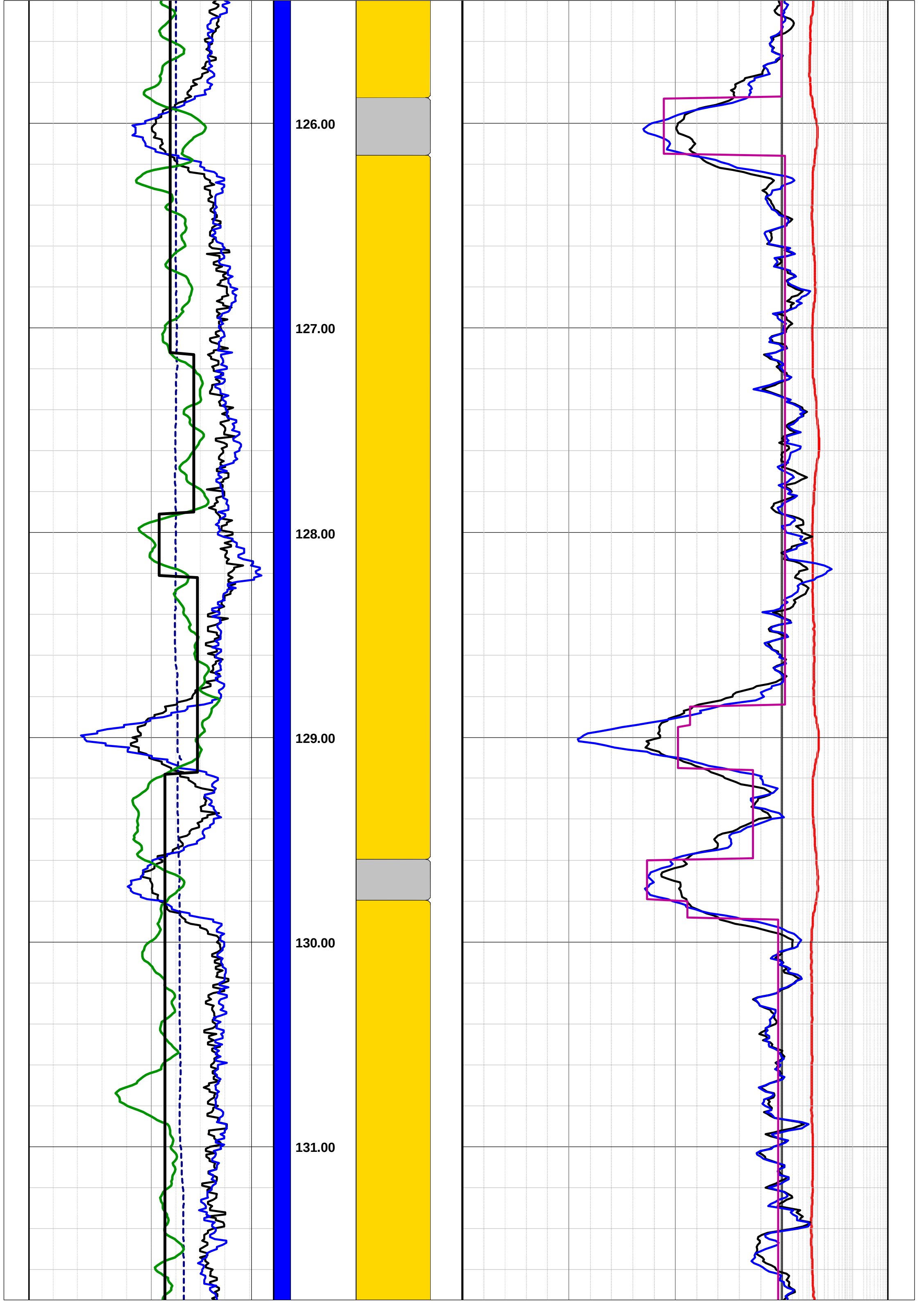
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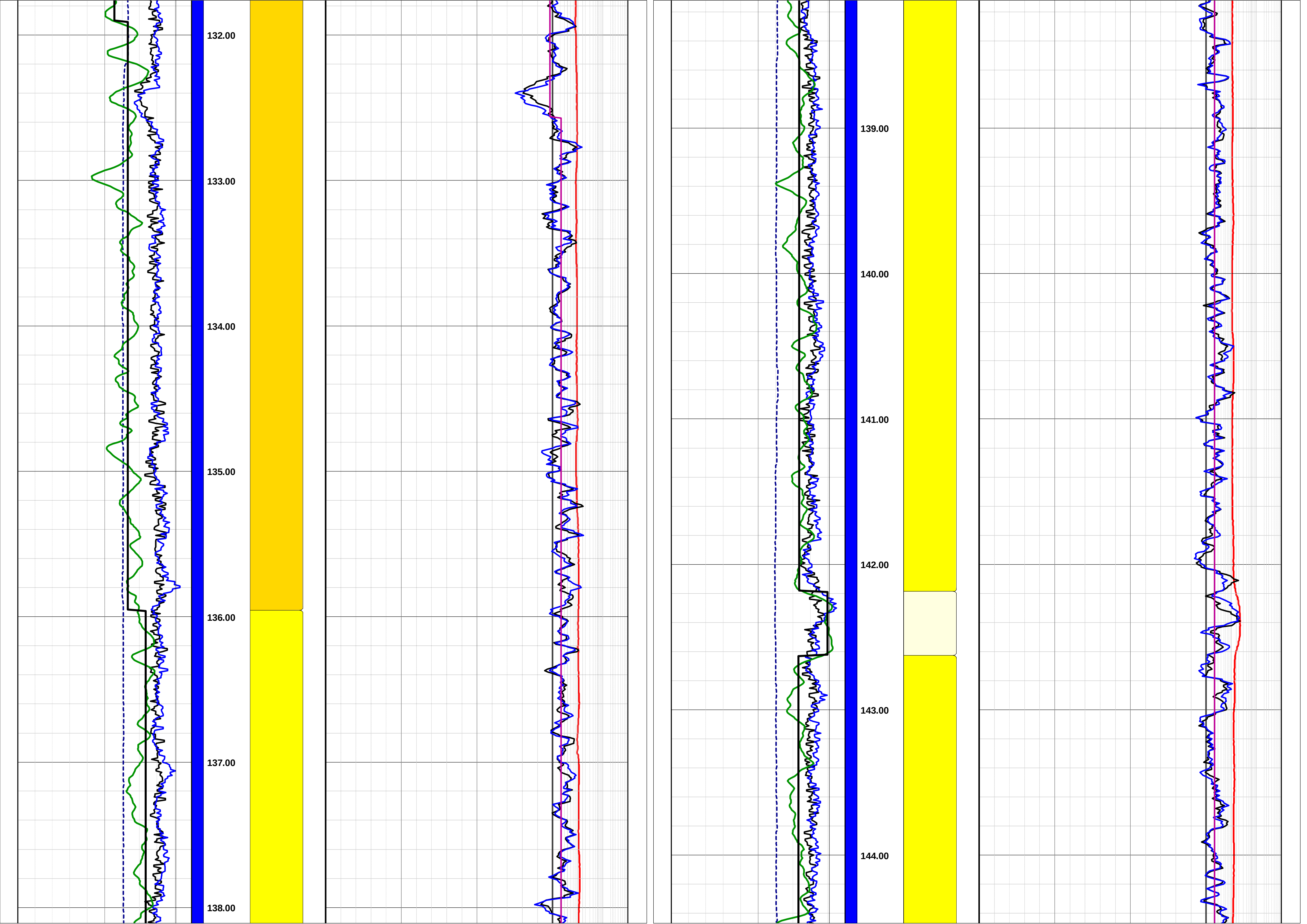
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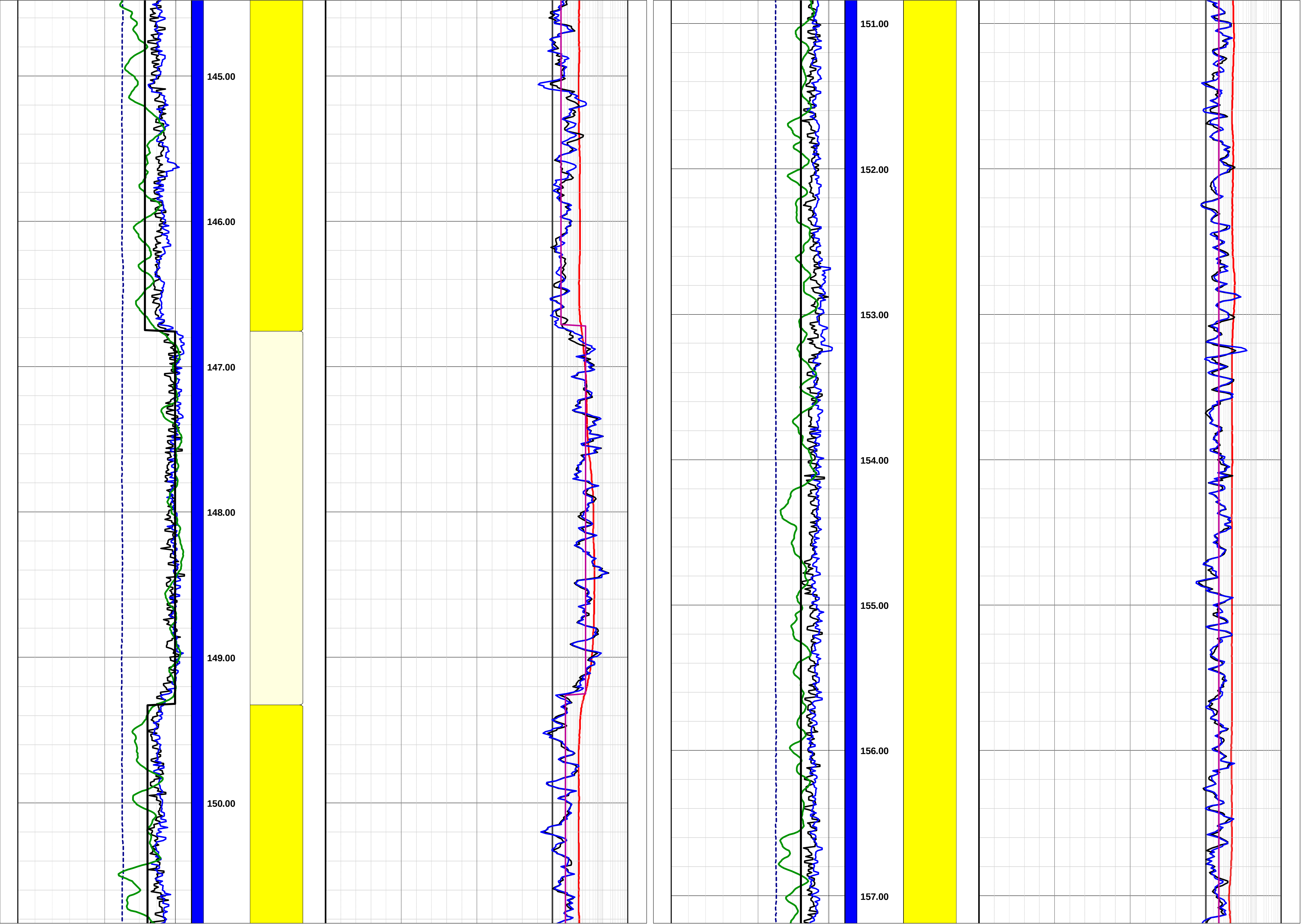
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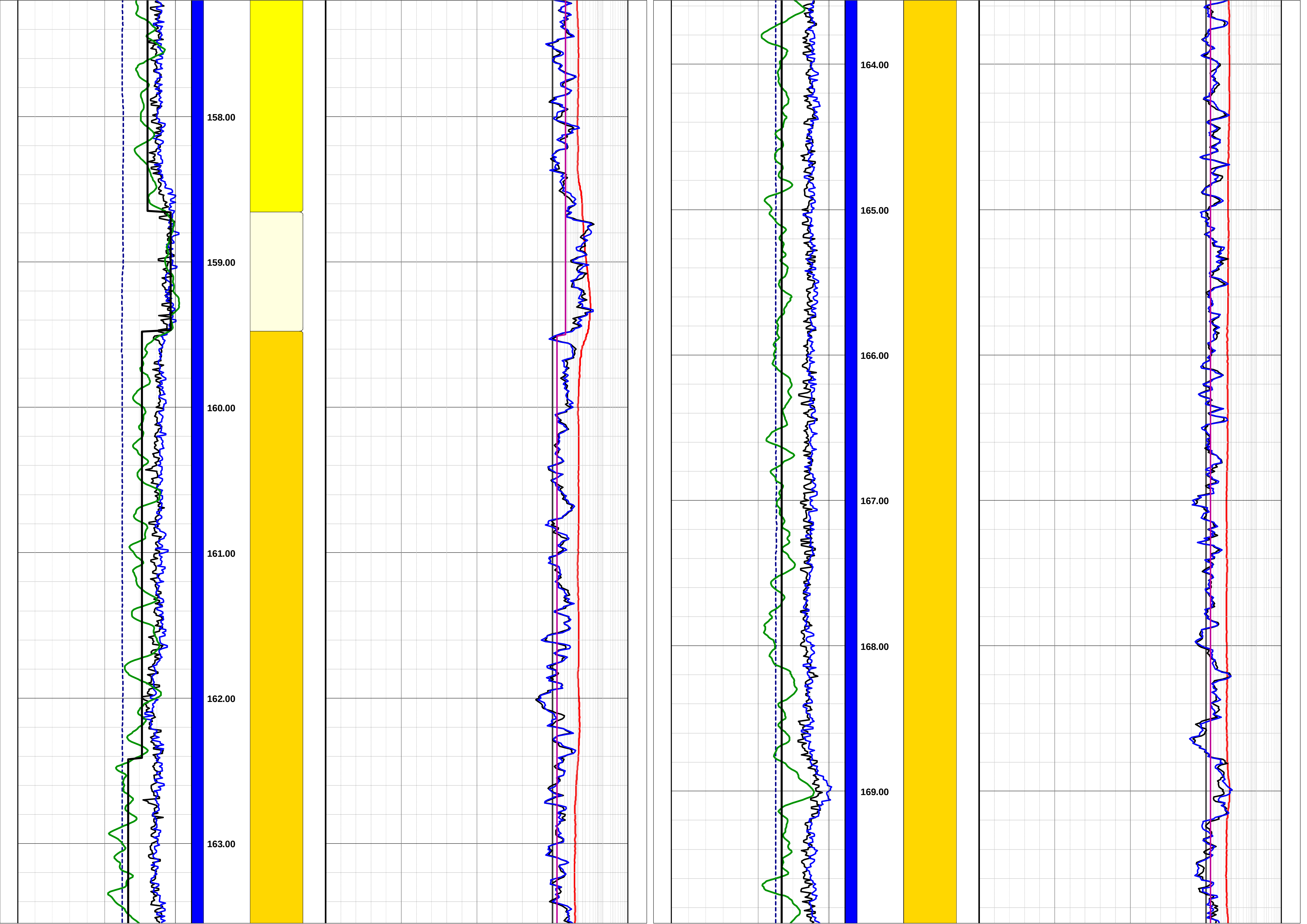
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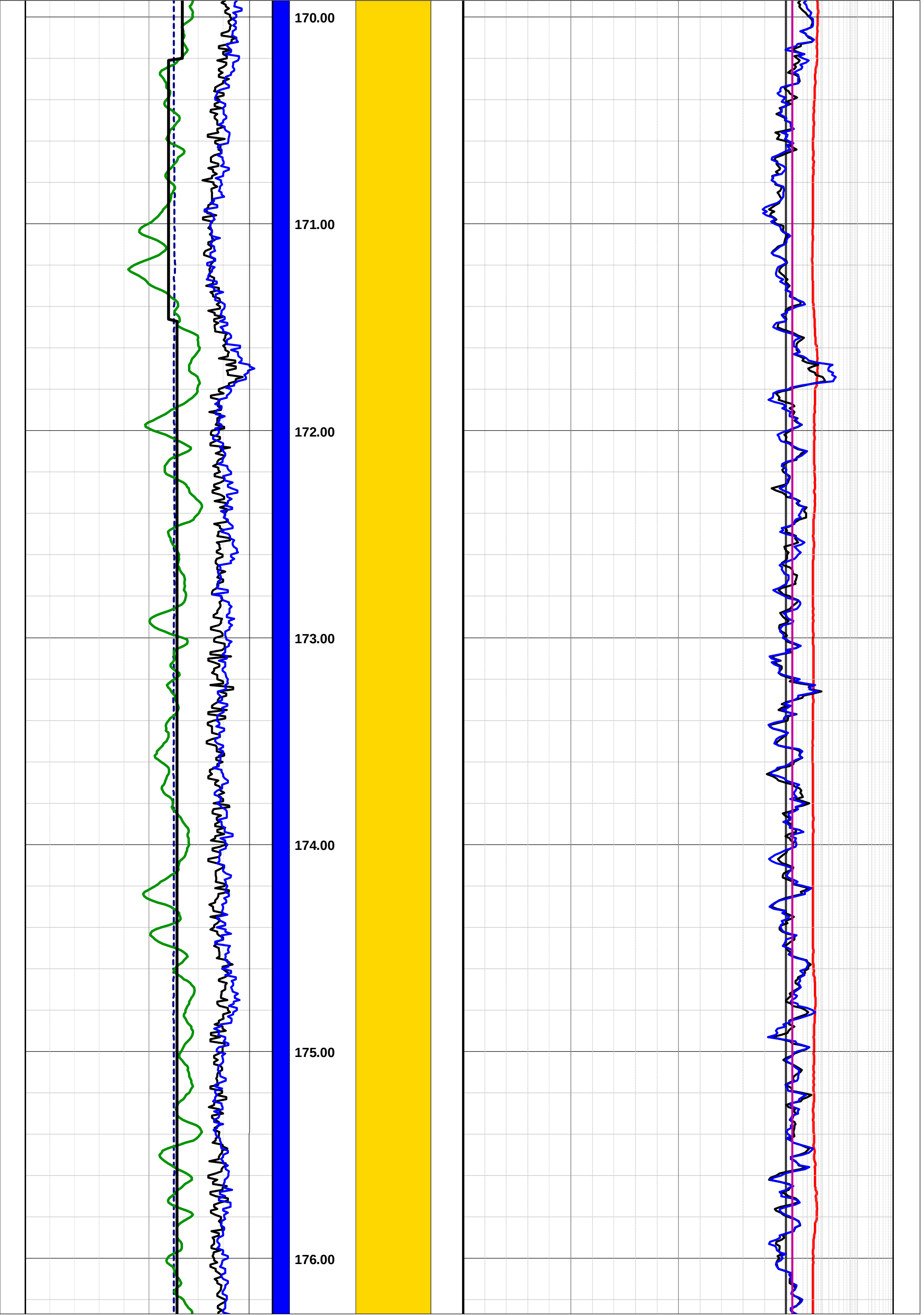
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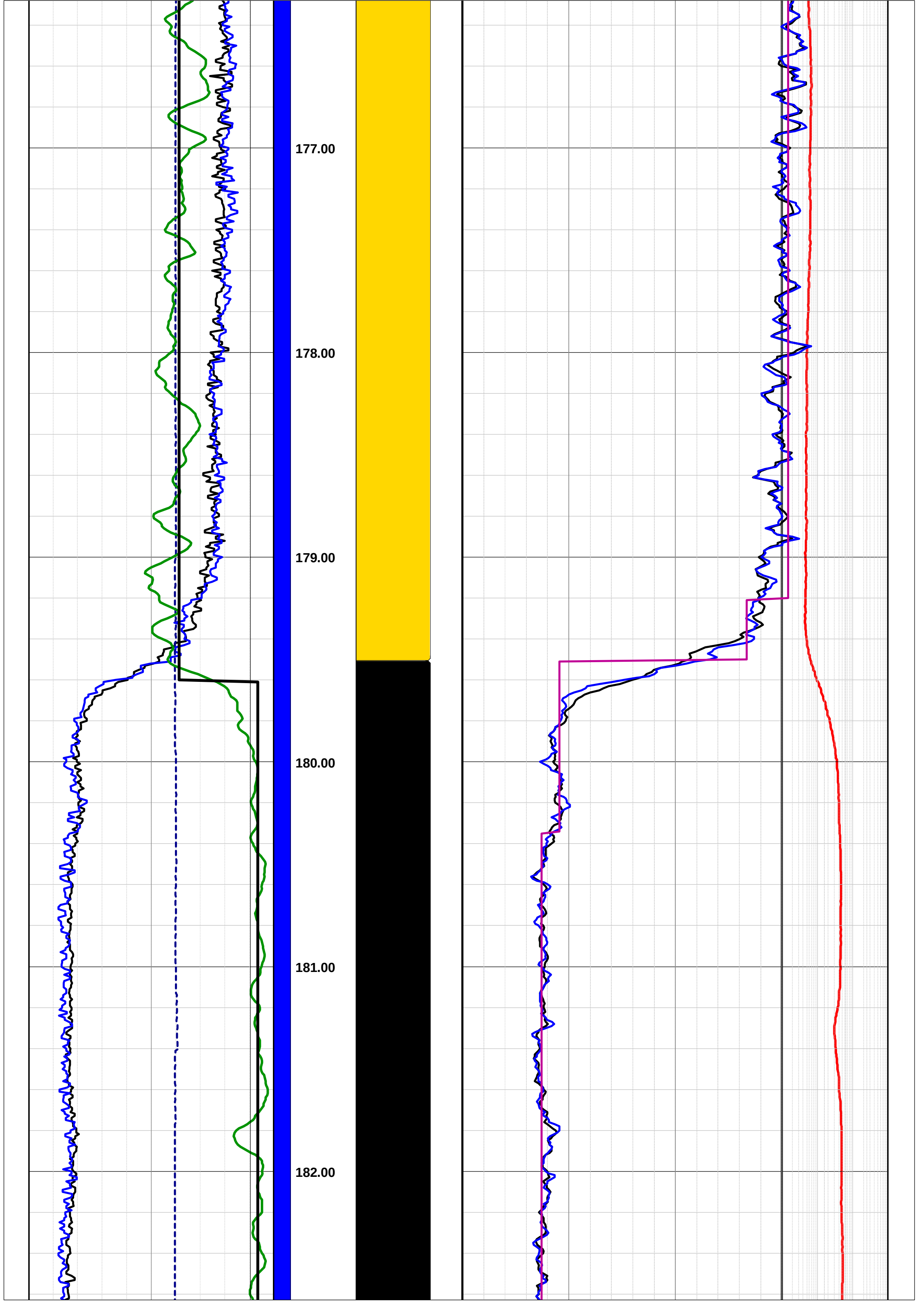
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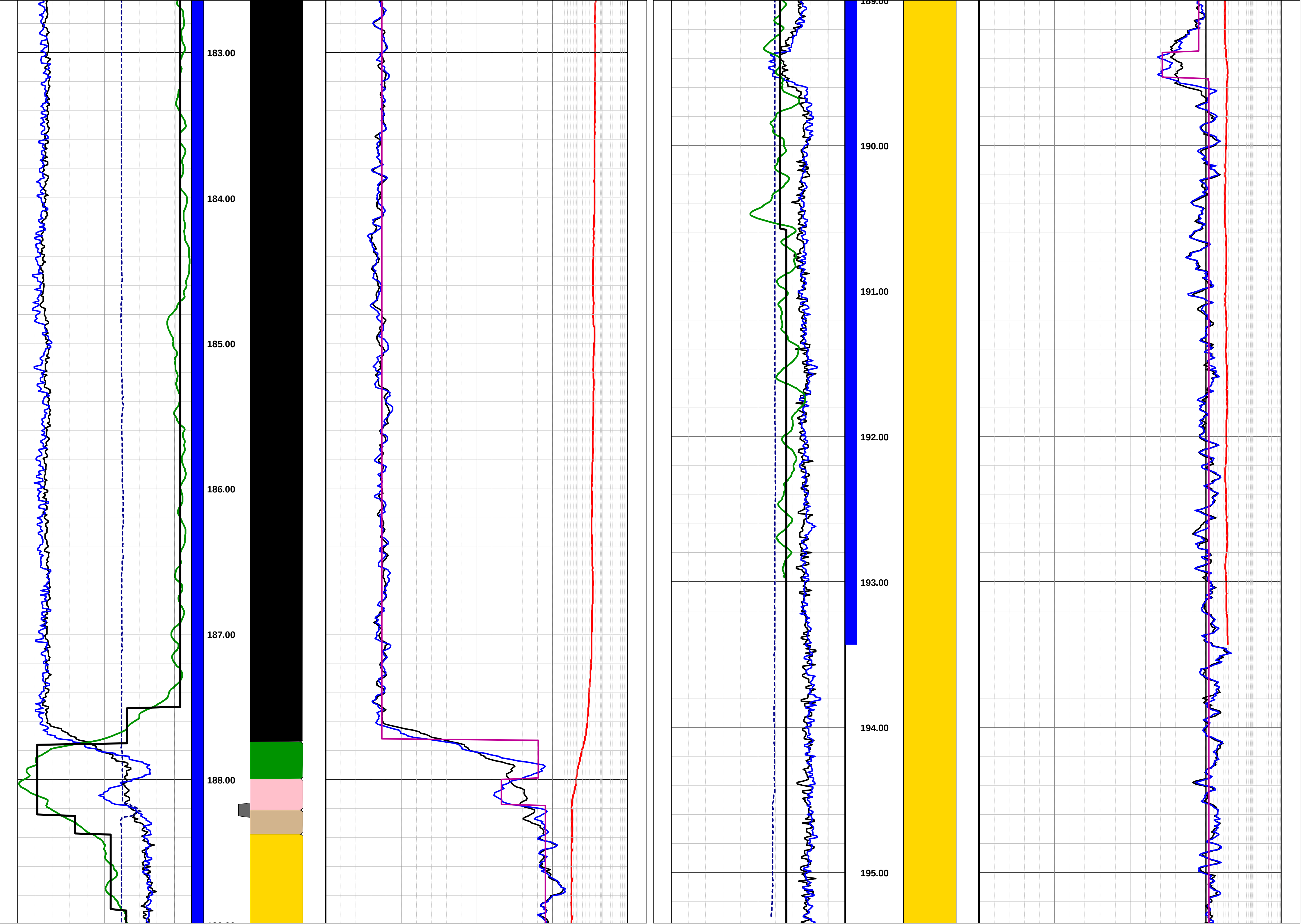
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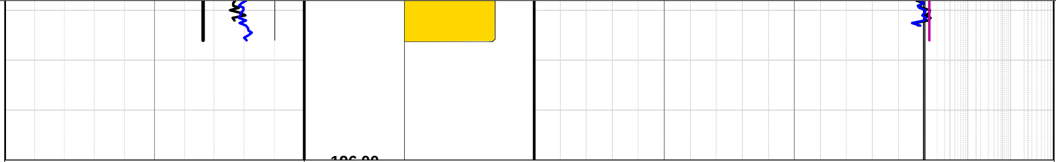


Track	Scale left	Units	Scale right
SANG	0	DEG	20
GAM(NAT)	200	API	0
CALIPER	150	mm	360
WT_FLAG	0		5
CASING			
DEN(ER)	1	g/cc	3
DEN(SS)	1	g/cc	3
DATA_FLAG	5		0
LITHOLOGY			
DEN(COD)	1	g/cc	3
DEN(LS)	1	g/cc	3
Depth		1m:20m	
COKED_COAL			
RES(SG)	1	OHM-M	1000

DEPTH SCALE 1:20

LITHOLOGY LEGEND	
CO - Coal	S3 - Sandstone - fine to medium grained
CF - Inferior Coal	S4 - Sandstone - medium grained
S1 - Sandstone - very fine grained	TF - TUFF
S2 - Sandstone - fine grained	CY - Claystone

COMPANY	BMA	**LOCATION**	PB19BWM01P
WELL	PB19BWM01P	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

PB19BWM01P

QUICKLOOK LITHOLOGY LOG

VWP19BWM01

MPC KINETIC

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	VWP19BWM01	**LOCATION**	VWP19BWM01	**COUNTRY**	AUSTRALIA

LOCATION: VWP19BWM01
FIELD: BLW
STATE: QLD
WELL: VWP19BWM01
COMPANY: BMA

	ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM		
DRILLING MEASURED FROM	KB	1.
PERMANENT DATUM	DF	2.
PERMANENT DATUM ELEVATION	GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	02-12-2019			RECORDED BY	KAR		
TIME	12-55			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V031		
DEPTH-DRILLER	270m			RIG NUMBER			
DEPTH-LOGGER	192.00m			TOOL TYPE	9239C		
BIT SIZE	146mm			TOOL SERIAL NO.	2807		
CASING TYPE	PVC			EASTING	689184		
CASING ID	200mm			NORTHING	7376892		
CASING BOTTOM	15m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09774			FEET OR METER	M		
WATER LEVEL	14.7m			SOURCE TYPE	CS137	SOURCE ID	CZ3498

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

- **CO - Coal**
- **S2 - Sandstone - fine grained**
- **CF - Inferior Coal**
- **S3 - Sandstone - fine to medium grained**
- **ST - SILTSTONE**
- **S4 - Sandstone - medium grained**
- **S1 - Sandstone - very fine grained**

MNEMONICS

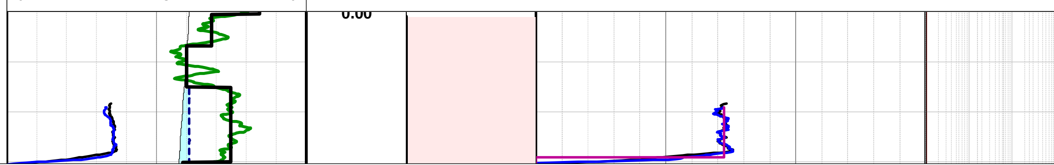
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

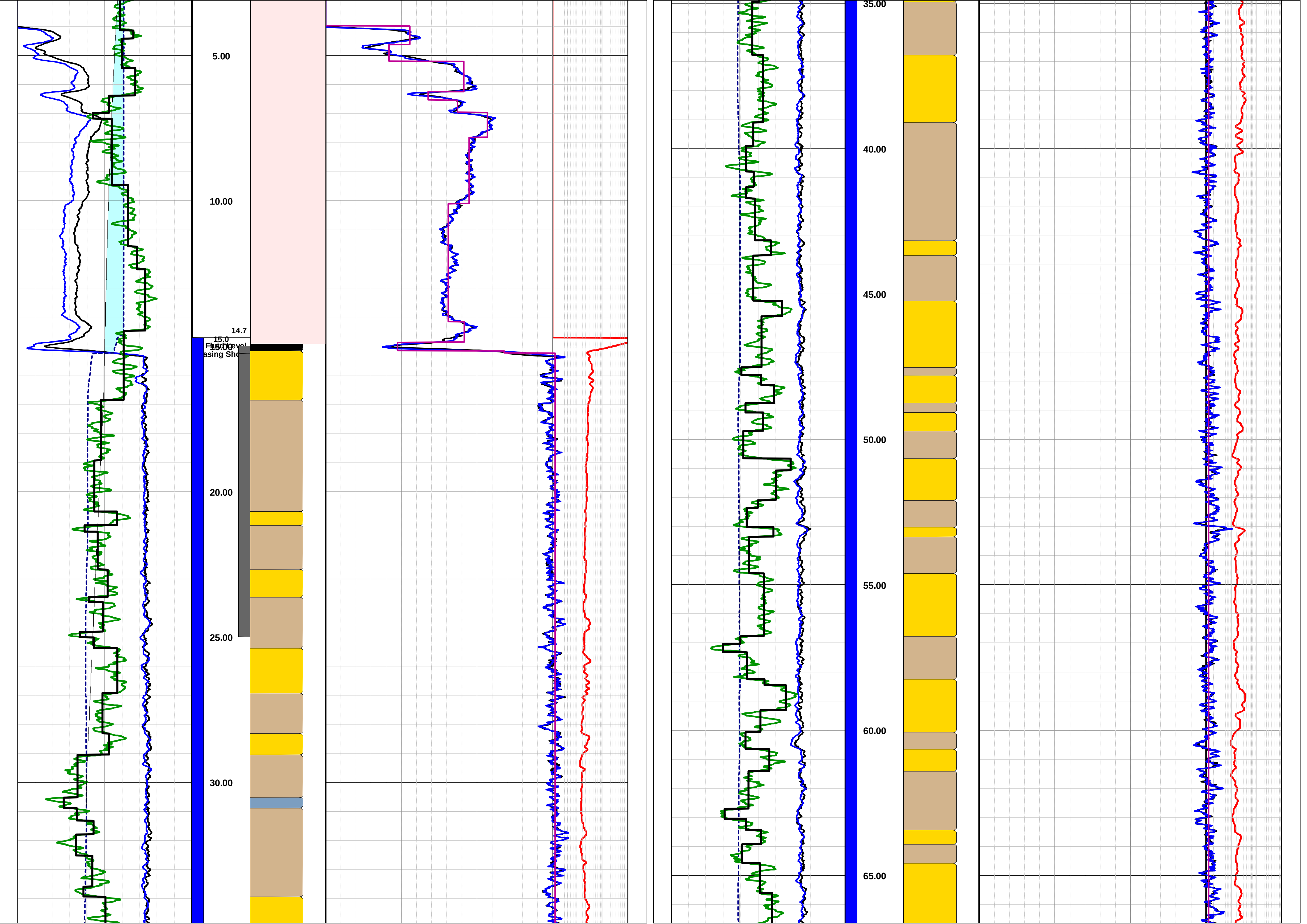
IMPORTANT NOTE

The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

Track	Left scale	Units	Right scale
DEN(LS)	1	g/cc	3
DEN(SS)	1	g/cc	3
CALIPER	50	mm	300
GAM(NAT)	200	API	0
NOM_BIT	50	mm	300
SANG	0	DEG	20
Depth		1m:100m	
DATA_FLAG			
WT_FLAG			
COKED_COAL			
LITHOLOGY			
CASING			
RES(SG)	1	OHM-M	1000
DEN(COD)	1	g/cc	3
DEN(ER)	1	g/cc	3





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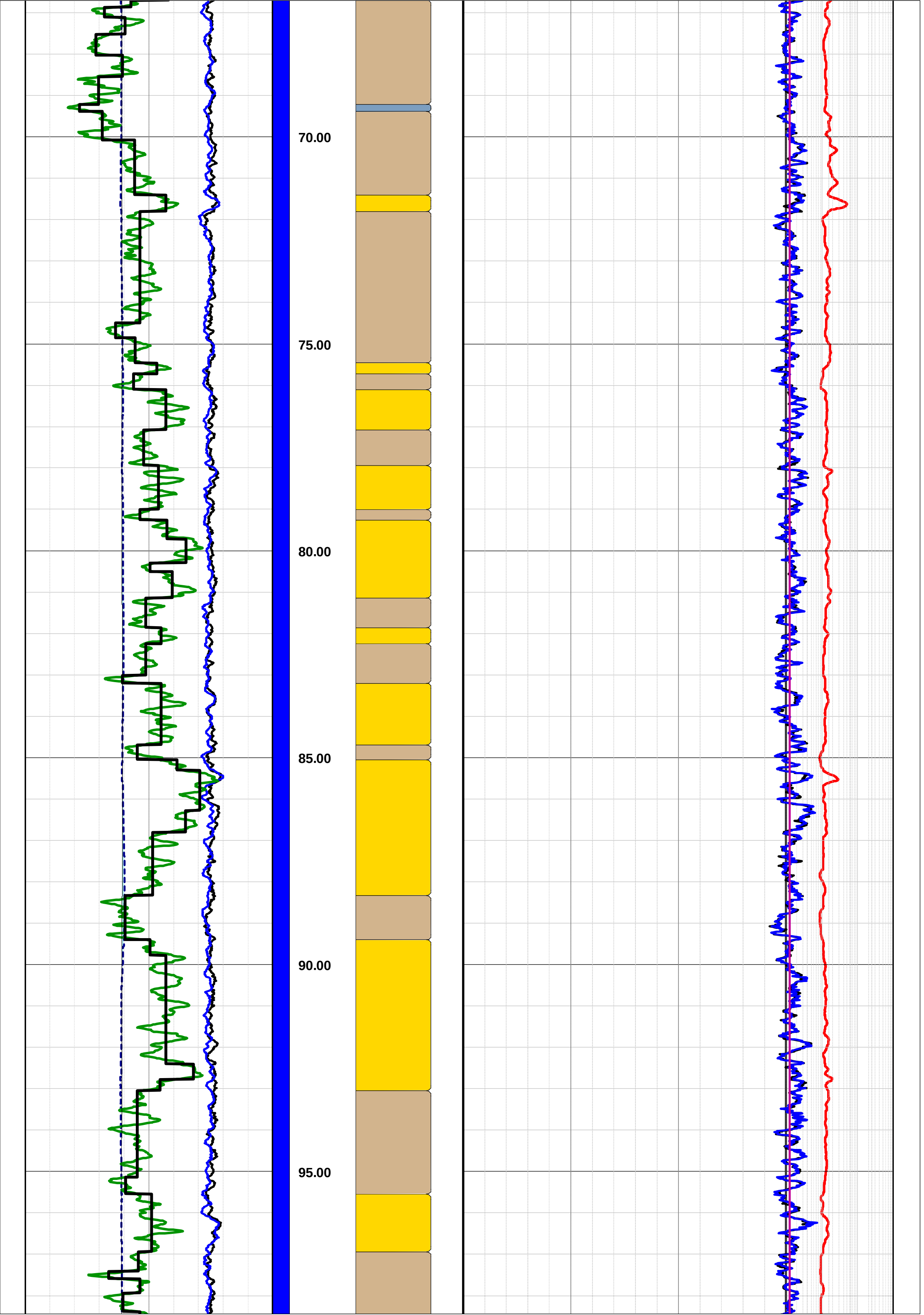
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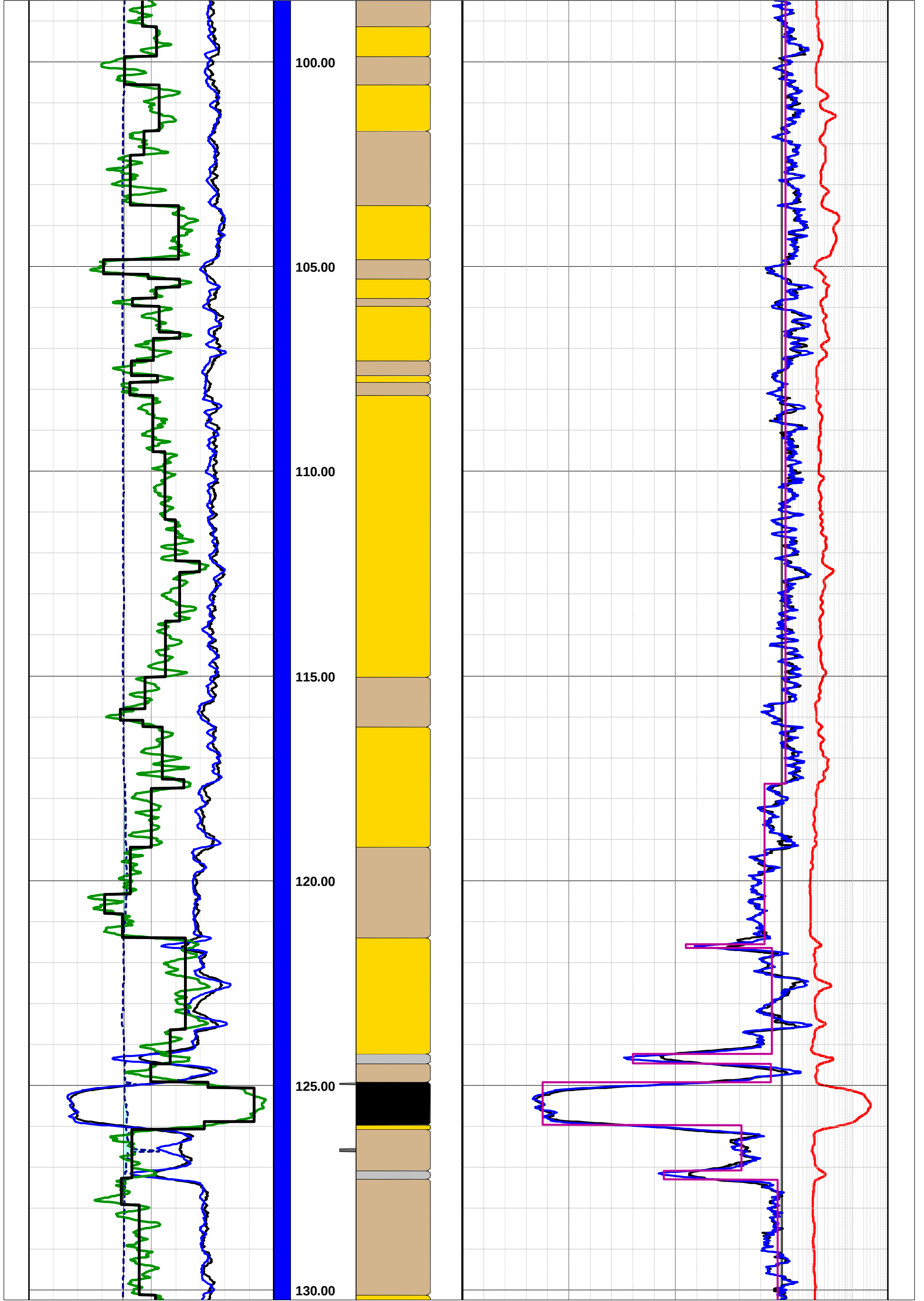
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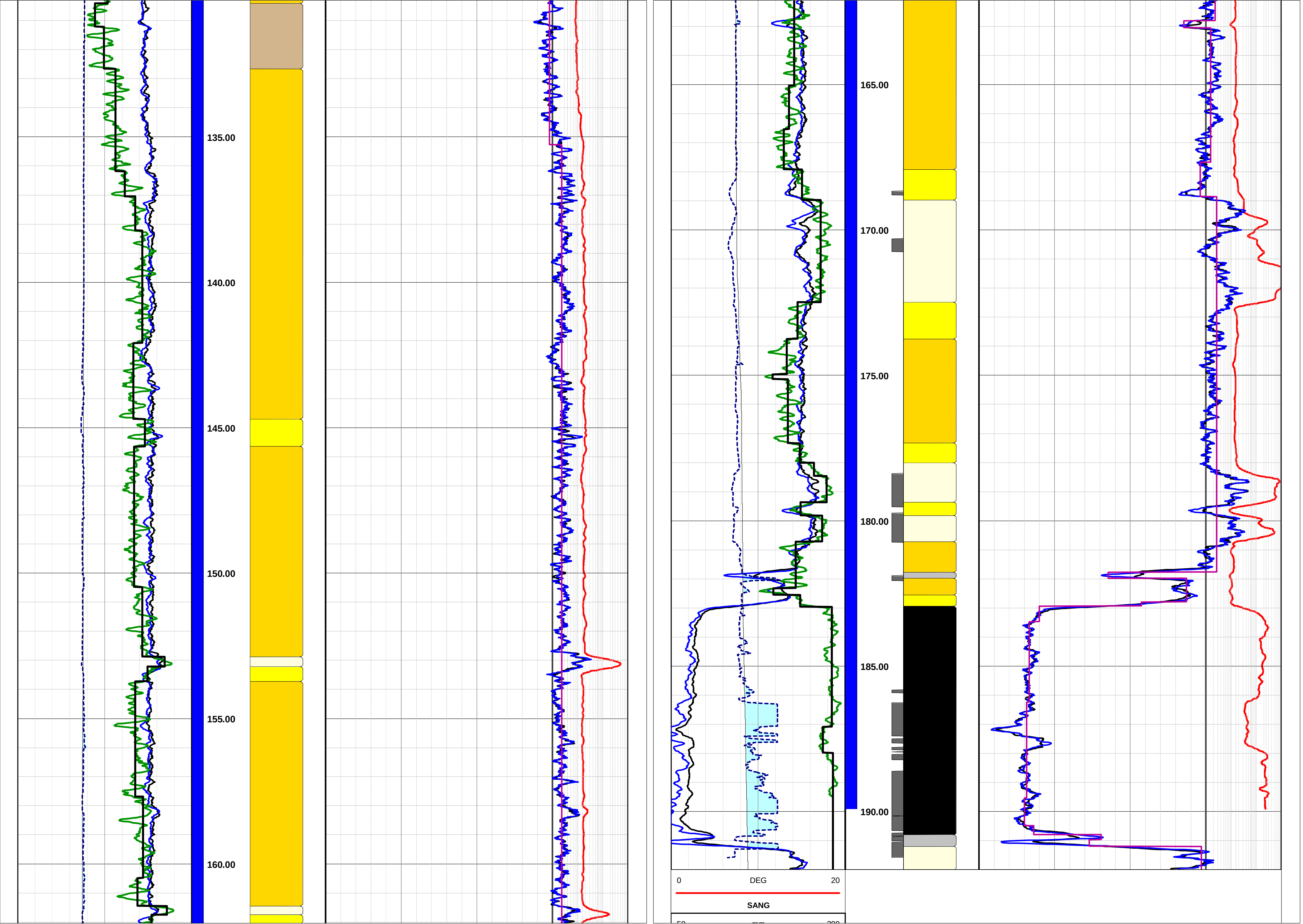
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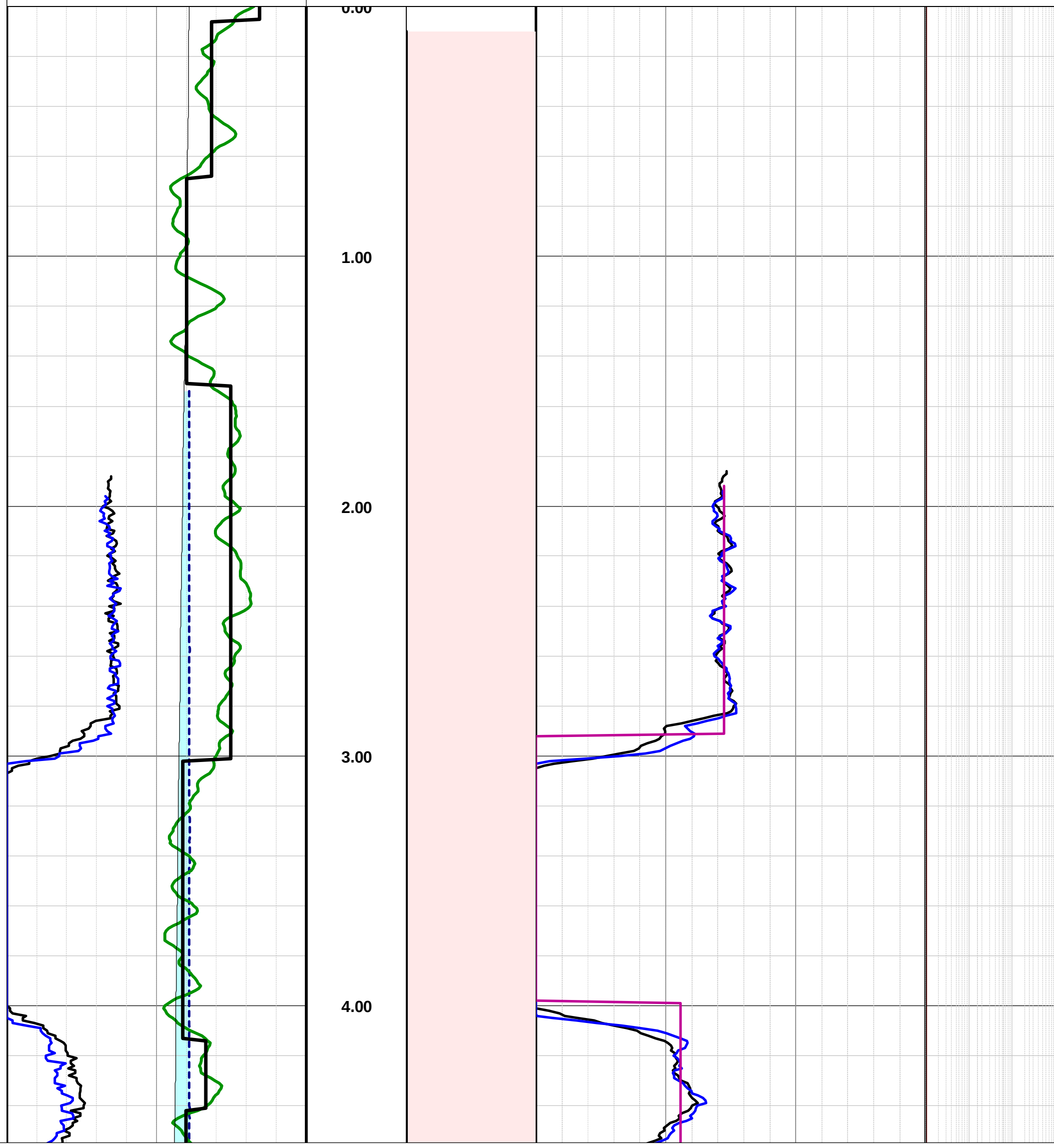
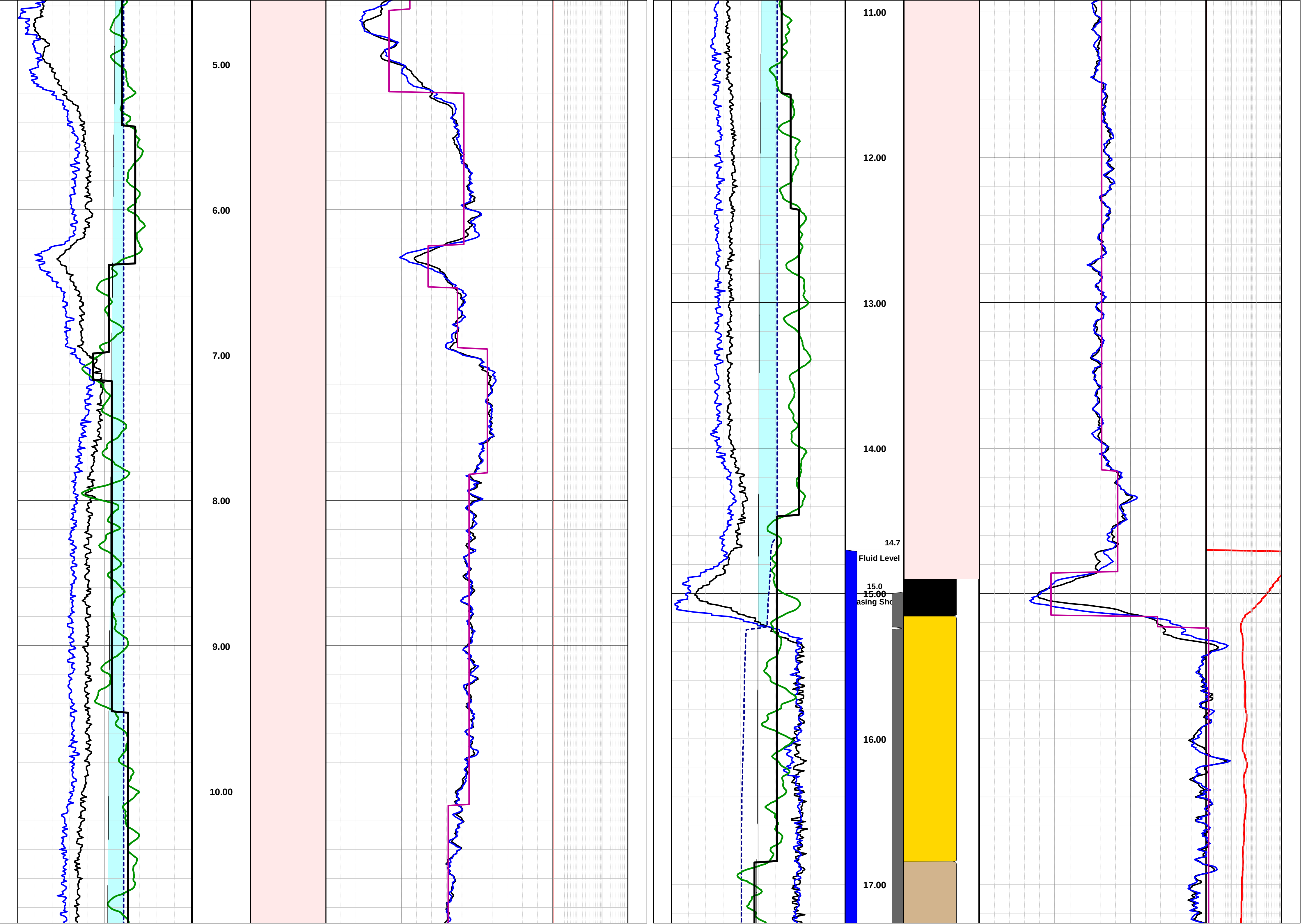
NOM_BIT			
200 API 0 — GAM(NAT)			
50 mm 300 — CALIPER	WT_FLAG	CASING	1 g/cc 3 — DEN(ER)
1 g/cc 3 — DEN(SS)	DATA_FLAG	LITHOLOGY	1 g/cc 3 — DEN(COD)
1 g/cc 3 — DEN(LS)	1m:100m Depth	COKED_COAL	1 OHM-M 1000 — RES(SG)

DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) — 1 g/cc 3	Depth 1m:20m	COKED_COAL	RES(SG) — 1 OHM-M 1000
DEN(SS) — 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) — 1 g/cc 3
CALIPER — 50 mm 300	WT_FLAG 0 5	CASING	DEN(ER) — 1 g/cc 3
GAM(NAT) — 200 API 0			
SANG — 0 DEG 20			

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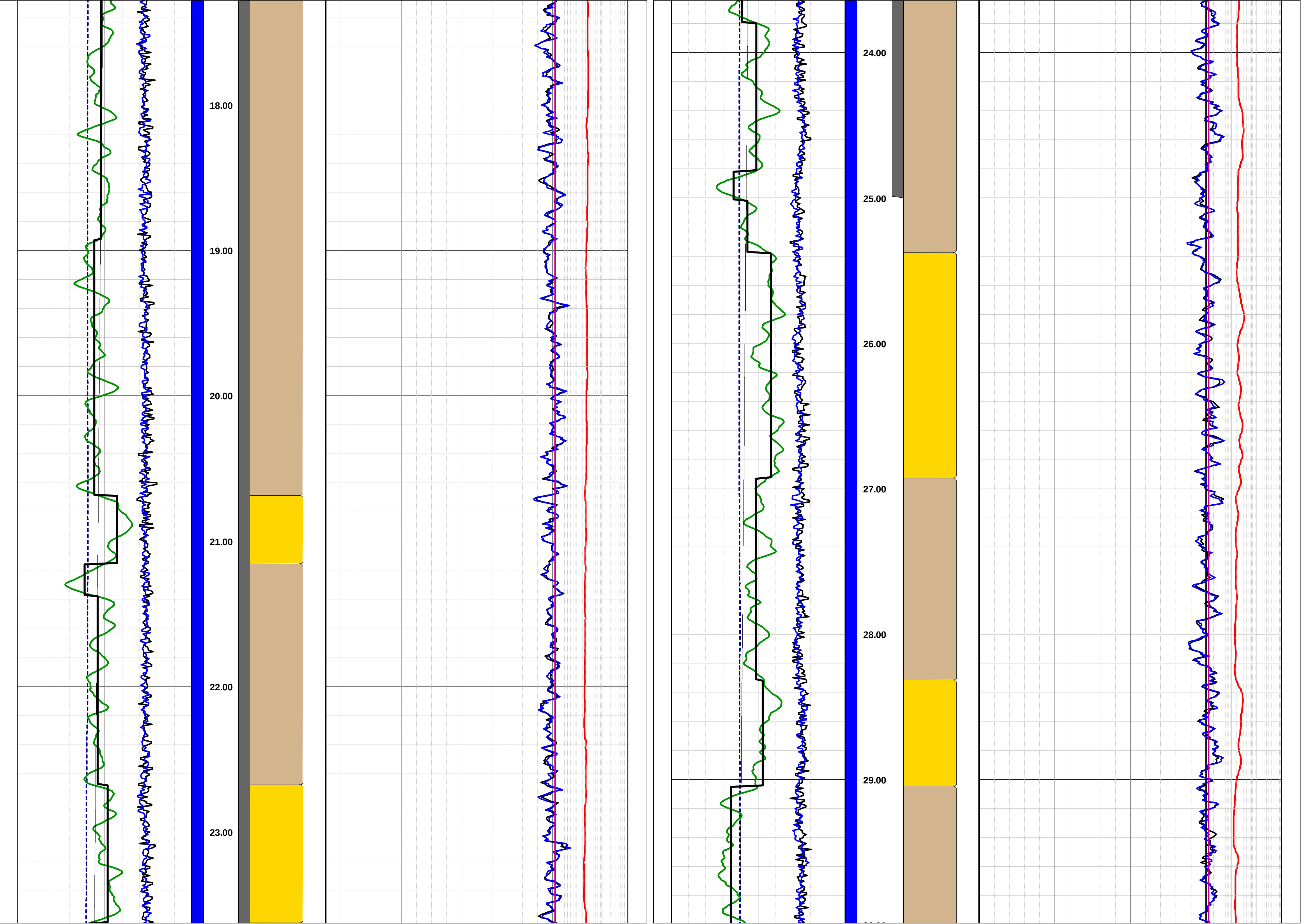
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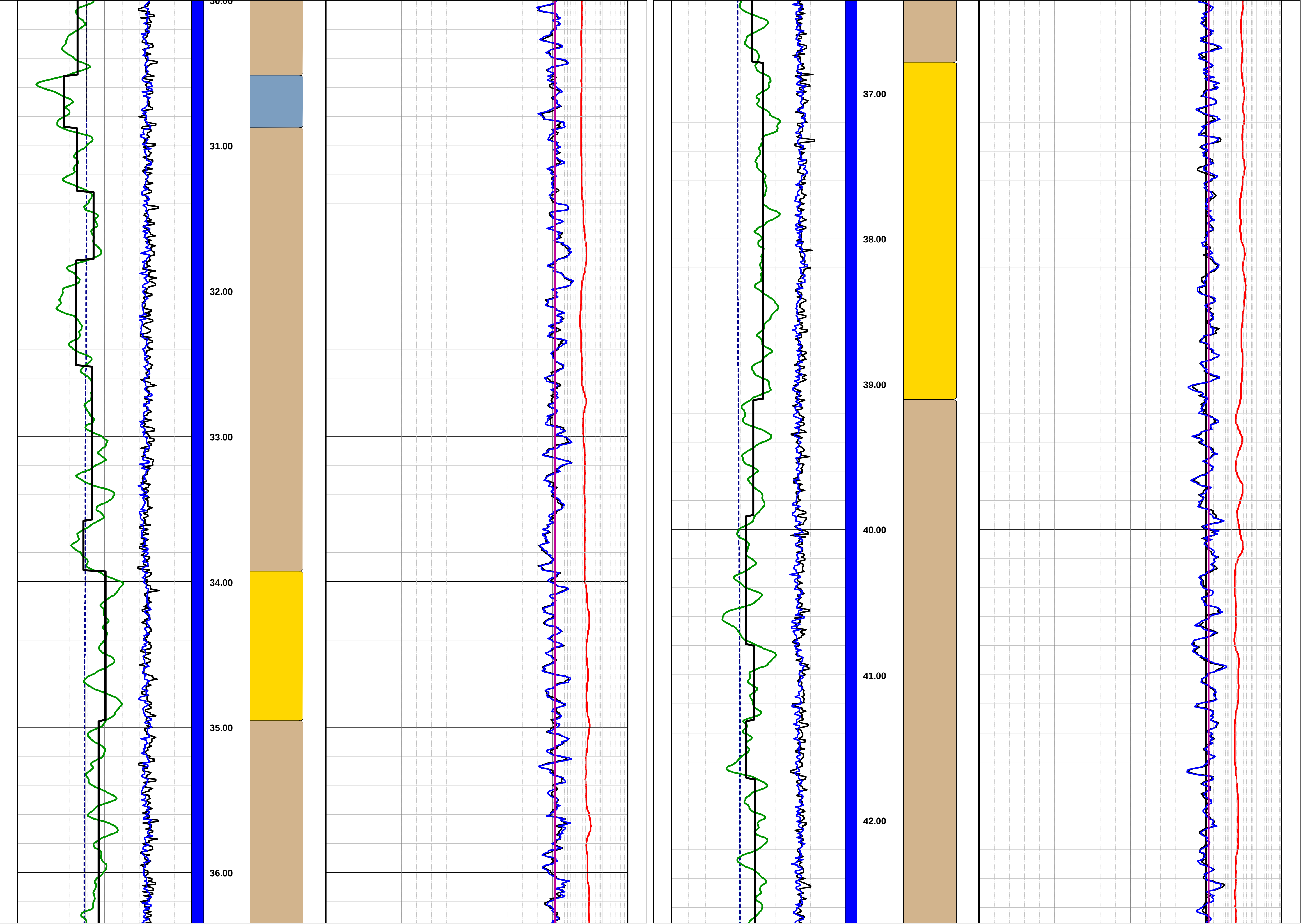
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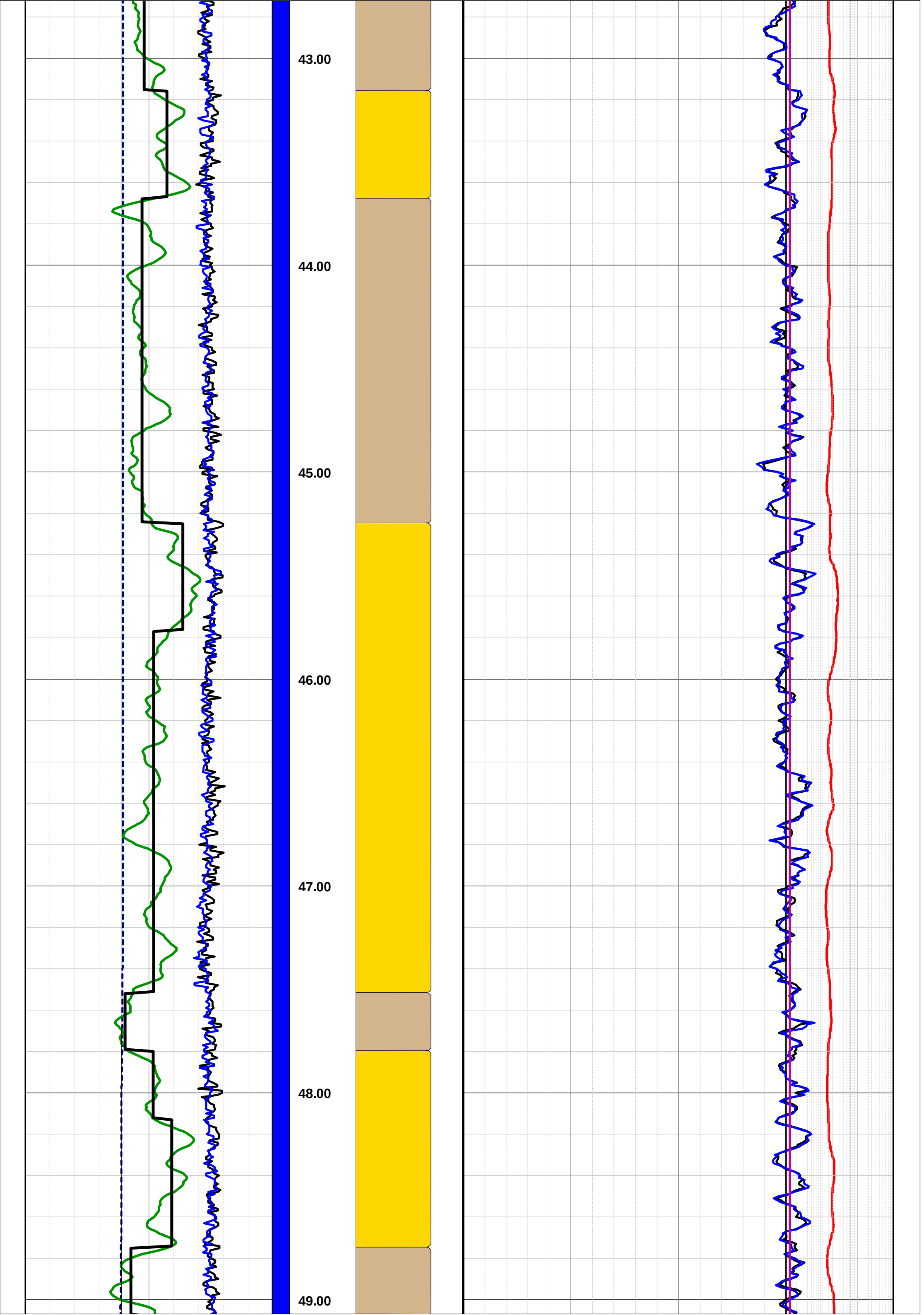
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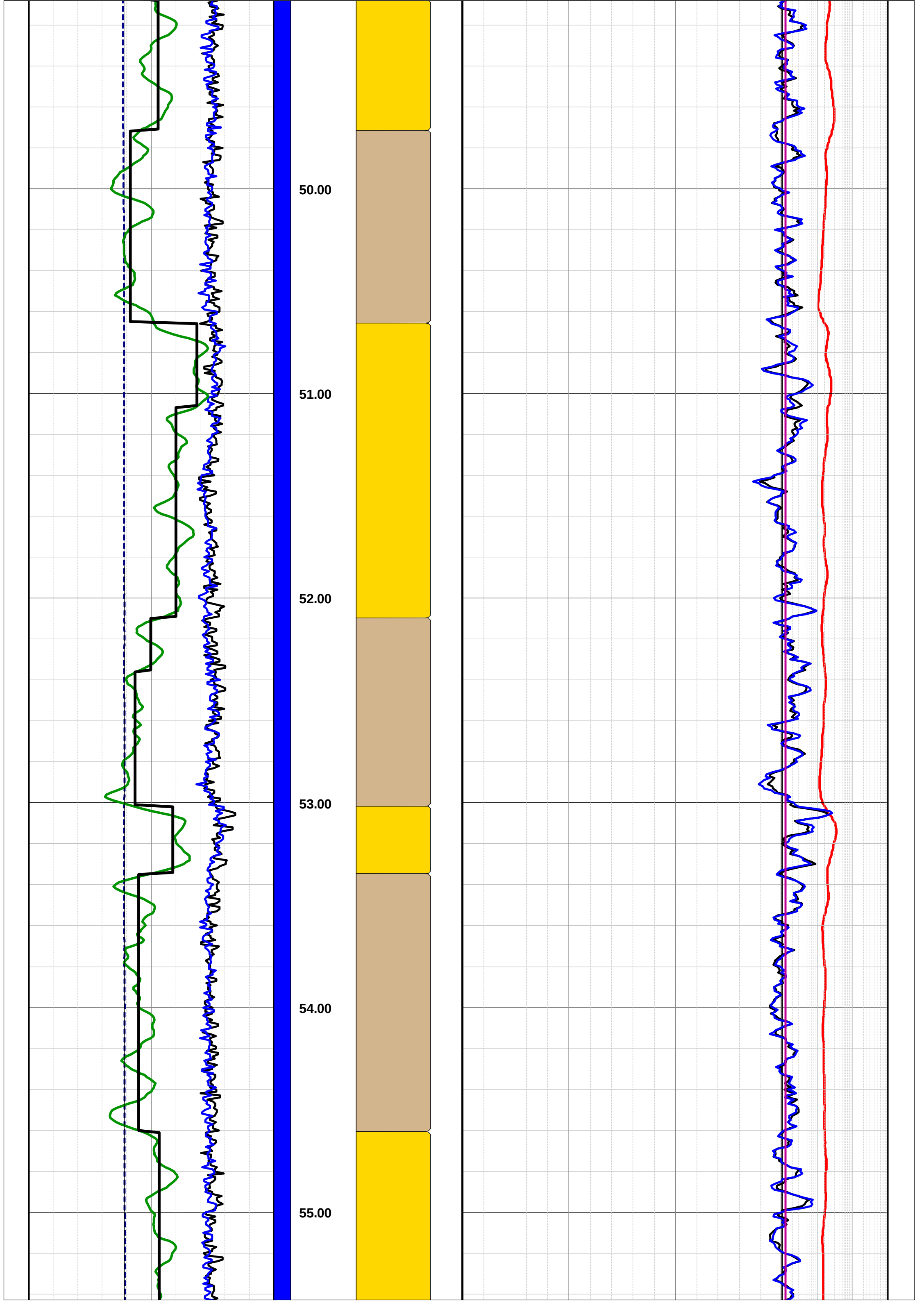
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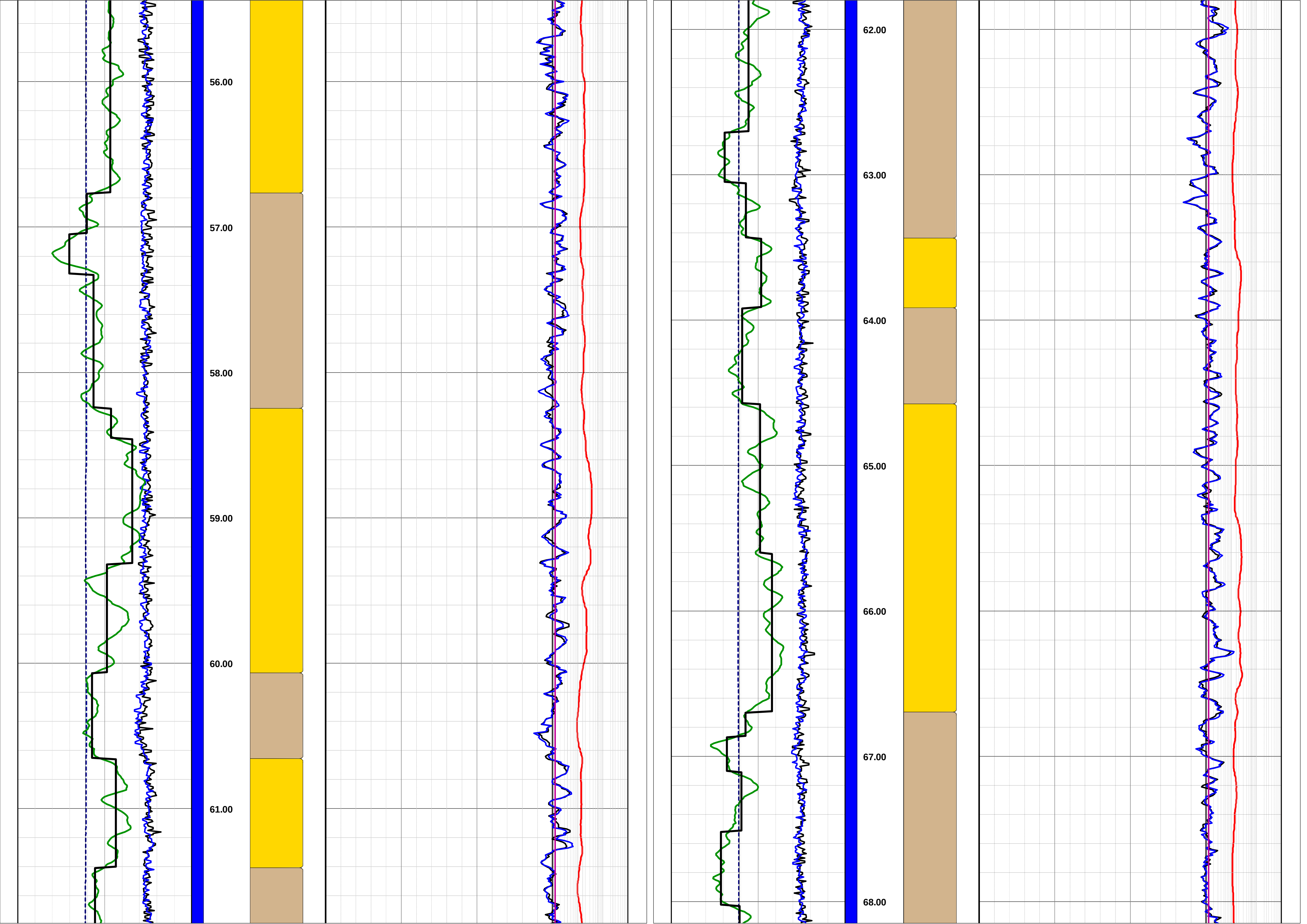
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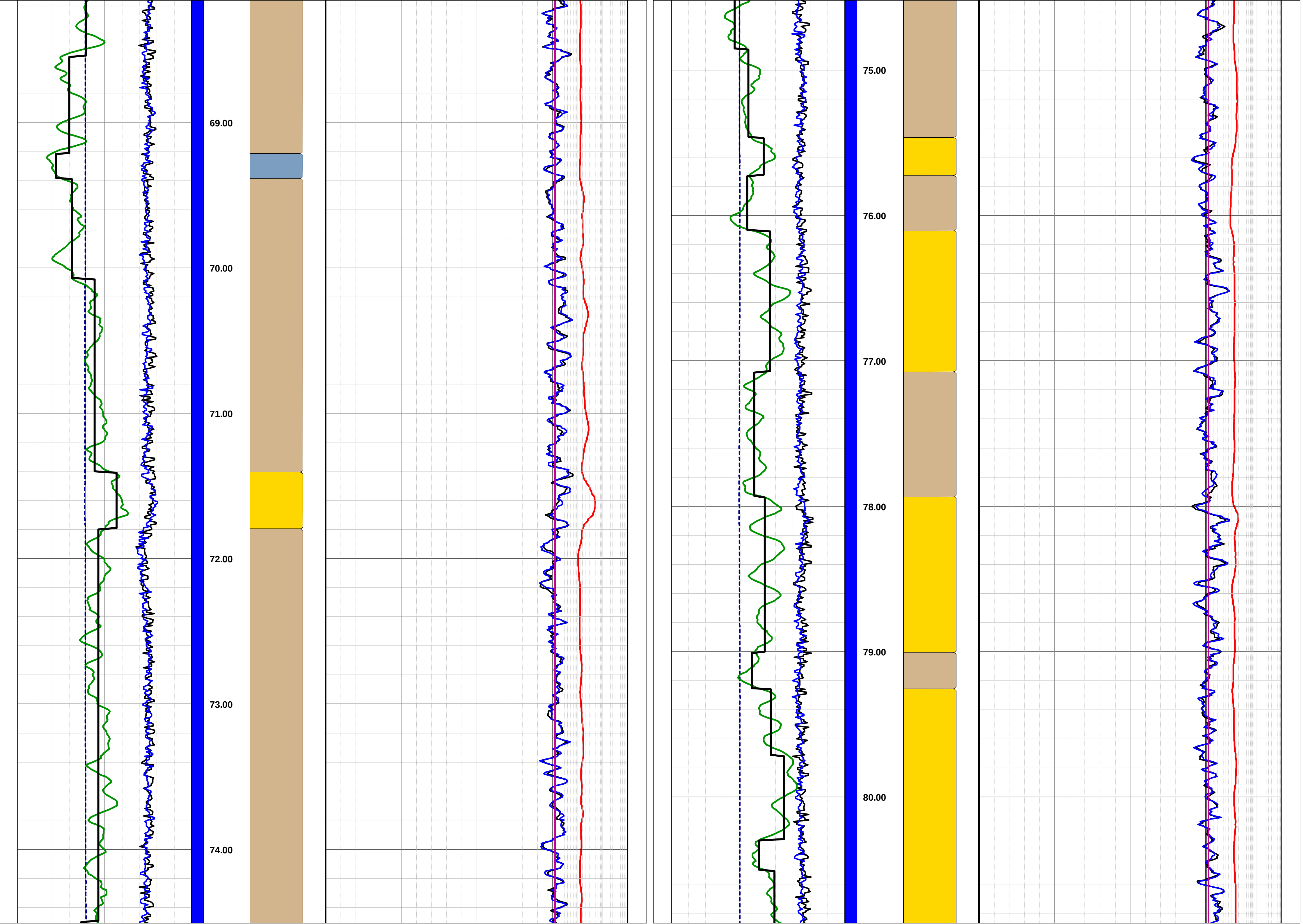
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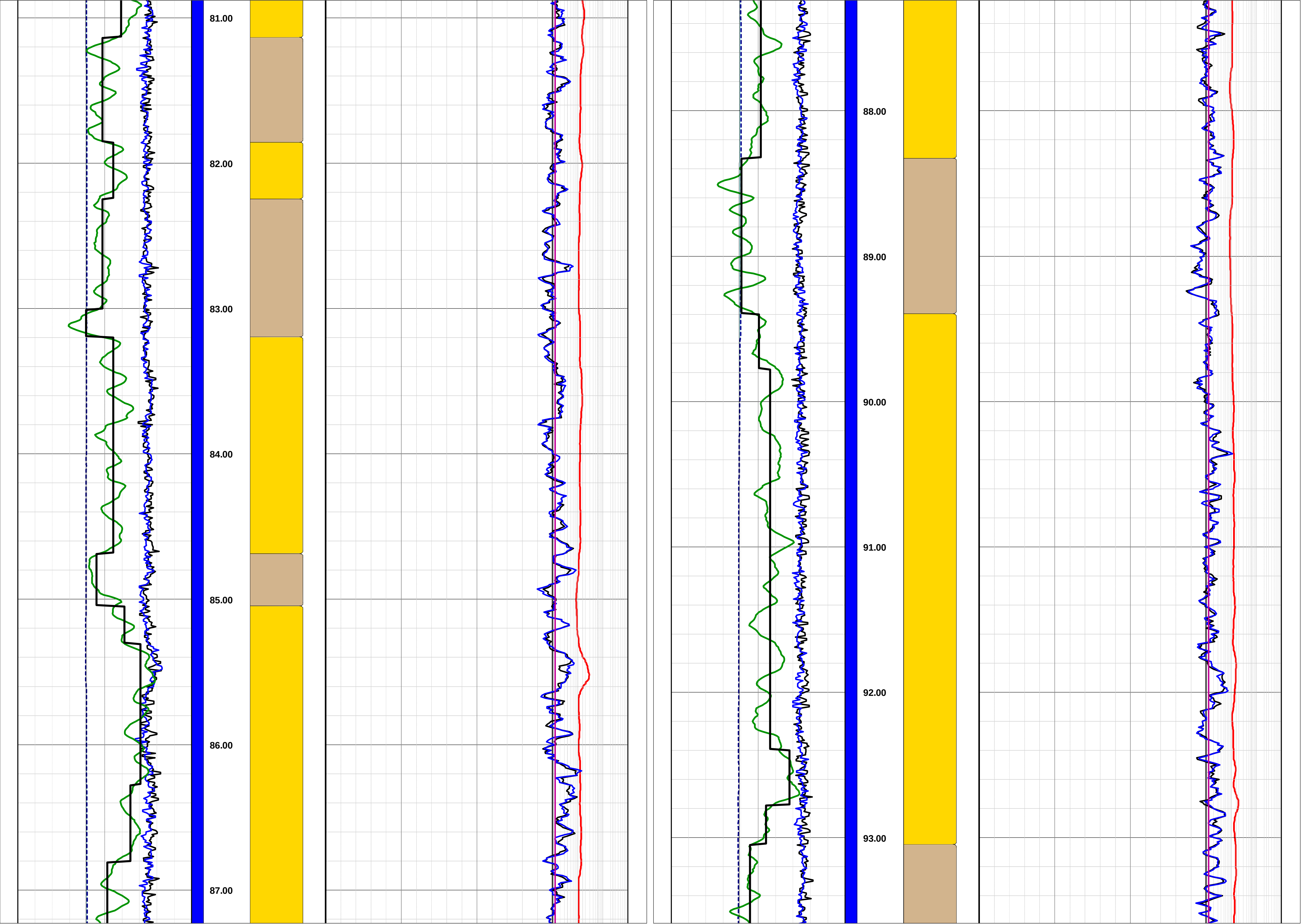
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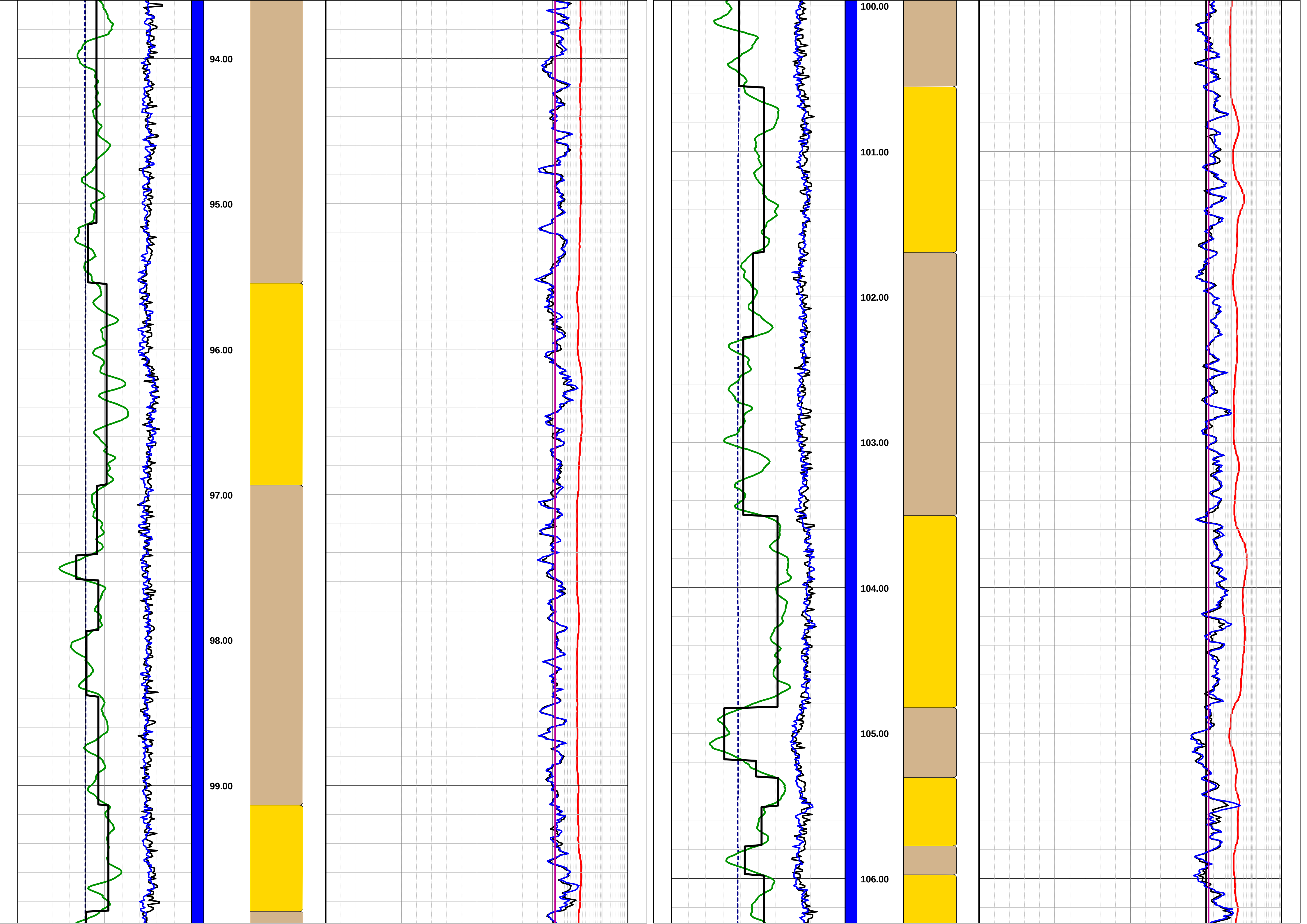
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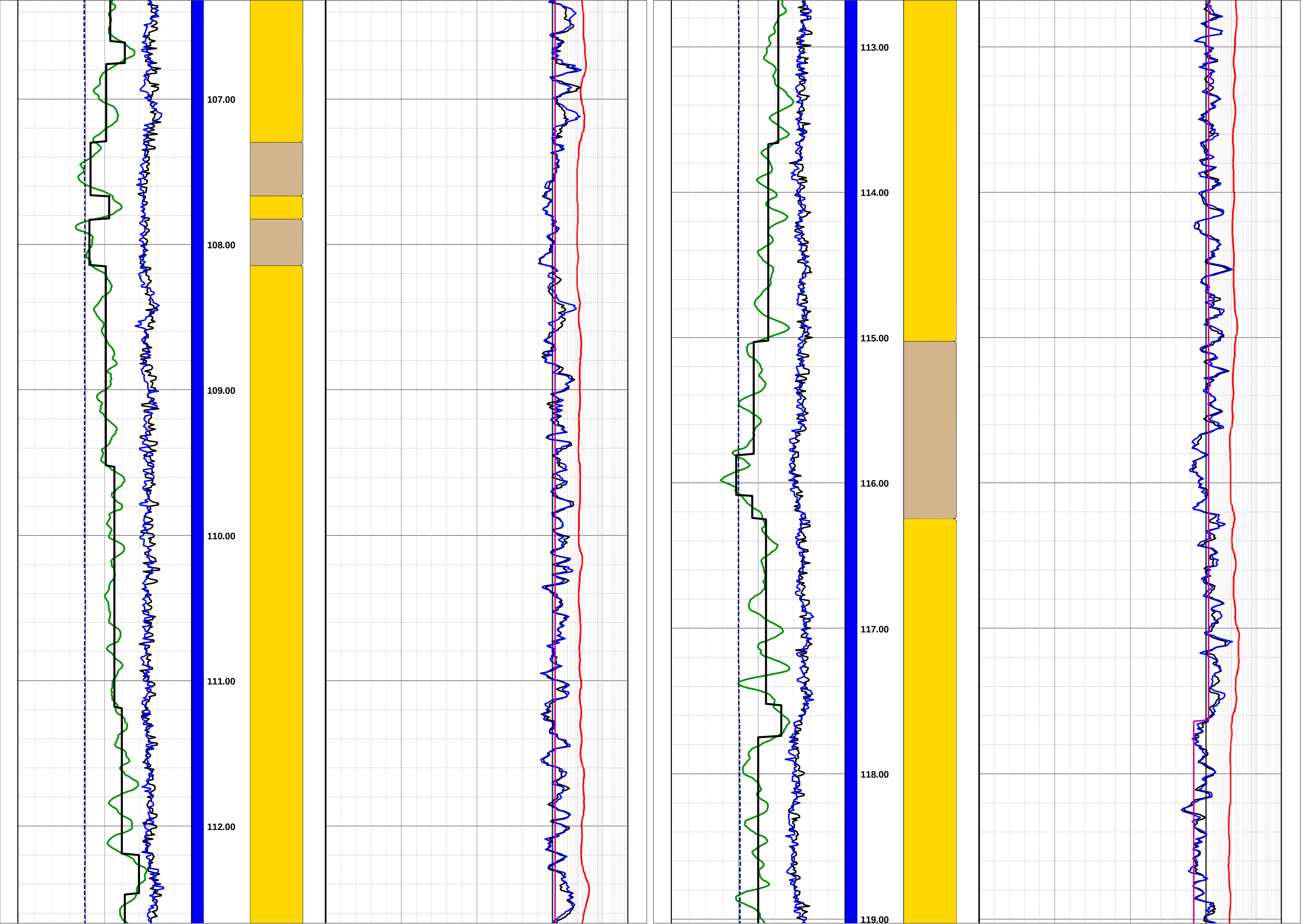
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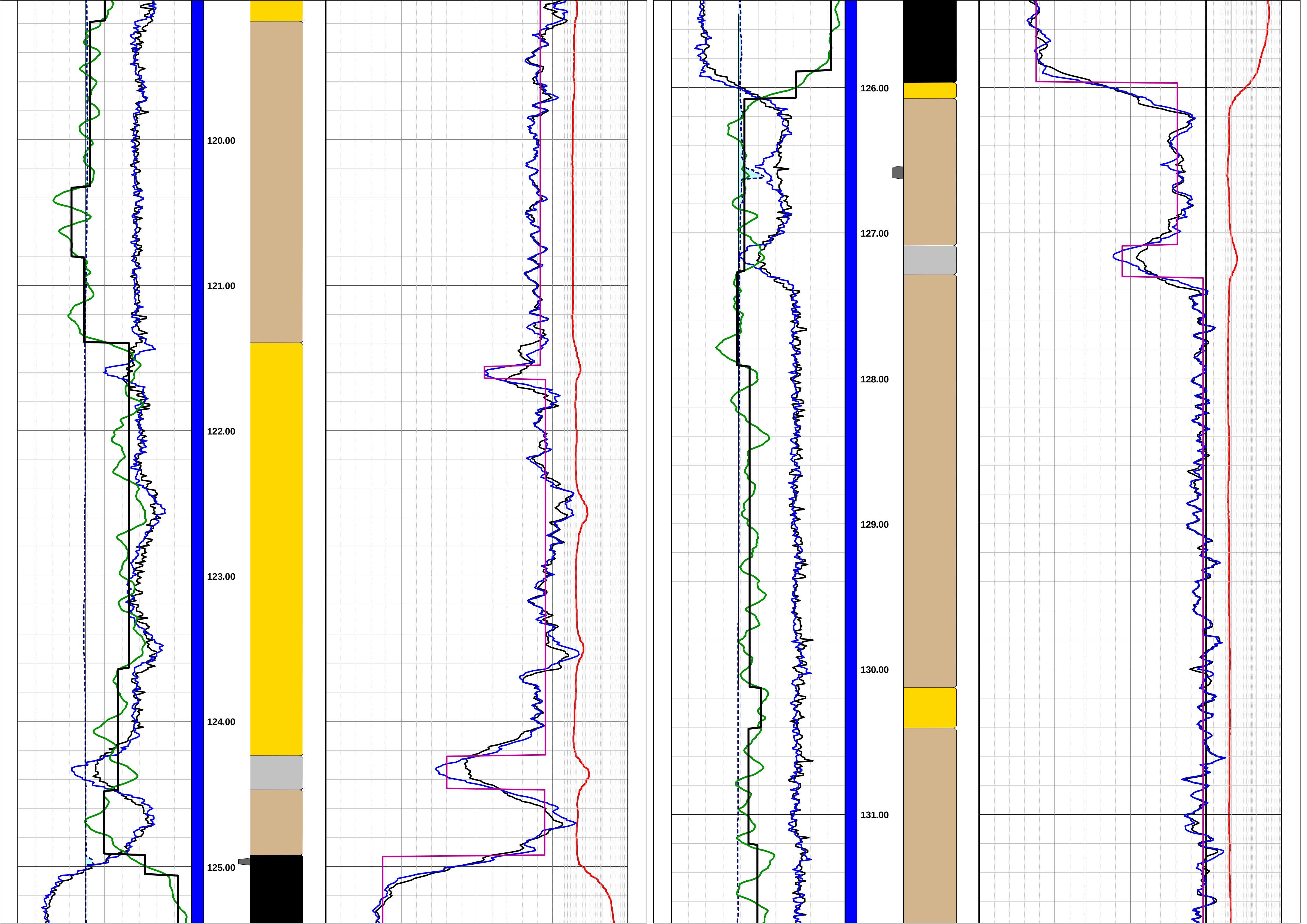
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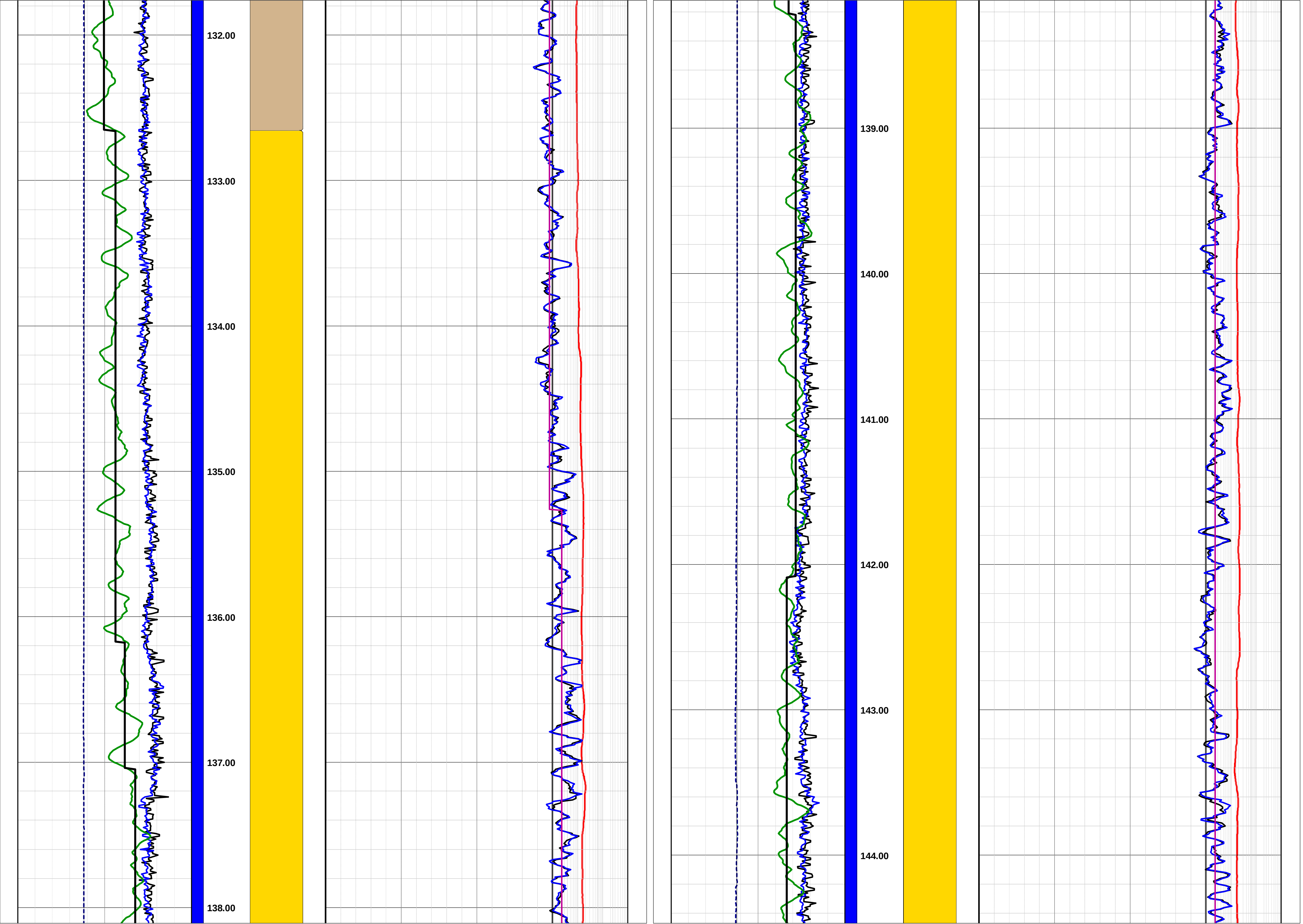
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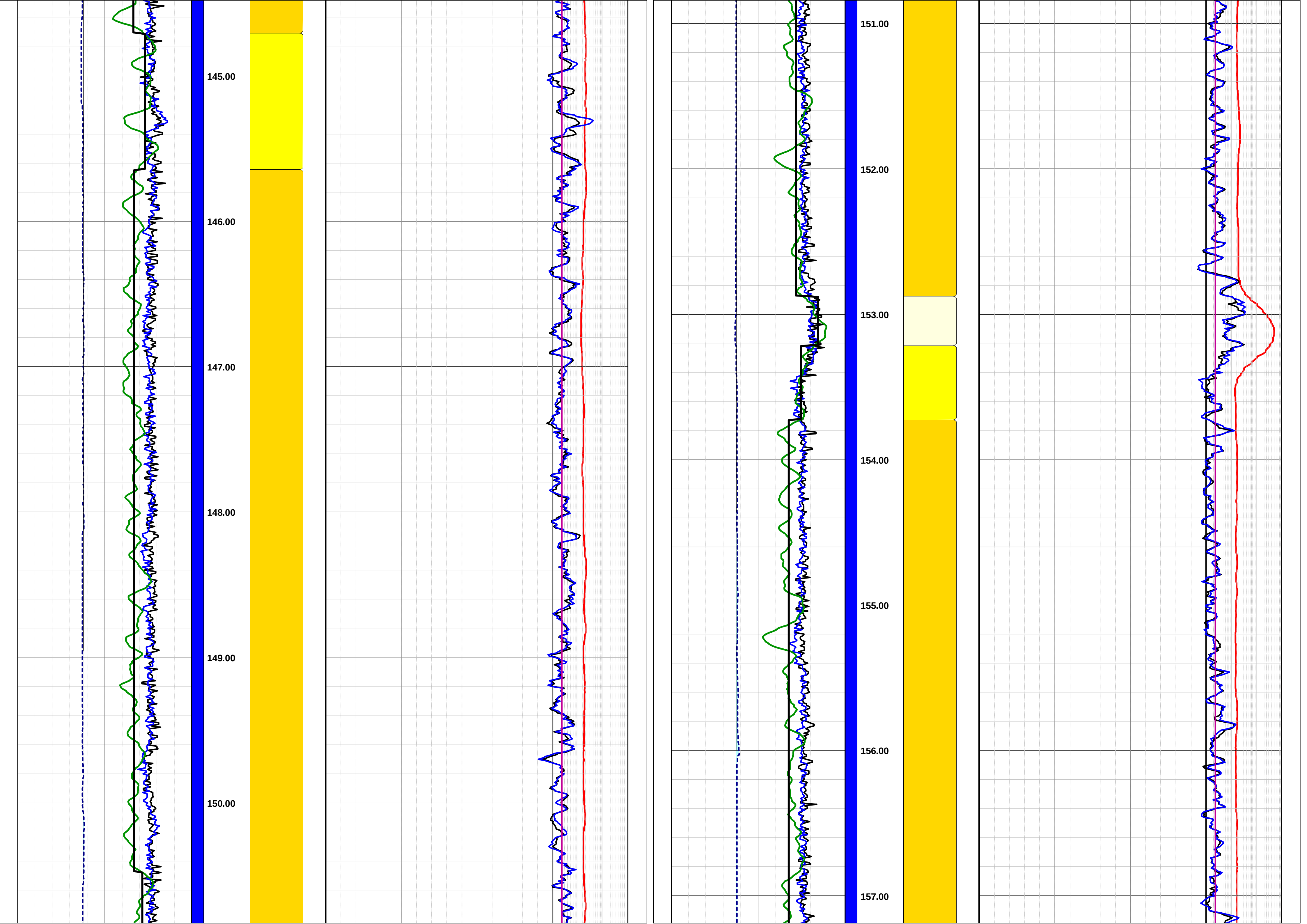
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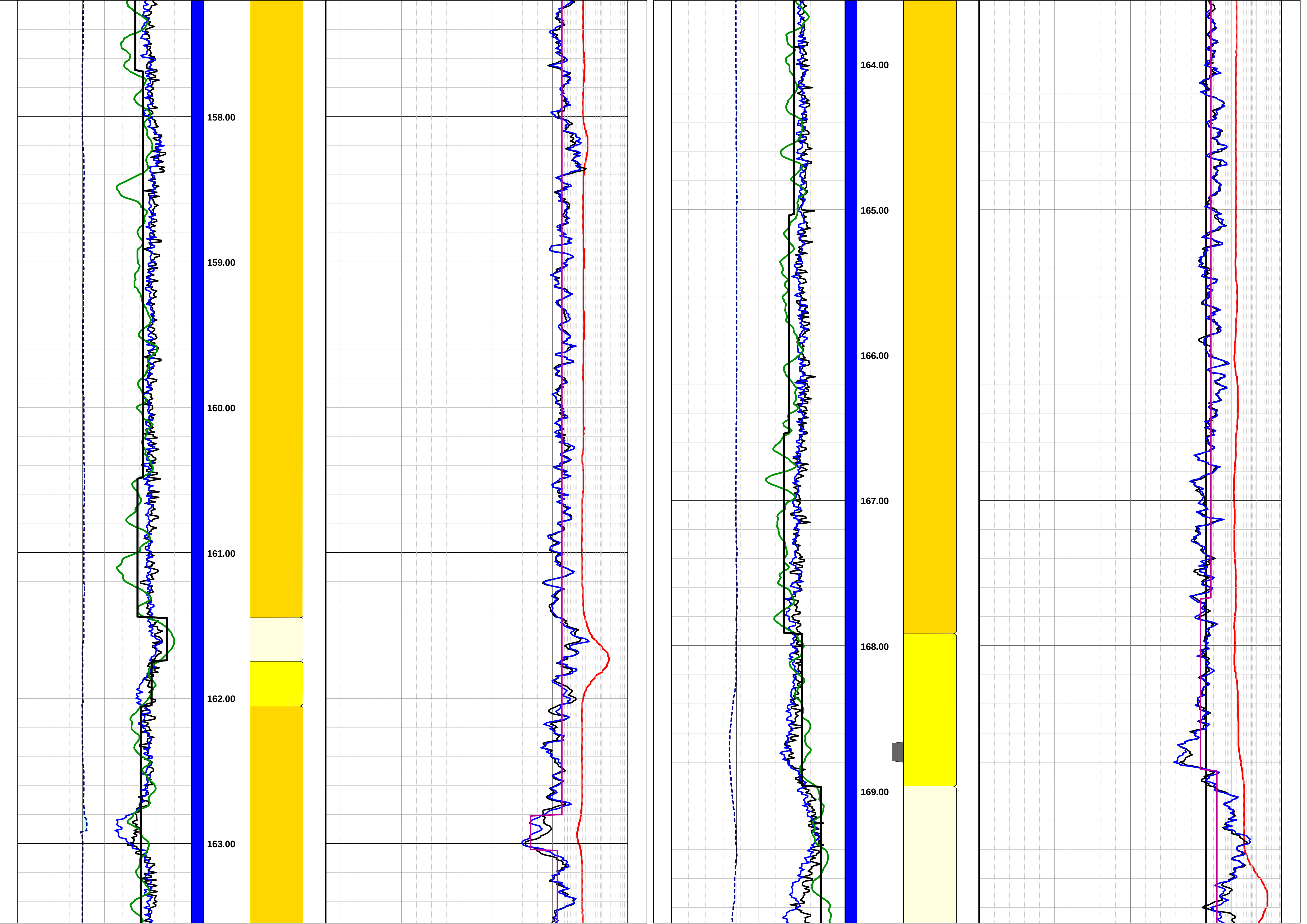
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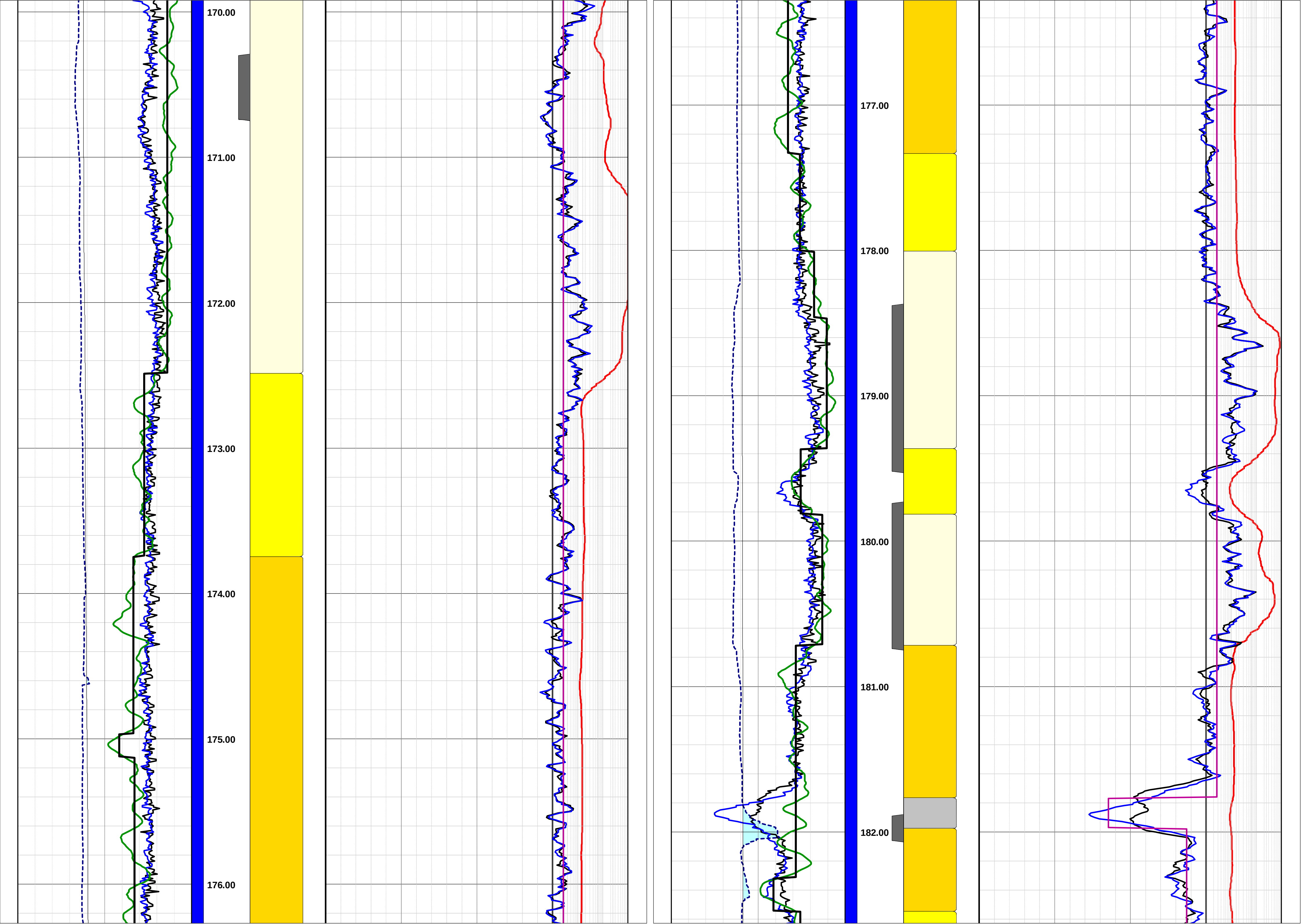

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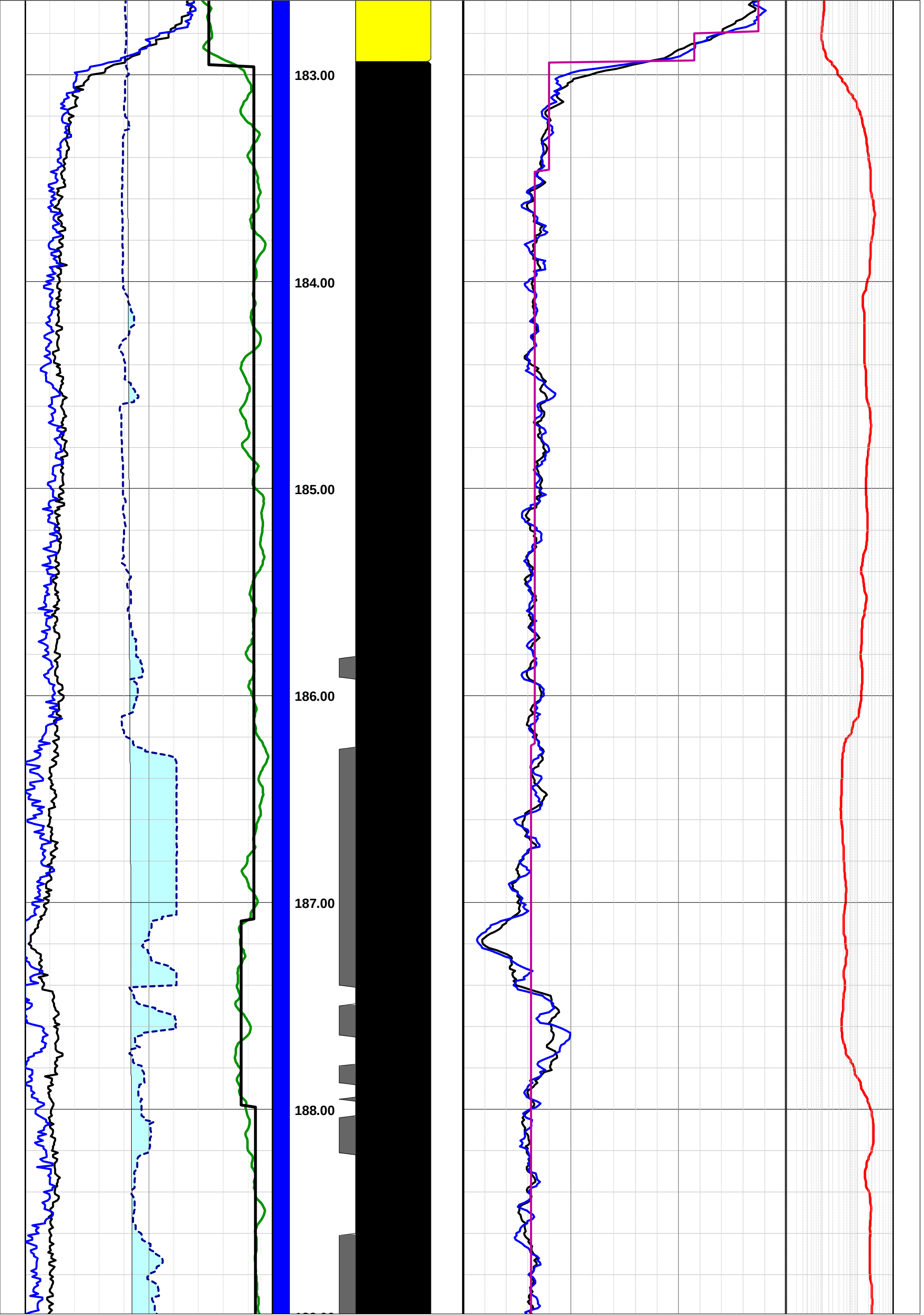
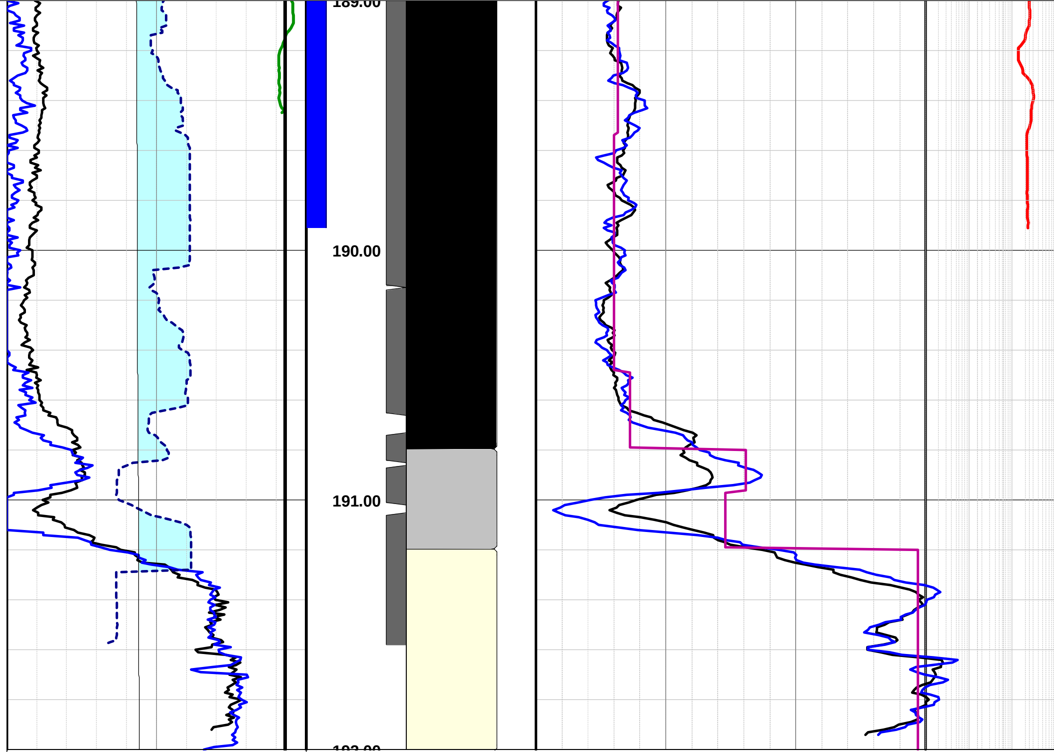




0 DEG 20 SANG				
200 API 0 GAM(NAT)				
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)	
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)	
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL		1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND

CO - Coal	S2 - Sandstone - fine grained
CF - Inferior Coal	S3 - Sandstone - fine to medium grained
ST - SILTSTONE	S4 - Sandstone - medium grained
S1 - Sandstone - very fine grained	

COMPANY	BMA	**LOCATION**	VWP19BWM01
WELL	VWP19BWM01	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

VWP19BWM01

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

VWP19BWM02

COMPANY	BMA	**FIELD**	BLW	**STATE**	QLD
WELL	VWP19BWM02	**LOCATION**	VWP19BWM02	**COUNTRY**	AUSTRALIA

LOCATION: VWP19BWM02 **FIELD:** BLW **STATE:** QLD **WELL:** VWP19BWM02 **COMPANY:** BMA

		ELEVATIONS:	OTHER SERVICES:
LOG MEASURED FROM	GL		
DRILLING MEASURED FROM	GL	KB	1.
PERMANENT DATUM		DF	2.
PERMANENT DATUM ELEVATION		GL	3.

LICENSE	SECTION	TOWNSHIP	RANGE	MAGNETIC DECLINATION
				8.76deg

DATE	28-03-2020			RECORDED BY	KAR		
TIME	08-10			WITNESSED BY			
RUN NUMBER	1			LOGGING UNIT	V016		
DEPTH-DRILLER	174m			RIG NUMBER			
DEPTH-LOGGER	171.93m			TOOL TYPE	9239C		
BIT SIZE	121mm			TOOL SERIAL NO.	2554		
CASING TYPE	PVC			EASTING	7366099		
CASING ID	200mm			NORTHING	691947		
CASING BOTTOM	17m			SAMPLE INT.	.01m		
FLUID TYPE	0			LOG DIRECTION	U		
TRUCK CAL NO.	0.09769			FEET OR METER	M		
WATER LEVEL	78.9m			SOURCE TYPE	CS137	SOURCE ID	CZ3956

QUICKLOOK LITHOLOGY ANALYSIS PARAMETERS

1. HYBRID BOUNDARY PICK ANALYSIS APPLIED.
2. BLOCK AVERAGED GAMMA AND DENSITY USED.
3. GAMMA-DENSITY CROSSPLOT CLUSTER CHART APPLIED - CCC.v.1.13
4. LITHOLOGICAL DICTIONARY APPLIED - COAL.
5. CASING DEPTH SUPPLIED BY LOG
6. THE QUICKLOOK PROCESS HAS BEEN DEVELOPED TO PROCESS DATA RECORDED IN OPENHOLE.
   THE INTERPRETATION PROVIDED FOR DATA RECORDED EITHER IN-ROD OR IN CASING SHOULD BE TREATED WITH CAUTION

LOGGER COMMENTS:

1.

2.

3.

LITHOLOGY LEGEND

CO - Coal	**S1 - Sandstone - very fine grained**
CF - Inferior Coal	**S2 - Sandstone - fine grained**

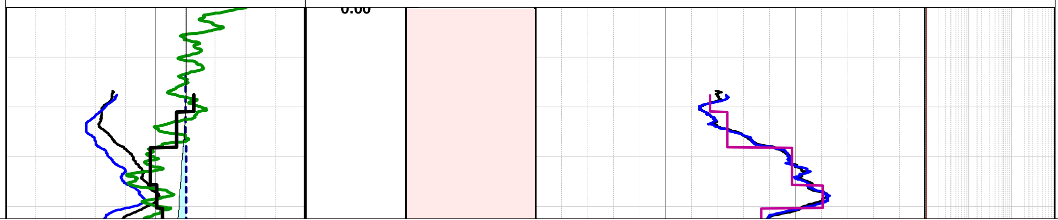
MNEMONICS

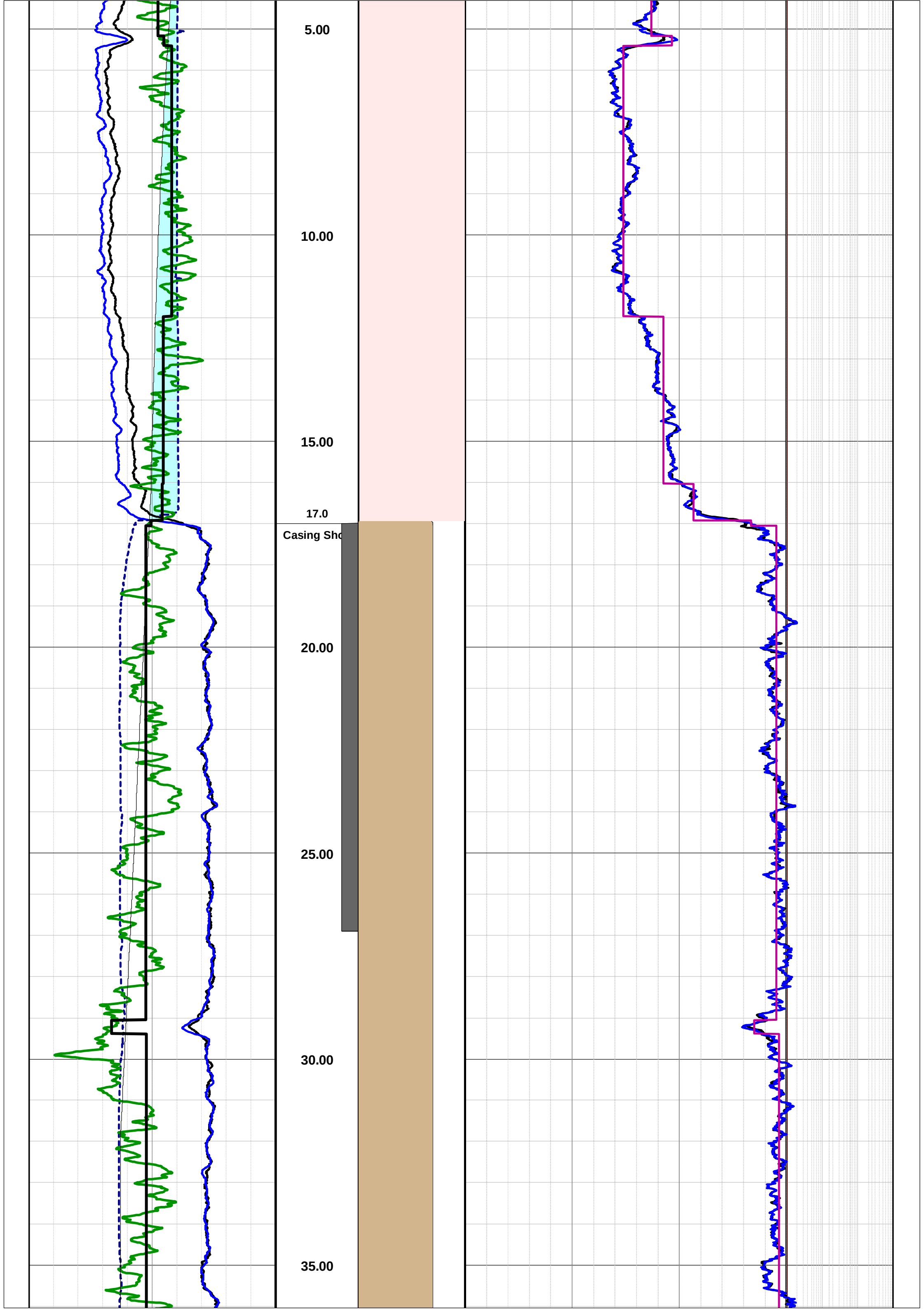
DEN(LS)	LONG SPACED DENSITY STANDARD UNITS
DEN(SS)	SHORT SPACED DENSITY STANDARD UNITS
RES(SG)	SHORT GUARD RESISTIVITY
DENR(LS)	LONG SPACED DENSITY RESPONSE UNITS
DENR(SS)	SHORT SPACED DENSITY RESPONSE UNITS
DEN(CDL)	COMPENSATED DENSITY
POR(DEN)	SANDSTONE DENSITY POROSITY
CALIPER	MECHANICAL CALIPER FROM DENSITY
GAM(NAT)	NATURAL GAMMA FROM DENSITY
DEN(COD)	COMPENSATED DENSITY FORMULA
DEN(ER)	VECTAR PROCESSED DENSITY
SANGB	SAMPLE ANGLE BEARING
SANG	SAMPLE SLANT ANGLE (0 DEG = VERTICAL DOWN)
TVD	TRUE VERTICAL DEPTH
EAST	BOREHOLE EAST DEVIATION
NORTH	BOREHOLE NORTH DEVIATION
CDIST	DEVIATED CLOSURE DISTANCE
CANGB	DEVIATED CLOSURE ANGLE BEARING

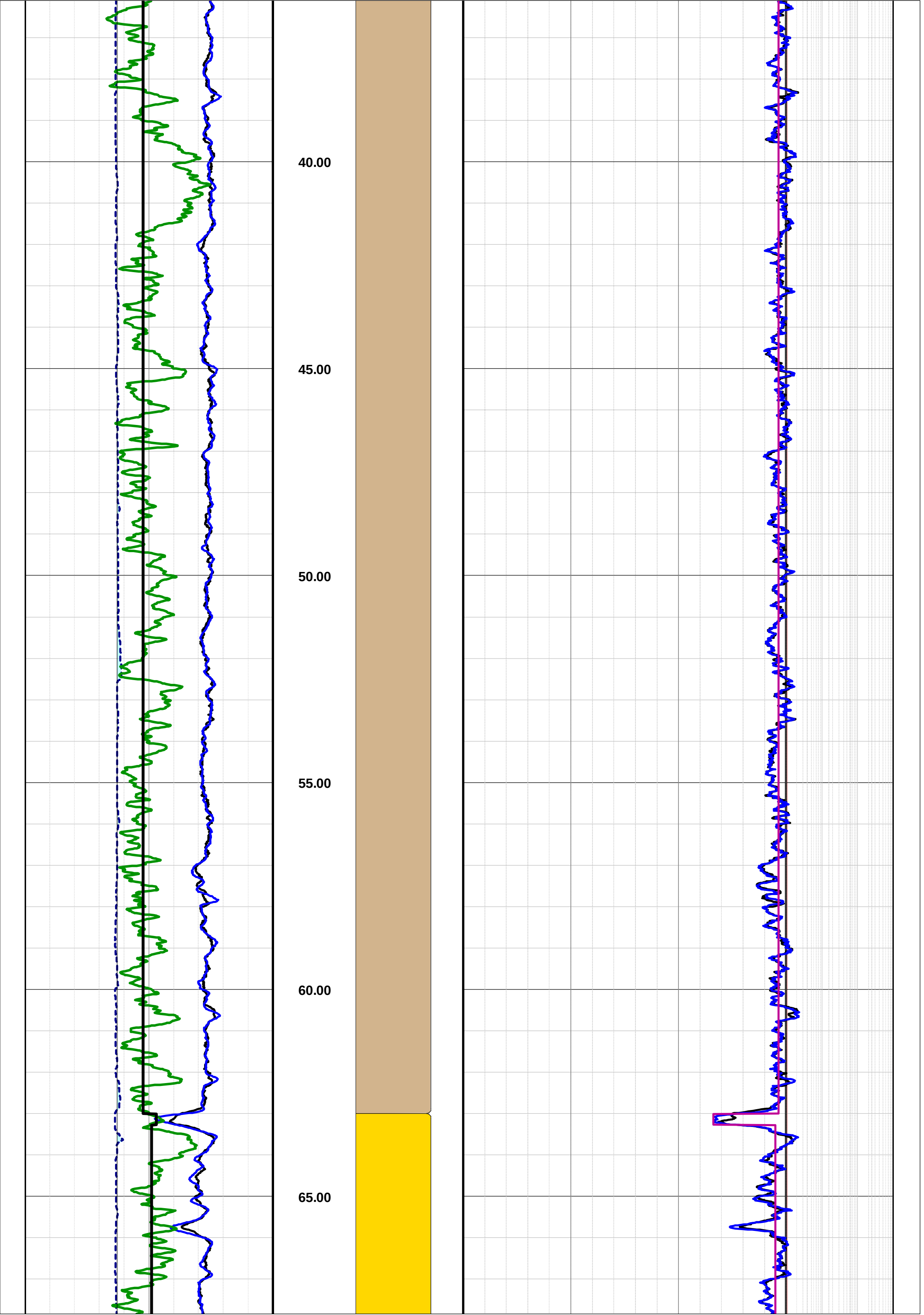
IMPORTANT NOTE	The following interpretations are opinions based upon inferences from borehole logs, Kinetic Logging Services Pty Ltd cannot and does not guarantee the correctness or accuracy of any interpretations. Therefore Kinetic Logging Services Pty Ltd shall not be liable or responsible for any loss, damage, cost or expense incurred or sustained by anyone resulting from any interpretations.

DEPTH SCALE 1:100

Track	Scale
DEN(LS)	1 g/cc 3
DEN(SS)	1 g/cc 3
CALIPER	50 mm 300
GAM(NAT)	200 API 0
NOM_BIT	50 mm 300
SANG	0 DEG 20
Depth	1m:100m
DATA_FLAG	
WT_FLAG	
COKED_COAL	
LITHOLOGY	
CASING	
DEN(COD)	1 g/cc 3
DEN(ER)	1 g/cc 3
RES(SG)	1 OHM-M 1000



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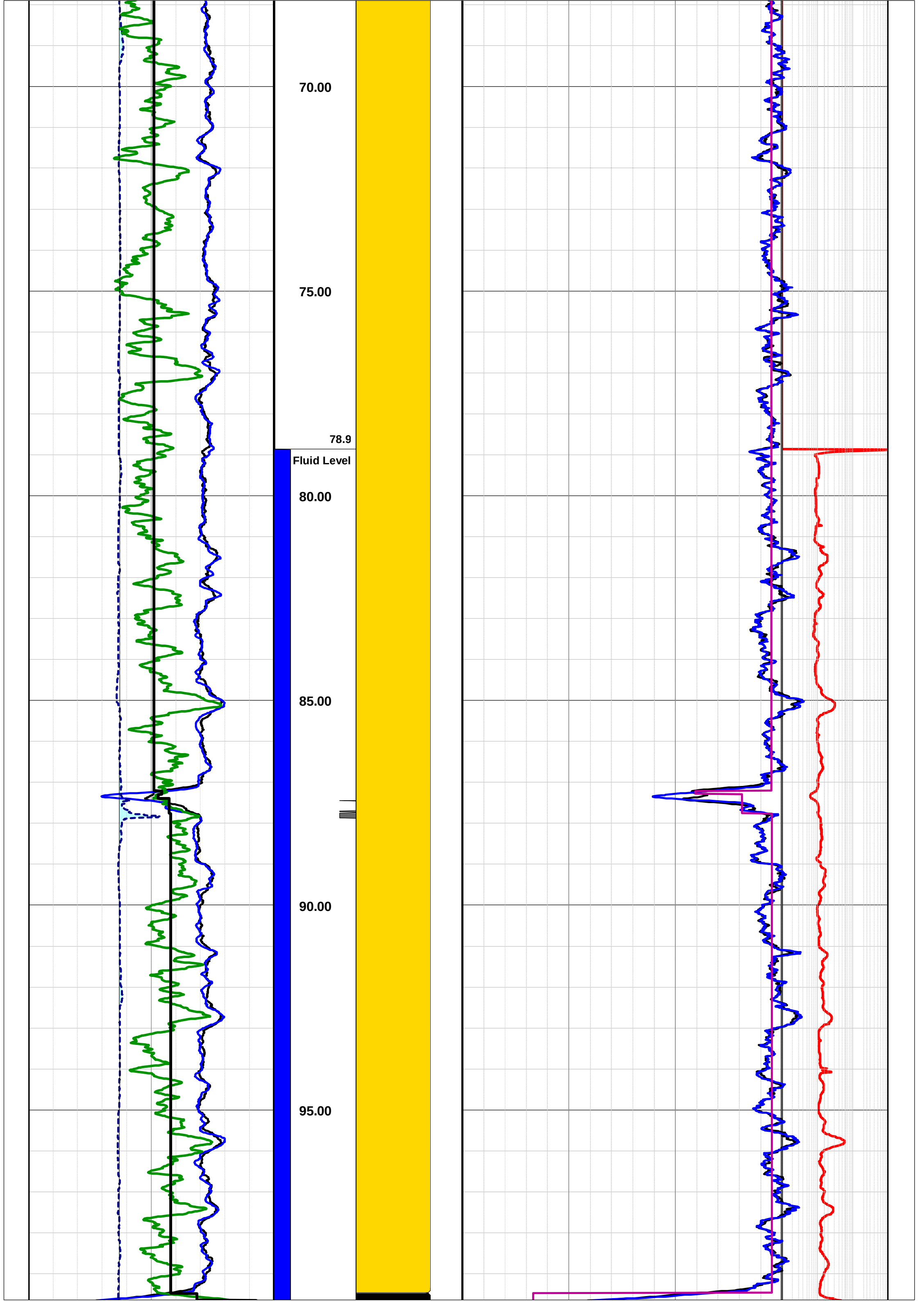
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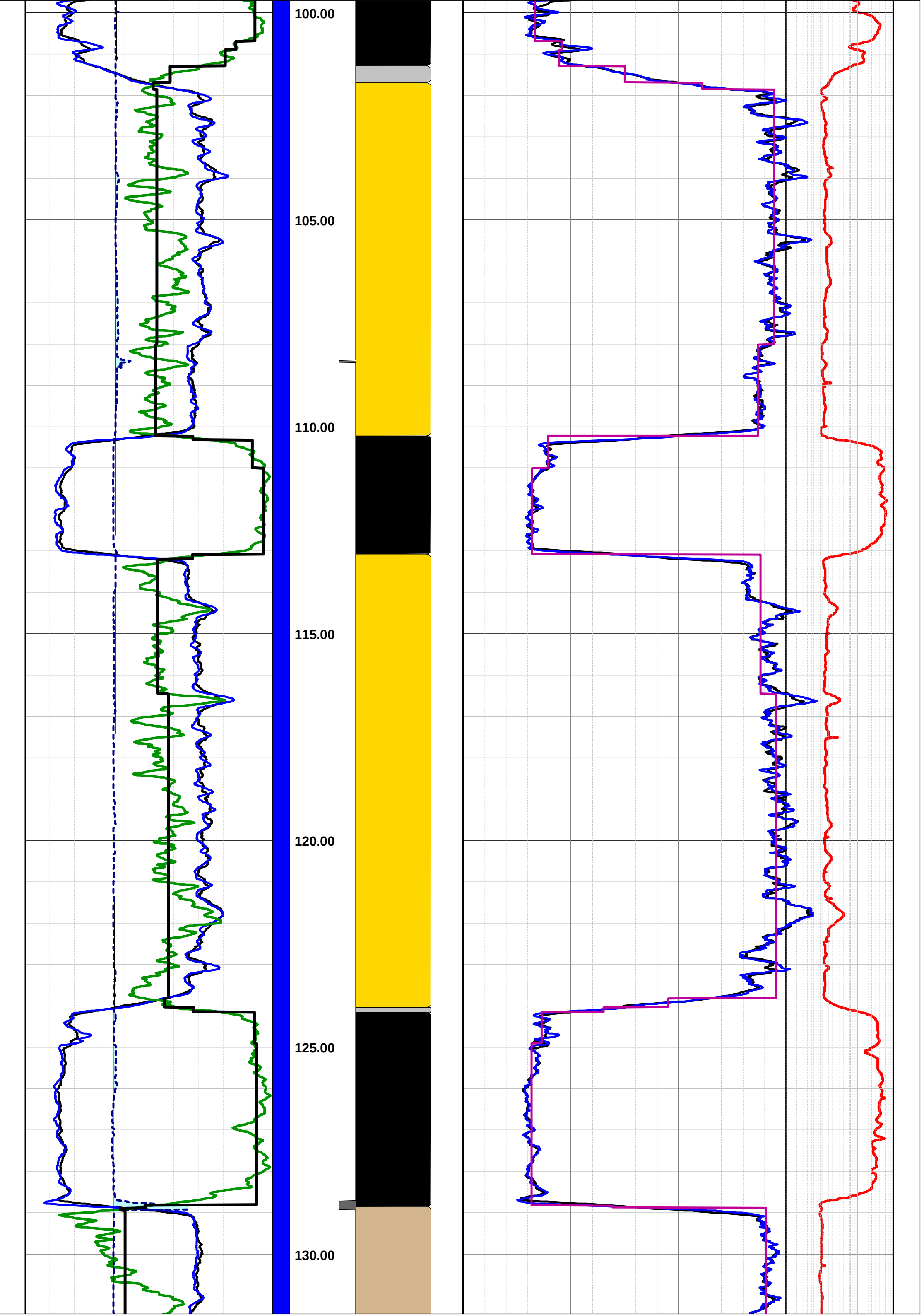
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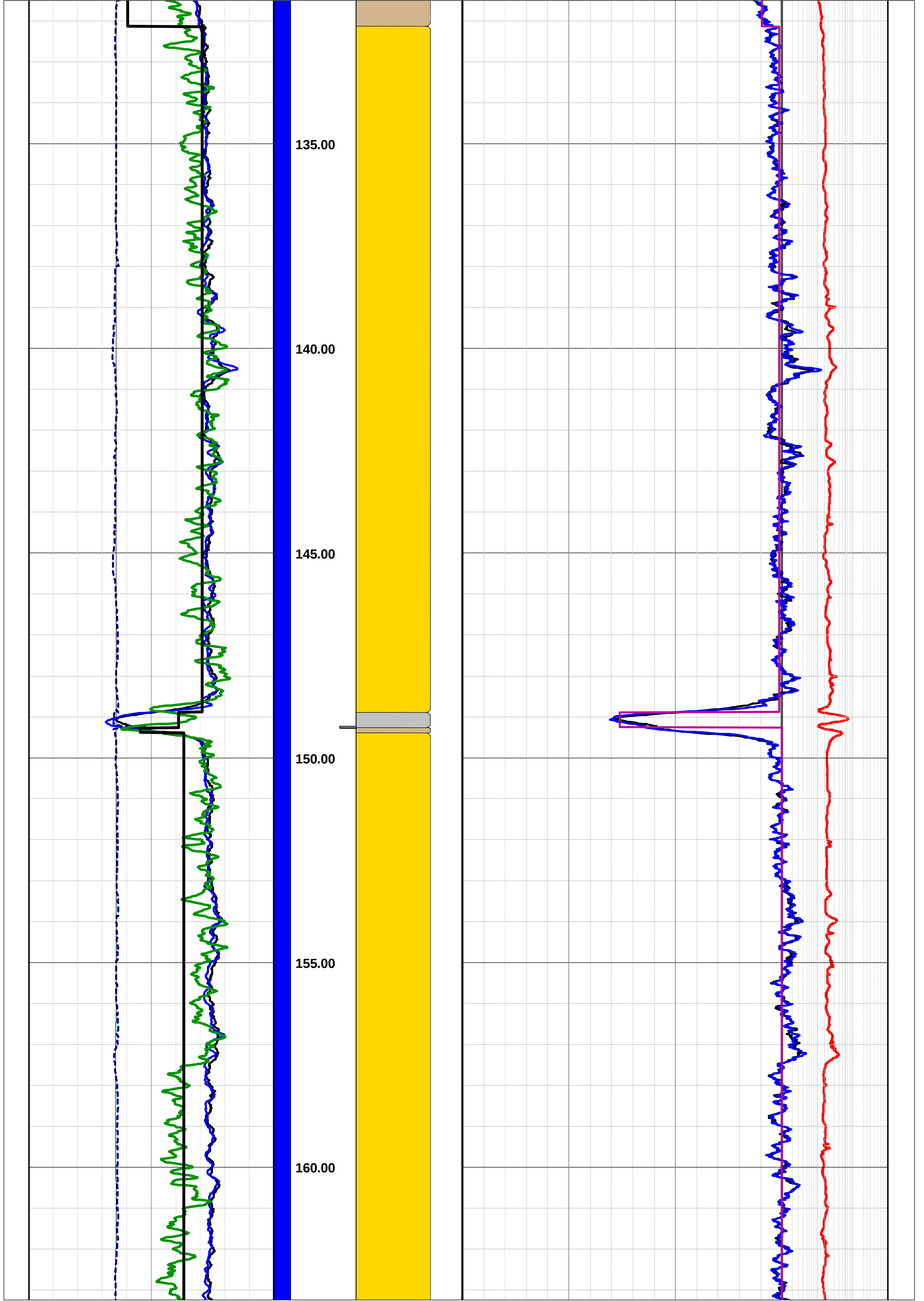
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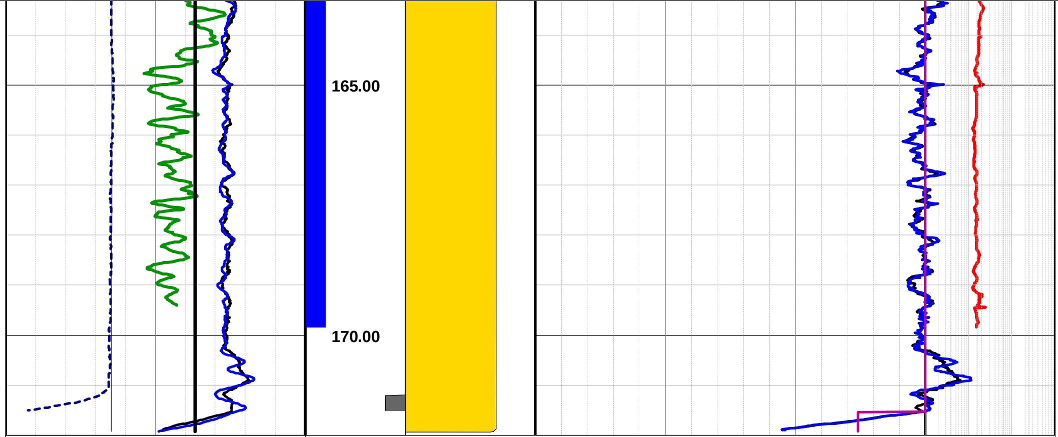

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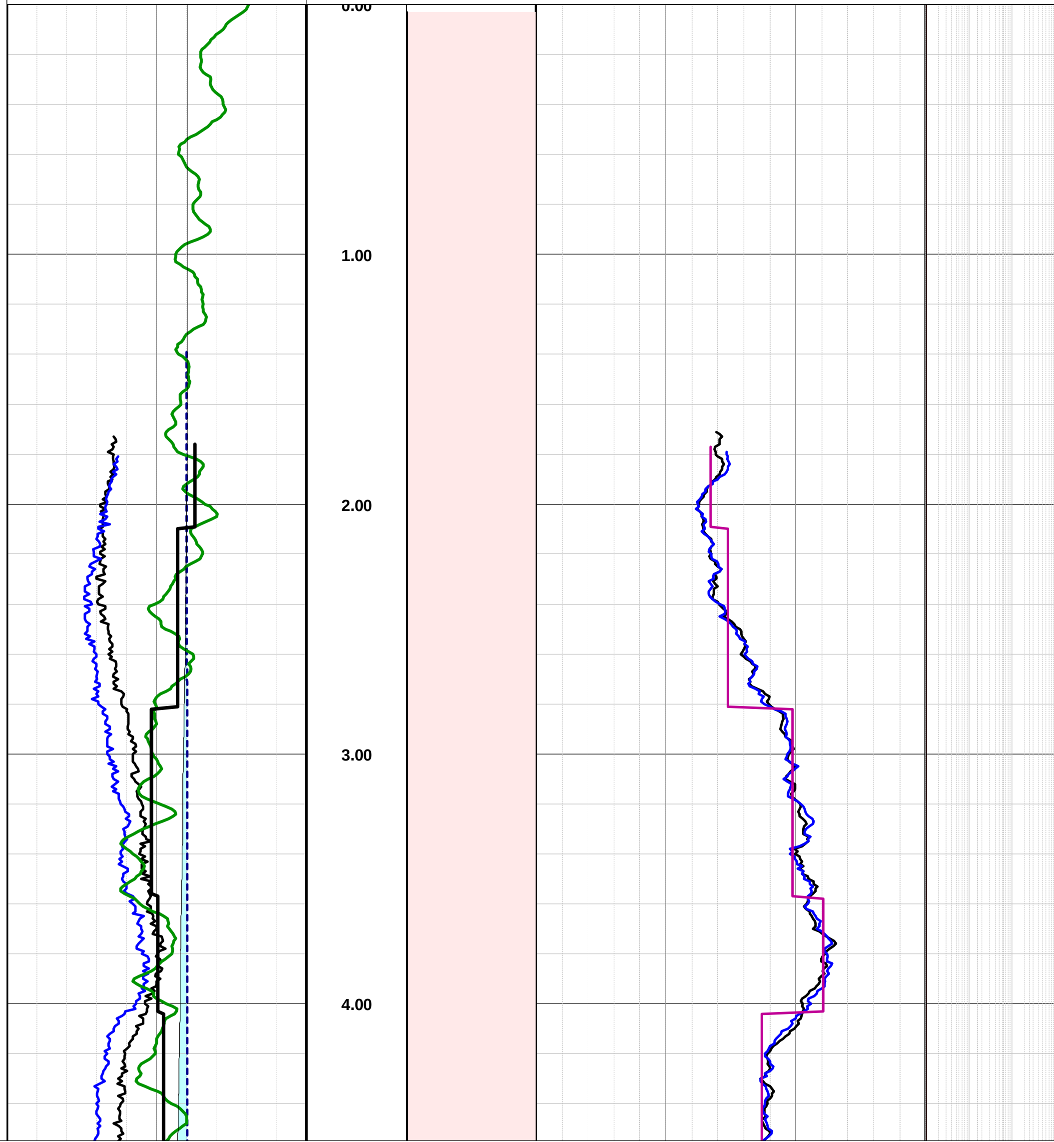
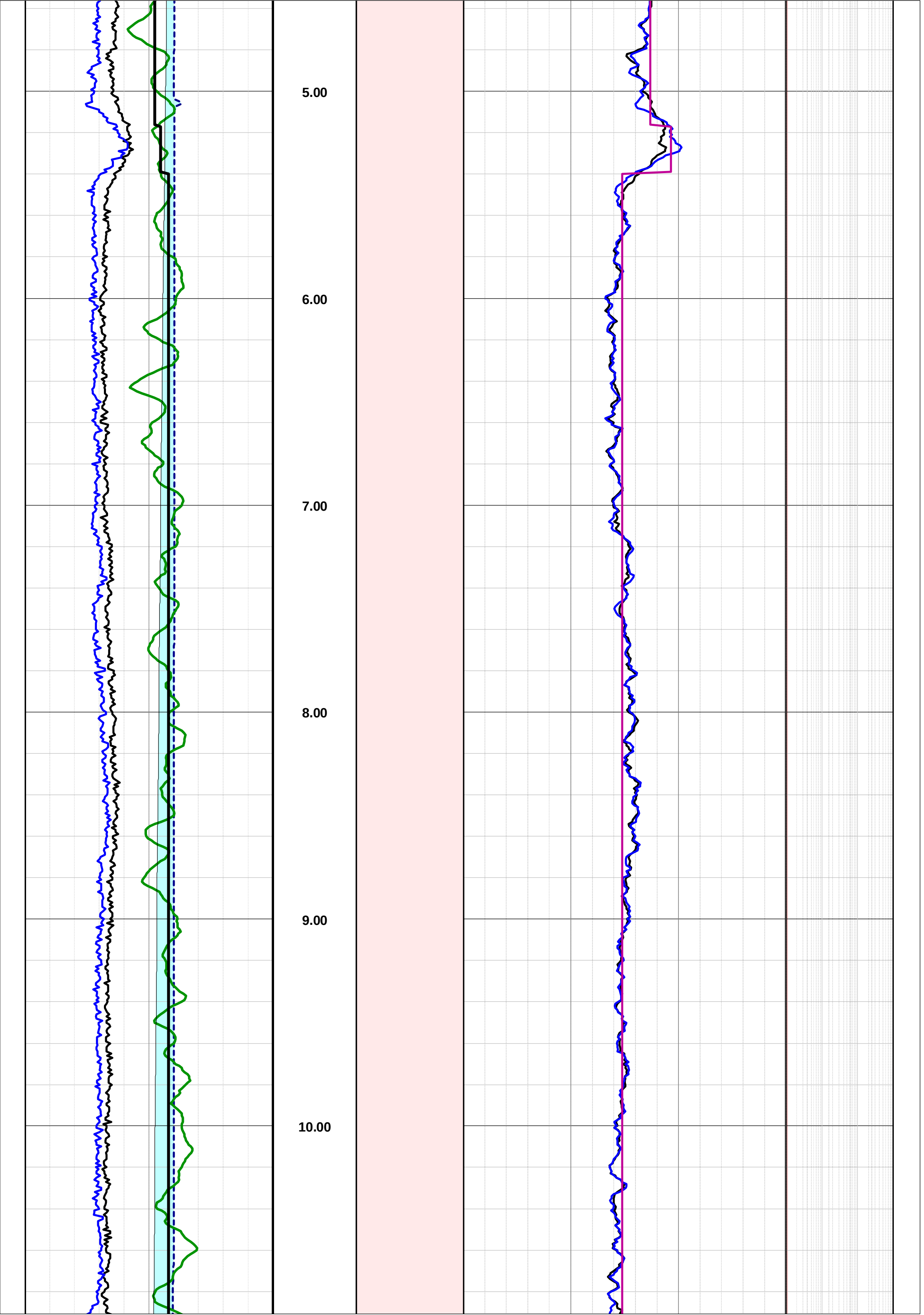
50 mm 300 NOM_BIT			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:100m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:100

DEPTH SCALE 1:20

DEN(LS) 1 g/cc 3	Depth 1m:20m	COKED_COAL		RES(SG) 1 OHM-M 1000
DEN(SS) 1 g/cc 3	DATA_FLAG 5 0	LITHOLOGY	DEN(COD) 1 g/cc 3	
CALIPER 50 mm 300	WT_FLAG 0 5	CASING	DEN(ER) 1 g/cc 3	
GAM(NAT) 200 API 0				
SANG 0 DEG 20				





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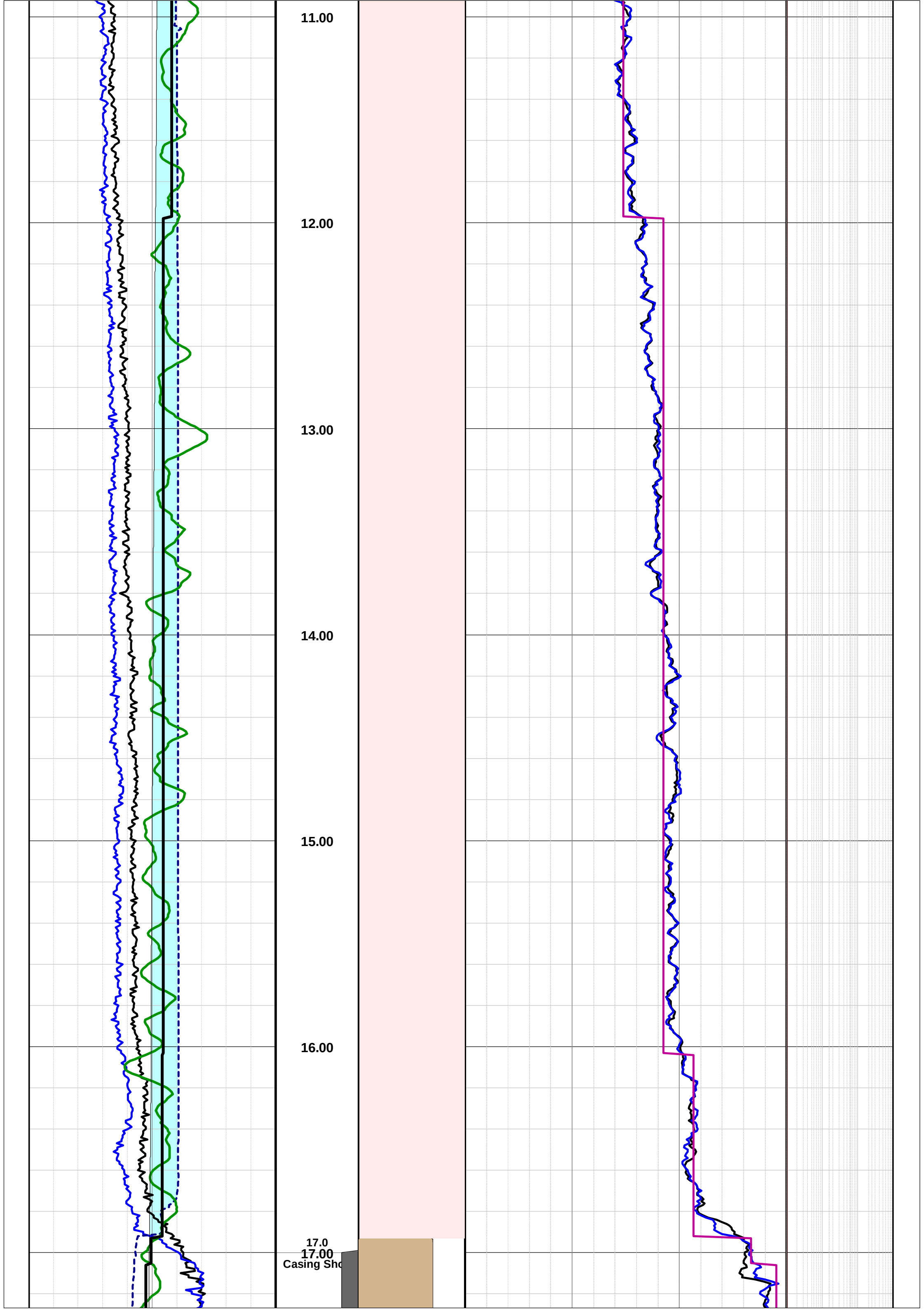

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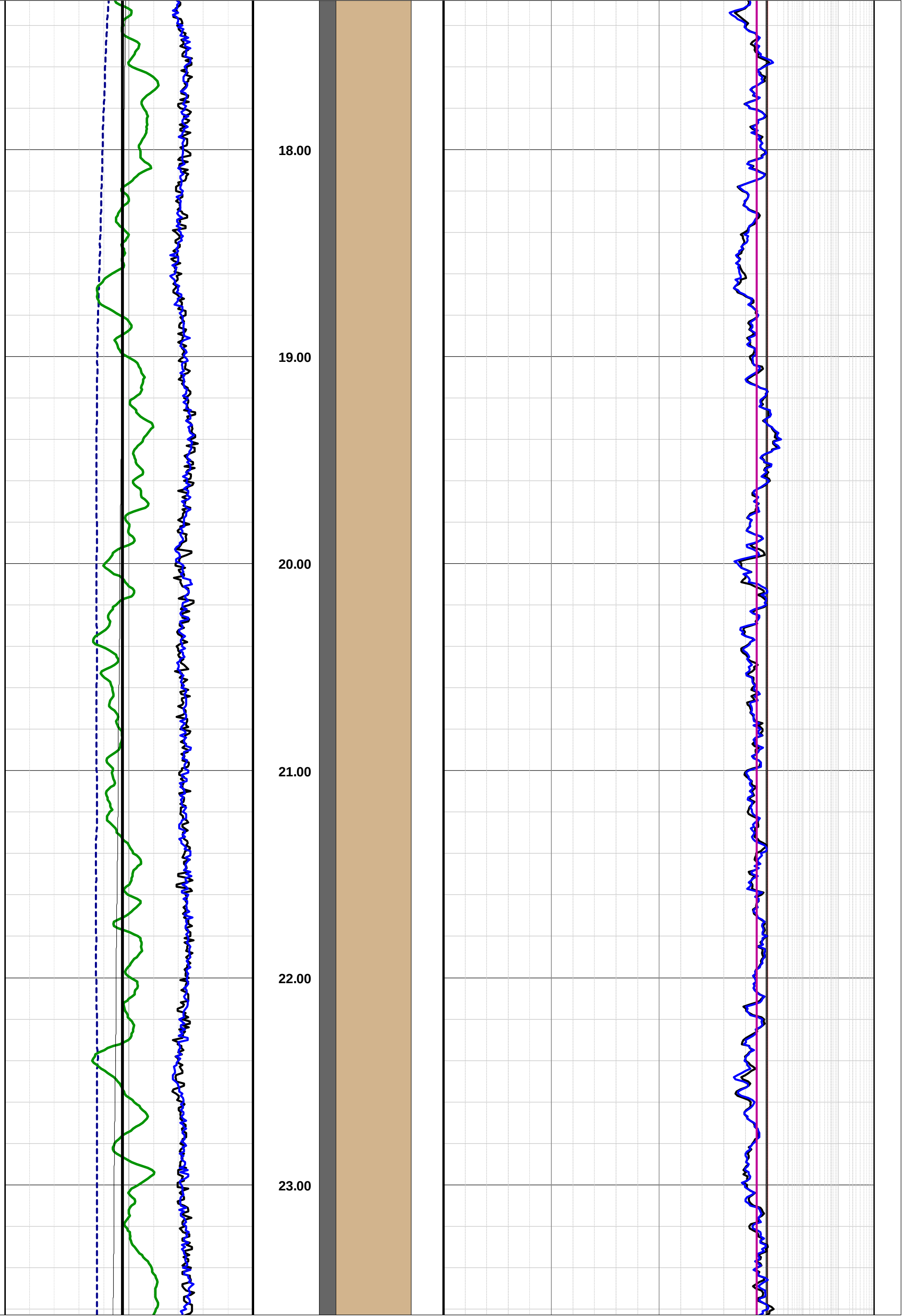
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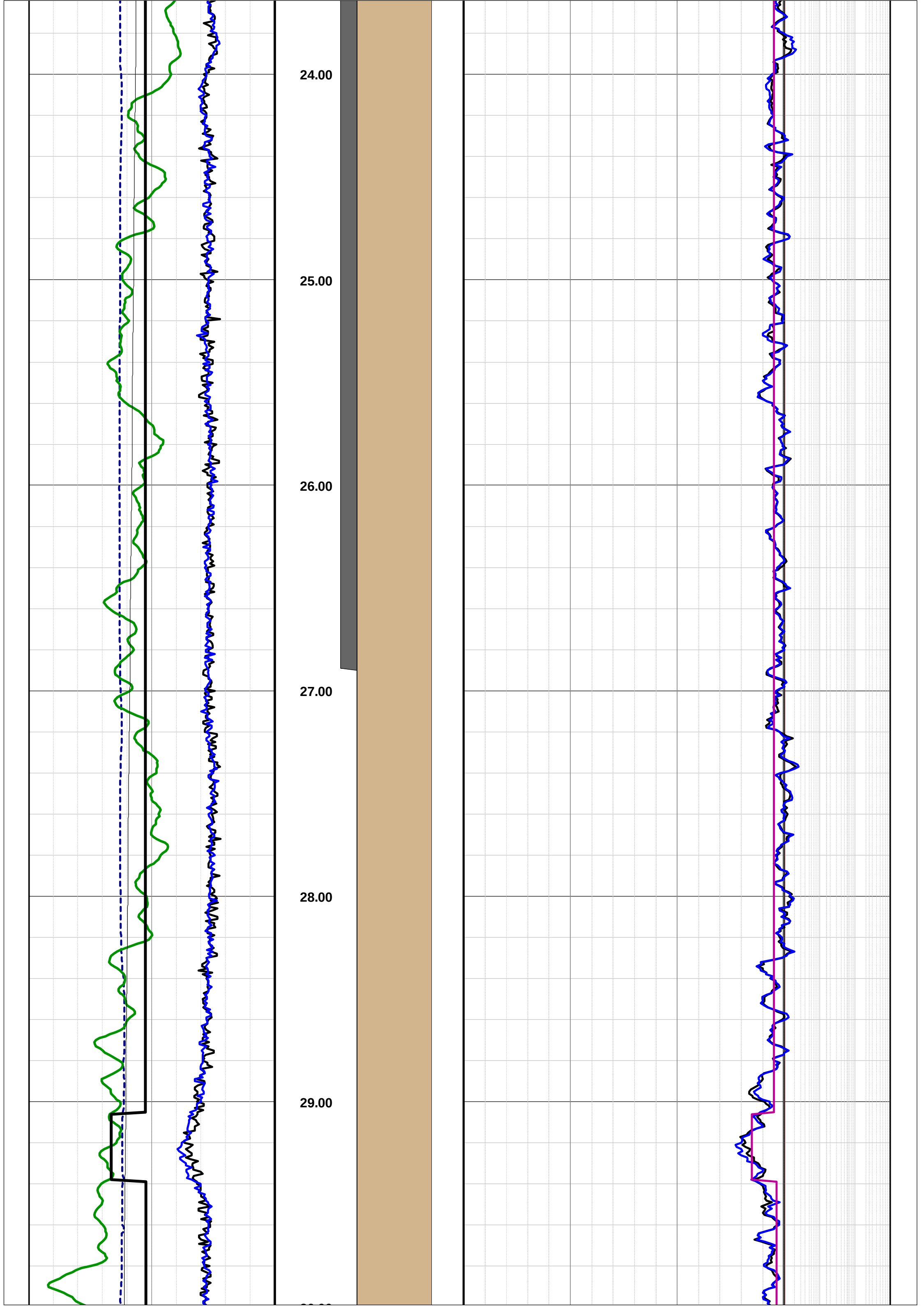
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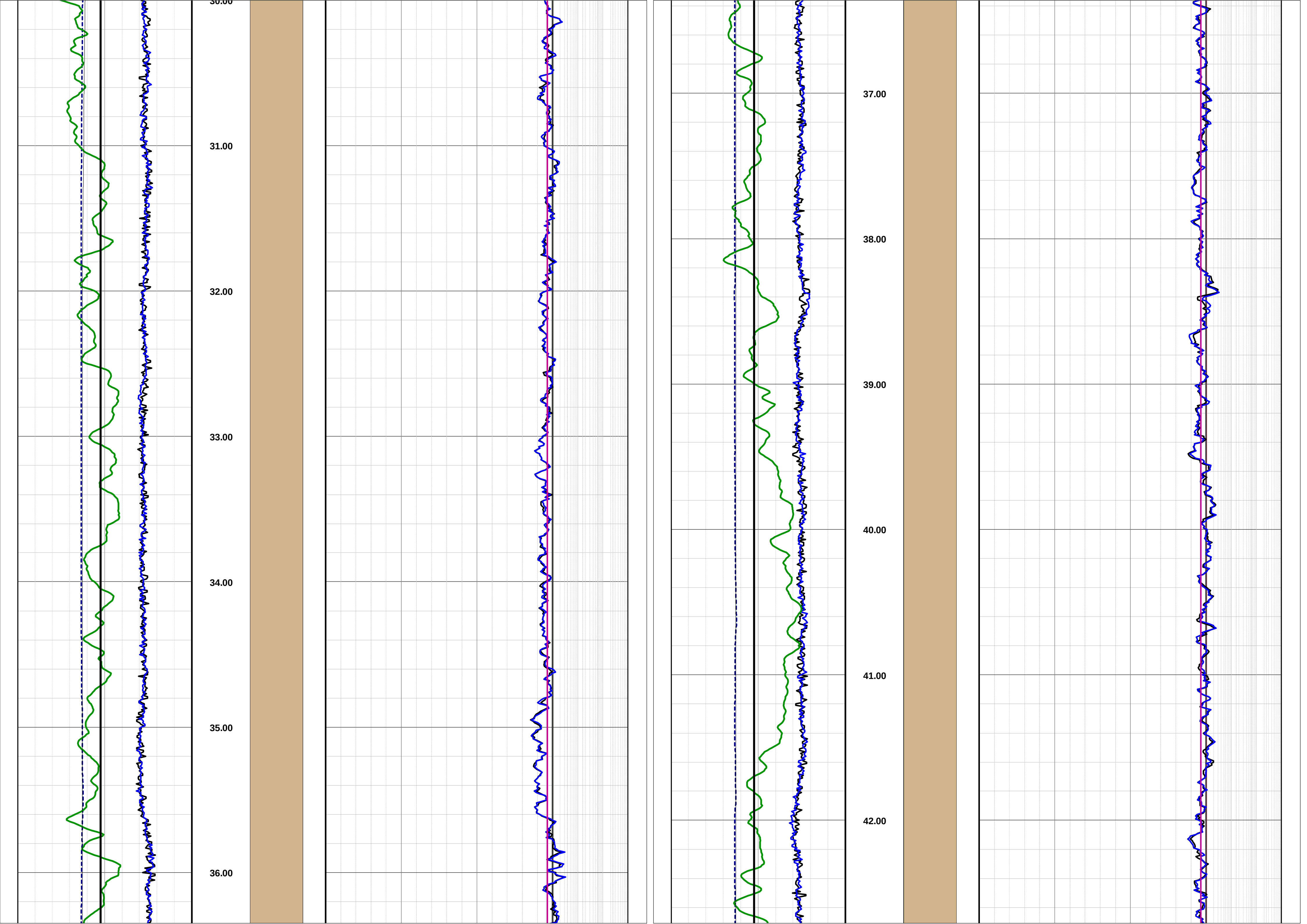
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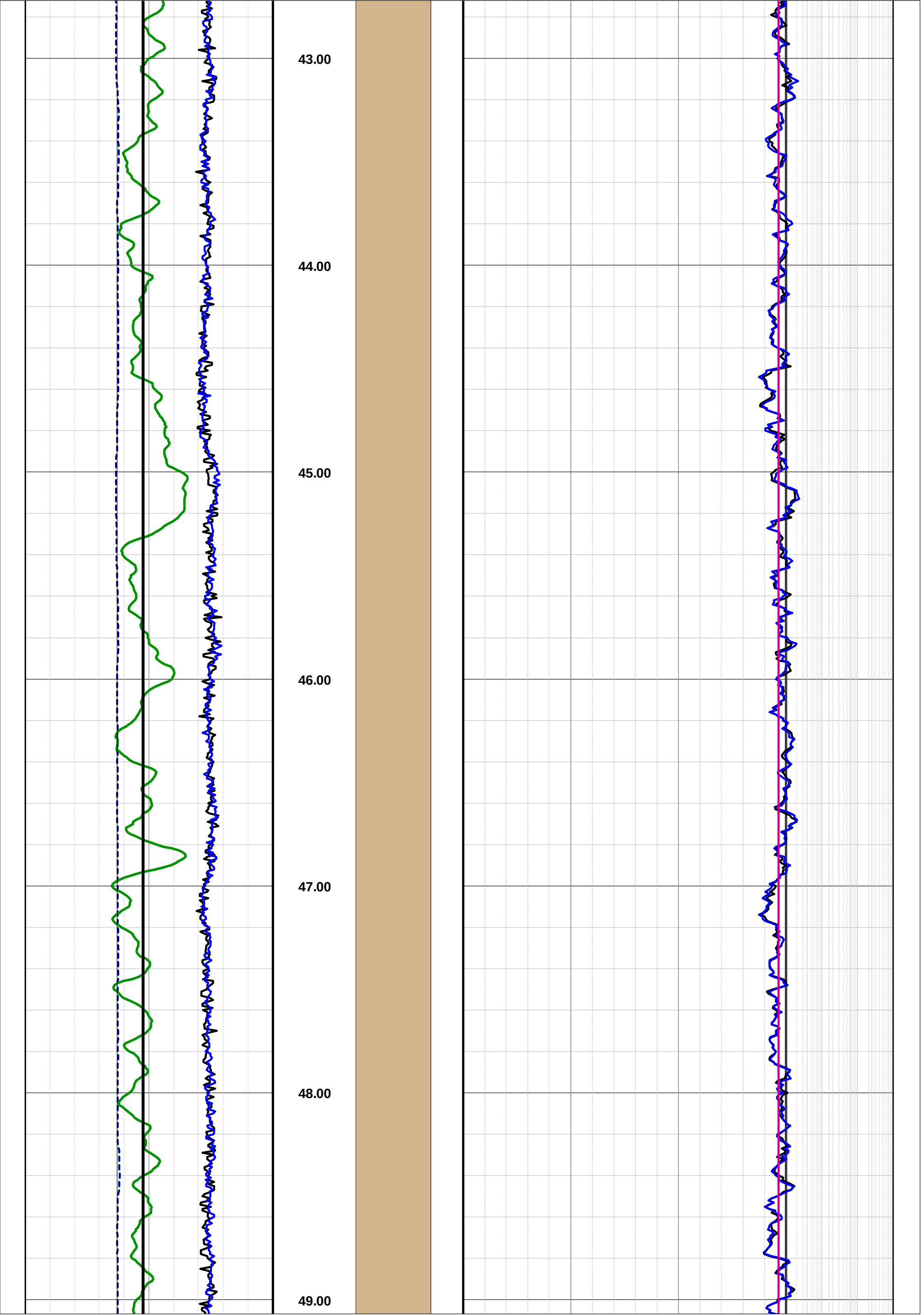
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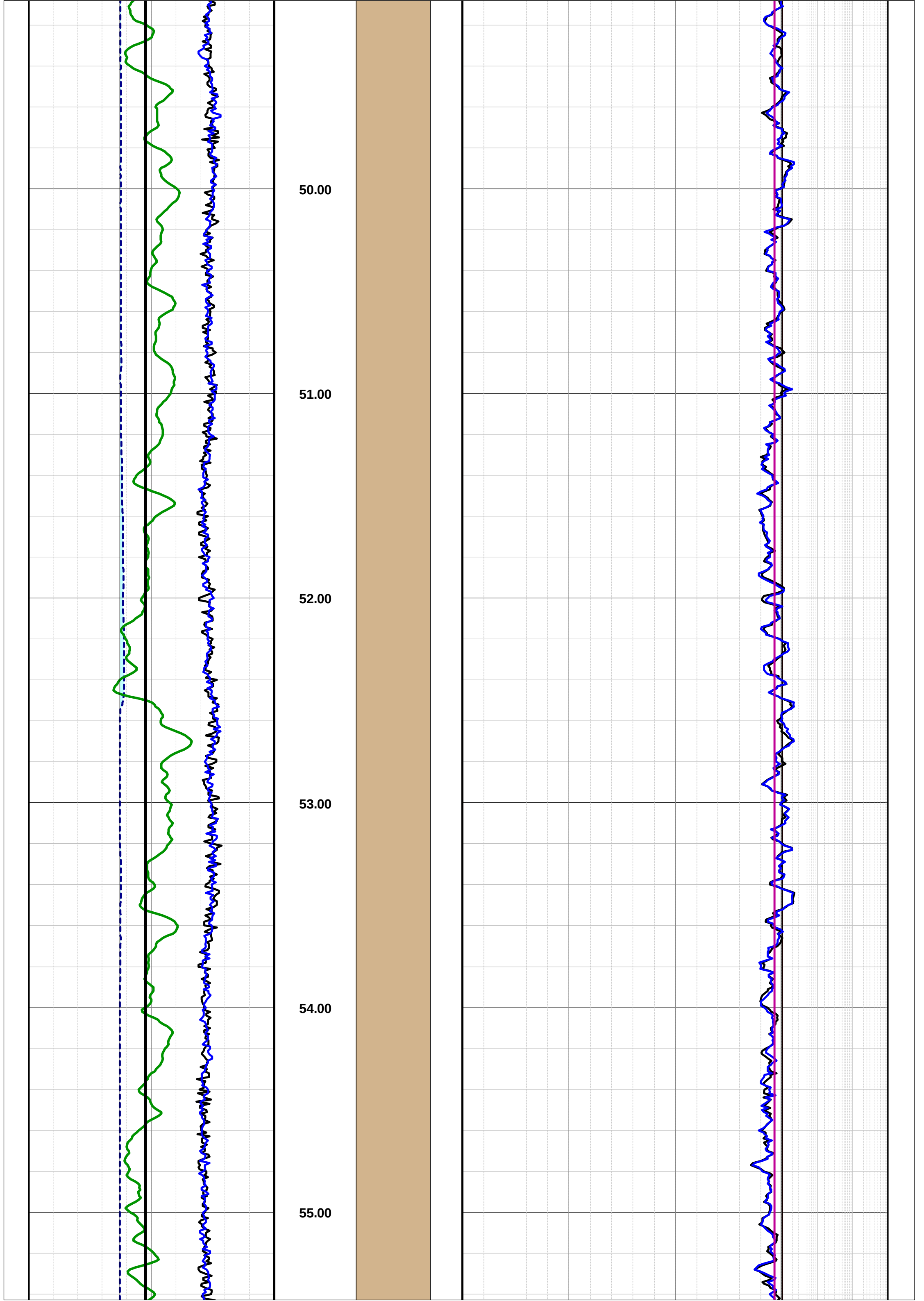
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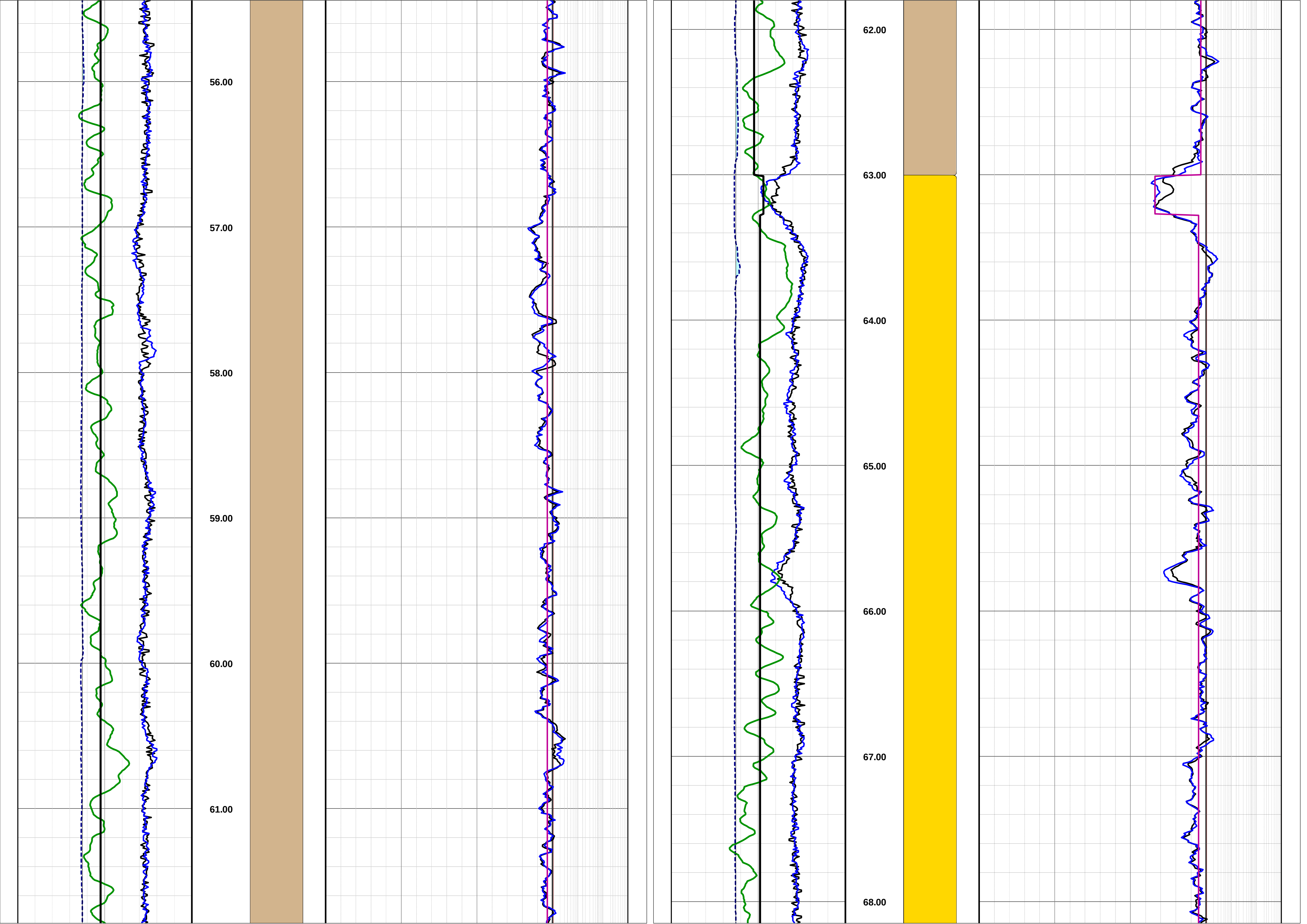
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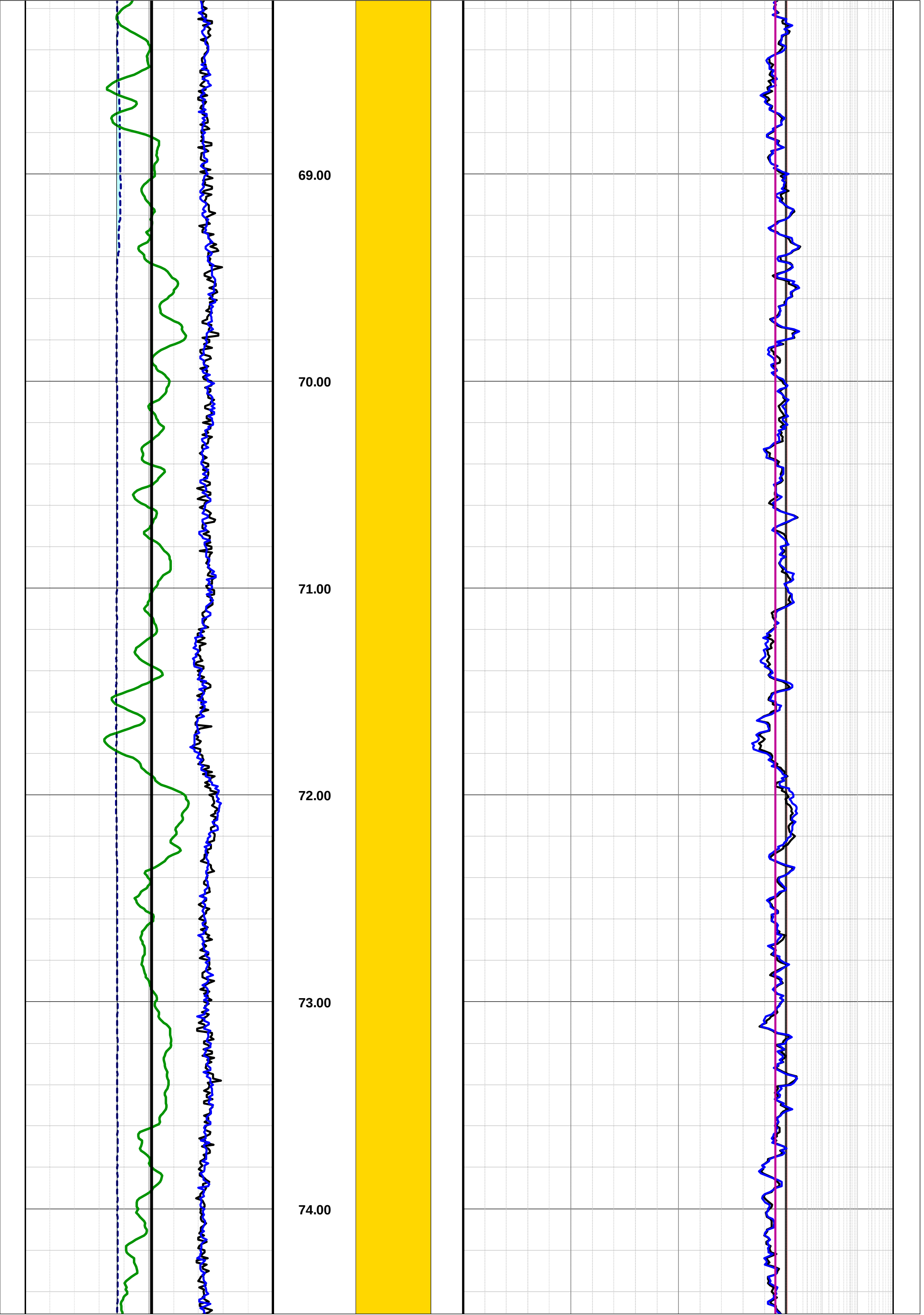
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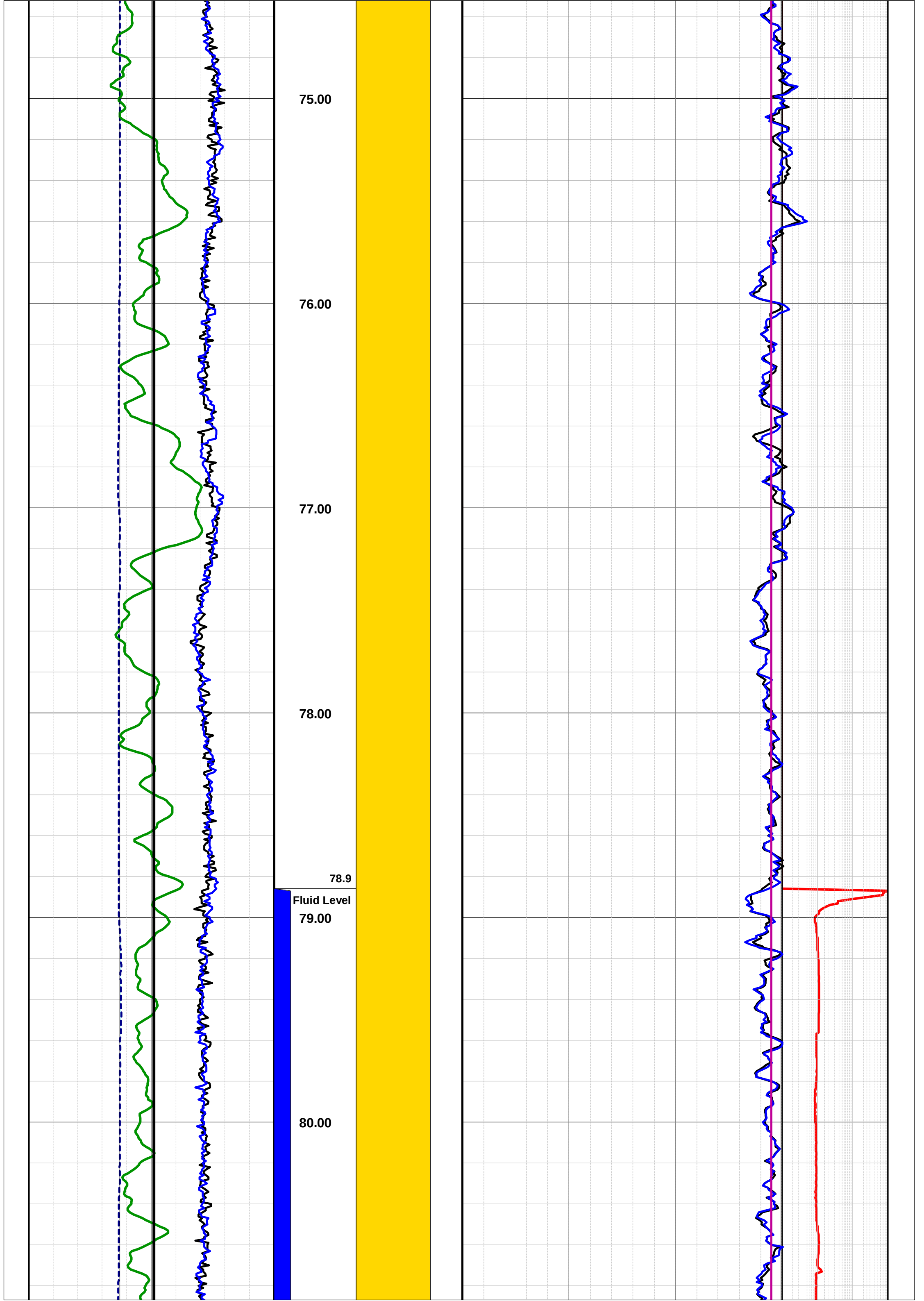
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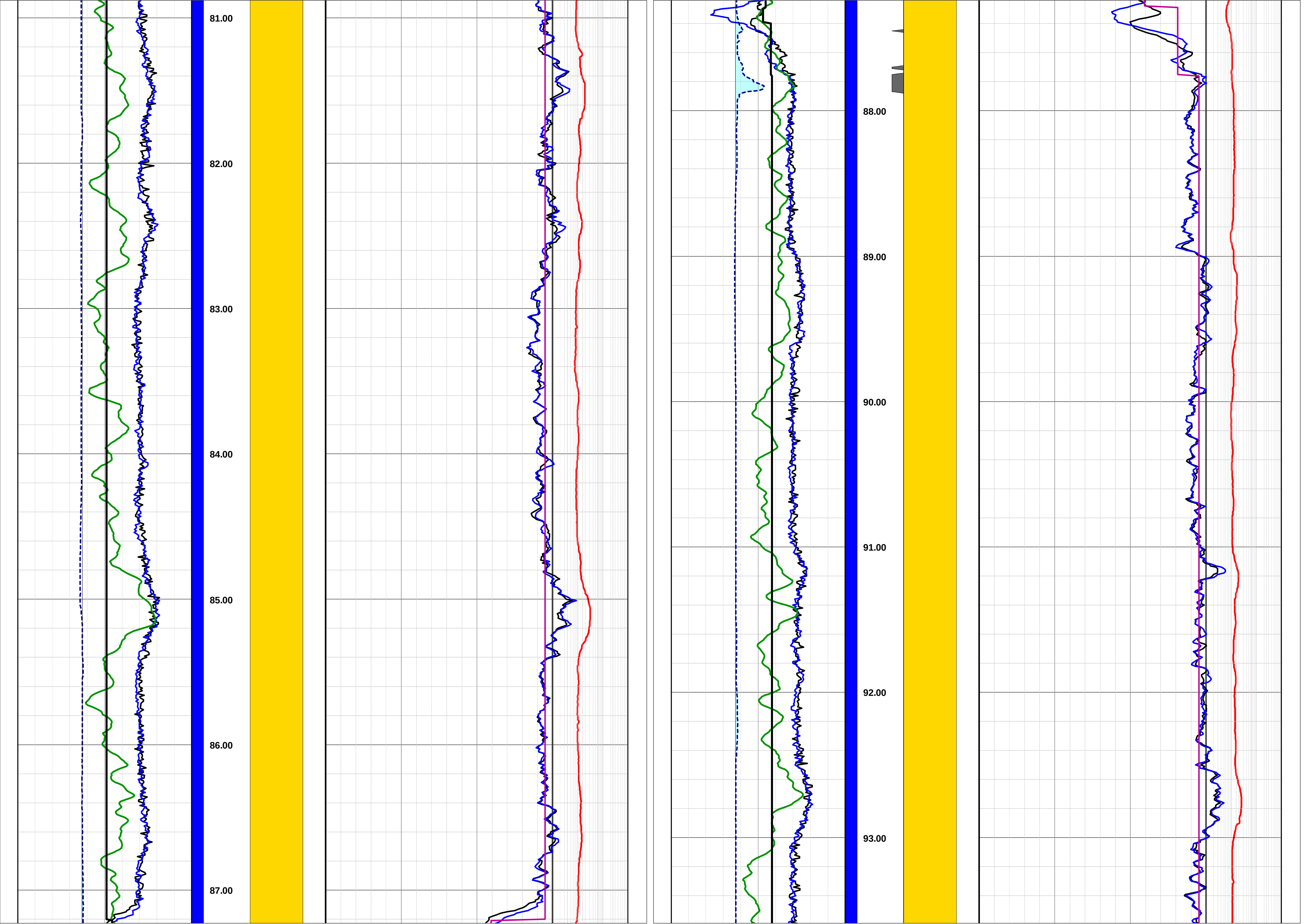

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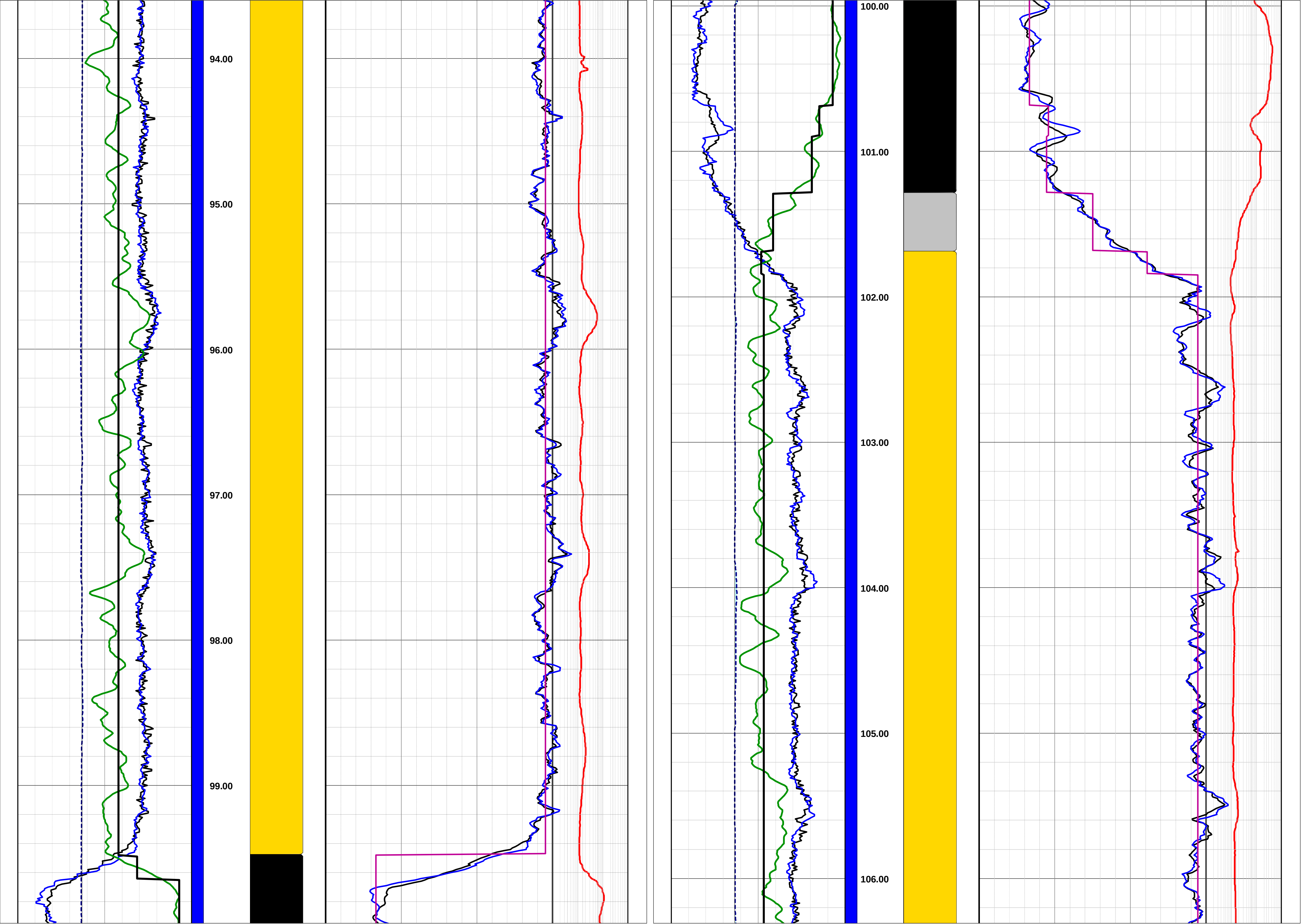
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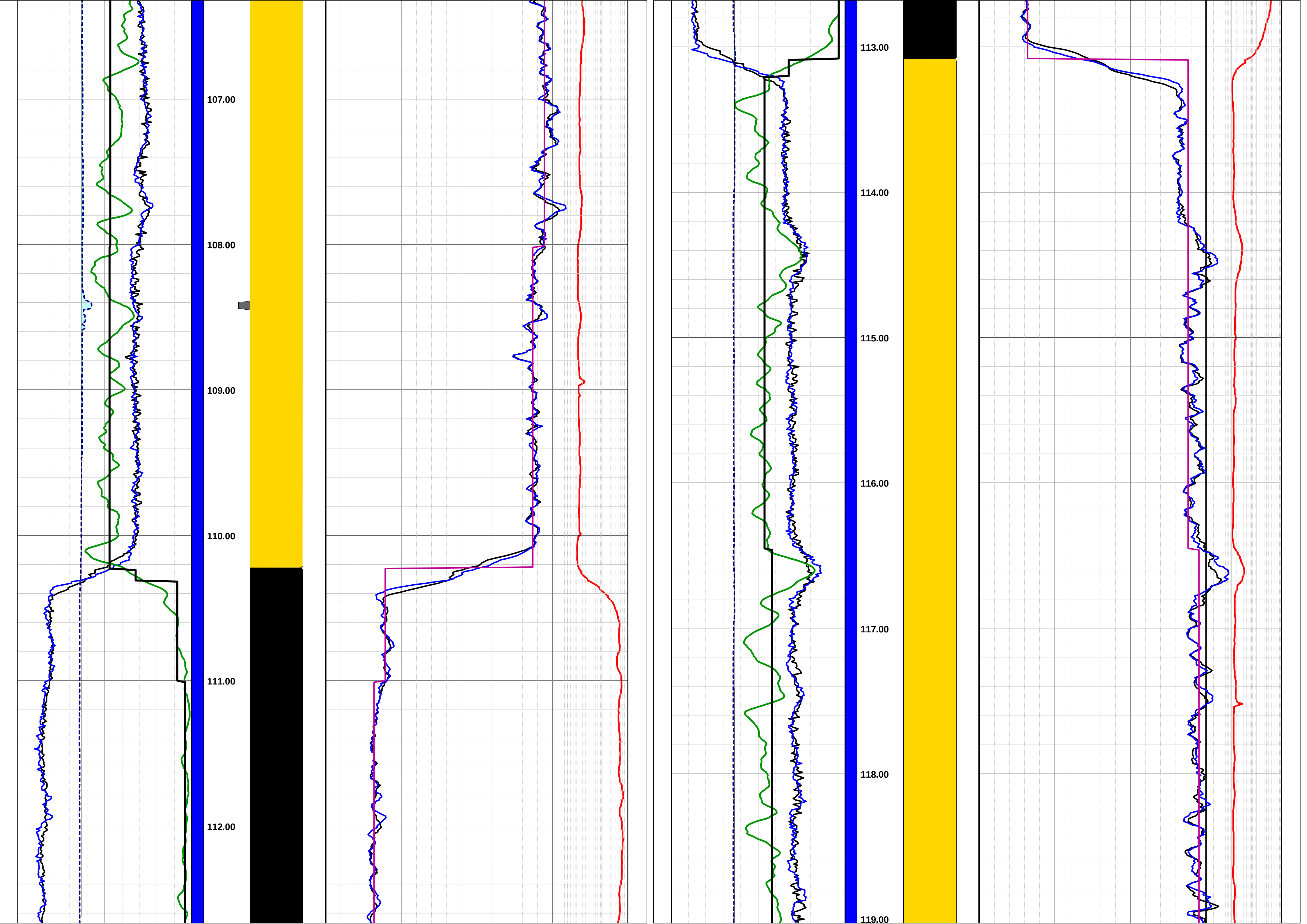
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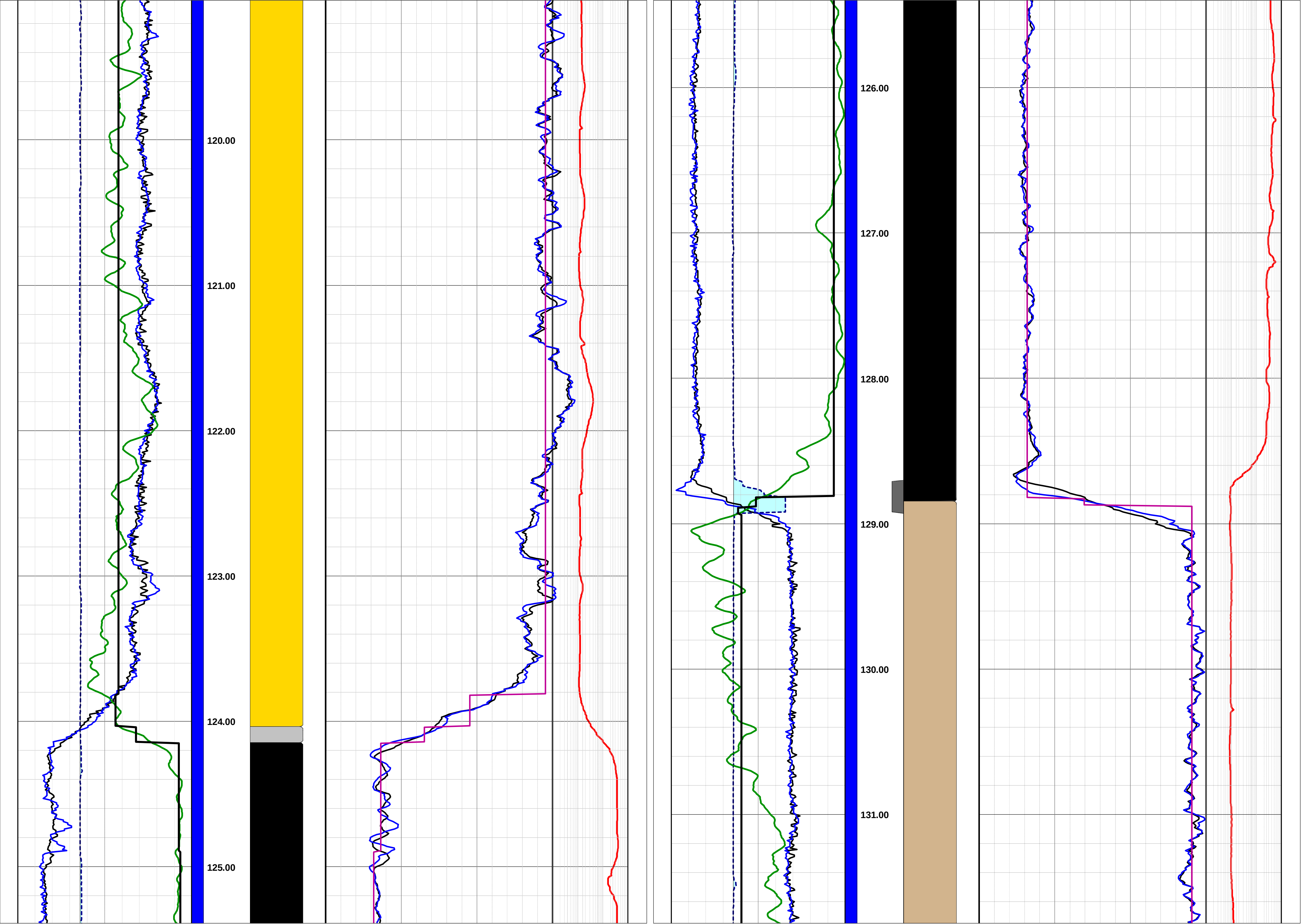
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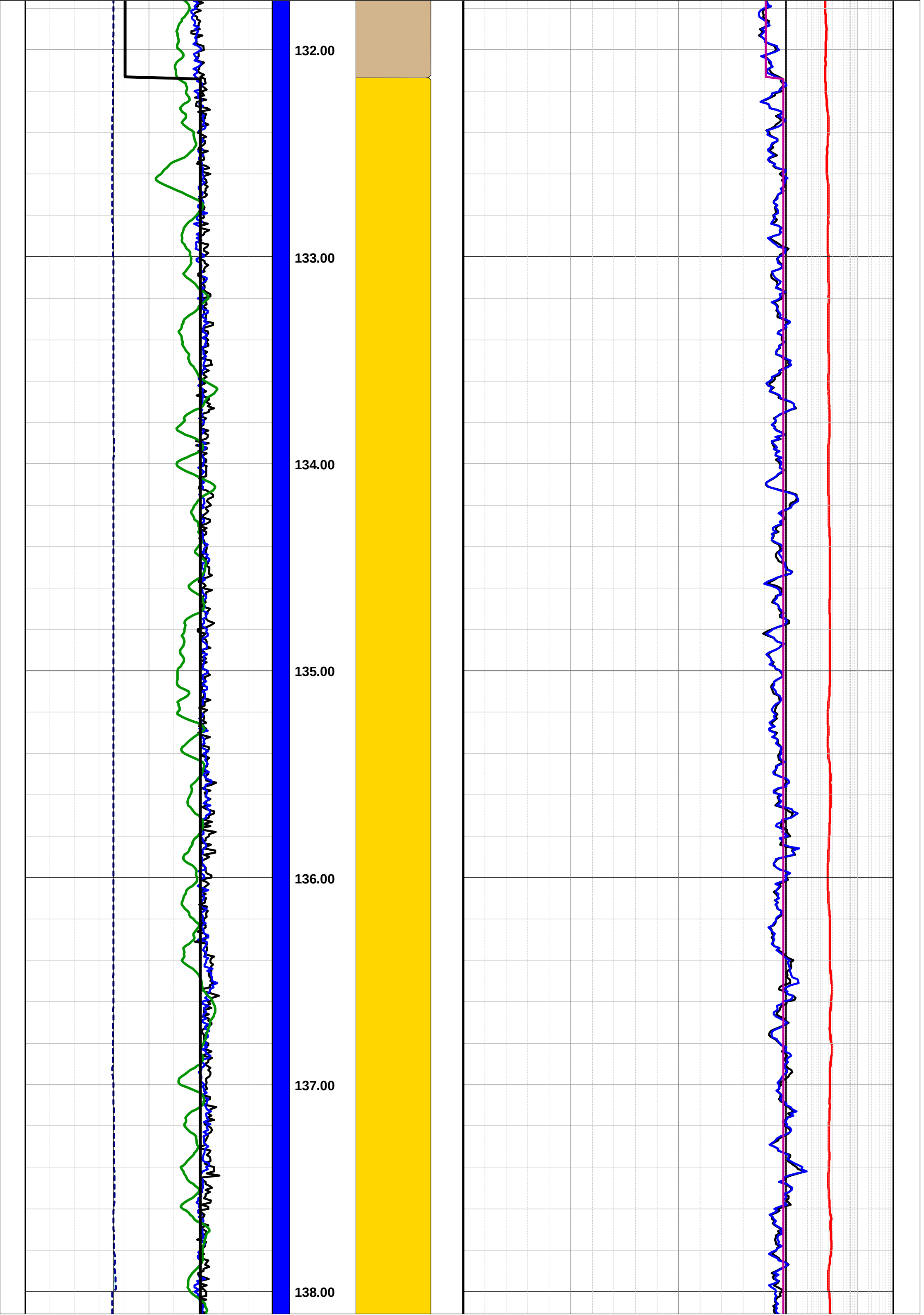
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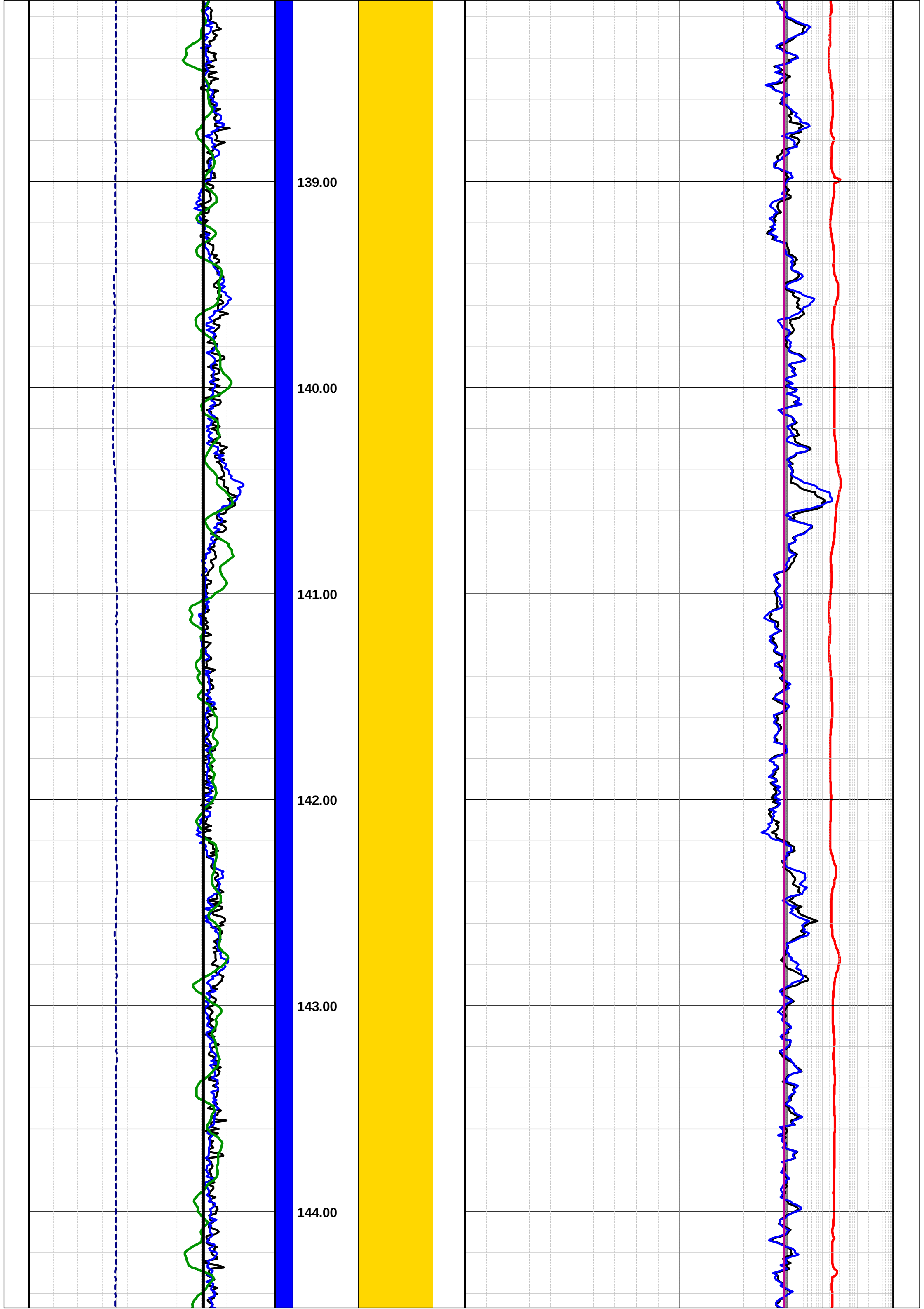
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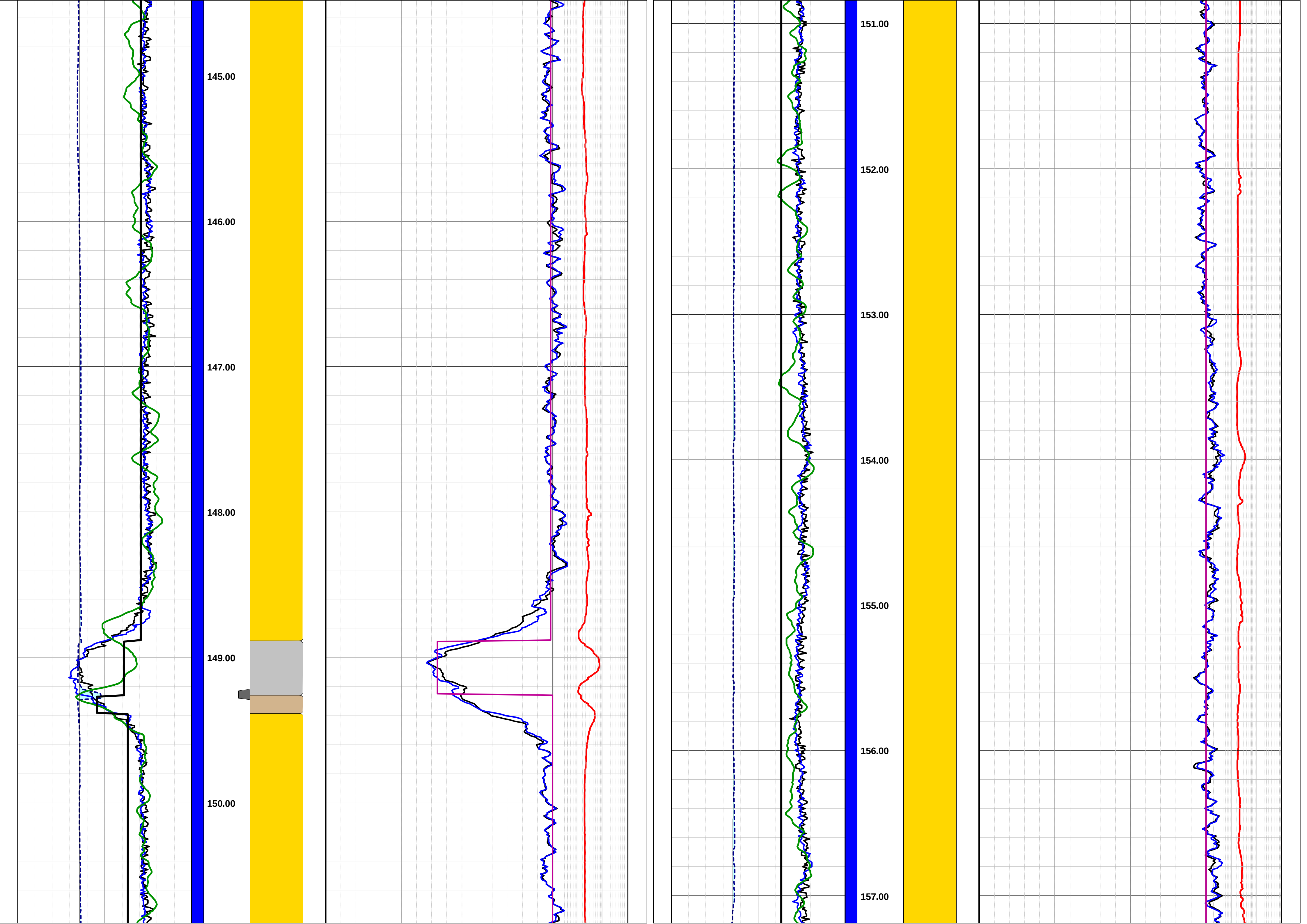
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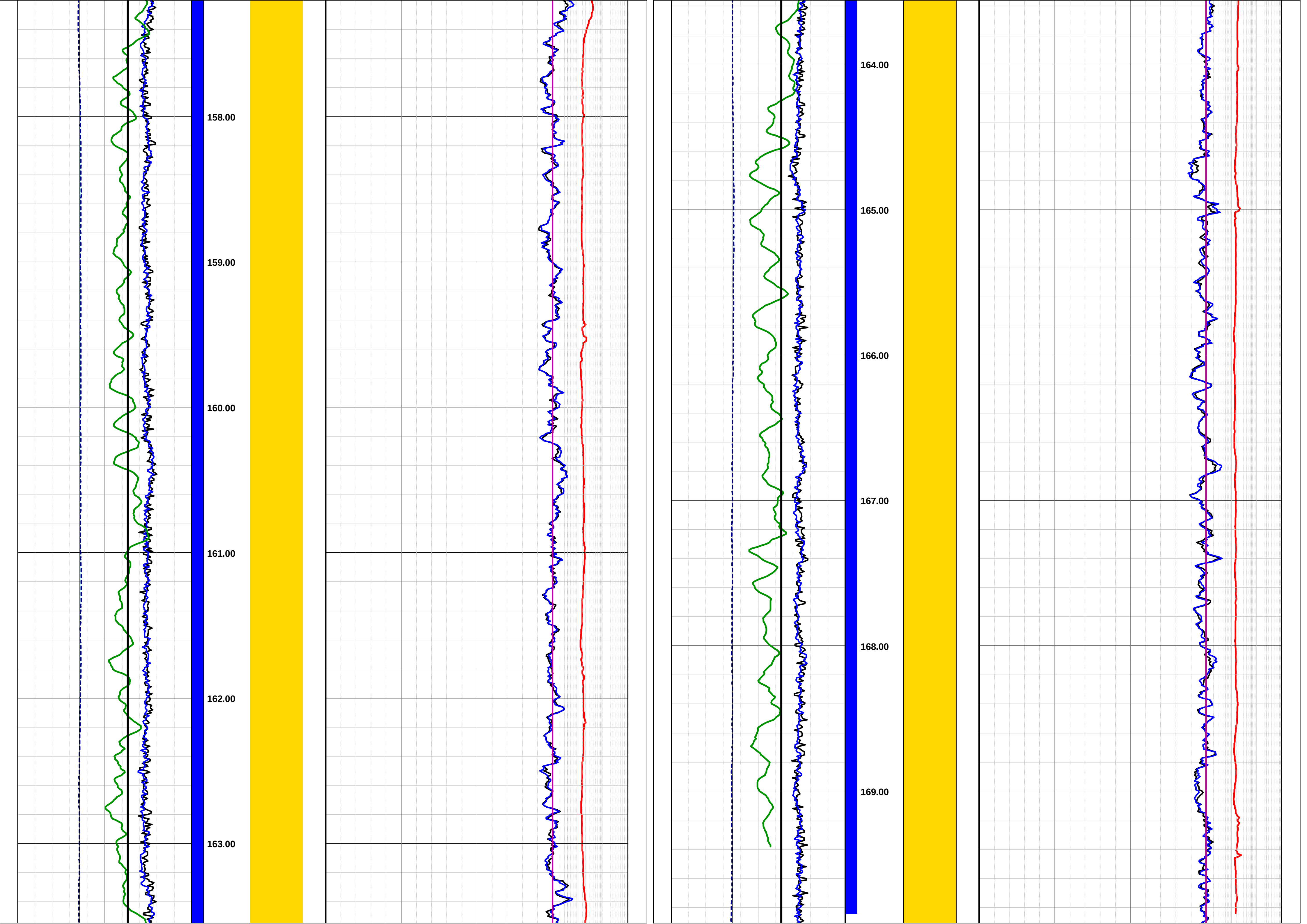
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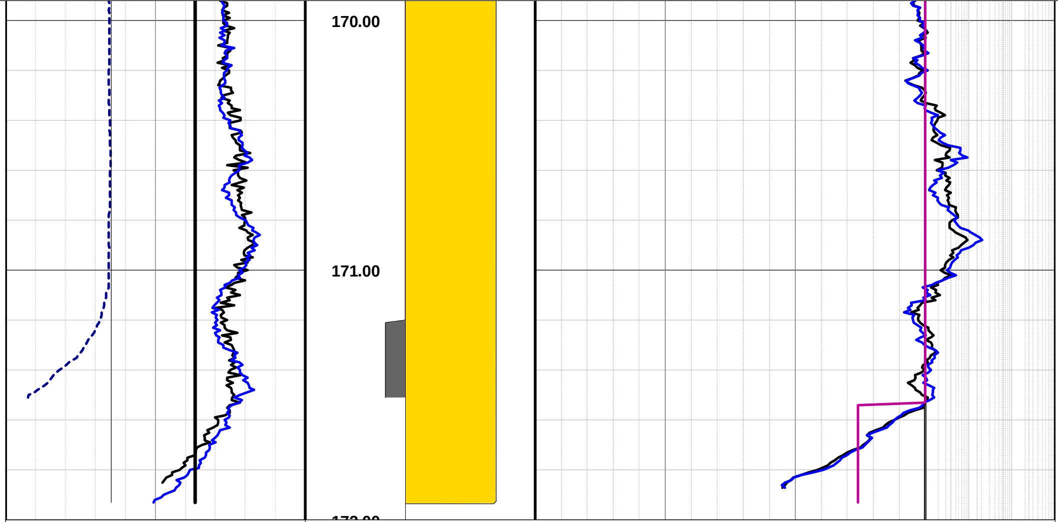


0 DEG 20 SANG			
200 API 0 GAM(NAT)			
50 mm 300 CALIPER	0 5 WT_FLAG	CASING	1 g/cc 3 DEN(ER)
1 g/cc 3 DEN(SS)	5 0 DATA_FLAG	LITHOLOGY	1 g/cc 3 DEN(COD)
1 g/cc 3 DEN(LS)	1m:20m Depth	COKED_COAL	1 OHM-M 1000 RES(SG)

DEPTH SCALE 1:20

LITHOLOGY LEGEND	
CO - Coal	S1 - Sandstone - very fine grained
CF - Inferior Coal	S2 - Sandstone - fine grained

COMPANY	BMA	**LOCATION**	VWP19BWM02
WELL	VWP19BWM02	**STATE**	QLD
FIELD	BLW	**COUNTRY**	AUSTRALIA

MPC KINETIC

QUICKLOOK LITHOLOGY LOG

VWP19BWM02

Appendix B Monitoring bore construction logs

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

BOREHOLE LOG

MB19BWM01P

PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **12/11/2019**
LOGGED BY: **Cameron Hall**

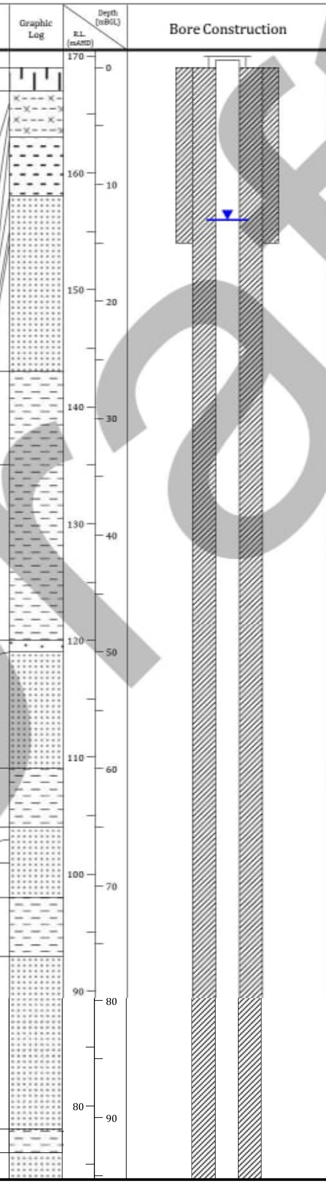
DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **192 mBGL**
GL ELEVATION: **169 mAHD**
EASTING: **690037 mE**
NORTHING: **7390281 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description

SOIL: medium plasticity, clay matrix, dark brown, stiff.
SILTY CLAY (85 %): low plasticity, brown, soft / GRAVEL (15 %): medium grained to fine grained, sub-rounded, quartz and lithic clasts, poorly graded, red / white, extremely weathered.
SILTY CLAY (70 %): medium plasticity, brownish grey, stiff / GRAVEL (30 %): medium grained to fine grained, rounded, lithic clasts, poorly graded, red / white / black, extremely weathered.
SILTY CLAY (60 %): low plasticity, light brown, stiff / GRAVEL (40 %): fine gravel to fine grained, sub-rounded, lithic clasts, well graded, red / white / black, distinctly weathered.
CLAYSTONE: light brown, slightly weathered.
SANDSTONE: bluish grey / brown, slightly weathered, some grey clay.
SANDSTONE: bluish grey / brown, slightly weathered, damp.
SANDSTONE: / grey, moist.
SILTSTONE: grey, low strength.
SILTSTONE: dark grey, medium strength, thin sandstone layers throughout.
QUARTZITE: white / brown, wet.
SANDSTONE: silty matrix, light grey, granular.
SILTSTONE: dark grey, thin light grey sandstone throughout.
SANDSTONE: light grey, granular.
SANDSTONE: dark grey, granular, thin siltstone bands.
SANDSTONE: light grey, granular.
SILTSTONE: dark grey.
SANDSTONE: light grey, granular, thin dark grey siltstone layers.
SILTSTONE: dark grey, thin light grey sandstone layers.
SANDSTONE: light grey, granular.



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.6 m
300 mm Blade: 0 m to 15 m (Air Rotary)
200 mm (203) uPVC Class 12 (11.1 mm) surface casing: 0 m to 15 m
Water level: 13.05 m bgl on 17/12/2019
Bentonite grout (2 %): 0 m to 163 m
50 mm uPVC Class 18 blank casing: 0 m to 168 m

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

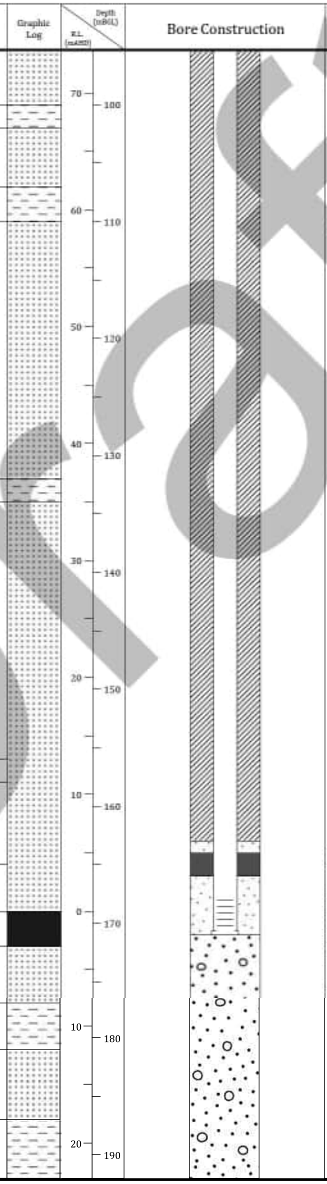
BOREHOLE LOG

MB19BWM01P

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **192 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **169 mAHD**
DATE DRILLED: **12/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **690037 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7390281 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SANDSTONE: light grey, granular.
SILTSTONE: dark grey.
SANDSTONE: silty matrix, light grey, granular.
SILTSTONE: dark grey.
SANDSTONE: light grey, granular, thin dark grey siltstone layers.
SILTSTONE: dark grey, carbonaceous.
SANDSTONE: silty matrix, light grey, granular.
SANDSTONE: brown / grey, granular.
SANDSTONE: very fine grained, light grey, granular, thin dark grey siltstone layers.
SANDSTONE: very fine grained, light grey.
COAL: black.
SANDSTONE: grey, thin carbonaceous siltstone bands.
SILTSTONE: dark grey / black, thin carbonaceous siltstone bands and some thin coal layers.
SANDSTONE: silt to very fine grained, light grey.
SILTSTONE: dark grey, some thin sandstone layers.



Bore Description

170 mm PCD: 15 m to 192 m (Air rotary)

Fine gravel (1 mm): 163 m to 164 m
Bentonite seal: 164 m to 166 m

5 mm washed, rounded, quartz gravel pack: 166 m to 171 m
50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 168 m to 171 m

Bore development: 3 hours 5 mins; EC: 27,350 µS/cm; pH: 8.24
Airlift flow rate: 0.01 L/s
Dark grey, coals fines. Development incomplete due to low flows.

Backfill / hole collapse: 171 m to 192 m

End cap
End of hole: 192 m BGL

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

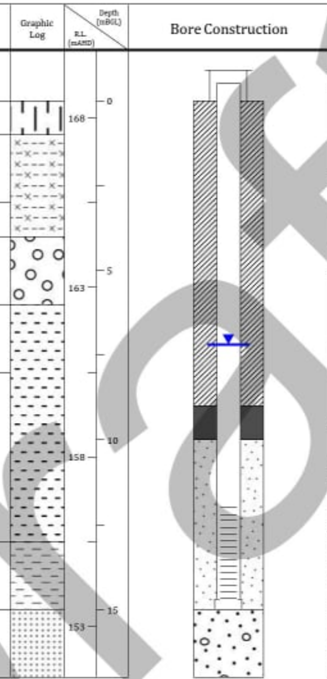
BOREHOLE LOG

MB19BWM02A

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **17 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **168 mAHD**
DATE DRILLED: **15/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **690127 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7390182 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SOIL: low plasticity, clay matrix, dark brown, trace amounts of fine sand sized lithic clasts.
SILTY CLAY: medium plasticity, reddish brown, firm.
SILTY CLAY: high plasticity, brown, stiff.
GRAVEL (60 %): fine grained to medium grained, sub-angular, lithic clasts, brown / red / grey, extremely weathered, / CLAY (40 %): medium plasticity, light brown, soft.
CLAYSTONE: brown / red, distinctly weathered.
CLAYSTONE: light brown, slightly weathered.
SILTSTONE: brown / grey / green, low strength, slightly weathered, damp.
SANDSTONE: silt to very fine grained, light grey, low strength, fresh, moist.



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.5 m

170 mm PCD: 0 m to 17.1 m (Air Rotary)

Bentonite grout (2 %): 0 m to 9 m

50 mm uPVC Class 18 blank casing: 0 m to 12 m

Water level: 7.18 m bgl on 17/12/2019

Bentonite seal: 9 m to 10 m

5 mm washed, rounded, quartz gravel pack: 10 m to 15 m

50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 12 m to 15 m

Open hole flow rate at 17 m: 0.1 L/s
Bore development: 1 hr 9 mins; EC: 36,630 µS/cm; pH: 7.86
Airlift flow rate: 0.05 L/s
End cap

Gravel backfill: 16 m to 17.1 m

End of hole: 17.1 m BGL

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BOREHOLE LOG

MB19BWM03P

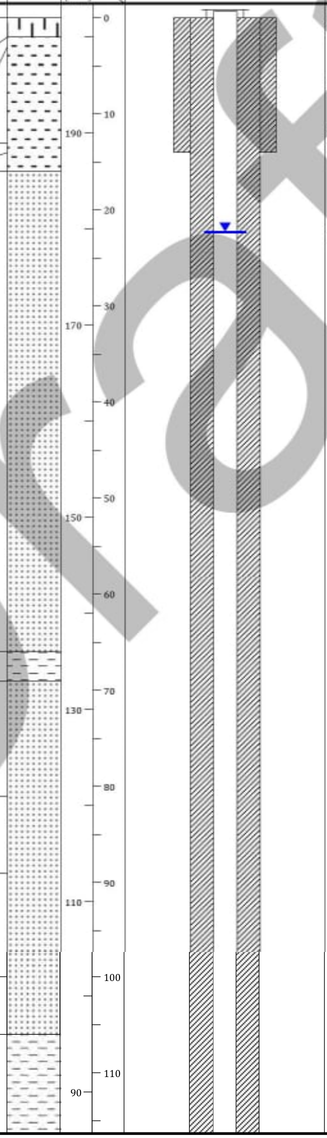
PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **7/11/2019**
LOGGED BY: **Cameron Hall**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **234 mBGL**
GL ELEVATION: **202 mAHD**
EASTING: **688454 mE**
NORTHING: **7383473 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description



Soil or Rock Field Material Description:

- SOIL: low plasticity, very fine grained, clay matrix, dark brown.
- CLAYSTONE: lithic clasts, brown, very low strength, extremely weathered.
- CLAYSTONE: brown, low strength, distinctly weathered.
- CLAYSTONE: brown, medium strength, slightly weathered.
- CLAYSTONE: brown / grey, some thin layers of sandstone.
- SANDSTONE: very fine grained, grey.
- SILTSTONE: brown.
- SANDSTONE: grey.
- SANDSTONE: fine grained, light grey.
- SANDSTONE: very fine grained, grey.
- SANDSTONE: fine grained, light grey.
- SILTSTONE: grey, some thin carbonaceous bands.

Bore Description:

- Protective lockable steel collar: +0.9 m
- Stick up: +0.65 m
- 300 mm Blade: 0 m to 14 m (Air Rotary)
- 200 mm (203) uPVC Class 12 (11.1 mm) surface casing: 0 m to 14 m
- Water level: 22.33 m bgl on 15/12/2019
- 50 mm uPVC Class 18 blank casing: 0 m to 222.5 m

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

BOREHOLE LOG

MB19BWM03P

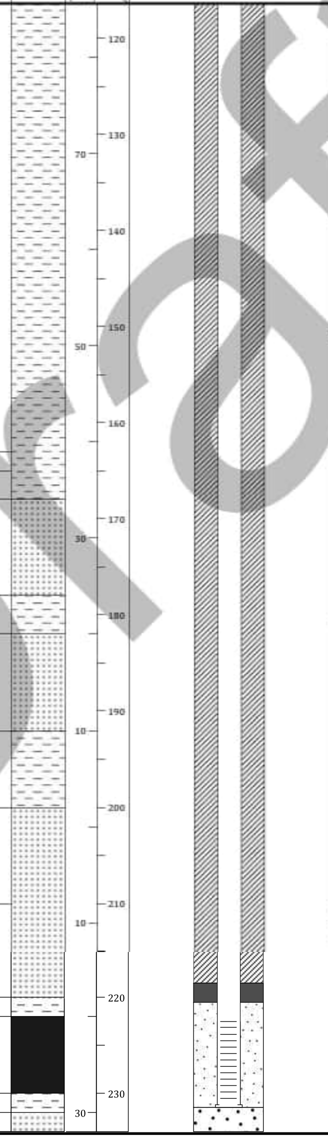
PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **7/11/2019**
LOGGED BY: **Cameron Hall**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **234 mBGL**
GL ELEVATION: **202 mAHD**
EASTING: **688454 mE**
NORTHING: **7383473 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description



Soil or Rock Field Material Description:

- SILTSTONE: grey, some thin carbonaceous bands.
- SILTSTONE: grey, some thin coal bands.
- SILTSTONE: brown, some thin carbonaceous bands.
- SANDSTONE: very fine grained, light grey.
- SILTSTONE: grey.
- SANDSTONE: very fine grained, light grey, some thin siltstone bands.
- SILTSTONE: grey, some thin carbonaceous bands.
- SANDSTONE: fine grained, light grey.
- SANDSTONE: very fine grained, light grey.
- SILTSTONE: dark grey, some thin carbonaceous bands.
- COAL: black.
- SILTSTONE: dark grey.
- SANDSTONE: very fine grained to fine grained, light grey.

Bore Description:

- 170 mm PCD: 14 m to 234 m (Air rotary)
- Bentonite grout (2 %): 0 m to 218.5 m
- Bore development: 1 hour 15 mins; EC: 21,170 µS/cm; pH: 8.33. Airlift flow rate: <0.01 L/s
- Dark grey, heavy sediment load. Development incomplete due to low flows.
- Bentonite seal: 218.5 m to 220.5 m
- 5 mm washed, rounded, quartz gravel pack: 220.5 m to 231.5 m
- 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 222.5 m to 231.5 m
- End cap. End of hole: 234 m BGL.
- Hole collapse: 231.5 m to 234 m

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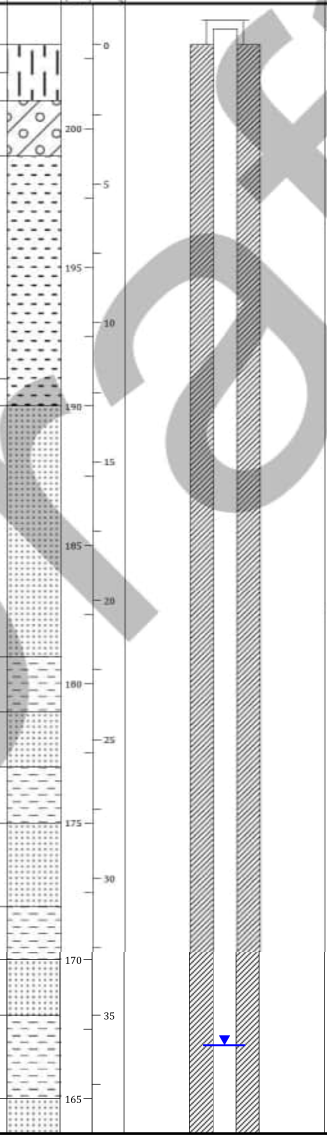
BOREHOLE LOG

MB19BWM04R

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **50 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **203 mAHD**
DATE DRILLED: **11/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **688315 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7383604 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SOIL: silt, clay matrix, dark brown, hard.				Protective lockable steel collar: +0.9 m Stick up: +0.55 m
SOIL: low plasticity, fine grained to medium grained, angular, lithic clasts, clay matrix, light brown, stiff.				
GRAVELLY CLAY: fine gravel to fine grained, sub-angular, lithic clasts, well graded, reddish brown, extremely weathered.				
CLAYSTONE: fine grained to very fine grained, quartz and lithic clasts, mottled brown / grey / red, slightly weathered.				
CLAYSTONE: light brown, trace red lithic clasts.				
SANDSTONE: very fine grained to silt, quartz and lithic clasts, light grey.				170 mm PCD: 0 m to 80 m (Air Rotary)
SILTSTONE: silt, grey.				
SANDSTONE: light grey, trace silt particles.				
SILTSTONE: grey.				
SANDSTONE: light grey, trace silt particles.				
SILTSTONE: grey.				
SANDSTONE: light grey, trace silt particles.				
SILTSTONE: grey.				Water level: 36.09 m bgl on 15/12/2019
SANDSTONE: light grey.				



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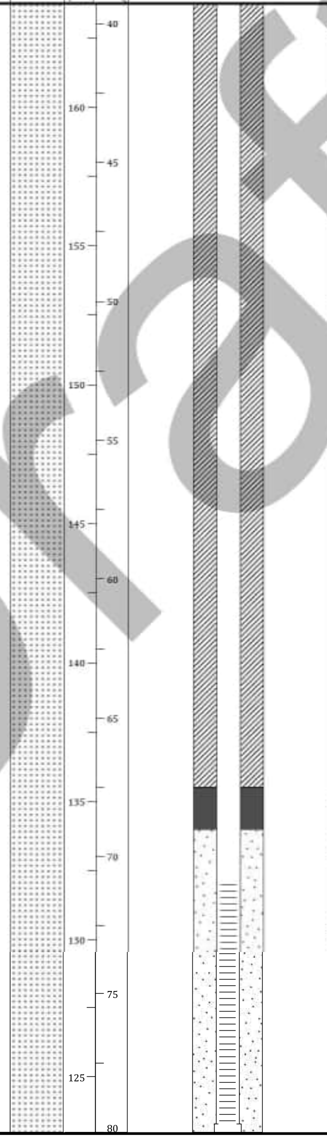
BOREHOLE LOG

MB19BWM04R

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **50 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **203 mAHD**
DATE DRILLED: **11/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **688315 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7383604 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	Depth (mBGL) / R.L. (mAHD)	Bore Construction	Bore Description
SANDSTONE: light grey.				Bentonite grout (2 %): 0 m to 67.5 m 50 mm uPVC Class 18 blank casing: 0 m to 71 m Bentonite seal: 67.5 m to 69 m 5 mm washed, rounded, quartz gravel pack: 69 m to 80 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 71 m to 80 m Bore development: 30 mins; EC: 39,470 µS/cm; pH: 6.8 Airlift flow rate: very low flow - dry Grey, high sediment load. Development incomplete. End cap End of hole: 80 m BGL



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BOREHOLE LOG

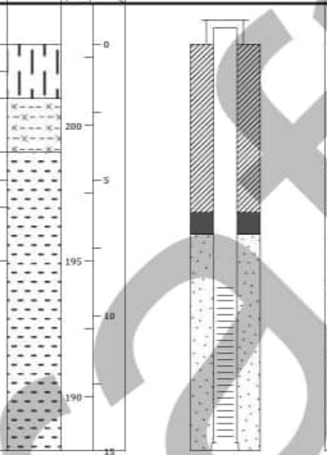
MB19BWM05A

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **15 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **203 mAHD**
DATE DRILLED: **7/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **688501 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7383611 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SOIL: silty matrix, dark brown, hard.
SOIL: silty matrix, light orangey brown, hard.
SILTY CLAY: high plasticity, silty matrix, light brown.
CLAYSTONE: light brown, extremely weathered.
CLAYSTONE: brown, distinctly weathered.
CLAYSTONE: reddish brown, slightly weathered.
CLAYSTONE: light orangey brown, slightly weathered.

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



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.6 m

170 mm PCD: 0 m to 15 m (Air rotary)

Bentonite grout (2 %): 0 m to 6.2 m

Bentonite seal: 6.2 m to 7 m

50 mm uPVC Class 18 blank casing: 0 m to 9 m

5 mm washed, rounded, quartz gravel pack: 7 m to 15 m

50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 9 m to 15 m

Dry

End cap
End of hole: 15 m BGL

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BOREHOLE LOG

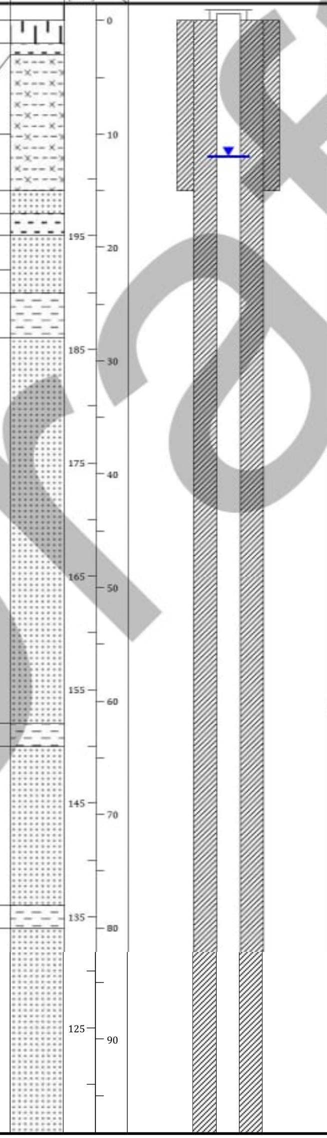
MB19BWM06P

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **192 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **214 mAHD**
DATE DRILLED: **5/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **697680 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7379450 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SOIL: high plasticity, clay matrix, dark brown, very stiff.
CLAYSTONE: reddish brown, low strength, distinctly weathered.
SILTY CLAY: greenish grey / brown, low strength, extremely weathered.
SILTY CLAY: greenish grey, low strength, distinctly weathered.
SANDSTONE: grey, slightly weathered.
CLAYSTONE: grey, fresh.
SANDSTONE: grey.
SANDSTONE: dark grey.
SILTSTONE: dark grey.
SANDSTONE: grey, high strength.
SILTSTONE: dark grey.
SANDSTONE: grey.
SILTSTONE: dark grey.
SANDSTONE: grey, thin carbonaceous layers.

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



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.55 m

300 mm Blade: 0 m to 15 m (Air Rotary)

200 mm (203) uPVC Class 12 (11.1 mm) surface casing: 0 m to 15 m

Water level: 12.02 m bgl on 16/12/2019

Bentonite grout (2 %): 0 m to 177 m

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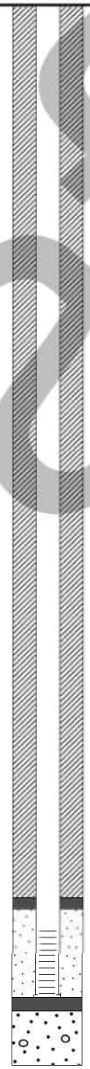
BOREHOLE LOG

MB19BWM06P

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **192 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **214 mAHD**
DATE DRILLED: **5/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **697680 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7379450 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
SANDSTONE: grey, thin carbonaceous layers.		115 / 100; 105 / 110; 95 / 120; 85 / 130		170 mm PCD: 15 m to 192 m (Air rotary) 50 mm uPVC Class 18 blank casing: 0 m to 180 m
SILTSTONE: dark grey, some thin coal bands.				
SANDSTONE: light grey.		75 / 140		
SANDSTONE: very fine grained, light grey.				
SANDSTONE: fine grained, light grey.		65 / 150		
SILTSTONE: dark grey.		55 / 160; 45 / 170		
SILTSTONE: black, carbonaceous.		35 / 180		Bentonite seal: 177 m to 178 m 5 mm washed, rounded, quartz gravel pack: 178 m to 186 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 180 m to 186 m Bore development: 58 mins; EC: 20,410 µS/cm; pH: 8.54. Airlift flow rate: 0.01 L/s Light grey, no sediment. Development incomplete due to low flows. Bentonite seal: 186 m to 187.2 m End cap. Gravel backfill: 187.2 m to 192 m End of hole: 192 m BGL
COAL: black.				
SANDSTONE: fine grained, grey.				
SANDSTONE: very fine grained, light grey.		25 / 190		



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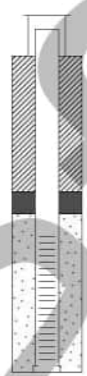
BOREHOLE LOG

MB19BWM07A

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **7 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **198 mAHD**
DATE DRILLED: **29/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **689279 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7376877 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
				Protective lockable steel collar: +0.9 m Stick up: +0.6 m
SOIL: medium plasticity, silty matrix, dark brown.		198 / 0		170 mm PCD: 0 m to 7 m (Air rotary) Bentonite grout (2 %): 0 m to 3 m 50 mm uPVC Class 18 blank casing: 0 m to 4 m
SOIL: medium plasticity, silty matrix, brown.				
GRAVEL: medium gravel to fine grained, sub-rounded to sub-angular, quartz and lithic clasts, well graded, silty matrix, white / red / black, very loose, damp.				Bentonite seal: 3 m to 3.5 m 5 mm washed, rounded, quartz gravel pack: 3.5 m to 7 m 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 4 m to 7 m
GRAVEL: coarse gravel to fine grained, sub-angular to angular, quartz and lithic clasts, well graded, silty matrix, white / red / black, very loose.		193 / 5		Dry End cap End of hole: 7 m BGL



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

BOREHOLE LOG

MB19BWM08P

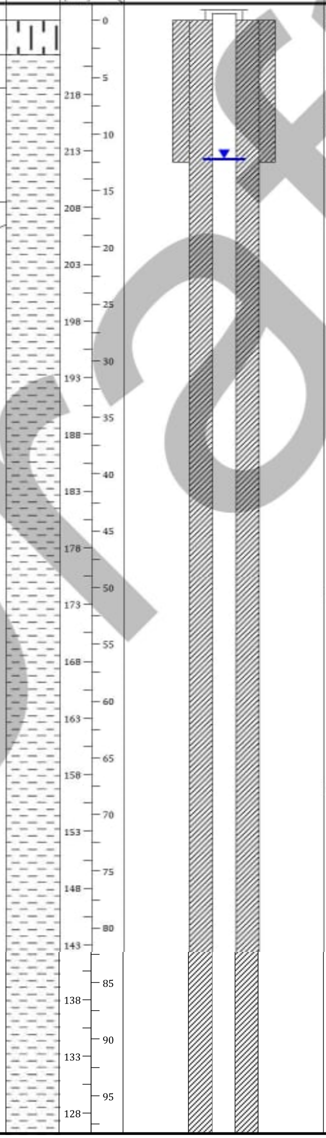
PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **16/10/2019**
LOGGED BY: **Peter Khor**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **198 mBGL**
GL ELEVATION: **224 mAHD**
EASTING: **691542 mE**
NORTHING: **7370739 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Bore Description
SILTY CLAY: low plasticity, clay matrix, dark greenish brown, residual soil, dry.	Protective lockable steel collar: +0.9 m Stick up: +0.6 m
SILTSTONE: dark reddish brown, low strength, extremely weathered, dry.	300 mm Blade: 0 m to 12.5 m (Air Rotary)
SILTSTONE: light reddish brown, low strength, distinctly weathered dry, Slow drilling < 0.5 m / 30 minutes @ 12 mBGL.	200 mm (203) uPVC Class 12 (11.1 mm) surface casing: 0 m to 12.5 m Water level: 12.23 m bgl on 19/12/2019
SILTSTONE: dark greenish grey, medium strength, distinctly weathered Inject water for drilling from 18 mBGL.	170 mm PCD: 12.5 m to 198 m (Air Rotary) Bentonite grout (2%): 0 m to 180 m
SILTSTONE: dark greenish grey, medium strength, fresh.	50 mm uPVC Class 18 blank casing: 0 m to 184 m



AGE **Australasian Groundwater & Environmental Consultants Pty Ltd**

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

BOREHOLE LOG

MB19BWM08P

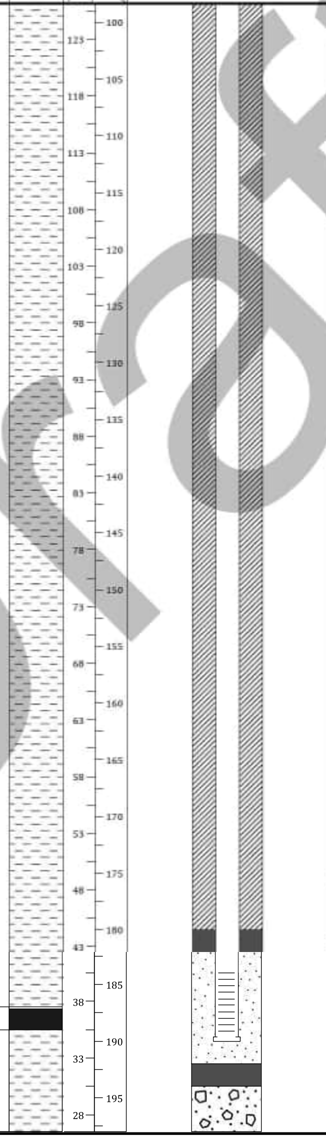
PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **16/10/2019**
LOGGED BY: **Peter Khor**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **198 mBGL**
GL ELEVATION: **224 mAHD**
EASTING: **691542 mE**
NORTHING: **7370739 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Bore Description
SILTSTONE: dark greenish grey, medium strength, fresh.	Open hole flow rate at 192 m: 0.035 L/s Bentonite seal: 180 m to 182 m 5 mm washed, rounded, quartz gravel pack: 182 m to 192 m Bore development: 2 hours; EC: 5,164 µS/cm; pH: 8.69 50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 184 m to 190 m
COAL: dark grey, low strength, fresh, Low density, oily sheen.	Airlift flow rate: 0.05 L/s. Clear.
SILTSTONE: dark grey, medium strength, fresh.	Bentonite seal: 192 m to 194 m Gravel backfill: 194 m to 198 m End of hole: 198 m BGL



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

BOREHOLE LOG

MB19BWM25P

PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **29/11/2019**
LOGGED BY: **Cameron Hall**

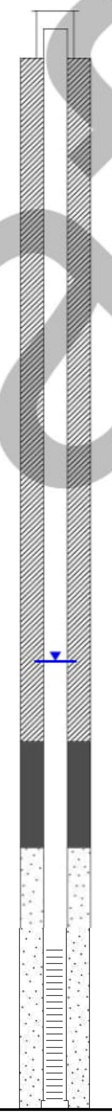
DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **20 mBGL**
GL ELEVATION: **192 mAHD**
EASTING: **689259 mE**
NORTHING: **7376879 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SOIL: medium plasticity, silty matrix, dark brown.
SILTY CLAY: low plasticity, brown.
SILTY CLAY (75 %): medium plasticity, brown / GRAVEL (25 %): fine gravel to fine grained, sub-rounded to rounded, quartz and lithic clasts, poorly graded, red / white / black, very loose.
SANDSTONE: fine grained, brown / grey, distinctly weathered.
SANDSTONE: very fine grained, grey / brown, slightly weathered.
SANDSTONE: very fine grained, light grey, medium strength, granular, damp at 17 m.

Bore Construction



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.55 m

170 mm PCD: 0 m to 20 m (Air rotary)

Bentonite grout (2 %): 0 m to 13 m

Water level: 11.47 m bgl on 16/12/2019

Bentonite seal: 13 m to 15 m

5 mm washed, rounded, quartz gravel pack: 15 m to 20 m

50 mm uPVC Class 18 machine slotted casing, slot aperture: 1 mm, slot length: 45 mm, 131 slots / m, 17 m to 20 m

Bore development: 1 hour 54 mins; EC: 7,389 µS/cm; pH: 8.64
Airlift flow rate: 0.01 L/s
Grey, high sediment load. Development incomplete due to low flows.
End cap
End of hole: 20 m BGL

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BOREHOLE LOG

MB19BWM27P

PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **18/12/2019**
LOGGED BY: **Cameron Hall**

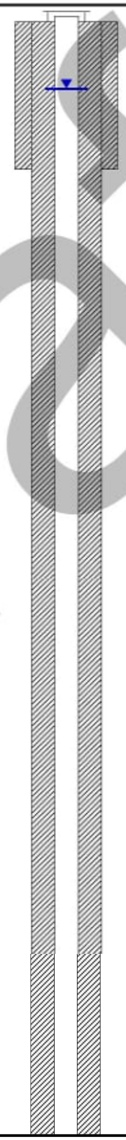
DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **198 mBGL**
GL ELEVATION: **198 mAHD**
EASTING: **688958 mE**
NORTHING: **7376559 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SILTY CLAY: low plasticity, clay matrix, dark greenish brown.
SAND: fine grained to medium grained, sub-rounded, well graded, silty matrix, orange / black.
SILTY CLAY: high plasticity, clay matrix, greyish orange.
GRAVEL: fine gravel, sub-angular, well graded, clay matrix, orange / black / red.
SAND: fine grained to medium grained, sub-rounded, well graded, silty matrix, orange / black.
GRAVEL: fine gravel, sub-angular, poorly graded, clay matrix, orange / black / red.
SAND: coarse grained, sub-angular, gap graded, silty matrix, black / grey / orange.
SILTSTONE: dark greenish grey, low strength, distinctly weathered.
SILTSTONE: dark greenish grey, low strength, slightly weathered.
SILTSTONE: dark greenish grey, medium strength, fresh, waterstrike at 30 mBGL.

Bore Construction



Bore Description

Protective lockable steel collar: +0.9 m
Stick up: +0.5 m

300 mm Blade: 0 m to 13 m (Air Rotary)

200 mm (203) uPVC Class 12 (11.1 mm) surface casing: 0 m to 13 m

170 mm PCD: 13 m to 200 m (Air Rotary)

Australasian Groundwater & Environmental Consultants Pty Ltd

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

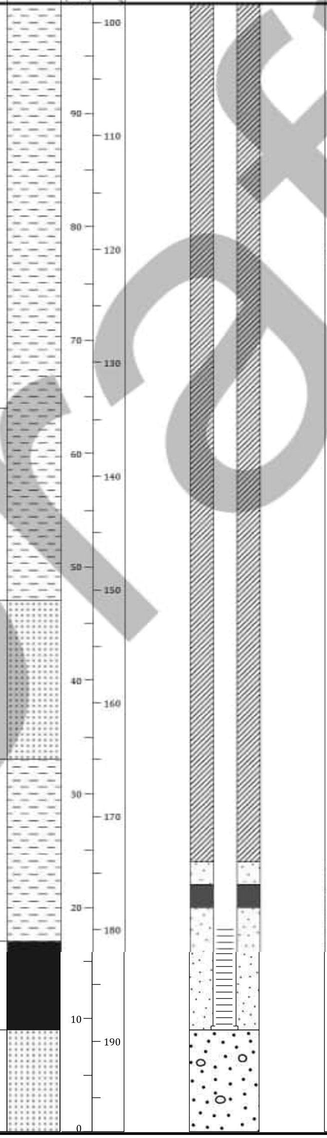
BOREHOLE LOG

MB19BWM27P

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **198 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **198 mAHD**
DATE DRILLED: **18/12/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **688958 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7376559 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description



Soil or Rock Field Material Description

- SILTSTONE: dark greenish grey, medium strength, fresh, waterstrike at 30 mBGL.
- SILTSTONE (50 %): dark greenish grey, medium strength, fresh / SANDSTONE (50 %): light greenish grey, medium strength, fresh.
- SANDSTONE: light greenish grey, medium strength, fresh.
- SILTSTONE: dark greenish grey, medium strength, fresh.
- COAL: dark black, low strength, fresh.
- SANDSTONE: light greenish grey, medium strength, fresh.

Bore Description

Bentonite grout (2 %): 0 m to 174 m

50 mm uPVC Class 18 blank casing: 0 m to 180 m

Fine gravel (1 mm): 174 m to 176 m

Bentonite seal: 176 m to 178 m

5 mm washed, rounded, quartz gravel pack: 178 m to 189 m

50 mm uPVC Class 18 machine slotted casing
slot aperture: 0.5 mm, slot length: 45 mm, 131 slots / m, 180 m to 189 m

Bore development: 2 hours 23 mins; EC: 14,740 µS/cm; pH: 8.76

Airlift flow rate: 0.05 L/s

Clear

End cap

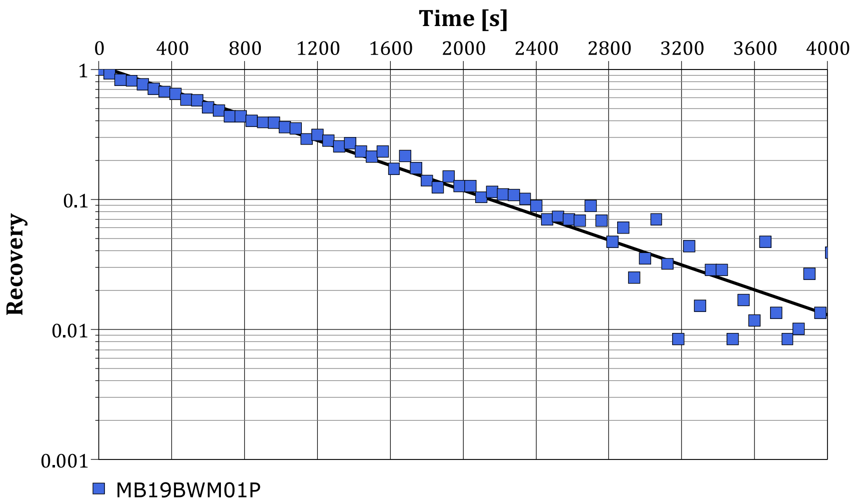
Hole collapse: 189 m to 200 m

End of hole: 200 m BGL

Appendix C Permeability test results

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: FHT	Test Well: MB19BWM01P
Test Conducted by: Cameron Hall		Test Date: 17/12/2019
Analysis Performed by: Cameron Hall	MB19BWM01P_FHT	Analysis Date: 5/02/2020
Aquifer Thickness: 3.00 m		

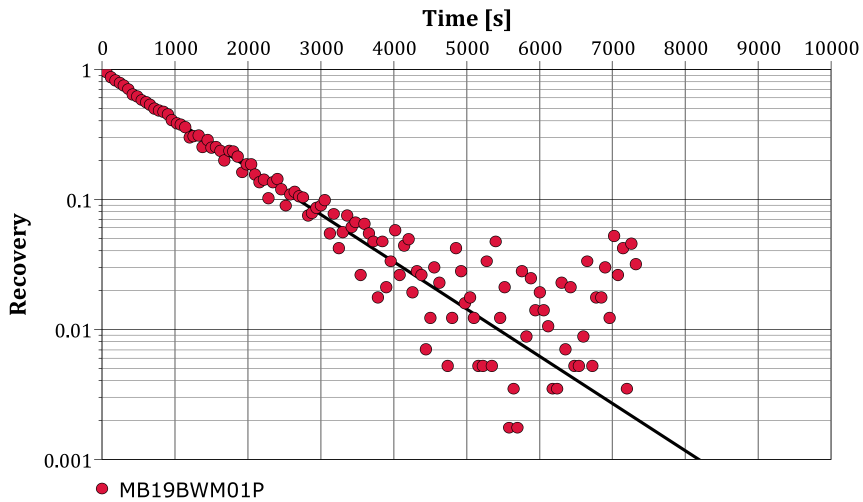


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM01P	3.70×10^{-2}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM01P_RHT	Test Well: MB19BWM01P
Test Conducted by: Cameron Hall		Test Date: 17/12/2019
Analysis Performed by: Cameron Hall	MB19BWM01P	Analysis Date: 5/02/2020
Aquifer Thickness: 3.00 m		

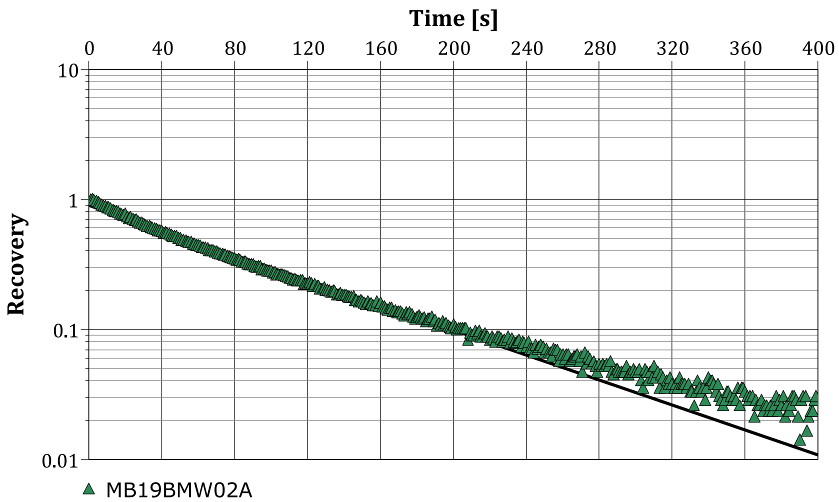


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM01P	2.80×10^{-2}	

Slug Test Analysis Report	
Project:	Blackwater Mine
Number:	G1679C
Client:	BMA

Location: Blackwater QLD	Slug Test: MB19BWM02A_FHT	Test Well: MB19BMW02A
Test Conducted by: Cameron Hall		Test Date: 17/12/2019
Analysis Performed by: Cameron Hall	MB19BWM02A_FHT	Analysis Date: 5/02/2020
Aquifer Thickness: 3.00 m		

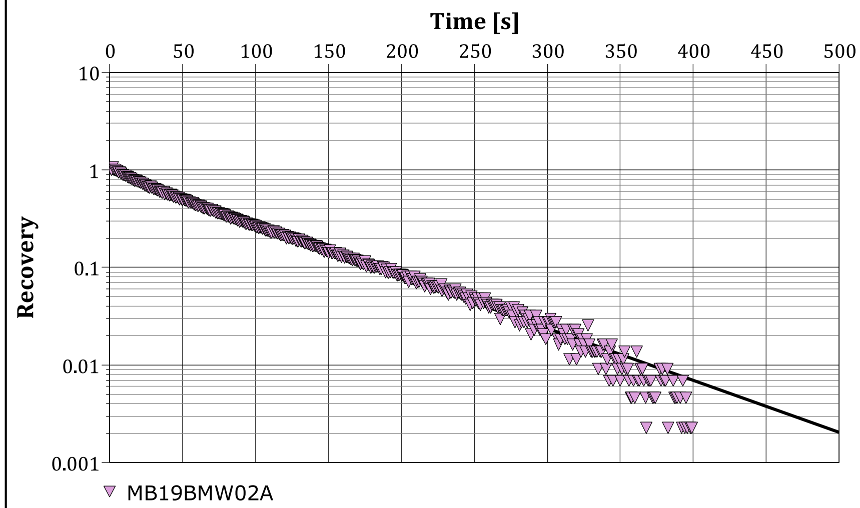


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BMW02A	3.70×10^{-1}	

Slug Test Analysis Report	
Project:	Blackwater Mine
Number:	G1679C
Client:	BMA

Location: Blackwater QLD	Slug Test: MB19BWM02A_RHT	Test Well: MB19BMW02A
Test Conducted by: Cameron Hall		Test Date: 17/12/2019
Analysis Performed by: Cameron Hall	MB19BWM02A_RHT	Analysis Date: 5/02/2020
Aquifer Thickness: 3.00 m		

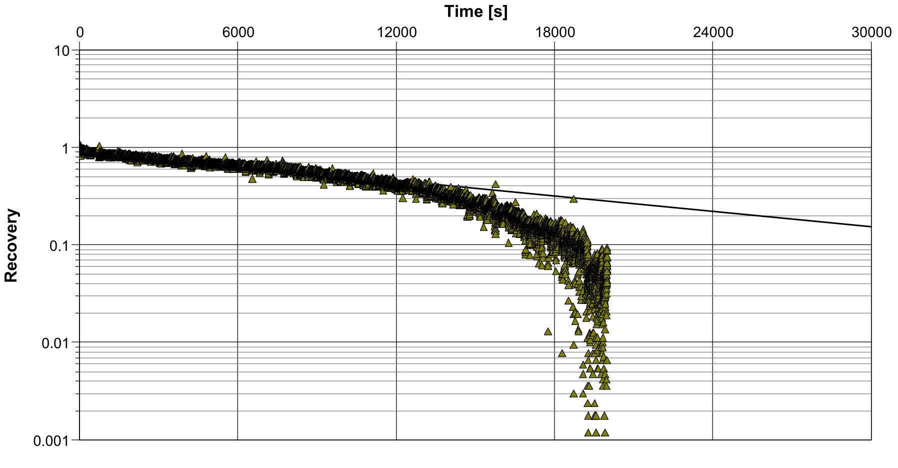


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BMW02A	4.10×10^{-1}	

Slug Test Analysis Report	
Project: Blackwater Mine	
Number: G1679C	
Client: BMA	

Location: Blackwater QLD	Slug Test: MB19BWM03P_FHT	Test Well: MB19BWM03P
Test Conducted by: Cameron Hall		Test Date: 15/12/2019
Analysis Performed by: Cameron Hall	MB19BWM03P_FHT	Analysis Date: 18/05/2020
Aquifer Thickness: 9.00 m		

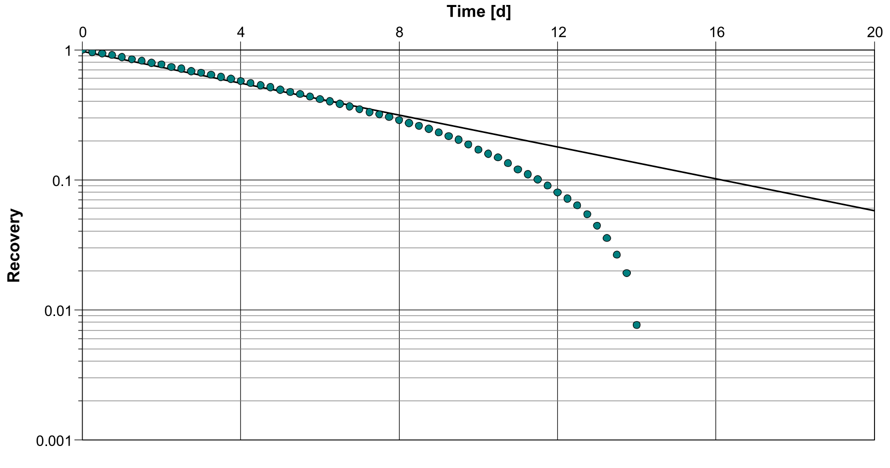


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM03P	8.50×10^{-4}	

Slug Test Analysis Report	
Project: Blackwater Mine	
Number: G1679C	
Client: BMA	

Location: Blackwater QLD	Slug Test: MB19BWM03P_RHT	Test Well: MB19BWM03P
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM03P_Recovery_RHT	Analysis Date: 18/05/2020
Aquifer Thickness: 9.00 m		

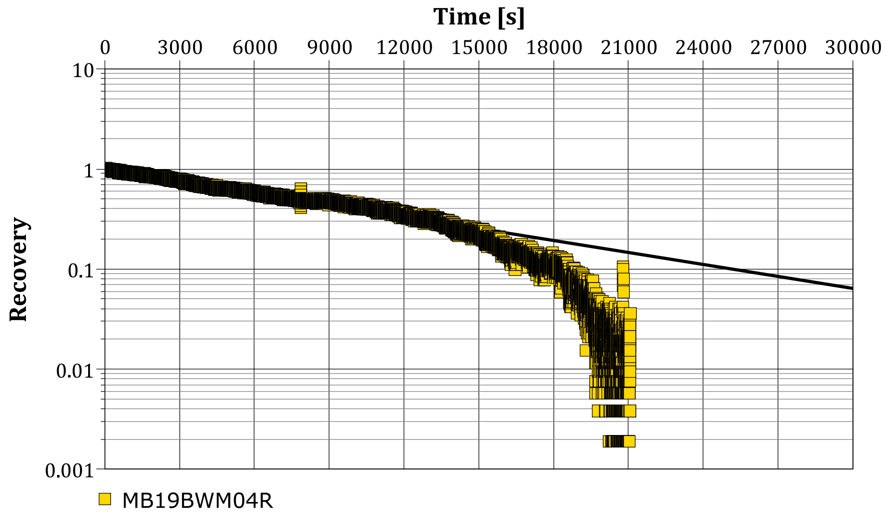


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM03P	2.90×10^{-5}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM04R_FHT	Test Well: MB19BWM04R
Test Conducted by: Cameron Hall		Test Date: 15/12/2019
Analysis Performed by: Joshua Yu	MB19BWM04R_FHT	Analysis Date: 5/02/2020
Aquifer Thickness: 9.00 m		

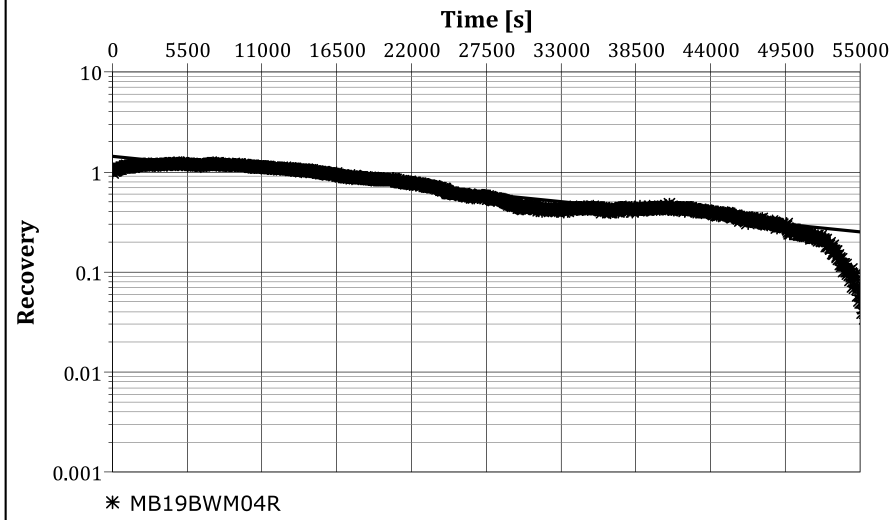


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM04R	1.30×10^{-3}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM04R_RHT	Test Well: MB19BWM04R
Test Conducted by: Cameron Hall		Test Date: 15/12/2019
Analysis Performed by: Joshua Yu	MB19BWM04R_RHT	Analysis Date: 5/02/2020
Aquifer Thickness: 9.00 m		

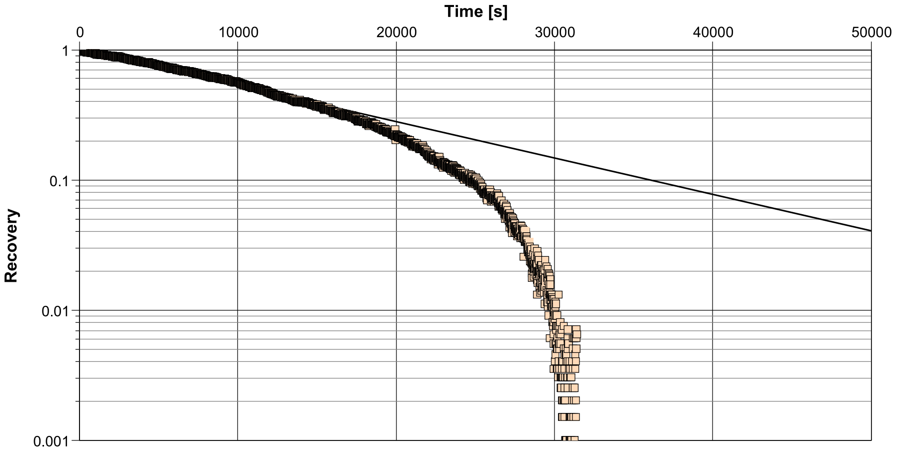


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM04R	4.50×10^{-4}	

Slug Test Analysis Report	
Project:	Blackwater Mine
Number:	G1679C
Client:	BMA

Location: Blackwater QLD	Slug Test: MB19BWM06P_FHT_2	Test Well: MB19BWM06P
Test Conducted by: Cameron Hall		Test Date: 16/12/2019
Analysis Performed by: Cameron Hall	MB19BWM06P_FHT	Analysis Date: 19/05/2020
Aquifer Thickness: 6.00 m		

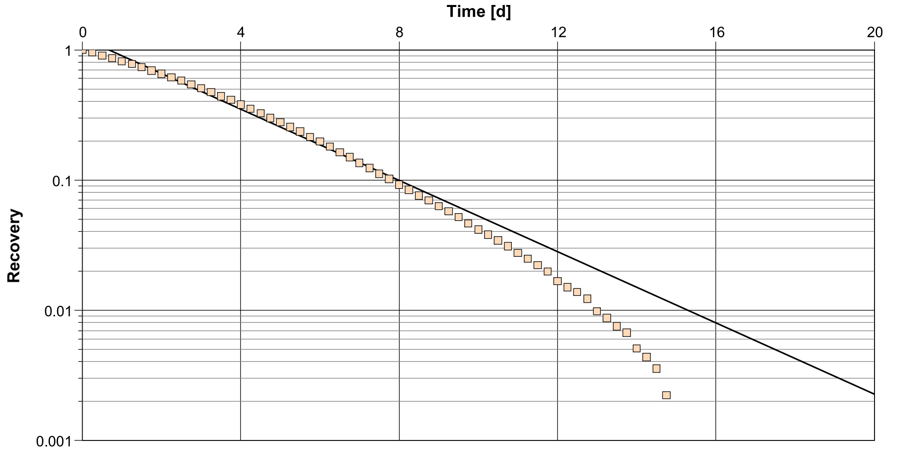


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM06P	1.60×10^{-3}	

Slug Test Analysis Report	
Project:	Blackwater Mine
Number:	G1679C
Client:	BMA

Location: Blackwater QLD	Slug Test: MB19BWM06P_RHT	Test Well: MB19BWM06P
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM06_RHT_Recovery	Analysis Date: 18/05/2020
Aquifer Thickness: 6.00 m		

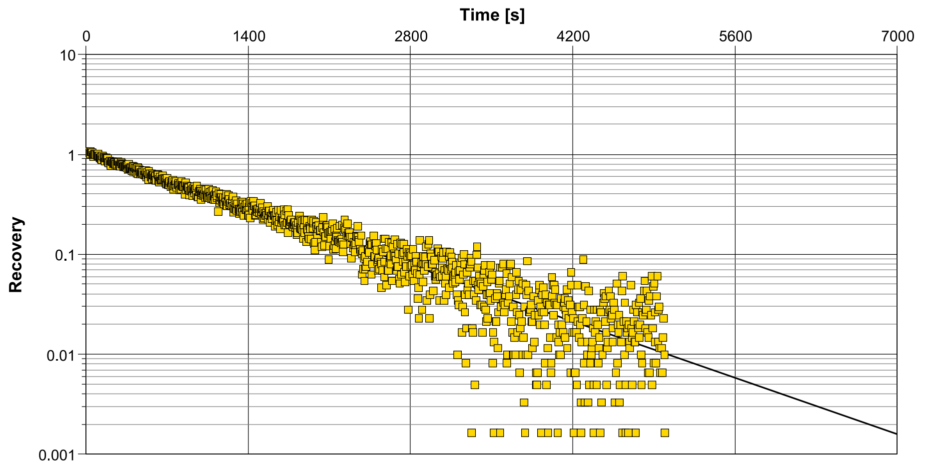


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM06P	7.10×10^{-5}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM08P_FHT	Test Well: MB19BWM08P
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM08P_FHT	Analysis Date: 18/05/2020
Aquifer Thickness: 6.00 m		

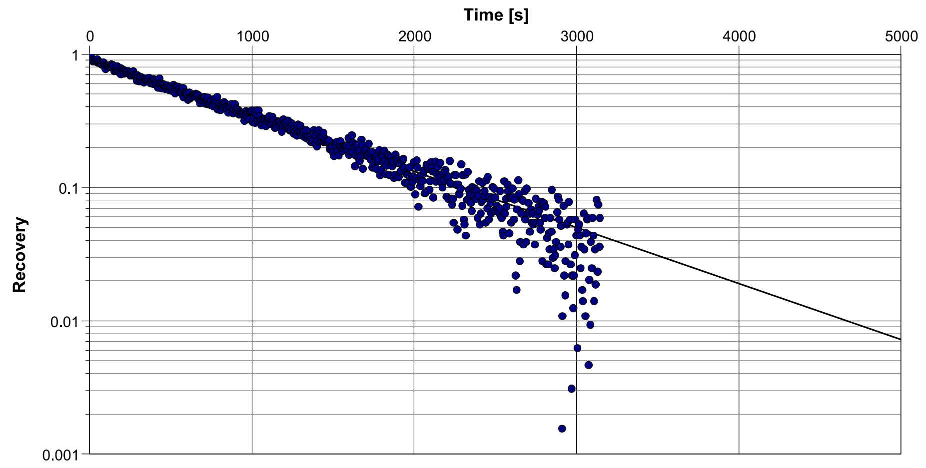


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM08P	2.30×10^{-2}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

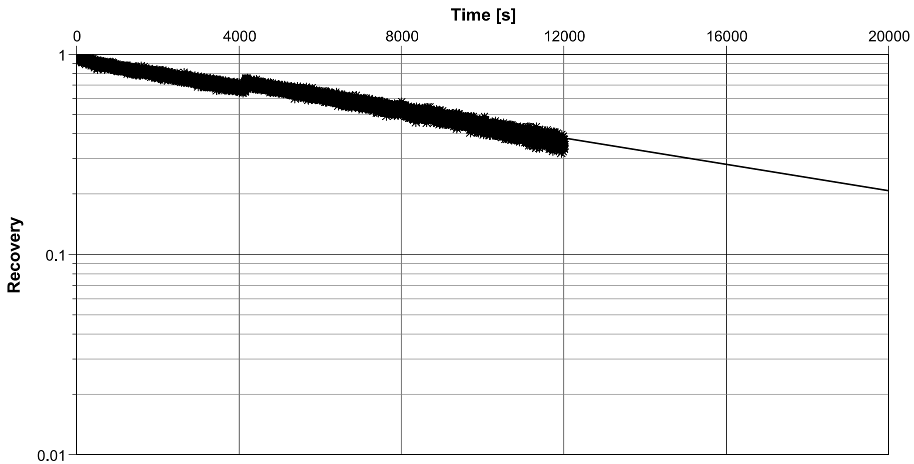
Location: Blackwater QLD	Slug Test: MB19BWM08P_RHT	Test Well: MB19BWM08P
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM08P_RHT	Analysis Date: 18/05/2020
Aquifer Thickness: 6.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM08P	2.40×10^{-2}	

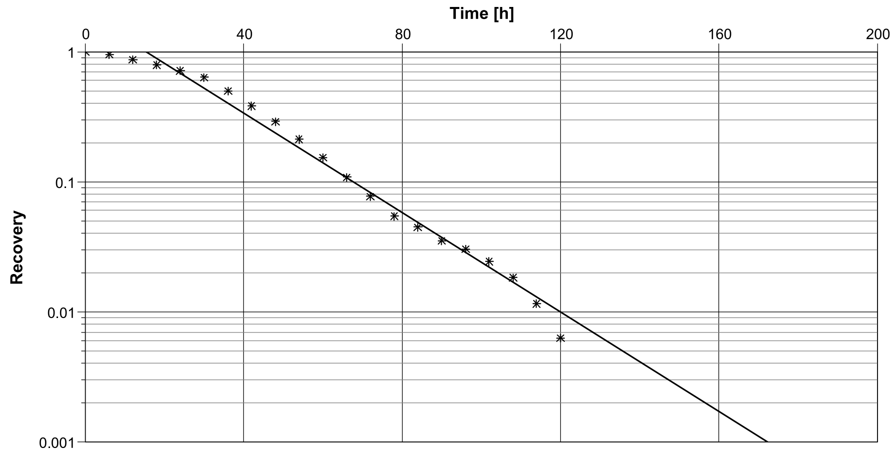
Slug Test Analysis Report		
Project: Blackwater Mine		
Number: G1679C		
Client: BMA		
Location: Blackwater QLD	Slug Test: MB19BWM25P_FHT	Test Well: MB19BWM25P
Test Conducted by: Cameron Hall		Test Date: 18/12/2019
Analysis Performed by: Cameron Hall	MB19BWM25P_FHT	Analysis Date: 18/05/2020
Aquifer Thickness: 3.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM25P	3.30×10^{-3}	

Slug Test Analysis Report		
Project: Blackwater Mine		
Number: G1679C		
Client: BMA		
Location: Blackwater QLD	Slug Test: MB19BWM25P_RHT	Test Well: MB19BWM25P
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWMP25_RHT	Analysis Date: 18/05/2020
Aquifer Thickness: 3.00 m		

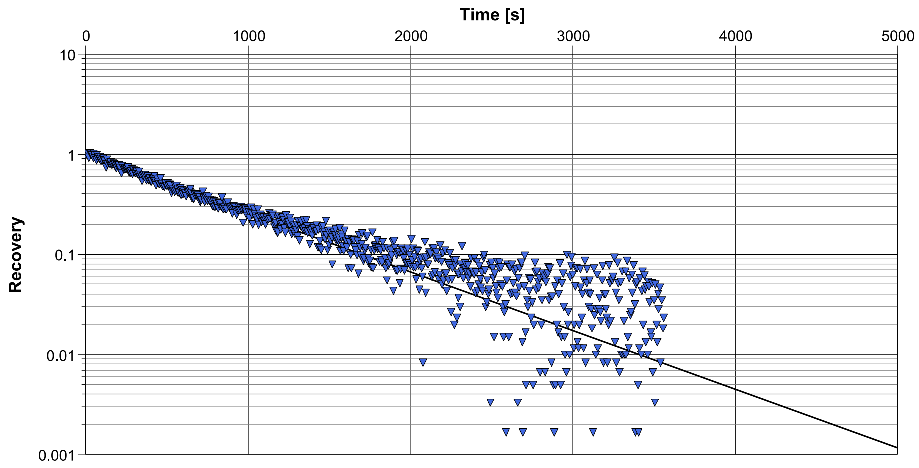


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM25P	5.30×10^{-4}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM27P_FHT	Test Well: MB19BWM27
Test Conducted by: Cameron Hall		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM27P_FHT	Analysis Date: 18/05/2020
Aquifer Thickness: 9.00 m		

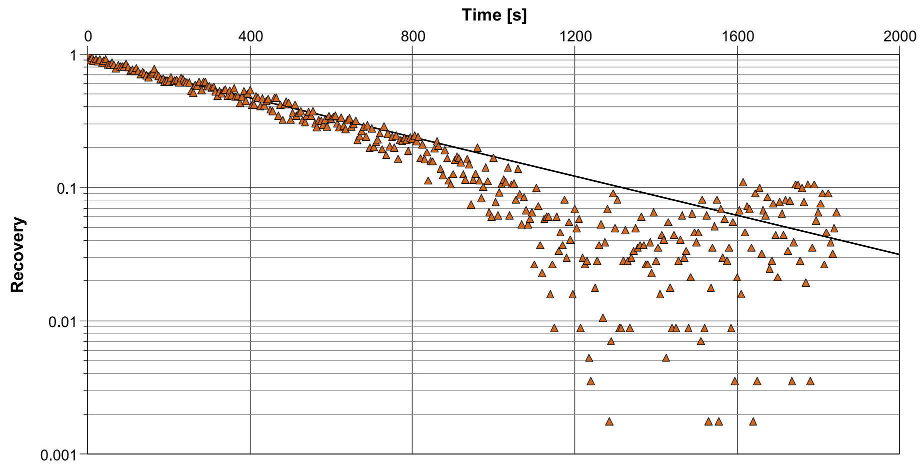


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM27	2.40×10^{-2}	

	Slug Test Analysis Report
	Project: Blackwater Mine
	Number: G1679C
	Client: BMA

Location: Blackwater QLD	Slug Test: MB19BWM27P_RHT	Test Well: MB19BWM27P
Test Conducted by:		Test Date: 18/05/2020
Analysis Performed by: Jacob Egan	MB19BWM27P_RHT	Analysis Date: 18/05/2020
Aquifer Thickness: 9.00 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/d]	
MB19BWM27P	3.00×10^{-2}	

Appendix D VWP construction logs

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

BOREHOLE LOG

VWP19BWM01

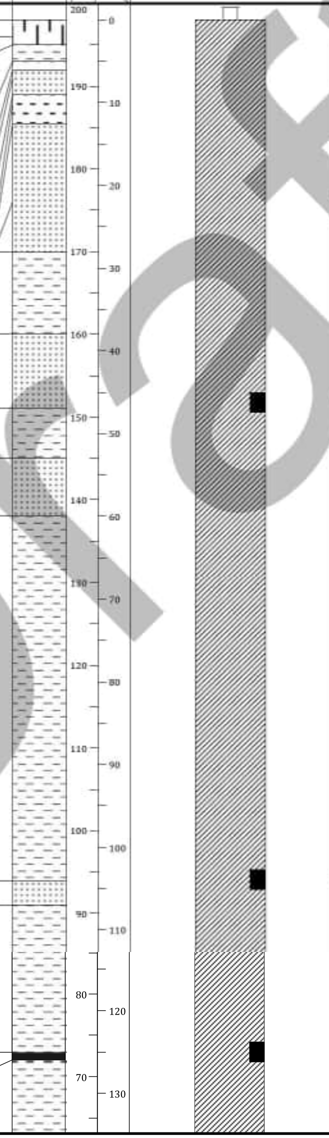
PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **28/11/2019**
LOGGED BY: **Cameron Hall**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **271.5 mBGL**
GL ELEVATION: **198 mAHD**
EASTING: **689178 mE**
NORTHING: **7376893 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description
SOIL: medium plasticity, clay matrix, dark brown.
SOIL: high plasticity, clay matrix, reddish brown.
CLAY: low plasticity, silty matrix, brown / GRAVEL (25 %): coarse grained to fine grained, sub-rounded, quartz and lithic clasts, well graded, white / red / black, loose.
CLAYSTONE: medium grained to fine grained, sub-angular, lithic clasts, brown, distinctly weathered.
SANDSTONE: very fine grained, brown, slightly weathered.
SANDSTONE: very fine grained, brown, medium strength, granular, some grey siltstone layers.
CLAYSTONE: very fine grained, silty matrix, brown, slightly weathered, some grey siltstone layers.
CLAYSTONE: dark grey, medium strength, damp.
SANDSTONE: light grey, medium strength, granular, some black silt. Flow at 15 m was 1 L/s.
SANDSTONE: dark grey, granular.
SILTSTONE: dark grey.
SANDSTONE: light grey.
SILTSTONE: dark grey.
SANDSTONE: light grey.
SILTSTONE: dark grey, some light grey sandstone bands throughout.
SANDSTONE: light grey.
SILTSTONE: dark grey.
COAL: black.
SILTSTONE: dark grey, low strength, carbonaceous.



Bore Description

- Logger enclosure on a steel post: +1.5 m
- Bentonite grout (5%): 0 m to 271.5 m
- VWP Sensor 1 - Overburden sandstone - 46m
- VWP Sensor 2 - Overburden sandstone - 104m
- VWP Sensor 3 - Aries Coal Seam - 125m

Australasian Groundwater & Environmental Consultants Pty Ltd

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

BOREHOLE LOG

VWP19BWM01

PROJECT No: **G1679C**	DRILLING COMPANY: **J&S Drilling**	TD: **271.5 mBGL**
PROJECT NAME: **BMA Blackwater Mine**	DRILLER: **Ryan Sainsbury**	GL ELEVATION: **198 mAHD**
DATE DRILLED: **28/11/2019**	DRILLING METHOD: **Air Rotary**	EASTING: **689178 mE**
LOGGED BY: **Cameron Hall**	DRILL RIG: **Fraste 400**	NORTHING: **7376893 mN**
		DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Bore Description
SILTSTONE: dark grey, low strength, carbonaceous.	
SANDSTONE: light grey.	
SILTSTONE: dark brown.	
SANDSTONE: fine grained, light grey, granular.	VWP Sensor 4 - Interburden sandstone - 154m
SILTSTONE: dark grey, medium strength.	
SANDSTONE: fine grained, light grey, low strength.	
SILTSTONE: dark grey.	
COAL: black, glassy.	VWP Sensor 5 - Pollux Coal Seam - 186m
SANDSTONE: fine grained to medium grained, brownish grey, granular.	
SANDSTONE: fine grained, light grey, granular.	
SANDSTONE: very fine grained to fine grained, light brownish grey.	
SILTSTONE: dark grey.	End of hole: 271.5 m BGL

Australasian Groundwater and Environmental Consultants Pty Ltd
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brisbane@ageconsultants.com.au
www.ageconsultants.com.au

VW PIEZOMETER INSTALLATION RECORD

Project name: G1679C BMA Blackwater Mine

Borehole name: VWP19BWM01

Installation date: 28 November 2019

Piezometer Hole Identification

BH ID	Easting	Northing	RL (m)
VWP19BWM01	689178	7376893	198.0

Coordinates in GDA94 (z55)

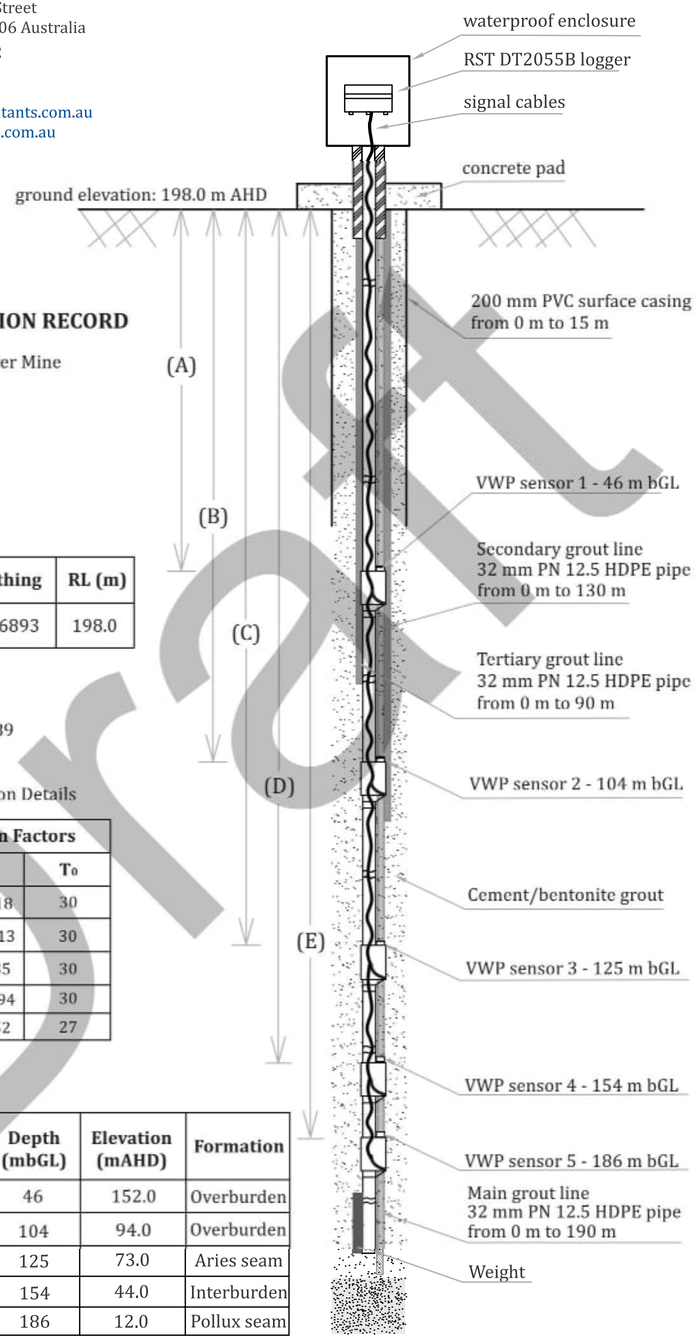
RST DT2055B Logger Serial No: 09789

Pre-installation Piezometer Calibration Details

ID	Piezometer Calibration Factors			
	F_0	C_P	C_T	T_0
VWP1	8928	0.3346	0.02618	30
VWP2	8791	0.3372	-0.02713	30
VWP3	8736	0.3382	-0.1435	30
VWP4	8543	0.3421	-0.01094	30
VWP5	8684	0.3393	-0.3352	27

Piezometer Installation Details

Symbol	Piezometer Name	S/N	Depth (mbGL)	Elevation (mAHD)	Formation
(A)	VWP1	S2178	46	152.0	Overburden
(B)	VWP2	S2179	104	94.0	Overburden
(C)	VWP3	S2125	125	73.0	Aries seam
(D)	VWP4	S2126	154	44.0	Interburden
(E)	VWP5	S2127	186	12.0	Pollux seam



Not to Scale

AGE Australasian Groundwater & Environmental Consultants Pty Ltd

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

BOREHOLE LOG

VWP19BWM02

PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **28/03/2020**
LOGGED BY: **Cameron Hall**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **174 mBGL**
GL ELEVATION: **249 mAHD**
EASTING: **691839 mE**
NORTHING: **7365920 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
		250 / 0		Logger enclosure on a steel post: +1.5 m
GRAVELLY CLAY: fine gravel to medium grained, sub-angular to angular, lithic clasts, well graded, light brown, extremely weathered, loose,				
CLAY: light grey, stiff,				
CLAY: high plasticity, brown, firm,		245 / 5		
CLAYSTONE: dark brown / grey, very low strength,		240 / 10; 235 / 15		
SANDSTONE: very fine grained, light grey, medium strength, granular,		230 / 20; 225 / 25; 220 / 30		
SANDSTONE: very fine grained, dark grey, granular,		215 / 35; 210 / 40; 205 / 45		
SILTSTONE: dark grey,				
SANDSTONE: dark grey, granular,				
SILTSTONE: dark grey,				
SANDSTONE: light grey, granular,		200 / 50; 195 / 55		Bentonite grout (5%): 0 m to 174 m
SILTSTONE: dark grey,		190 / 60		
SANDSTONE: light grey, granular, quartz at 64 m		185 / 65; 180 / 70; 175 / 75		
SILTSTONE: dark grey, siltstone bands throughout		170 / 80		
SANDSTONE: light grey, granular, carbonaceous bands throughout		165 / 85		

AGE Australasian Groundwater & Environmental Consultants Pty Ltd

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

BOREHOLE LOG

VWP19BWM02

PROJECT No: **G1679C**
PROJECT NAME: **BMA Blackwater Mine**
DATE DRILLED: **28/03/2020**
LOGGED BY: **Cameron Hall**

DRILLING COMPANY: **J&S Drilling**
DRILLER: **Ryan Sainsbury**
DRILLING METHOD: **Air Rotary**
DRILL RIG: **Fraste 400**

TD: **174 mBGL**
GL ELEVATION: **249 mAHD**
EASTING: **691839 mE**
NORTHING: **7365920 mN**
DATUM: **GDA94 z55 UTM**

COMMENTS:

Soil or Rock Field Material Description	Graphic Log	R.L. (mAHD) / Depth (mBGL)	Bore Construction	Bore Description
SANDSTONE: light grey, granular, carbonaceous bands throughout		160 / 90; 155 / 95		VWP Sensor 1 - Overburden sandstone - 87.5 m
COAL: black, Aries coal seam		150 / 100		VWP Sensor 2 - Aries Coal Seam - 101 m
SILTSTONE: black,		145 / 105		
SANDSTONE: grey, granular,		140 / 110		
COAL: black, Castor coal seam				VWP Sensor 3 - Castor Coal Seam - 112 m
SANDSTONE: grey,		135 / 115; 130 / 120		
COAL: black, Pollux coal seam		125 / 125		VWP Sensor 4 - Pollux Coal Seam - 127 m
SILTSTONE: black,		120 / 130		
SANDSTONE: light grey, granular,				
SANDSTONE: very fine grained to fine grained, light grey, very fine sand - sample losses		115 / 135		
SANDSTONE: fine grained, light grey, granular,		110 / 140		
SANDSTONE: very fine grained to silt, light grey,		105 / 145		
		100 / 150		VWP Sensor 5 - Rewan Group - 149 m
SANDSTONE: fine grained, light grey, granular,		95 / 155; 90 / 160; 85 / 165; 80 / 170; 75		
				End of hole: 174 m BGL

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brisbane@ageconsultants.com.au
www.ageconsultants.com.au

VW PIEZOMETER INSTALLATION RECORD

Project name: G1679C BMA Blackwater Mine

Borehole name: VWP19BWM02

Installation date: 30 March 2020

Piezometer Hole Identification

BH ID	Easting	Northing	RL (m)
VWP19BWM02	691839	7365920	249

Coordinates in GDA94 (z55)

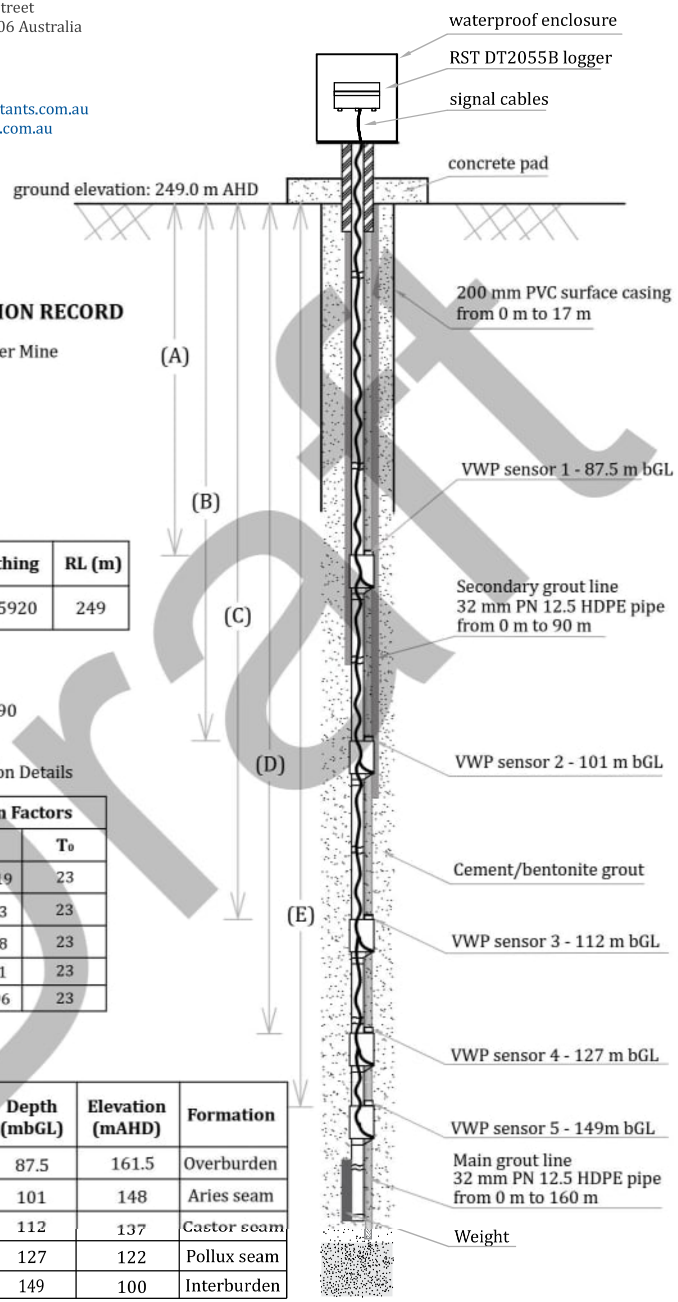
RST DT2055B Logger Serial No: 09790

Pre-installation Piezometer Calibration Details

ID	Piezometer Calibration Factors			
	F_0	C_P	C_T	T_0
VWP1	8838	0.3363	-0.05319	23
VWP2	8791	0.3372	-0.1513	23
VWP3	8915	0.3350	-0.1808	23
VWP4	8714	0.3387	-0.0331	23
VWP5	8776	0.3376	0.07896	23

Piezometer Installation Details

Symbol	Piezometer Name	S/N	Depth (mbGL)	Elevation (mAHD)	Formation
(A)	VWP1	S2352	87.5	161.5	Overburden
(B)	VWP2	S2353	101	148	Aries seam
(C)	VWP3	S2180	112	137	Castor seam
(D)	VWP4	S2181	127	122	Pollux seam
(E)	VWP5	S2182	149	100	Interburden



Not to Scale

Appendix E VWP calibration certificates

Calibration Sheet

HMA GEOTECHNICAL

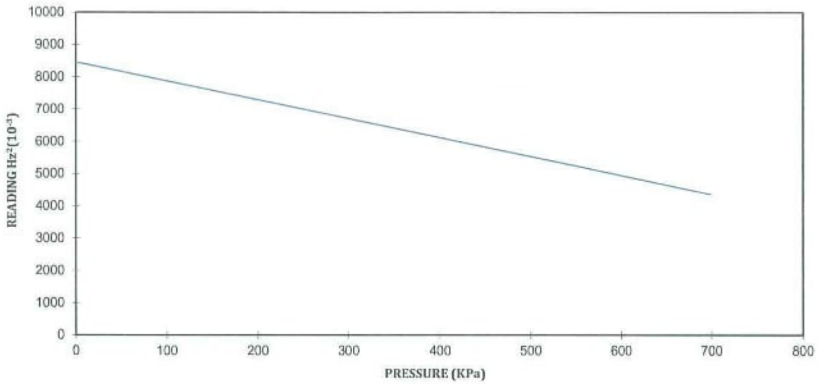
CLIENT : J S Drilling
SERIAL : S2443
RATING : 700 KPa

JOB No: GSA-81825

DATE: 3/09/2019

SHEET: 1

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8448	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.17070	$KPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	12	°C		
THERMAL COEFFICIENT :	-0.15900	KPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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Calibration Sheet

HMA GEOTECHNICAL

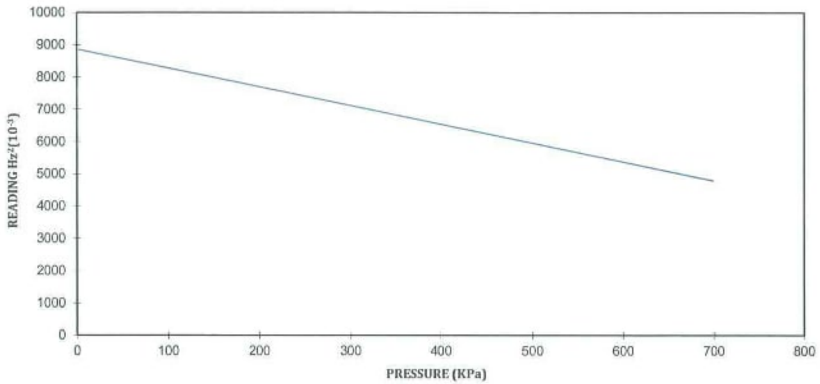
CLIENT : J S Drilling
SERIAL : S2444
RATING : 700 KPa

JOB No: GSA-81825

DATE: 3/09/2019

SHEET: 2

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8854	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.17200	$KPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	12	°C		
THERMAL COEFFICIENT :	-0.16150	KPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1050	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

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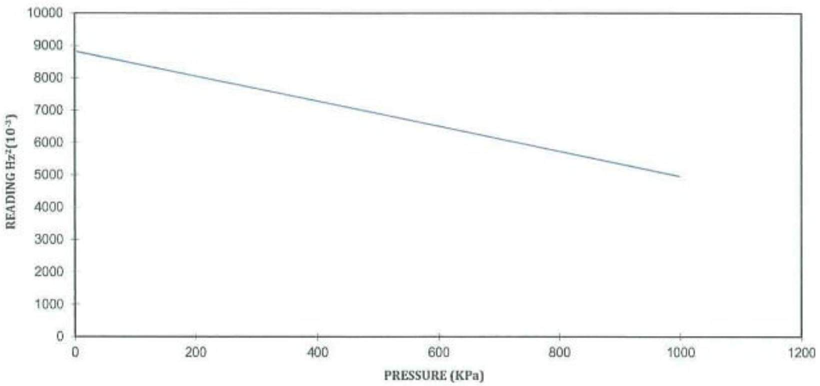
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2352
RATING : 1000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 3

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8838	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.25820	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.05319	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

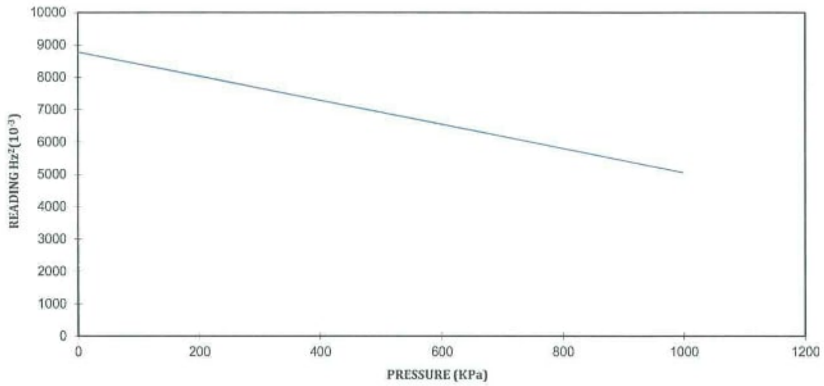
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2353
RATING : 1000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 4

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8785	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.26840	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.15130	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

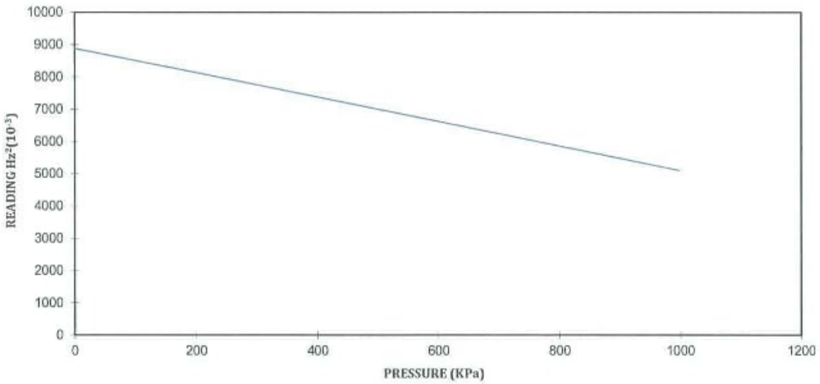
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2354
RATING : 1000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 5

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8878	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.26390	$KPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	12	°C		
THERMAL COEFFICIENT :	-0.03982	KPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	1500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0 - F_1)C_P + (T_1 - T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

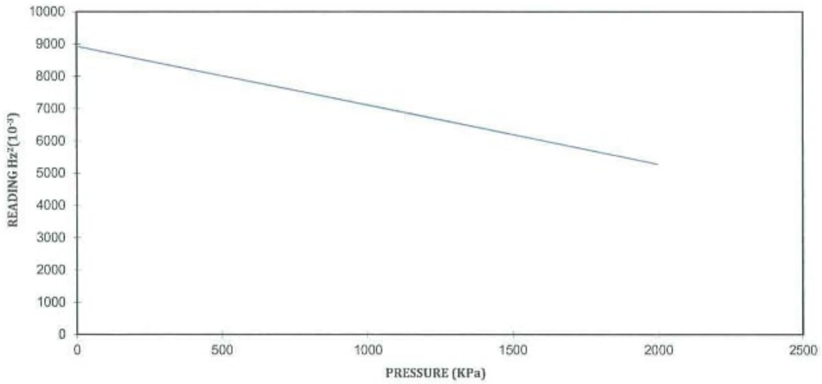
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2178
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 6

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8922	$Hz^2(10^{-3})$		
PRESSURE COEFFICIENT :	0.54730	$KPa/Hz^2(10^{-3})$	----------	(C_P)
AMBIENT TEMPERATURE :	12	°C		
THERMAL COEFFICIENT :	0.02618	KPa/°C	----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0 - F_1)C_P + (T_1 - T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

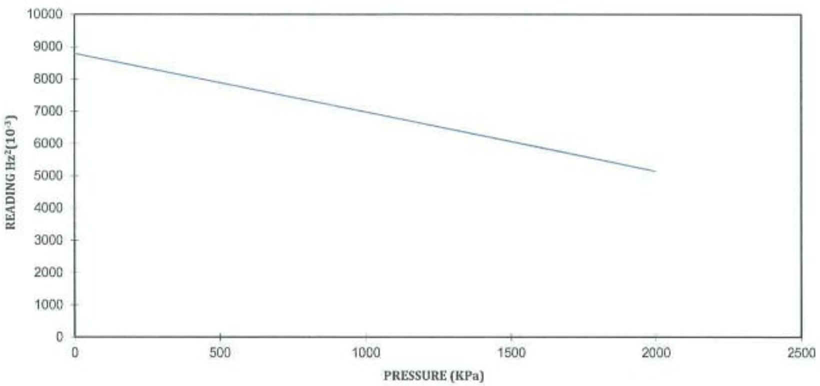
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2179
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 7

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8780	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.54880	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.02713	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

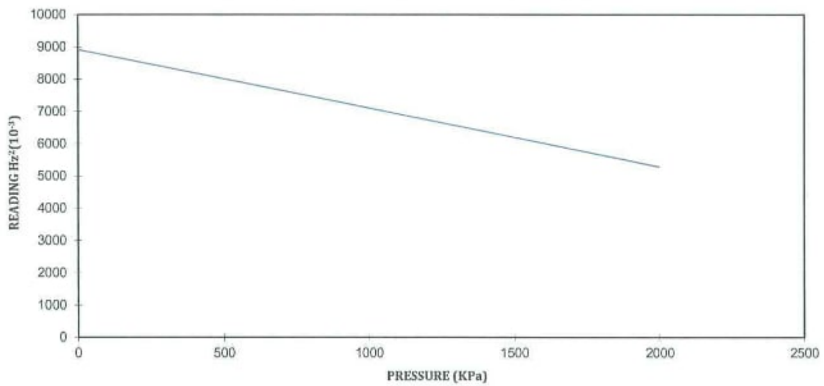
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2180
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 8

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8914	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.54930	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.18080	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

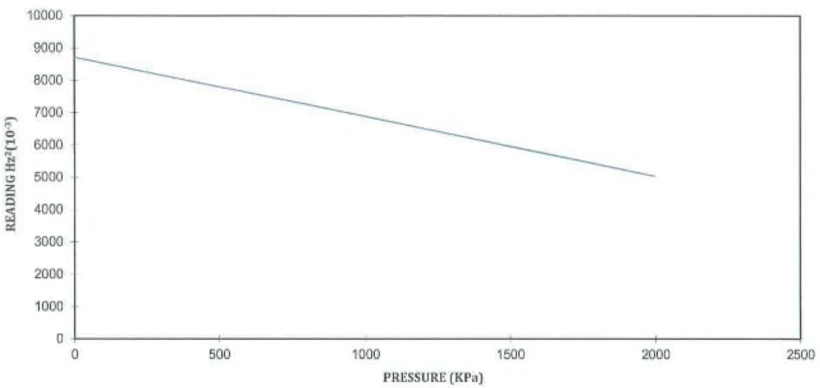
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2181
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 9

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8703	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.54280	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	-0.03310	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

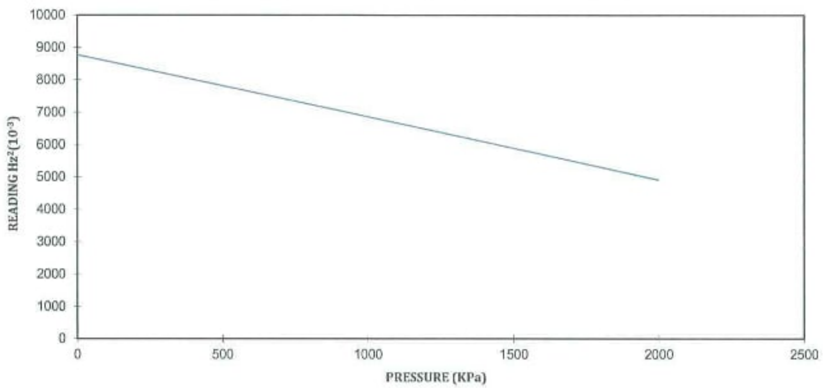
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2182
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 10

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8781	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.51680	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	0.07896	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

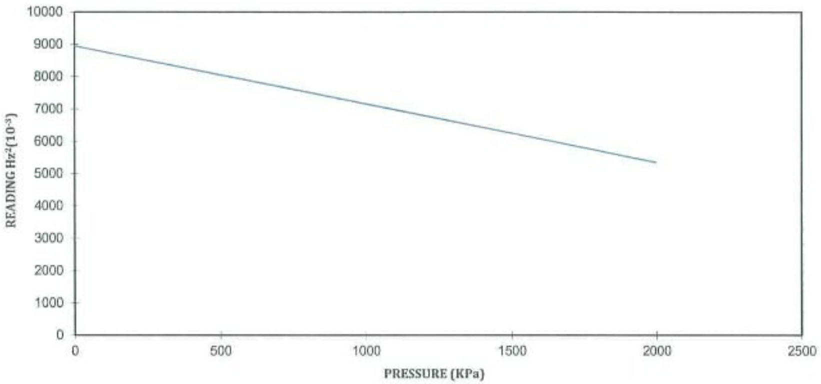
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2183
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 11

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8945	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.55440	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	0.14690	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

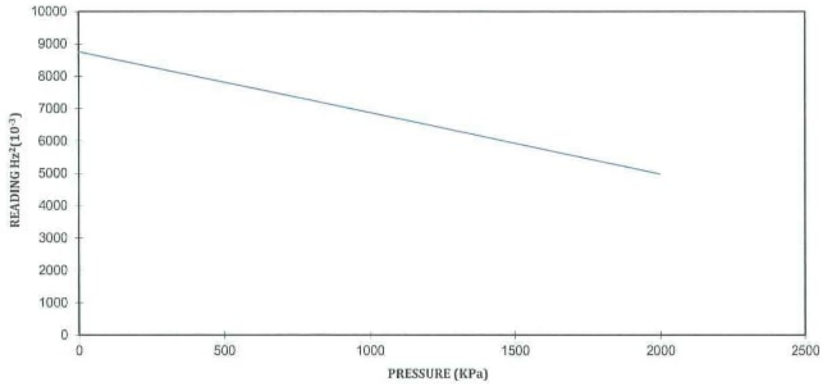
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2184
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 12

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8749	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.52890	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	0.14130	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0\text{-}F_1)C_P + (T_1\text{-}T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

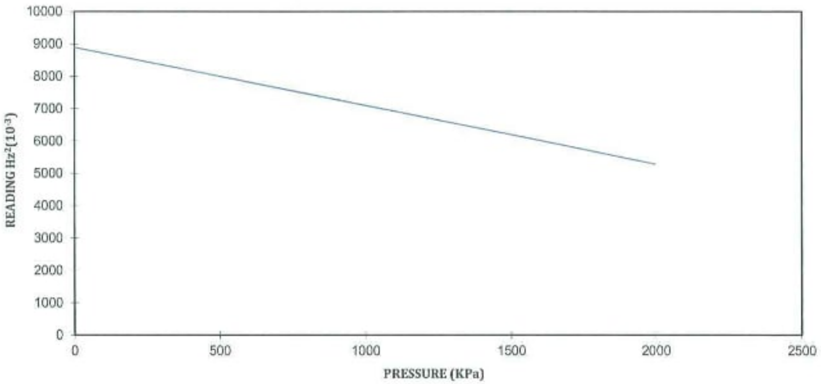
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2185
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 13

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8886	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.55400	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	0.17680	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

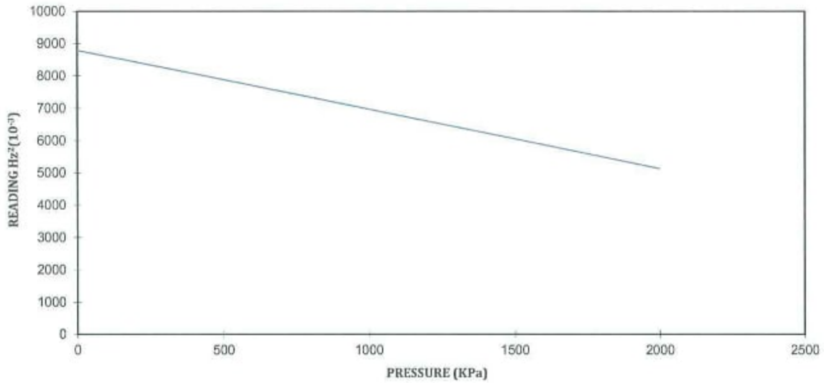
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2186
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 14

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8788	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.54610	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	0.02916	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

HMA GEOTECHNICAL

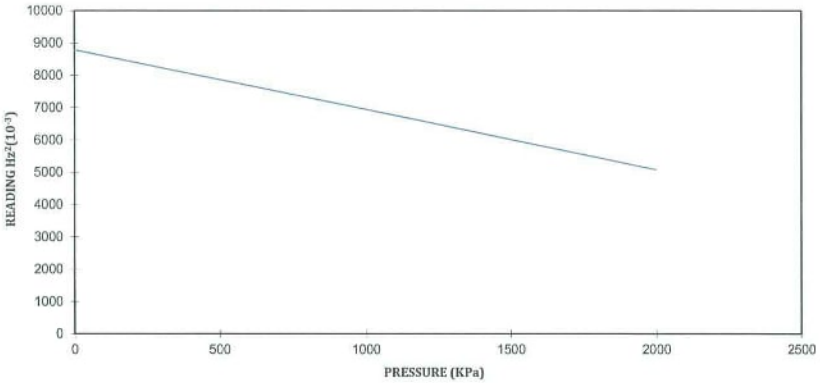
CLIENT : J S Drilling
SERIAL : S2187
RATING : 2000 KPa

JOB No: GSA-81825

DATE: 3/09/2019

SHEET: 15

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8797	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.53840	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	0.22430	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

Calibration Sheet

HMA GEOTECHNICAL

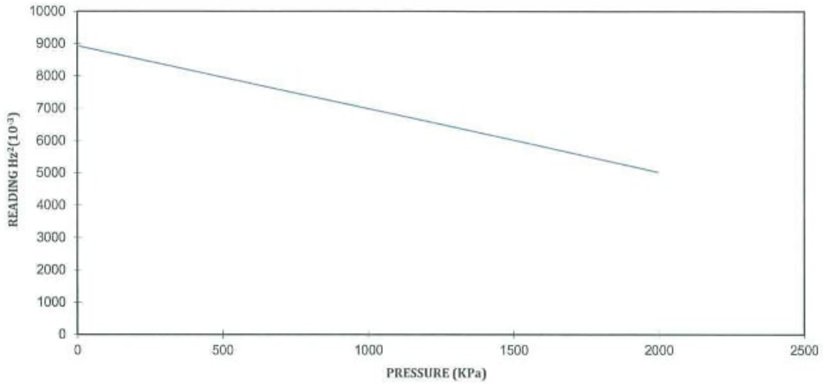
CLIENT : J S Drilling
SERIAL : S2188
RATING : 2000 KPa

JOB No: GSA-81825

DATE: 3/09/2019

SHEET: 16

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8941	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.51100	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.03678	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

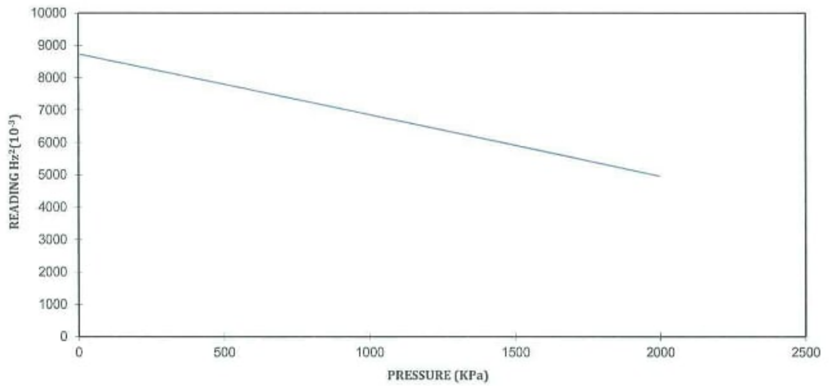
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2189
RATING : 2000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 17

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8742	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.52880	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	0.10410	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	3000	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

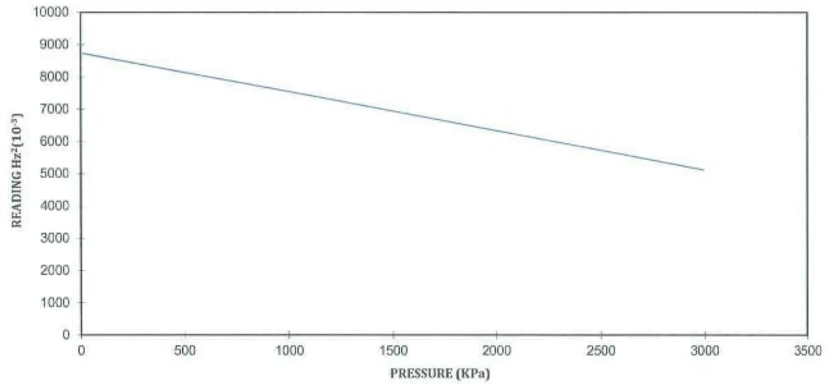
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2125
RATING : 3000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 18

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8740	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.82790	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	^oC	
THERMAL COEFFICIENT :	-0.14350	$KPa/^oC$ ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	4500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30^oC to $+65^oC$	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

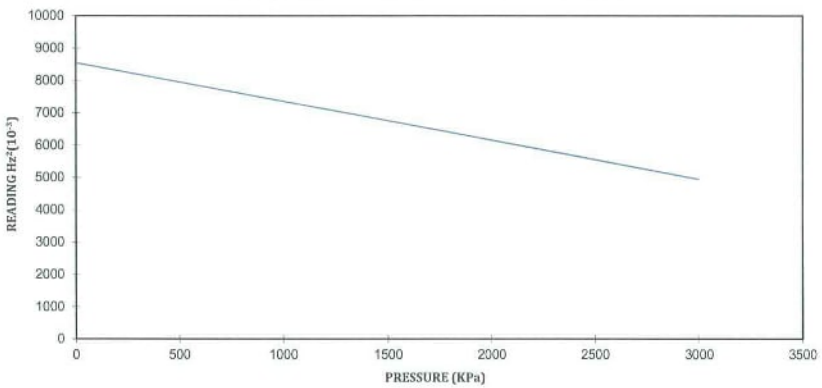
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2126
RATING : 3000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 19

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8543	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.83290	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	-0.01094	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	4500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

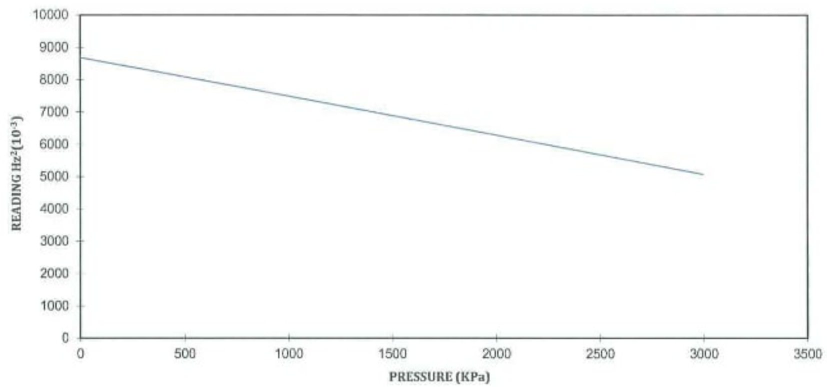
Calibration Sheet

HMA GEOTECHNICAL

CLIENT : J S Drilling
SERIAL : S2127
RATING : 3000 KPa

JOB No: GSA-81825
DATE: 3/09/2019
SHEET: 20

Vibrating Wire Piezometer Calibration Results



FACTORY ZERO READING :	8690	$Hz^2(10^{-3})$	
PRESSURE COEFFICIENT :	0.82960	$KPa/Hz^2(10^{-3})$ ----------	(C_P)
AMBIENT TEMPERATURE :	12	°C	
THERMAL COEFFICIENT :	-0.33520	KPa/°C ----------	(C_T)

SEE INSTRUCTION MANUAL FOR STANDARD TEMPERATURE/THERMISTOR DATA

MAXIMUM PRESSURE :	4500	kPa
BAROMETRIC PRESSURE :	1002	hPa
OPERATING TEMPERATURE RANGE :	-30°C to +65°C	

PORE PRESSURE = $(F_0-F_1)C_P + (T_1-T_0)C_T$

(F_0) & (T_0) TO BE ESTABLISHED DURING INSTALLATION

PIEZO SUMMARY

JOB NUMBER: **GSA-81825**
NAME: **J S Drilling**

CAL SHEET No	SERIAL No	KPA	Gauge Factor kPa /Hz^2(10^{-3})	Thermal Factor kPa/DegC	LENGTH	GSA ZERO	LOCATION
1	S2443	700	0.1707	-0.159	52	8448	
2	S2444	700	0.172	-0.1615	52	8854	
3	S2352	1000	0.2582	-0.05319	115	8838	
4	S2353	1000	0.2684	-0.1513	125	8785	
5	S2354	1000	0.2639	-0.03982	127	8878	
6	S2178	2000	0.5473	0.02618	173	8922	
7	S2179	2000	0.5488	-0.02713	224	8780	
8	S2180	2000	0.5493	-0.1808	140	8914	
9	S2181	2000	0.5428	-0.0331	162	8703	
10	S2182	2000	0.5168	0.07896	184	8781	
11	S2183	2000	0.5544	0.1469	155	8945	
12	S2184	2000	0.5289	0.1413	167	8749	
13	S2185	2000	0.554	0.1768	179	8886	
14	S2186	2000	0.5461	0.02916	212	8788	
15	S2187	2000	0.5384	0.2243	140	8797	
16	S2188	2000	0.511	-0.03678	168	8941	
17	S2189	2000	0.5288	0.1041	196	8742	
18	S2125	3000	0.8279	-0.1435	236	8740	
19	S2126	3000	0.8329	-0.01094	288	8543	
20	S2127	3000	0.8296	-0.3352	298	8690	
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Appendix B Groundwater Modelling Technical Report

Blackwater Mine - North Extension Project

Groundwater Impact Assessment

BM Alliance Coal Operations Pty Ltd
SLR Project No.: 620.014601.00006 R01

11 December 2023

Blackwater Mine - North Extension Project

Groundwater Modelling Technical Report

BM Alliance Coal Operations Pty Ltd

480 Queen St, Brisbane, QLD 4000

Prepared by:

SLR Consulting Australia

Level 16, 175 Eagle Street, Brisbane QLD 4000,
Australia

SLR Project No.: 620.014601.00006

29 November 2023

Revision: 4.0

Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
1.0	19 September 2023	P Rachakonda	I Epari	I Epari
2.0	31 October 2023	P Rachakonda	I Epari	I Epari
3.0	20 November 2023	A Mohajeri	I Epari	I Epari
4.0	29 November 2023	A Mohajeri	I Epari	P Allen

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with BM Alliance Coal Operations Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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Appendices

Appendix A **Calibration Residuals**

Appendix B **Calibration Hydrographs**

Appendix C **Calibrated Hydraulic Parameters**

Appendix D **Prior and posterior distribution plot (UA)**

1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by BM Alliance Coal Operations Pty Ltd (BMA) to undertake a Groundwater Impact Assessment for the Blackwater Mine (BWM) North Extension Project (the Project), for incorporation into an application for an Environmental Authority (EA) Amendment and an application for an *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Approval.

As a part of the Groundwater Impact Assessment, numerical groundwater modelling was undertaken to predict impacts of the Project on the local groundwater regime.

The Project is an extension of mining into SA10 on ML1759 and SA7 on ML1762 utilising existing BWM mining methods, mining fleet, mine infrastructure and facilities.

The overall objectives of this modelling are to:

- Assess the groundwater inflow to the mine workings as a function of mine position and timing.
- Simulate and predict the extent of dewatering due to the Project and the level and rate of drawdown at specific locations.
- Simulate the long-term impacts by running a recovery scenario.
- Identify areas of potential risk, where groundwater impact management measures may be necessary.

Conceptualisation of the groundwater regime and the calibration of the model against observed data are key to achieving a reliable numerical model. Conceptualisation is a simplified overview of the groundwater regime (i.e., the distribution and flow of groundwater) based on available data and experience. Consistency between numerical model results and the conceptual understanding of the groundwater regime increases the credibility of the numerical model predictions. The conceptualisation of the groundwater regime was carried out by SLR in 2023 and is reported in the *Blackwater Mine North Extension Groundwater Impact Assessment Report* (SLR, 2023) to which this groundwater modelling technical report forms an appendix.

Confidence in the numerical model is increased by calibration of numerical model results against observed data. A well calibrated model has demonstrated the ability to simulate groundwater levels that approximate observed levels at specific locations. The model confidence can be further assessed by undertaking an Uncertainty Analysis for the quantities of interest (groundwater inflow and drawdown), which quantifies the likelihood of the model results in relation to these quantities of interest.

The numerical groundwater model for the Project was created based on a geological model provided by BMA and other publicly available data. Then boundary conditions and hydraulic parameters were assigned to the model in accordance with the conceptual understanding.

The report is structured as follows:

- **Section 2:** Model Construction and Calibration.
- **Section 3:** Predictive Modelling.
- **Section 4:** Recovery Model.
- **Section 5:** Sensitivity Analysis.
- **Section 6:** Uncertainty Analysis.
- **Section 7:** Model Confidence and Limitations.
- **Section 8:** Conclusions.

2.0 Model Construction and Calibration

2.1 Model Code

MODFLOW-USG was used as the model code (Panday et al. 2013). MODFLOW-USG is a recent version of industry standard MODFLOW code and was determined to be the most suitable modelling code for accomplishing the model objectives. MODFLOW-USG optimises the model grid and increases numerical stability by using unstructured, variably sized cells. These cells take any polygonal shape, with variable size constraints allowing for refinement in areas of interest (i.e., geological or mining features).

Where previous MODFLOW versions restricted interlayer flow to vertical connectivity, MODFLOW-USG offers lateral connectivity between model layers. Lateral connectivity enables more accurate representations of hydrostratigraphic units, particularly those that pinch out, outcrop, or to simulate flow across geological faults.

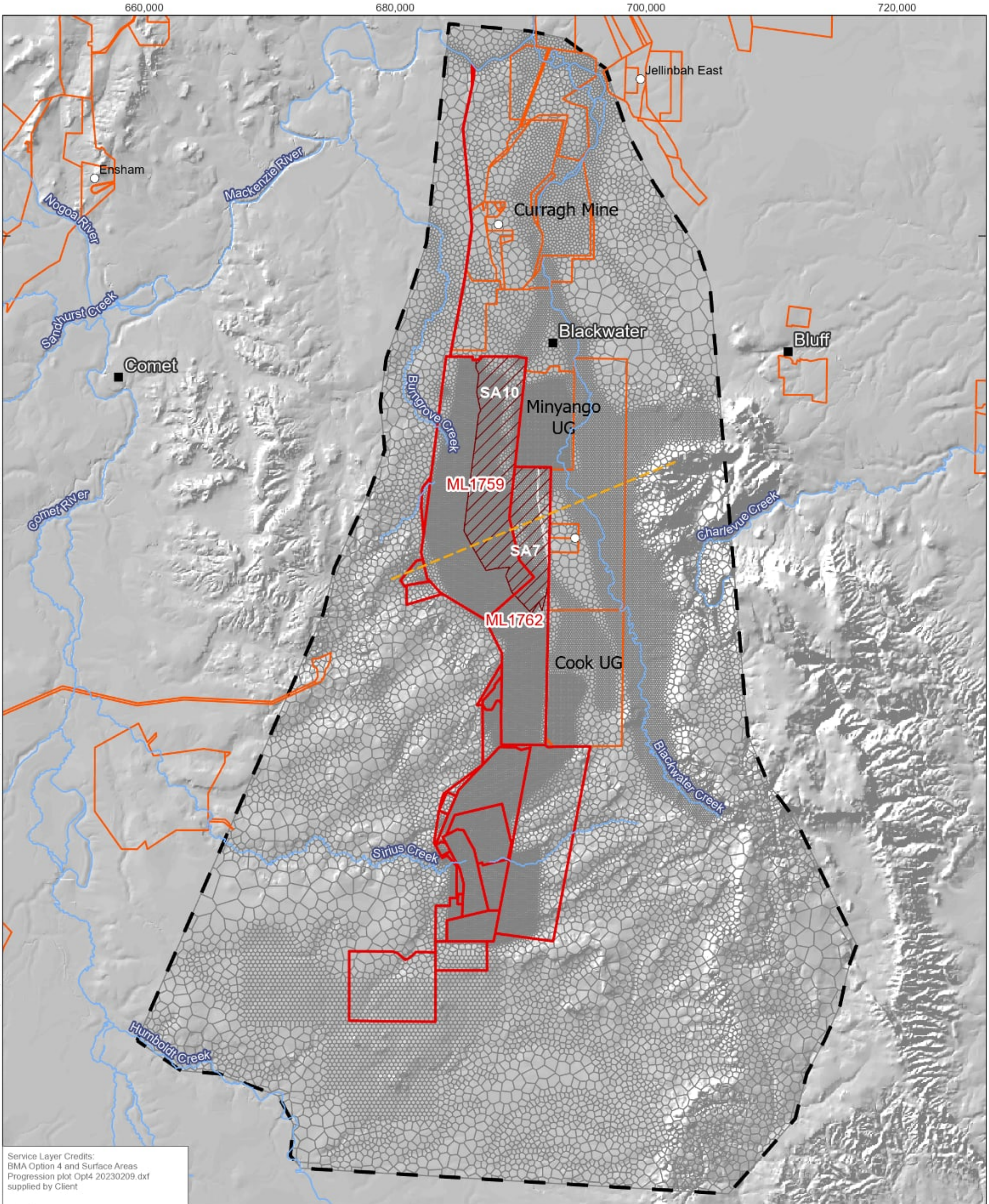
MODFLOW-USG is also able to simulate unsaturated conditions, allowing progressive mine dewatering and post closure recovery to be represented by the model. For the Project model, vadose zone properties have been excluded, and the unsaturated zone was simulated using the upstream-weighting method.

Fortran code and a MODFLOW-USG edition of the Groundwater Data Utilities (Watermark Numerical Computing) were used to construct the MODFLOW-USG input files and post-processing the results.

2.2 Model Extent and Mesh Design

Figure 2-1 shows the model domain. The model domain is designed large enough to allow the adjacent mines/projects to be assessed for potential cumulative impacts. At its widest extents, the model measures approximately 50 kilometres (km) by 90 km. The model domain was selected based on the following considerations:

- The western boundary is represented by the outcrop boundary of the Burngrove Formation, which underlies the Rangal Coal Measures and is considered the basement formation for the purpose of this modelling.
- The northern boundary extents to include the open-cut Curragh mine and is 25 km north of the Project area.
- The eastern boundary is set along the Shotover fault which is located approximately 20 km to the east of the Project area. This boundary is expected to be far outside the range of predicted Project related drawdown.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- Coal Mine
- City/Town
- Watercourse
- West to East Cross Section
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

MODEL DOMAIN

SLR

FIGURE 2-1

To allow stable numerical modelling of the large spatial area of the model domain, an unstructured grid with varying Voronoi cell sizes was designed using Algomesh (HydroAlgorithmics, 2014). Varying Voronoi cell sizes allowed refinement around areas of interest, while a coarser resolution elsewhere reduces the total cell count to a manageable size (**Figure 2-1**). The model domain was vertically discretised into 14 layers, each layer comprising a cell count of up to 43,912. The total number of model cells is 441,276. This is after pinching out areas in layers 3 to 14 where a layer is not present based on the structural geology.

The following features have been included in the grid design:

- Open-cut mining for the Blackwater mine including the historical mine and proposed extension is represented with a 100 m cell size constraint.
- Alluvium extent and major rivers are represented with a 150 m cell size constraint.
- Minor Creek and drains are represented with a 350m cell size constraint.
- Open-cut mine areas for Curragh mine and the future Blackwater South Coking Coal Project have a 350 m cell size constraint.
- Underground mining at Cook Colliery and proposed Minyango projects has an oriented regular grid of 125 m width squares to represent longwalls.

Regional faults are represented using a 250 m cell constraint. While none of the faults were included in this modelling work, increasing the cell resolution along the fault was done only for the future investigation of the impacts of faults on regional flow.

2.3 Model Layers

Topography within the model domain has been defined using high resolution (1 m) Digital Elevation Model (DEM) data for Blackwater mine (extent around the existing mining lease (**Figure 2-1**). Public domain 25 m DEM data sourced from Geoscience Australia (with 3m subtracted for consistency between datasets) was used to define topography in the remainder of the model domain.

The model domain is discretised into 14 layers, as listed in **Table 2-1**. Model layer extents (lateral and vertical) have been defined using data from the following sources:

- Blackwater site geological model.
- CSIRO Regolith depth survey (Wilford et al, 2016).
- Queensland Globe bore hole logs.
- Queensland surface geology and basement geological maps.
- Office of Groundwater Impact Assessment (OGIA) model layers.

Table 2-1 presents the average and maximum thicknesses across the model domain for each layer.

Table 2-1 Model Layers and Thicknesses

Model Layer	Formation	Unit	Average Thickness (m)[1]	Maximum Thickness (m)[2]
1	Alluvium/Tertiary	Surface cover and Tertiary	8	87
2	Alluvium/ Weathered zone	Weathered zone / Regolith	9	34
3	Clematis Group	Triassic	353	1036
4	Rewan Group (Upper)	Triassic	296	500
5	Rewan Group (Middle)	Triassic	178	250
6	Rewan Group (Lower)	Triassic	110	150
7	Rangal Coal Measures	Overburden	46	50
8		Aries seam	2	6
9		Interburden	21	73
10		Castor seam	2	5
11		Interburden	16	66
12		Pollux seam	4	10
13		Underburden	30	79
14	Burngrove Formation	Permian	177	402

Notes: 1 the average thickness was calculated as a weighted average based on cell area. The areas where layers pinch out are not included. 2 note that large differences in the vertical thicknesses between adjacent model layers are common and do not create numerical instabilities.

The regional site geology model (BMA, 25m grid) provides the surfaces for tertiary and weathering zone within the BWM area. These surfaces were used to assign the bottom of layers 1 (i.e., Tertiary) and 2 (i.e., weathering) in the model. Outside the geology model extent, CSIRO Regolith survey depths (i.e., weathering depth) was used to define the base of layers 1 and 2. In doing so, the CSIRO Regolith depth was divided into two with each layer covering fifty percent of total depth. Both layers 1 and 2 are fully extensive across the model with an average thickness of 8 m and 9 m respectively. The depth of alluvium was calculated from the site monitoring bores, drill holes, and available public QLD Globe bore logs. Similar to the weathering zone, layers 1 and 2 each cover fifty percent of total alluvium thickness, where present.

The underlying Rewan and Permian layers are present only to their outcrop extents, with some inference made for the presence of older units beneath the surface outcrop due to folding and faulting. The bottom of layers 3 to 14 was constructed based on the Blackwater geology model. Outside of the geology model extent, the surface geology map was used to define the location of outcrops of each unit. The average thicknesses were then extrapolated out into the extended model area to cover the layer outside the geology model.

It is not practical to represent every individual coal seam in a regional groundwater model, therefore a “combined thickness” totalling the individual seam thicknesses for each relevant seam has been simulated. The coal seams of the Rangal Coal Measures were combined into three major coal seams, the Aries, Castor and Pollux seams.

The Burngrove Group is considered the regional low-permeability basement for the purpose of this modelling and defines the base of the model, and the western and eastern model boundaries.

Figure 2-2 shows a cross section from West to East through the model domain. This cross section is based on model layers and visualises the thicknesses and presence of layers across the strike of the coal seam. The location of the cross section is presented in **Figure 2-1**.

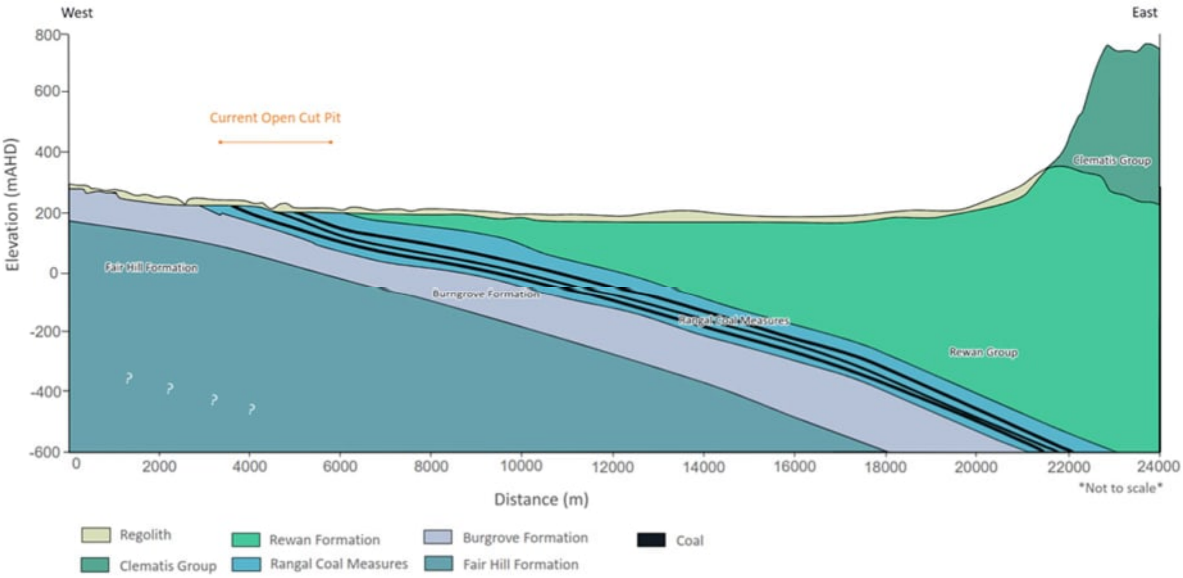
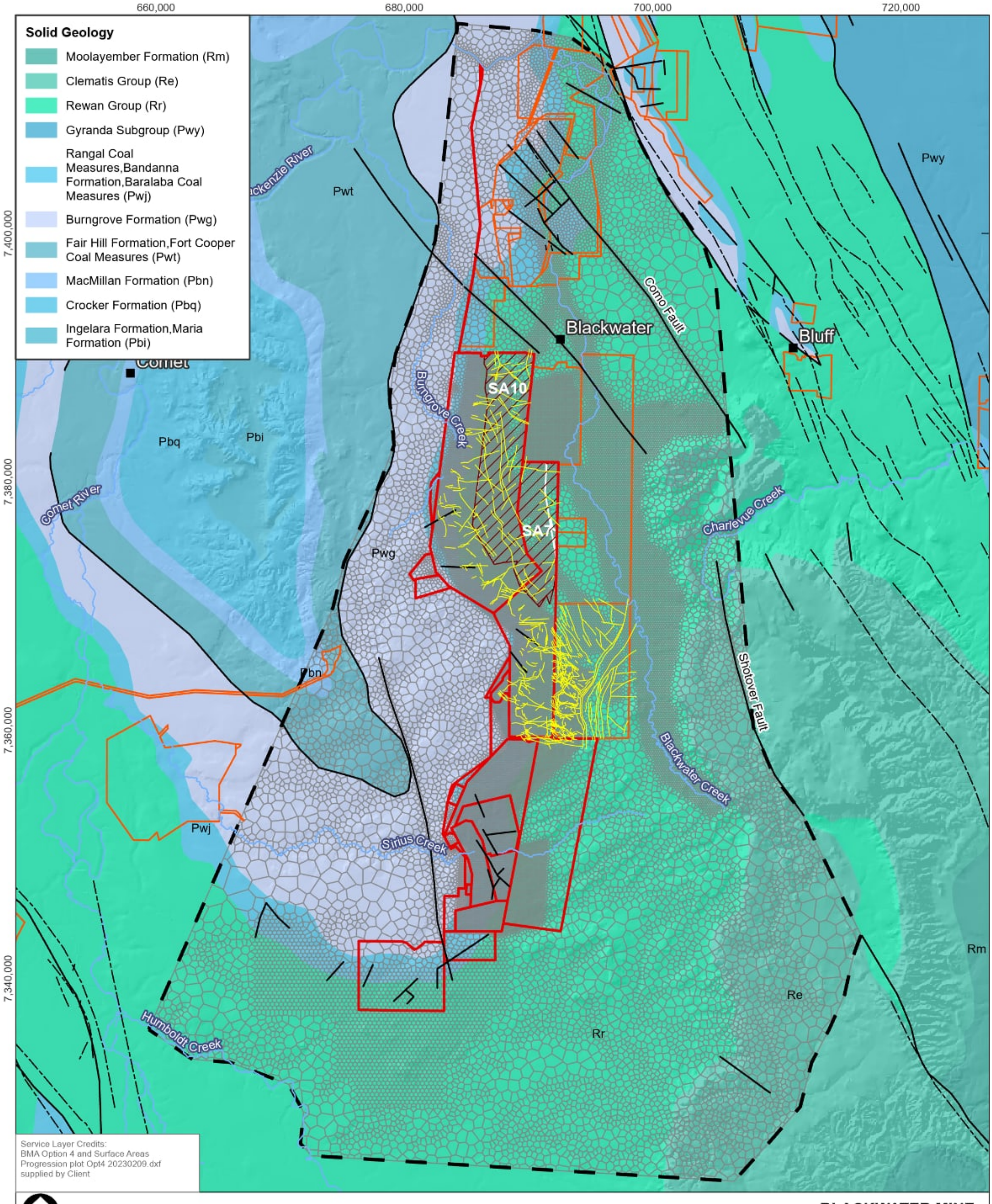


Figure 2-2 Model Cross Section West-East

2.3.1 Geological Faults

The location of mapped faults and structures are shown in **Figure 2-3**. The most significant geological structure in the area is the Shotover fault, which is an east dipping, thrust fault with a displacement of up to 3,000 m (Mallet et al, 1988). This fault is located approximately 20 km to the east of the Project area and was incorporated along the eastern boundary of the model as a no flow boundary condition. **Figure 2-3** also shows numerous mapped faults within the BWM extent and proposed extension. The local faults are typically less than 5 m throw but can increase to as much as 20 m throw in some areas of BWM (Jeuken, 2011). These faults can fully offset the coal seams and act as barrier to groundwater flow. However, the true impact of the local faults on the groundwater flows are not known. Therefore, geological structures (i.e., faults) have not been included in the model other than through the layer displacement from site geological models. This approach is considered conservative, as it likely results in more drawdown impacts due to a better connectivity.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Basin Scale Fault (1995)
- Basin Scale Fault
- Local Fault
- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

LOCAL AND REGIONAL FAULTS

SLR

FIGURE 2-3

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F02_3_Local and Regional Faults

2.4 Timing

A combined steady state and transient warm up and transient calibration model was developed, followed by a transient prediction model:

- A combined steady state (pre-mining) model and transient warm-up model from January 1970 to January 2005 with a 10 yearly time interval between 1970 and 1990 and a 15-year time interval between 1990-2005. The steady state model was used to derive initial hydraulic heads for the transient warm-up model.
- Transient calibration model from January 2005 to July 2023 with quarterly time intervals to replicate influence of historical mining.
- Transient predictive model from July 2023 to July 2085 with annual time intervals, including the Project time span of 2025-2085.

More information on the time resolution of the model is presented in **Section 2.6** (Calibration) and **Section 3.1** (Prediction).

To assist the model in overcoming numerical difficulties, MODFLOW-USG Adaptive Time-Stepping (ATS) option was used. The ATS option of MODFLOW automatically decreases time-step size when the run fails to converge. Once the run converged with a reduced time-step size, it increases the time-step size for the next time step to speed up the model run time. The minimum time step size used in the simulations was one day.

2.5 Model Stresses and Boundary Conditions

2.5.1 Regional Groundwater Flow

General Head Boundaries (GHB) have been specified along the southern and northern model boundaries. The GHB boundary condition is used to represent the regional flow into and out of the model area and has been assigned using GHB cells in all layers using pre-mining head elevations. Groundwater will enter the model where the head set in the GHB is higher than the modelled head in the adjacent cell and will leave the model when the water level in the GHB is lower than the modelled head in the adjacent cell. The GHB conductance is calculated using the hydraulic conductivity and the dimensions of each GHB cell and is therefore variable in this model due to variable cell-size.

A no flow boundary was applied to the western boundary of the model that represents the outcrop of the Burngrove Group. A no flow boundary was also applied to the eastern boundary where the Shotover fault is located.

2.5.2 Watercourses

2.5.2.1 Natural Watercourses

The largest local creek (Blackwater Creek) as well as minor creeks were built into the model using MODFLOW-USG RIV package. The waterways within and around the Project that were included in the RIV package are presented in **Figure 2-4.**

The rivers are set with the riverbed 3 m below the surrounding topography to represent the steep-banked incised channels. The river widths were assumed to be fixed for each river in the model. The river conductance was calculated using river width, river length, riverbed thickness, and the vertical hydraulic conductivity of riverbed material (Kz), refer to **Table 2-2** for the values used. Therefore, the river conductance is variable due to the non-constant spatial discretisation in each of the model river cells.

Table 2-2 River and Surface Water Features in the Model

Boundary	River Stage (m)	River Bed Kz (m/day)
Blackwater Creek	Warm Up Simulation (1970- 2005) - Long term annual average (2005-2021). Calibration Simulation (2005- 2023) - Historical Quarterly observations for that timeframe. Predictive Simulation (2023 onwards) - Long term annual averages (2005-2021).	5.0×10^{-2}
Other Minor Creeks	0	5.0×10^{-1}

The river stage height at Blackwater Creek was based on the observations at the Blackwater Downstream Gauge (**Figure 2-4**). **Table 2-2** lists the river stage values used for the three simulation types.

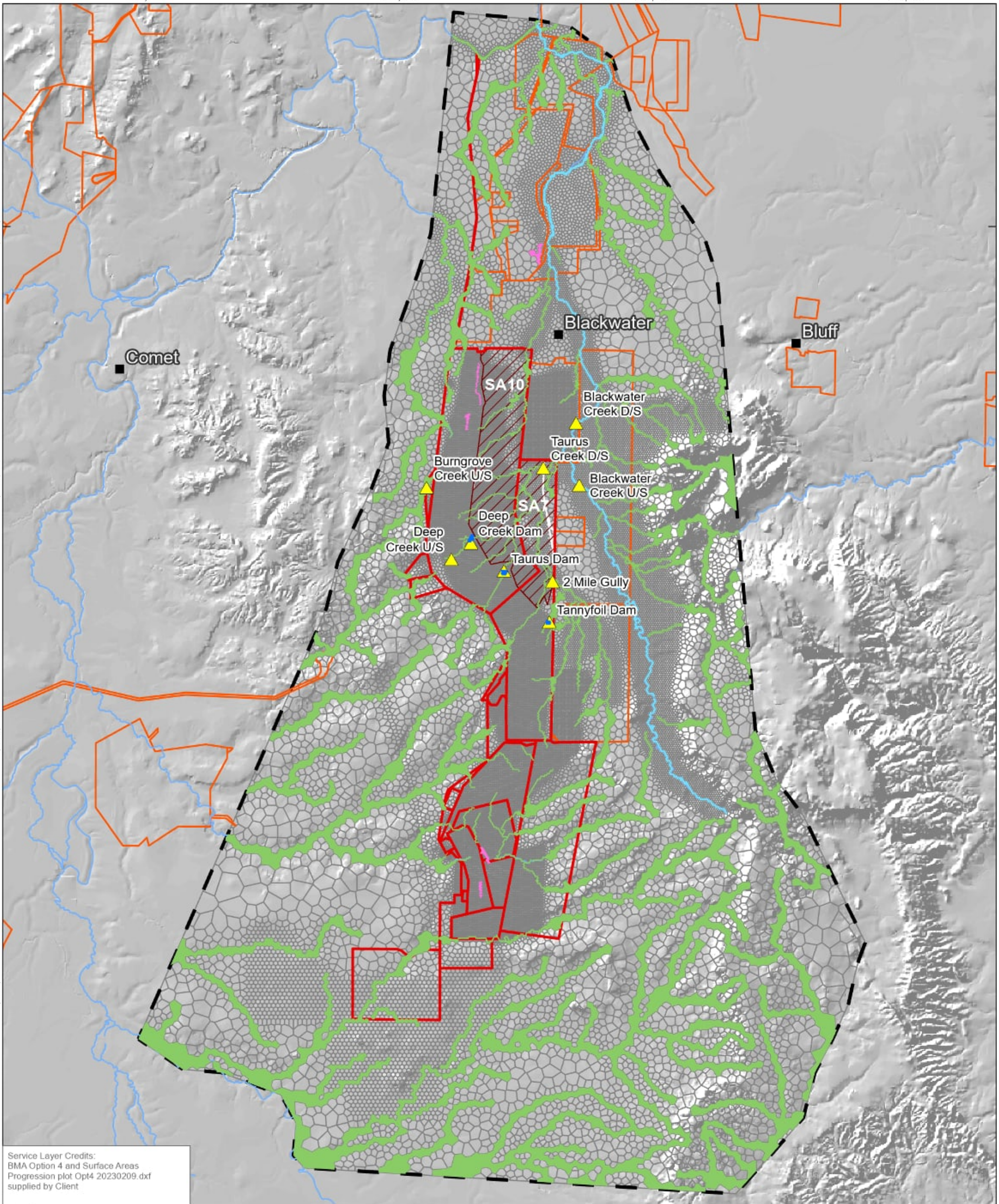
The river stage height in the minor tributaries or drainage lines was set to 0 m (i.e., river stage elevation was equal to river bottom elevation). Therefore, the minor tributaries or drainage lines act as drains to the groundwater system and do not result in any recharge into the groundwater, which is consistent with the conceptual model and reasonable on a regional level. Locally, some recharge from smaller creeks might occur around smaller creeks, however, this is not considered recharge to the deep regional groundwater system, but rather perched local lenses.

2.5.2.2 Mining Infrastructure

The RIV package was also used to simulate the pit lakes and dams within the area. **Table 2-3** lists the mining infrastructure elements, such as in-pit water storages and dams, that were included in the model.

Table 2-3 Mining Infrastructure in the Model

Boundary	Stage (m)	Kz (m/day)
In-pit water storages (Bonnie Doon, Mimosa pits)	Calibration Simulation (2005- 2022) - Historical Quarterly observations. Predictive Simulation (2023 onwards) – No stage height applied. It was assumed that voids (Bonnie Doon) will be filled during the mining at the prediction stage.	5.0×10^{-1}
Water Storage Dams New Taurus, Tanny Foil and Deep Creek dams	Calibration Simulation (2005- 2022) - Historical Quarterly observations. Predictive Simulation (2023 onwards) – Long term annual averages (2005-2023)	1.0×10^{-2}



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Gauging Station
- Watercourse
- Dam
- In-Pit Stroage
- Model Grid
- Model Boundary
- BWM North Extension Project Area
- BWM Mining Lease
- Mining Lease

Model River Cell

- Blackwater Creek
- Minor Drainage Feature

BLACKWATER MINE - NORTH EXTENSION PROJECT

RIVER CELLS AND GAUGING STATIONS

SLR

FIGURE 2-4

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F02_4_River Cells and Gauging Stations

2.5.3 Rainfall Recharge

The dominant mechanism for recharge to the regional groundwater system is through diffuse infiltration of rainfall through the soil profile, and subsequent deep drainage to underlying groundwater systems. Diffuse rainfall recharge to the model was represented using the MODFLOW-USG Recharge package (RCH).

The time-series recharge rate utilised in the model was derived from the Australian Landscape Water Balance model (AWRA-L) Deep Drainage estimate for the Project area (Frost, Ramchurn and Smith, 2018).

The AWRA-L model provides estimates of water fluxes and storages in the Australian landscape and is based on a model that simulates the flow of water through the landscape, through vegetation and soil, and then out again as evapotranspiration, runoff, and deep drainage to groundwater. The outputs from the model consist of soil moisture, runoff, evapotranspiration, deep drainage, and precipitation at the spatial resolution of 5 km^2. For this Project, the deep drainage component was derived for the location of the Project and used as the initial estimate of recharge to the aquifer. **Figure 2-5** presents the local transient recharge estimate from the AWRA-L model in comparison with observed groundwater levels at shallow bore MB21. The groundwater level at MB21 follows a similar trend to the recharge estimate. That is, periods of high recharge correlate with increased groundwater levels (i.e., 2010 to 2013), and following this high recharge event, both recharge and water levels decline at the similar rate between 2013 and 2020. This correlation indicates the time series estimate for recharge in the Blackwater area from the AWRA-L model is an appropriate starting point for simulating diffuse rainfall recharge to the model (RCH).

The recharge estimate was derived for each cell (5km by 5km) of the AWRA-L model and applied to the Blackwater groundwater model. These estimates as well as surface geology were used as a guidance to delineate the potential groundwater recharge zones. In summary, four zones were assigned to the upper layer of the model (Alluvium, Regolith, Clematis and Regolith high recharge area). These zones are shown on **Figure 2-6**. To include the AWRA-L recharge estimate in the model, the average of the recharge rate from AWRA-L model across the model domain was calculated and used as the initial estimate of the recharge rate for each zone. A multiplier was then assigned to each zone to estimate the final recharge rate at each zone. These multipliers were then calibrated to provide the best fit to groundwater level observations. The long-term average deep drainage rate from AWRA-L was used for the steady-state model and the prediction model. The calibrated recharge rates for the regional groundwater system are 0.1-1% and are further discussed in **Section 2.6.7.**

An enhanced recharge was applied to spoil areas. The recharge to the spoil is set to 7.4% of the average annual rainfall. This value was not calibrated.

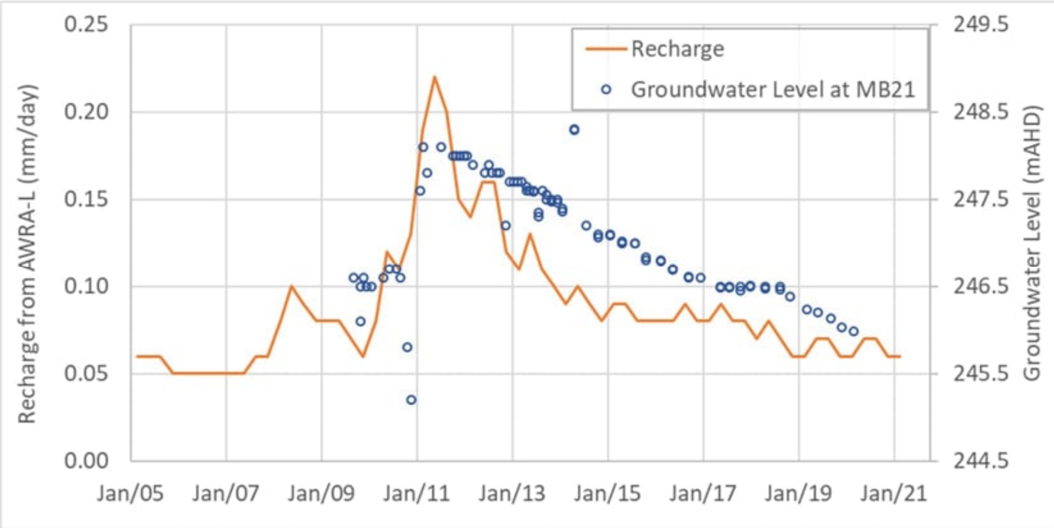
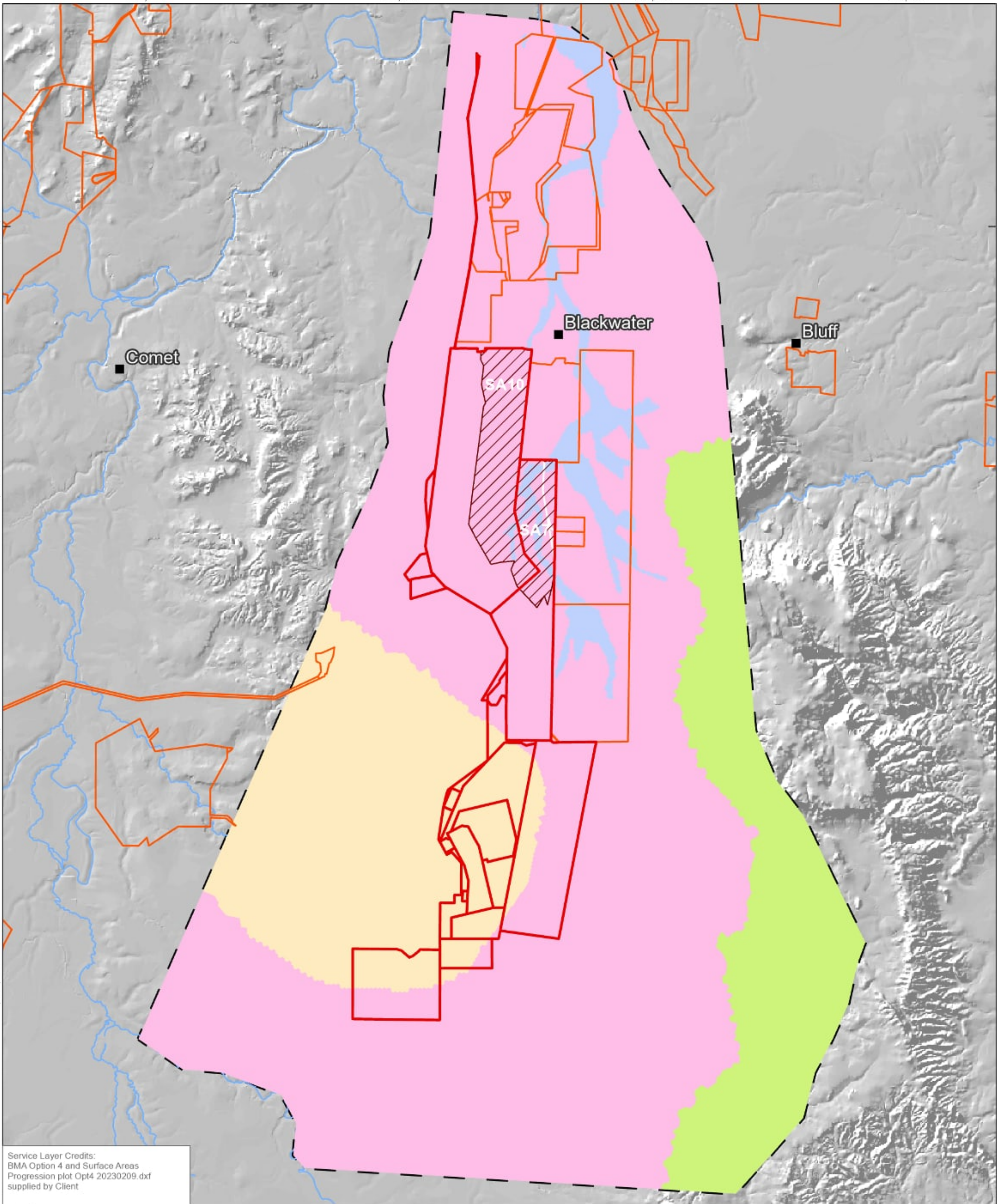


Figure 2-5 Recharge Rate and Water Levels at Bore MB21



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Recharge Zone

- Zone 1 - Blackwater Creek Alluvium
- Zone 2 - Regolith
- Zone 3 - Clematis
- Zone 4 - Regolith High Recharge Area

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

RECHARGE ZONES

FIGURE 2-6

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F02_6_Recharge Zones

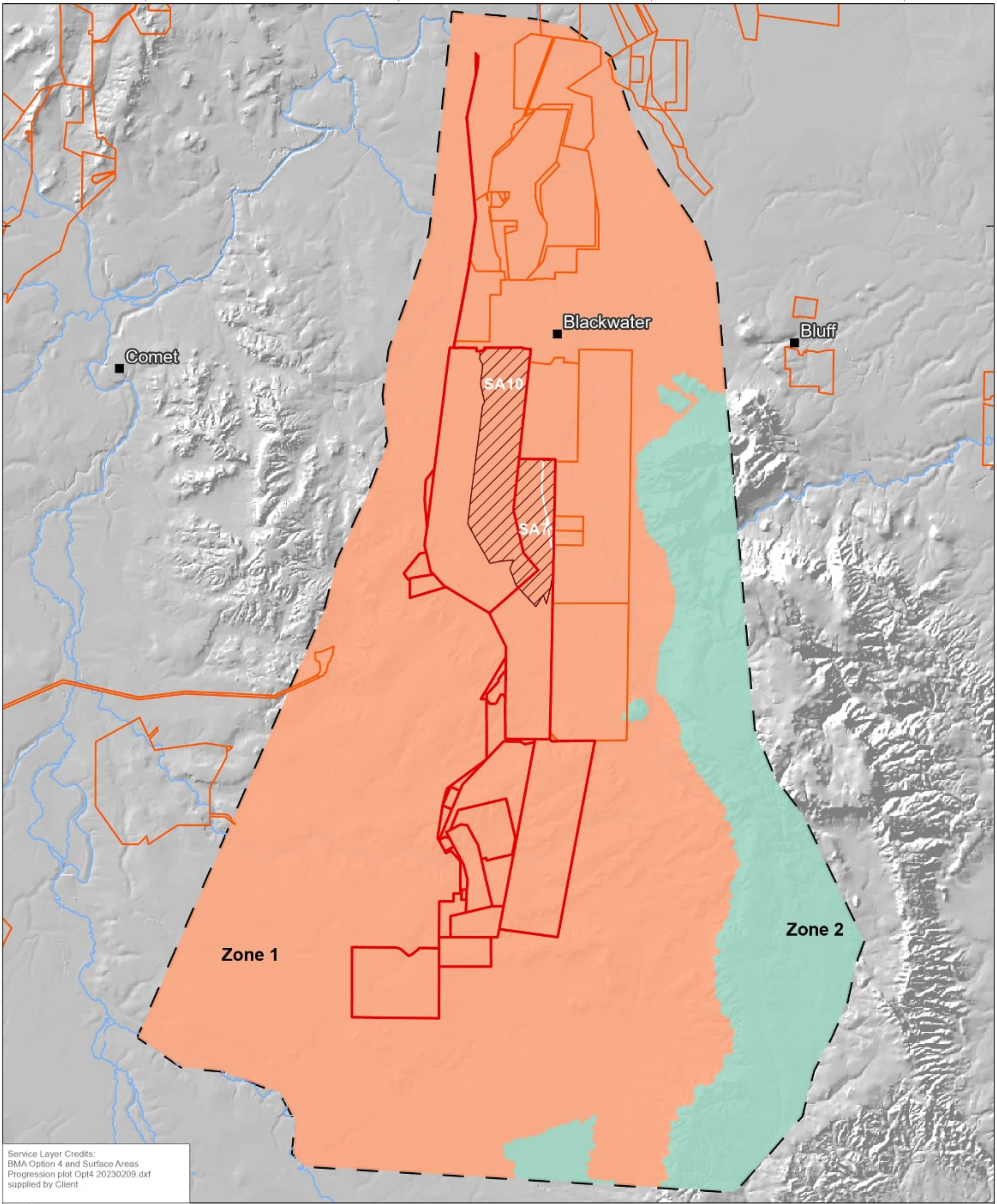
2.5.4 Evapotranspiration

Evapotranspiration from the shallow water table was simulated using the evapotranspiration package (EVT). Evapotranspiration was represented in the upper most cells of the model domain, with the extinction depth varied spatially based on the estimated rooting depths of regional vegetation type.

Overall, two zones were assigned (refer to **Figure 2-7**):

- Zone 1 represents the general vegetation in the lower lying areas. Model extinction depth of 2.5 m.
- Zone 2 represents the woodland area above the Clematis Formation. Model extinction depth of 7.5 m.

A maximum rate of evapotranspiration was generated from the SILO Grid Point series (refer to SLR, 2023). The value used in the model was 0.0027 m/day. An evapotranspiration rate of 0 was assigned to the model cells representing the rivers.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Evapotranspiration Zone

- General Vegetation in Lower Lying Area
- Woodland Area above the Clematis Formation

BLACKWATER MINE - NORTH EXTENSION PROJECT

EVAPOTRANSPIRATION ZONES OF EXTINCTION DEPTH

SLR

FIGURE 2-7

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F02_7_EVT

2.5.5 Groundwater Use

Private groundwater pumping bores have not been included in the model due to lack of information regarding abstraction rates. Due to generally low groundwater abstraction across the model area, it is likely that the bores have very localised drawdowns and will not significantly impact model results.

2.5.6 Mining

All mines included in this assessment, namely BWM, Cook Colliery, Minyango and Curragh Mines are targeting the Rangal Coal Measures, hence a cumulative assessment of impacts was carried out. The location of the mines is shown in **Figure 2-1**.

2.5.6.1 Dewatering

The MODFLOW Drain (DRN) package is used to simulate mine dewatering in the model for the Project and surrounding mines. Boundary conditions for drain cells allow one-way flow of water out of the model. When the computed head drops below the pre-defined stage elevation of the drain, the drain cells become inactive. This is an effective way of theoretically representing removal of water seeping into a mine over time, with the actual removal of water being via pumping and evaporation.

To simulate Blackwater open cut mine in the model, drain cells were applied to all active layers from the surface to the base of the lowermost mined seam, which is the Pollux Seam (Layer 12). The drain cells representing the surrounding open-cut mines were interpolated from previous reports, publicly available EIS documentation and aerial photography.

Historical mine inflows were provided by BMA based on the Associated Water Licence reporting for ML1759, ML1762, ML1862, ML1792, ML1767 and ML1907 during the four financial years from 2018/19 to 2021/22. These estimates are based on water balance modelling. The reported groundwater inflows were ranging from 1,337 ML/year to 1,852 ML/year during those four years.

2.5.6.2 Variation in Hydraulic Properties due to Mining

Two types of mining have been simulated, open-cut and underground.

For open cut mining, Hawkins (1998) and Mackie (2009) indicate that spoil and waste rock are more permeable than the undisturbed strata. Completed open cut mining areas will be backfilled with waste overburden as the extraction proceeds. Backfilling of open cut mine areas with spoil was modelled using the Time-Variant Material (TVM) package. The model cell properties were updated to spoil properties guided by operational mine plans. Horizontal hydraulic conductivity of 0.3 m/day and vertical hydraulic conductivity of 0.1 m/day was applied to the spoil, based on expert knowledge. The storage parameters used for the spoil were a specific yield of 0.1 and a specific storage of 1×10^{-5} m^{-1}.

For the underground mines, the hydraulic properties were changed with time in the goaf and overlying fractured zone directly above each longwall panel. MODFLOW-USG Time Varying Materials (TVM) package was used to simulate changes to aquifer properties in response to mining within the overlying strata and fracture zone. A number of multipliers were used to enhance hydraulic conductivities within the fracture zone overlying coal extraction areas, with multipliers generally following a ramp function, so that the multipliers with highest values were applied to the units closest to the mined seam and then gradually decreased as the units became close to the maximum height of connective cracking. The fracture zone multipliers are listed in **Table 2-4**.

Table 2-4 Fracture Zone multipliers

Layer	Unit	Average Kx multipliers	Average Kz multipliers
2	Weathered zone / Regolith	2	3
5	Rewan Group (Middle)	2	3
6	Rewan Group (Lower)	2	4
7	Overburden	11	814
8	Aries seam	2	3
9	Interburden	4	4
10	Castor seam	4	4
11	Interburden	69	315

The maximum height of connective cracking was derived using the Ditton/Merrick equation (Ditton and Merrick, 2014). The fracture heights at Minyango UG (underground) mine ranged from 132 m to 229 m, with an average fracture height of 168 m. This equates to fractures reaching from 183 mbgl to 57 mbgl, i.e., no fracturing of the surface is expected.

2.6 Calibration

2.6.1 Calibration Set-up

The automated calibration utility PEST ++ (White et al., 2019) and manual calibration were used to match the available transient water level data. The groundwater levels recorded between April 2005 to December 2022 were used for the model calibration. In total, 2037 target heads were available from 68 bores.

Groundwater targets were selected where:

- Valid information on bore construction or geology information was available for the site.
- Data was collected prior to 1988 or reasonably around 1988 to reflect baseline condition at the start of the model.

Groundwater bores used for the calibration were weighted equally in the calibration. Details on each of the observation points and their residuals are presented in **Appendix A** of this report. The regional spread of the bores is shown in **Figure 2-11**.

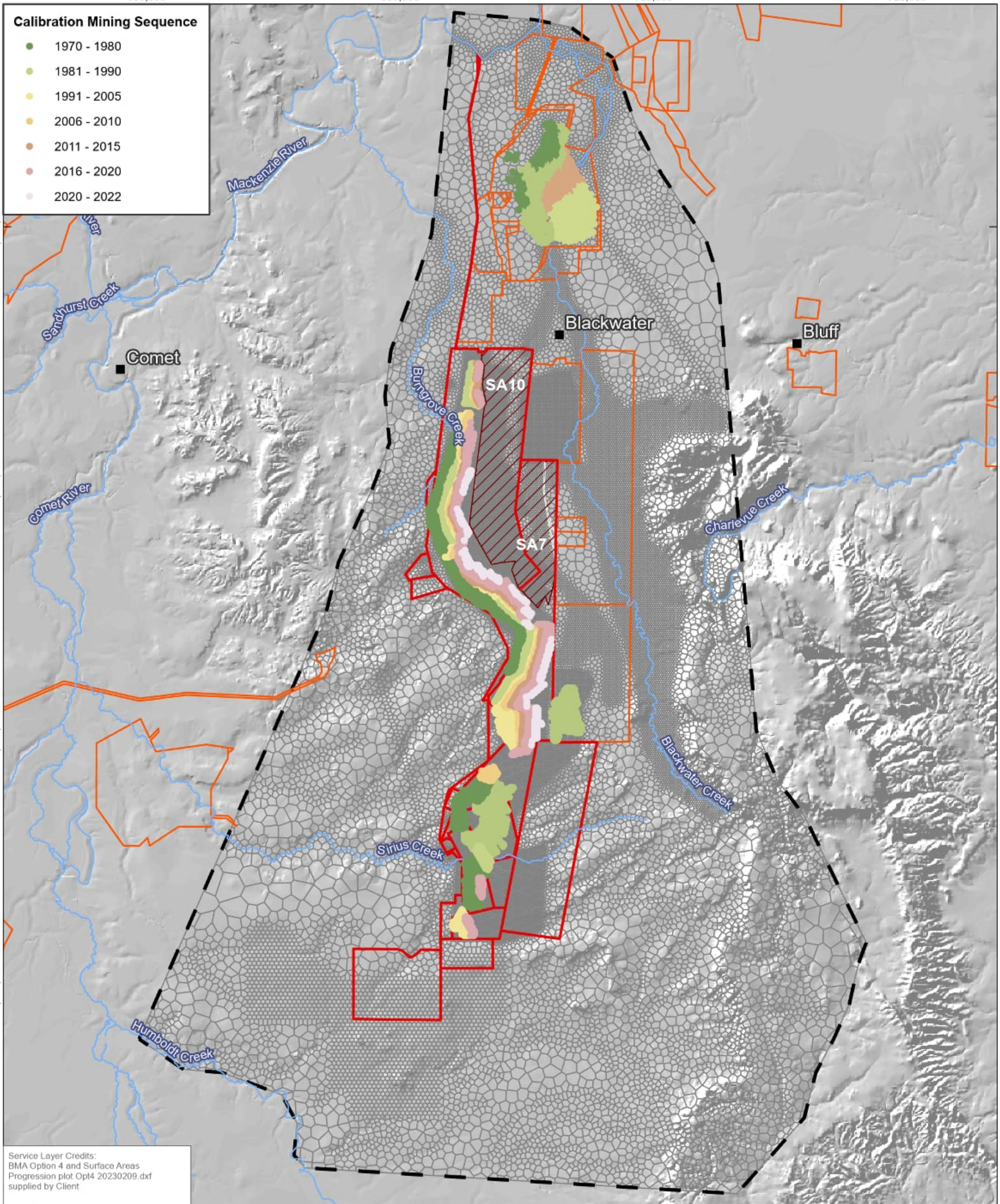
The transient warm-up model was built to incorporate pre-2005 mining activities and their impacts on groundwater levels around the Project area. The warm-up model provided appropriate starting conditions for the calibration model (i.e., starting heads and hydraulic properties). Together, the warm-up and transient calibrations comprise 78 stress periods. **Table 2-5** summarises the calibration model stress periods and simulated active mines during each stress period. **Figure 2-8** presents the mining sequence in a spatial context.

As shown in **Table 2-5**, the first stress period of the warm-up model was steady-state and did not include any mining. This warm-up model was used to simulate the pre-mining conditions.

The hydraulic properties (i.e., horizontal and vertical conductivity, specific yield, and specific storage) and recharge rates were adjusted during the calibration to provide best match between the measurements and model simulated heads.

Table 2-5 Calibration Model Stress Period Setup

Calibration Period	Interval	Stress Period	Date (from)	Date (to)	BWM (OC)	Curragh mine (OC)	Cook Colliery (UG)	Kenmare and Laleham (UG)
Steady-State		1	Steady-state					
Warm- up	35 Years	2,3,4	Transient Warm up (1970-2005)		x	x	X	x
Transient	Quarterly	5 to 78	01/01/2005	01/07/2023	x	x		



N
0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

CALIBRATION MINING SEQUENCE

SLR

FIGURE 2-8

2.6.2 Calibration Statistics

One of the industry standard methods to evaluate the calibration of the model is to examine the statistical parameters associated with the calibration. This is done by assessing the error between the modelled and observed (measured) water levels in terms of the root mean square (RMS). The RMS is expressed as:

$$RMS = \left[1/n \ \Sigma(h_o - h_m)_i^{\ 2} \right]^{0.5}$$

where: n = number of measurements

h_o = observed water level

h_m = simulated water level

The overall transient calibration statistics are presented in **Table 2-6**. The RMS error calculated for the calibrated model is 11.68 m. The acceptable value for the calibration criterion depends on the magnitude of the change in heads over the model domain. If the ratio of the RMS error to the total head change in the system is small, the errors are considered small in relation to the overall model response(s). The total measured head change across the model domain is 182.5 m; therefore, the ratio of RMS to the total head change (scaled root mean square, SRMS) is 6.40%. While there is no recommended universal SRMS error, The Australian Groundwater Modelling Guidelines suggests that setting Scaled RMS targets such as 5 or 10% may be appropriate in some circumstances (Barnett et al, 2012).

As shown in **Table 2-6**, 90% (1,836 of the 2,037 calibration targets) are within ±20 m of the observed measurements. This provides an indication of reasonable fit for the dataset. Further discussion on the fit between modelled and observed trends is included in **Section 2.6.3**.

Table 2-6 Calibration Statistics

Statistic	Value
Sum of Squared residuals (m^2)	269,670.33
Mean of Squared residuals (m)	136.47
Root of Mean of Squared residuals (RMS) (m)	11.68
Scaled Root Mean Square (SRMS) (%)	**6.40%**
Sum of Absolute Residuals (m)	18,473
Mean Sum of Absolute Residual (m)	9.07
Targets within ±2m	400
Targets within ±5m	741
Targets within ±20m	1836

Figure 2-9 presents the observed and simulated groundwater levels graphically as a scattergram for the initial and historic transient calibration (2005 to 2022), grouped for the Alluvium and Tertiary, Rewan Group and Permian bores respectively. Overall, there is a reasonable fit between simulations and observed levels and the residual in most calibration data points are within ± 20 m.

Figure 2-10 shows the distribution of calibration residuals.

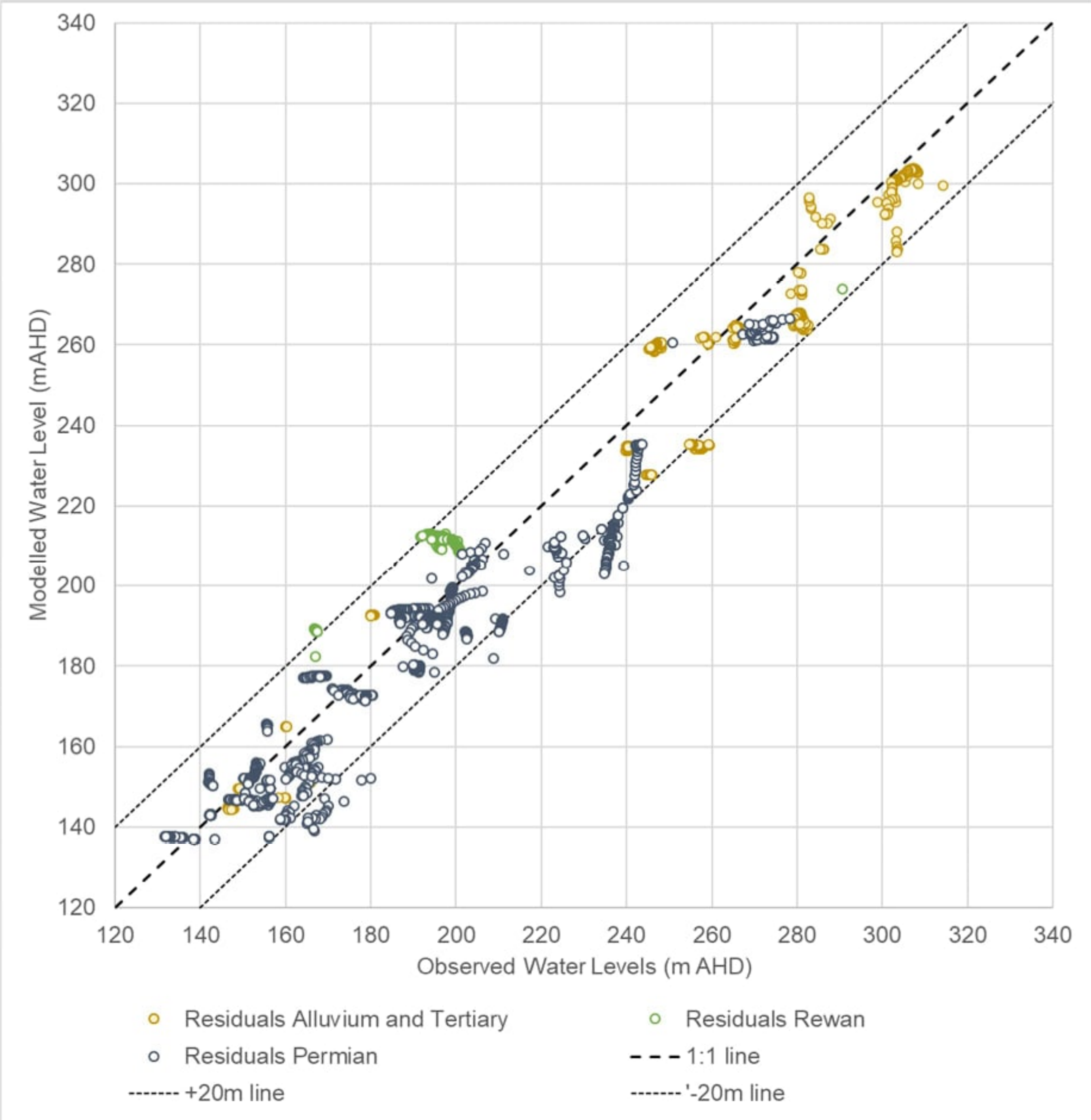


Figure 2-9 Calibration Scattergram – Modelled vs Observed Groundwater Levels

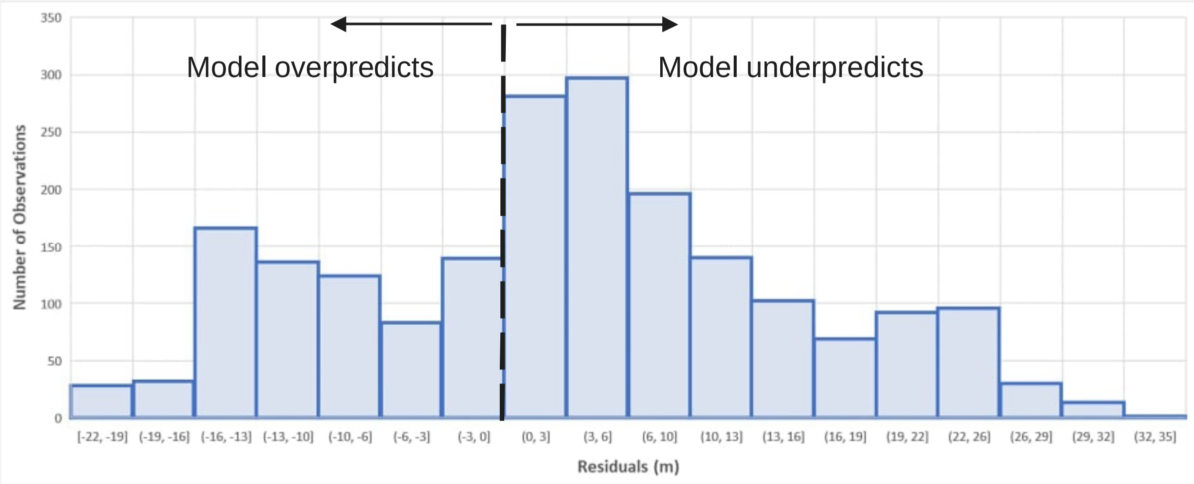


Figure 2-10 Calibration Residual Histogram Scattergram

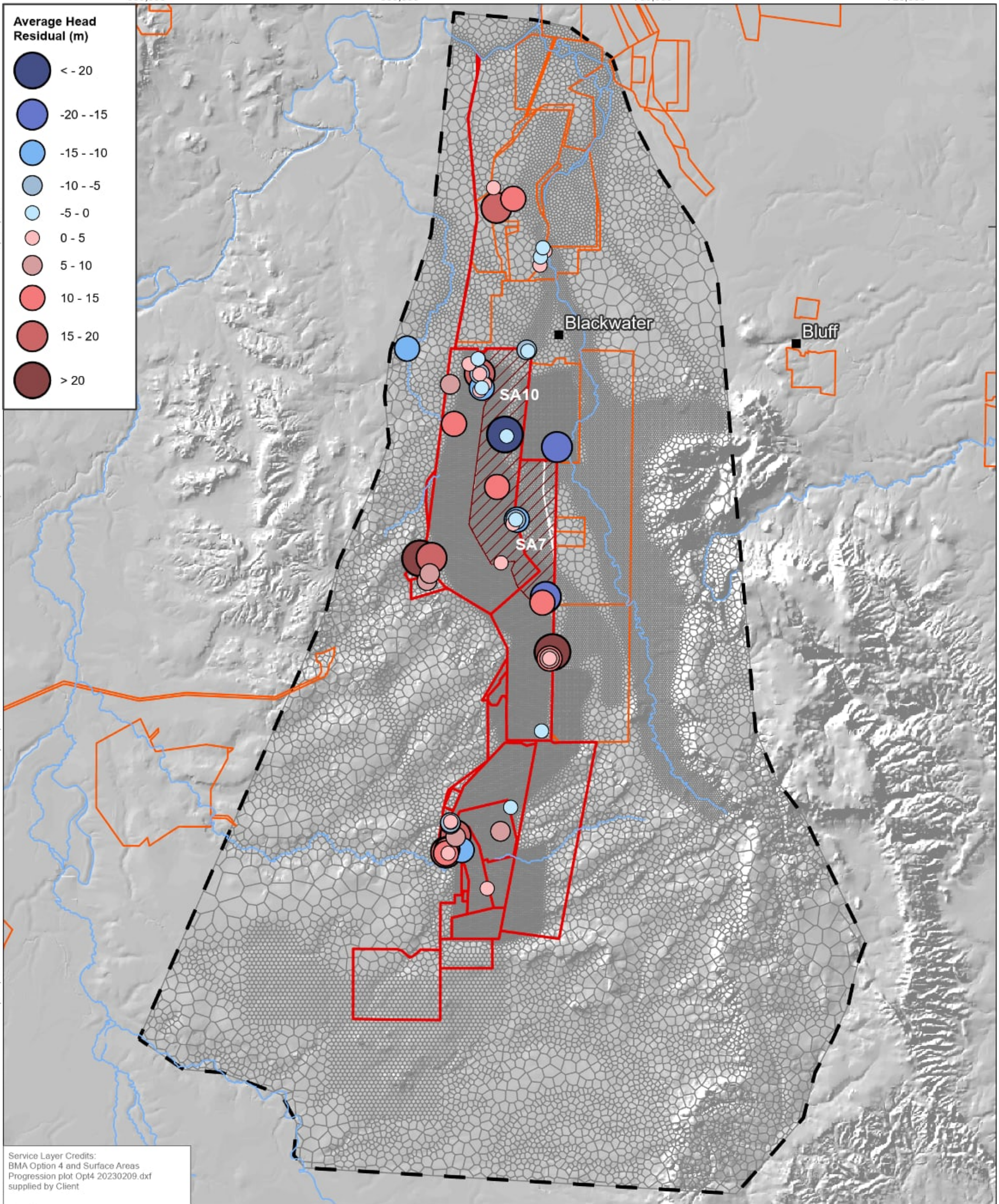
Table 2-7 shows the average calibration residual and absolute average residual per model layer. The residual is the difference between the measured and the modelled water level at each bore. A negative residual represents an overestimation of water levels, while a positive residual represents an underestimate. As indicated in the table, the majority of bores are screened at weathered zone and Permian layers (i.e., layer 2 and layers 7 to 8) and the absolute residual is generally low in these layers.

Table 2-7 Average Residual by Model Layer

Model Layer	Formation	Unit	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of bores
1	Alluvium, Tertiary	Surface cover	2.25	2.25	33	2
2	Alluvium, Weathered zone	Weathered zone	4.52	10.85	552	19
3	Clematis	Clematis formation	----	----	----	----
4	Rewan	Upper	----	----	----	----
5	Rewan	Middle	-15.20	15.20	1	1
6	Rewan	Lower	-14.74	14.90	210	4
7	Rangal Coal Measures	Overburden	8.11	11.10	430	11
8		Aries coal seam	3.51	6.16	438	13
9		Interburden	3.13	3.53	36	1
10		Castor coal seam	12.10	12.10	26	1
11		Interburden	----	----	----	----

Model Layer	Formation	Unit	Average Residual (m)	Average Absolute Residual (m)	Number of Observation Targets	Number of bores
12		Pollux seam	6.31	6.31	80	3
13		Underburden	16.77	16.77	26	1
14	Burngrove	Burngrove formation	3.60	8.99	193	4

The spatial distribution of average residuals for each bore from the transient calibration is shown in **Figure 2-11**. The figure shows regionally there is a good match between the observed and simulated groundwater levels.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	29-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

TRANSIENT CALIBRATION AVERAGE HEAD RESIDUALS (M)

SLR

FIGURE 2-11

2.6.3 Calibration Fit

This section provides discussion on the modelled to observed groundwater level trends (calibration hydrographs) for key bores across the BWM site. Calibration hydrographs for the full calibration dataset is presented as **Appendix B.**

2.6.3.1 Alluvium and Regolith

Figure 2-12 presents the fit between simulated and observed heads in selected Regolith bores. For bore 158142 there is a limited data set from 2013 to 2015 available. The calibrated water levels are matched well for this time period.

The calibration hydrographs for MB6, MB12 and MB20 in **Figure 2-12** show that the model can replicate the hydrological conditions (rise of groundwater level in wet conditions, a decrease in groundwater level during dry conditions). Even though the model has simulated the rise of the water levels within year 2011 and 2012 and the decline in groundwater level from 2012 to 2020 for bore MB6, there is an absolute error between simulation and observed heads at these locations. However, as the model will be used to calculate impacts based on drawdowns (the difference between two model runs), the replication of the trend is deemed more important than matching the absolute water level at each calibration target.

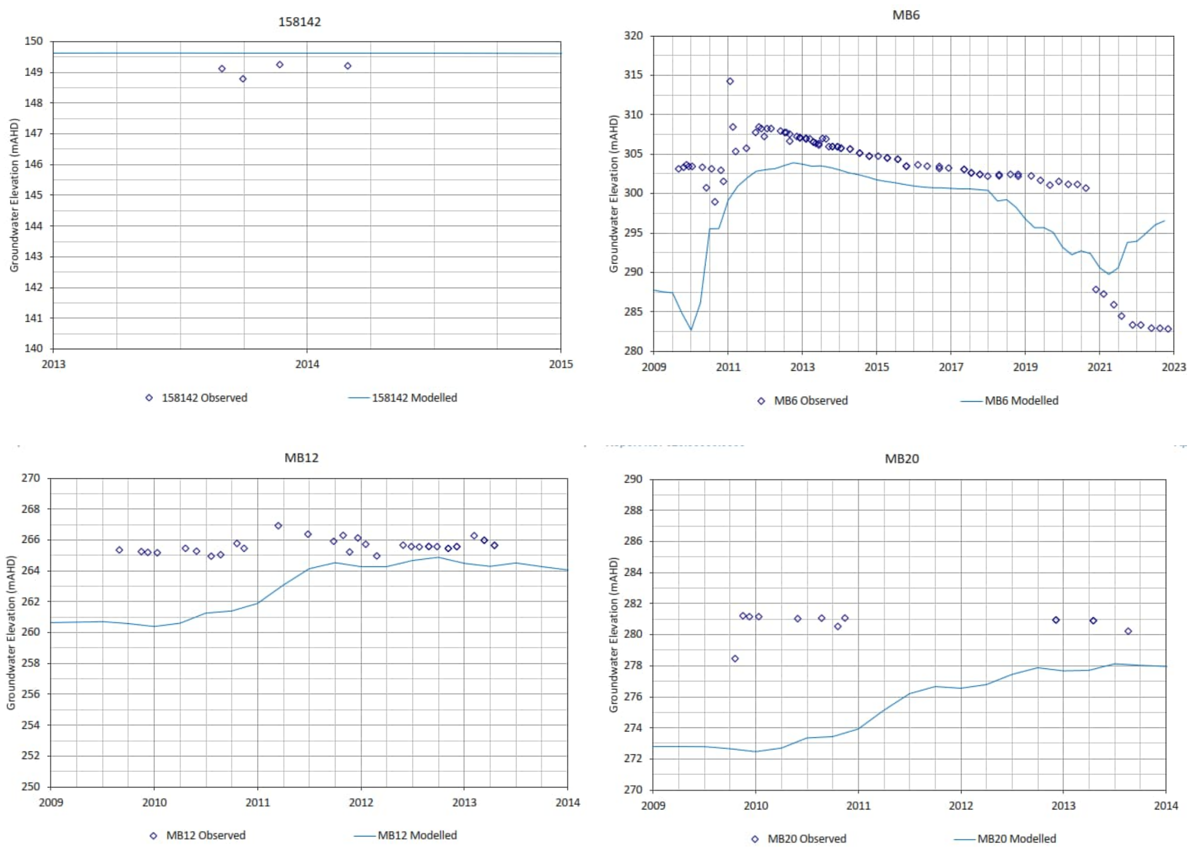


Figure 2-12 Calibration Fit - Regolith Bores

2.6.3.2 Permian Coal Measures

Figure 2-13 shows the calibration results for the bores screened within the coal seam and the overburden and interburden of the Rangal Coal Measures. The calibration results at the VWP bore VWP19BWM02 (top left) show that the model is able to reproduce the depressurisation in the coal seams (Sensors 2, 3 and 4) while the overburden (Sensor 1) is showing only a slight decrease. Further, the hydrographs for MB1 and MB5 show that the decrease in the coal seams is well reflected. Bore MB1 is screened in the overburden. The model predicts a decline of 15 m at the bore during the calibration timeframe, however, the observations showed a steady water level with a slight increase of 5 m. This could potentially be due to the cell size and/or historical mining not being accurately included in the model.

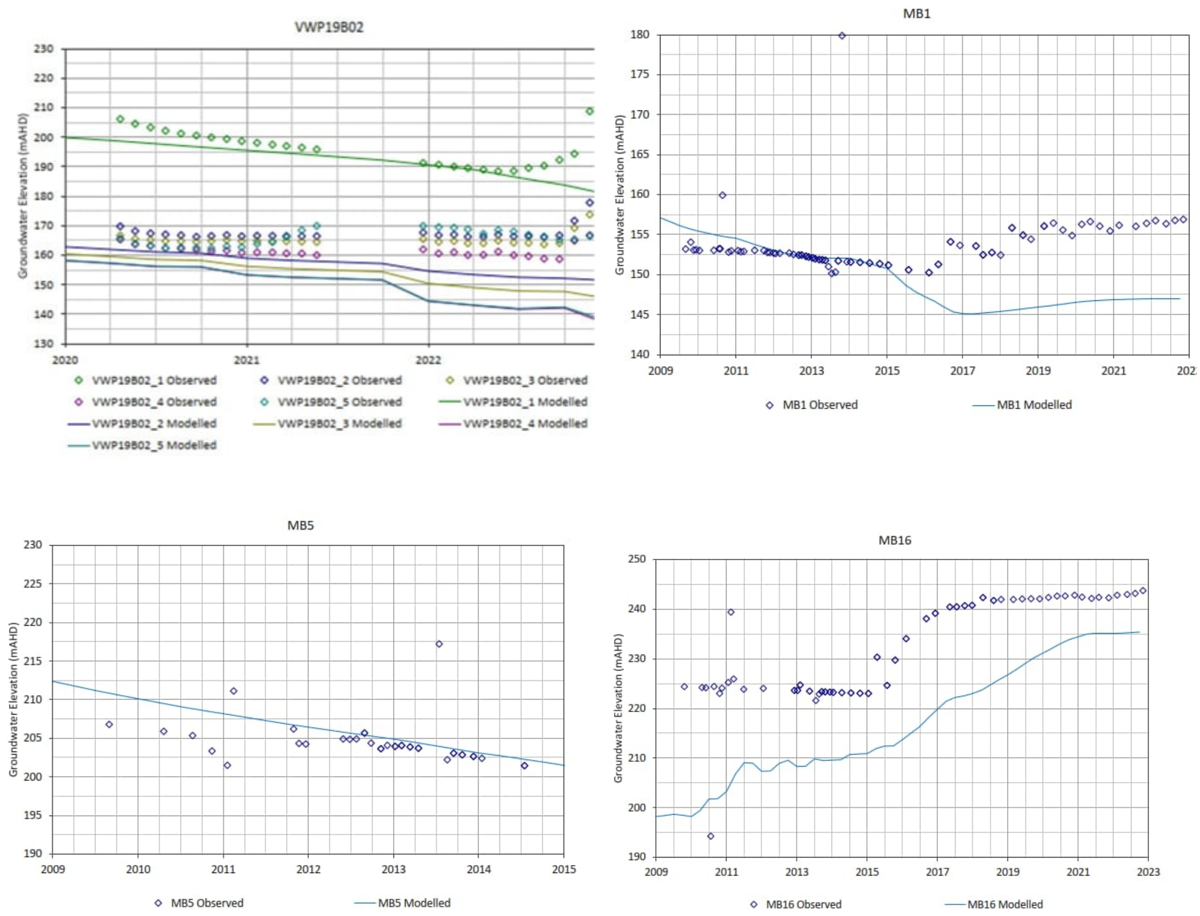


Figure 2-13 Calibration Fit - Permian Bores

2.6.4 Water Balance

2.6.4.1 Steady State Calibration

The water balance for the steady state model calibration as part of the model warm-up simulations is shown in **Table 2-8**. The water balance for the steady-state model indicates that recharge was the largest net inflow contributor to the model (14.70 ML/d). Given that the steady state heads were assigned at the regional groundwater flow (GHB), there are no further flux changes along the GHB boundary condition and hence the flow in and out are zero.

A net outflow of 0.71 ML/d from the model occurs due to baseflow seepage to Blackwater Creek (i.e., surface water and groundwater interaction in the Blackwater Creek). Other factors that contribute to outflow from the groundwater system are evapotranspiration (5.87 ML/d outflow) and baseflow seepage to minor drainage systems (8.12 ML/d outflow). The mass balance error for the steady state calibration is 0.00%, within the error threshold recommended by the Australian Groundwater Modelling Guidelines (Barnett et al., 2012), and indicating the model is stable and achieves an accurate numerical solution.

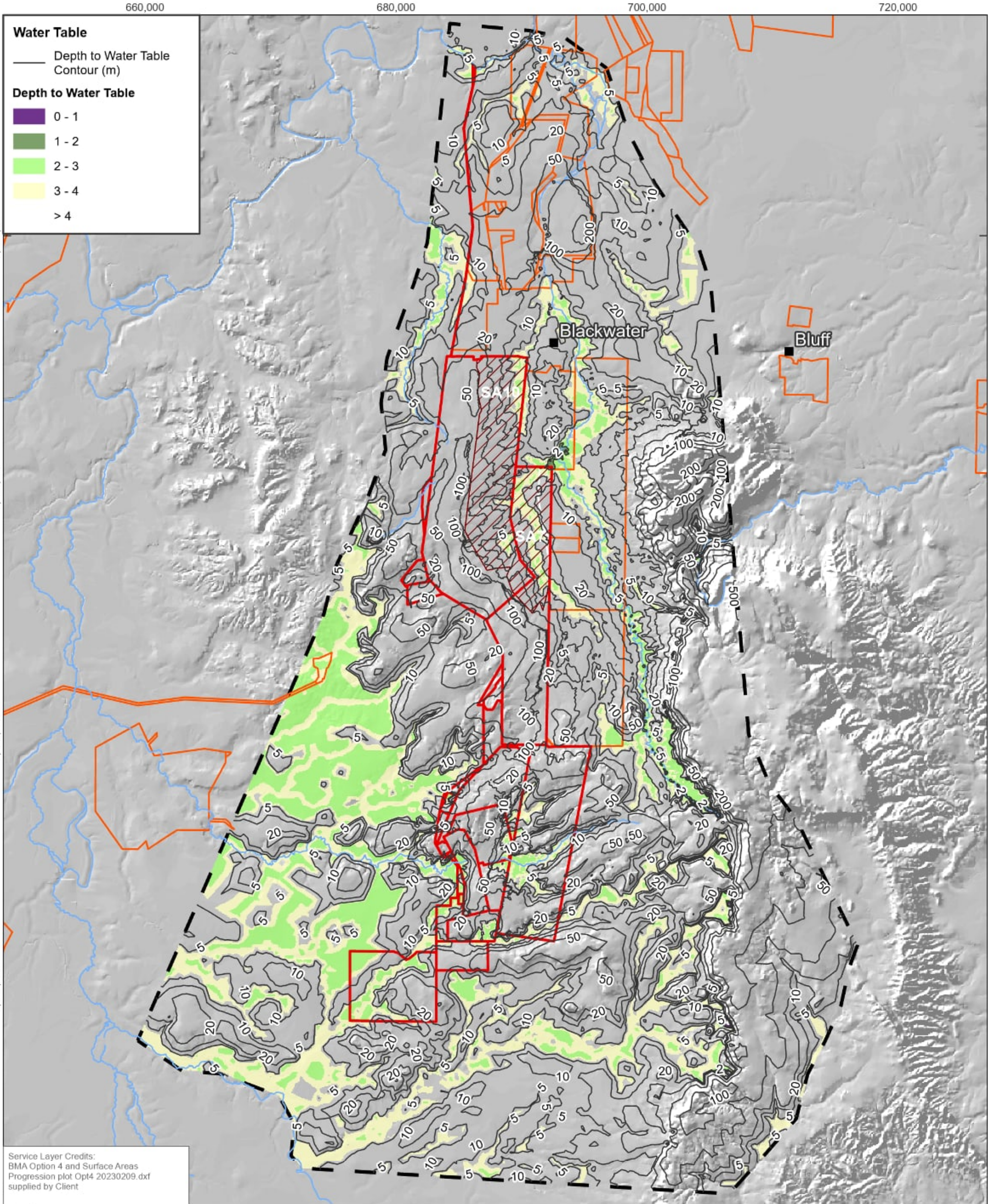
Table 2-8 Steady-State Model Water Balance

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total Inflow (%)
Recharge (RCH)	14.7	100.0	0.0	0.0
ET (from GW) (EVT)	0.0	0.0	5.87	39.93
SW-GW Interaction Blackwater Creek (RIV)	0.0	0.0	0.71	4.83
SW-GW Interaction other rivers (RIV)*	0.0	0.0	8.12	55.24
Pit Lakes and dams	0.0	0.0	0.0	0.0
Regional GW Flow (GHB)	0.0	0.0	0.0	0.0
Mines (DRN)	0.0	0.0	0.0	0.0
Storage	0.0	0.0	0.0	0.0
Total	14.7	100.0	14.7	100.0

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

Figure 2-14 shows the modelled depth to groundwater map for December 2022 (end of calibration timeframe). Shallow depths of less than 4 m are highlighted with colour in addition to the contours. The figure shows that the groundwater table is shallow in the south-western part of the model. In that area, there are no calibration targets to match the groundwater levels to, so there is uncertainty around the pre-mining depth to groundwater.

However, due to the shallow modelled water table, the creeks in the area will take on baseflow, which is likely draining excess recharge in that area (**Figure 2-6**, Zone 4). This could explain the large outflow of 8.12 ML/day in the steady state water balance. Similarly, the model indicates depth to water table is lower around Blackwater Creek. The outflow of 0.71 ML/day is still small considering this is a sum over the entire length of the creek.



0 5 10 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:400,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- City/Town
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

BLACKWATER MINE - NORTH EXTENSION PROJECT

MODELLED DEPTH TO WATER TABLE (m) END OF CALIBRATION (DECEMBER 2022)

SLR

FIGURE 2-14

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F02_14_Depth to WT EndEofCal

2.6.4.2 Transient Calibration

The water balance for the transient simulation averaged over the duration of the calibration period is presented in **Table 2-9**. The mass balance error, that is the difference between calculated model inflows and outflows at the completion of the transient calibration, was 0.00%, which indicates the model is stable and achieves numerical convergence. The water balance for the transient model indicates that recharge was the largest net inflow contributor to the model, contributing an average of 20.36 ML/d to the groundwater system. The transient recharge is higher when compared to steady state recharge rate. This is mainly due to additional recharge (i.e. 7.4% of average rainfall) being applied to spoil. **Table 2-9** shows 5.43 ML/day is lost to evapotranspiration in areas where the water table is within 2 m of the land surface. In total 7.63 ML/day is discharged via surface drainages.

A net flow loss of approximately 0.27 ML/day occurs from the Blackwater Creek, which is considered to be negligible when compared to the total inflows and outflows of the model. Other rivers contribute to a loss of approximately 7.63 ML/day from the groundwater system with no inflow component. The fluxes from the GHB component (inflow and outflow) are 0.002 and 0.01 ML/day respectively. The GHB inflow and outflow are generally very low indicating a small volume of water leaving or adding to the model through this boundary. This is mainly due to the low conductance value been assigned to the cells which are active in the GHB. This is a conservative way of simulating the mining impact as it assumes that any drawdown due to mining activities will not be offset by the inflow from the GHB and so the boundary condition does not have any impact on the model predictions.

An average of 5.29 ML/day is removed from the model by the Drain boundary condition that represents historical mining (1970-2023) in the model. This equates to 1,932 ML/year. The reported mine inflows for the four financial years between 2018/19 and 2021/22 ranged from 1,337 ML/year to 1,852 ML/year (**Section 2.5.6.1**). As a quantitative measure, the reported inflows and the modelled inflows show a good match.

Pit lakes and water storage ponds including New Taurus, Tanny Foil, and Deep Creek dams contribute 7.55 ML/day to the model.

Table 2-9 Transient Model Water Balance

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total Inflow (%)
Recharge (RCH)	20.36	60.42	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	5.43	16.13
SW-GW Interaction Blackwater Creek (RIV)	0.27	0.82	0.64	1.90
SW-GW Interaction other rivers (RIV)*	0.00	0.00	7.63	22.64
Pit Lakes and dams	7.55	22.42	0.33	0.99
Regional GW Flow (GHB)	0.002	0.01	0.01	0.02
Mines (DRN)	0.00	0.00	5.29	15.71

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total Inflow (%)
Storage	5.51	16.34	14.35	42.60
Total	33.69	100.00	33.69	100.00

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

2.6.5 Calibrated Hydraulic Parameters

Table 2-10 provides a summary of the calibrated values for horizontal and vertical hydraulic conductivity used in the model. The hydraulic parameter zones in all the model layers are presented in **Appendix C**.

Table 2-10Calibrated Hydraulic Parameters

Model Layer	Formation	Unit	Horizontal Hydraulic Conductivity (m/day)	Anisotropy Kz/Kx
1	Alluvium	Surface cover	1	0.1
1	Tertiary	Surface cover	0.05	0.02
2	Alluvium	Surface cover	1	0.1
2	Weathered zone	Surface cover	0.025	0.01
3	Clematis Group	Triassic	0.01	0.05
4	Rewan Group (Upper)	Triassic	0.000005 to 0.0094	0.1
5	Rewan Group (Middle)	Triassic	0.000005 to 0.0099	0.1
6	Rewan Group (Lower)	Triassic	0.000005 to 0.0097	0.01
7	Rangal Coal Measures	Overburden	0.000005 to 0.0079	0.005
8		Aries seam	0.000005 to 0.59	0.2
9		Interburden	0.000005 to 0.0099	0.025
10		Castor seam	0.000005 to 0.3	0.5
11		Interburden	0.000005 to 0.0098	0.05
12		Pollux seam	0.000005 to 0.3	0.5
13		Underburden	0.000005 to 0.025	0.1
14	Burngrove Formation	Permian	0.000005 to 0.03	0.3

The hydraulic conductivity of the coal seams and interburden material in the Rangal Coal Measures reduces with depth to reflect field observations. As the decrease of Kx within the interburden rock units is driven by an increase in overburden pressure, the relationship between Kx and depth is different from that of coal seams. The hydraulic conductivity for the interburden and coal seam material is capped at a minimum of 5.0 x 10^{-6} m/day.

The hydraulic conductivity of the interburden/overburden and coal seam layers decreases exponentially with depth according to Equations 1, 2. The type of equation used to simulate the hydraulic property changes due to depth is consistent with the ones used to model the surrounding mines including Minyango underground assessment (AGE 2013):

Coal: $HC1 = HC01 \times e^{(Slope1 \times depth)}$ (Eq. 1)

Interburden (RCM): $HC2 = HC02 \times e^{(Slope2 \times depth)}$ (Eq. 2)

Where:

- HC1 and HC2 is the horizontal hydraulic conductivity at the specific depth for the coal seam and interburden, respectively.
- HC01 and HC02 is the horizontal hydraulic conductivity at depth of 0 m (intercept of the curve) for the coal seam and interburden, respectively.
- Depth is depth of the floor of the layer (thickness of the cover material).
- Slope is a term representing slope of the formula (steepness of the curve) for the coal seam and interburden, respectively.

The hydraulic conductivity at zero depth (HC0) was estimated in the calibration. It varied for the coal seams and for the interburden and overburden units in the model. It should be mentioned that only HC0 was estimated in the calibration and the slope was assumed to be fixed during the calibration. The Kx vs depth relationships for the interburden/overburden are presented in **Figure 2-15**, while the calibrated relationships for coal units are presented in **Figure 2-16**. The HC0 used to create the lines in **Figure 2-15** and **Figure 2-16** is the average of calibrated HC0 for interburden and coal measures respectively. The figures present all available data at BWM and for the wider Bowen Basin. No BWM data is available for the interburden/overburden.

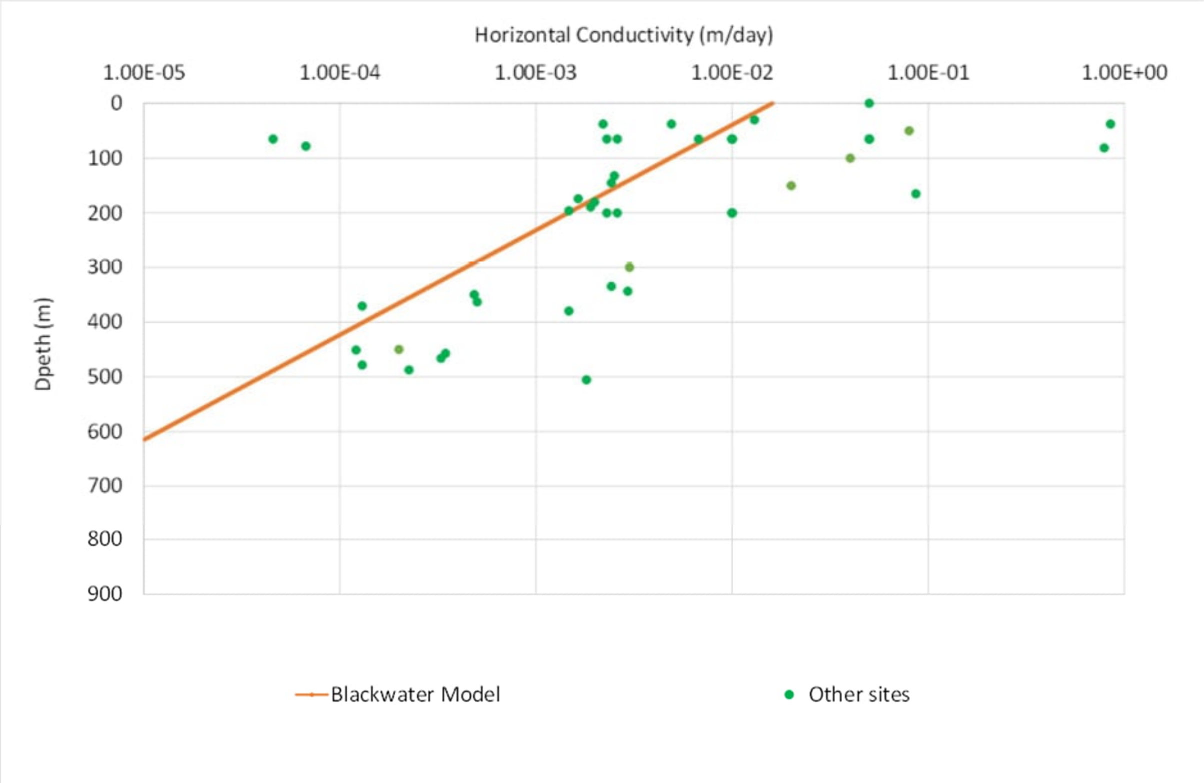


Figure 2-15 Hydraulic Conductivity vs Depth – Interburden/Overburden (Rangal Coal Measures)

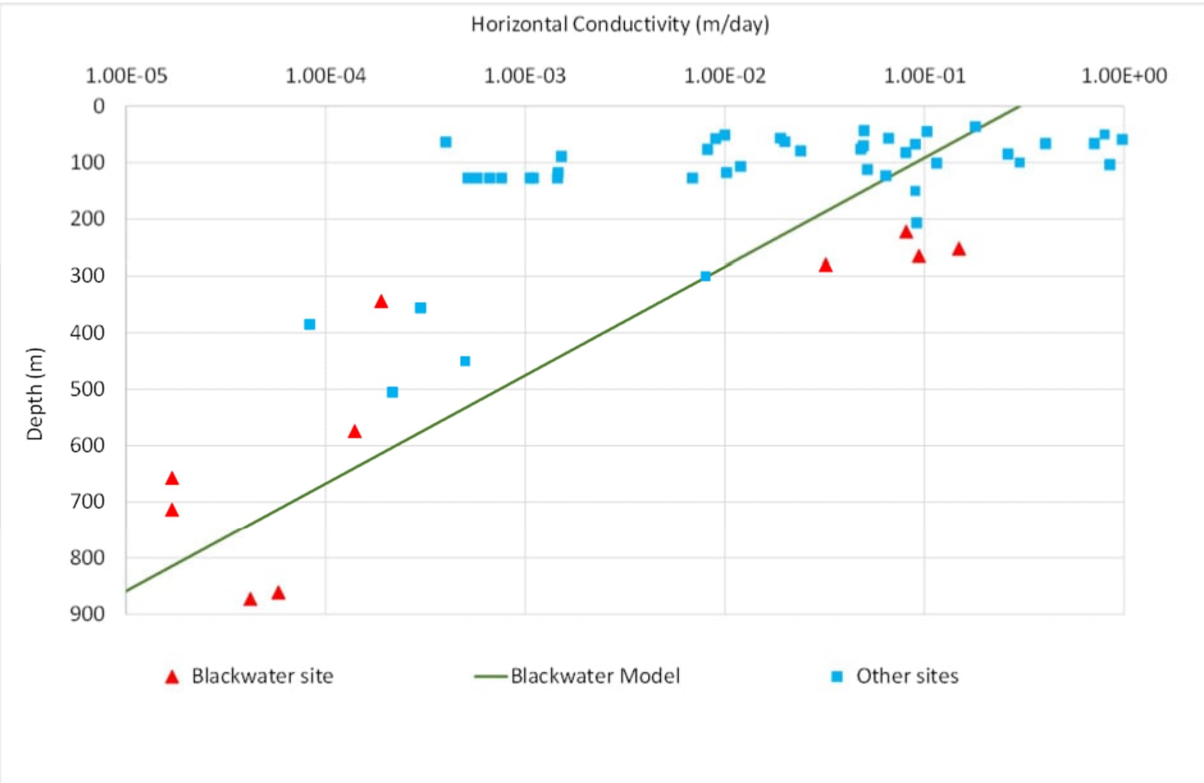


Figure 2-16 Hydraulic Conductivity vs Depth – Coal

Figure 2-17 illustrates the range in the horizontal hydraulic conductivity obtained from site testing and publicly available data. The data are focused on the key site units, being the alluvium, Regolith, Rewan Group and the coal and interburden sequences of the Rangal Coal Measures. The data are compared to the horizontal hydraulic conductivity values used in the model. Given that a depth dependence equation for the coal measures was used in the numerical groundwater model, the calibrated hydraulic conductivity values vary across the model domain. Accordingly, the average value for Rewan, Rangal Coal Measures and Burngrove formation is displayed. For the alluvium, the calibrated value is larger than the site average. For all other formations, the calibrated value is lower than the site average. However, as shown in **Figure 2-17**, the calibrated horizontal hydraulic conductivity values are all within the range of field data.

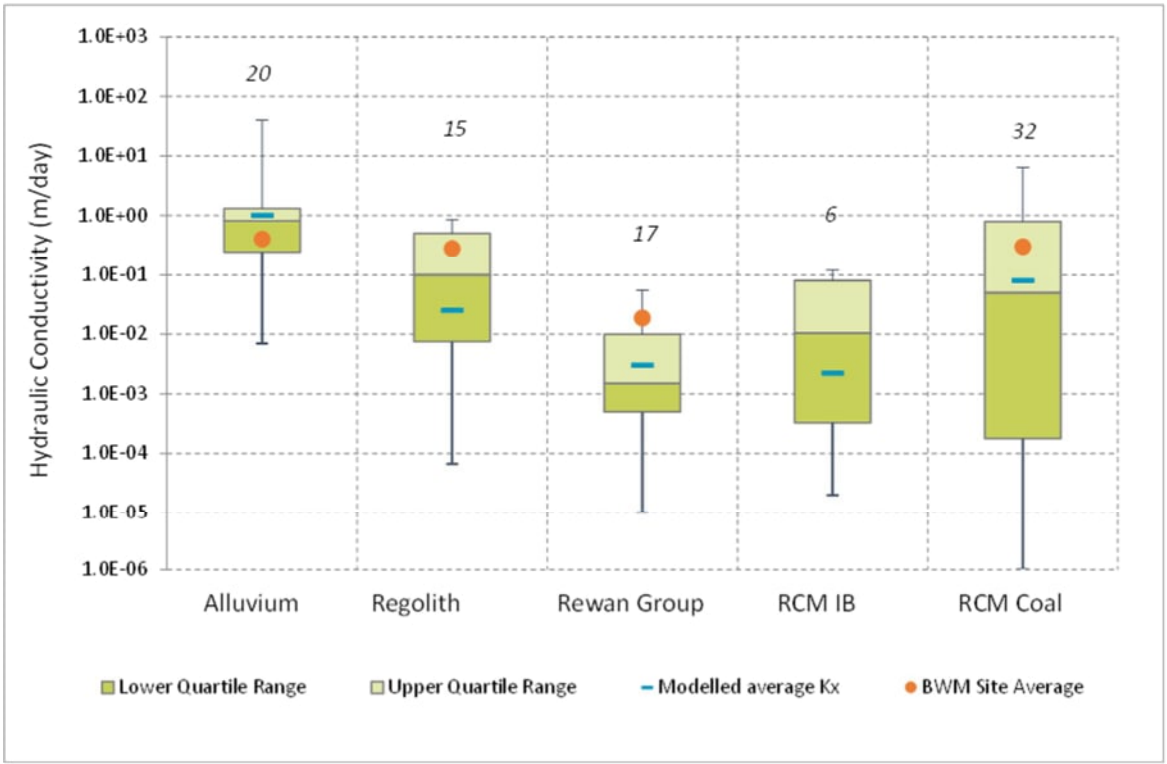


Figure 2-17 Hydraulic Parameters Estimates vs Calibrated Hydraulic Parameters

2.6.6 Calibrated Storage Properties

The specific storage and specific yield starting values were taken from the OGIA Groundwater modelling report (OGIA, 2019) and adjusted during the calibration process. **Table 2-11** summarises the calibrated values for specific storage and specific yield.

Table 2-11Calibrated Storage Parameters

Model Layer	Formation	Unit	Specific Yield Sy	Specific Storage Ss(m-1)
1	Alluvium	Surface cover	0.02	1E-05
1	Tertiary	Surface cover	0.01	1E-05
2	Alluvium	Surface cover	0.02	1E-05

Model Layer	Formation	Unit	Specific Yield Sy	Specific Storage Ss(m-1)
2	Weathered zone	Surface cover	0.002	1E-06
3	Clematis Group	Triassic	0.003	1E-06
4	Rewan Group (Upper)	Triassic	0.003	1E-06
5	Rewan Group (Middle)	Triassic	0.003	1E-06
6	Rewan Group (Lower)	Triassic	0.003	1E-06
7	Rangal Coal Measures	Overburden	0.003	5E-06
8		Aries seam	0.003	1E-06
9		Interburden	0.003	3E-06
10		Castor seam	0.003	3E-06
11		Interburden	0.003	3E-06
12		Pollux seam	0.003	3E-06
13		Underburden	0.003	1E-06
14	Burngrove Formation	Permian	0.003	3E-06

The OGIA, 2019 model of the Surat Basin used a pre-calibration Sy value of 1% for all layers (Including Bandanna formation which is called the Rangal Coal Measures in the Bowen Basin) except the Cenozoic Formations (incl Condamine Alluvium), which had Sy values of 0.1% to 10%. Post-calibration values for Sy were only presented for the coal bearing units. For the Bandana Formation, which is equivalent to the Rangal Coal Measures around Blackwater, the Sy value was 2% and 1% respectively. The calibrated Sy values for the model presented herein (**Table 2-11**) were lower by a factor 3 to 6 from the OGIA, 2019 estimates.

2.6.7 Calibrated Recharge

Table 2-12 presents the calibrated recharge rates for each geological unit in the model. It should be noted that the average recharge is calculated based on the transient recharge estimated from the method described in **Section 2.5.3**. To show the recharge as the percentage of annual rainfall, the average recharge for each zone is divided by the annual rainfall and shows as the percentage in third column of **Table 2-12**. These calibrated recharge rates have been adopted into the predictive model. The recharge zones in the model layers are presented in **Figure 2-5**.

Table 2-12Calibrated Rainfall Recharge

Model Geology Zone	Average recharge (mm/year)	% of average rainfall
Blackwater Creek Alluvium	2.9	0.5
Regolith	0.6	0.1
Clematis	2.1	0.3
Regolith high recharge area	5.8	1.0

Figure 2-18 compares the calibrated recharge rates in the model against the recharge rates estimated for the site using the chloride mass balance (CMB) method for the BWM (AGE 2013) and other publicly available data. As per the conceptual model, higher recharge occurs through the alluvium and lower recharge in Regolith. **Figure 2-18** indicates that the calibrated recharge values are within the range specified for each geology group.

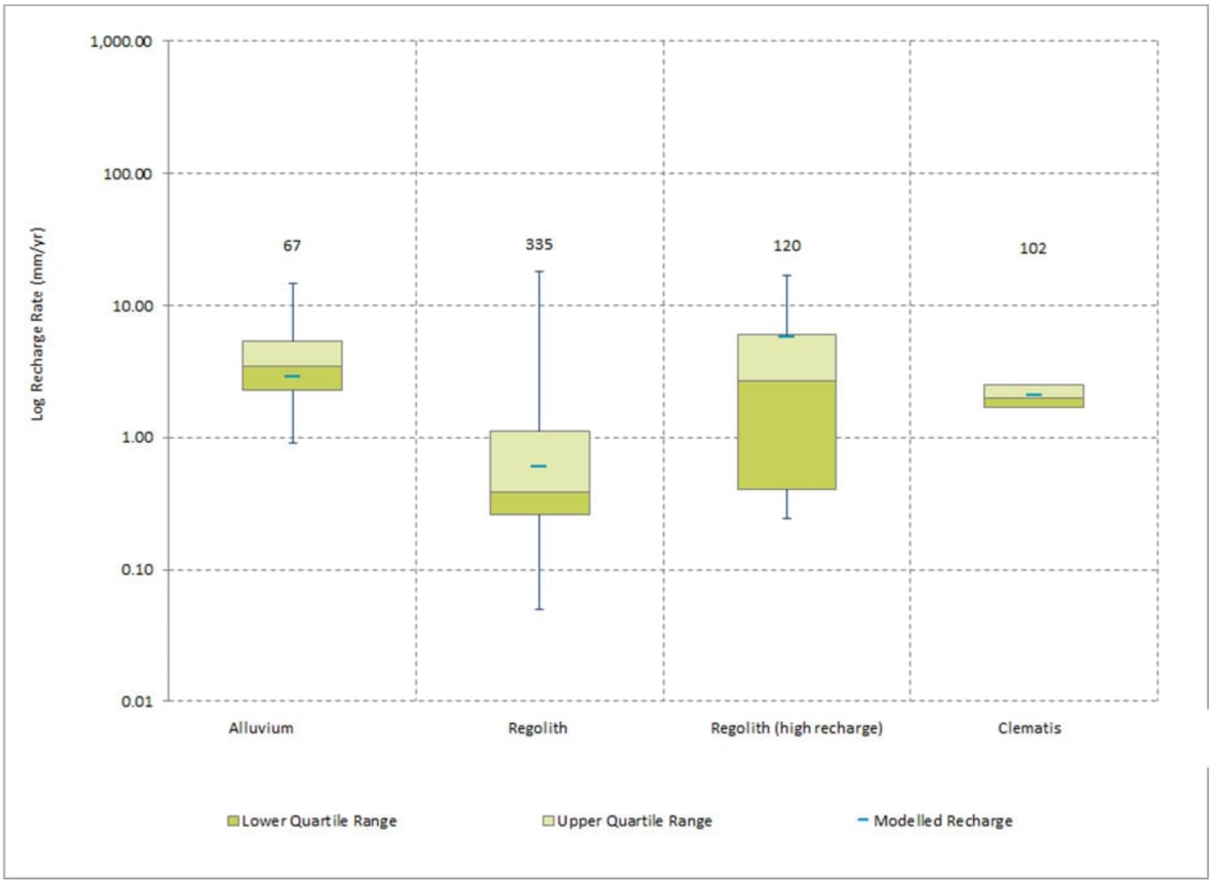


Figure 2-18 Site Recharge Estimates vs Modelled Recharge

3.0 Predictive Modelling

3.1 Timing and Mining

Transient predictive modelling was used to simulate the proposed mining at the Project as well as mining at other approved and foreseeable mines within the model domain. The cumulative assessment was undertaken for Curragh Mine (operating mine) and Minyango (foreseeable). The simulated predictive mine progression for the Project is presented in **Figure 3-1**.

The predictive part of the model comprises annual stress periods, starting from July 2023 until June 2085. The predictive model stress period setup is detailed in **Table 3-1**, alongside simulated mine timings.

Transient predictive models have been developed for three model scenarios:

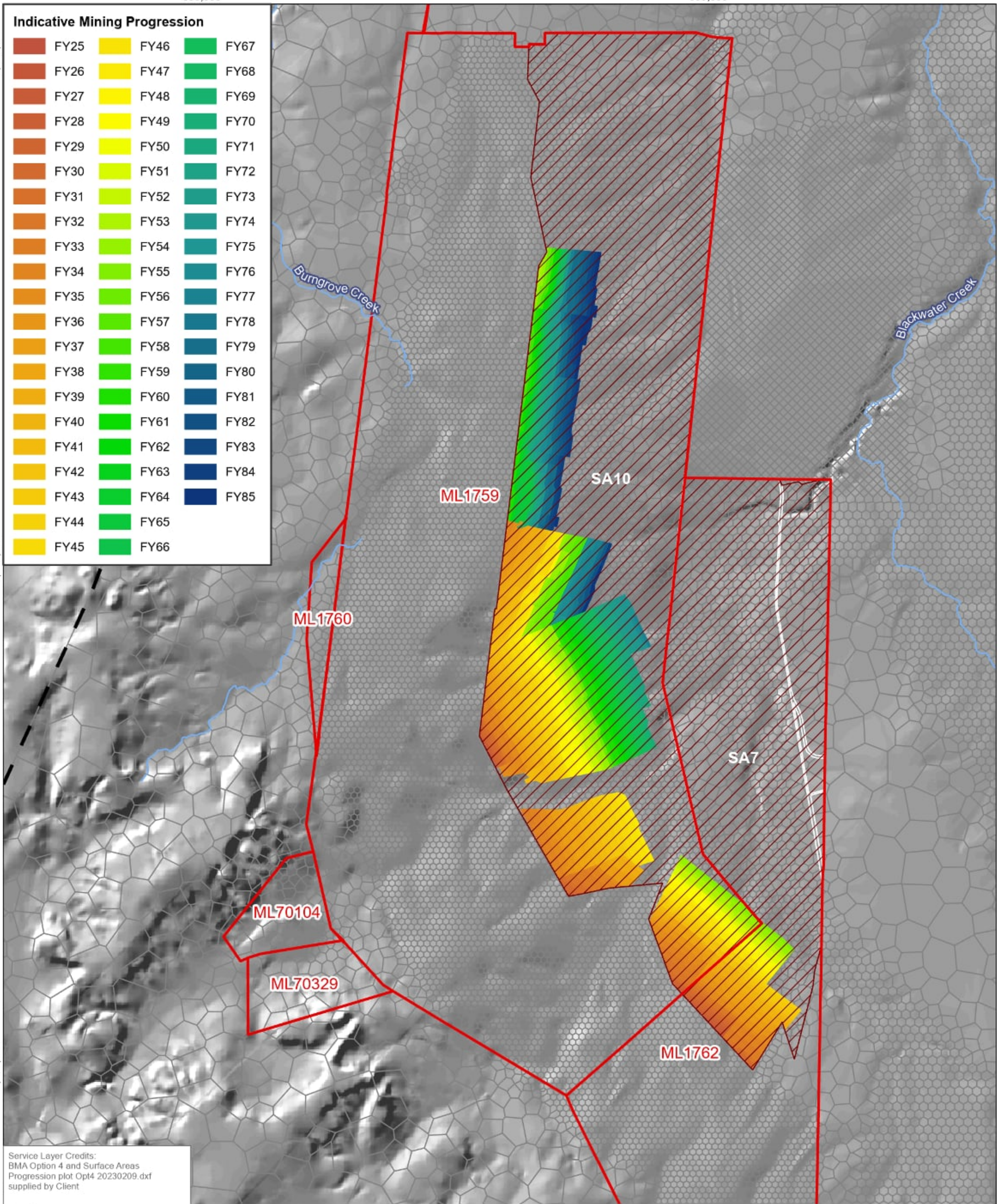
- Cumulative Scenario– all approved and foreseeable mining in the model area and at BWM plus the Project.
- Approved Scenario– all approved and foreseeable mining in in the model area and at BWM without the Project.
- Null Run – no mining within the model area.

The Project effects (i.e. the incremental changes) are determined by the difference between the Cumulative and Approved scenarios. Mining cells progressed annually and drain cells simulating the mining were projected down to the base of the lowermost target coal seam (i.e., the Pollux seam). A two-year operational window was assumed for mine cells at the Project, after which time the drains were removed and the MODFLOW Time Varying Materials (TVM) package was used to assign spoil properties to the cells.

Table 3-1 presents the simulated mine timings for the Project and surrounding mines used in the predictive model. Note that only the Project and Minyango were included for the predictive run, as all other mines have either been in closure or care and maintenance or the future mining sequence was not available. The cumulative impact assessment however will consider those mines as they were included in the calibration period up to 2022. The following applies:

- Kenmare and Laleham: Care and Maintenance.
- Cook Colliery: closure / mine plan for restart in 2022 not publicly available.
- Curragh mine: closure / mine plan any extensions not publicly available.
- Blackwater South: no foreseeable mine plans available.

All mines included in the model were simulated using the MODFLOW Drain (DRN) package. A nominally high drain conductance of 100 square metres per day (m^2/day) was applied to drain cells to simulate rapid removal of water from the system.



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Grid
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area

BLACKWATER MINE - NORTH EXTENSION PROJECT

PROJECT INDICATIVE MINING PROGRESSION

SLR

DISCLAIMER: All information within this document may be based on external sources. SLR Consulting Pty Ltd makes no warranty regarding the data's accuracy or reliability for any purpose.

FIGURE 3-1

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_1_Mine Progression

Table 3-1 Predictive Model Stress Period Setup and Mining

Interval	Stress Period	Date (from)	Date (to)	Blackwater North (OC)	Minyango (UG)
Annually	79	01/07/2023	01/07/2024	x	
Annually	80	01/07/2024	01/07/2025	x	
Annually	81	01/07/2025	01/07/2026	x	
Annually	82	01/07/2026	01/07/2027	x	x
Annually	83	01/07/2027	01/07/2028	x	x
Annually	84	01/07/2028	01/07/2029	x	x
Annually	85	01/07/2029	01/07/2030	x	x
Annually	86	01/07/2030	01/07/2031	x	x
Annually	87	01/07/2031	01/07/2032	x	x
Annually	88	01/07/2032	01/07/2033	x	x
Annually	89	01/07/2033	01/07/2034	x	x
Annually	90	01/07/2034	01/07/2035	x	x
Annually	91	01/07/2035	01/07/2036	x	x
Annually	92	01/07/2036	01/07/2037	x	x
Annually	93	01/07/2037	01/07/2038	x	x
Annually	94	01/07/2038	01/07/2039	x	x
Annually	95	01/07/2039	01/07/2040	x	x
Annually	96	01/07/2040	01/07/2041	x	x
Annually	97	01/07/2041	01/07/2042	x	x
Annually	98	01/07/2042	01/07/2043	x	x
Annually	99	01/07/2043	01/07/2044	x	x
Annually	100	01/07/2044	01/07/2045	x	x
Annually	101	01/07/2045	01/07/2046	x	x
Annually	102	01/07/2046	01/07/2047	x	x
Annually	103	01/07/2047	01/07/2048	x	x
Annually	104	01/07/2048	01/07/2049	x	x

Interval	Stress Period	Date (from)	Date (to)	Blackwater North (OC)	Minyango (UG)
Annually	105	01/07/2049	01/07/2050	x	x
Annually	106	01/07/2050	01/07/2051	x	x
Annually	107	01/07/2051	01/07/2052	x	x
Annually	108	01/07/2052	01/07/2053	x	
Annually	109	01/07/2053	01/07/2054	x	
Annually	110	01/07/2054	01/07/2055	x	
Annually	111	01/07/2055	01/07/2056	x	
Annually	112	01/07/2056	01/07/2057	x	
Annually	113	01/07/2057	01/07/2058	x	
Annually	114	01/07/2058	01/07/2059	x	
Annually	115	01/07/2059	01/07/2060	x	
Annually	116	01/07/2060	01/07/2061	x	
Annually	117	01/07/2061	01/07/2062	x	
Annually	118	01/07/2062	01/07/2063	x	
Annually	119	01/07/2063	01/07/2064	x	
Annually	120	01/07/2064	01/07/2065	x	
Annually	121	01/07/2065	01/07/2066	x	
Annually	122	01/07/2066	01/07/2067	x	
Annually	123	01/07/2067	01/07/2068	x	
Annually	124	01/07/2068	01/07/2069	x	
Annually	125	01/07/2069	01/07/2070	x	
Annually	126	01/07/2070	01/07/2071	x	
Annually	127	01/07/2071	01/07/2072	x	
Annually	128	01/07/2072	01/07/2073	x	
Annually	129	01/07/2073	01/07/2074	x	
Annually	130	01/07/2074	01/07/2075	x	
Annually	131	01/07/2075	01/07/2076	x	

Interval	Stress Period	Date (from)	Date (to)	Blackwater North (OC)	Minyango (UG)
Annually	132	01/07/2076	01/07/2077	x	
Annually	133	01/07/2077	01/07/2078	x	
Annually	134	01/07/2078	01/07/2079	x	
Annually	135	01/07/2079	01/07/2080	x	
Annually	136	01/07/2080	01/07/2081	x	
Annually	137	01/07/2081	01/07/2082	x	
Annually	138	01/07/2082	01/07/2083	x	
Annually	139	01/07/2083	01/07/2084	x	
Annually	140	01/07/2084	01/07/2085	x	

3.2 Water Balance

Table 3-2 to **Table 3-4** provide average flow rates (July 2023 until June 2085) for water transfer into and out of the groundwater model domain for the three predictive scenarios, the Cumulative, Approved and Null Run. All three scenarios maintained mass balance errors below 1% for all time steps throughout the simulations. The low error achieved indicates that the predictive model is stable, i.e., convergence was achieved (Barnett et al., 2012).

The tables show that simulated recharge increased from 14.95 ML/d in the Null scenario to 27.72 ML/day and 26.63 ML/day in the Cumulative scenario and the Approved scenario respectively. The increase in recharge is due to the presence of open cut mining and enhanced recharge through the spoil to the groundwater system in the Approved and Cumulative scenarios.

Table 3-2 to **Table 3-4** show that in all the three predictive scenarios, groundwater leaves the model through regional groundwater flow (GHB). The GHB inflow and outflow are less than 0.1% of the total inflow and outflow in water balance for all the scenarios indicating the model boundary conditions do not have a significant influence on the model predictions.

Evapotranspiration decreased from 6.03 ML/day in the Null Scenario to 5.25 ML/day in the Project and Approved scenarios. The evapotranspiration decline is mainly due to the mining activities and decline of water levels within the saturated shallow areas such as voids, pits or outcropping areas.

The net groundwater flow to Blackwater Creek is 0.48 ML/day in the Null Run whilst the net groundwater flow to Blackwater Creek is 0.27 ML/day and 0.26 ML/day for the Approved and Cumulative scenarios respectively. All three scenarios indicate the flow is generally from groundwater to the Creek, however this flow is very minor (and shows that Blackwater Creek does not receive continuous amounts of baseflow).

Groundwater outflow from the model mostly occurs via drain cells, used to simulate open cut and underground mining activity in the model. **Table 3-2** and **Table 3-3** show that the Cumulative scenario resulted in an increase in the average drain outflow (to 5.22 ML/day from 5.04 ML/day predicted for the Approved scenario). The storage component in the table refers to changes in the water level over the transient simulation timeframe. Changes in the storage between the Approved and Cumulative Scenarios relate to the change in mine footprint and added recharge through spoil.

Table 3-2 Average Simulated Water Balance over the Prediction Period- Cumulative

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total outflow (%)
Recharge (RCH)	27.72	80.96	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	5.25	15.34
SW-GW Interaction Blackwater creek (RIV)	0.10	0.30	0.36	1.06
SW-GW Interaction other rivers (RIV)*	0.00	0.00	7.22	21.08
Pit Lakes and dams	0.37	1.08	0.20	0.59
Regional GW Flow (GHB)	0.01	0.02	0.005	0.01
Mines (DRN)	0.00	0.00	5.22	15.25
Storage	6.04	17.64	15.97	46.66
Total	34.24	100.00	34.24	100.00

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

Table 3-3 Average Simulated Water Balance over the Prediction Period – Approved

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total outflow (%)
Recharge (RCH)	26.63	73.73	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	5.25	14.54
SW-GW Interaction Blackwater creek (RIV)	0.10	0.29	0.37	1.02
SW-GW Interaction other rivers (RIV)*	0.00	0.00	7.20	19.92
Pit Lakes and dams	3.57	9.88	0.30	0.82
Regional GW Flow (GHB)	0.01	0.02	0.005	0.01
Mines (DRN)	0.00	0.00	5.04	13.96

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total outflow (%)
Storage	5.81	16.09	17.96	49.73
Total	36.12	100.00	36.13	100.00

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

Table 3-4 Average Simulated Water Balance over the Prediction Period- Null Run

Component	Inflow (ML/day)	Percent of Total Inflow (%)	Outflow (ML/day)	Percent of Total outflow (%)
Recharge (RCH)	14.95	97.20	0.00	0.00
ET (from GW) (EVT)	0.00	0.00	6.03	39.21
SW-GW Interaction Blackwater creek (RIV)	0.07	0.48	0.55	3.58
SW-GW Interaction other rivers (RIV)*	0.00	0.00	8.5	53.61
Pit Lakes and dams	0.03	0.18	0.20	1.31
Regional GW Flow (GHB)	0.0009	0.01	0.006	0.04
Mines (DRN)	0.00	0.00	0.00	0.00
Storage	0.33	2.13	0.35	2.25
Total	15.38	100.00	15.38	100.00

* The other tributaries or drainage lines in the model are set as drains to the groundwater system and do not result in any recharge.

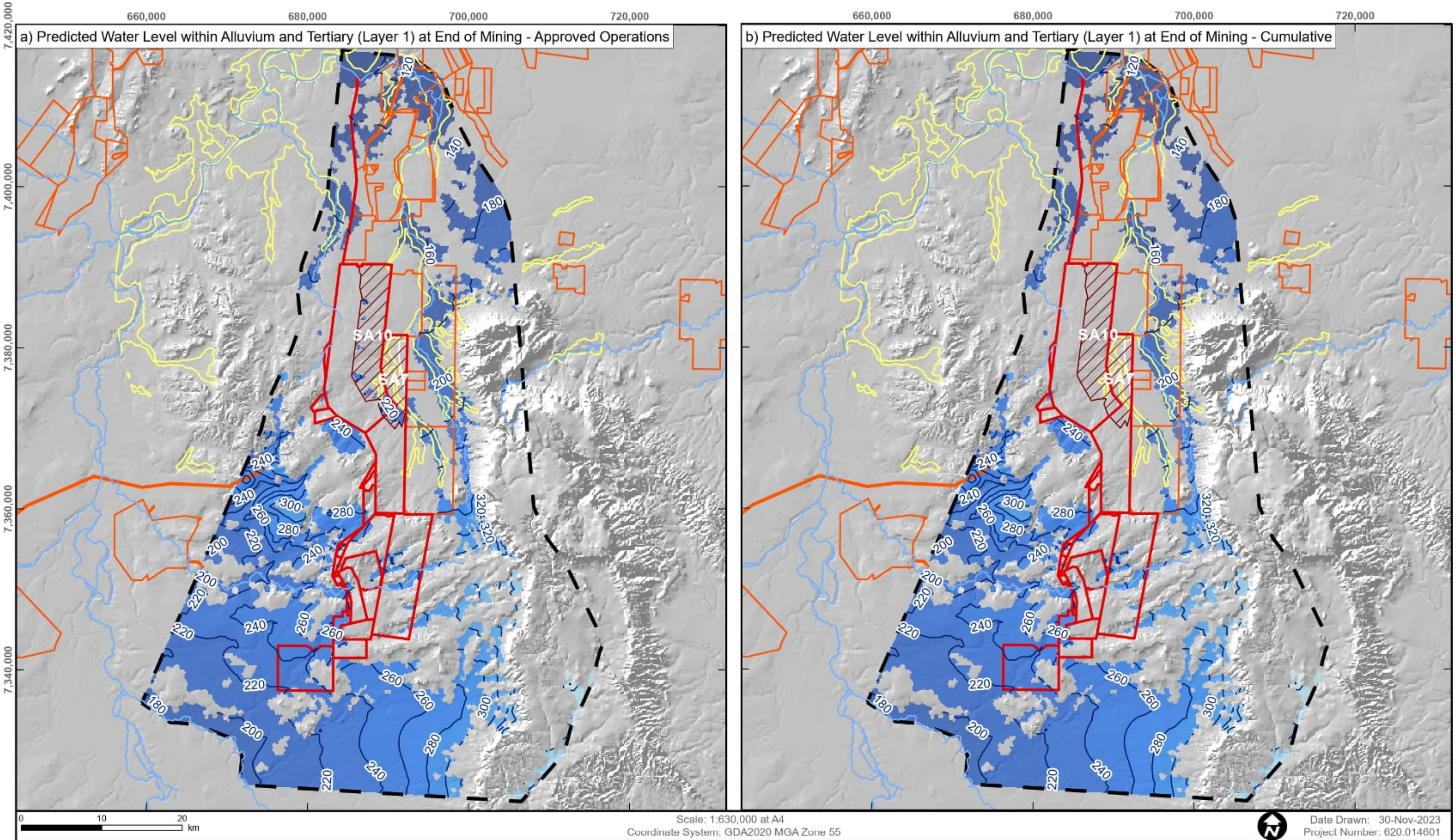
3.3 Predicted Groundwater Levels

Predicted groundwater levels at the end of the modelling timeframe for the Approved and Cumulative scenarios are provided in **Figure 3-2** to **Figure 3-5**. In these four figures, the Approved scenario is presented on the left side and the Cumulative scenario is presented on the right side. The grey cells in the water level grids represent unsaturated areas (i.e., where the simulated water level elevation is below the base of cell) or an area where the layer is not present. These figures will be used to calculate the incremental drawdowns (refer to **Section 3.4.1**)

Minimal changes to alluvium/tertiary (Layer 1) groundwater levels are observed between the Approved and Cumulative mining scenarios (**Figure 3-2**). **Figure 3-3** shows that the dewatering of the weathered zone (Layer 2) caused by the Project occurs particularly within the area immediately to the east of the Project area. **Figure 3-3** also shows that there are no significant changes to the water levels along Blackwater Creek between the Approved and Cumulative Scenarios.

Figure 3-4 shows the predicted groundwater levels in the Clematis Sandstone (Layer 3). The Clematis Sandstone is presenting as an outcrop at the eastern side of the model and is disconnected from the Permian Coal Measures by the Rewan Formation (**Figure 2-2**). **Figure 3-4** also shows that there are no significant changes to the water levels between the Approved and Cumulative Scenarios, indicating that the Clematis would not be impacted by the Project.

Figure 3-5 show the predicted water levels in the Permian Coal Measures (Layer 12) at the end of mining for the Approved and Cumulative mining scenarios. **Figure 3-5** shows that the groundwater flow is generally from southeast and south towards Blackwater Creek in the centre and north of the model. Zones of depressurisation at the Project and surrounding mines are shown to cause localised interruptions to the regional flow gradient.



SLR

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LEGEND

- Groundwater Contour (mAHD)
- Watercourse
- Alluvium Extent
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Groundwater Level (mAHD)

449

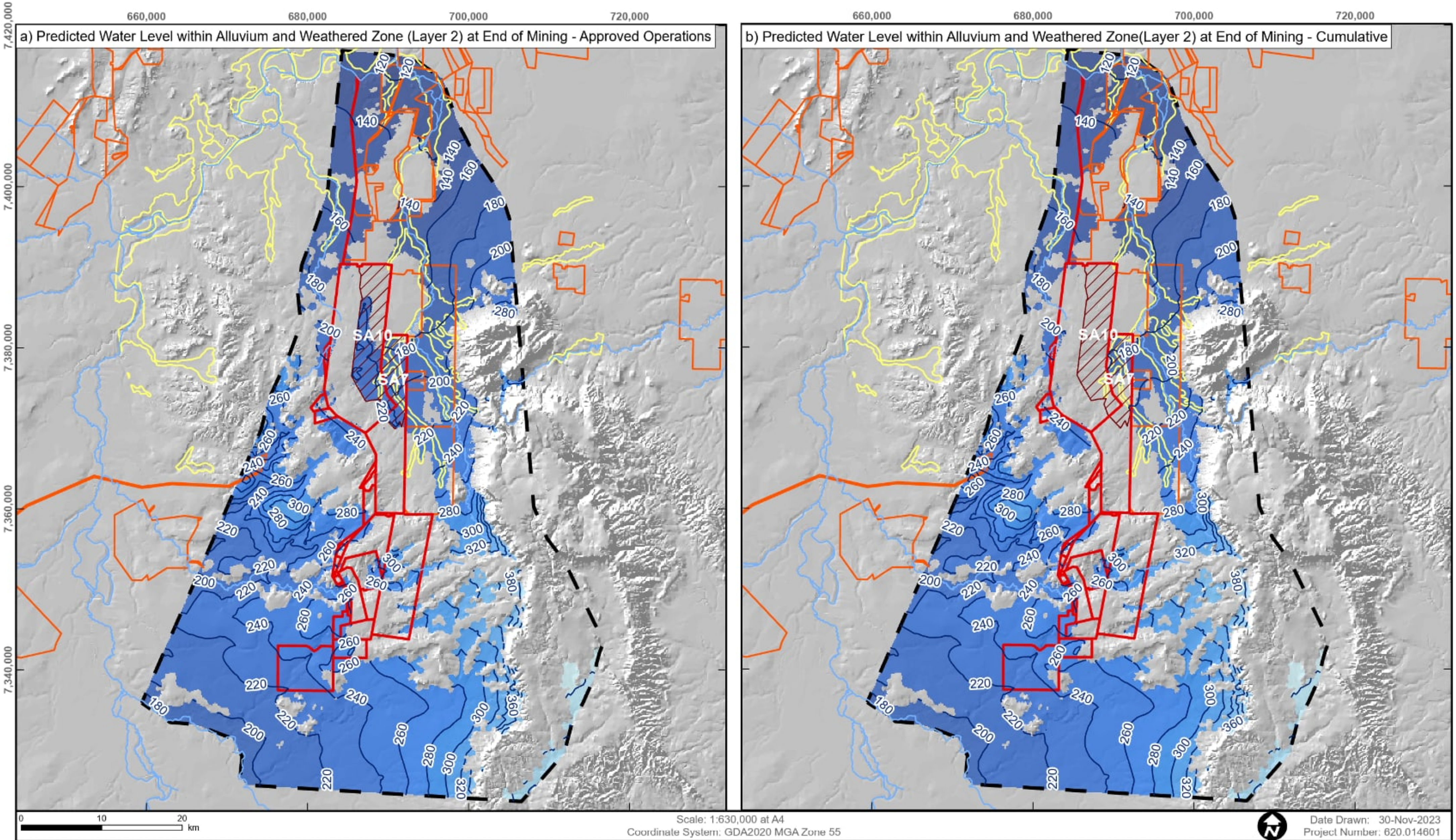
115

BLACKWATER MINE - NORTH EXTENSION PROJECT

PREDICTED WATER LEVEL WITHIN THE ALLUVIUM AND TERTIARY (LAYER 1) AT END OF MINING

FIGURE 3-2

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_2_Predicted WL Layer 1 EOM



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LEGEND

- Groundwater Contour (mAHD)
- Watercourse
- Alluvium Extent
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Groundwater Level (mAHD)

449

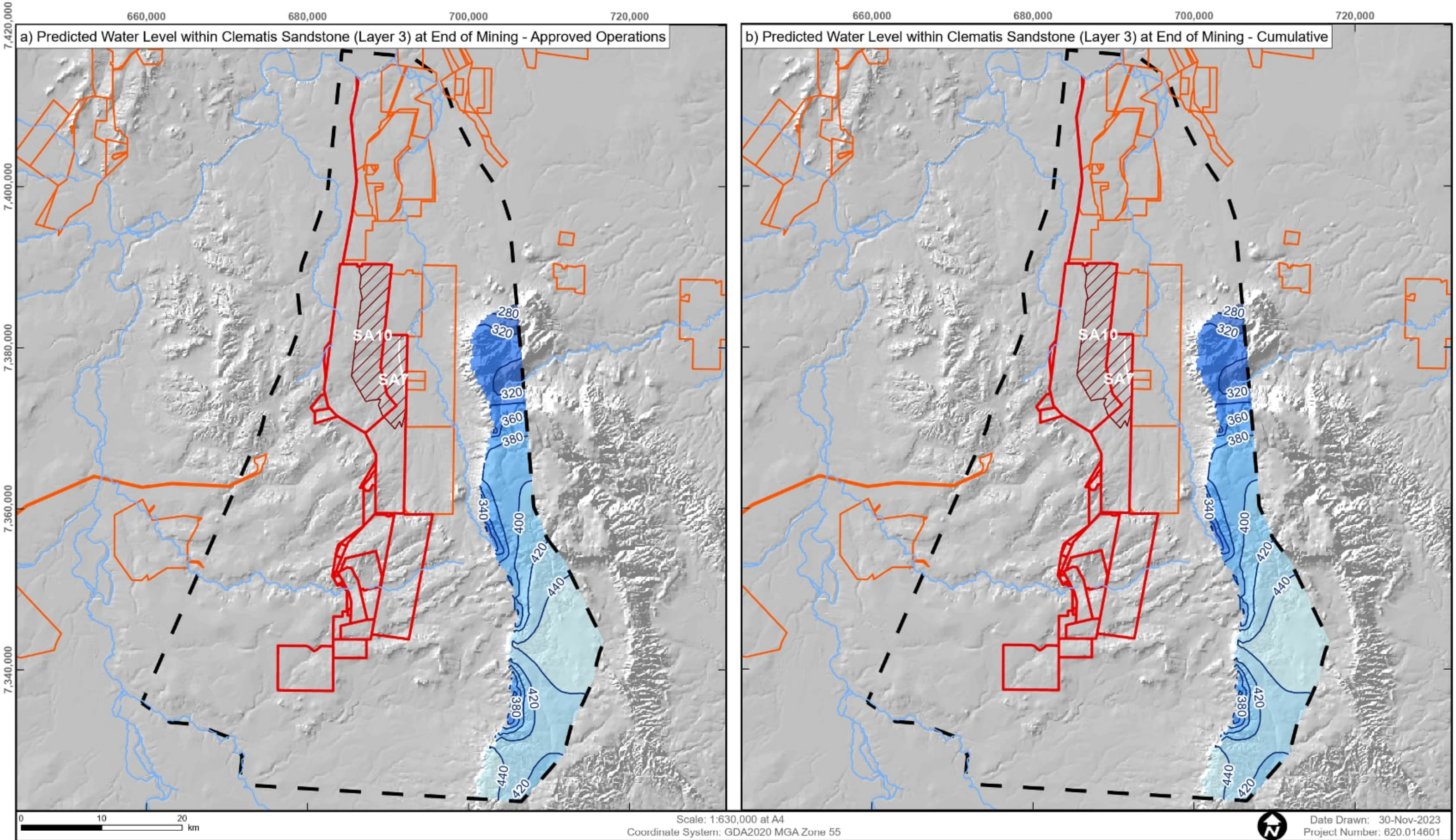
115

BLACKWATER MINE - NORTH EXTENSION PROJECT

PREDICTED WATER LEVEL WITHIN THE ALLUVIUM AND WEATHERED ZONE (LAYER 2) AT END OF MINING

FIGURE 3-3

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_3_Predicted WL Layer 2 EOM



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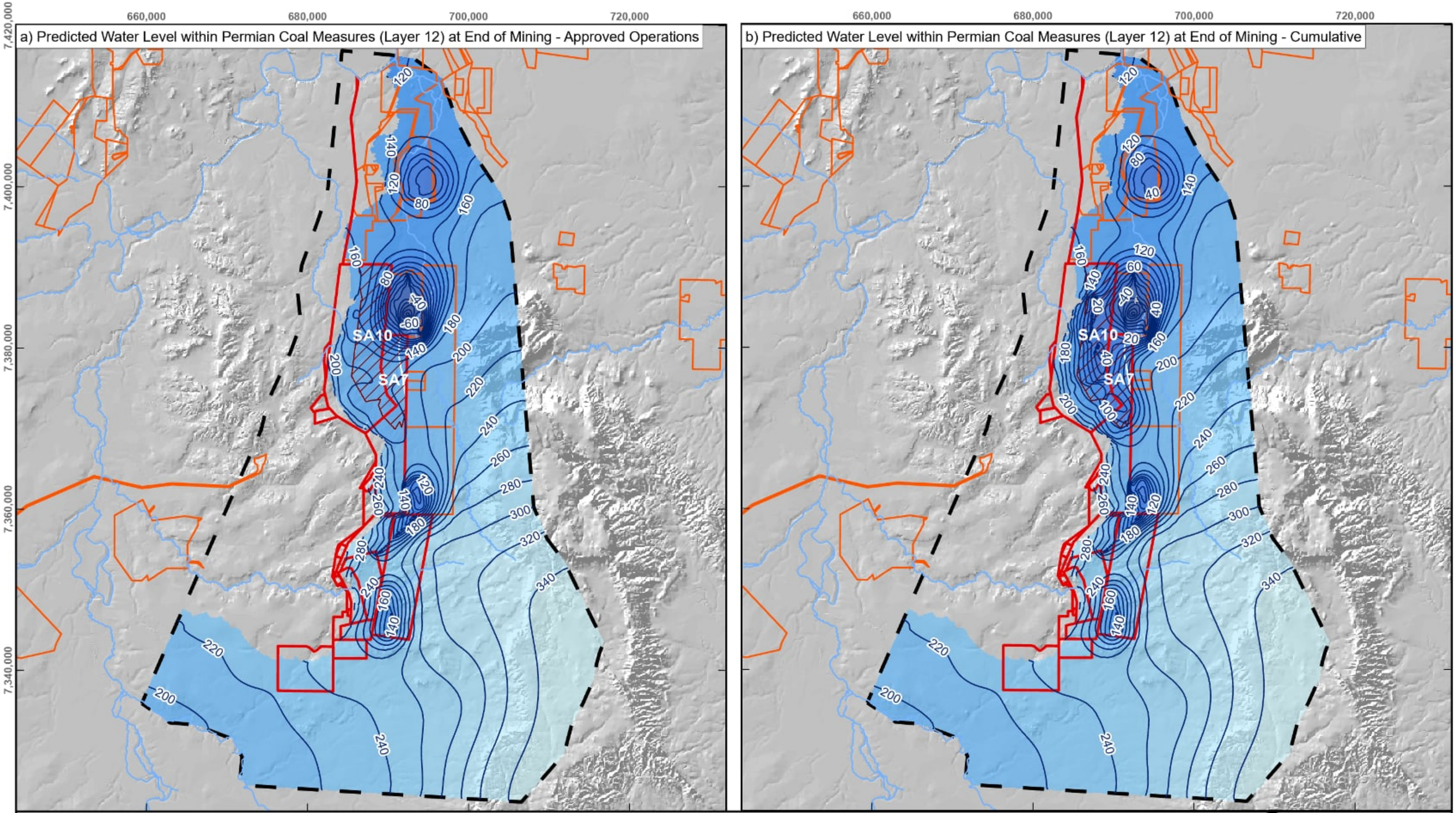
BLACKWATER MINE - NORTH EXTENSION PROJECT

PREDICTED WATER LEVEL WITHIN THE CLEMATIS SANDSTONE (LAYER 3) AT END OF MINING

FIGURE 3-4

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_4_Predicted WL Layer 3 EOM



0 10 20 km

Scale: 1:630,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 30-Nov-2023
Project Number: 620.014601

SLR

Service Layer Credits:

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LEGEND

- Groundwater Contour (mAHD)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Groundwater Level (mAHD)

352

-145

BLACKWATER MINE - NORTH EXTENSION PROJECT

PREDICTED WATER LEVEL WITHIN THE PERMIAN COAL MEASURES (LAYER 12) AT END OF MINING

FIGURE 3-5

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_5_Predicted WL Layer 12 EOM

3.4 Maximum Predicted Drawdowns

The process of mining directly removes water from the groundwater system and reduces water levels in surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Aquifer drawdown is greatest at the working coalface and decreases with distance from the mine.

3.4.1 Maximum Incremental Drawdowns

Maximum incremental drawdown refers to the drawdown impact associated with the Project and is obtained by subtracting the predicted aquifer groundwater levels for the Approved model scenario from the predicted aquifer groundwater levels for the Cumulative model scenario. The maximum drawdown represents the maximum drawdown values recorded at each model cell at any time over the model duration. Predicted incremental drawdown figures are presented in **Figure 3-6** to **Figure 3-10**, on the left side.

Figure 3-6 (a) shows that no incremental drawdown impacts are predicted for the alluvium as a result of mining at the Project. For a discussion on the potential incidental water impacts on the alluvium, see **Section 3.6.1**.

The maximum predicted incremental drawdowns associated with the Project within the weathered zone is shown in **Figure 3-7** (a). The incremental drawdown extent within the weathered zone (Layer 2) is largely confined to near the pit and is influenced by the distribution of predicted saturated zones in the weathered zone.

The Permian coal seams are the primary aquifers targeted by the Project and will experience drawdowns as a direct result of mining at the Project. Groundwater level drawdown within the mined coal seams is influenced by unit structure and is confined to unit extents. **Figure 3-8** (a) and **Figure 3-9** (a) show the maximum predicted incremental drawdown for the Aries and Pollux Seams in the Rangal Coal Measures, respectively. The figures show that to the west, the extent of maximum predicted incremental drawdown of the Permian coal measures is limited to near the pit due to the structural geology (i.e., coal seams subcrop). The extent of maximum predicted incremental drawdown in the coal seams towards the east is reaching Blackwater Creek (laterally at depth, not vertically into the shallow formations, such as alluvium or Tertiary).

Maximum predicted incremental drawdown for the Burngrove is shown in **Figure 3-10** (a). The figure shows that maximum predicted incremental drawdown is similar to the drawdown in the coal seams and is limited to the coal seam outcrop.

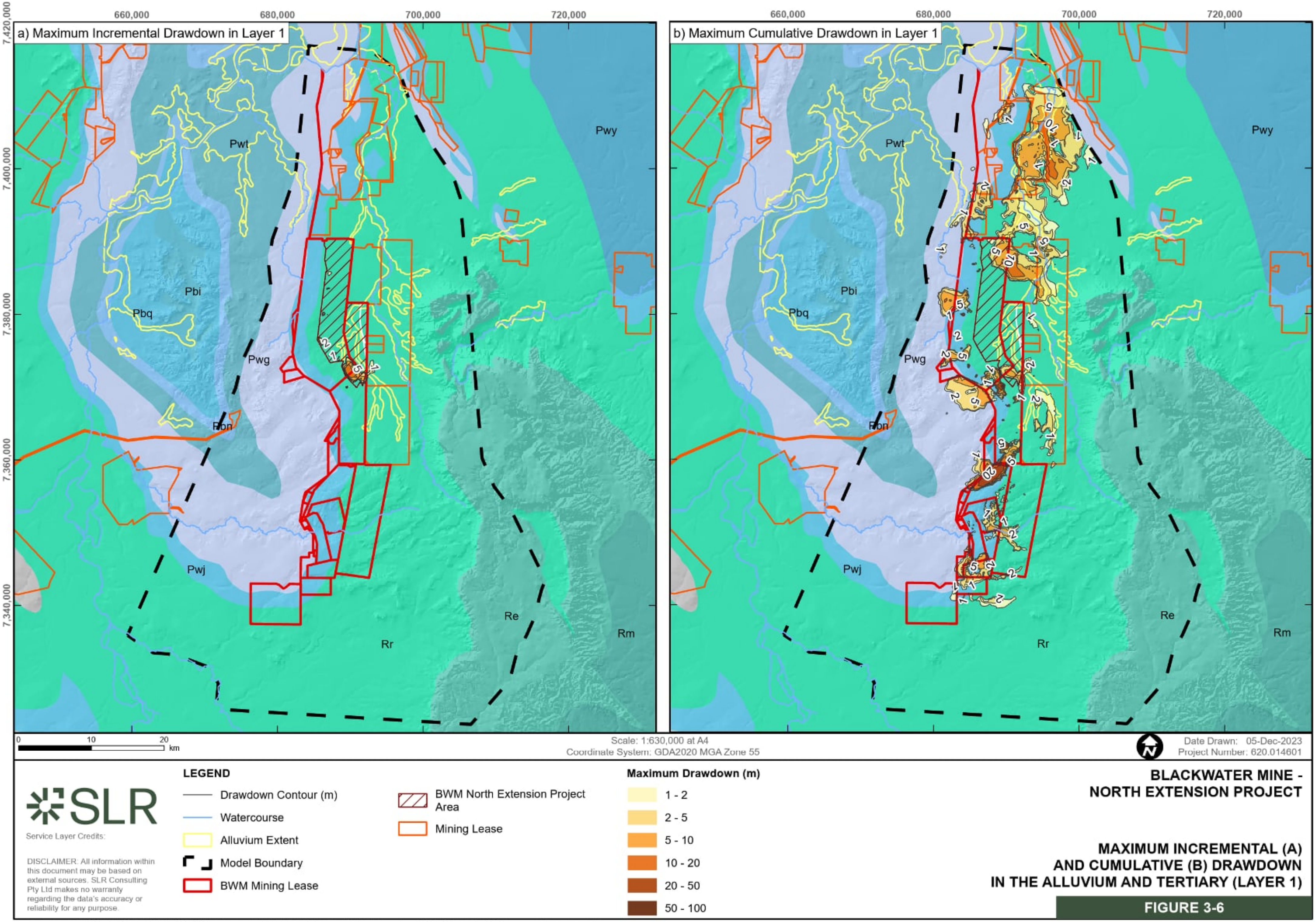
3.4.2 Maximum Cumulative Drawdowns

Maximum cumulative drawdown predicted impacts are shown in **Figure 3-6** to **Figure 3-10**, on the right side. These drawdowns represent the total impact of mining by all current mining and foreseeable mining, including the Project. The cumulative drawdown is derived by calculating the maximum difference in the groundwater levels for the Cumulative scenario with those in a theoretical “No Mining” or Null Run scenario, for all times during the predictive model period.

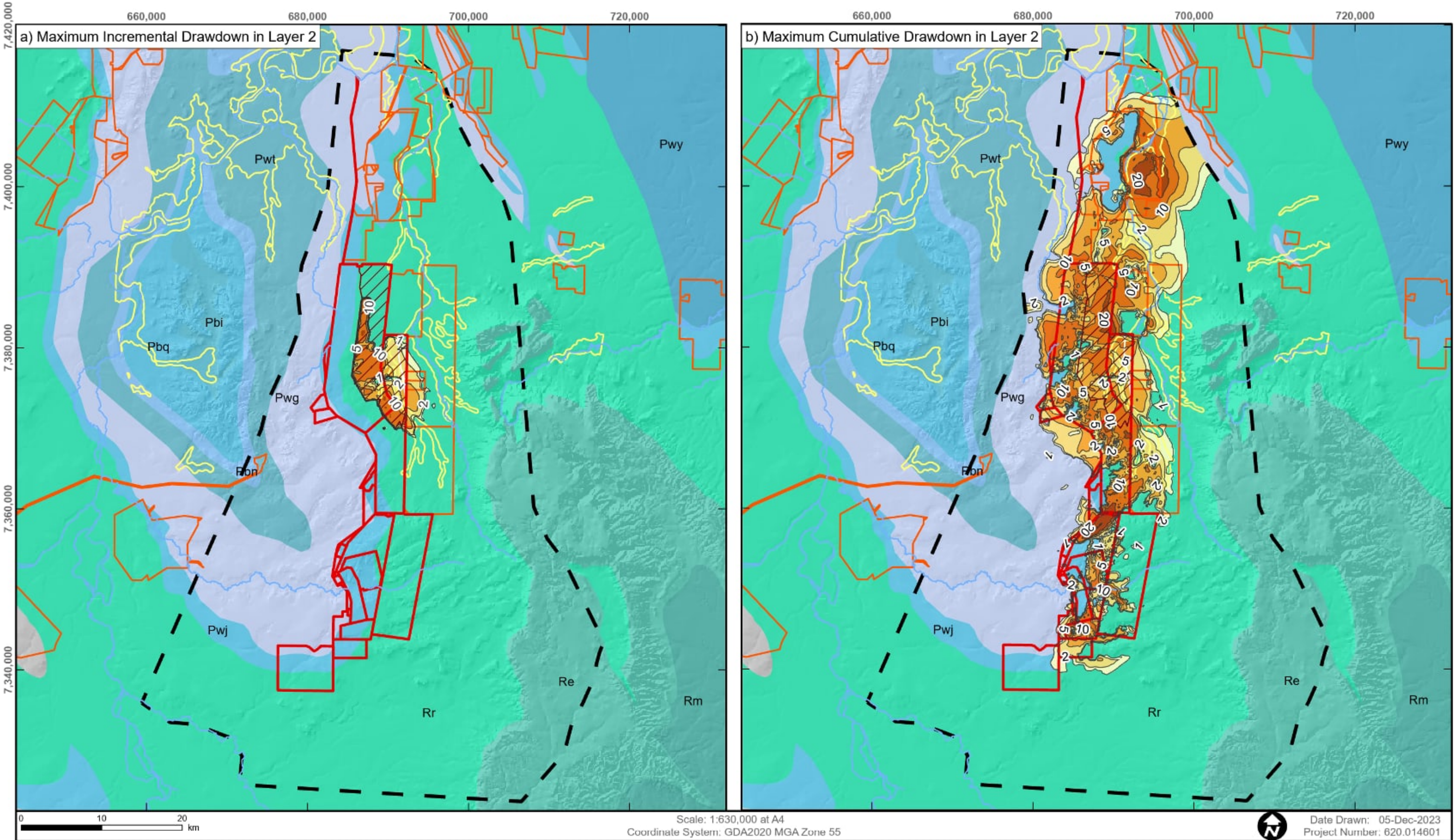
Cumulative drawdown impacts for the Alluvium and Tertiary (**Figure 3-6**, (b)) show that maximum predicted cumulative drawdown impacts are in the north near Blackwater Creek. Cumulative impacts within the weathered zone (**Figure 3-7**, (b)) can be seen connecting to the drawdown in the Tertiary.

Figure 3-8 (b) and **Figure 3-9** (b) show the maximum predicted cumulative drawdown in the Aries and Pollux seams in the Rangal Coal Measures. As shown in the figures the maximum cumulative drawdown is bounded on the western side by the coal seam outcrop and predicted to extend generally a distance of 5-7 km east of the mining areas. The cumulative drawdown reached the model boundary in the northeast, which coincides with a major fault. An extension of the model in that area would still result in the same drawdown, as the fault is likely to act as a barrier to flow.

Figure 3-10 (b) shows the maximum predicted cumulative drawdown in the Burngrove Formation. As shown in the figure, the maximum cumulative drawdown for Burngrove is similar to the drawdowns in Permian coal measures and predicted to extend approximately 5-7 km east of the mining areas.



Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_6_Incremental_Cumulative DD Layer 1



Scale: 1:630,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 05-Dec-2023
Project Number: 620.014601

SLR

Service Layer Credits:

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LEGEND

- Drawdown Contour (m)
- Watercourse
- Alluvium Extent
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

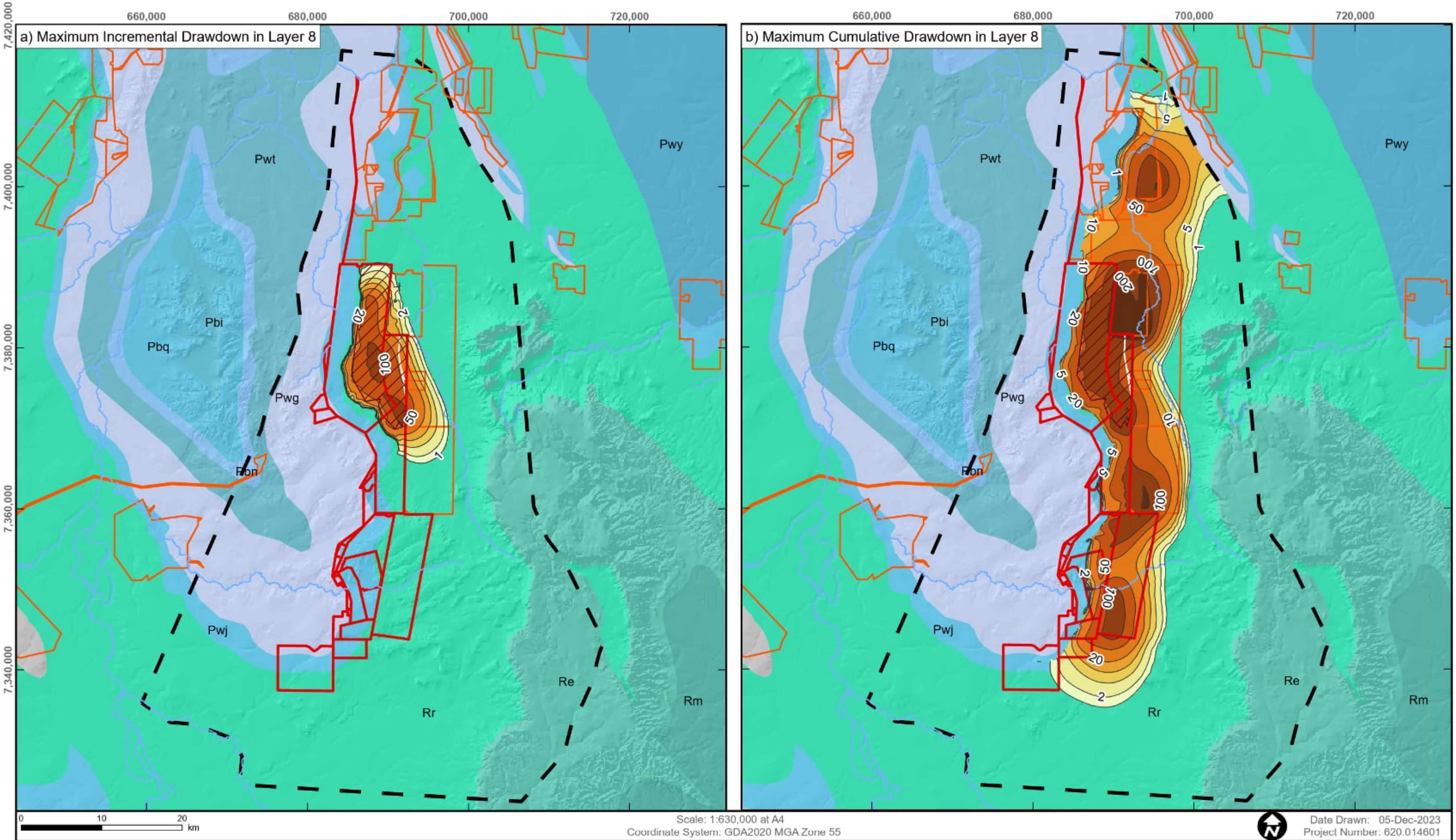
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100

BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE ALLUVIUM AND WEATHERED ZONE (LAYER 2)

FIGURE 3-7

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_7_Incremental_Cumulative DD Layer 2



Scale: 1:630,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 05-Dec-2023
Project Number: 620.014601

LEGEND

- Drawdown Contour (m)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

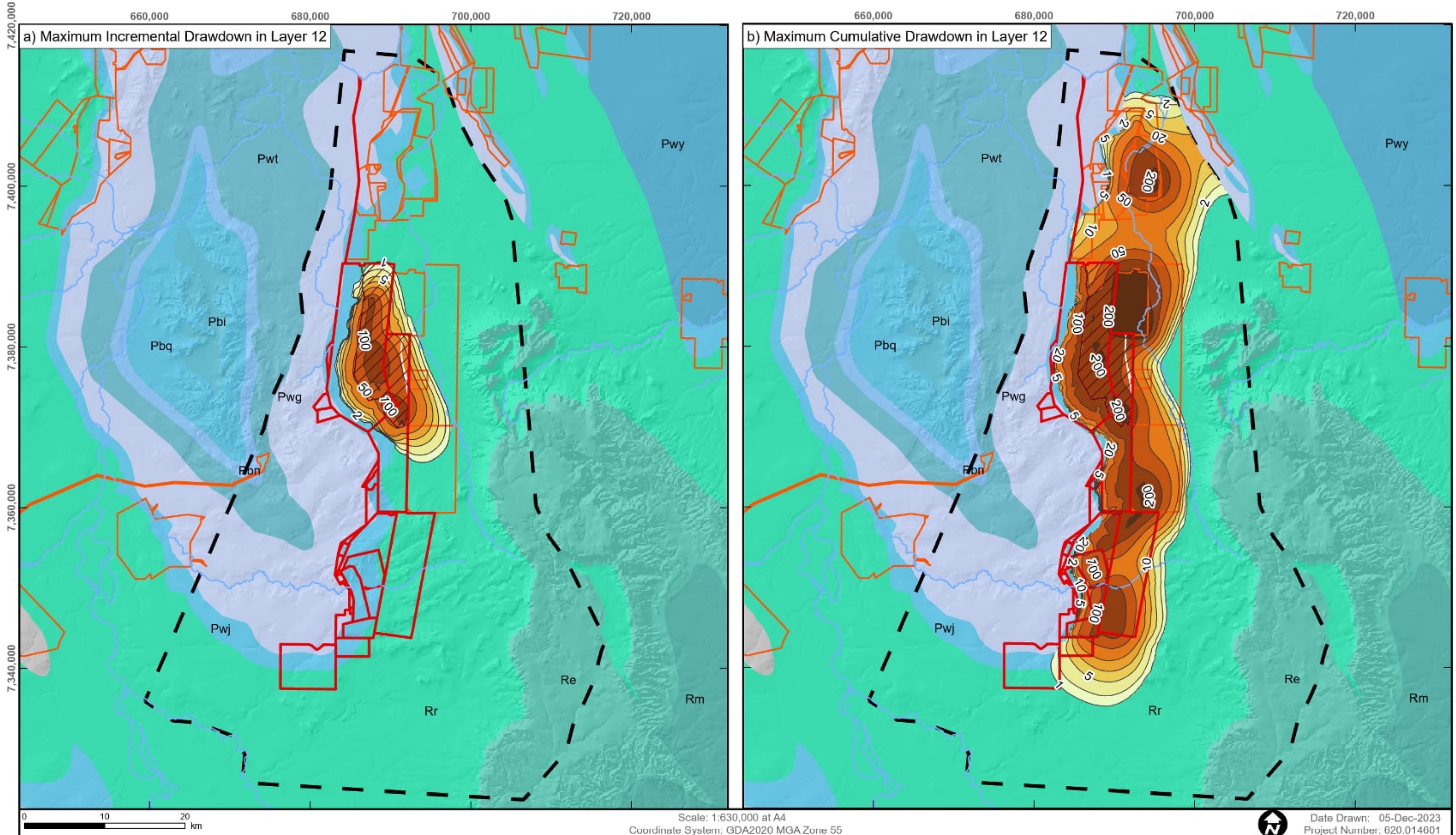
SLR

Service Layer Credits:

BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE ARIES SEAM (LAYER 8)

FIGURE 3-8



Scale: 1:630,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 05-Dec-2023
Project Number: 620.014601

SLR

Service Layer Credits:

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LEGEND

- Drawdown Contour (m)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

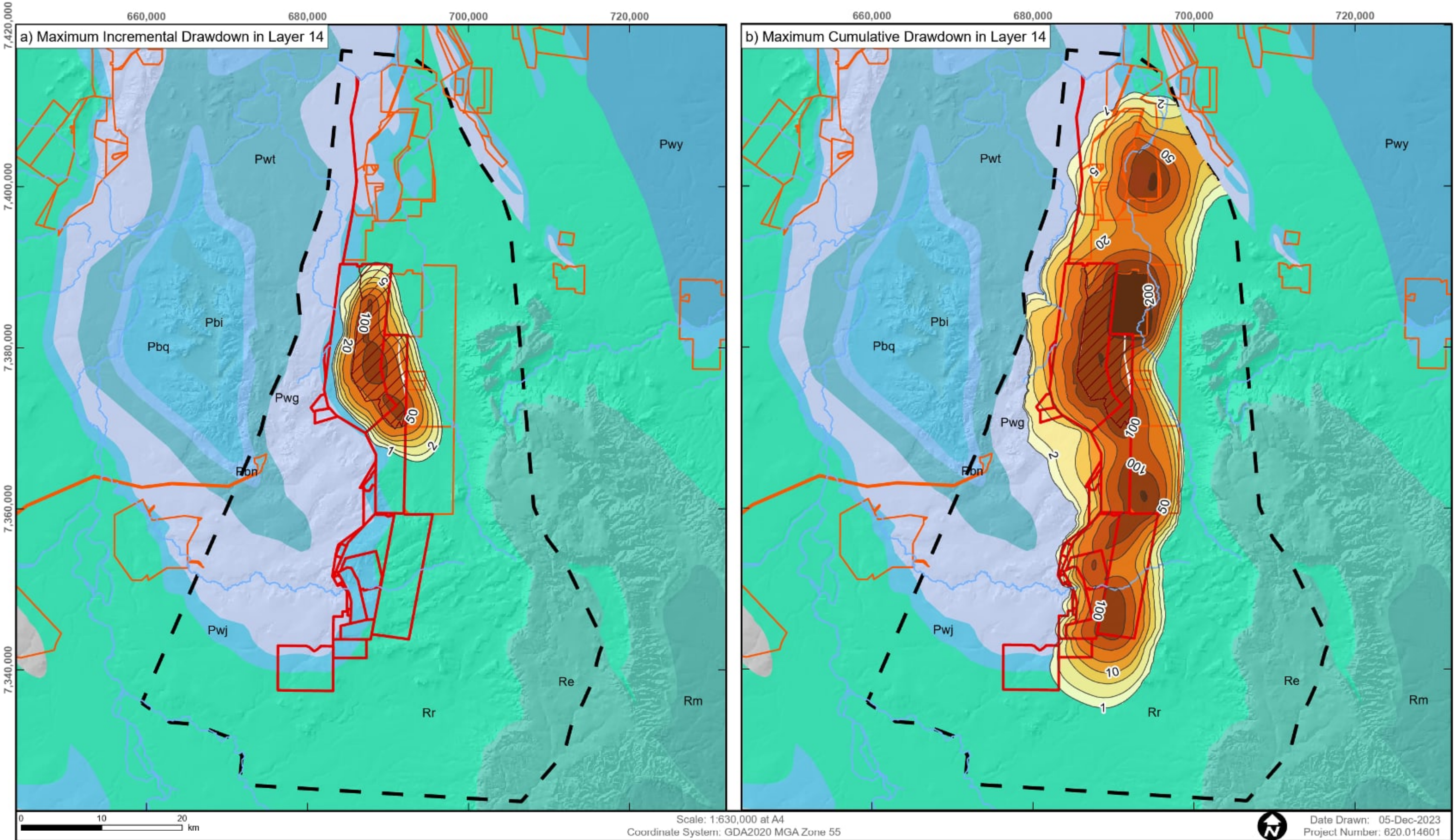
- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE POLLUX SEAM (LAYER 12)

FIGURE 3-9

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_9_Incremental_Cumulative DD Layer 12



Scale: 1:630,000 at A4
Coordinate System: GDA2020 MGA Zone 55

Date Drawn: 05-Dec-2023
Project Number: 620.014601

LEGEND

- Drawdown Contour (m)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Maximum Drawdown (m)

- 1 - 2
- 2 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 200
- 200 - 500

SLR

Service Layer Credits:

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BLACKWATER MINE - NORTH EXTENSION PROJECT

MAXIMUM INCREMENTAL (A) AND CUMULATIVE (B) DRAWDOWN IN THE BURNGROVE FORMATION (LAYER 14)

FIGURE 3-10

Path: H:\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F03_10_Incremental_Cumulative DD Layer 14

3.5 Predicted Groundwater Interception

The mine inflow volumes have been calculated as time weighted averages of the outflow reported by Zone Budget software for the relevant drain cells. The predicted inflows for the Cumulative inflows (Approved mining and Project) and the Incremental inflows (Project only) are presented in **Figure 3-11 a** and **b** respectively.

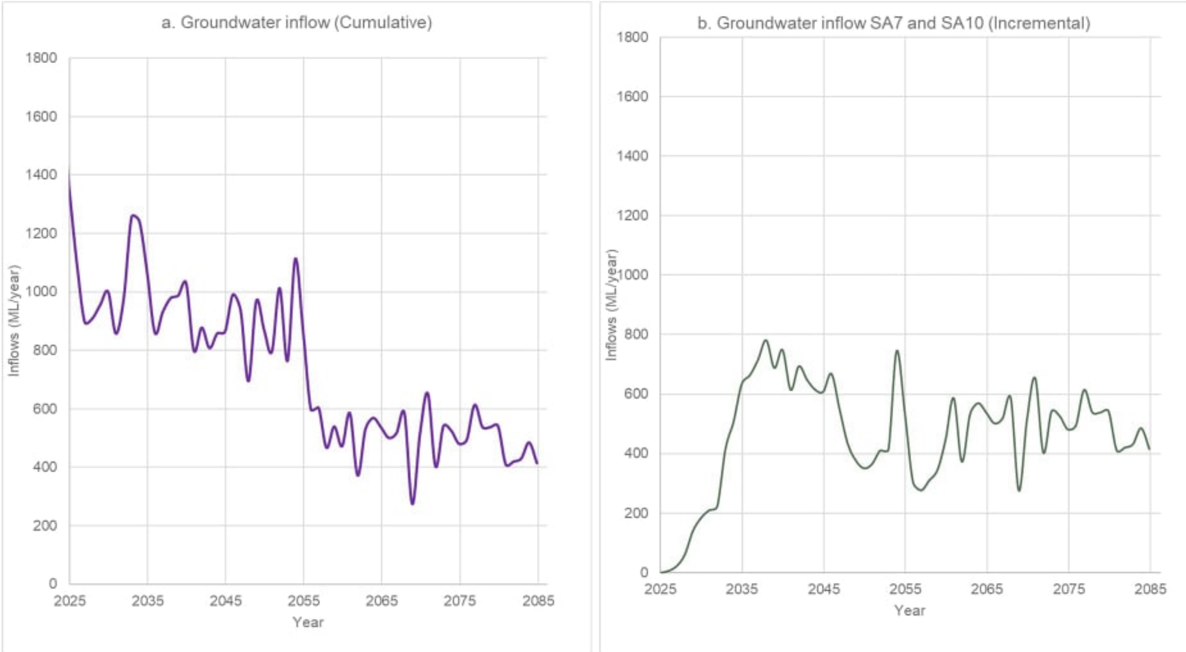


Figure 3-11 Predicted Cumulative (a) and Incremental (b) Mine Inflows

The cumulative inflows (Approved mining and Project) are predicted to reach a maximum in 2025 at 1,400 ML/year. Cumulative inflows are predicted to remain between 800 and 1,000 ML/year between 2025 and 2055, with inflows then decreasing to a range of 400 to 600 ML/year after 2055 until end of mining.

The incremental inflows into the mine pits on SA7 and SA10 are predicted to reach a maximum in year 2038, with a peak just below 800 ML/year (2.2 ML/day). The average inflow rate for the Project (2025 to 2085) is 470 ML/year (1.3 ML/day).

The Water Plan (Fitzroy Basin) 2011 groundwater area consists of the following:

- Groundwater Unit 1 (containing aquifers of the Quaternary alluvium).
- Groundwater Unit 2 (sub-artesian aquifers).

Planned mining operations at the Project will not intercept Quaternary alluvium at any of the proposed pits. As such, all direct groundwater take predicted by the model is from Groundwater Unit 2.

3.6 Incidental Water Impacts

3.6.1 Influence on the Alluvium

The change in alluvial water resources was estimated by comparing water budgets for alluvial zones using the Approved and Cumulative scenarios of the predictive model. Interference of the alluvial groundwater can occur due to reduced upward leakage from Permian coal measures that are depressurised because of mining activities. Over the extent of Quaternary alluvium along Blackwater Creek, there is a maximum flow reduction of 0.23 ML/day from underlying formation to alluvium as a result of the Project.

3.6.2 Groundwater – Surface Water Interaction

The change in groundwater flow to rivers and creeks due to the Project was calculated by comparing the river flow budgets for Blackwater Creek in the Cumulative scenario against the Approved scenario. This calculation showed that over the life of mine, the change of baseflow is 0.01 ML/day. Given the Blackwater Creek is highly ephemeral, the alluvium is not contributing large amounts of water and this reduction due to the Project is deemed insignificant.

3.6.3 Impact on Landholder Bores

The impact assessment included the drawdown at each of the eleven landholder bores identified in a 10 km radius of the Project area. **Table 3-5** lists the bores with their name, location, screened formation and use. The last two columns present the maximum incremental and cumulative drawdown predicted to occur at each location. Incremental drawdown from the Project is only expected at two bores. The maximum predicted incremental drawdown is 0.07m at Bore RN84221 and 0.01m at Bore 'Unregistered 11' (**Table 17**). The largest maximum cumulative drawdown is predicted at Bore RN84221 to the north of the mine with approximately 10 m, followed by bores "Unregistered 11", RN103345 and "Unregistered 18", all of which have predicted cumulative drawdowns of approximately 2 to 4 m. Seven bores are predicted to experience a maximum cumulative drawdown of 15 cm or less, which is considered insignificant.

3.6.4 Impacts on GDEs

Impacts on potential terrestrial GDEs and potential aquatic GDEs are assessed by EMM, 2023 and ESP, 2023.

The groundwater drawdown predictions from this groundwater model were provided in contoured shapefile format for the use in these GDE assessments as follows:

- The 90th percentile of the 1m water table drawdown from the Uncertainty Analysis (refer to **Section 6.0**) was provided to define the GDE assessment radius.
- The GDEs were then assessed by EMM, 2023 with a depth to water table map based on observations (RDM, 2023).
- Any identified GDEs were then assessed for the respective maximum water table drawdown at their location, based on the incremental maximum water table drawdown as predicted by this groundwater model.

Table 3-5 Drawdown Impact on Landholder Bores

Registered RN (ID)	Bore name	Easting (GDA94 z55)	Northing (GDA94 z55)	Geology	Bore depth (m)	Use	Maximum incremental Drawdown (m)	Maximum cumulative Drawdown (m)
38998	No 2 Bore	681119	7391492	Burngrove Formation	36.6	Unknown	0.00	0.09
43097	-	681800	7392230	Burngrove Formation	22.9	Unknown	0.00	0.08
43459	Top Bore	683719	7395787	Unknown	54.9	Unknown	0.00	0.06
57503	Stake Bore	680333	7361655	Burngrove Formation[1]	Unknown	Unknown	0.00	0.10
57504	Eighteen mile Bore	682192	7365312	Unknown	Unknown	Unknown	0.00	0.11
84221	-	683596	7390708	Burngrove Formation	24	Unknown	0.07	9.38
89034	-	680391	7390291	Unknown	Unknown	Unknown	0.00	0.00
103345	JWS Bore	684091	7363016	Burngrove Formation	47	Unknown	0.00	2.23
111709	-	680013	7390877	Burngrove Formation	72	Water Supply	0.00	0.02
Unregistered 11	-	680420.5	7378058.5	Burngrove Formation	Unknown	Unknown	0.01	3.66
Unregistered 18	-	684004.5	7362319.1	Burngrove Formation	Unknown	Unknown	0.00	1.69

4.0 Recovery Model

The potential post mining impacts of the Project were investigated with a recovery model, commencing at the end of mining at the Project with a run time of 200 years. The stress period lengths for the recovery model are shown in **Table 4-1**. In total, there are ten stress periods of varying lengths. Within each stress period, the model subdivided the time steps with a multiplier of 1.2.

Table 4-1 Stress Period Set-up for Recovery Model

Stress periods	Time interval
01/07/2085 – 01/07/2090	Annual (5 stress periods)
01/07/2090 – 01/07/2100	5 years (2 stress periods)
01/07/2100 – 01/07/2250	50 years (3 stress periods)
01/07/2250 – 01/07/2285	35 years (1 stress period)

A transient model was created to ascertain post-mining inflows, with all predictive model drain cells removed. At the end of mining of the Project, the hydraulic properties of the cells located at the four final void locations were converted to values representative of a void. The indicative location of the four voids at the Project is provided in **Figure 4-1**. The cells were assigned high horizontal and vertical hydraulic conductivities (100 m/day) and storage parameters based on the compressibility of water (specific yield of 1.0, storage coefficient of 5.0 x 10-6 m^{-1}), to simulate free water movement within the final voids. This approach is often referred to as a ‘high-K’ lake.

To assess the groundwater level recovery and the interaction with the surface water in the four voids, the groundwater model and surface water model (site water balance model for the Surface Water Impact Assessment (SLR, 2023a) were interactively run until convergence between the two models was reached. The convergence was assessed by the change in groundwater inflows after each iteration.

This process is required, because the surface water model does not account for any interactions between the voids. The groundwater model on the other hand does not have the capability to account for catchment run off.

Once the convergence was achieved, the final pit lake recovery level time series predicted by the surface water balance modelling was then incorporated into the final groundwater model recovery run. The recovery curves in the four void areas derived from the surface water modelling were integrated into the numerical groundwater model using the time variant constant head boundary condition (CHD). The recovery model was then re-run using CHD package for 200 years according to the time series provided by the water balance model. **Figure 4-2** shows the pit water level at each of the four voids. The equilibrated final void water levels are listed in **Table 4-2**. Void 3 is near equilibrium and the other three voids have reached equilibrium in the modelled time period. The predicted final groundwater water levels are presented in **Figure 4-3**. The figure shows that all four void areas will act as a groundwater sink, which means that groundwater will flow into the voids.

Table 4-2 also lists the recovered groundwater levels to the east of the pits, read out from the modelling result files at a distance of approximately 250 m (one grid cell at that location is 125 m). The head difference between the groundwater and the pit lake ranges between 17.6 m and 39.3 m for all pits. The head differential between pit water level and surrounding groundwater level is larger than 10 m for each pit. This is deemed enough to account for density corrections to not change the direction of hydraulic gradient.

Table 4-2 Final Voids – Equilibrium Water Levels and Groundwater Levels

Component	Equilibrium Void Water Level (m AHD)	Groundwater level (mAHD)[1]	Head difference (m)[2]
Void 1	57.5	96.8	39.3
Void 2	64.3	93.7	29.4
Void 3	120.6	138.2	17.6
Void 4	64.0	95.5	31.5

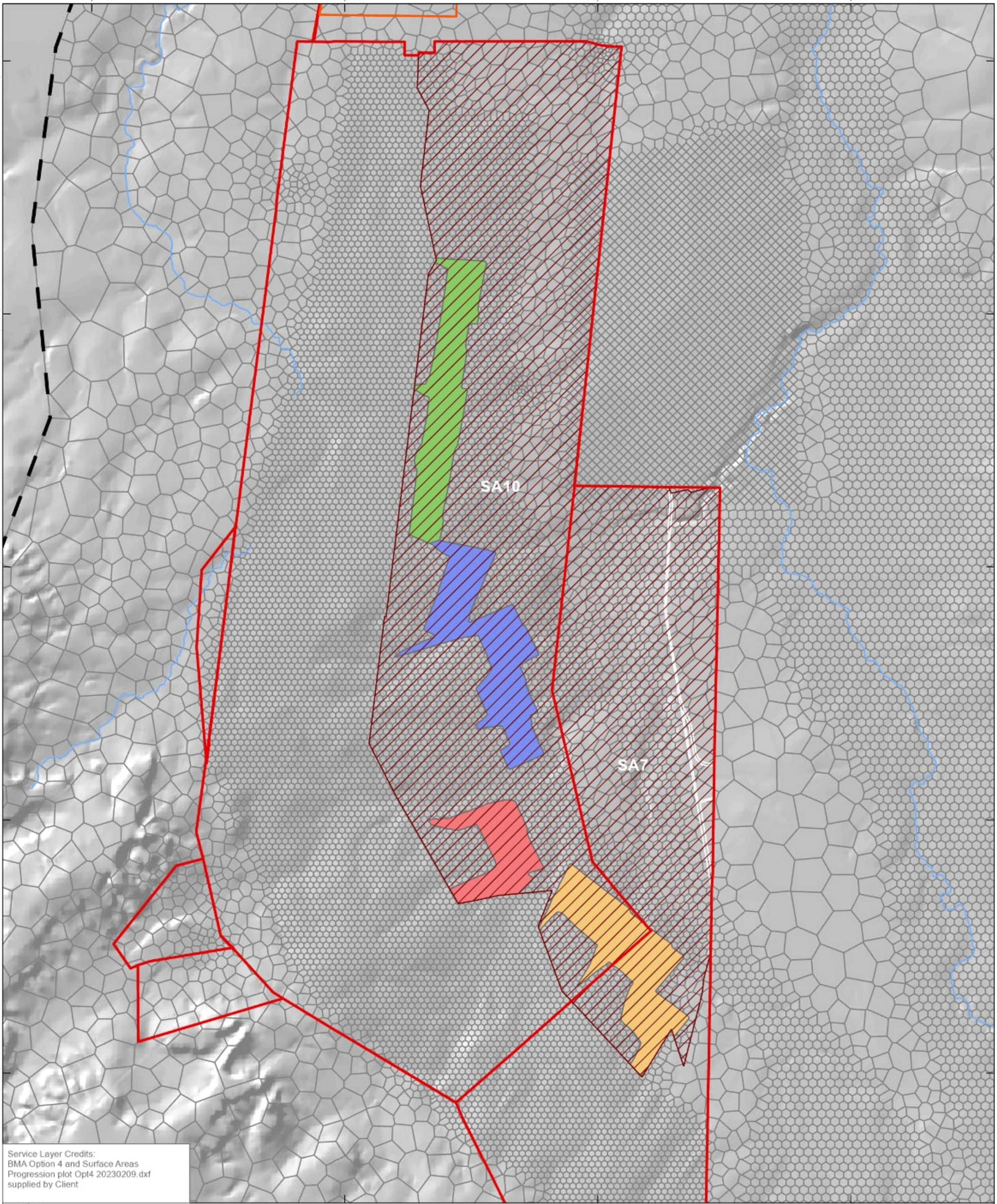
Note: 1 Groundwater level extracted from the recovered water level map, read out approximately 250m away from each pit to the east.

2 A positive number indicates gradient towards the void, a negative number would indicate a gradient away from void.

Table 4-3 lists the quantile of water levels from the surface water assessment for climate extremes (SLR, 2023a). The 10th and 90th percentiles are presented in comparison to the median water level estimate (50th percentile). Note that those differ slightly from **Table 4-2** due to the methodology applied in the Surface water assessment (assessment of six climate scenarios, which oscillate). The equilibrated water levels change by 1 to 4 m for the four voids from the median scenario. Therefore, if drier or wetter conditions should prevail, the voids would remain sinks to the groundwater.

Table 4-3 Final Voids – Equilibrium Water Levels – Climate Extremes

Component	P10 Equilibrium Pit Water Level (m AHD)	P50 Equilibrium Pit Water Level (m AHD)	P90 Equilibrium Pit Water Level (m AHD)
Void 1	49.01	51.65	58.08
Void 2	59.38	61.98	68.17
Void 3	116.40	118.55	122.1
Void 4	61.98	65.55	70.98



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- Model Grid
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Final Void

- Void 1
- Void 2
- Void 3
- Void 4

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

INDICATIVE FINAL VOID LOCATIONS

FIGURE 4-1

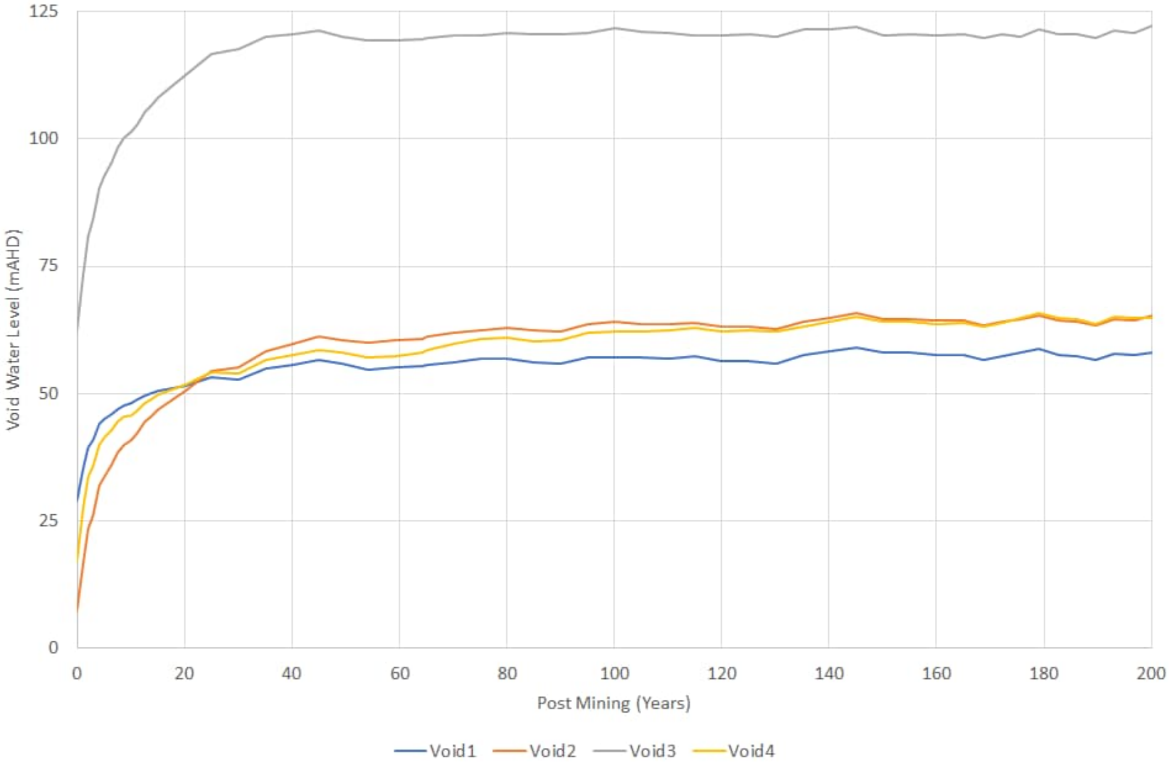
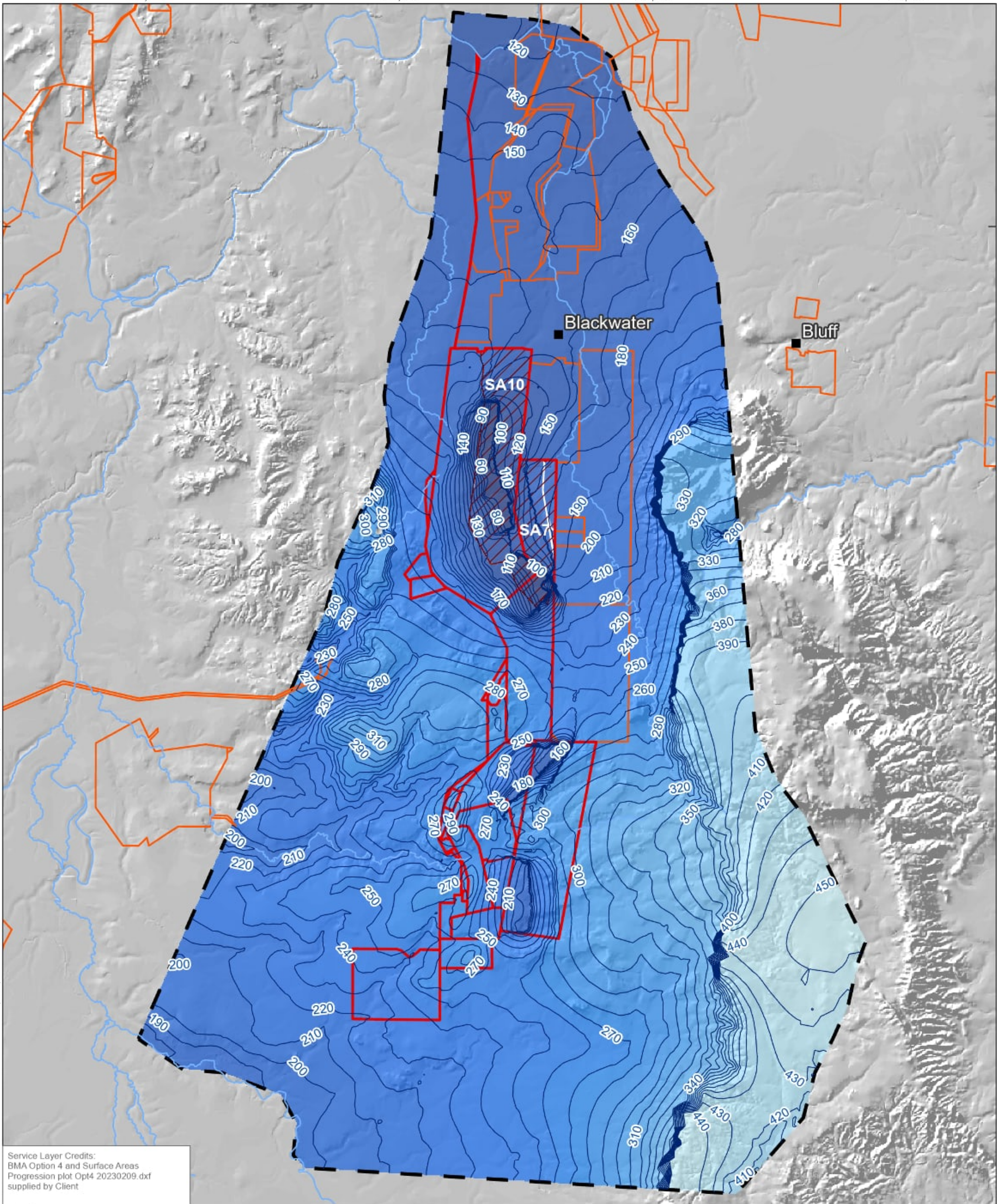


Figure 4-2 Final Void Recovery Curves



Coordinate System: GDA2020 MGA Zone 55
Scale: 1:400,000 at A4
Project Number: 620.014601
Date Drawn: 30-Nov-2023
Drawn by: NT

LEGEND

- City/Town
- Groundwater Level Contour (mAHD)
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease

Groundwater Level (mAHD)

454

58

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BLACKWATER MINE - NORTH EXTENSION PROJECT

GROUNDWATER TABLE RECOVERY (200 YEARS POST-MINING)

FIGURE 4-3

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F04_3_Recovered GW Table

5.0 Sensitivity Analysis

5.1 Calibration Sensitivity

As an additional step in the calibration process, a parameter sensitivity file containing the "composite sensitivity" of each parameter with respect to all observations was generated. The Relative Composite Sensitivity (RCS) of a parameter is obtained by multiplying its composite sensitivity by the magnitude of the value of the parameter. Therefore, RCS is a measure of the composite changes in model outputs that are incurred by a fractional change in the value of the parameter (Doherty, 2010).

Composite parameter sensitivities are used in identifying those parameters that may be degrading the performance of the parameter estimation process through lack of sensitivity to model outcomes. Relative Composite Sensitivity is a measure of the composite changes in the model outputs that have resulted by a change in the value of the parameter. RCS also show how much the model calibration is sensitive to an input parameter. The groundwater model is more sensitive to the parameters that have high RCS value. Where parameters have low RCS (<1), the model calibration is less sensitive to those which indicates a greater uncertainty associated with them.

The composite sensitivity values were calculated during the PEST calibration and are presented in **Figure 5-1** and **Figure 5-2**. **Figure 5-1** shows the RCS for the horizontal conductivity, anisotropy (KZ/Kx) and the slope used in the depth dependence equations used in the model (**Section 2.6.5**). **Figure 5-2** shows the RCS for the specific yield, specific storage, and recharge.

Figure 5-1 illustrates that horizontal hydraulic conductivities (Kx) are typically responsive to calibration, with Rewan and Overburden being the most influential parameters. Concerning anisotropy, the majority of parameters exhibit low sensitivity, except for Rewan and Overburden, which emerge as the most sensitive parameters.

Figure 5-2 shows that specific yield and storage exhibit an RCS of less than 0.5, indicating the model's relatively low sensitivity to these parameters. In the context of recharge, it is evident that the recharge zones are generally responsive to the calibration dataset, with recharge in Clematis emerging as the parameter least sensitive to calibration.

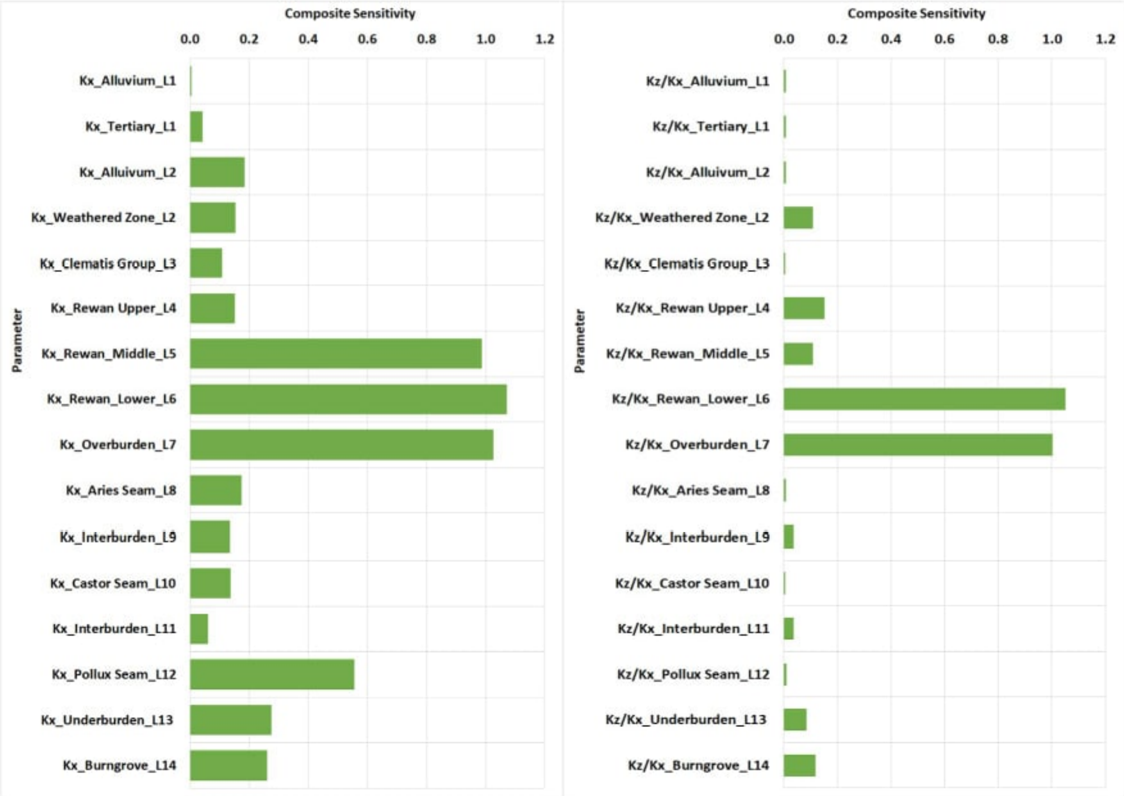


Figure 5-1 Composite Sensitivity – Kx and Kz/Kx

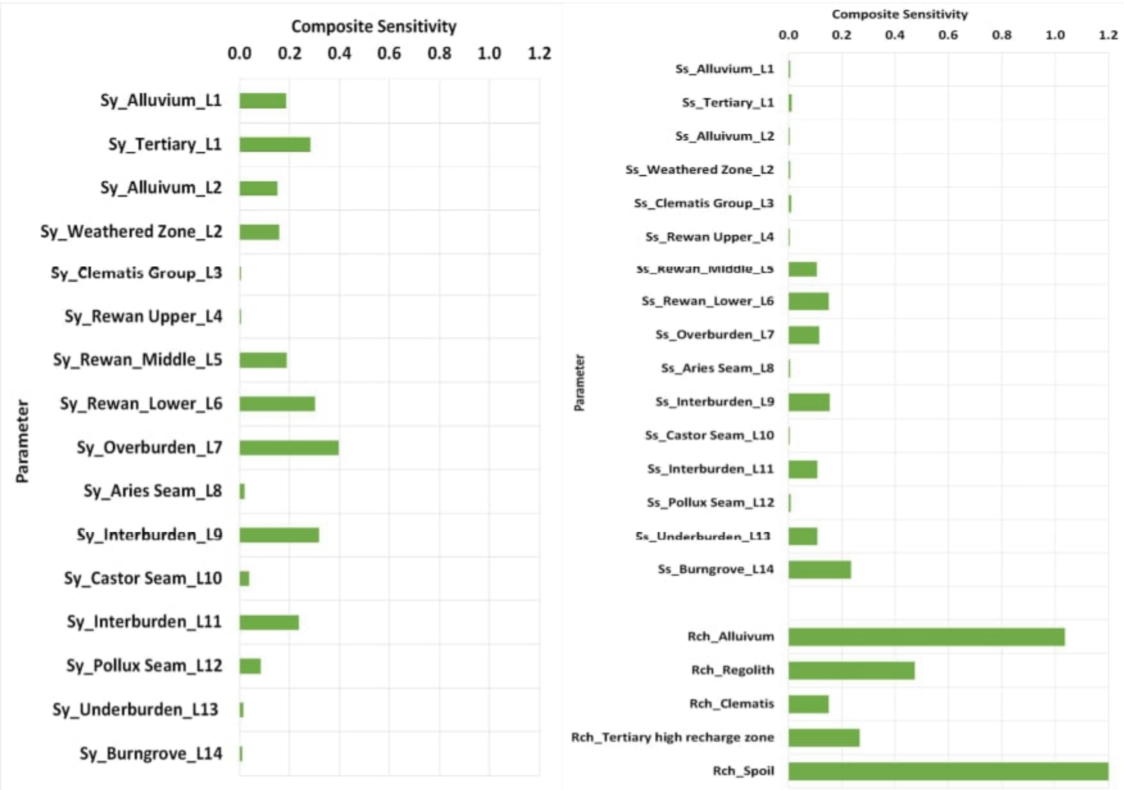


Figure 5-2 Composite Sensitivity – Sy, SS and Recharge

5.2 Calibration Identifiability

Identifiability describes a parameters capability to be constrained by the model calibration. Identifiability values range from zero to one. As identifiability approaches one, the parameter is increasingly able to be constrained. Likewise, as values approach zero the parameter is increasingly unable to be constrained by the calibration and uncertainty of model results is not reduced through calibration.

The PEST utility GENLINPRED (GENeral LINear PREDiction) was used to provide an estimate of parameter identifiability for each of the model parameters. Estimated identifiability values for the calibrated parameters horizontal hydraulic conductivity, anisotropy, Specific Yield and recharge are summarised in **Figure 5-3** through **Figure 5-7**.

Figure 5-3 indicates that in general the calibration process was successful in constraining the horizonal hydraulic conductivity. Notably, the horizontal hydraulic conductivity of the Tertiary, Weathered Zone, Overburden, Pollux Seam, Underburden and Burngrove are well constrained by calibration (high identifiability values above 0.7). The horizontal hydraulic conductivity of the Clematis and Upper Rewan has not been able to be constrained during calibration. This is expected as there is no bore screened in layers 3 and 4 (see **Table 2-7**).

Identifiability of hydraulic conductivity anisotropy for model zones is presented in **Figure 5-4**. Anisotropy in the Weathered Zone, Lower Rewan and Overburden, Interburden and Burngrove have high identifiability values (above 0.7) indicating these can be constrained and contribute to reducing model uncertainty. All other zones except the Underburden (relatively high at 0.4) feature relatively low values (below 0.1) and are less constrained by calibration.

In general, the Specific Yield in the model domain has low identifiability except in Burngrove, Weathered Zone, Overburdens and Underburden (**Figure 5-5**). **Figure 5-6** shows the calibration was not able to constrain the specific storage in all model layers except in the Overburden and Burngrove Formation.

The recharge zones for the Regolith, Tertiary and Spoil are highly constrained by the calibration, while the Clematis and Alluvium have low identifiability (**Figure 5-7**). Note that the alluvium represents a narrow zone along Blackwater Creek, with a small area relative to the other recharge zones. Also, the Clematis is conceptualised as being disconnected to the regional groundwater system due to a major displacement fault. It is, therefore, less likely to impact model predictions.

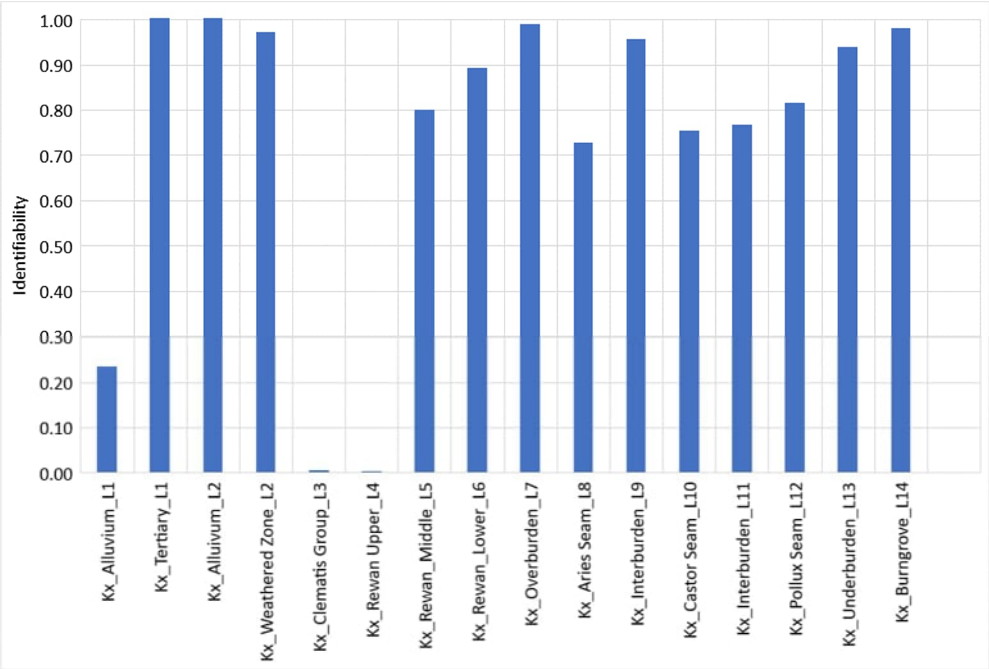


Figure 5-3 Identifiability – Horizontal Hydraulic Conductivity (Kx)

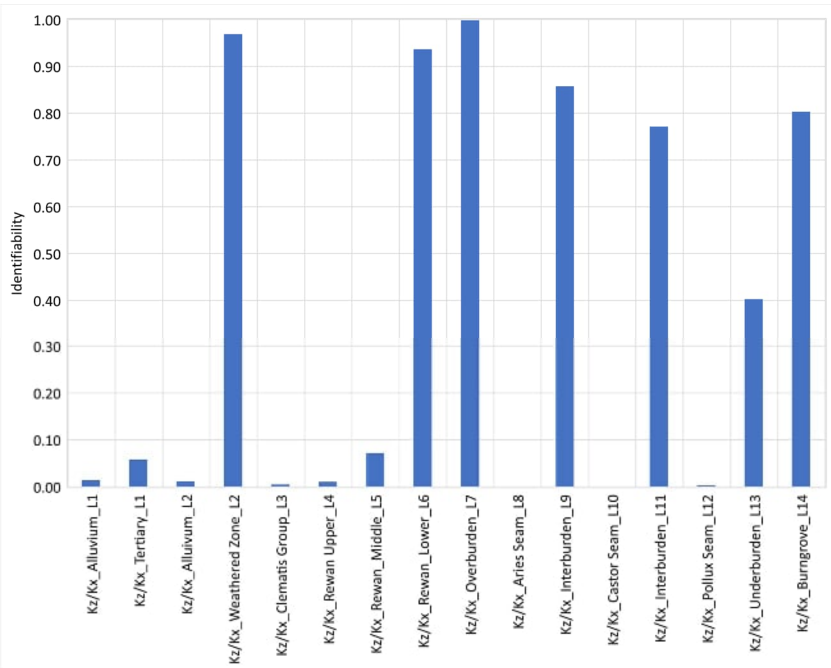


Figure 5-4 Identifiability – Anisotropy (Kz/Kx)

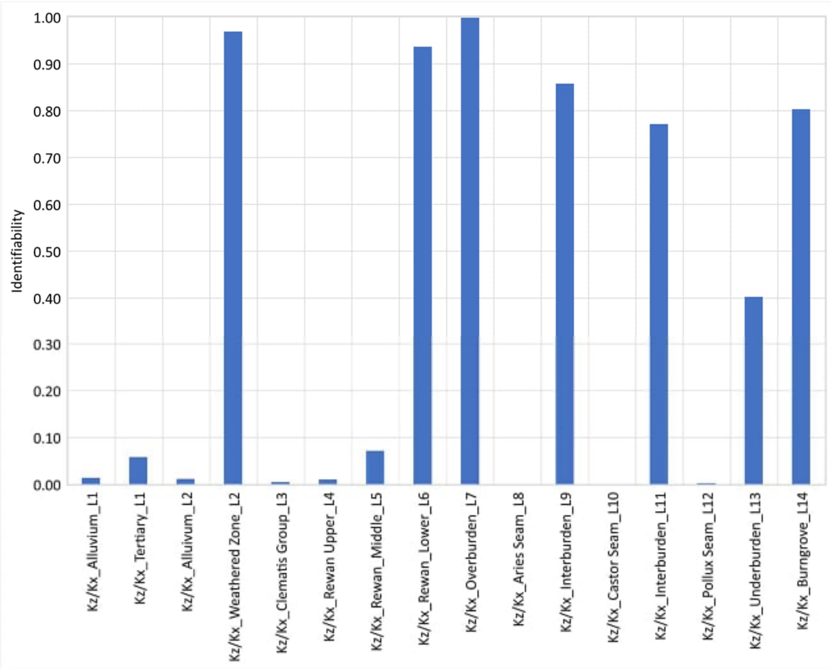


Figure 5-5 Identifiability – Specific Yield (Sy)

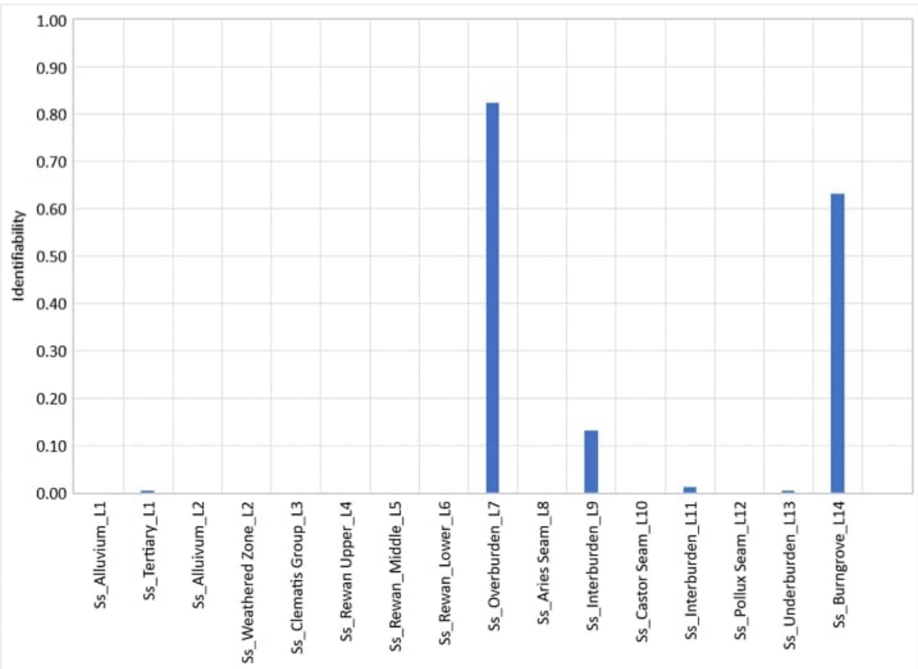


Figure 5-6 Identifiability – Specific Storage (SS)

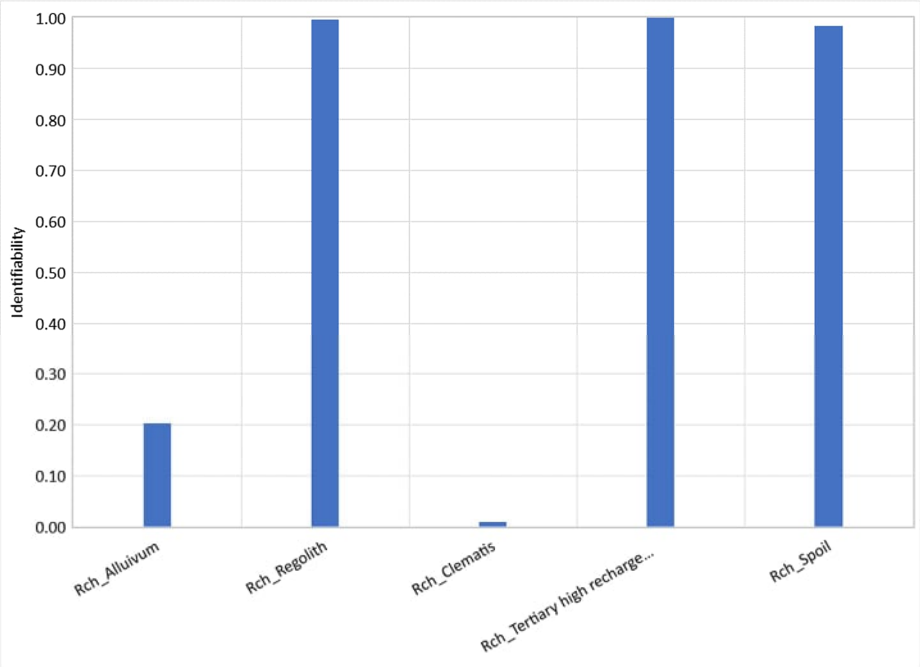


Figure 5-7 Identifiability – Recharge (RCH)

5.3 Prediction Identifiability

Prediction identifiability describes parameters capability on impacting the model predictions. To calculate the prediction identifiability the groundwater model is run once per each parameter. The predictions included in the analysis were the Project only inflows and maximum cumulative drawdown. The analysis then utilised the GENLINPRED utility to provide an estimate of parameter identifiability for each of the model parameters.

As identifiability approaches one, the parameter is increasingly able to change model predictions. On the contrary, as values approach zero the parameter is increasingly unable to change model predictions.

The Murray Darling Basin Modelling Guidelines (MDBC, 2001) recommends classifying sensitivity by the resultant changes (or contribution) to the model calibration and predictions. According to this process models can be classified as one of the four main types:

- Type I: Insignificant changes to calibration (low identifiability) and prediction (low uncertainty contribution).
- Type II: Significant changes to calibration (high identifiability) – insignificant changes to predictions (low uncertainty contribution).
- Type III: Significant changes to calibration (high identifiability) –significant changes to predictions (high uncertainty contribution).
- Type IV: Insignificant changes to calibration (low identifiability) – significant changes to predictions (high uncertainty contribution).

Types I-III are of less concern, as these Types have an insignificant impact on model predictions or are constrained by calibration. Type IV is classed as ‘a cause for concern’ as non-uniqueness in a model input might allow a range of valid calibrations but the choice of value impacts significantly on a prediction (MDBC, 2001).

To classify the sensitivity contribution to the model calibration and predictions for each model parameter, the calibration and prediction identifiability were compared against each other for each parameter.

Figure 5-8 presents the relationship between the identifiability of the predicted Project only inflow and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the identifiability. The results show that the key parameters that require further work to reduce their influence on predictive uncertainty groundwater inflows include the specific yield of the interburden between the Castor and Pollux Seam (layer 11) and the Lower Rewan (layer 6). As shown in **Figure 5-8**, for the inflow predictions a high proportion of parameters are classified as Type I or Type II which indicates they have low uncertainty contribution in inflow predictions.

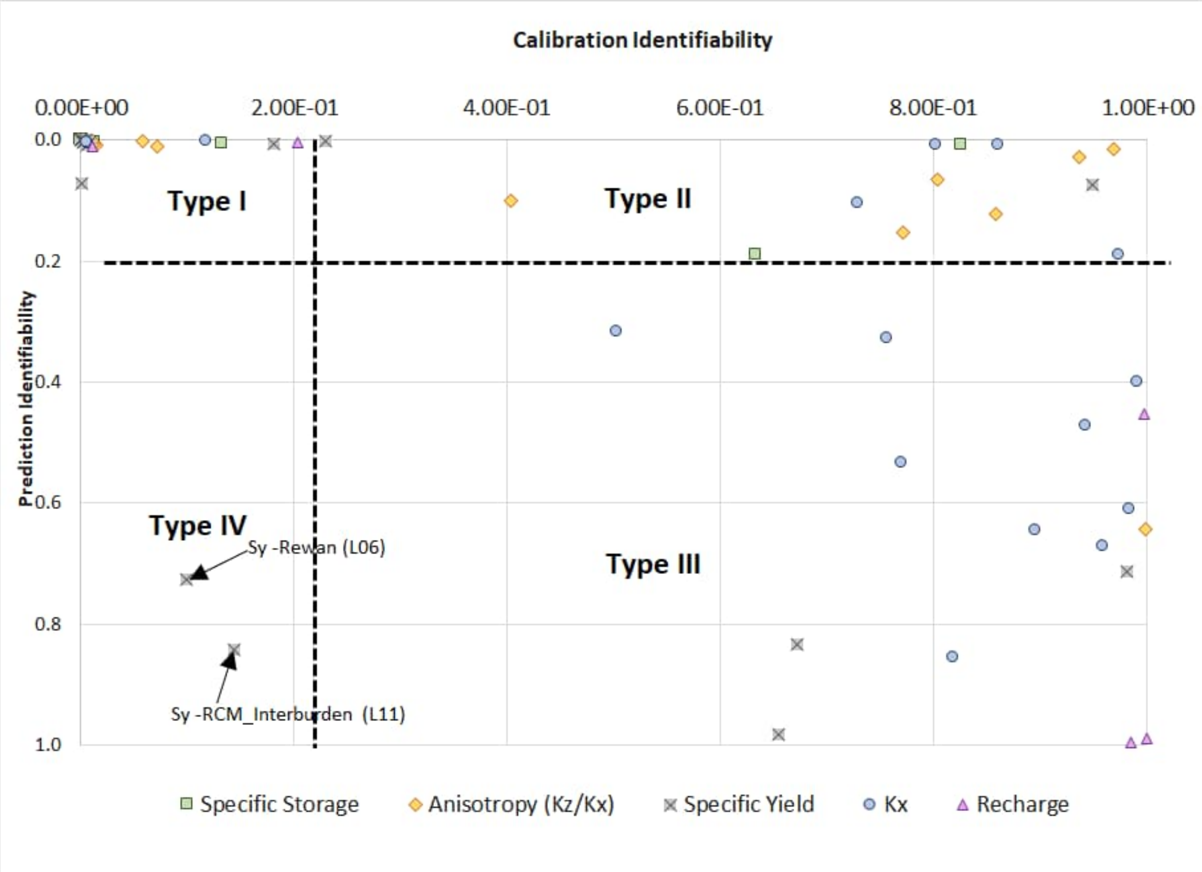


Figure 5-8 Identifiability of Prediction (Mine Inflow) versus Identifiability of Calibration

Figure 5-9 presents the relationship between identifiability of the maximum predicted drawdown and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the identifiability. The results show that the key parameter that requires further work to reduce its influence on predictive uncertainty in relation to the maximum drawdown extent is specific yield of the Lower Rewan (layer 6). **Figure 5-9** shows horizontal conductivity parameters in the model are mostly classified as Type II indicating they significantly impact the model calibration but have insignificant contribution in reducing uncertainty of the maximum drawdown.

Figure 5-10 presents the relationship between identifiability of alluvium flow change and the identifiability of the calibration. Sensitivity classifications for the sensitivity types have been assigned using judgement based on the range of the posterior predictions. The results show that the key parameters that requires further work to reduce their influence on predictive uncertainty in relation to the alluvium flow change are the anisotropy in the Lower and Middle Rewan, specific yield in the Alluvium and Middle Rewan and recharge in the Alluvium.

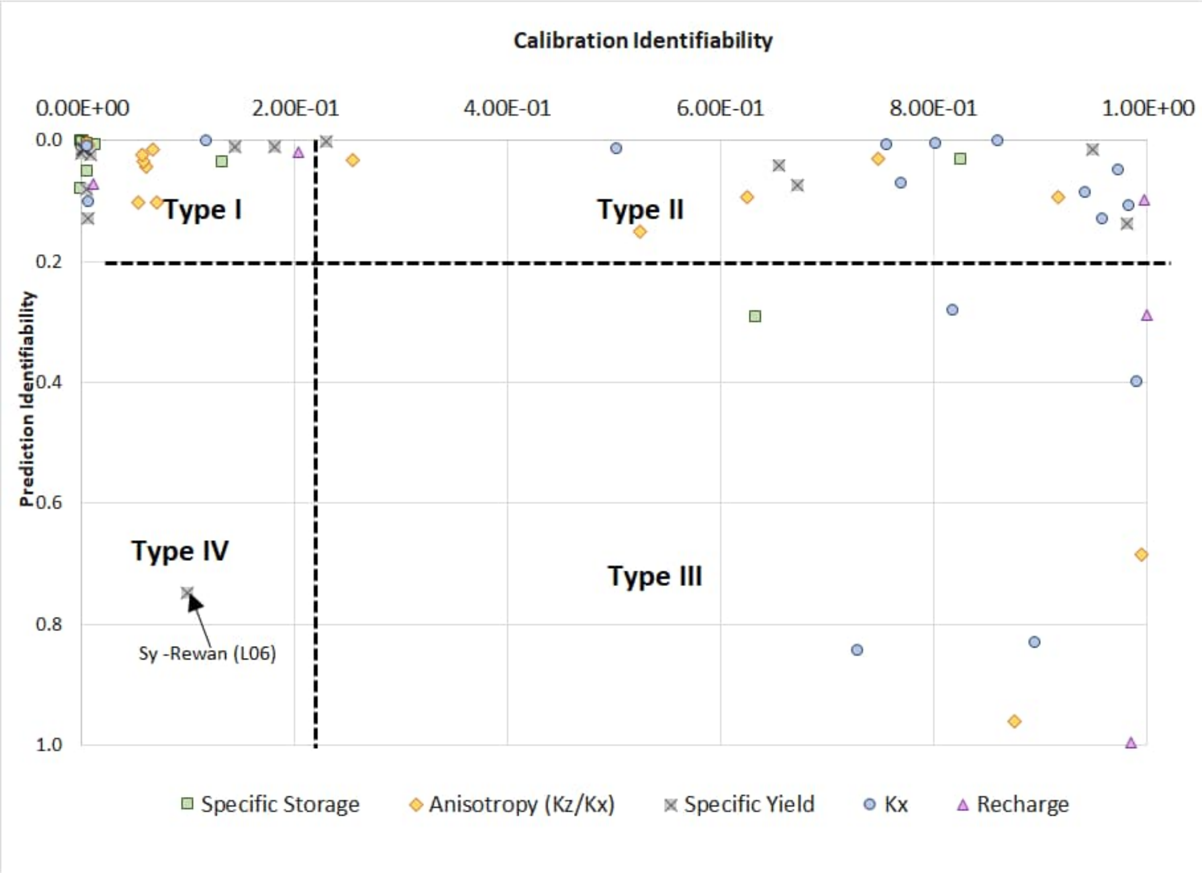


Figure 5-9 Identifiability of Prediction (Maximum Drawdown) versus Identifiability of Calibration

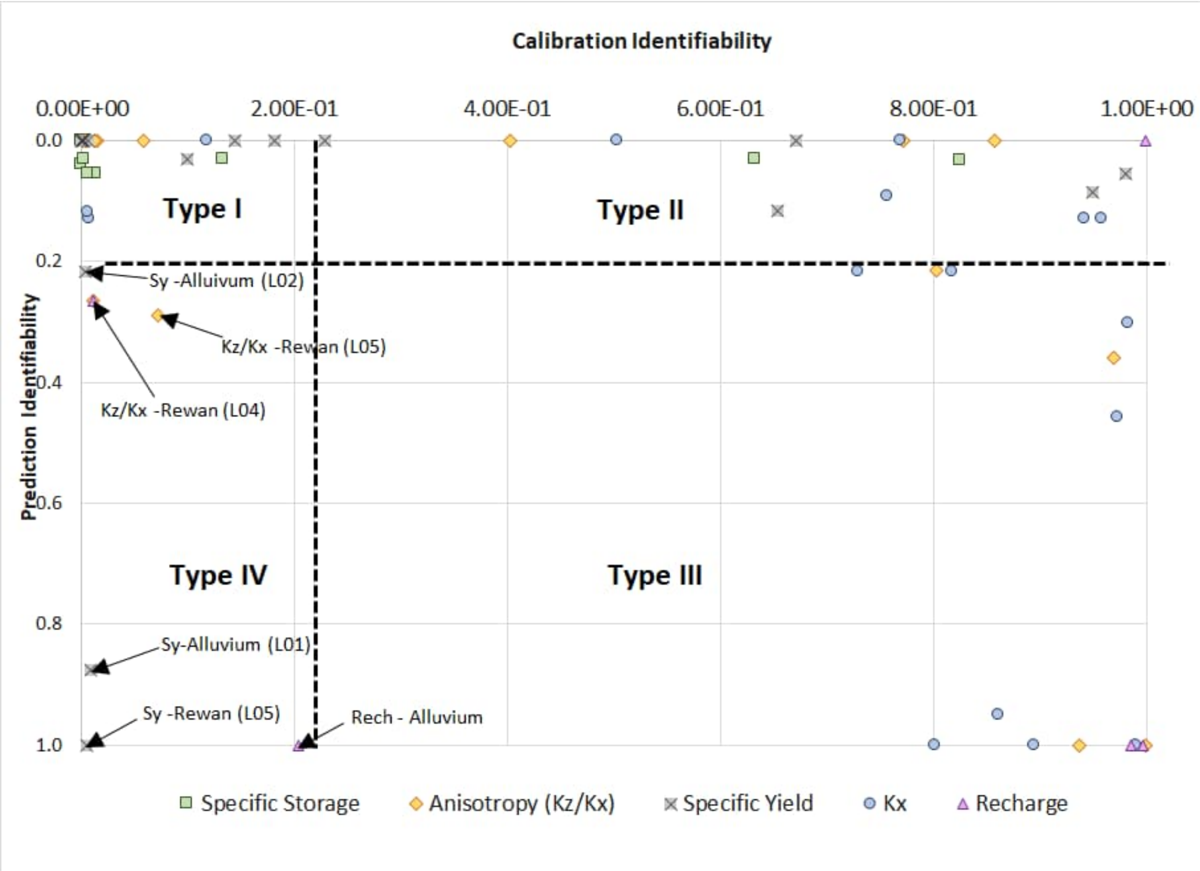


Figure 5-10 Identifiability of Prediction (Alluvium Flow Change) versus Identifiability of Calibration

6.0 Uncertainty Analysis

A Type 3 Monte Carlo uncertainty analysis (IESC, 2018) was undertaken to estimate the uncertainty in the future impacts predicted by the model. This method operates by generating numerous alternative sets of input parameters to the deterministic groundwater flow model (realisations), executing the model independently for each realisation, and then aggregating the results for statistical analysis.

6.1 Parameter Distribution

The first step in Monte Carlo analysis is to define the parameter distribution and range. For this Project, the parameters are assumed to be log-normally distributed around the optimum value derived from the calibration and the standard deviation attributed to the log (base 10) of parameter is 0.5**. Table 6-1** to **Table 6-5** show the parameter ranges explored during the sensitivity and uncertainty analysis simulation. Note that for the hydraulic conductivity the depth-dependent function described in **Section 2.6.5** was applied, with the hydraulic conductivity value at zero depth being varied and the slope assumed to be constant.

Instead of simple random sampling, the Latin Hypercube Sampling (LHS) method was used to create random realisations from parameter distribution. LHS aims to spread the sample points evenly across all possible values. In doing so, it divides parameter space into N intervals of equal probability and chooses one sample from each interval. The generated random numbers derived from LHS approach is distributed sufficiently across the parameter space even at the small sample size. The main advantage of LHS over simple random sampling is that a lower number of realisations are needed to obtain a reasonable convergence of the uncertainty results.

The distribution for each parameter were checked and constrained such that upper or lower ranges do not go beyond ranges in literature for physical constraints. 1000 model realisations were generated, each having differing values of key parameters. The prior parameter distribution for all 1000 realisations is provided in **Appendix D**.

The realisations were run, and calibration quality was assessed. In this case, models were considered to have an acceptable calibration if they achieved an SRMS less or equal to calibration SRMS of 7% (as a comparison, the calibrated model had a SMRS of 6.40%). Of the 1000 model runs, 354 model runs were found to meet the above criteria. These were used in all model scenarios (calibration, cumulative mining, approved mining, and no mining) and statistically analysed for uncertainty analysis. **Appendix D** also shows the posterior parameter distribution for the selected 354 model runs.

Table 6-1 Uncertainty Parameter Range for Horizontal Hydraulic Conductivity

Zone	Layer – Unit	Horizontal Hydraulic Conductivity (m/day)			
		Basecase (Log10)	Lower (log10)	Upper (log10)	Conceptual Constraint
1	Layer 1 – Alluvium upper	0.00	-1.00	2.30	No constraint
2	Layer 1 – Regolith upper	-1.30	-2.30	0.70	< Kx_Alluvium L1 and L2
3	Layer 1 – Alluvium lower	0.00	-1.00	2.30	No constraint
4	Layer 2 – Regolith lower	-1.60	-2.30	0.70	< Kx_Alluvium L1 and L2
5	Layer 3_Clematis Group	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2
6	Layer 4_Rewan upper	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2
7	Layer 5_Rewan middle	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2
8	Layer 6_Rewan lower	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2
9	Layer 7_Overburden	-2.10	-5.00	-0.30	< Kx_Alluvium L1 and L2
10	Layer 8_Aries seam	-0.40	-3.00	0.70	< Kx_Alluvium L1 and L2
11	Layer 9_Interburden	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2, < Kx_Aries Seam L8
12	Layer 10_Castor seam	-0.60	-3.00	0.70	< Kx_Alluvium L1 and L2
13	Layer 11_Interburden	-2.00	-5.00	-0.30	< Kx_Alluvium L1 and L2, < Kx_Castor Seam L10
14	Layer 12_Pollux Lower	-0.60	-3.00	0.70	< Kx_Alluvium L1 and L2

Zone	Layer – Unit	Horizontal Hydraulic Conductivity (m/day)			
		Basecase (Log10)	Lower (log10)	Upper (log10)	Conceptual Constraint
15	Layer 13_Underburden	-1.60	-5.00	-0.30	< Kx_Alluvium L1 and L2, < Kx_Pollux Seam L12
16	Layer 14_Burngrove formation	-1.52	-5.00	-0.30	< Kx_Alluvium L1 and L2

**Standard deviation = 0.5 order of magnitude for all units.

Table 6-2 Uncertainty Parameter Range for Vertical to Horizontal Conductivity (Kz/Kx)

Zone	Layer – Unit	Anisotropy (Kv/Kx)			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Conceptual Constraint
1	Layer 1 – Alluvium upper	-1.00	-3.00	0.00	No constraint
2	Layer 1 – Regolith upper	-1.70	-3.00	0.00	No constraint
3	Layer 1 – Alluvium lower	-1.00	-3.00	0.00	No constraint
4	Layer 2 – Regolith lower	-2.00	-3.00	0.00	No constraint
5	Layer 3_Clematis Group	-1.30	-3.00	0.00	No constraint
6	Layer 4_Rewan upper	-1.00	-3.00	0.00	No constraint
7	Layer 5_Rewan middle	-1.00	-3.00	0.00	No constraint
8	Layer 6_Rewan lower	-2.00	-3.00	0.00	No constraint

Zone	Layer – Unit	Anisotropy (Kv/Kx)			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Conceptual Constraint
9	Layer 7_Overburden	-2.52	-3.00	0.00	No constraint
10	Layer 8_Aries seam	-0.70	-3.00	0.00	No constraint
11	Layer 9_Interburden	-1.60	-3.00	0.00	No constraint
12	Layer 10_Castor seam	-0.30	-3.00	0.00	No constraint
13	Layer 11_Interburden	-1.30	-3.00	0.00	No constraint
14	Layer 12_Pollux Lower	-0.30	-3.00	0.00	No constraint
15	Layer 13_Underburden	-1.00	-3.00	0.00	No constraint
16	Layer 14_Burngrove formation	-0.52	-3.00	0.00	No constraint

**Standard deviation = 0.5 order of magnitude for all units.

Table 6-3 Uncertainty Parameter Range for Specific Yield

Zone	Layer – Unit	Specific Yield (Sy)			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Constraint
1	Layer 1 – Alluvium upper	-1.70	-4.00	-0.82	No constraint
2	Layer 1 – Regolith upper	-2.00	-4.00	-0.82	< Kx_Alluvium L1 and L2
3	Layer 1 – Alluvium lower	-1.70	-4.00	-0.82	No constraint

Zone	Layer – Unit	Specific Yield (Sy)			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Constraint
4	Layer 2 – Regolith lower	-2.70	-4.00	-0.82	< Kx_Alluvium L1 and L2
5	Layer 3_Clematis Group	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
6	Layer 4_Rewan upper	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
7	Layer 5_Rewan middle	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
8	Layer 6_Rewan lower	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
9	Layer 7_Overburden	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
10	Layer 8_Aries seam	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
11	Layer 9_Interburden	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
12	Layer 10_Castor seam	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
13	Layer 11_Interburden	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
14	Layer 12_Pollux Lower	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
15	Layer 13_Underburden	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2
16	Layer 14_Burngrove formation	-2.52	-4.00	-1.30	< Kx_Alluvium L1 and L2

**Standard deviation = 0.5 order of magnitude for all units.

Table 6-4 Uncertainty Parameter Range for Specific Storage (1/m)

Zone	Layer – Unit	Specific Storage (SS) 1/m			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Constraint
1	Layer 1 – Alluvium upper	-5.00	-7.00	-4.30	No constraint
2	Layer 1 – Regolith upper	-5.00	-7.00	-4.30	No constraint
3	Layer 1 – Alluvium lower	-5.00	-7.00	-4.30	No constraint
4	Layer 2 – Regolith lower	-6.00	-7.00	-4.30	< Kx_Alluvium L1 and L2
5	Layer 3_Clematis Group	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2
6	Layer 4_Rewan upper	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2
7	Layer 5_Rewan middle	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2
8	Layer 6_Rewan lower	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2
9	Layer 7_Overburden	-5.30	-7.30	-4.30	< Kx_Alluvium L1 and L2
10	Layer 8_Aries seam	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2
11	Layer 9_Interburden	-5.52	-7.30	-4.30	< Kx_Alluvium L1 and L2
12	Layer 10_Castor seam	-5.52	-7.30	-4.30	< Kx_Alluvium L1 and L2
13	Layer 11_Interburden	-5.52	-7.30	-4.30	< Kx_Alluvium L1 and L2
14	Layer 12_Pollux Lower	-5.52	-7.30	-4.30	< Kx_Alluvium L1 and L2
15	Layer 13_Underburden	-6.00	-7.30	-4.30	< Kx_Alluvium L1 and L2

Zone	Layer – Unit	Specific Storage (SS) 1/m			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Constraint
16	Layer 14_Burngrove formation	-5.52	-7.30	-4.30	< Kx_Alluvium L1 and L2

**Standard deviation = 0.5 order of magnitude for all units.

Table 6-5 Uncertainty Ranges for Recharge Rates

Zone	Unit	Recharge Multiplier			
		Basecase (Log10)	Lower (Log10)	Upper (Log10)	Constraint
1	Alluvium	0.23	0.0001	5	No constraint
2	Regolith	0.01	0.0001	0.5	< Alluvium, < Clematis, < Basalt high recharge area
3	Clematis	0.01	0.0001	5	
4	Basalt high recharge zone	0.01	0.0001	5	

**Standard deviation = 0.5 order of magnitude for all units.

6.2 Uncertainty Results

6.2.1 Number of Realisations

As discussed in **Section 6.1**, 354 realisations met the calibration criteria and were selected as calibrated realisations. The predictive model was run using the 354 parameter sets. The results from the predictive model were used to conduct statistical analyses to assess if additional realisations were likely to provide results that would significantly change the reported predictive results. The uncertainty analysis was undertaken to add a likelihood estimate to the prediction for the main two quantities of interest, the groundwater inflows into the mining pits and predicted drawdowns in a multitude of relevant geological formations. The 95% confidence interval was calculated for the mine inflows and the maximum drawdown.

Figure 6-1 and **Figure 6-2** show the 95% confidence intervals of the median and maximum inflows and predicted drawdowns, as well as the variance of the median and maximum inflows and predicted drawdowns as more realisations are added to the uncertainty analysis. These plots show that with an increasing number of realisations, the confidence interval decreases. When the lines flatten out, adding more realisations will not improve confidence significantly. For example, for the inflow (**Figure 6-1**), the 95th percentile confidence interval fell below 0.1 ML/day after approximately 200 realisations and the next 150 realisations only slightly improved the confidence to 0.08 ML/day.

For example, the 95% confidence interval for the maximum drawdown is calculated by first estimating the maximum drawdown for each realisation and then calculating the 95% confidence interval of the maximum drawdowns as each realisation is added to the dataset. As shown in **Figure 6-1** and **Figure 6-2**, additional realisations are unlikely to significantly increase or decrease the confidence intervals of predictions of mine inflows and maximum drawdowns. Therefore, the results from the 354 realisations are considered representative and used for predicted drawdown and indirect water take (alluvium and surface water).

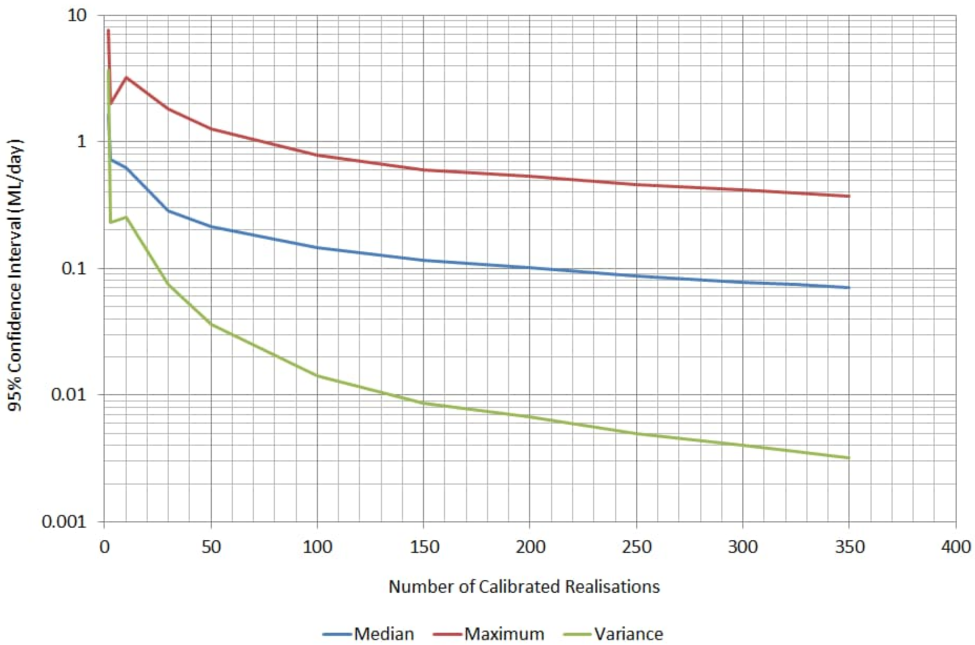


Figure 6-1 95% Confidence Interval for Pit Inflows

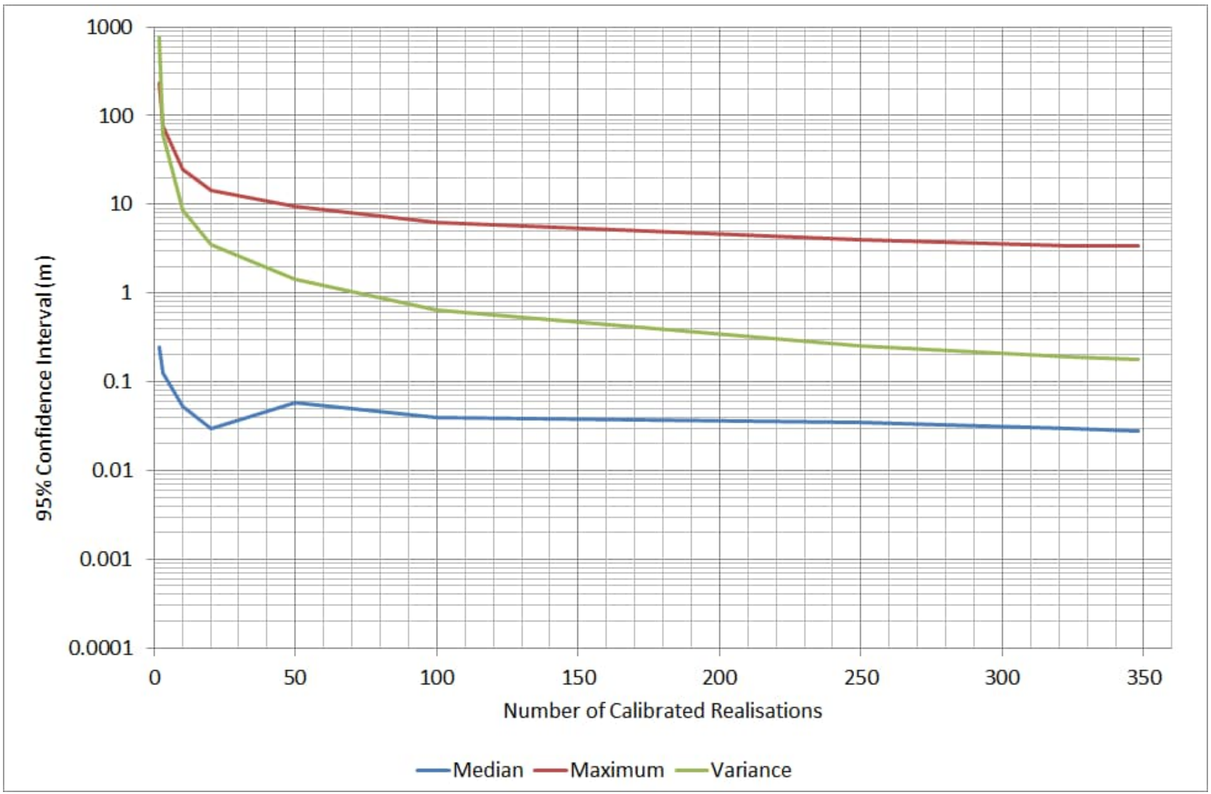


Figure 6-2 95% Confidence Interval for Maximum Drawdowns

6.2.2 Uncertainty of Mine Inflows

Figure 6-3 presents the uncertainty of the cumulative groundwater inflow into the mine from 2021 to the end of planned mining in 2085. The figure shows the predicted cumulative inflows for the base case (i.e., the calibrated predictive model presented in **Section 3.5**) model and different percentiles including 10th, 33rd, 67th and 90th prediction bounds. Based on the IESC (2018) guidelines these represent:

- The 10th percentile indicates it is very likely the outcome is larger than this value.
- The 10th – 33rd percentile range indicates it is likely that the outcome is larger than this value.
- The 33rd – 67th percentile range indicate it is as likely as not that the outcome is larger or smaller than this value.
- The 67th – 90th percentile range indicates it is unlikely that the outcome is larger than this value.
- The 90th percentile range indicates it is very unlikely the outcome is larger than this value.

The bounds in the figure demonstrate the uncertainty within the predicted cumulative inflow rate. As shown in **Figure 6-3**, the maximum mine inflow in the uncertainty analysis was approximately 3,650 ML/year (10 ML/day) (very unlikely outcome is larger than this value). The 10th to 90th percentiles over the prediction period averaged 441 ML/year (1.21 ML/day) to 1,013 ML/year (2.77 ML/day). The base case (i.e., the calibrated predictive model presented in **Section 3.5**) is following the 67th percentile curve, which can be interpreted that it is unlikely that the future inflow will be larger than this base case estimate.

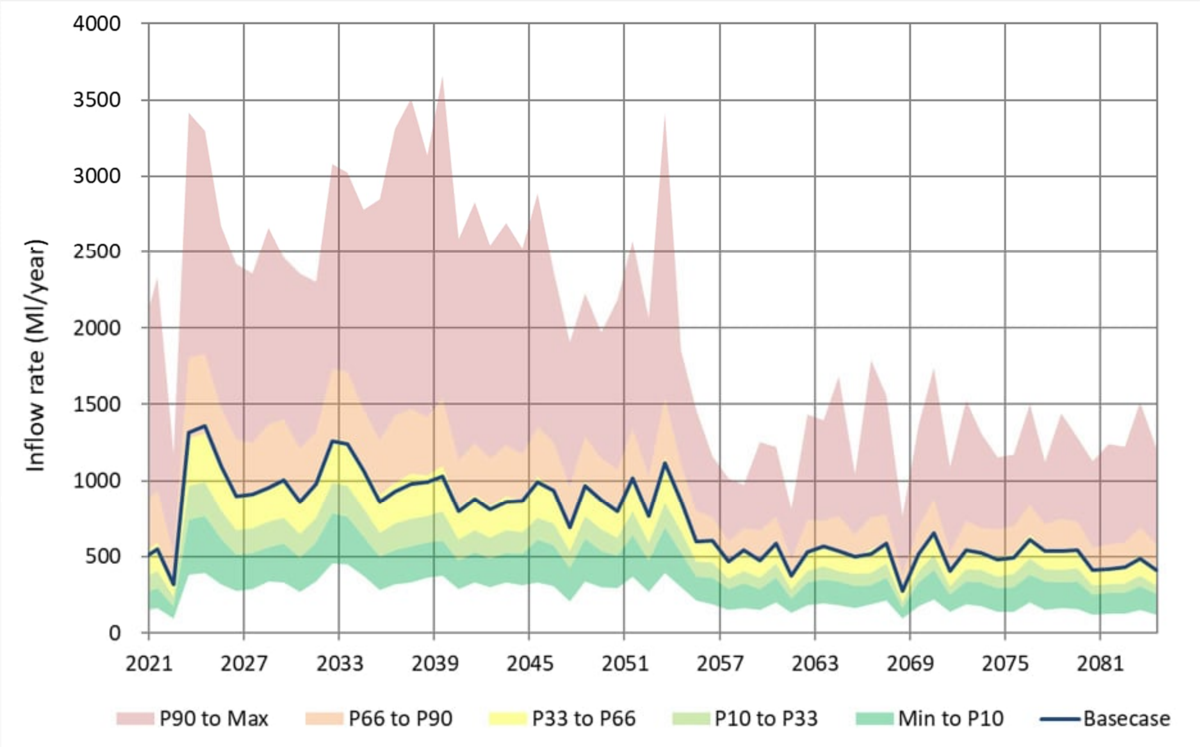


Figure 6-3 Mine Inflow Uncertainty

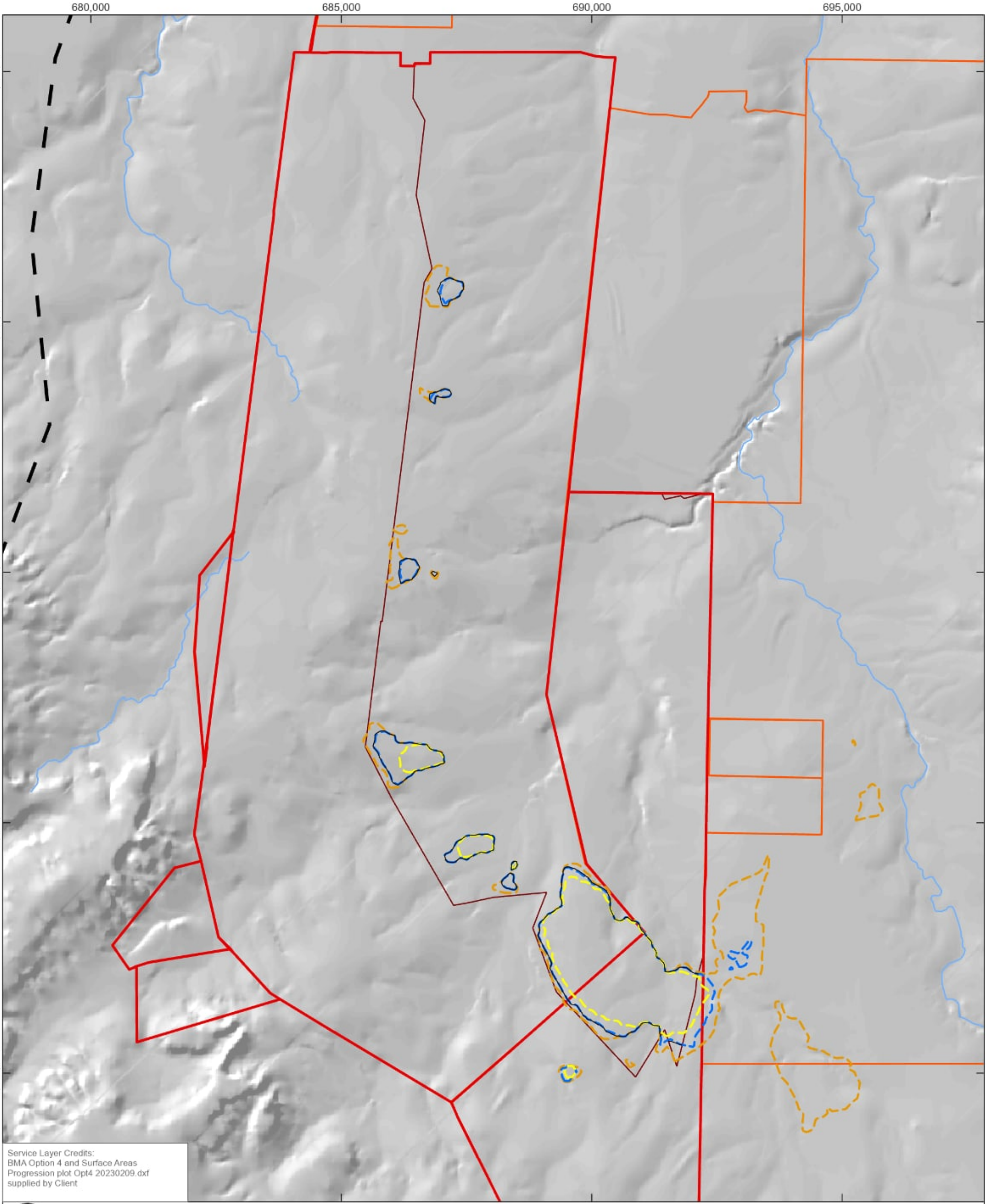
6.2.3 Groundwater Drawdowns

To illustrate the level of uncertainty in the extent of predicted Project incremental drawdown, the base case maximum drawdown and the 50th percentile maximum drawdown extent were compared to the maximum drawdown extent for the 10th and 90th percentiles.

Figure 6-4 and **Figure 6-5** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Alluvium and the Weathered Zone. The figures show that in localised areas, 90th percentile maximum drawdown extends to a maximum of approximately 5 km south of the Project area.

Figure 6-6 and **Figure 6-7** show the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Aries and Pollux Seams. The figures show that the 90th percentile drawdown in the Aries and seams extend to a maximum of approximately 7 km to the east and 11 km to the south of the Project area.

Figure 6-8 shows the uncertainty in the extent of predicted 1 m maximum incremental drawdown in the Burngrove Formation. The figure shows that the 90th percentile drawdown in the Burngrove Formation extends to a maximum of approximately 8 km to the east and 9 km to the south of the Project area.



0 1 2 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:100,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

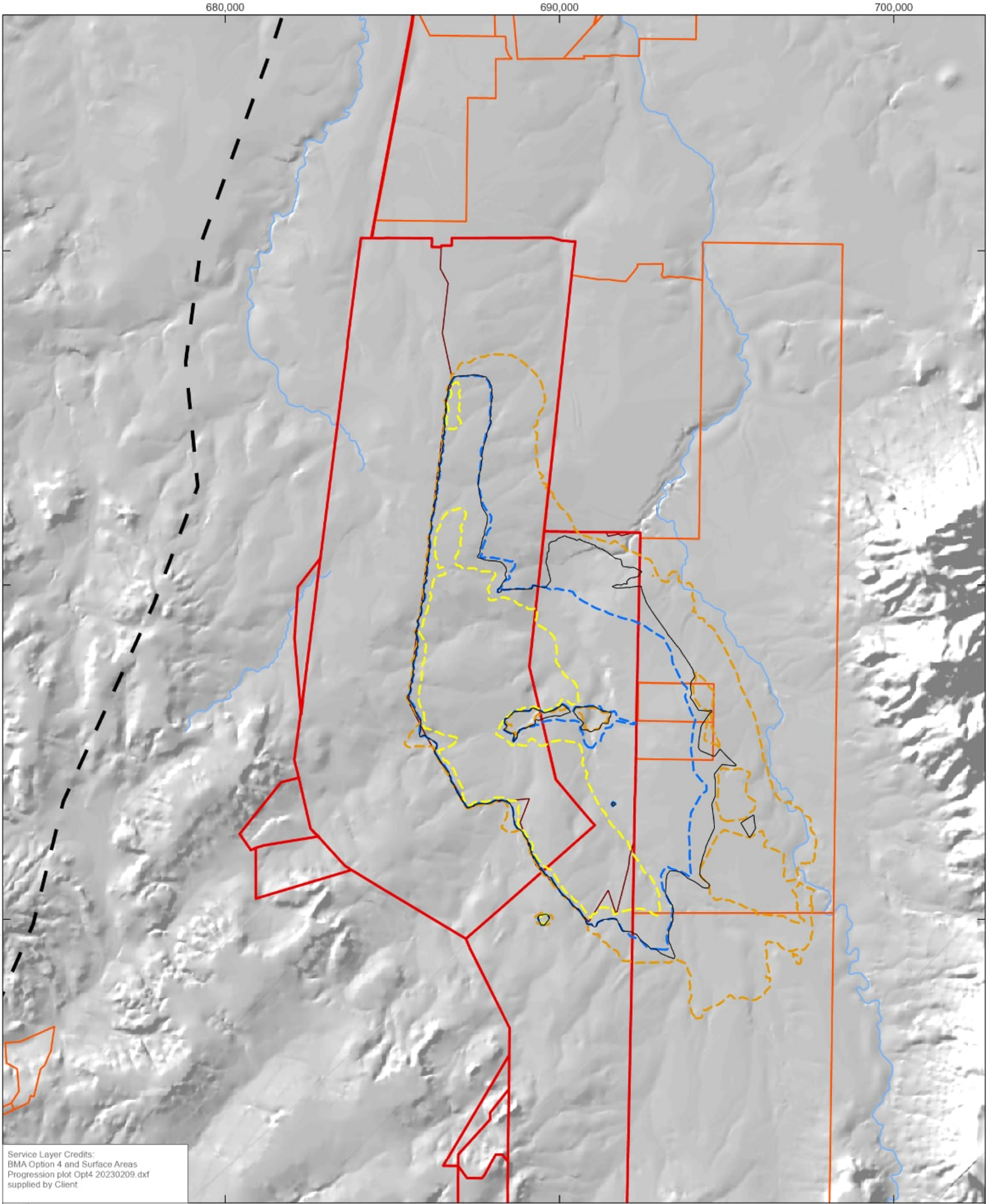
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Perentile
- 50th Percentile
- 10th Percentile

SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE TERTIARY (LAYER 1)

FIGURE 6-4



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Perentile
- 50th Percentile
- 10th Percentile

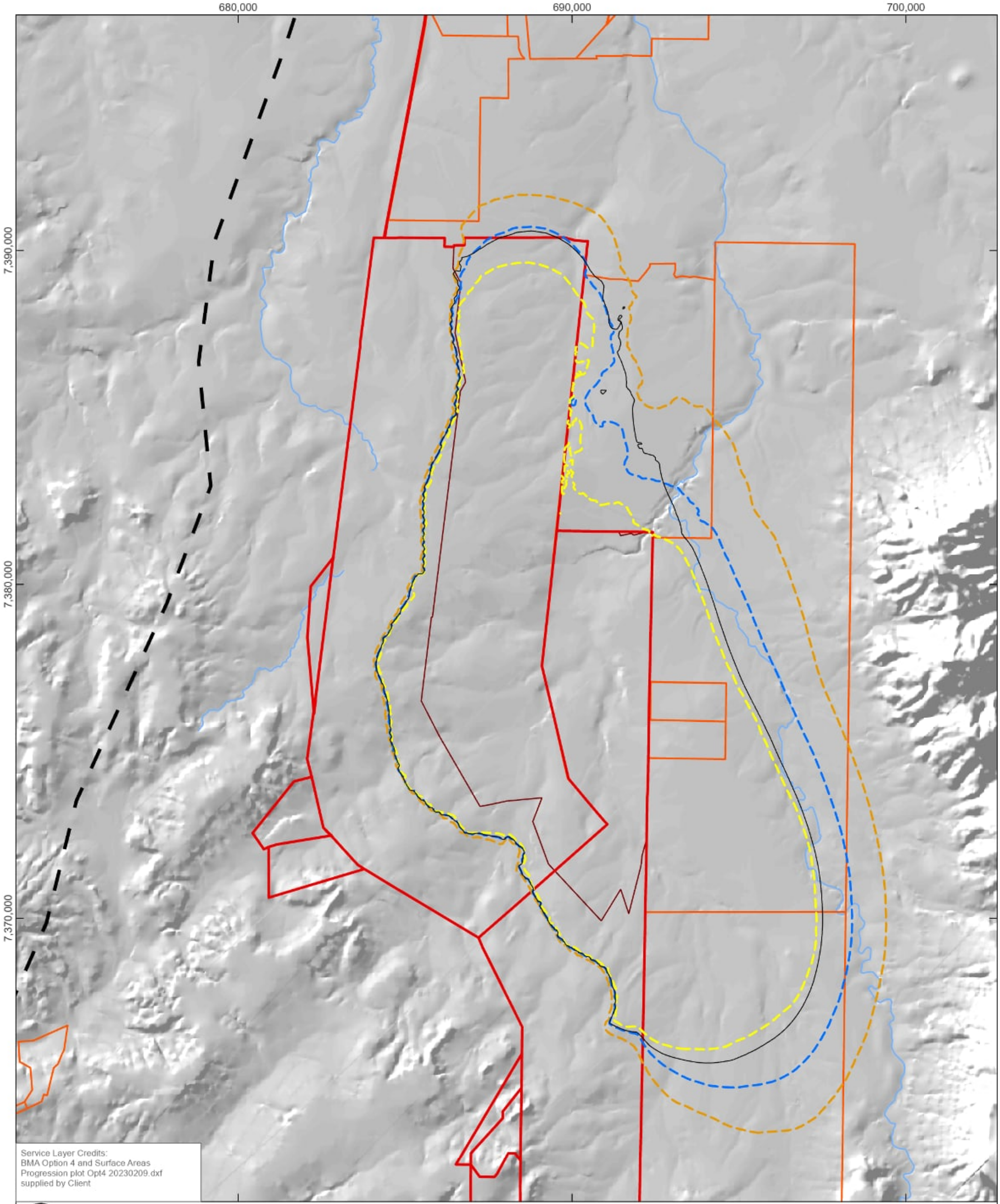
BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE WEATHERED ZONE (LAYER 2)

SLR

FIGURE 6-5

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F06_5_Predicted 1m Max Inc DD in Layer 2



Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

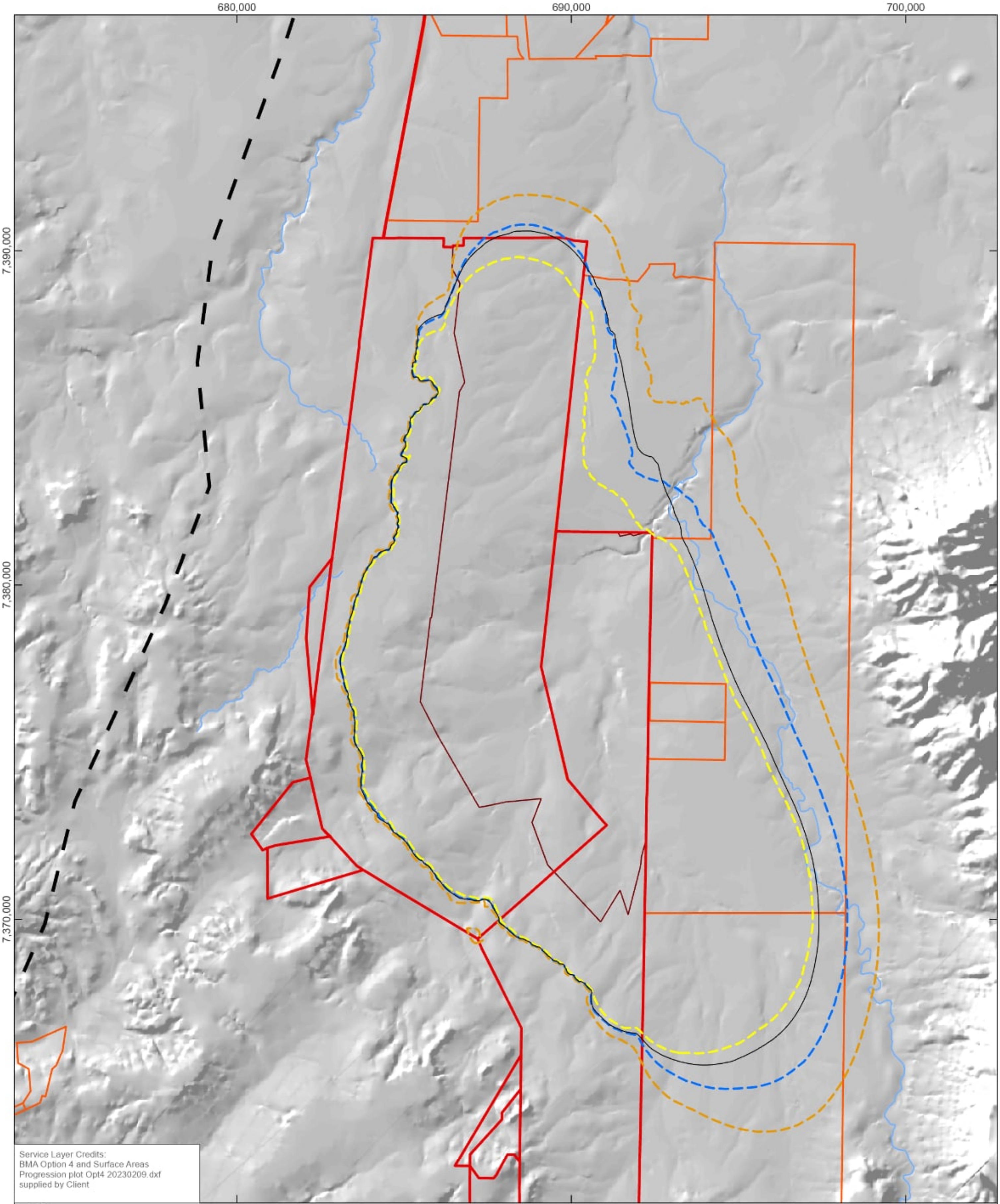
SLR

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE ARIES SEAM (LAYER 8)

FIGURE 6-6

Path: \\au.slr.local\Corporate\Projects-SLR\620-BNE\620-BNE\620.014601.00001 Blackwater NEP\08 GIS\BWM NEP Pro\BWM NEP Pro v1.aprx\620014601_GWM_F06_6_Predicted 1m Max Inc DD in Layer 8



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

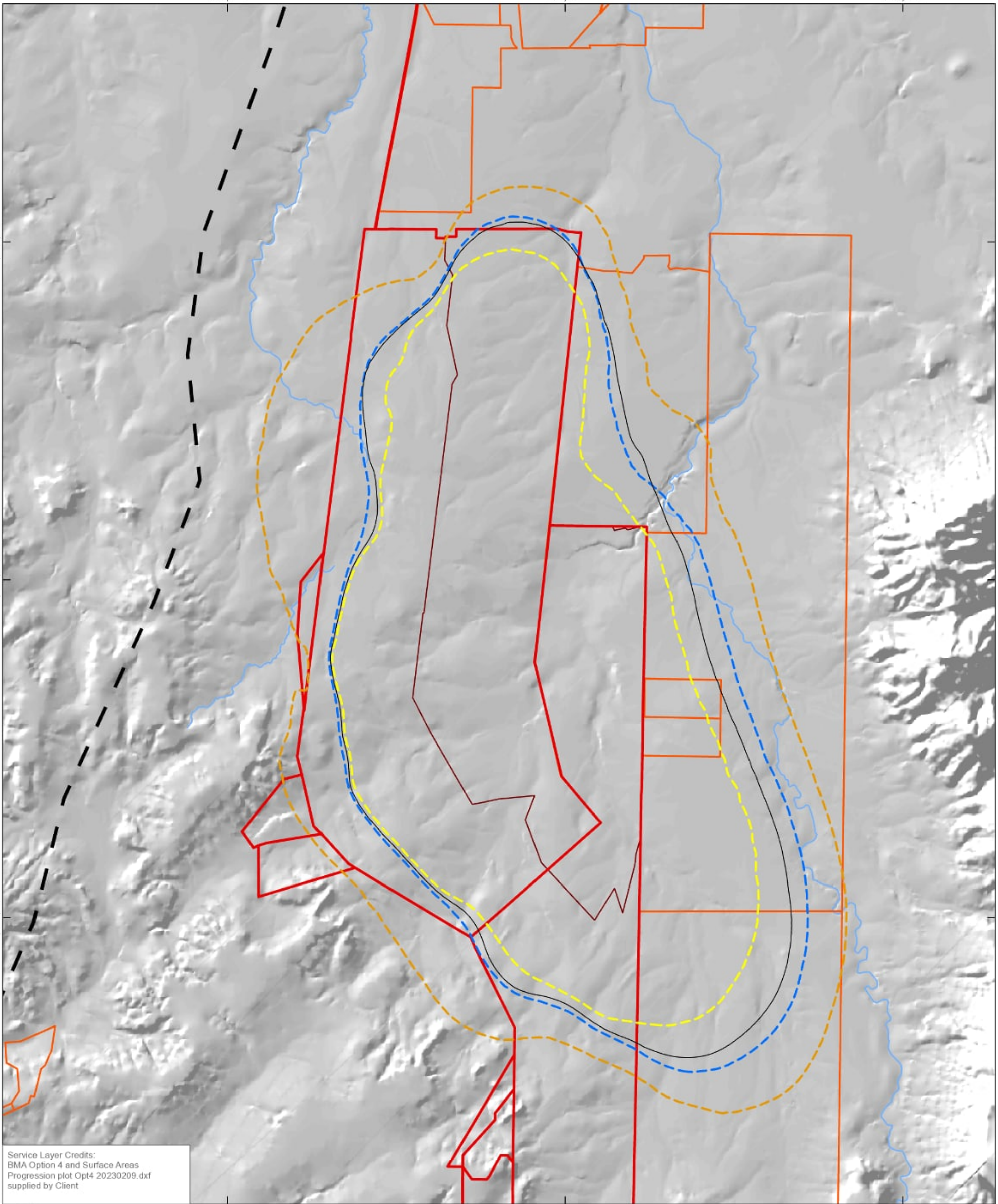
- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Perentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE POLLUX SEAM (LAYER 12)

SLR

FIGURE 6-7



0 2.5 5 km

Coordinate System:	GDA2020 MGA Zone 55
Scale:	1:150,000 at A4
Project Number:	620.014601
Date Drawn:	30-Nov-2023
Drawn by:	NT

LEGEND

- Watercourse
- Model Boundary
- BWM Mining Lease
- BWM North Extension Project Area
- Mining Lease
- Base Case
- 90th Percentile
- 50th Percentile
- 10th Percentile

BLACKWATER MINE - NORTH EXTENSION PROJECT

UNCERTAINTY IN PREDICTED 1m MAXIMUM INCREMENTAL DRAWDOWN IN THE BURNGROVE FORMATION (LAYER 14)

SLR

FIGURE 6-8

6.2.4 Uncertainty of Drawdown at Landholder Bores

Table 6-6 summarises the 95th percentile maximum drawdown at water supply bores predicted to be impacted during the mining period.

The uncertainty results show that the 95th percentile of the maximum incremental impact from the Project would be 0.54m at bore RN84221. The highest expected 95th percentile of the cumulative maximum drawdown is 16.34m at the same bore RN84221, which was estimated to be 9.38m for the base case.

Table 6-6 Predicted Maximum Drawdown Impact on Landholder Bores (Uncertainty Analysis)

Registered RN (ID)	Bore name	Geology	Bore Depth (m)	Use	Maximum Incremental Drawdown (m) Predictive model	Maximum Cumulative Drawdown (m) Predictive model	Maximum Incremental Drawdown (95th Percentile) (m)	Maximum Cumulative Drawdown (95th Percentile) (m)
38998	No 2 Bore	Burngrove Formation	36.6	Unknown	0.00	0.09	0.09	7.82
43097	-	Burngrove Formation	22.9	Unknown	0.00	0.08	0.13	10.54
43459	Top Bore	Unknown	54.9	Unknown	0.00	0.06	0.05	10.34
57503	Stake Bore	Burngrove Formation[1]	Unknown	Unknown	0.00	0.10	0.02	0.90
57504	Eighteen mile Bore	Unknown	Unknown	Unknown	0.00	0.11	0.01	1.00
84221	-	Burngrove Formation	24	Unknown	0.07	9.38	0.54	16.34
89034	-	Unknown	Unknown	Unknown	0.00	0.00	0.00	0.02
103345	JWS Bore	Burngrove Formation	47	Unknown	0.00	2.23	0.18	6.50
111709	-	Burngrove Formation	72	Water Supply	0.00	0.02	0.01	0.68
Unregistered 11	-	Burngrove Formation	Unknown	Unknown	0.01	3.66	0.11	5.03
Unregistered 18	-	Burngrove Formation	Unknown	Unknown	0.00	1.69	0.12	5.57

6.2.5 Uncertainty of Influence on Alluvium and Surface Water Flow

The uncertainty analysis results showed that even for the 95th percentile prediction, which is a very unlikely outcome, the indirect take from the Blackwater Creek alluvium and the change in Blackwater Creek baseflow due to the Project were 0.33 and 0.15 ML/day respectively.

7.0 Model Confidence and Limitations

The groundwater modelling was conducted in accordance with the Australian Groundwater Modelling Guidelines (Barnett et al. 2012), the MDBC Groundwater Flow Modelling Guideline (MDBC 2001) and the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023).

The model confidence level (Class 1, Class 2 or Class 3 in order of increasing confidence) based on the Australian Groundwater Modelling Guidelines (Barnett et al. 2012) was previously widely used in the industry**.** The latest version of the IESC Explanatory Note for Uncertainty Analysis (Peeters and Middlemis, 2023) introduces a new concept on how model confidence can be assessed. The document also indicates that this change will follow in the next iteration of the Australian Modelling Guidelines and the new concept for assessing model confidence is hence applied for this model.

The latest version of the IESC Explanatory Note for Uncertainty Analysis defines a model fit for purpose when model results are:

- Usable -- Relevant to the decision-making process, providing information about the uncertainty in conceptualisations and modelling simulations in a way that allows decision-makers to understand the effects of uncertainty on project objectives and the effects of potential bias. The relevant Quantities of Interests (QoI) in this context are the groundwater inflows and drawdowns to assess licensing, site water management and drawdown impacts on bores.
- Reliable -- Demonstrate that the range of model outcomes is consistent with the system knowledge and honours historical observations, and provides objective evidence that uncertainties affecting decision-critical predictions of impacts on aquifer resources and dependent systems are not underestimated. The calibration performance was deemed acceptable, and a rigorous UA was undertaken to further improve confidence in the modelling outputs.
- Feasible -- Trade-offs due to budget, time and technical constraints are reasonable and justifiable within the risk context of the project. This study is an update of a 2021 model variation, which shows that there are several model revisions and the latest data has been included. The model has been peer reviewed for each revision. This model build and associated review process is deemed commensurate with the Project related risk to the groundwater environment.

In order to assess these three points above, the four sources of scientific uncertainty (structural, parametrisation, measurement error, predictions) have been qualitatively assessed with regards key aspects of the BWM groundwater model, as presented in **Table 7-1.**

Overall, the model captures depressurisation due to active mining. The model is numerically stable with no mass balance error. The model shows a good fit between observed and modelled groundwater levels (**Section 2.6.2**). A depth dependence function was used for hydraulic conductivity, with the calibrated values showing a good fit to observed data as presented in **Section 2.6.5**. Overall, the model is considered fit for purpose to achieve the objectives outlined in **Section 1** based on the data provided and the Project timeframe. Updates could be conducted in future to further refine the model, but this would be dependent on the purpose of the modelling and availability of data to inform future changes.

The model sensitivity was explored for an array of parameters. This showed that these parameters were generally well constrained by the calibration. For the predictions, two parameters fell into the type 4 error, which has low identifiability, but high predictive uncertainty.

The uncertainty analysis was undertaken to add a likelihood estimate to the prediction for the main two quantities of interest, the groundwater inflows and predicted drawdowns in a multitude of relevant geological formations.

Table 7-1 Groundwater Model and Data Limitations

Type	Part	Status	Comment
Structural/ Conceptual	Grid and Model Extent	Fit for purpose	The model has an unstructured Voronoi grid that includes detailed cell refinement around site, neighbouring mines and along drainage features.
	Layers	Fit for purpose	Top of layer 1 incorporates site LiDAR data.
		Fit for purpose	Representation of alluvium based on the CSIRO Regolith mapping Wilford et al (2016) and refined based on site drill data.
	Conceptualisation – Geological Structure	Fit for purpose, future improvements possible where new data collected	The local structure of the geology is based on detailed data at site (BWM Mine geology model), and regional model geometry (outside of site) interpolated based on publicly available data, such as geological mapping and the CSIRO Regolith data set. Geophysical surveys across the Project area have identified minor faulting in the BWM area. Faulting is typically confined to the coal seams of the Rangal Coal Measures. The minor faults show a displacement of up to 5m. Hence, no geological structures (i.e. faults) have been included within the Project area in the model other than through layer displacements from the site geological model. The main regional fault (Shot over fault) was included as the eastern model boundary. Displacements of up to 3,000m are reported at this fault. The Permian coal measures outcrop along the western edge of the site. Therefore, how this is captured within the model influences the model predictions. The structure of the coal seams was checked to ensure it matches observed and mapped geology. The predictions of drawdown adjacent to mining was checked and the model shows a good fit between modelled and observed trends.
	Conceptualisation – GDEs	Fit for purpose, future improvements possible	A GDE conceptualisation is provided in SLR, 2023.
	Conceptualisation – Surface Water Groundwater Interactions	Fit for purpose	The groundwater -surface water interactions are conceptualised as limited. Due to the gauged creeks to be classified as ephemeral (SLR, 2023), no long-term baseflow contribution from the groundwater is expected. Rather, surface water is expected to recharge the groundwater and after such recharge events, some minor baseflow contributions back into the creeks is possible.
	Conceptualisation – Saturated	Fit for purpose future	Site monitoring network includes one bore mapped within alluvium that was used to inform saturated extent of alluvium locally at site and for calibration targets. However, the alluvium in

Type	Part	Status	Comment
	Extent of Alluvium and Regolith	improvements possible	the area was found dry at this location. Other attempts to drill into the alluvium were abandoned, as either no alluvium was found or the alluvium was dry, or the bores were installed into the Rewan instead. The modelled groundwater levels in alluvium have hence no comparison available.
Parameterisation	Hydraulic Conductivity – Shallow layers	Fit for purpose, future improvements possible	The simulation of the Alluvium and Regolith in the model involves the use of zones in Layer 1 and Layer 2. In the calibration process, a single hydraulic property was assigned to the alluvium zone in layers 1 and 2. However, given the inferred heterogeneity in the alluvium system, it is likely that hydraulic parameters vary across this unit at different observation locations. The parameter zones current setup are inflexible in capturing the heterogeneity in the alluvium, potentially resulting in the model's inability to accurately replicate water level measurements in the alluvium. Future versions of the model could consider assessing the spatial variability of hydraulic parameters in the Alluvium and Regolith by incorporating pilot points. This enhancement would allow for a more accurate representation of the heterogeneity in the alluvial system, potentially improving the model's ability to replicate water level measurements.
	Hydraulic Conductivity – Depth Dependence	Fit for purpose	Field testing of hydraulic conductivity (horizontal and to a lesser extent vertical) has been conducted in the area. Hydraulic conductivity test results from the other sites within the model domain were also considered. The data shows a general decline in hydraulic conductivity with depth that is replicated in the model.
	Spoil Properties	Fit for purpose, future improvements possible	Limited site-specific data is available for the spoil. Spoil properties were adopted using the previous studies.
	Rivers	Fit for purpose, future improvements possible	Blackwater Creek stage height is changed temporally in the historical calibration model based on observed levels from site stream gauges, and long term annual average level assumed in the predictive model. Blackwater Creek records flow only for a few days per year. The simulation of river stage height involves representing it as the average stage over the entire model stress period. However, since the stress periods (i.e., time slices) in the model are quarterly or annual, the stage height for Blackwater Creek persists in the model for a much longer period than it does in reality. This conservative design approach results in the simulation of what is naturally an ephemeral river reach as a perennial river in the model. Consequently, this leads to an overprediction of water levels in the alluvium along Blackwater Creek.

Type	Part	Status	Comment
			All other watercourses within and in the vicinity of the Project area are ephemeral and only flow briefly after rainfall. Therefore, river stage height of zero was assigned to these watercourses in the model.
	Recharge	Fit for purpose	Recharge zonation is based on mapped surface geology and calibrated recharge rates.
Measurement Error	Observation Data Quality	Fit for purpose	Bore logs and construction details available for most site bores, and long-term site water level data available for various units.
	Landholder Bore Data Quality	Fit for purpose, future improvements possible	Impacts on registered landholder bores are influenced by the assumptions of the bore design, target geology and use. Verification of landholder bore details may be required in future.
	Temporal spread	Fit for purpose	Timeseries water level data from the site as well as for the tertiary and Permian coal measures.
Scenario Uncertainties Future stresses/ conditions	Calibration	Fit for purpose	Transient warm-up (1970-2005) and transient (2005 to 2021) calibration model set up and a depth dependence function used and calibration to water levels conducted using automated (PEST) and manual methods.
	Predictive	Fit for purpose	Model captures approved and proposed open cut mining at BWM. The model also includes future mining at Blackwater South, Minyango and Curragh mines, mainly based on publicly available data. The actual future mine progression for these sites may vary.
	Sensitivity and uncertainty	Fit for purpose	Uncertainty analysis has been conducted by stochastic modelling using an adapted Monte Carlo method with modern software packages. The Latin Hypercube Sampling (LHS) method was used to create random realisations from parameter and PEST++ was used to orchestrate the model runs. The uncertainty analysis quantified the variability in predictions with changes in maximum predicted drawdowns, mine inflows, impact on alluvium flow and impacts on surface water flow.

8.0 Conclusions

The numerical groundwater model developed for the Project successfully achieved the modelling objectives, as outlined in **Section 1**. Model calibration statistics are within suggested guidelines (Barnett et al., 2012) and mass balance errors remain low, through the model calibration and predictive modelling. Model construction considers all available data, including the current site mine plan and site geological model for the Project area. The uncertainty analysis has demonstrated a low likelihood for the Project to impact on alluvial water levels, with Project related drawdown primarily contained within the Project area. The model serves as a suitable representation of possible transient groundwater conditions within the Study Area, over the life of the Project, however, the uncertainty in predictions should be acknowledged.

Limited site-specific information on hydraulic conductivities and storage parameters were available during calibration. As more site-specific hydraulic data becomes available, new data should be compared with the calibrated parameters achieved and the validity of the model calibration should be assessed. Additional site-specific data is expected to “tighten” uncertainty bounds for model prediction results.

Predictive sensitivity indicates that mine inflows are most sensitive to the specific yield values of the Permian units. However, calibration sensitivity to these parameters is relatively low. Future work should consider opportunities to further constrain values of these parameters.

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Appendix A Calibration Residuals

Blackwater Mine - North Extension Project

Groundwater Modelling Technical Report

BM Alliance Coal Operations Pty Ltd

SLR Project No.: 620.014601.00006

29 November 2023

ID	Easting	Northing	Layer	Average Residual	Min	Max
158138	691481	7398090	2	0.38	0.06	0.66
158139	691481	7398084	2	0.20	-0.46	0.77
158141	691086	7396966	2	1.17	1.12	1.22
158142	691118	7397611	2	-0.27	-0.56	-0.11
158143	691308	7398335	2	-0.66	-1.33	0.06
158144	691313	7398339	2	-0.89	-1.20	-0.21
158148	687647	7401486	2	15.83	15.83	15.83
158153	687417	7403078	14	4.44	4.15	4.94
158155	688976	7402204	2	12.67	11.24	13.18
158687	692424	7382611	5	-15.20	-15.20	-15.20
13010010	680591	7390381	14	-10.20	-12.90	-8.14
BG_1_AP	683994	7387561	14	6.43	-0.67	7.70
BG_2_BG	684300	7384441	14	10.72	7.33	16.23
FY16_PZ_2	686714	7387553	8	3.97	3.60	5.73
FY16_PZ_4	686215	7389566	8	-1.44	-1.80	-0.29
FY16_PZ_5	685482	7389166	12	4.85	2.60	5.14
MB19BWM01P	690037	7390281	8	-9.00	-9.47	-7.53
MB19BWM02A	690127	7390182	2	-4.86	-4.97	-4.69
MB19BWM03P	688454	7383473	8	-0.62	-5.00	3.89
MB19BWM04R	688315	7383604	6	-22.04	-22.71	-21.50
MB19BWM06P	687698	7379464	7	14.69	13.55	15.78
MB19BWM08P	691542	7370739	7	19.33	16.74	20.40
MB19BWM25P	689259	7376879	2	-12.32	-12.61	-11.87
MB19BWM27P	688958	7376559	8	2.86	2.46	3.43
MB20BWM2P1	686325	7388394	7	17.84	17.73	18.07
MB20BWM2P2	686320	7388393	8	-5.25	-6.76	-2.10
MB20BWM3P1	686489	7387295	7	-11.60	-12.42	-10.55
MB20BWM3P2	686490	7387287	8	-1.83	-2.27	-1.61
MB20BWM05P	686190	7389569	7	-3.01	-3.85	-2.03
MB1	686331	7387080	8	2.40	-4.99	28.50
MB10	684049	7353001	2	5.03	5.03	5.03
MB11	684034	7353051	2	4.13	3.60	4.40
MB12	683841	7350555	1	2.32	0.76	4.86
MB13	683775	7350893	2	14.22	12.31	18.75
MB15	688771	7354179	7	8.00	-10.03	12.48
MB16	687965	7352288	8	14.60	-7.70	34.14
MB17	691279	7370332	6	-15.64	-20.72	-12.69

ID	Easting	Northing	Layer	Average Residual	Min	Max
MB18	691537	7370787	6	-12.64	-20.51	-7.20
MB20	684424	7351853	2	5.71	2.16	8.40
MB21	684900	7350805	2	-12.87	-13.79	-11.12
MB22	683730	7350786	1	13.5	13.5	13.5
MB23	683679	7350669	2	15.3	15.3	15.3
MB24	683660	7350614	2	18.5	18.5	18.5
MB25	683666	7350549	2	12.9	12.9	12.9
MB3	688011	7373473	7	3.24	-0.44	8.63
MB4	692071	7366434	7	25.51	21.37	31.63
MB5	691205	7360205	8	-1.00	-6.68	13.06
MB6	686915	7347772	2	1.31	-17.95	15.09
MB7	682518	7373865	2	17.67	16.82	18.21
MB8	681616	7373831	2	22.18	19.51	24.27
MB9	682377	7372625	2	5.81	5.22	8.18
VWP19B01_1	689178	7376893	7	-5.89	-7.26	-1.23
VWP19B 01_2	689178	7376893	7	-6.92	-8.56	-0.90
VWP19B 01_3	689178	7376893	8	-3.78	-4.79	0.30
VWP19B01_4	689178	7376893	9	3.08	-2.06	5.14
VWP19B 01_5	689178	7376893	12	1.60	1.48	1.81
VWP19B 02_1	691839	7365920	7	1.13	-3.64	20.94
VWP19B02_2	691839	7365920	8	7.91	1.84	24.59
VWP19B02_3	691839	7365920	10	8.62	1.80	24.82
VWP19B02_4	691839	7365920	12	7.91	-1.37	22.89
VWP19B02_5	691839	7365920	13	12.13	0.33	24.54

Appendix B Calibration Hydrographs

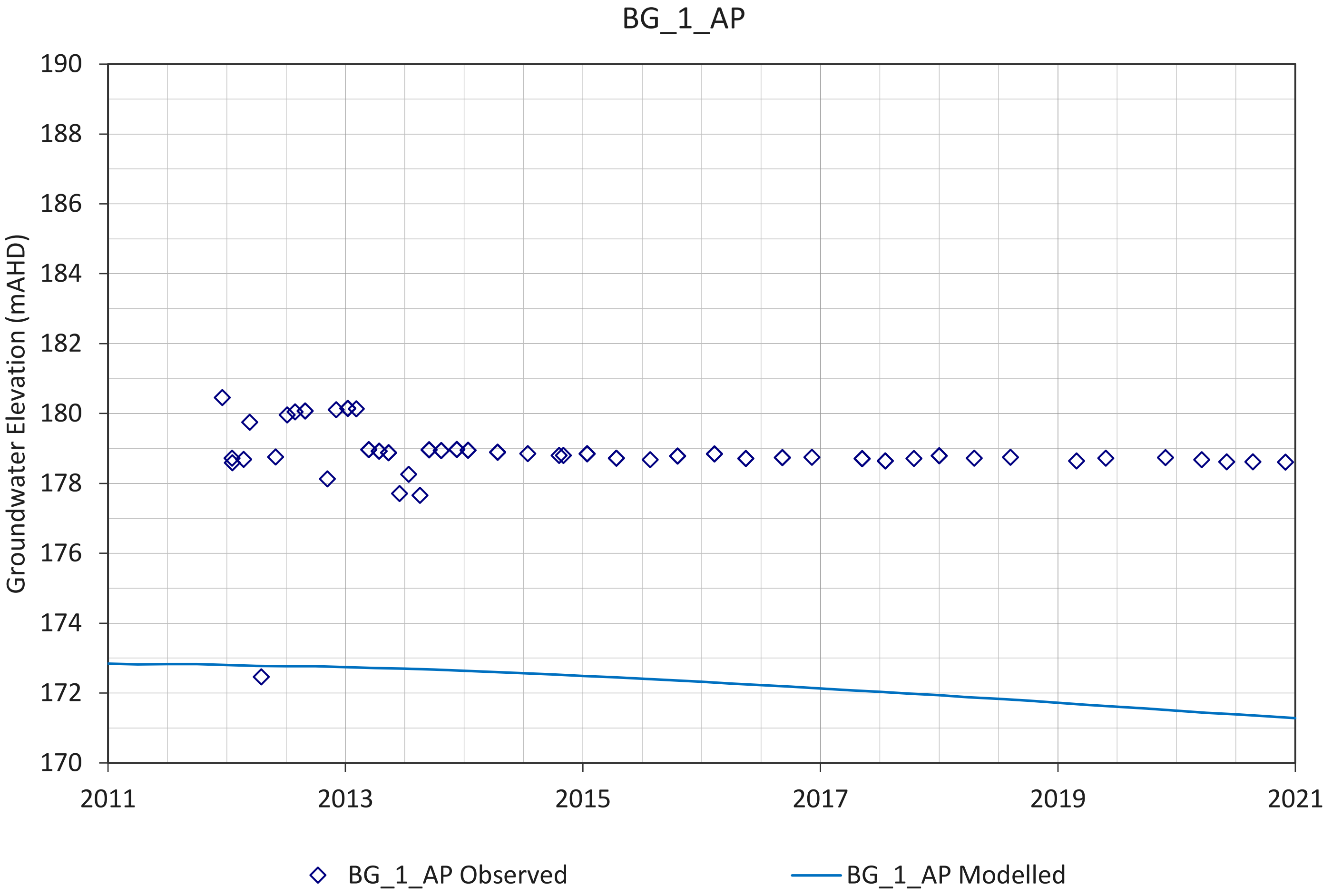
Blackwater Mine - North Extension Project

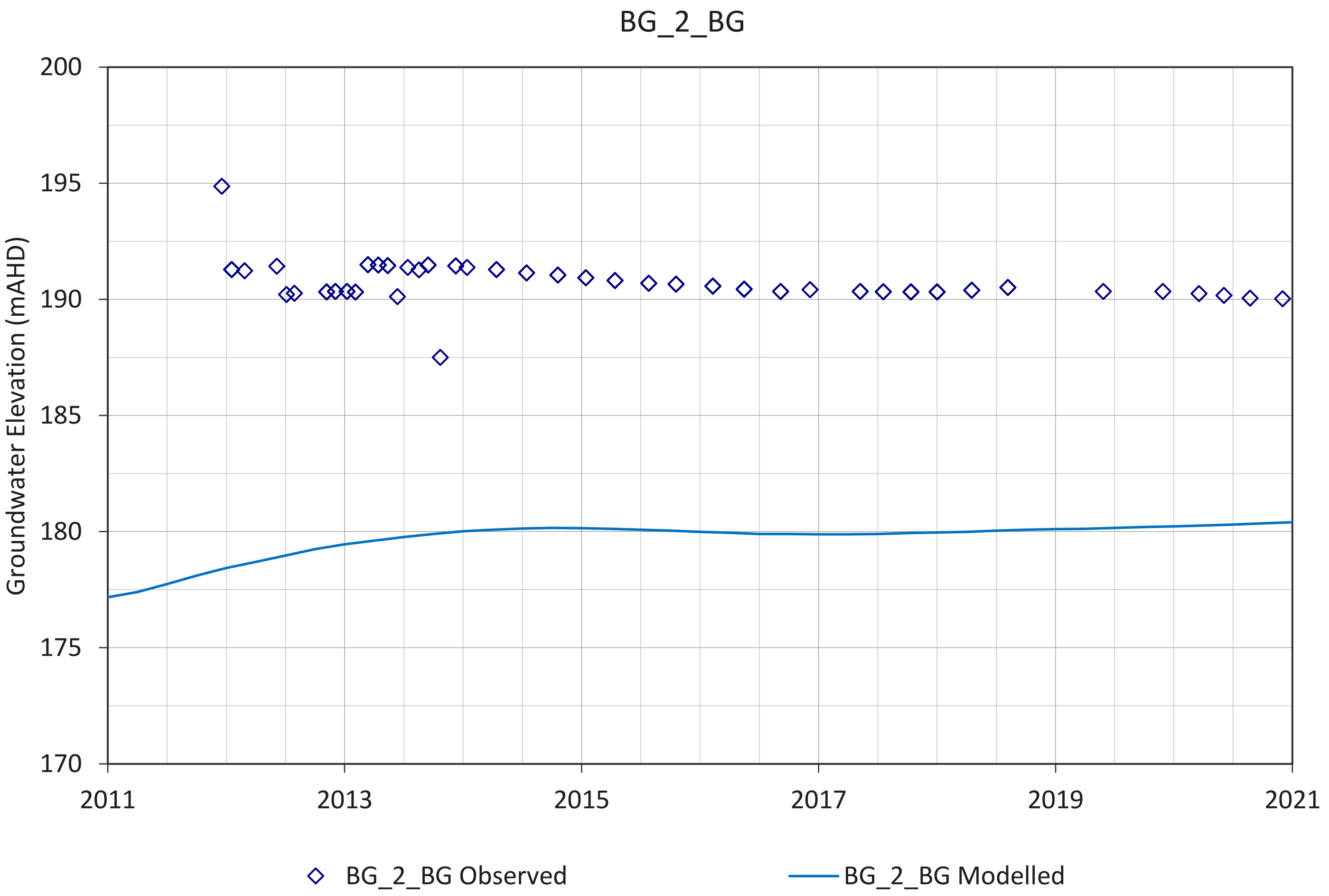
Groundwater Modelling Technical Report

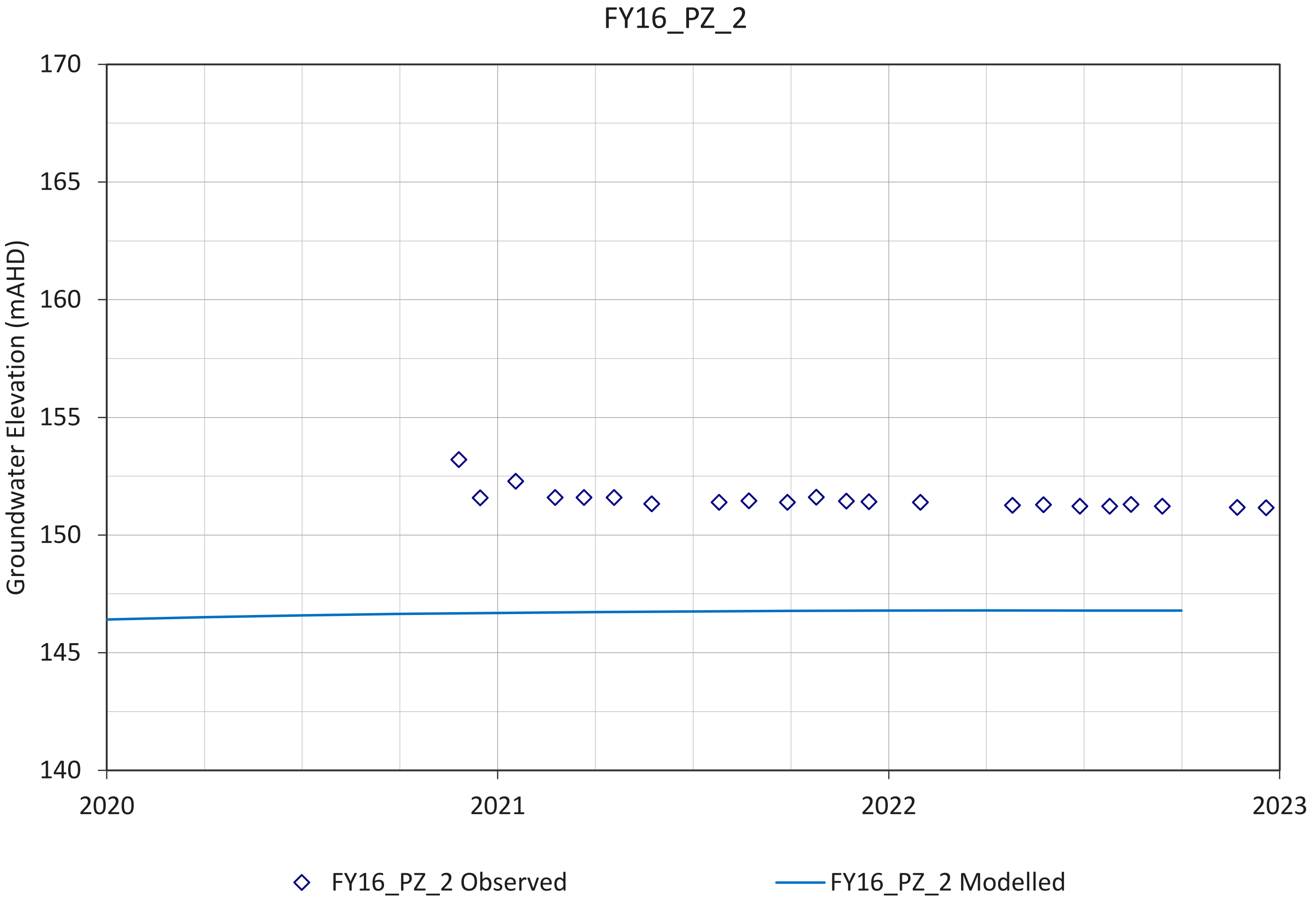
BM Alliance Coal Operations Pty Ltd

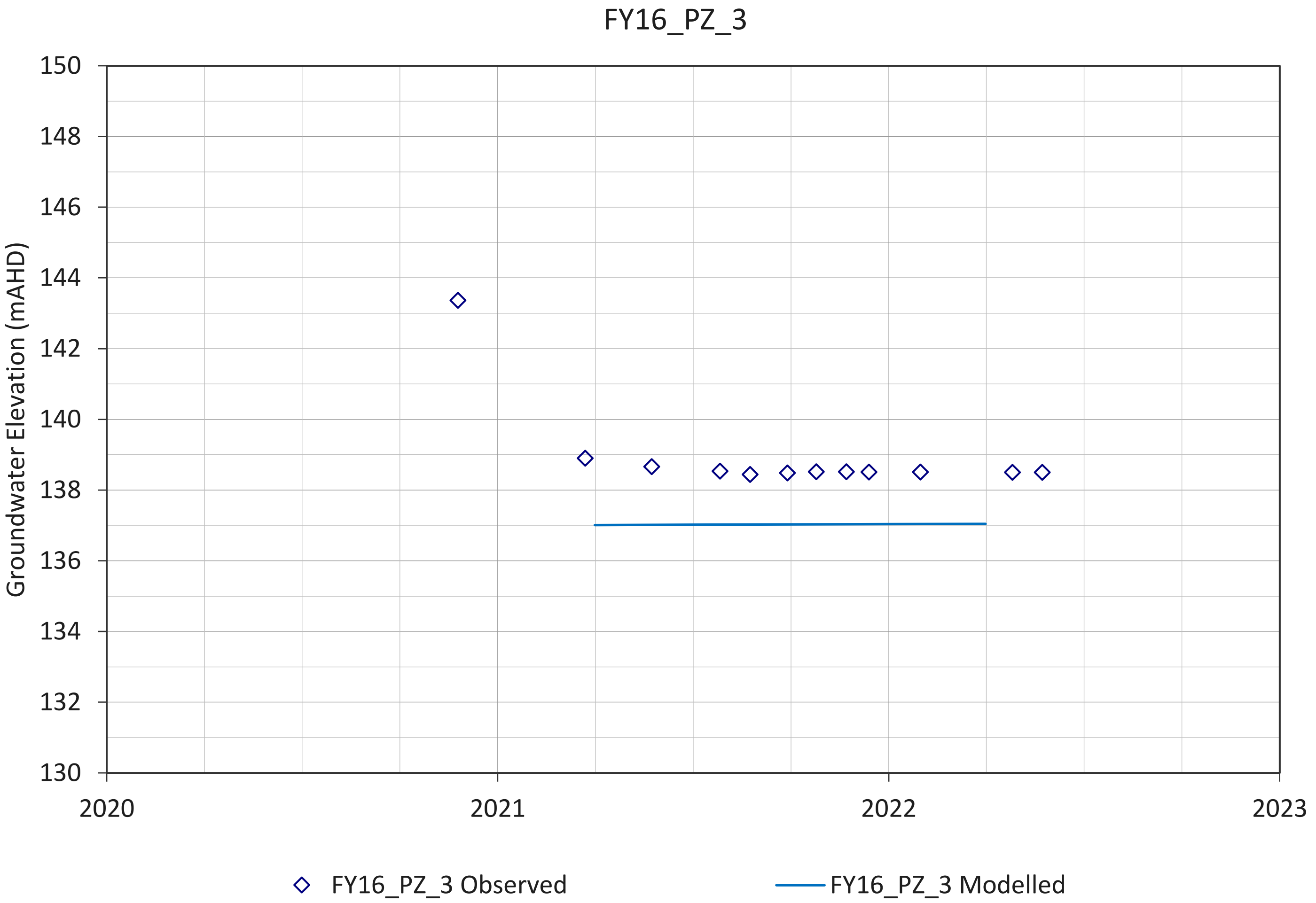
SLR Project No.: 620.014601.00006

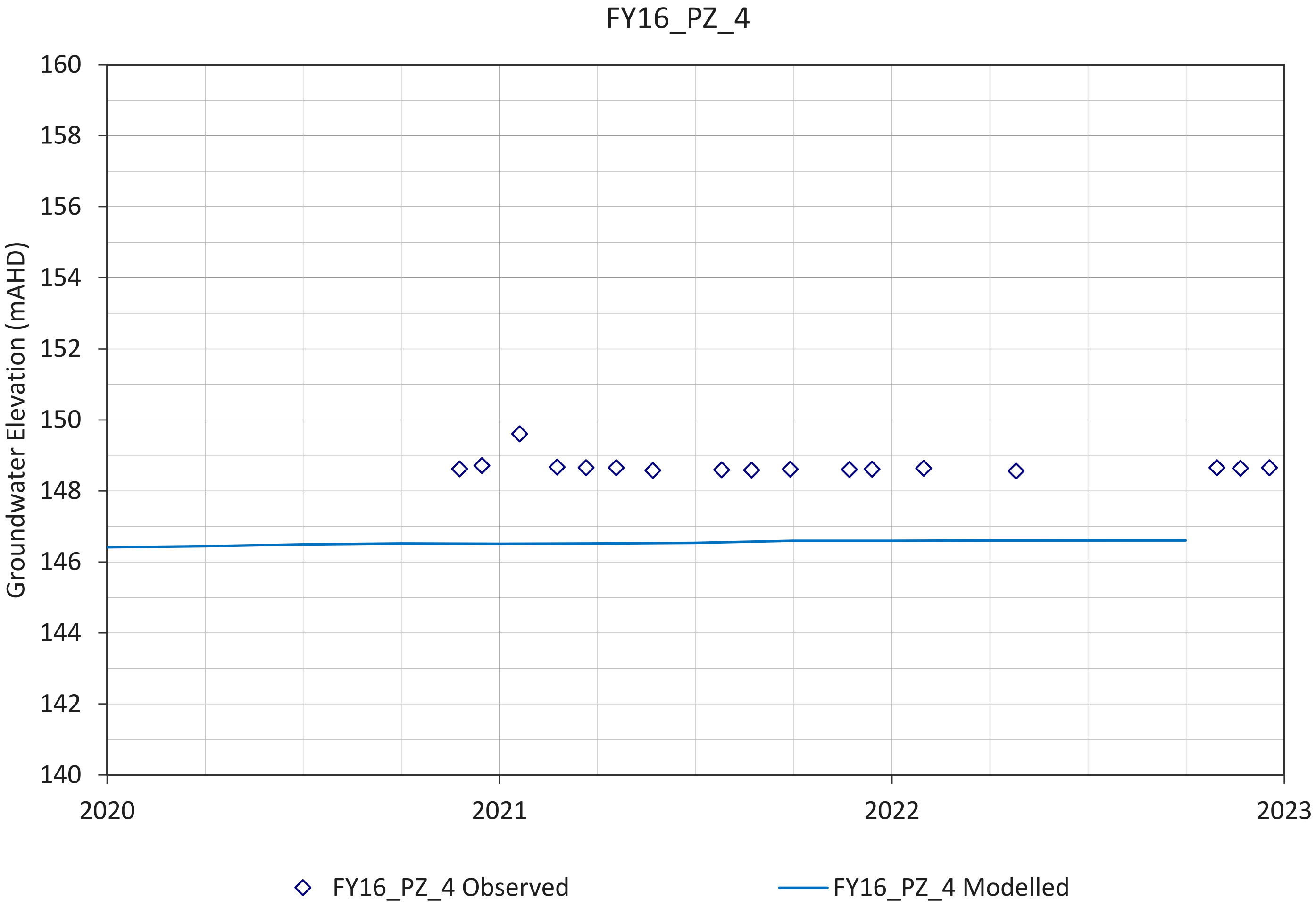
29 November 2023

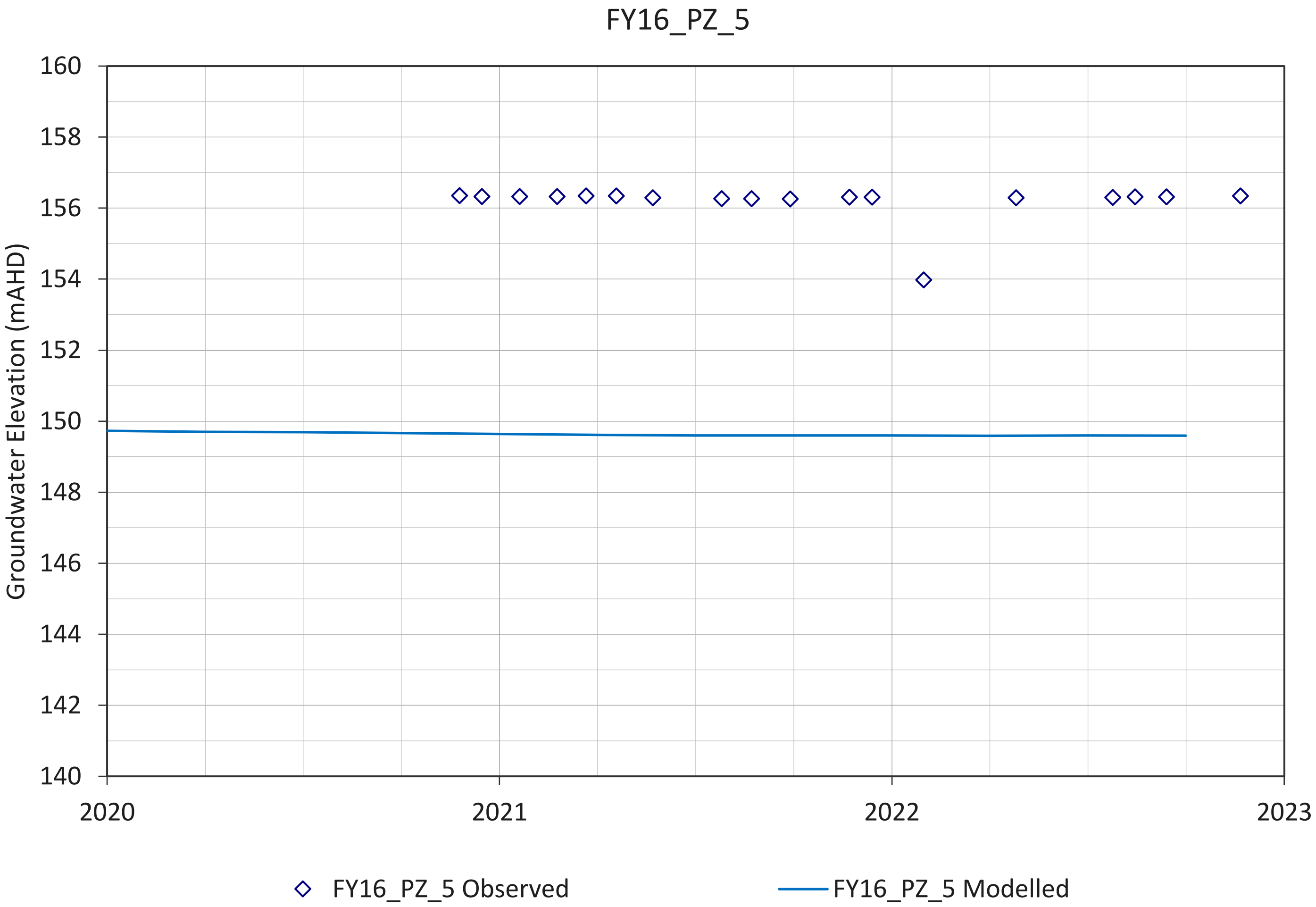

BG_1_AP
Groundwater Elevation (mAHD)
190
188
186
184
182
180
178
176
174
172
170
2011
2013
2015
2017
2019
2021
BG_1_AP Observed
BG_1_AP Modelled

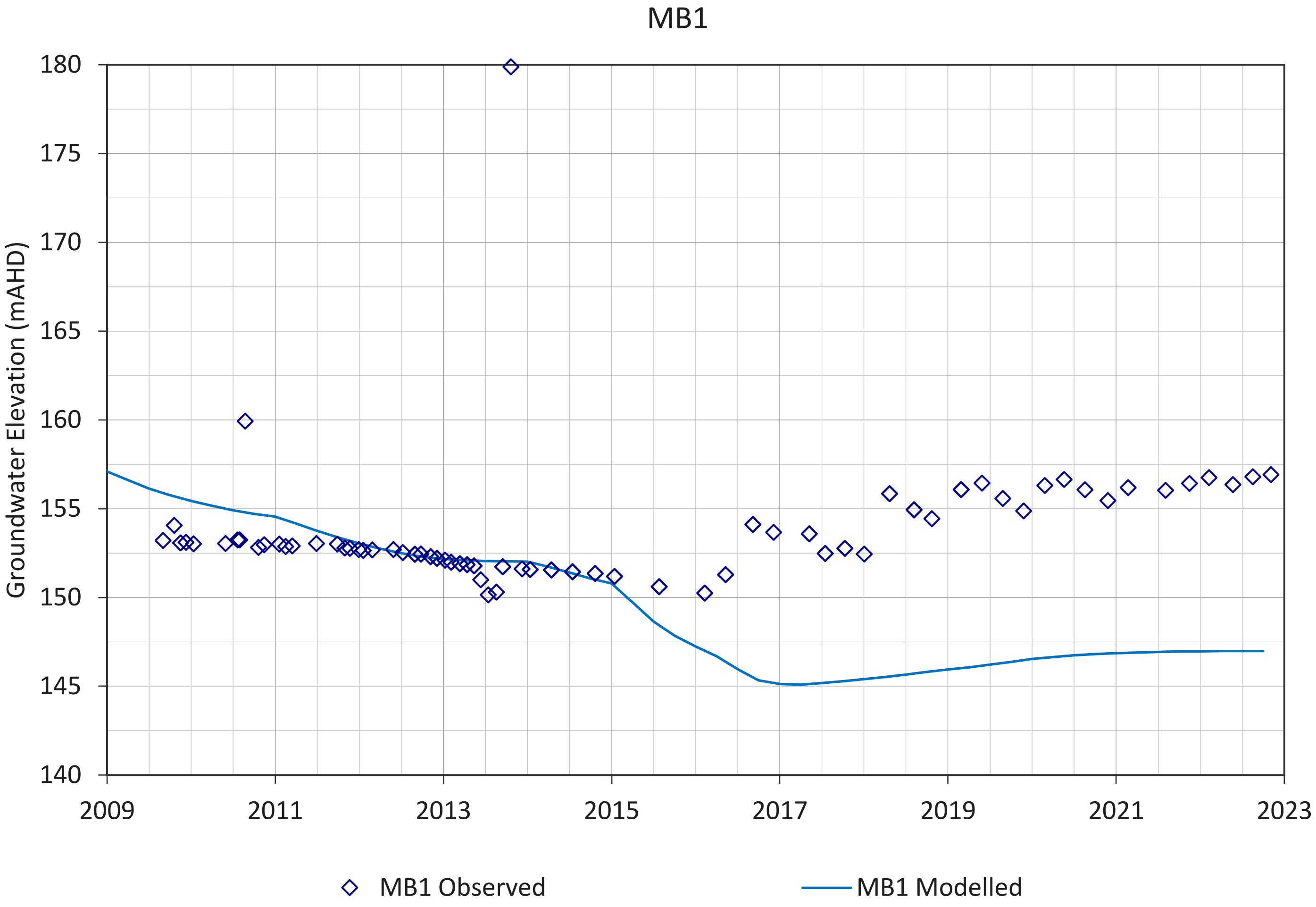

BG_2_BG
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
2011
2013
2015
2017
2019
2021
BG_2_BG Observed
BG_2_BG Modelled

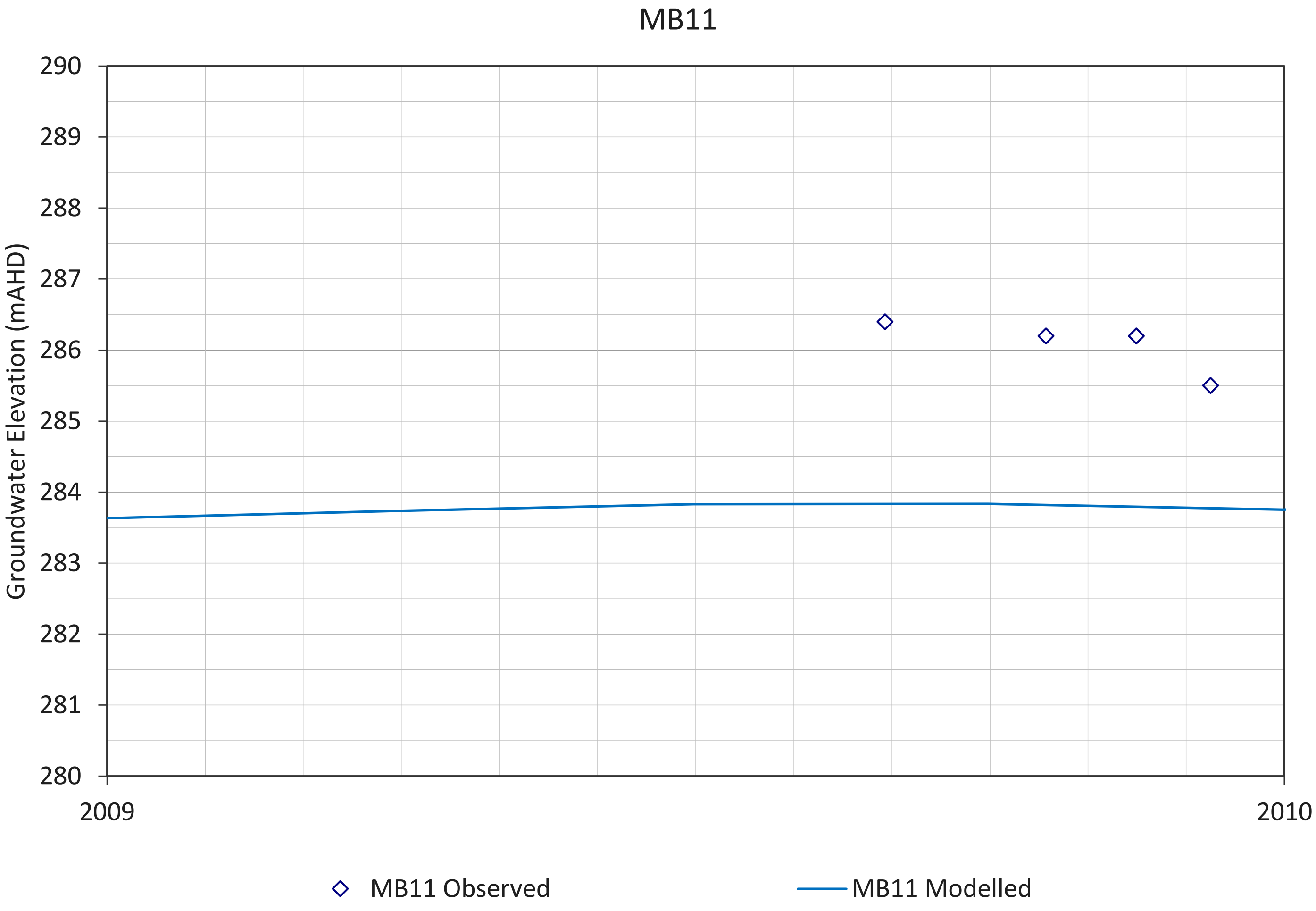

FY16_PZ_2
Groundwater Elevation (mAHD)
170
165
160
155
150
145
140
2020
2021
2022
2023
FY16_PZ_2 Observed
FY16_PZ_2 Modelled

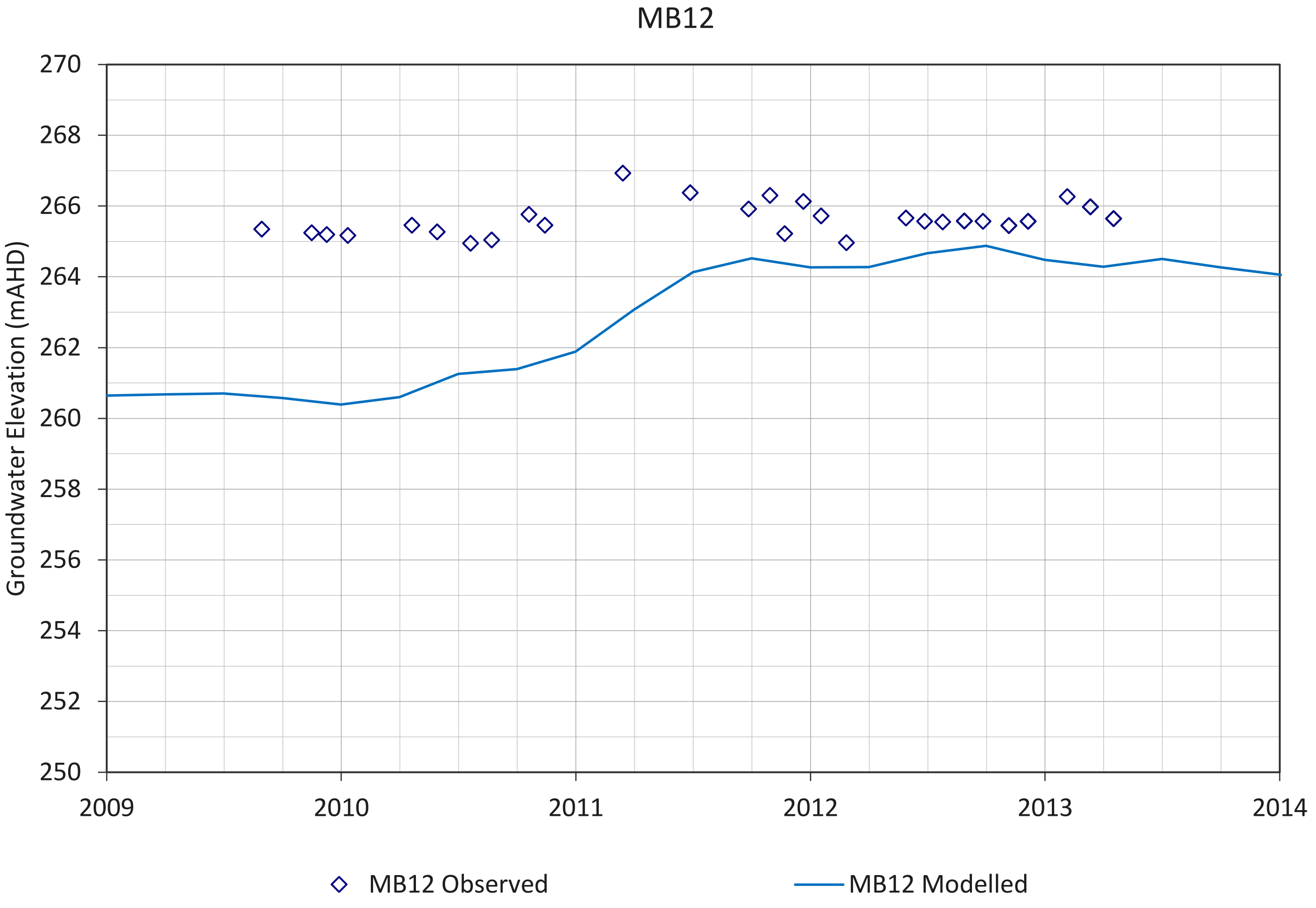

FY16_PZ_3
Groundwater Elevation (mAHD)
150
148
146
144
142
140
138
136
134
132
130
2020
2021
2022
2023
FY16_PZ_3 Observed
FY16_PZ_3 Modelled

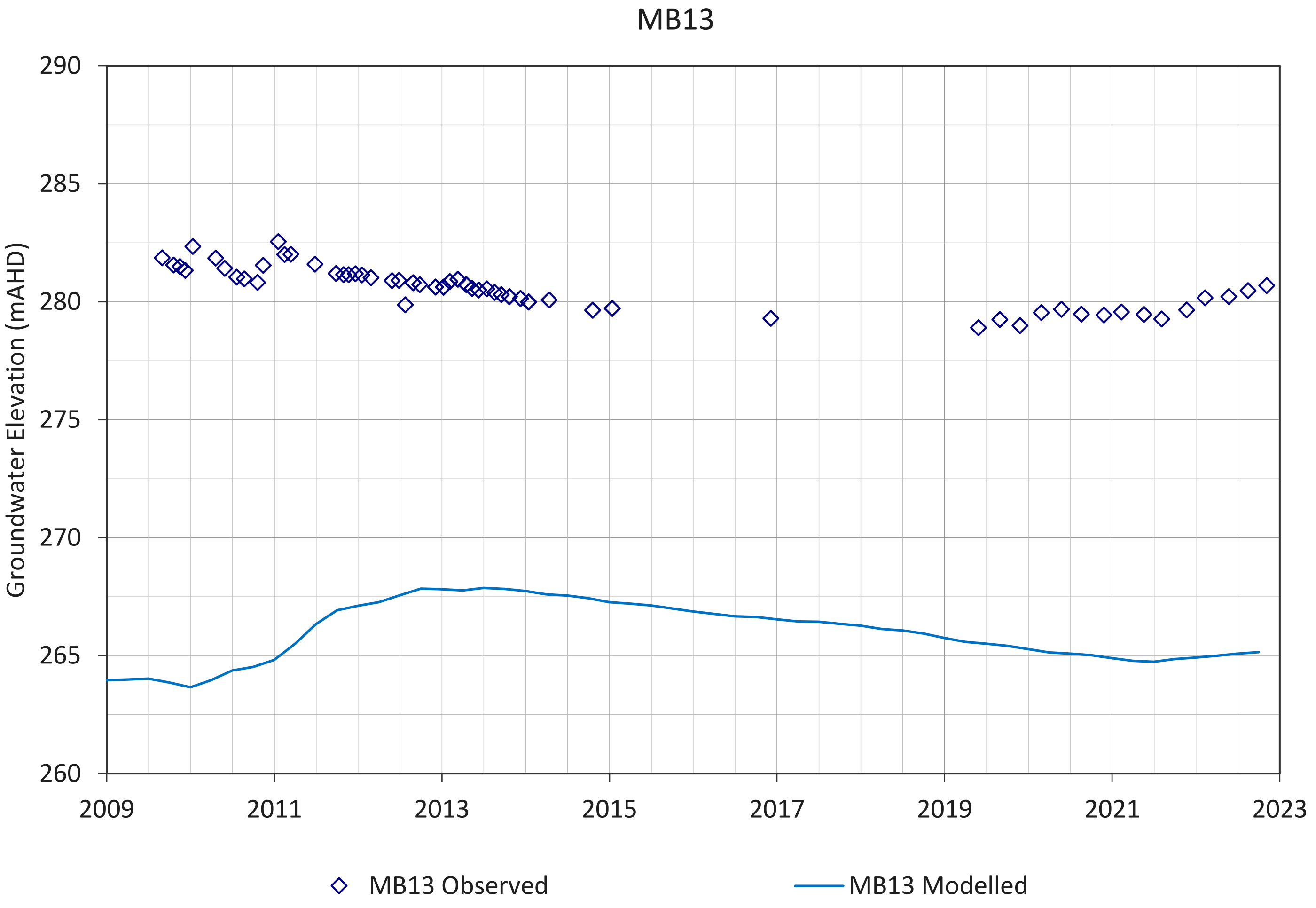

FY16_PZ_4
Groundwater Elevation (mAHD)
160
158
156
154
152
150
148
146
144
142
140
2020
2021
2022
2023
FY16_PZ_4 Observed
FY16_PZ_4 Modelled

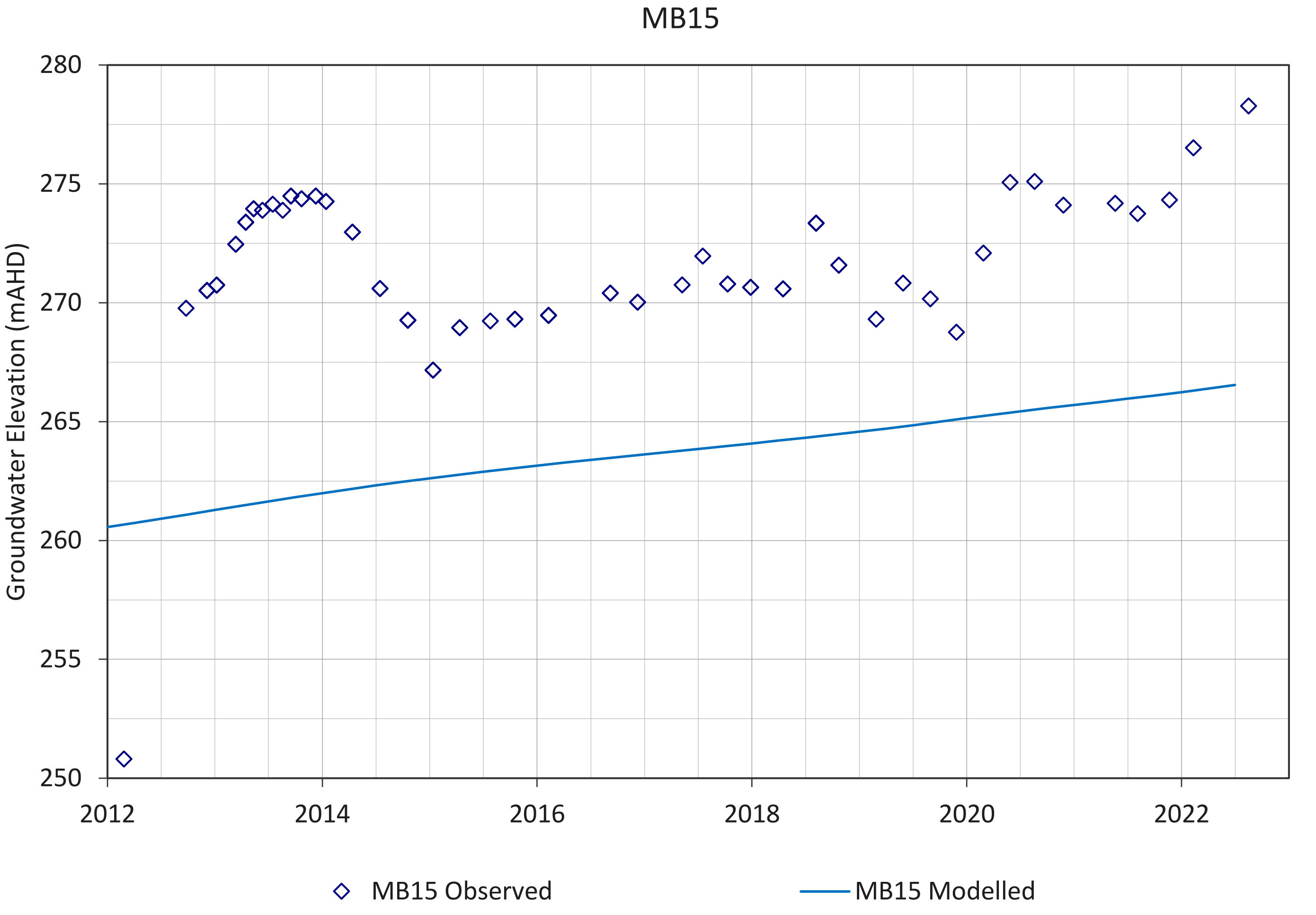

FY16_PZ_5
Groundwater Elevation (mAHD)
160
158
156
154
152
150
148
146
144
142
140
2020
2021
2022
2023
FY16_PZ_5 Observed
FY16_PZ_5 Modelled

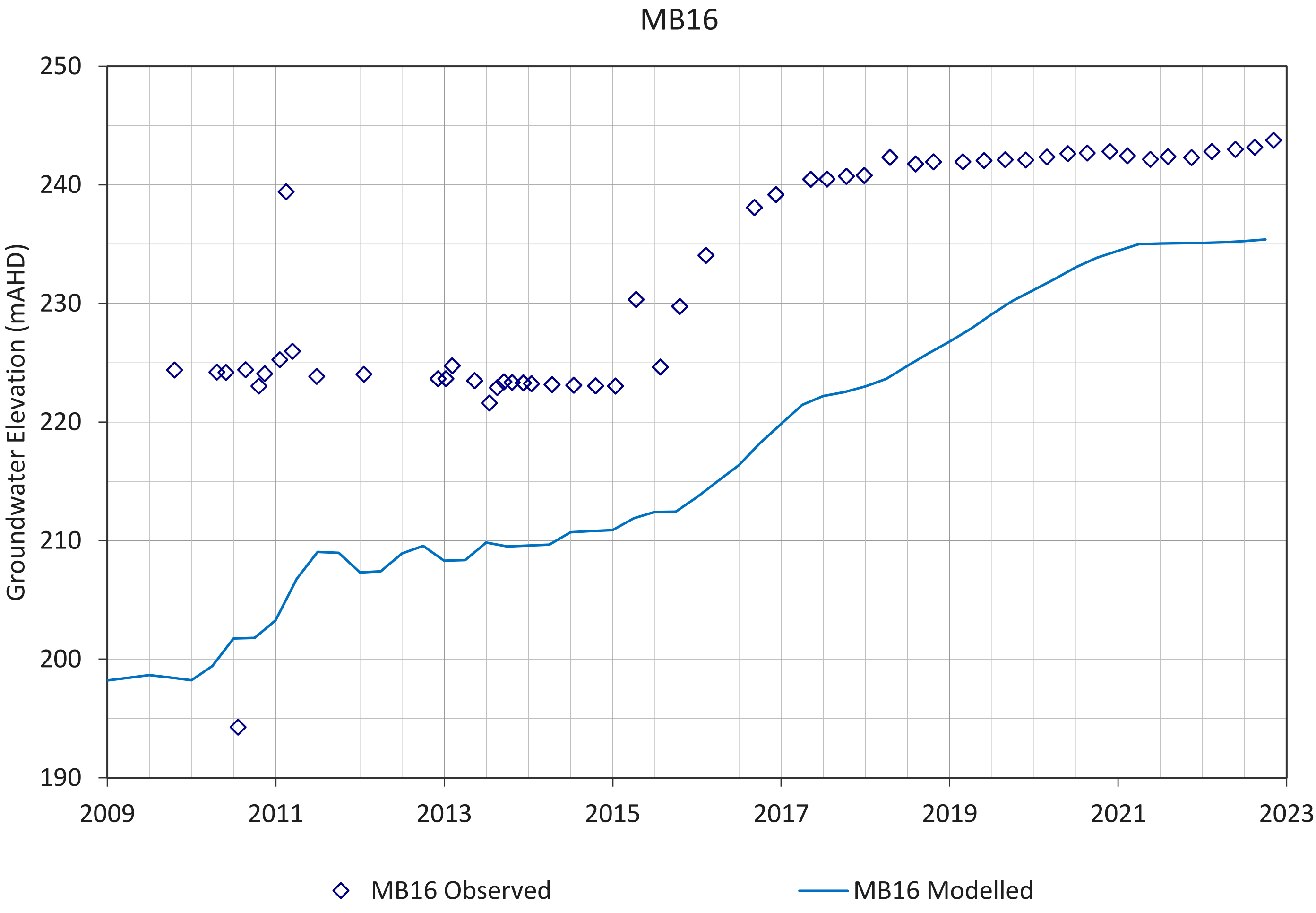

MB1
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
145
140
2009
2011
2013
2015
2017
2019
2021
2023
MB1 Observed
MB1 Modelled

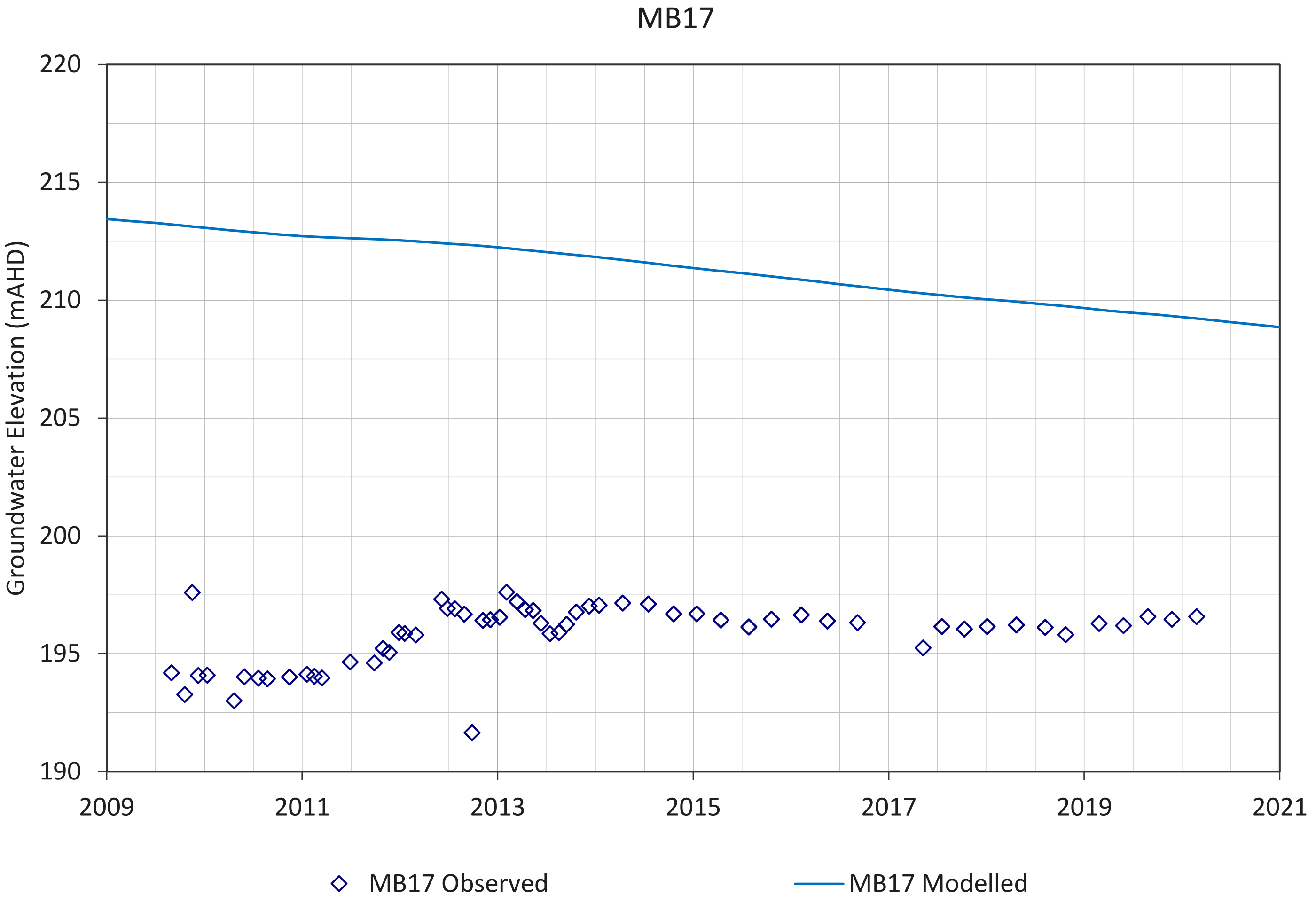

MB11
Groundwater Elevation (mAHD)
290
289
288
287
286
285
284
283
282
281
280
2009
2010
MB11 Observed
MB11 Modelled

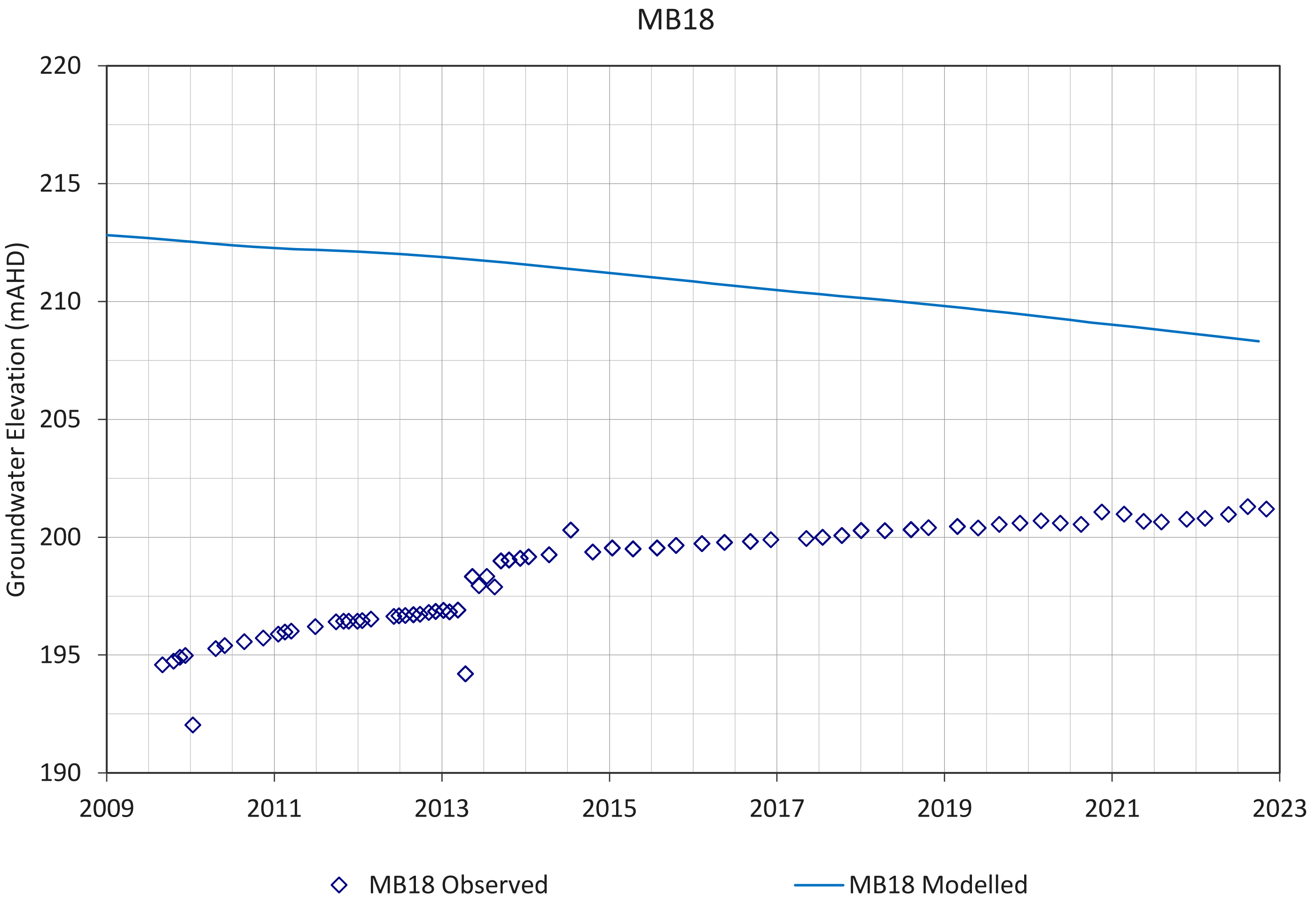

MB12
270
268
266
264
262
260
258
256
254
252
250
Groundwater Elevation (mAHD)
2009
2010
2011
2012
2013
2014
MB12 Observed
MB12 Modelled


MB13
290
285
280
275
270
265
260
Groundwater Elevation (mAHD)
2009
2011
2013
2015
2017
2019
2021
2023
MB13 Observed
MB13 Modelled


MB15
280
275
270
265
260
255
250
2012
2014
2016
2018
2020
2022
Groundwater Elevation (mAHD)
MB15 Observed
MB15 Modelled


MB16
250
240
230
220
210
200
190
2009
2011
2013
2015
2017
2019
2021
2023
Groundwater Elevation (mAHD)
MB16 Observed
MB16 Modelled


MB17
Groundwater Elevation (mAHD)
220
215
210
205
200
195
190
2009
2011
2013
2015
2017
2019
2021
MB17 Observed
MB17 Modelled


MB18
Groundwater Elevation (mAHD)
220
215
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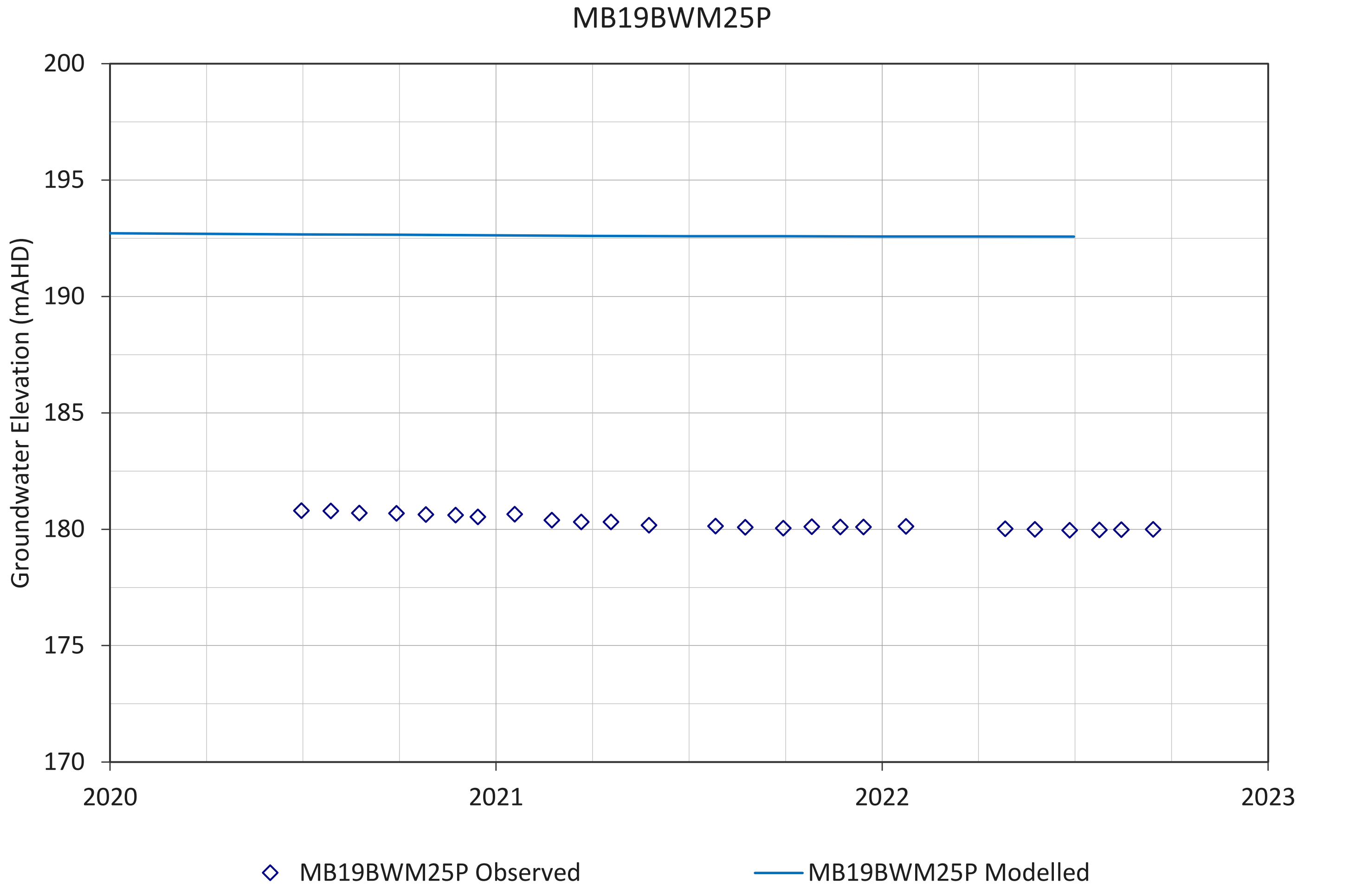
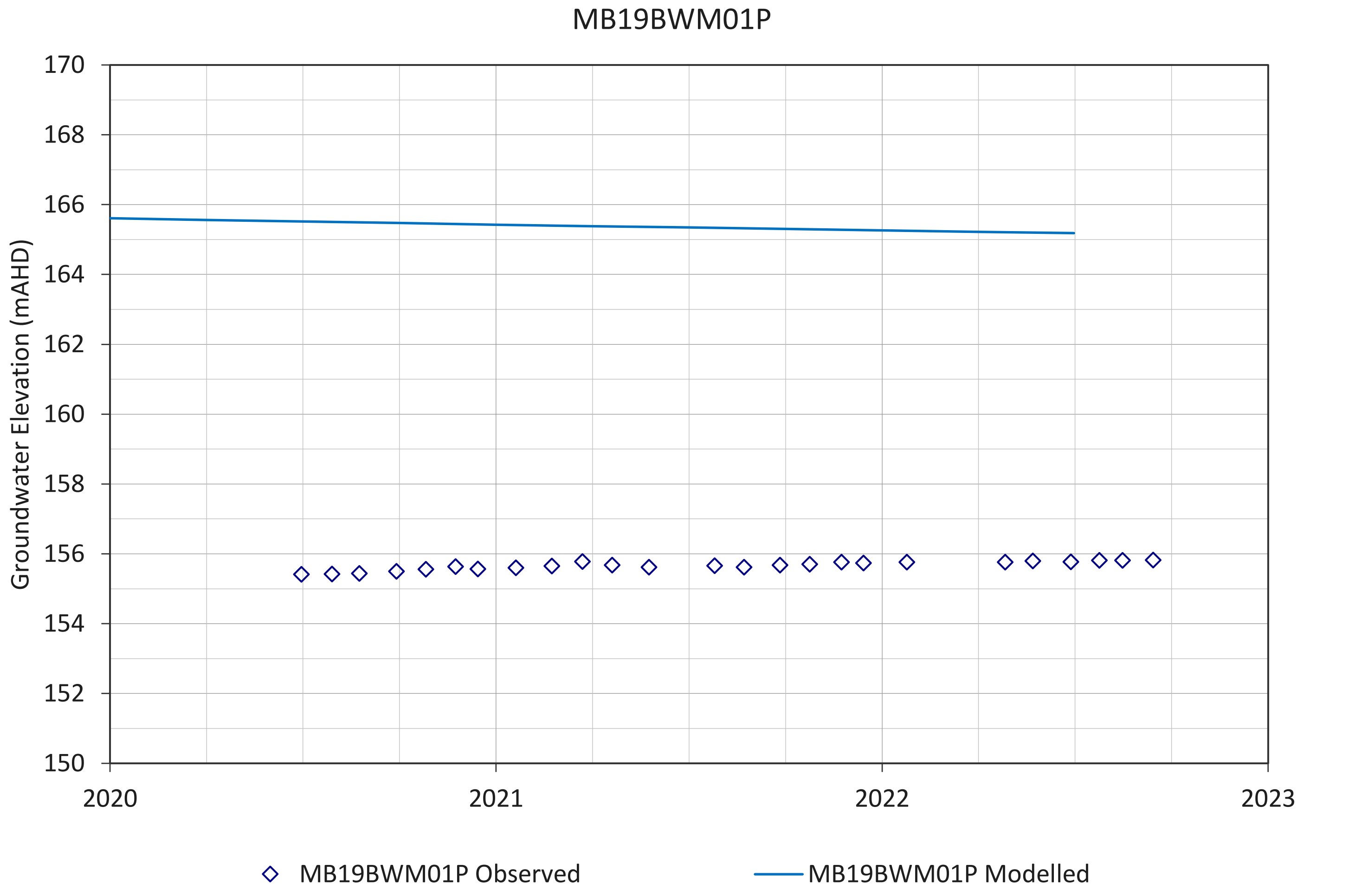
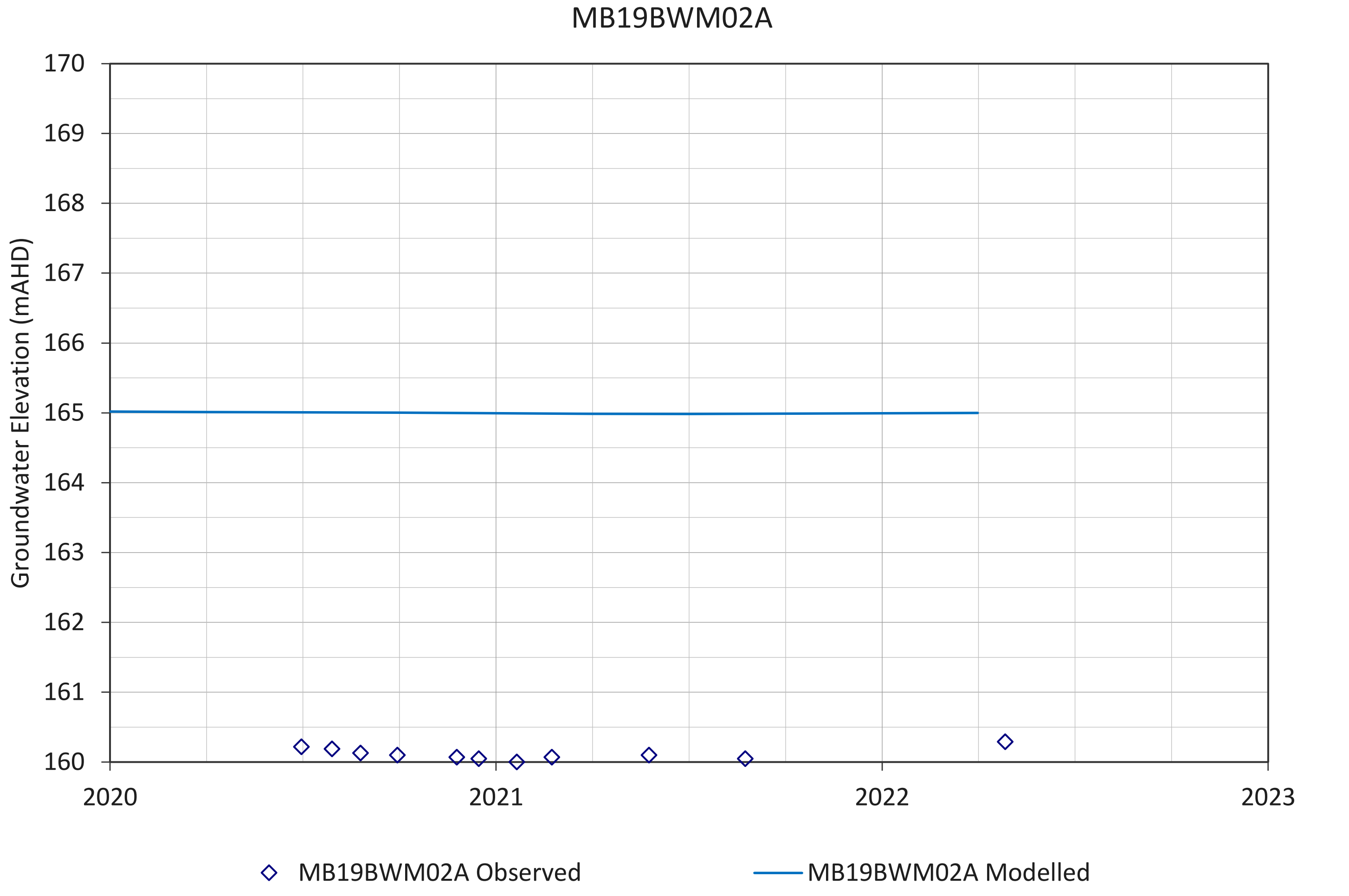
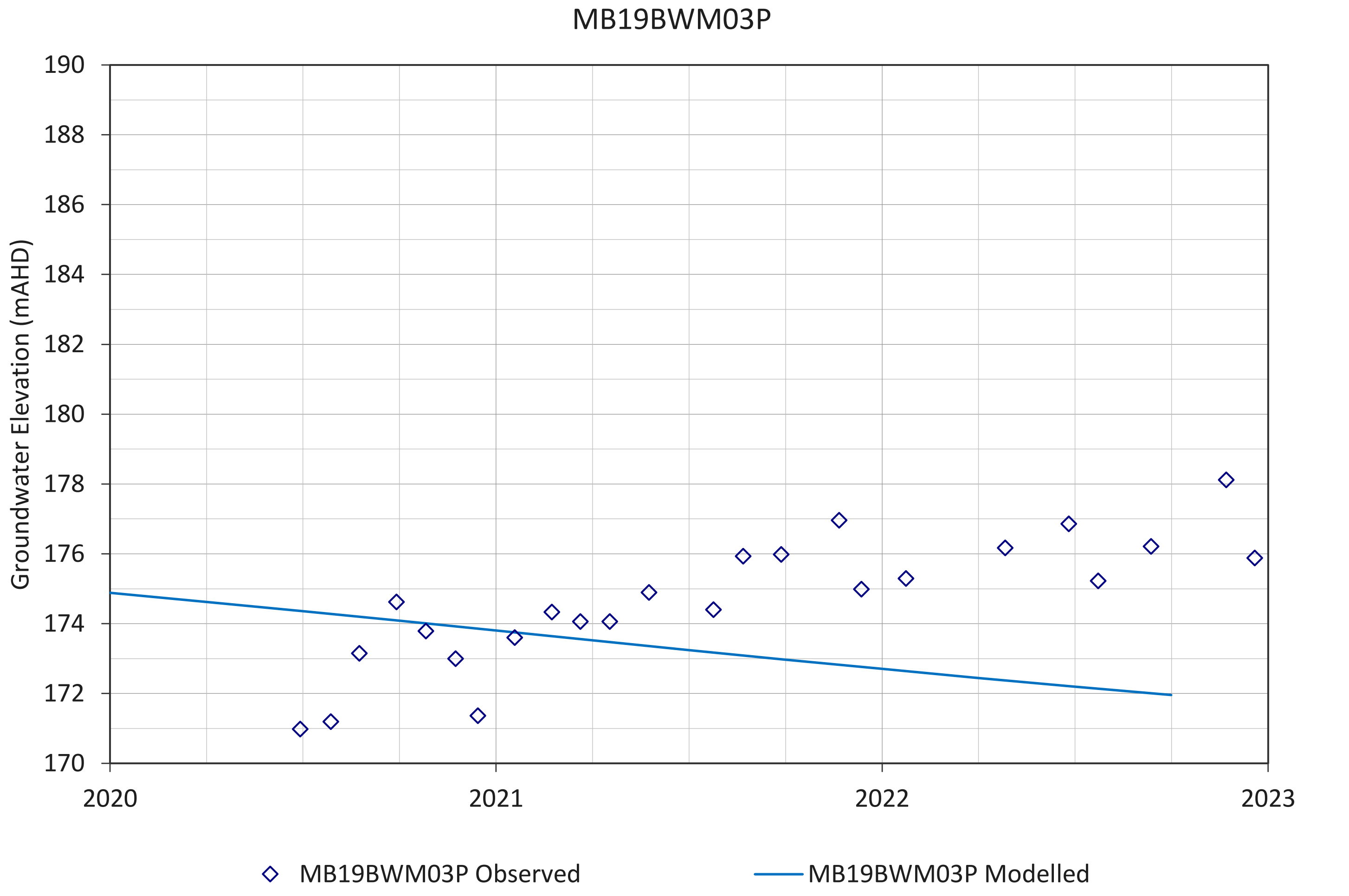
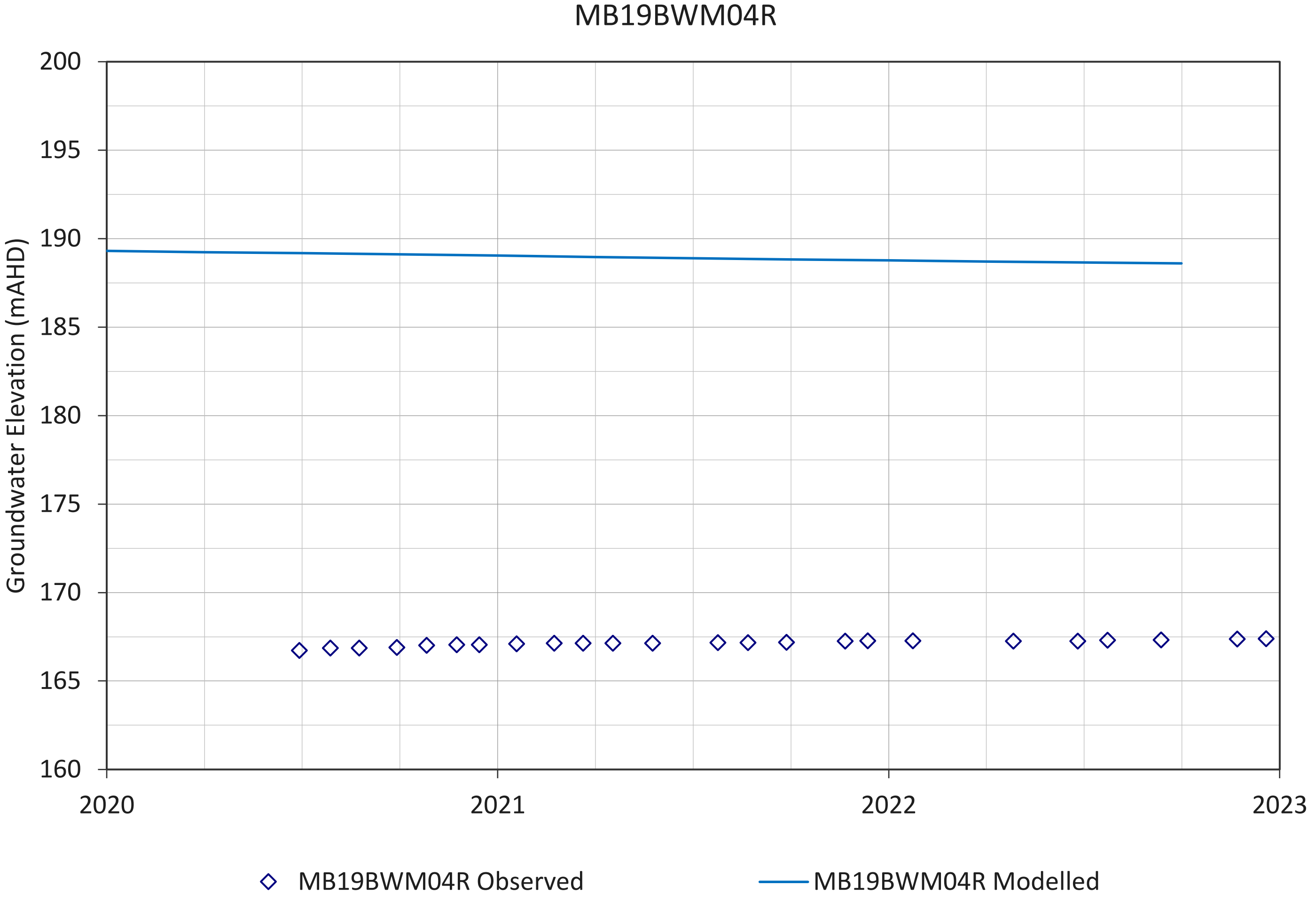
205
200
195
190
2009
2011
2013
2015
2017
2019
2021
2023
MB18 Observed
MB18 Modelled

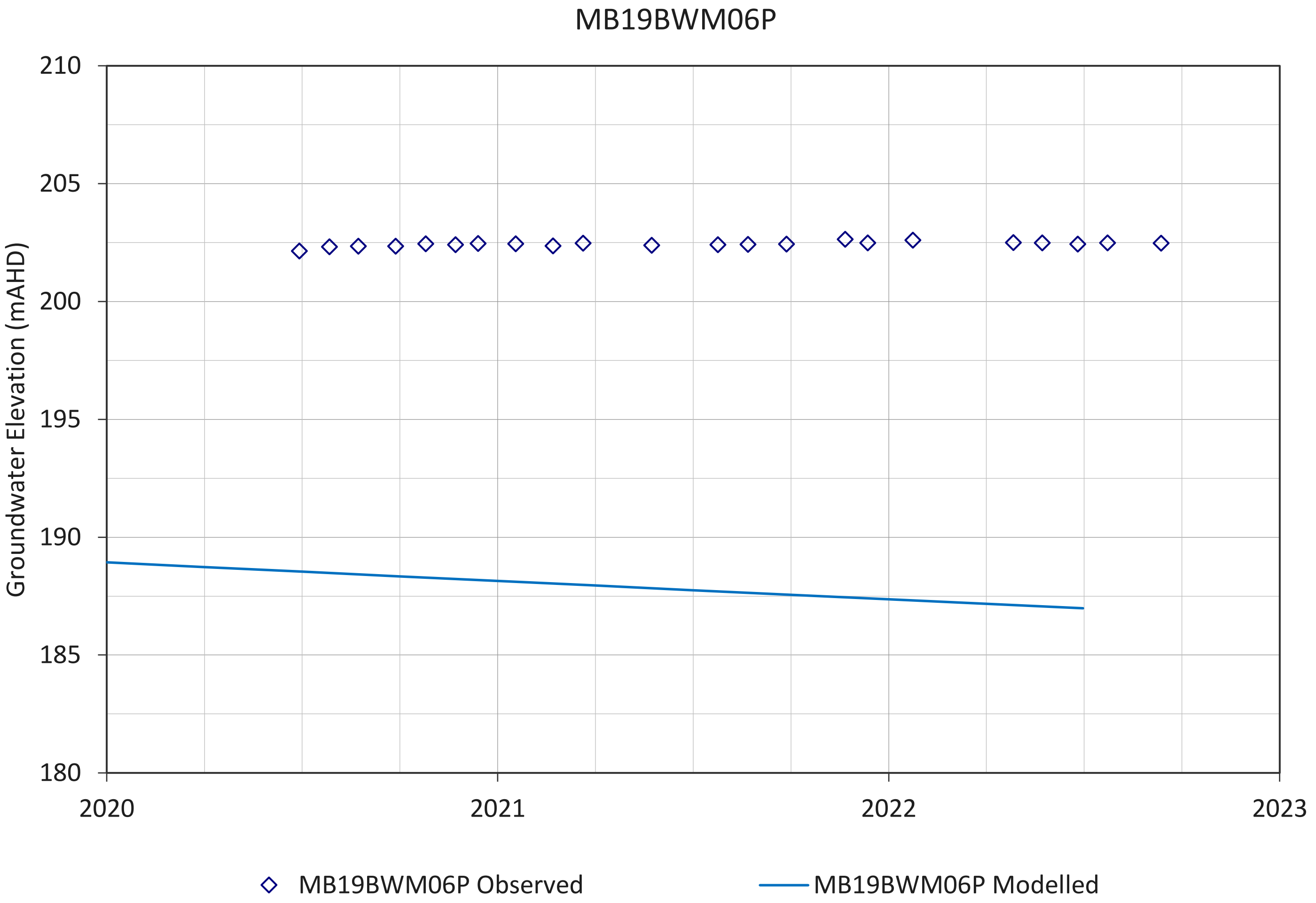

MB19BWM25P
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
2020
2021
2022
2023
MB19BWM25P Observed
MB19BWM25P Modelled

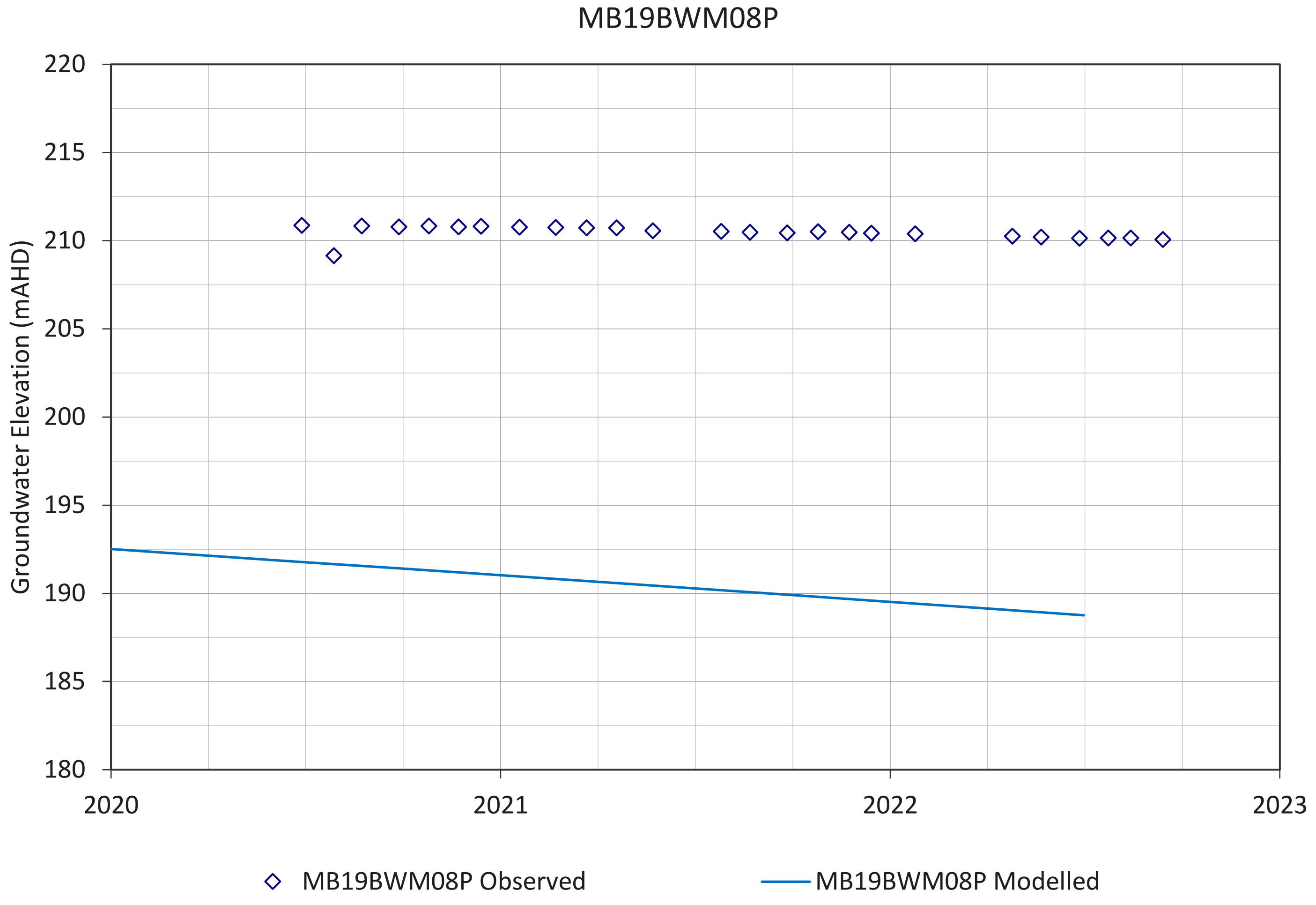

MB19BWM01P
Groundwater Elevation (mAHD)
170
168
166
164
162
160
158
156
154
152
150
2020
2021
2022
2023
MB19BWM01P Observed
MB19BWM01P Modelled

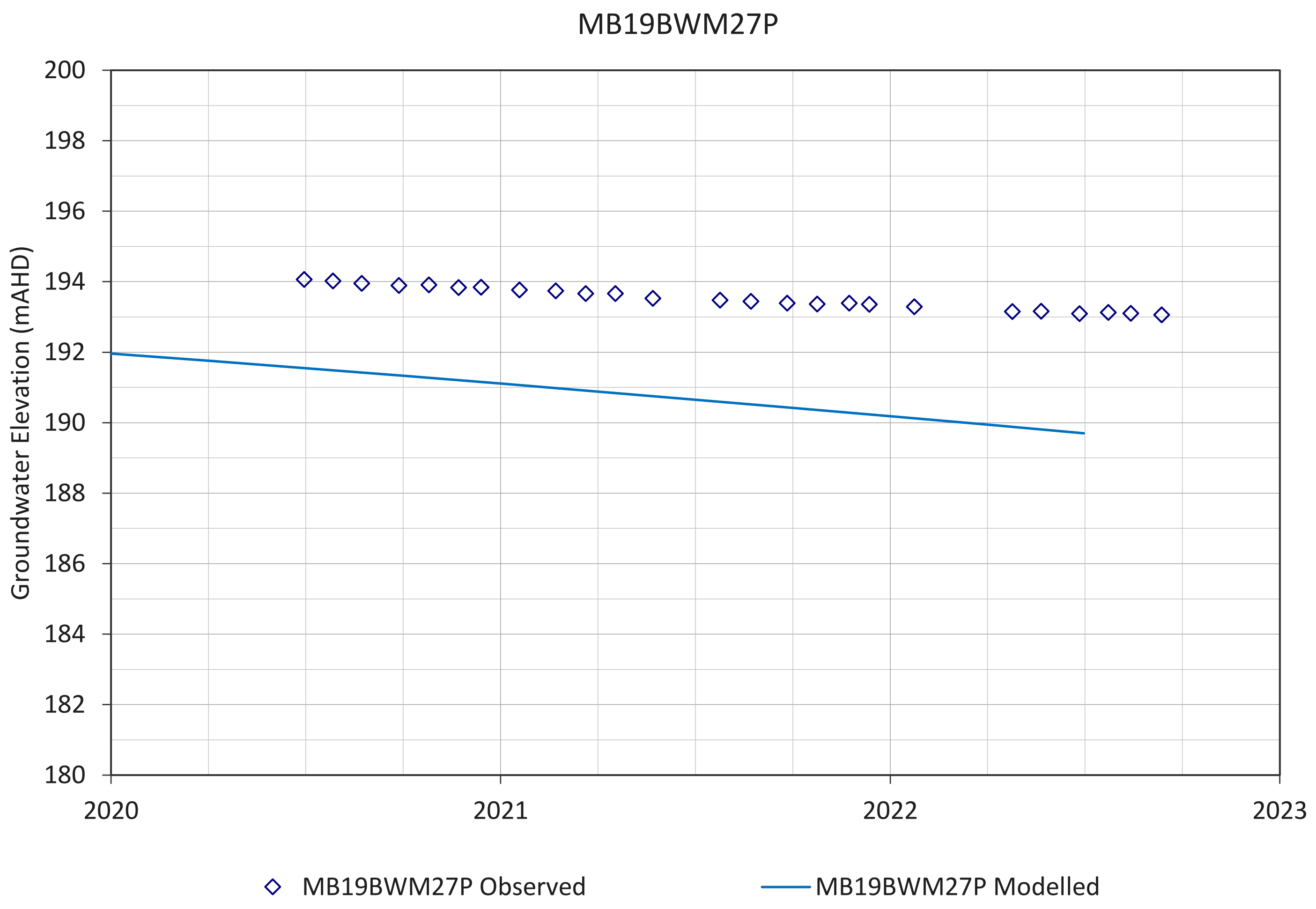

MB19BWM02A
Groundwater Elevation (mAHD)
170
169
168
167
166
165
164
163
162
161
160
2020
2021
2022
2023
MB19BWM02A Observed
MB19BWM02A Modelled

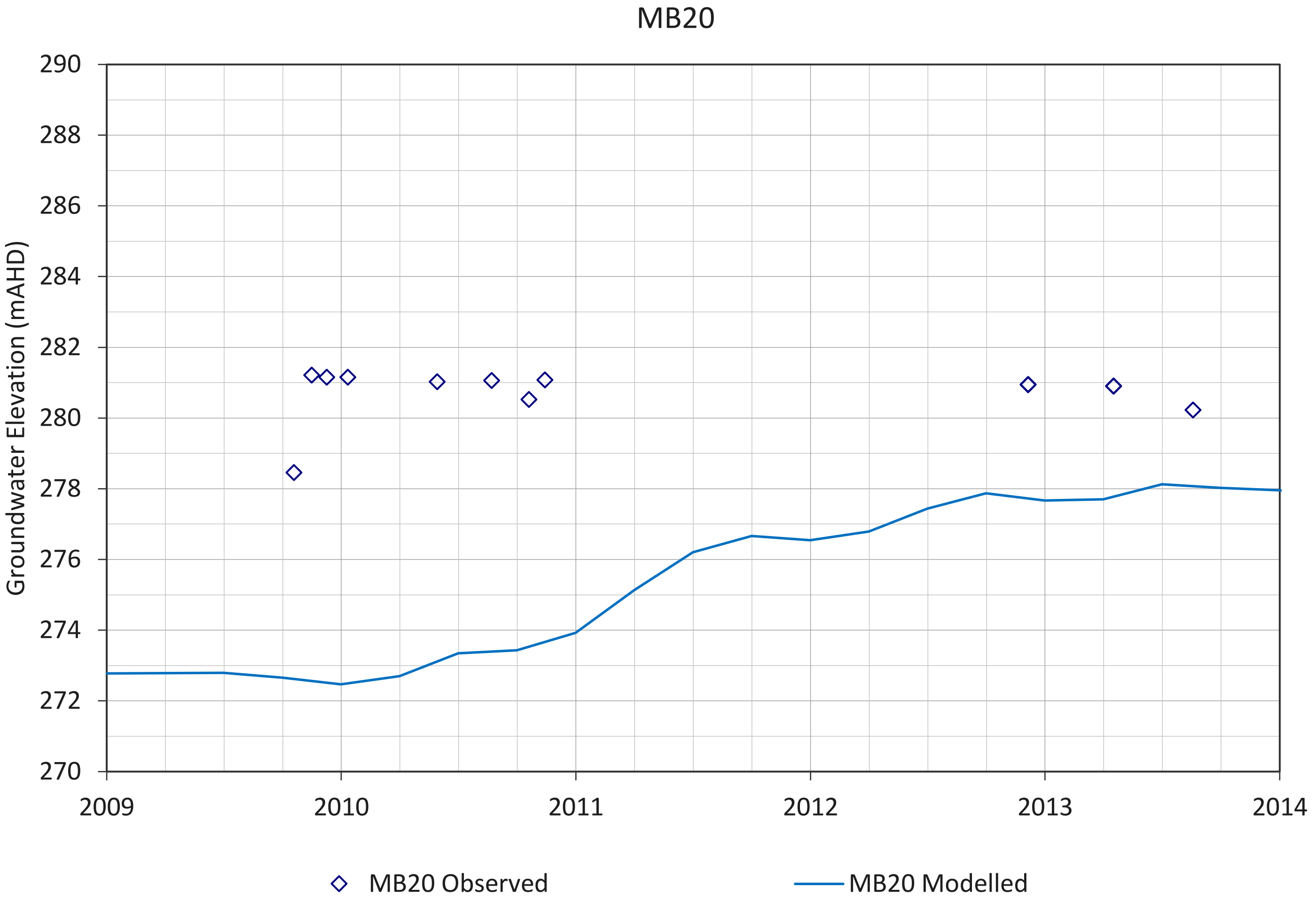

MB19BWM03P
Groundwater Elevation (mAHD)
190
188
186
184
182
180
178
176
174
172
170
2020
2021
2022
2023
MB19BWM03P Observed
MB19BWM03P Modelled

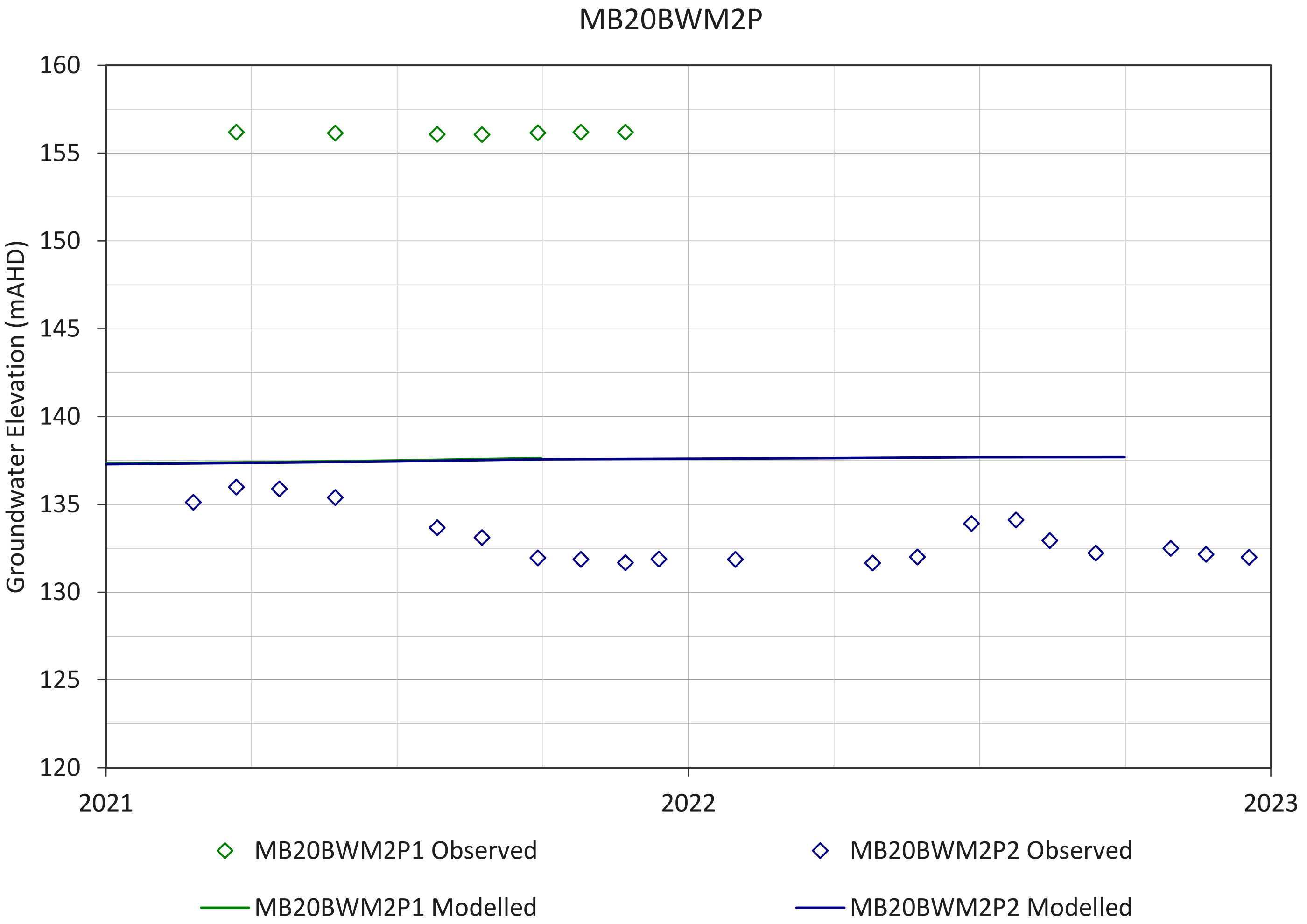

MB19BWM04R
Groundwater Elevation (mAHD)
200
195
190
185
180
175
170
165
160
2020
2021
2022
2023
MB19BWM04R Observed
MB19BWM04R Modelled

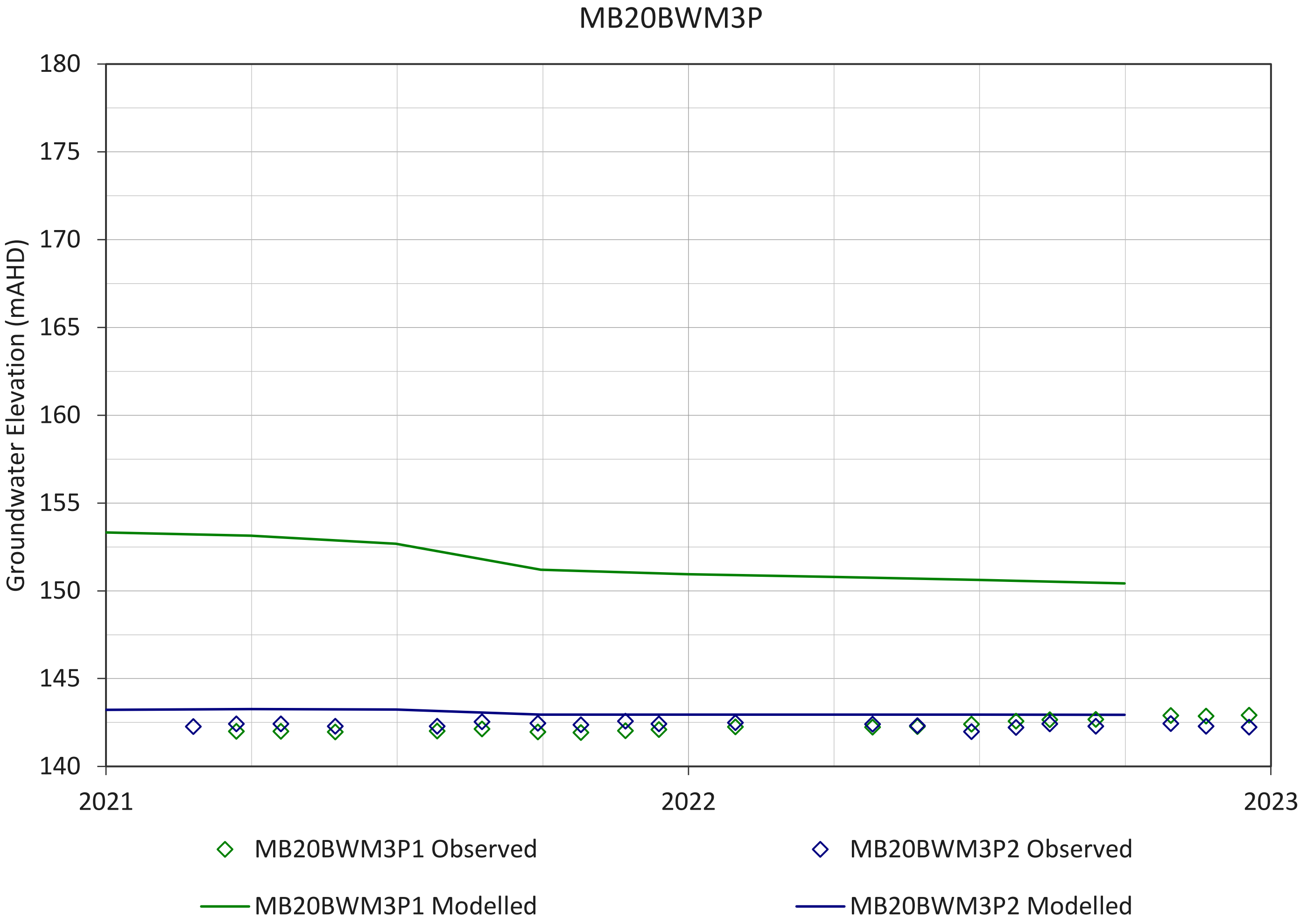

MB19BWM06P
Groundwater Elevation (mAHD)
210
205
200
195
190
185
180
2020
2021
2022
2023
MB19BWM06P Observed
MB19BWM06P Modelled

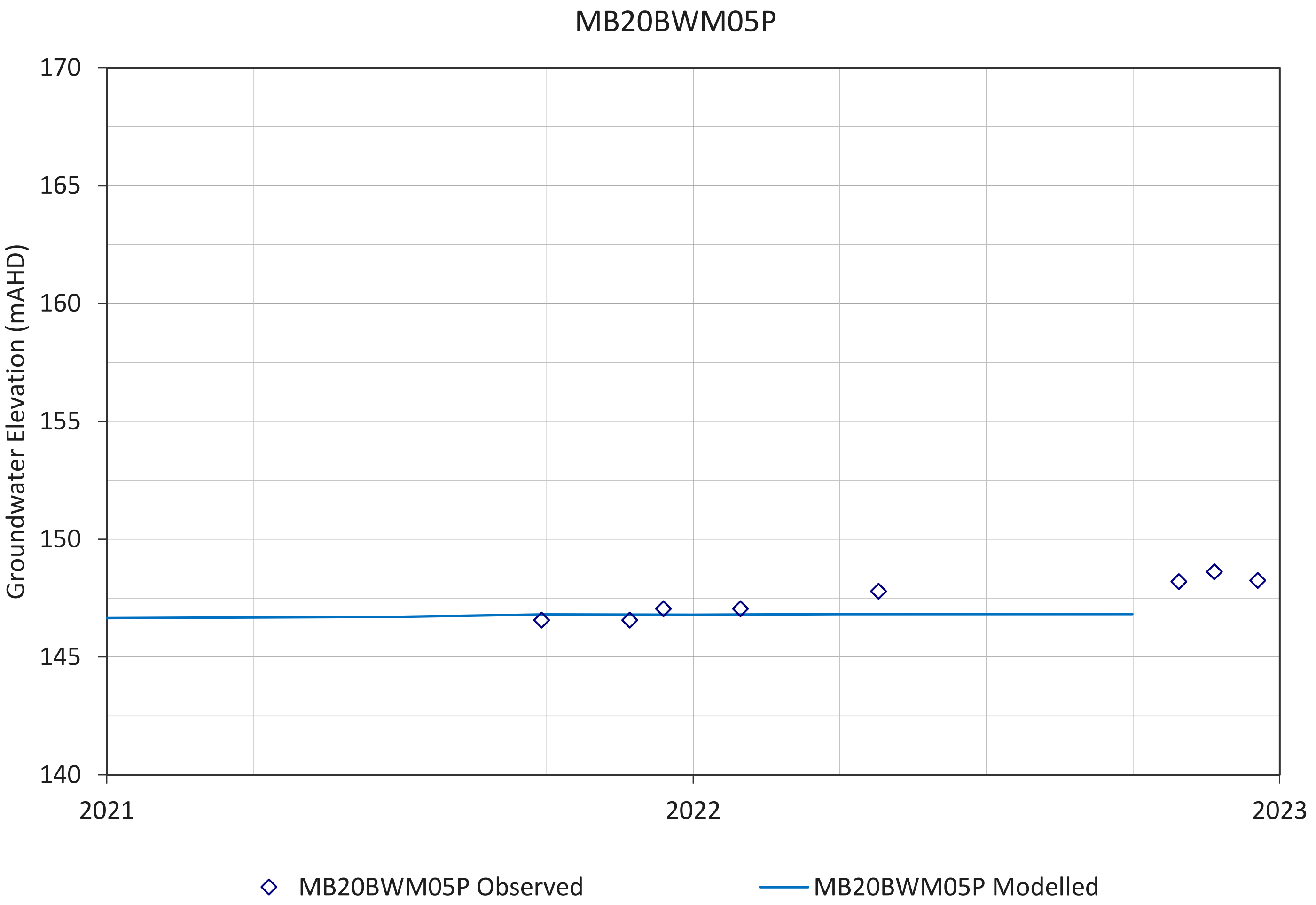

MB19BWM08P
Groundwater Elevation (mAHD)
220
215
210
205
200
195
190
185
180
2020
2021
2022
2023
MB19BWM08P Observed
MB19BWM08P Modelled

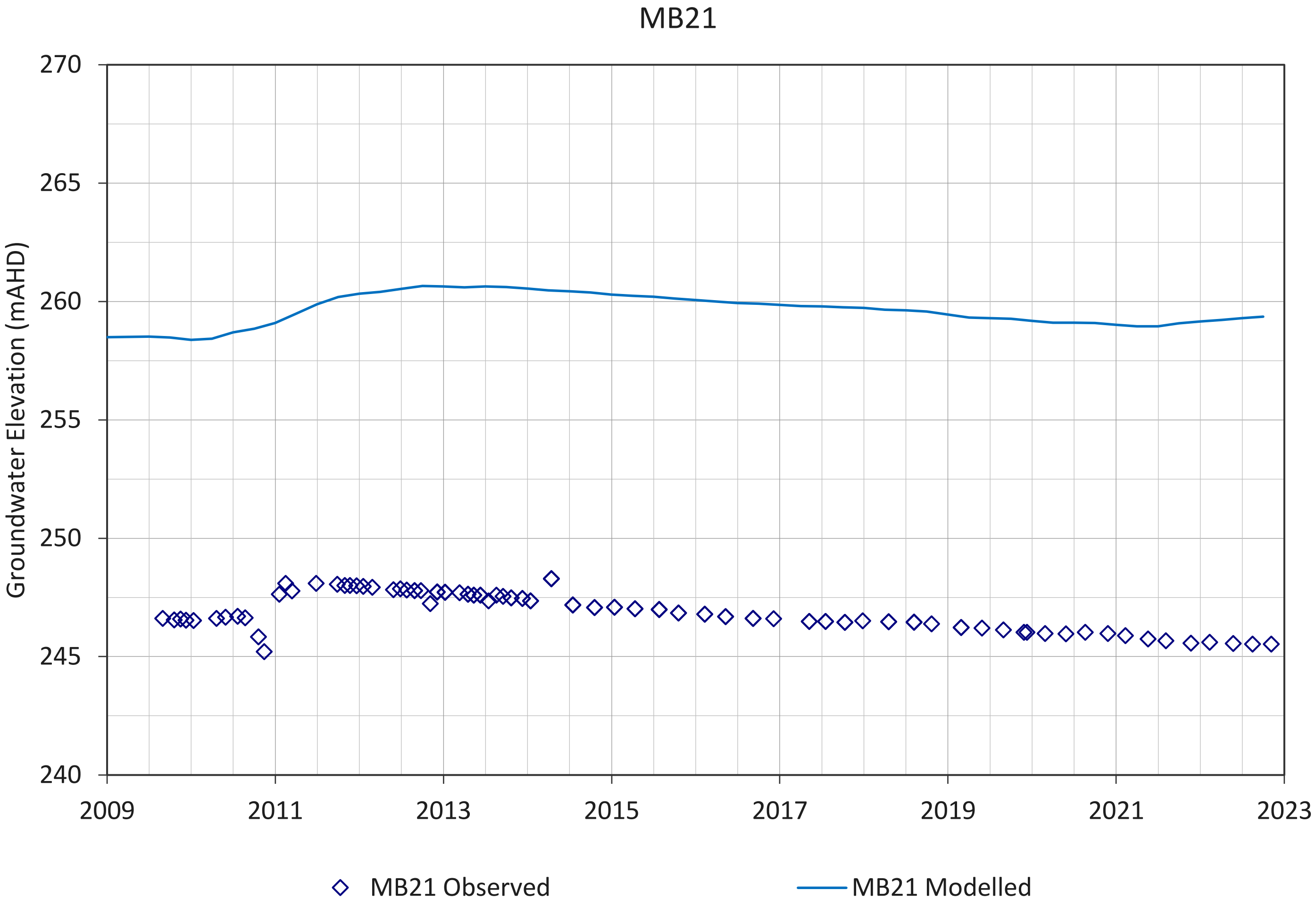

MB19BWM27P
Groundwater Elevation (mAHD)
200
198
196
194
192
190
188
186
184
182
180
2020
2021
2022
2023
MB19BWM27P Observed
MB19BWM27P Modelled

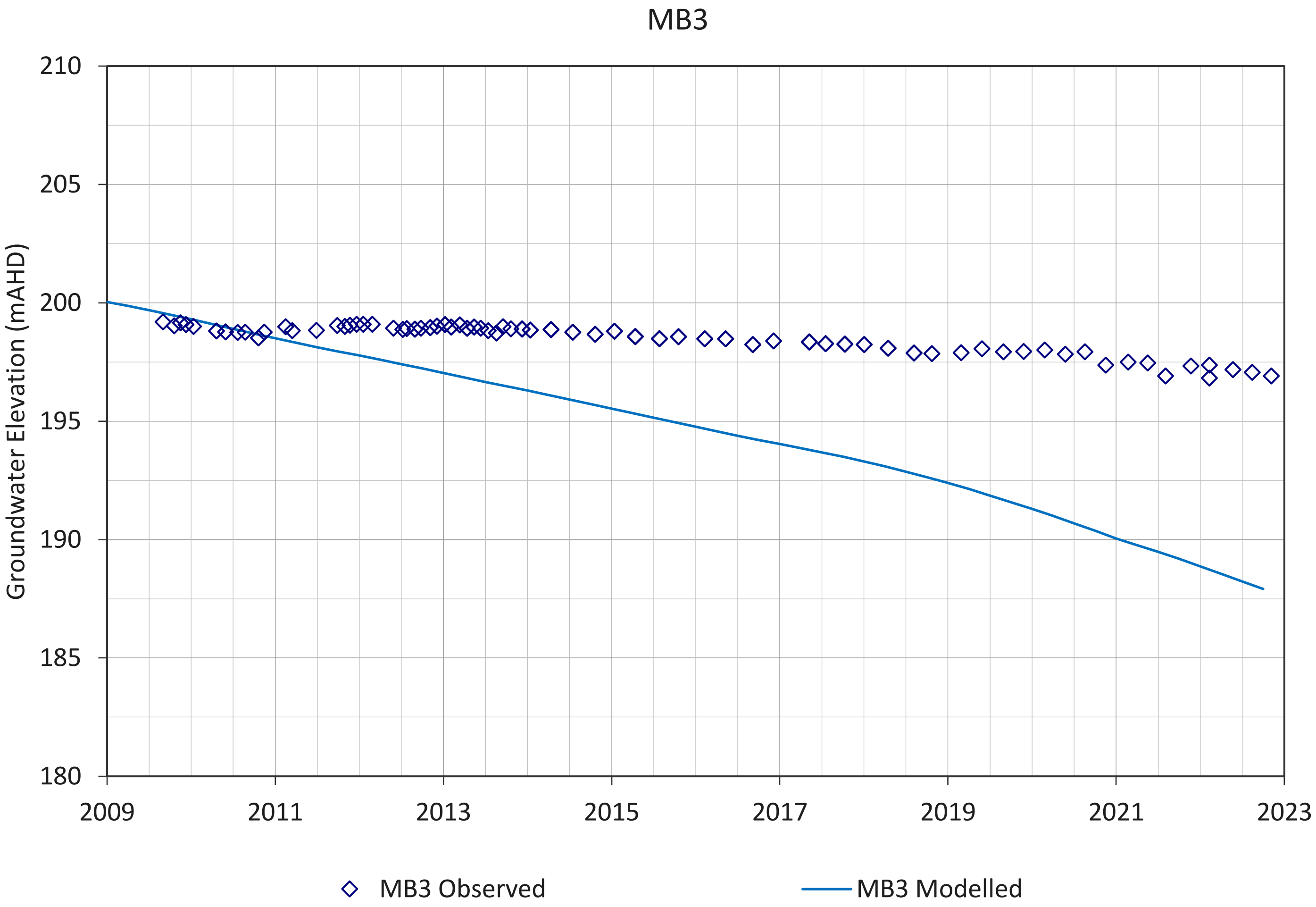

MB20
Groundwater Elevation (mAHD)
290
288
286
284
282
280
278
276
274
272
270
2009
2010
2011
2012
2013
2014
MB20 Observed
MB20 Modelled

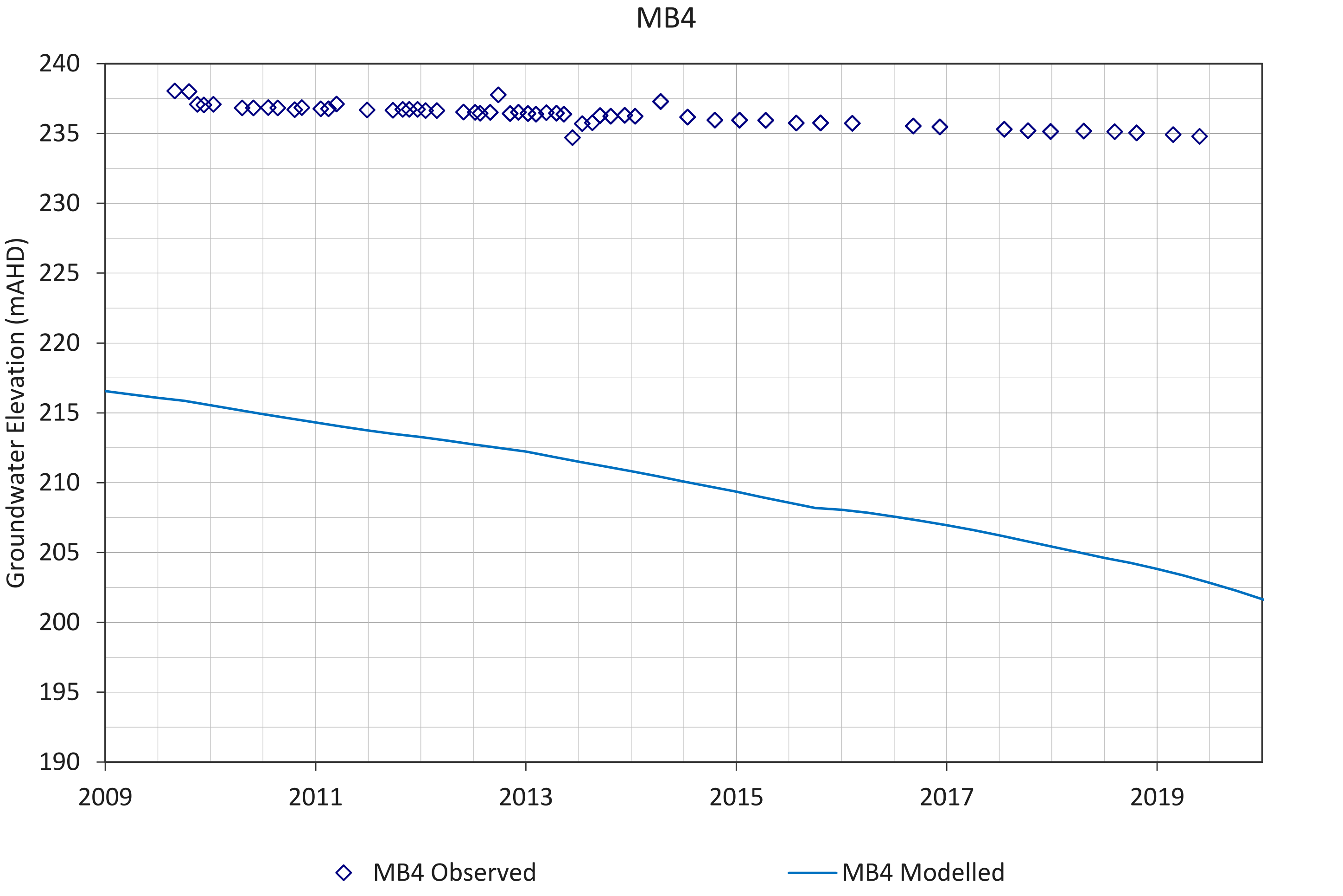

MB20BWM2P
Groundwater Elevation (mAHD)
160
155
150
145
140
135
130
125
120
2021
2022
2023
MB20BWM2P1 Observed
MB20BWM2P2 Observed
MB20BWM2P1 Modelled
MB20BWM2P2 Modelled

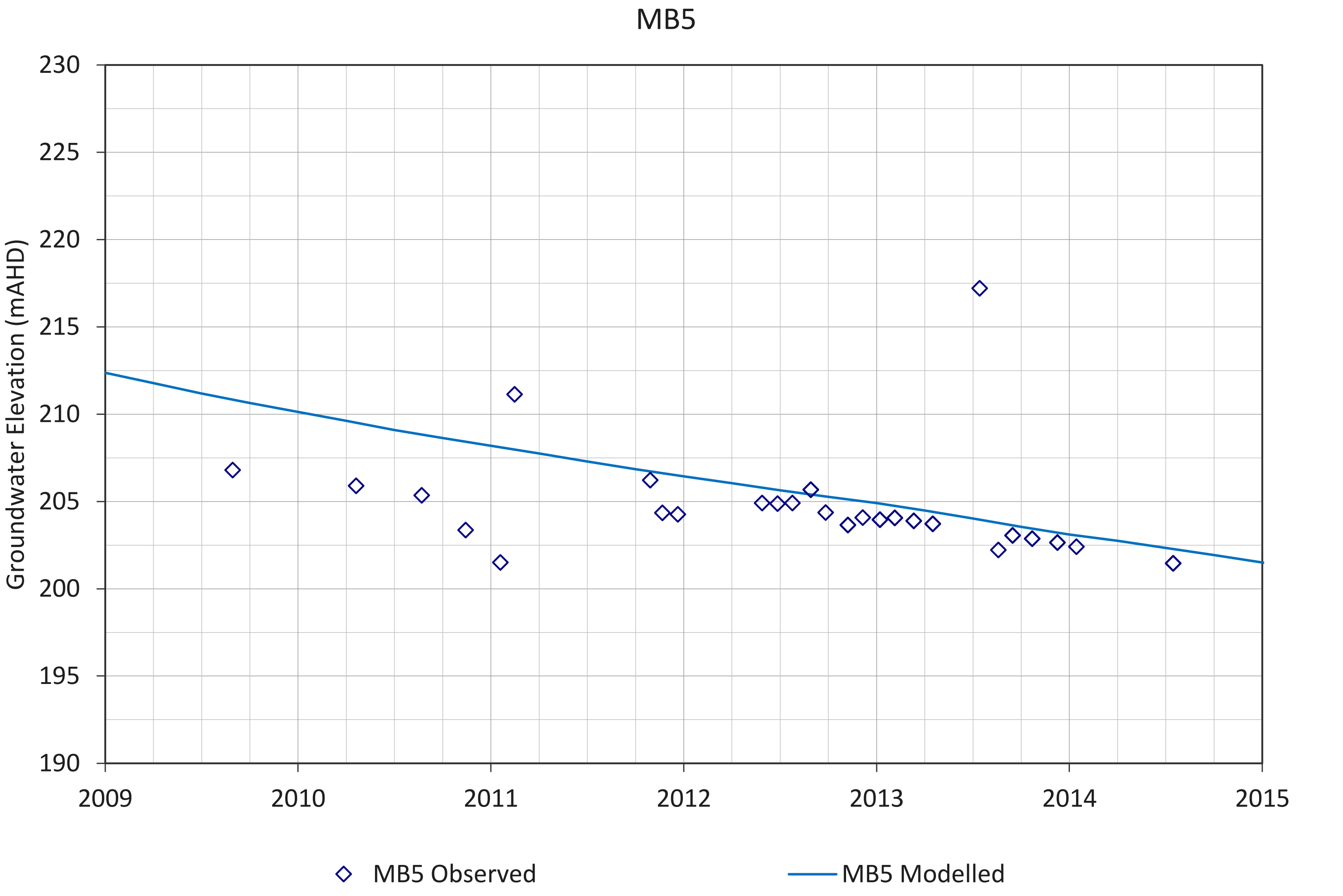

MB20BWM3P
Groundwater Elevation (mAHD)
180
175
170
165
160
155
150
145
140
2021
2022
2023
MB20BWM3P1 Observed
MB20BWM3P2 Observed
MB20BWM3P1 Modelled
MB20BWM3P2 Modelled

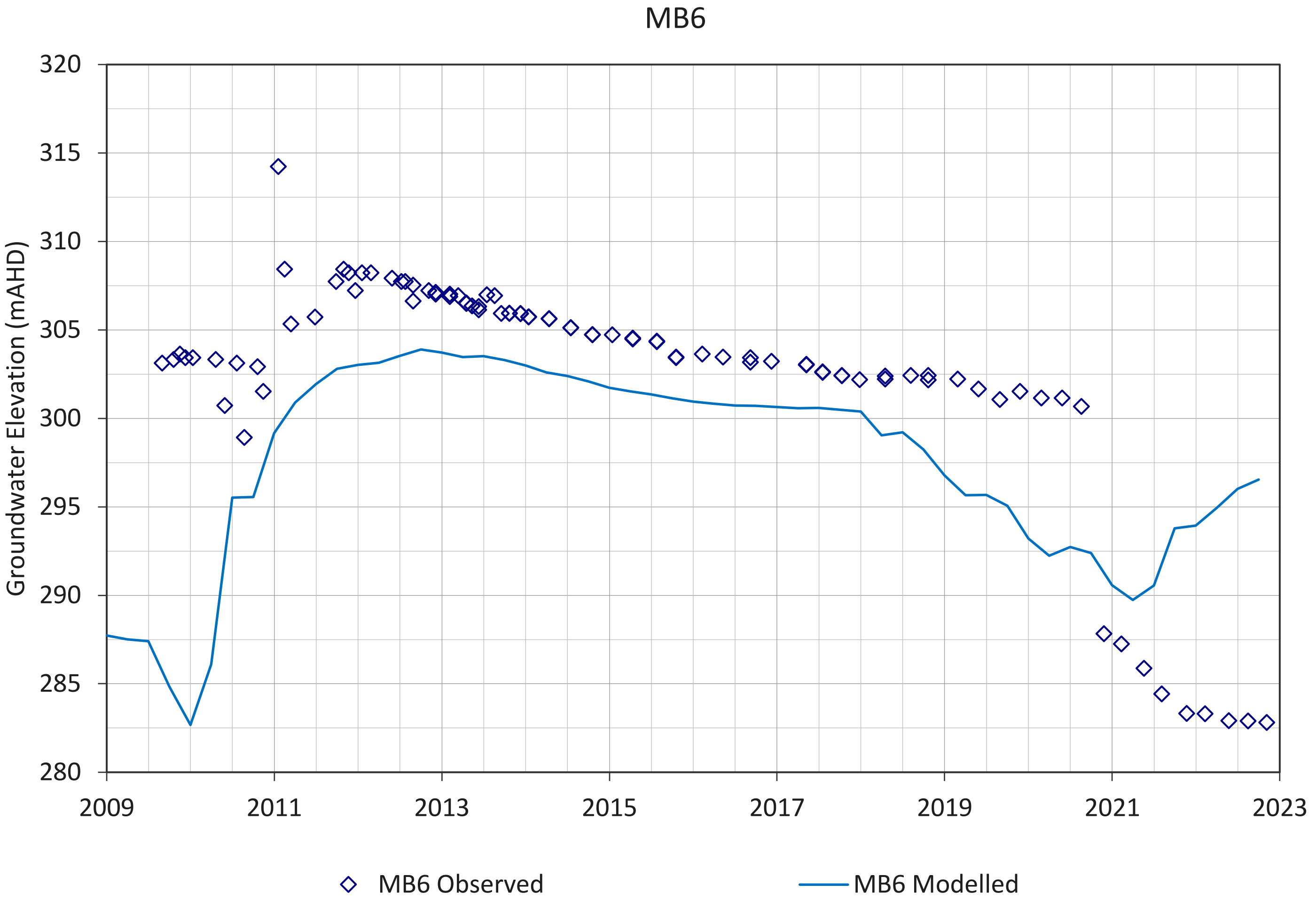

MB20BWM05P
Groundwater Elevation (mAHD)
170
165
160
155
150
145
140
2021
2022
2023
MB20BWM05P Observed
MB20BWM05P Modelled

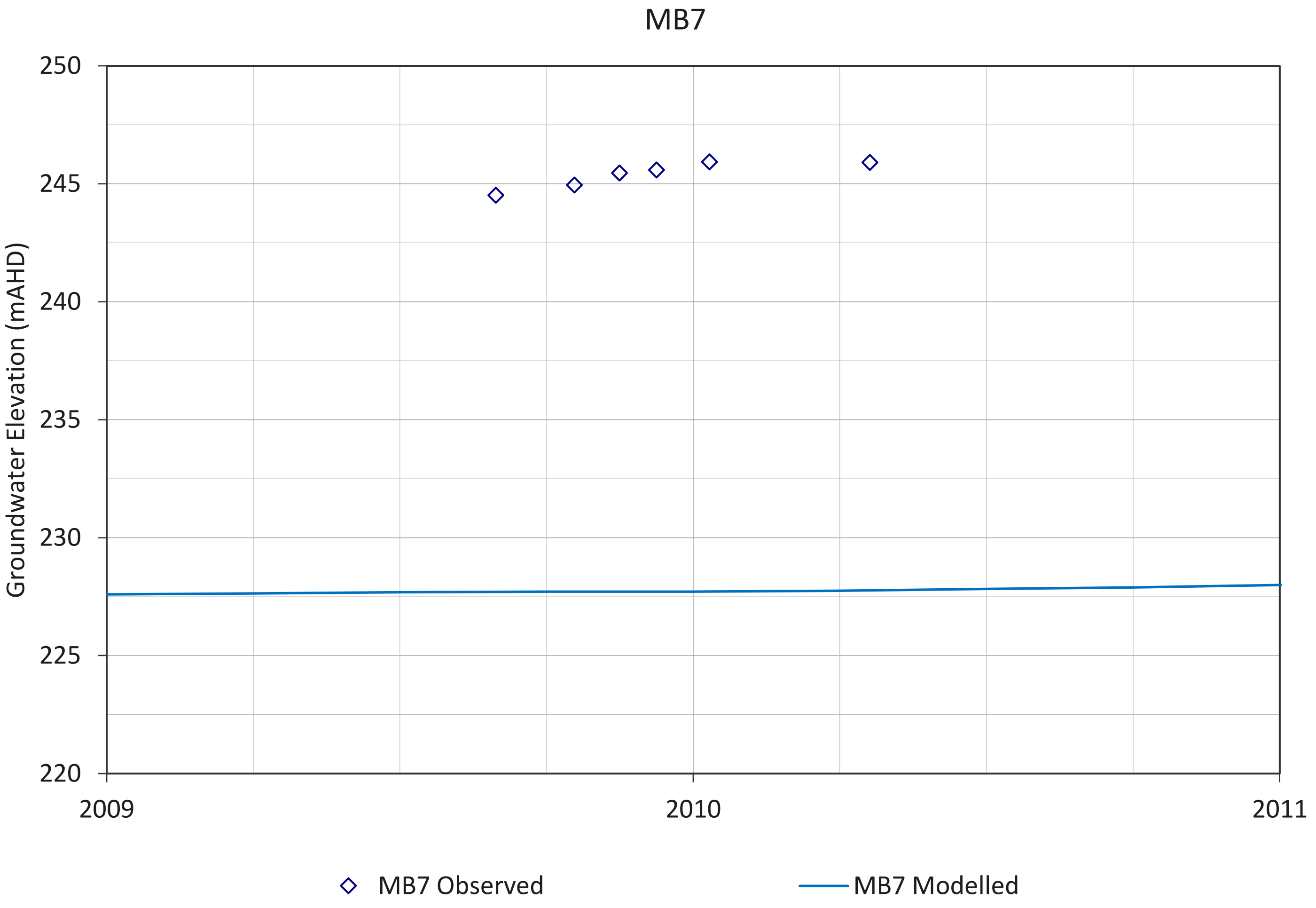

MB21
270
265
260
255
250
245
240
Groundwater Elevation (mAHD)
2009
2011
2013
2015
2017
2019
2021
2023
MB21 Observed
MB21 Modelled

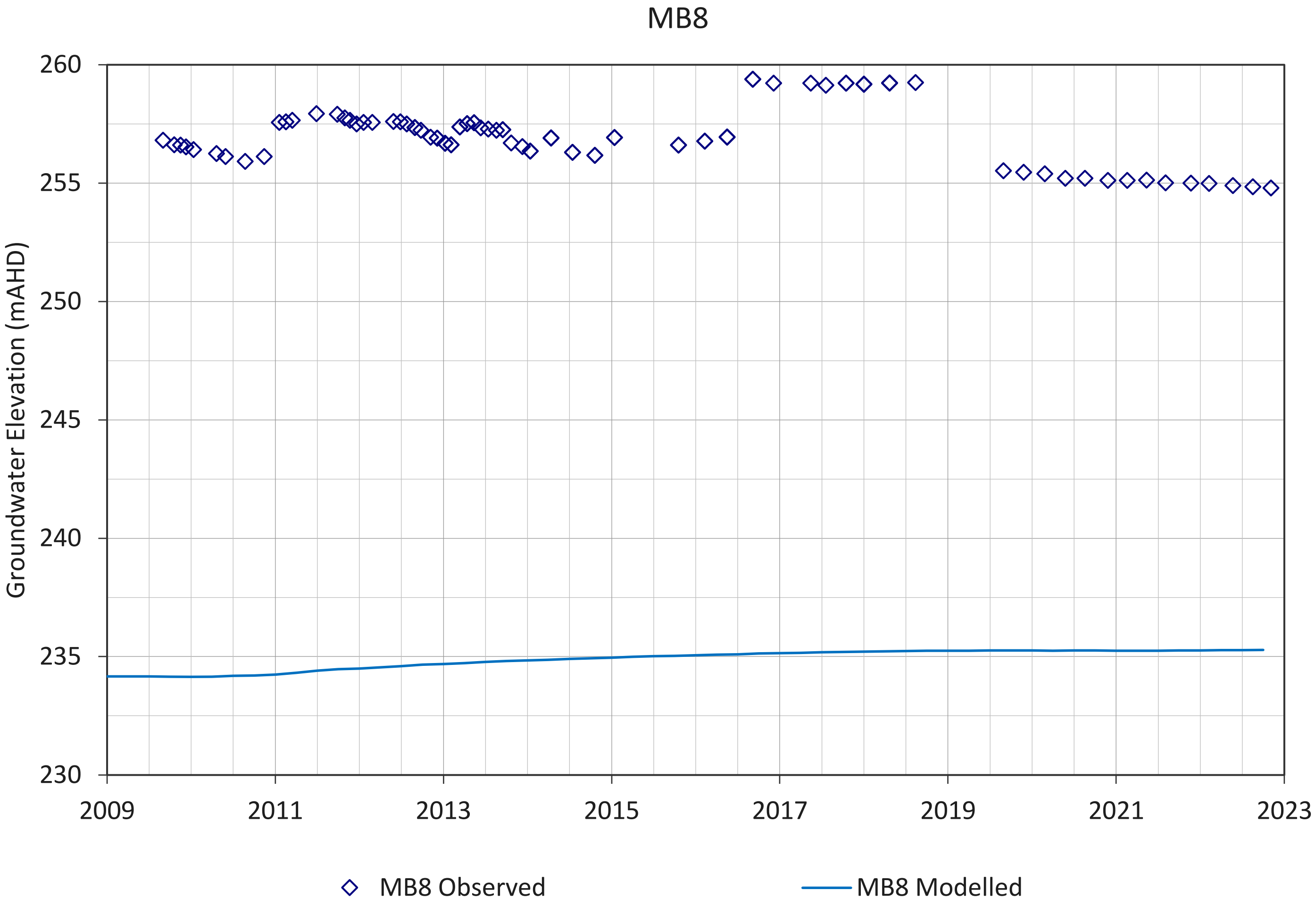

MB3
210
205
200
195
190
185
180
Groundwater Elevation (mAHD)
2009
2011
2013
2015
2017
2019
2021
2023
MB3 Observed
MB3 Modelled

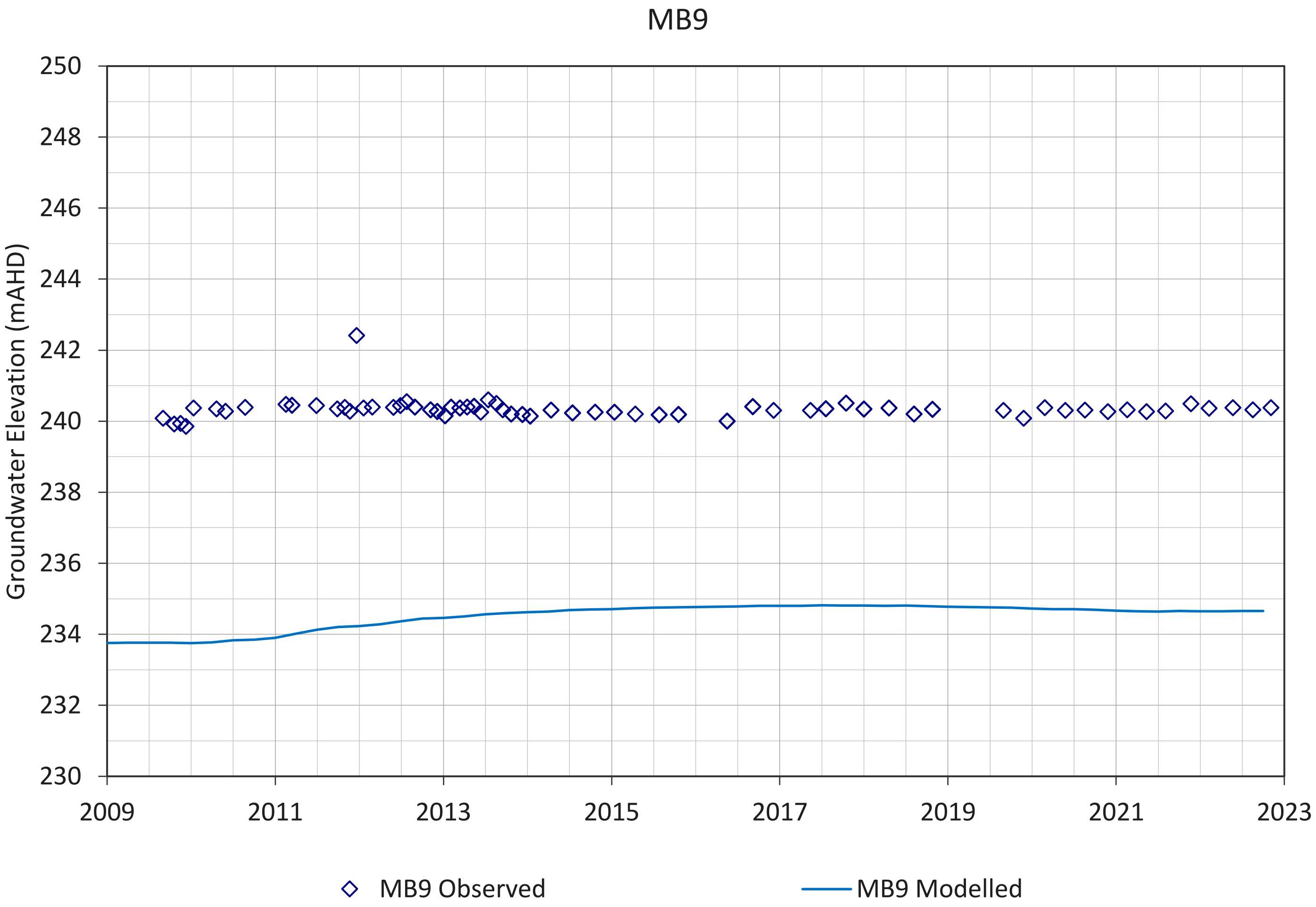

MB4
Groundwater Elevation (mAHD)
240
235
230
225
220
215
210
205
200
195
190
2009
2011
2013
2015
2017
2019
MB4 Observed
MB4 Modelled

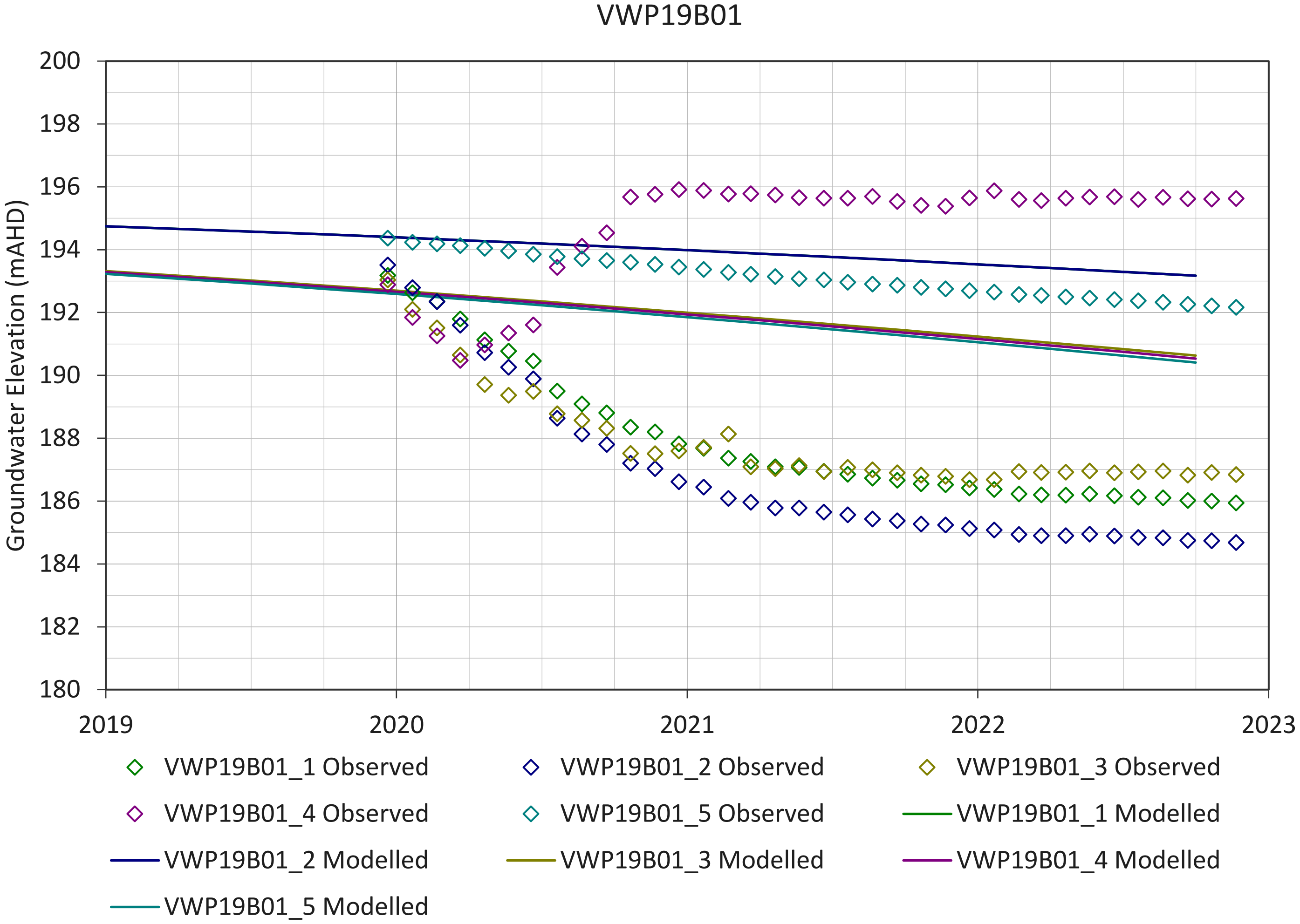

MB5
Groundwater Elevation (mAHD)
230
225
220
215
210
205
200
195
190
2009
2010
2011
2012
2013
2014
2015
MB5 Observed
MB5 Modelled

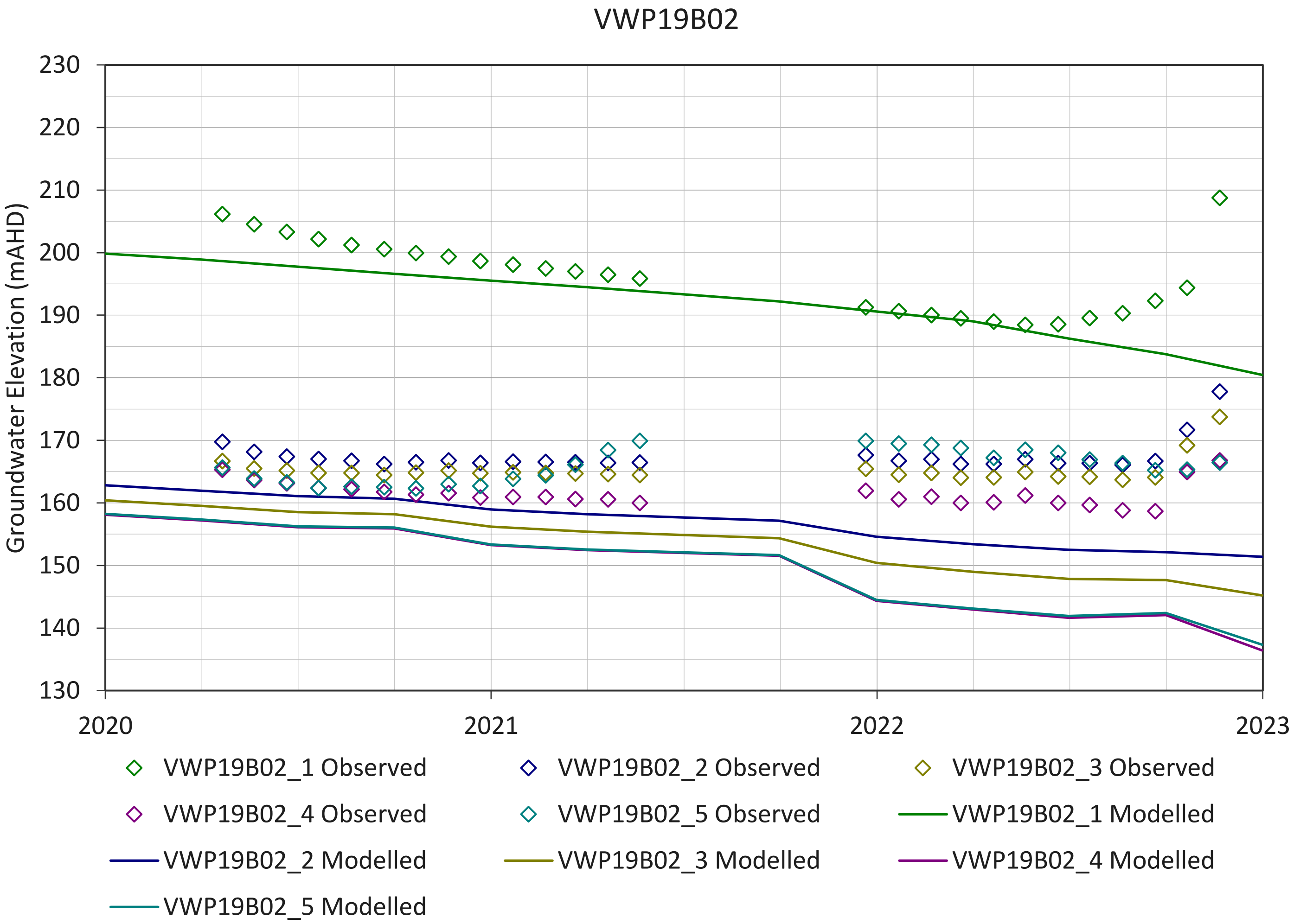

MB6
Groundwater Elevation (mAHD)
320
315
310
305
300
295
290
285
280
2009
2011
2013
2015
2017
2019
2021
2023
MB6 Observed
MB6 Modelled

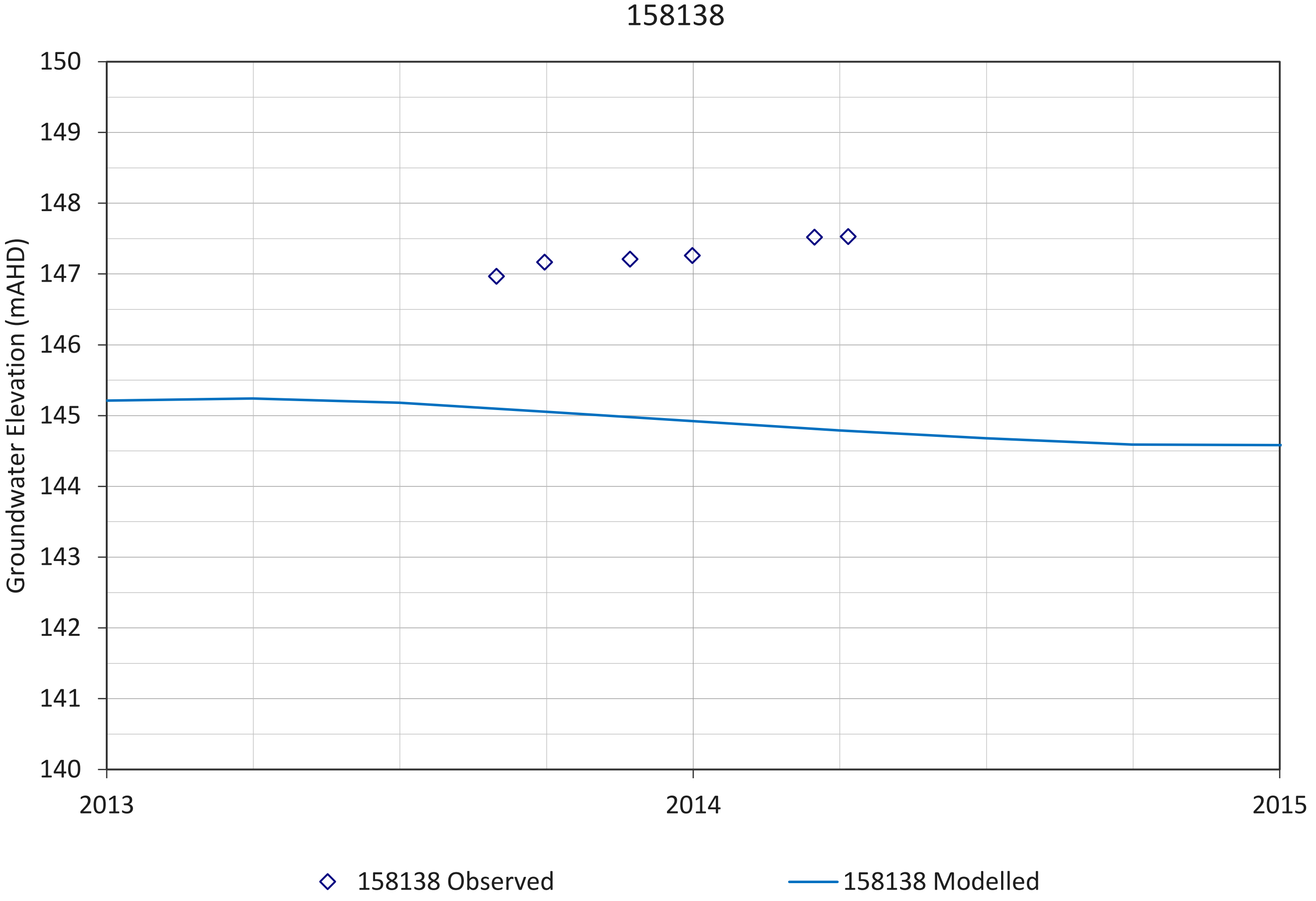

MB7
Groundwater Elevation (mAHD)
250
245
240
235
230
225
220
2009
2010
2011
MB7 Observed
MB7 Modelled


MB8
Groundwater Elevation (mAHD)
260
255
250
245
240
235
230
2009
2011
2013
2015
2017
2019
2021
2023
MB8 Observed
MB8 Modelled


MB9
Groundwater Elevation (mAHD)
250
248
246
244
242
240
238
236
234
232
230
2009
2011
2013
2015
2017
2019
2021
2023
MB9 Observed
MB9 Modelled


VWP19B01
Groundwater Elevation (mAHD)
200
198
196
194
192
190
188
186
184
182
180
2019
2020
2021
2022
2023
VWP19B01_1 Observed
VWP19B01_2 Observed
VWP19B01_3 Observed
VWP19B01_4 Observed
VWP19B01_5 Observed
VWP19B01_1 Modelled
VWP19B01_2 Modelled
VWP19B01_3 Modelled
VWP19B01_4 Modelled
VWP19B01_5 Modelled


VWP19B02
Groundwater Elevation (mAHD)
230
220
210
200
190
180
170
160
150
140
130
2020
2021
2022
2023
VWP19B02_1 Observed
VWP19B02_2 Observed
VWP19B02_3 Observed
VWP19B02_4 Observed
VWP19B02_5 Observed
VWP19B02_1 Modelled
VWP19B02_2 Modelled
VWP19B02_3 Modelled
VWP19B02_4 Modelled
VWP19B02_5 Modelled


158138
Groundwater Elevation (mAHD)
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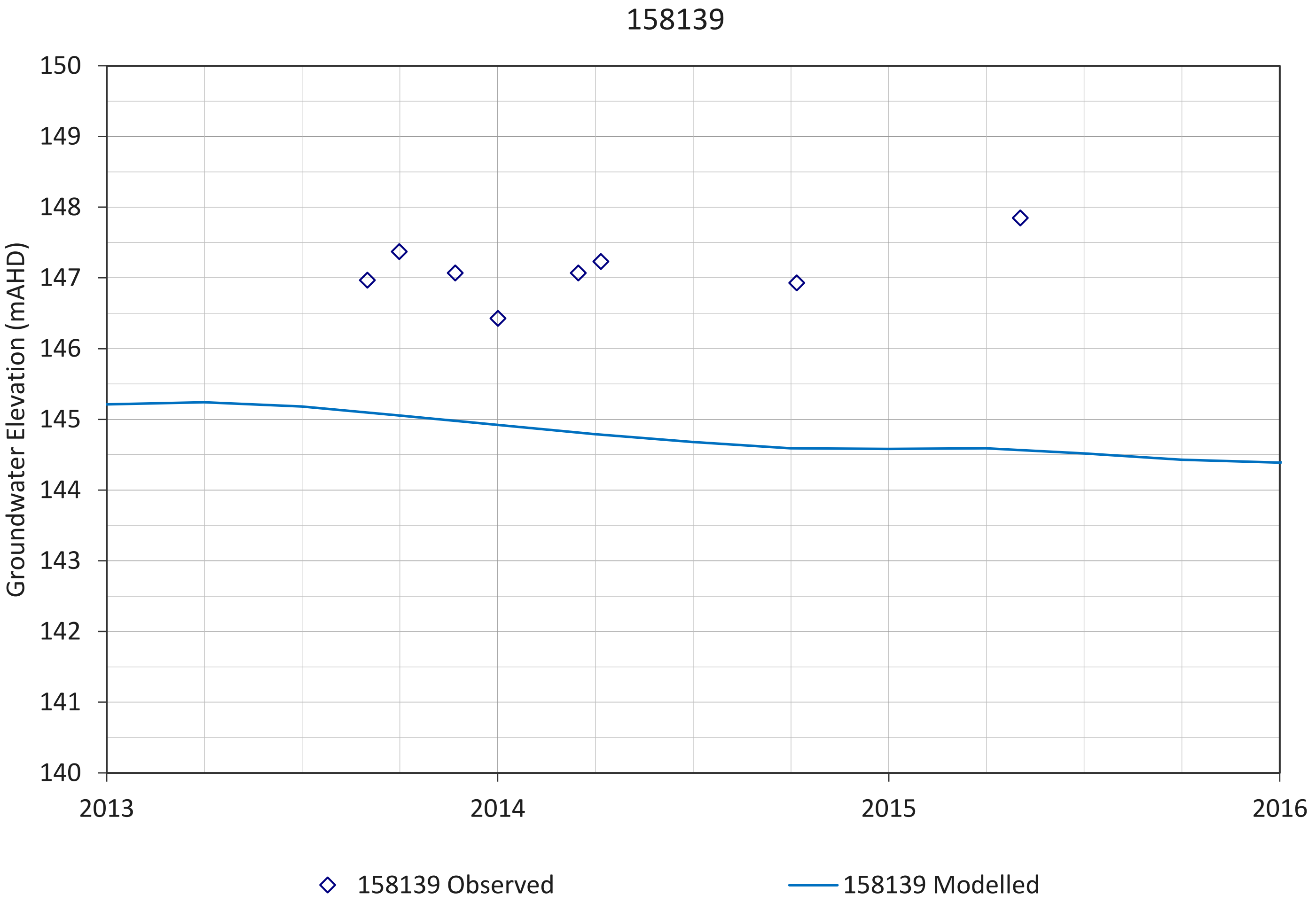
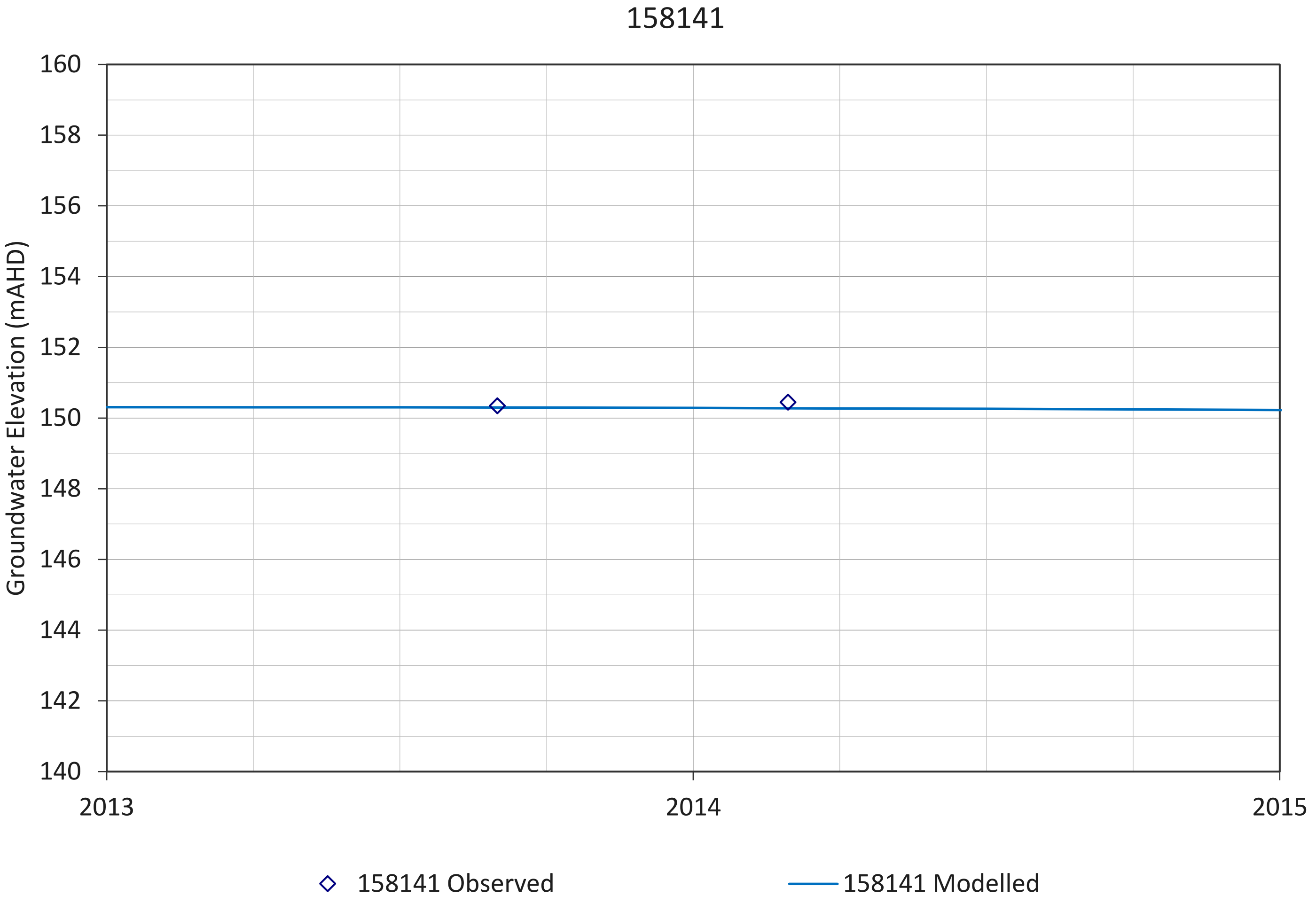
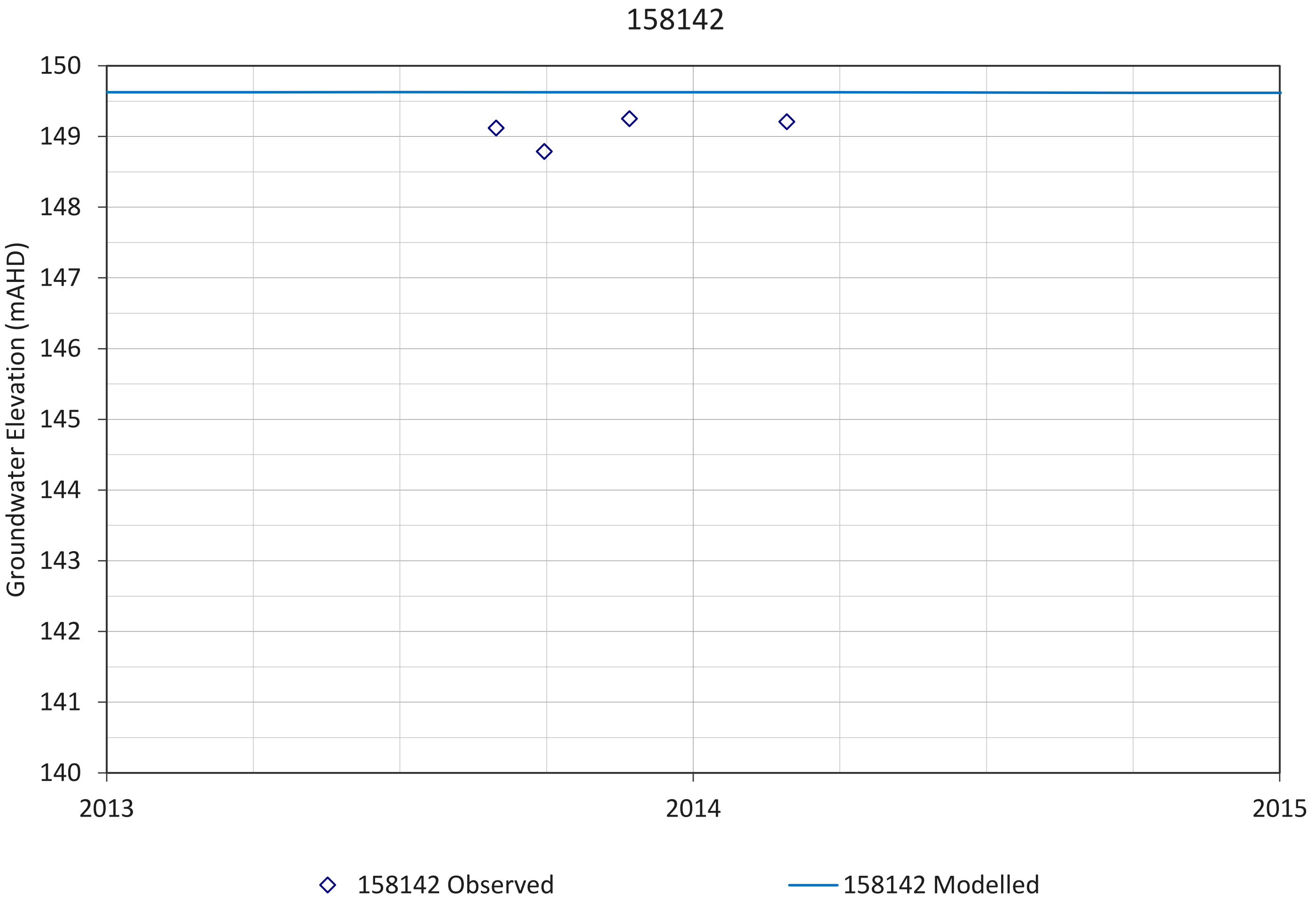
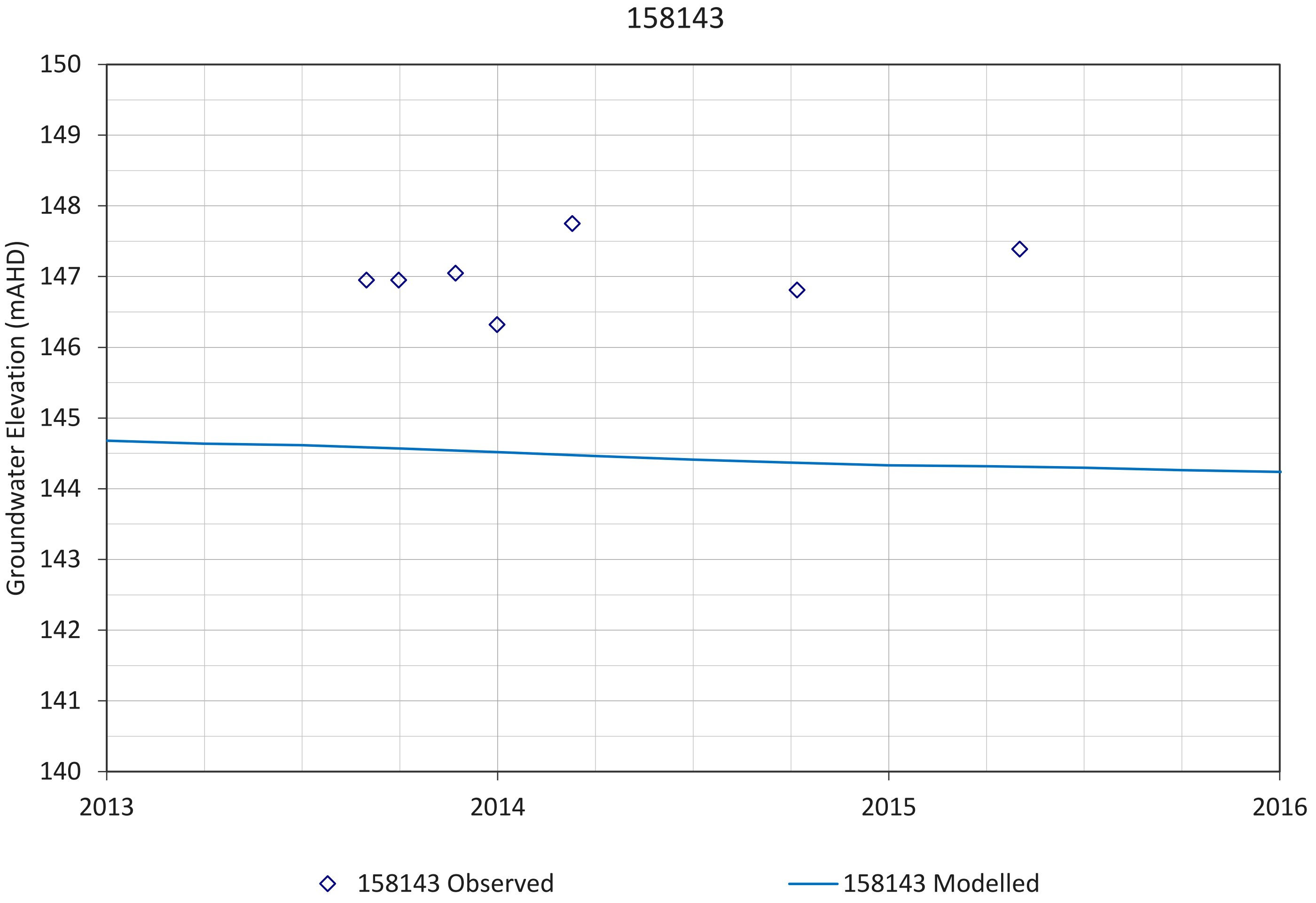
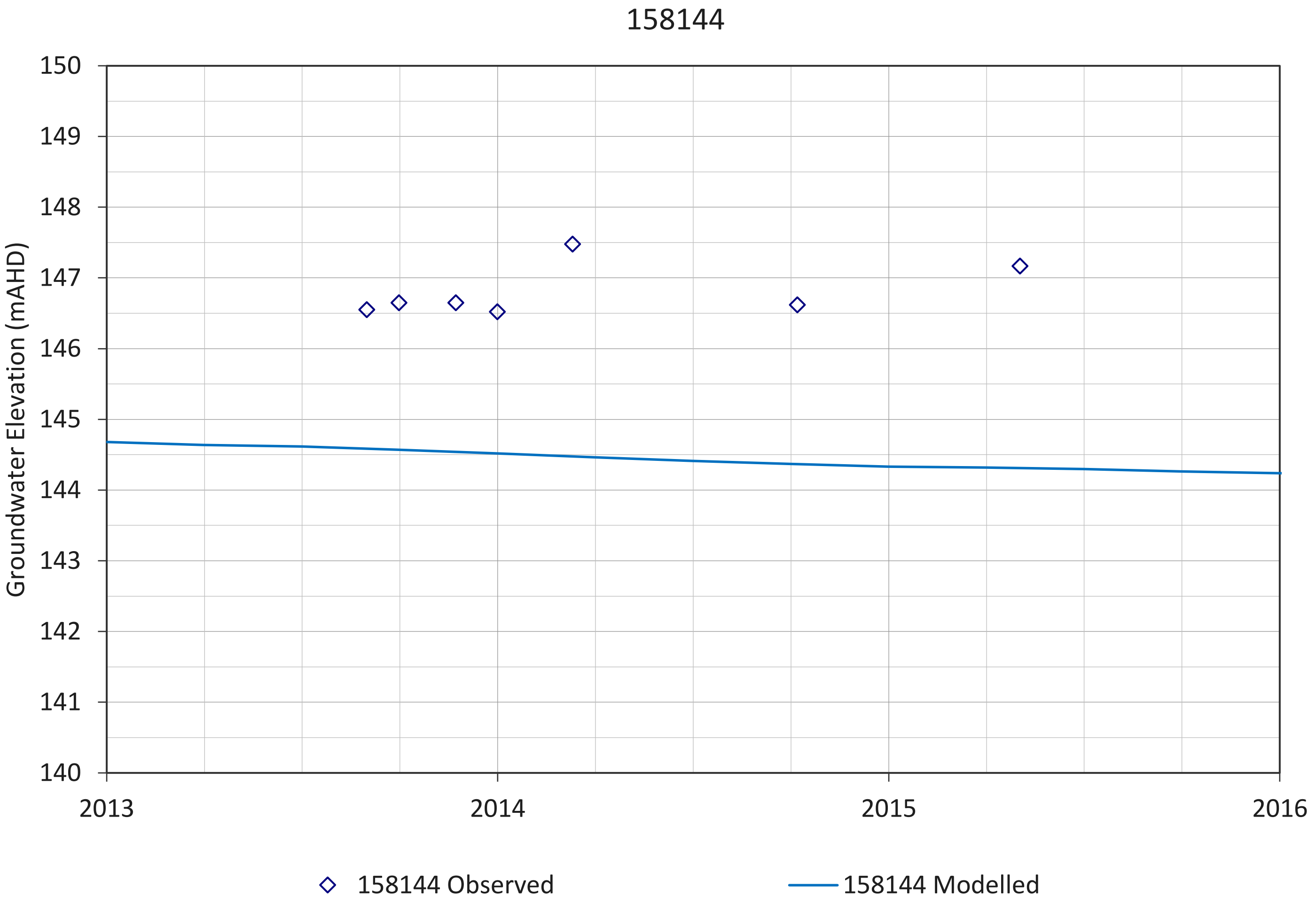
149
148
147
146
145
144
143
142
141
140
2013
2014
2015
158138 Observed
158138 Modelled

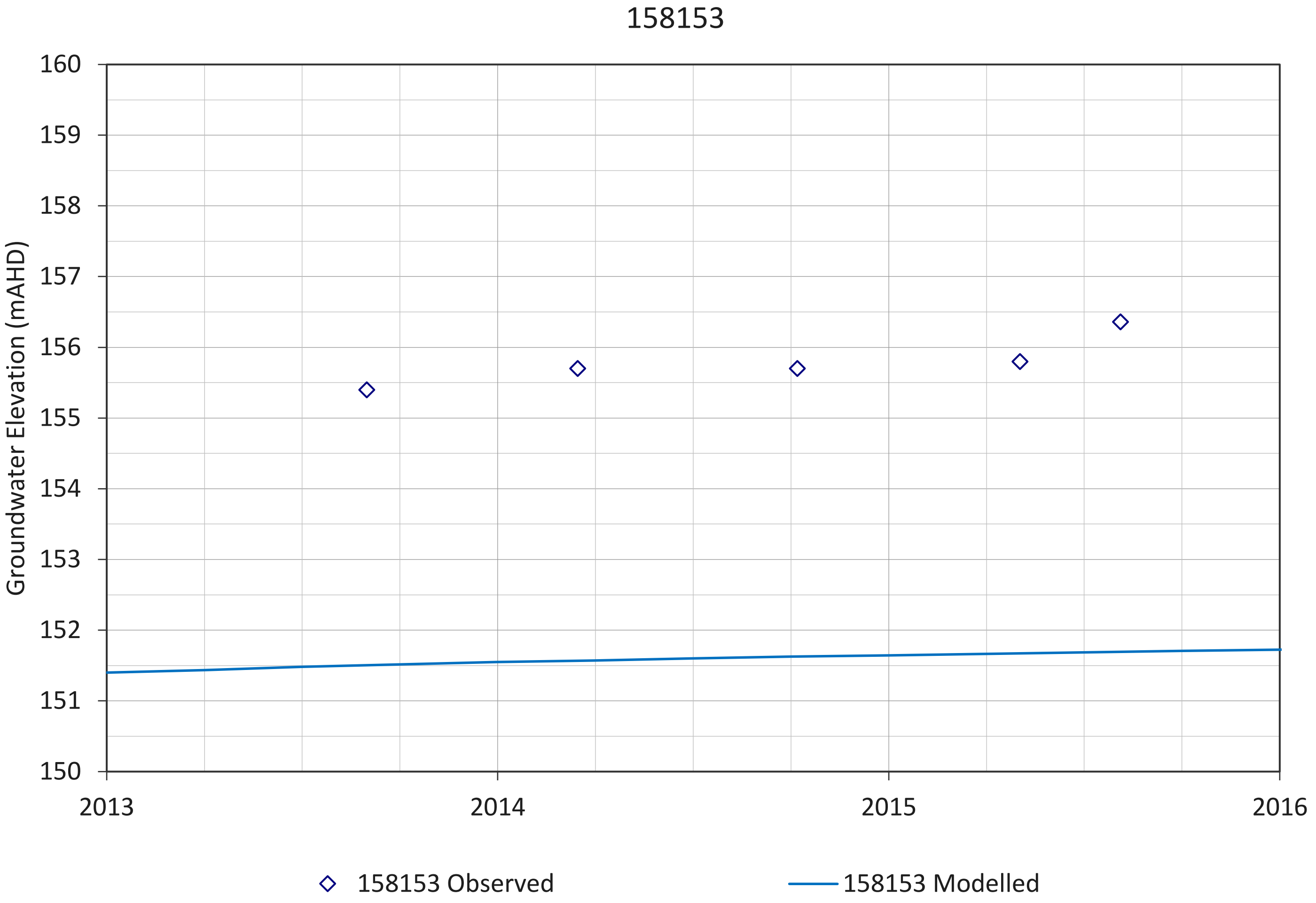

158139
Groundwater Elevation (mAHD)
150
149
148
147
146
145
144
143
142
141
140
2013
2014
2015
2016
158139 Observed
158139 Modelled

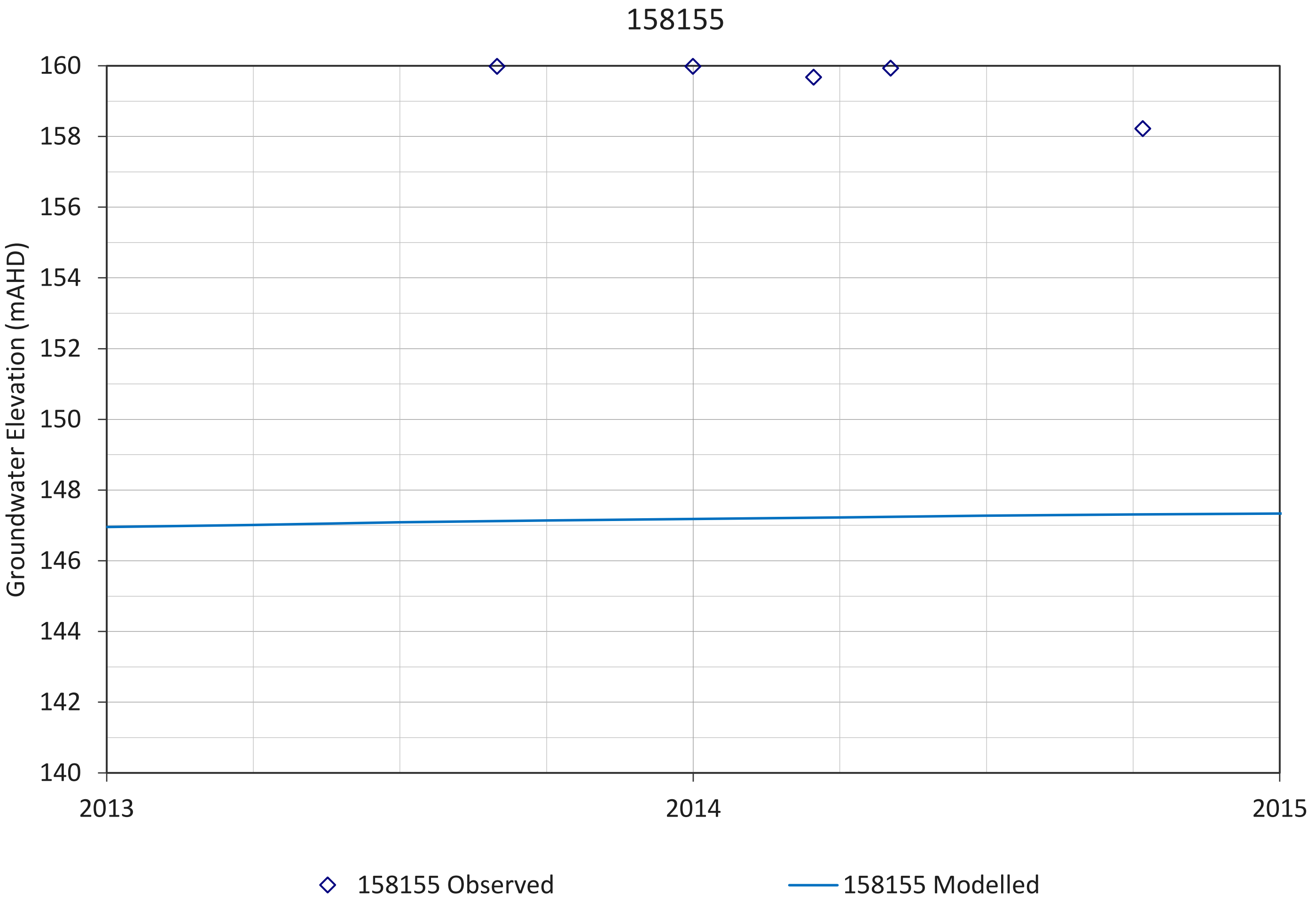

158141
160
158
156
154
152
150
148
146
144
142
140
Groundwater Elevation (mAHD)
2013
2014
2015
158141 Observed
158141 Modelled

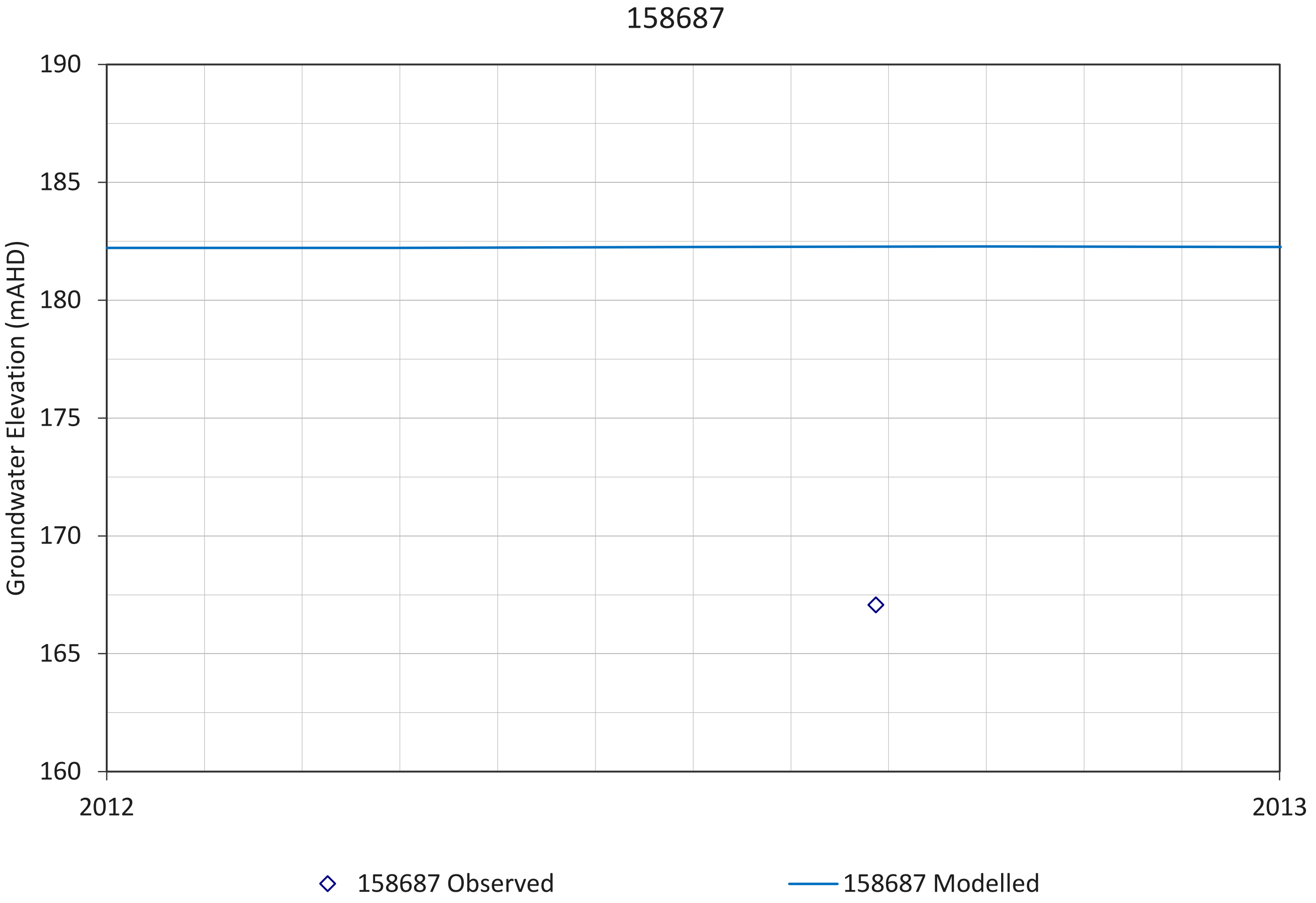

158142
150
149
148
147
146
145
144
143
142
141
140
Groundwater Elevation (mAHD)
2013
2014
2015
158142 Observed
158142 Modelled

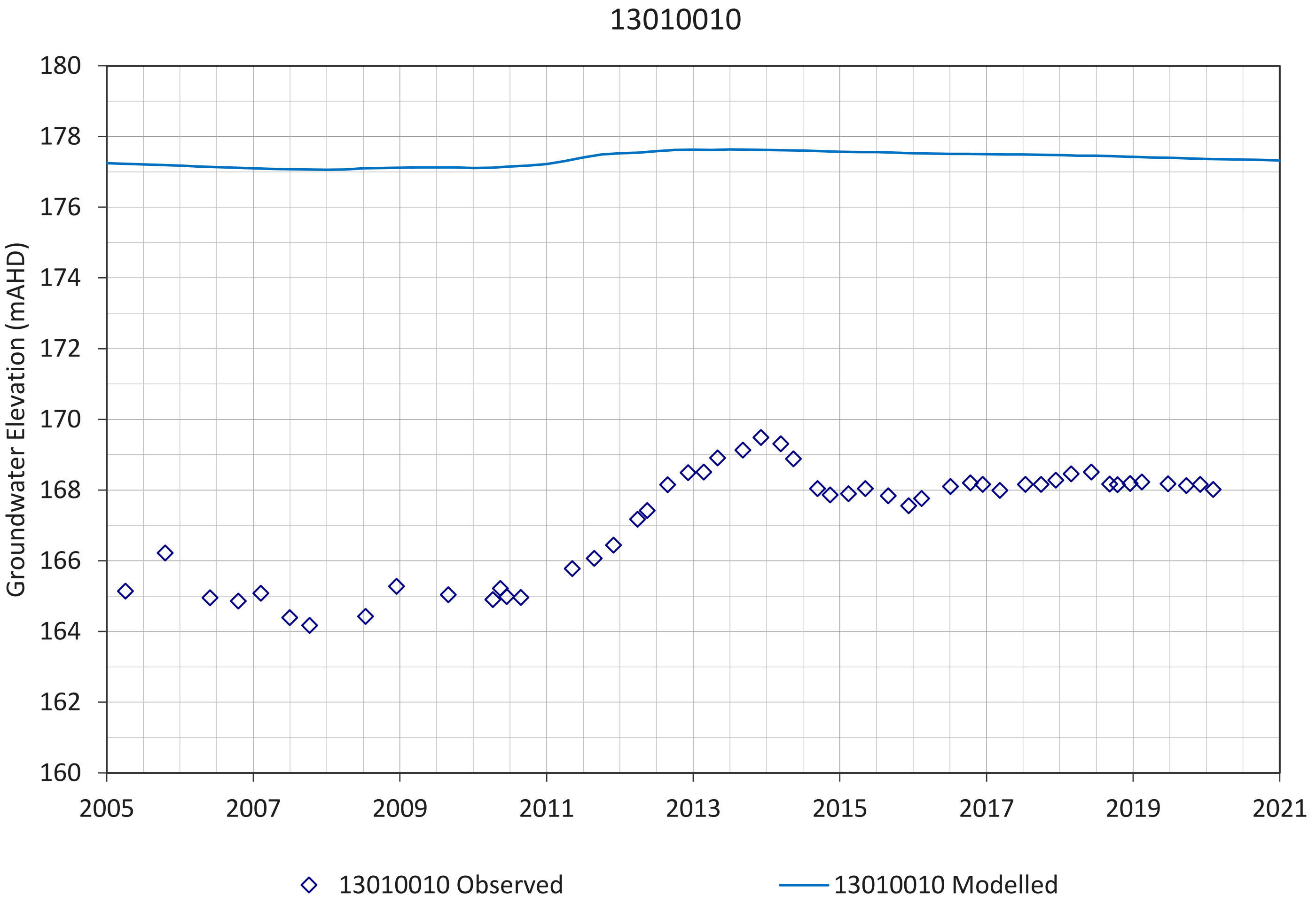

158143
Groundwater Elevation (mAHD)
150
149
148
147
146
145
144
143
142
141
140
2013
2014
2015
2016
158143 Observed
158143 Modelled


158144
Groundwater Elevation (mAHD)
150
149
148
147
146
145
144
143
142
141
140
2013
2014
2015
2016
158144 Observed
158144 Modelled


158153
160
159
158
157
156
155
154
153
152
151
150
Groundwater Elevation (mAHD)
2013
2014
2015
2016
158153 Observed
158153 Modelled


158155
160
158
156
154
152
150
148
146
144
142
140
Groundwater Elevation (mAHD)
2013
2014
2015
158155 Observed
158155 Modelled


158687
190
185
180
175
170
165
160
Groundwater Elevation (mAHD)
2012
2013
158687 Observed
158687 Modelled


13010010
180
178
176
174
172
170
168
166
164
162
160
Groundwater Elevation (mAHD)
2005
2007
2009
2011
2013
2015
2017
2019
2021
13010010 Observed
13010010 Modelled

Appendix C Calibrated Hydraulic Parameters

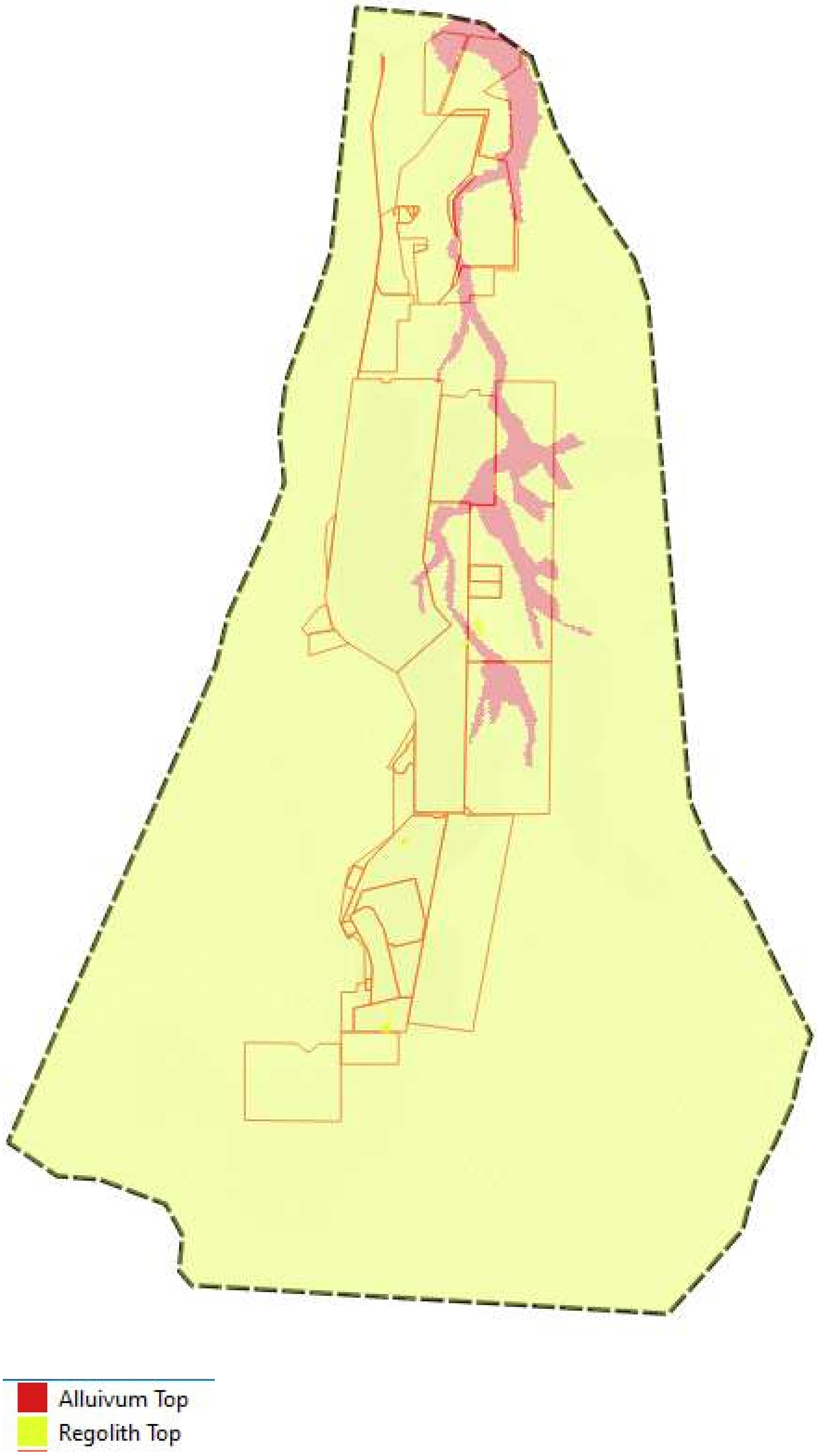
Blackwater Mine - North Extension Project

Groundwater Modelling Technical Report

BM Alliance Coal Operations Pty Ltd

SLR Project No.: 620.014601.00006

29 November 2023



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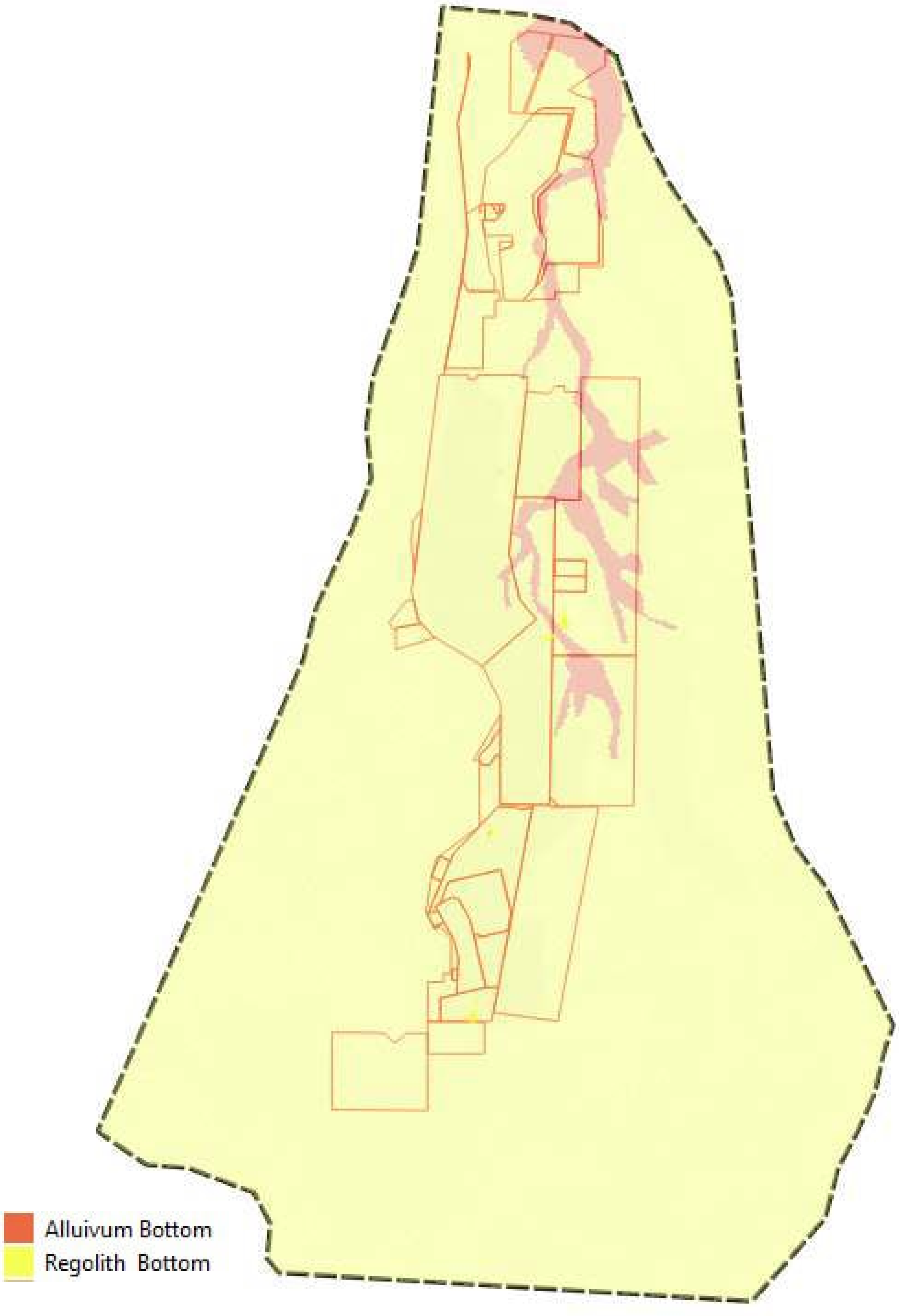

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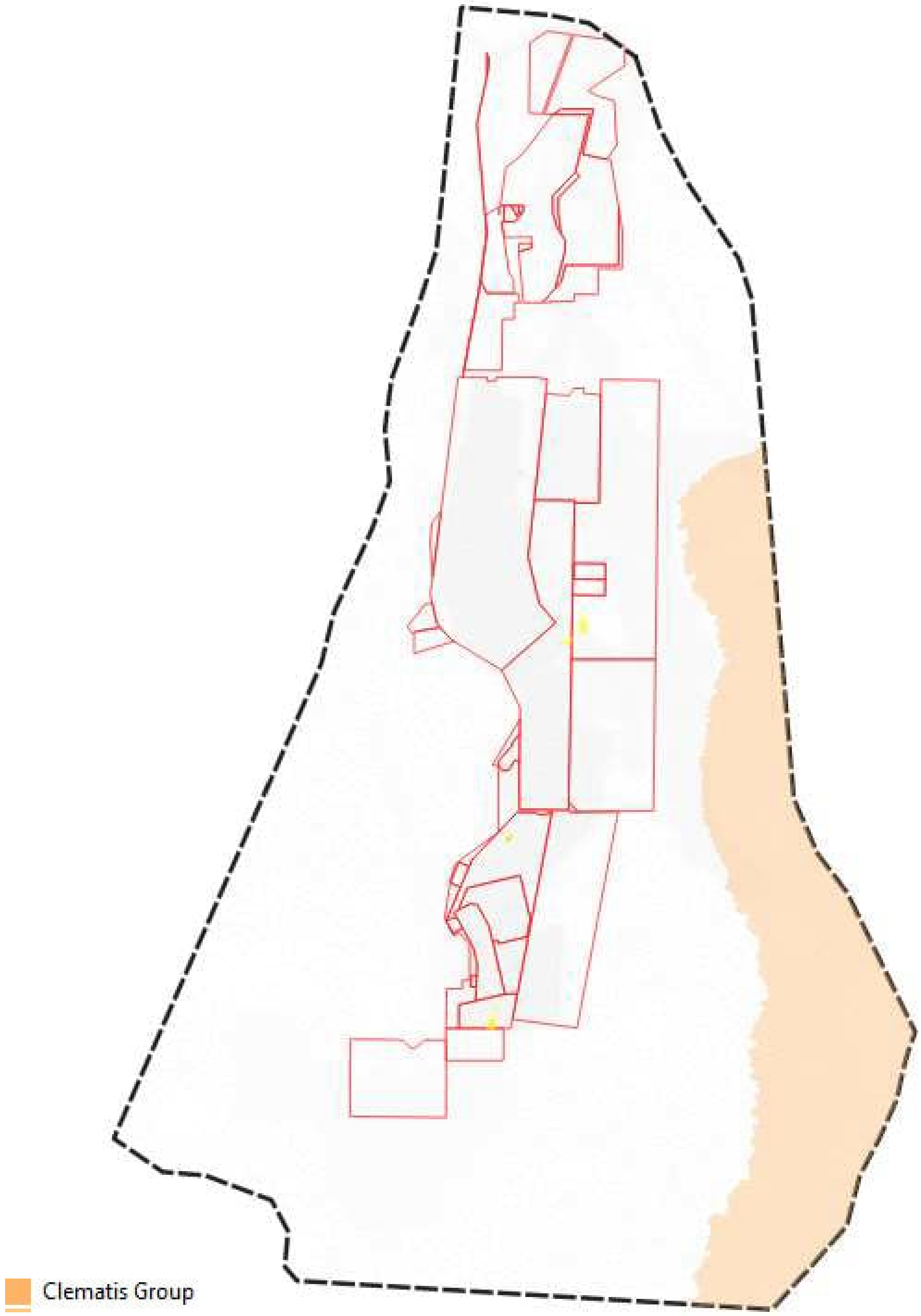

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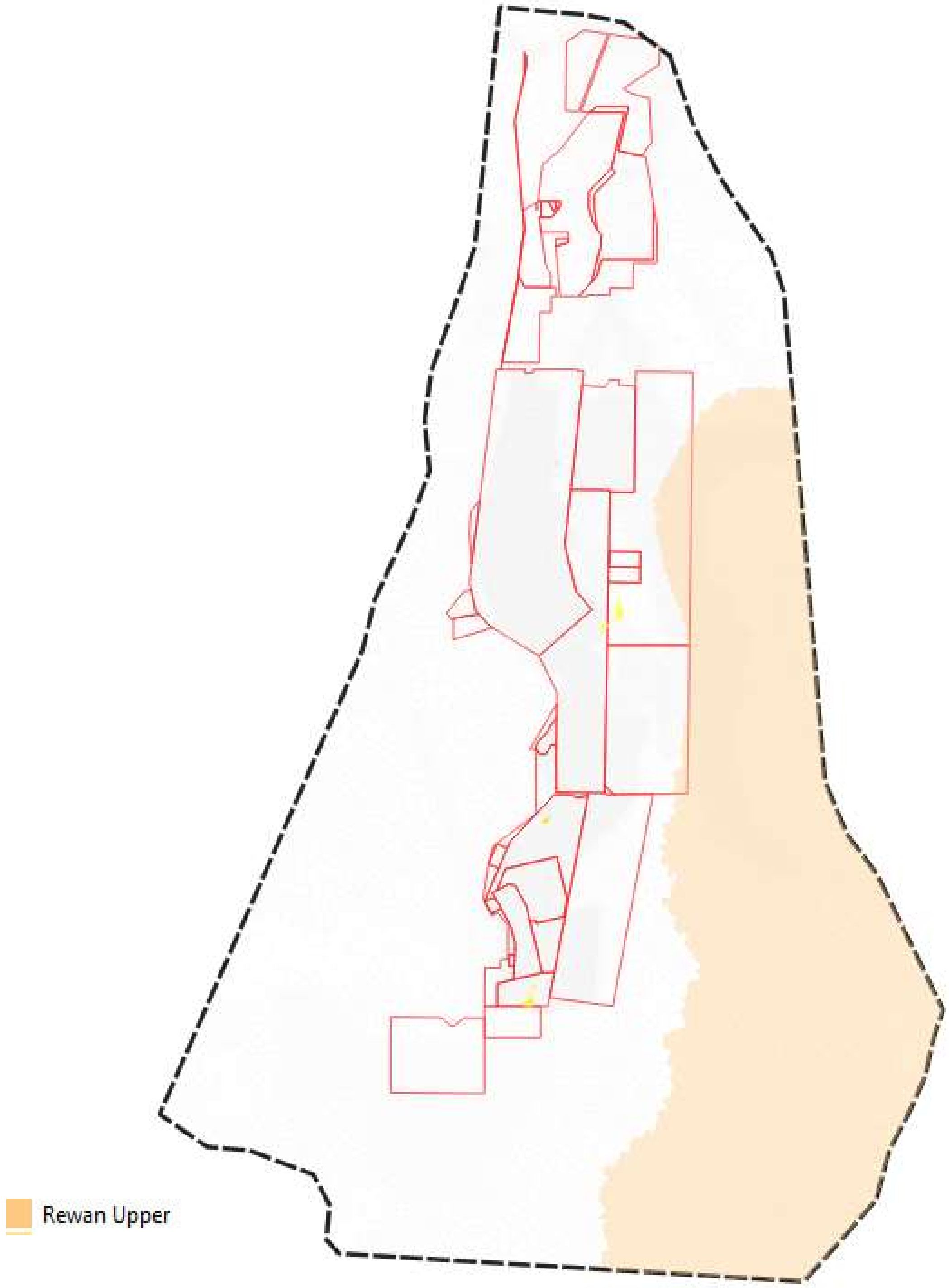

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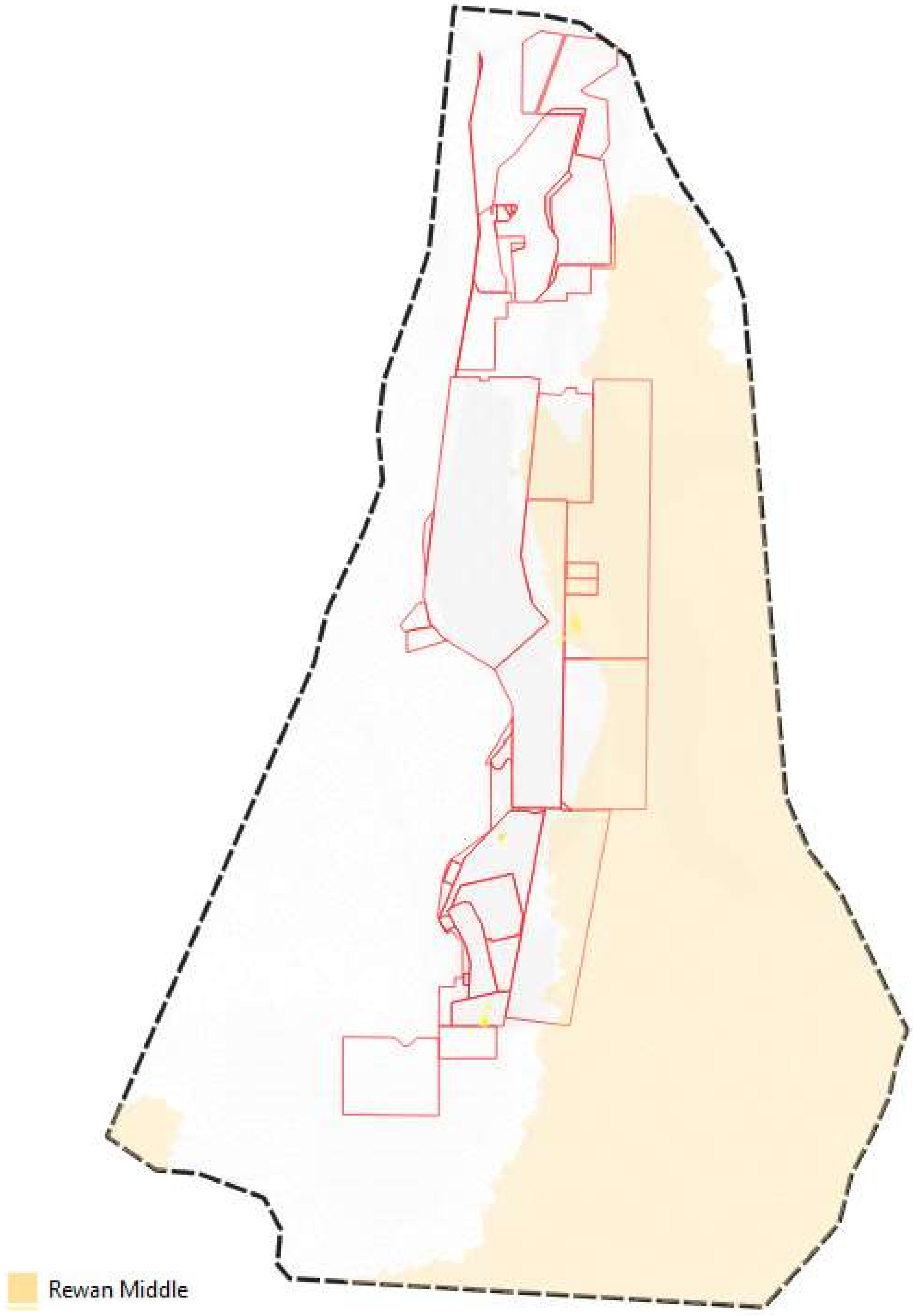

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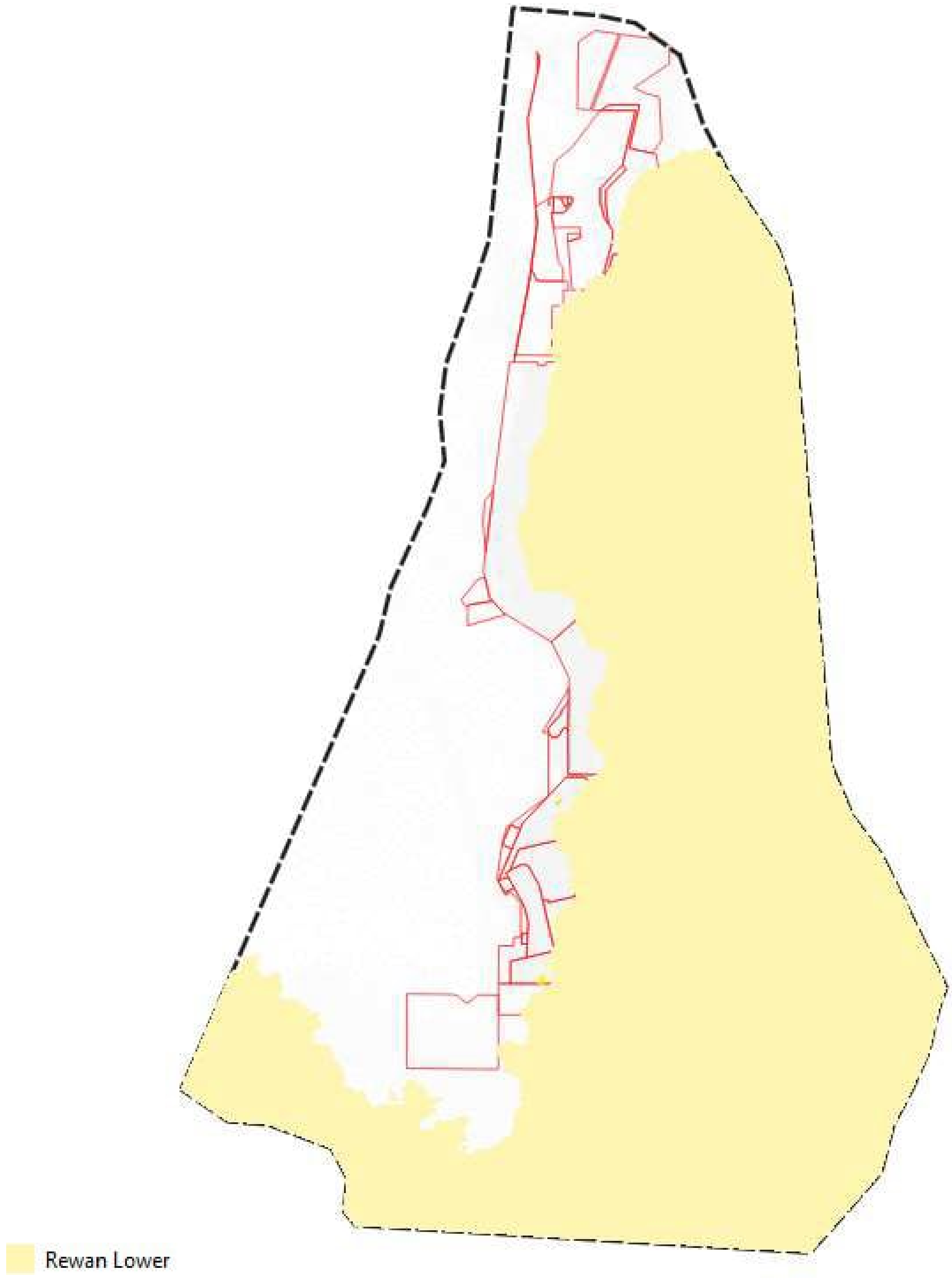

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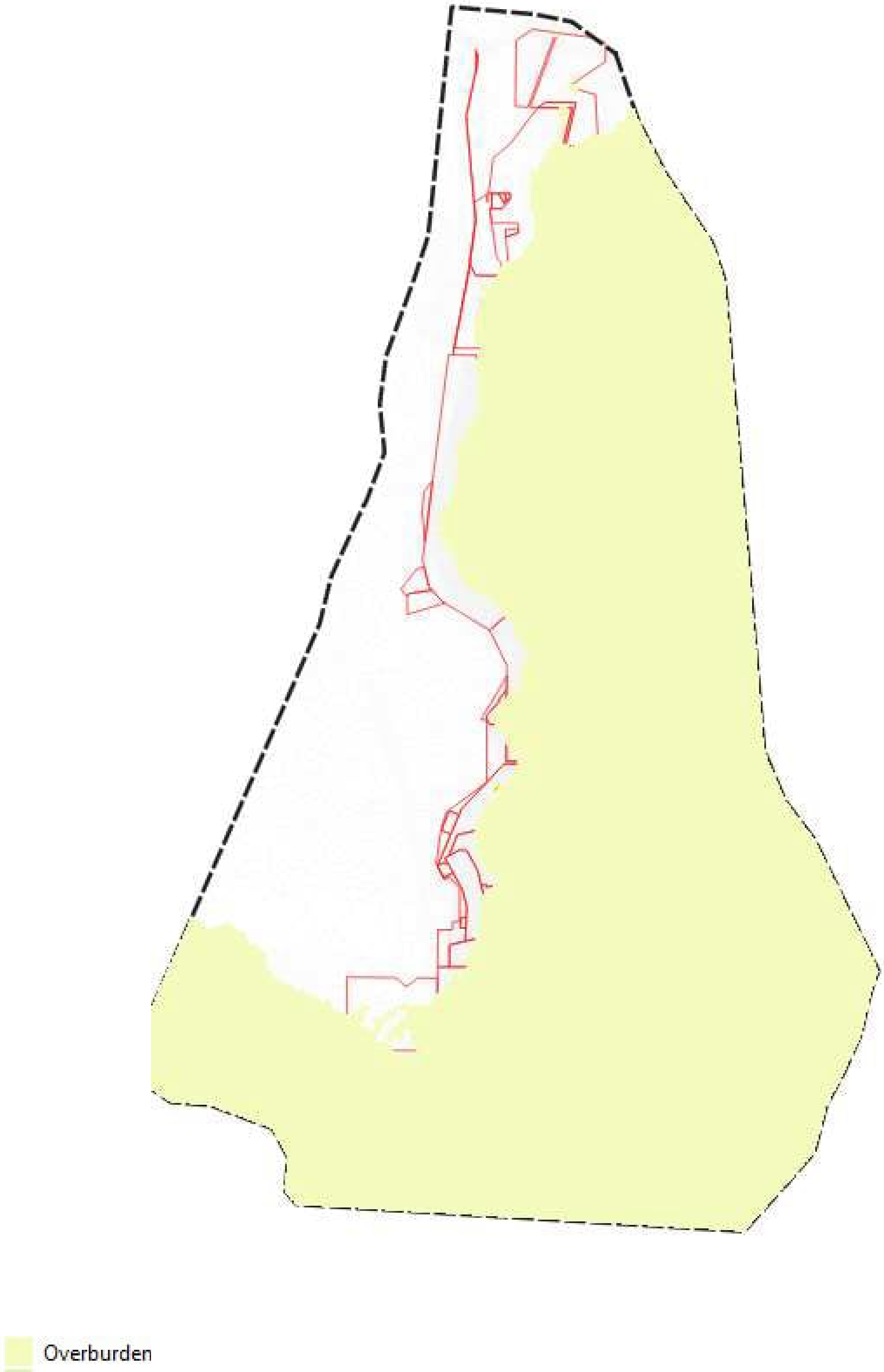

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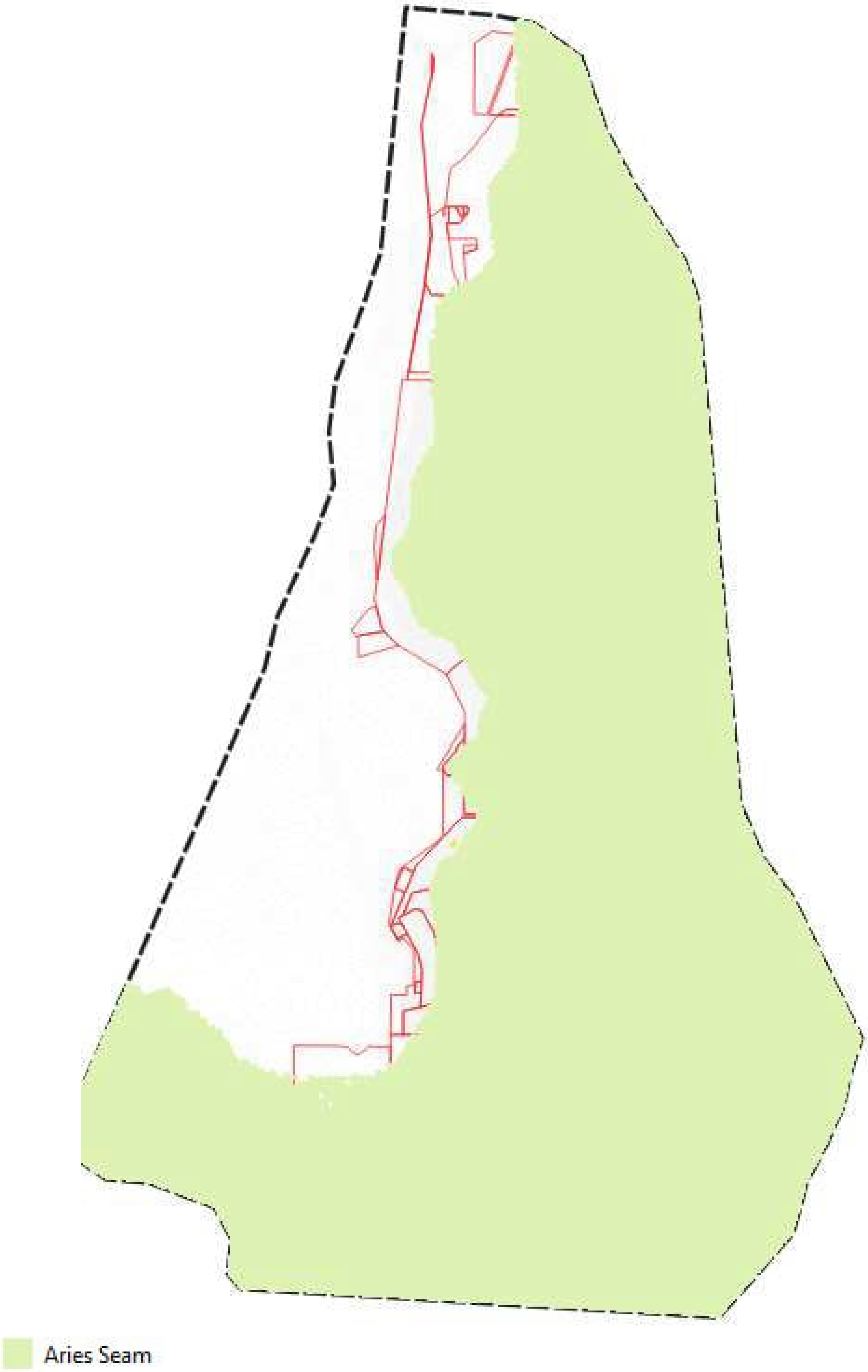

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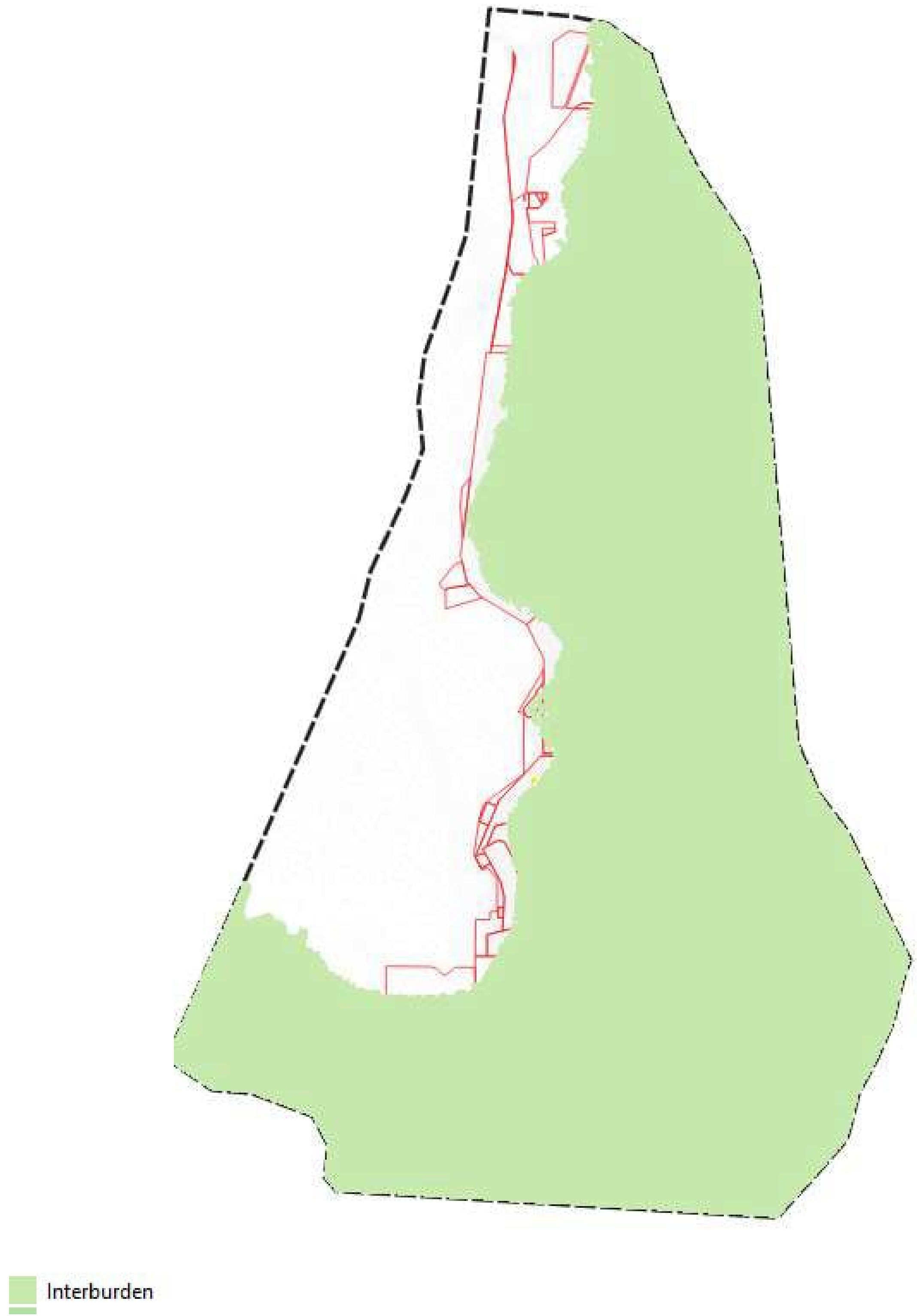

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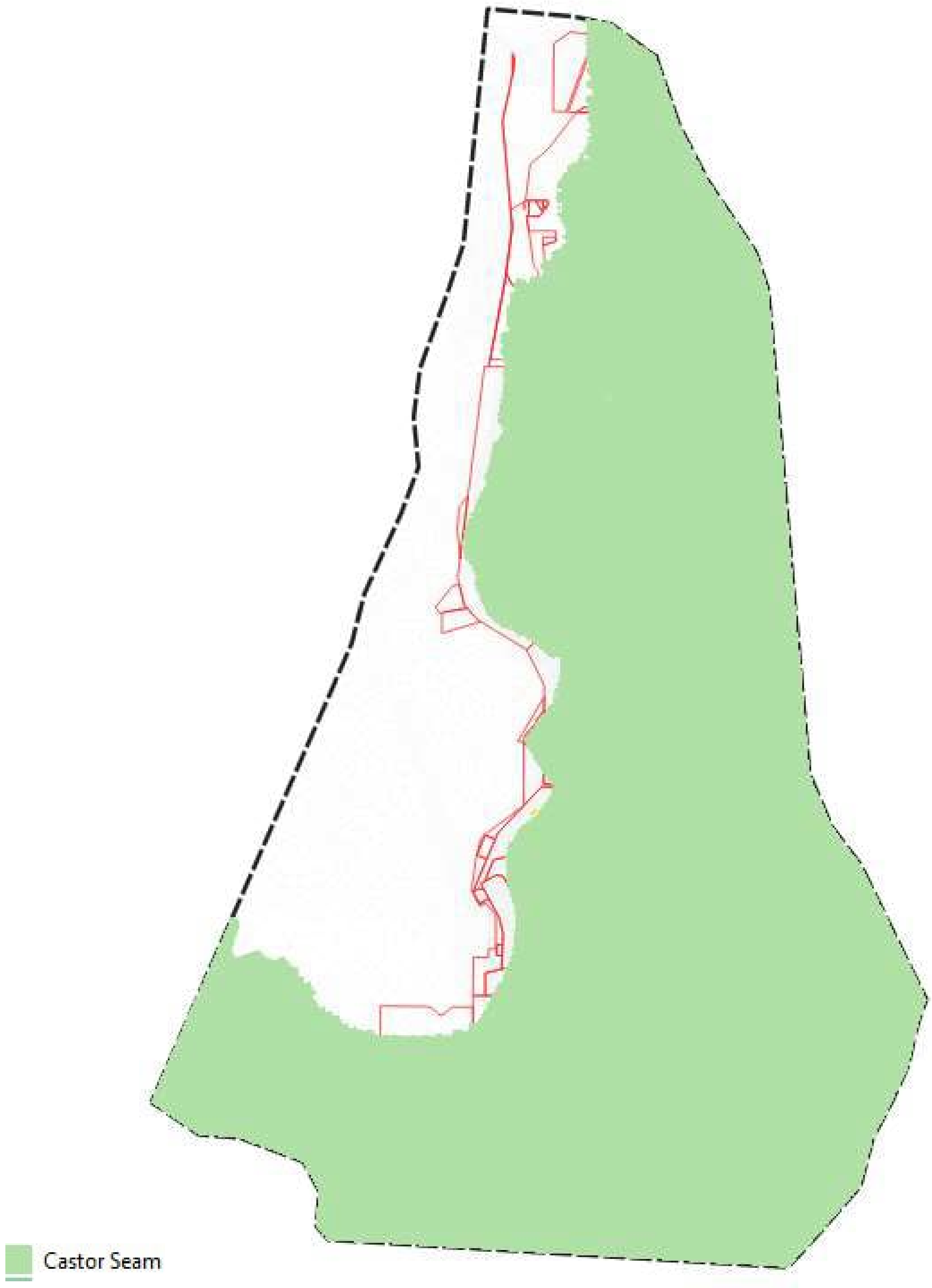

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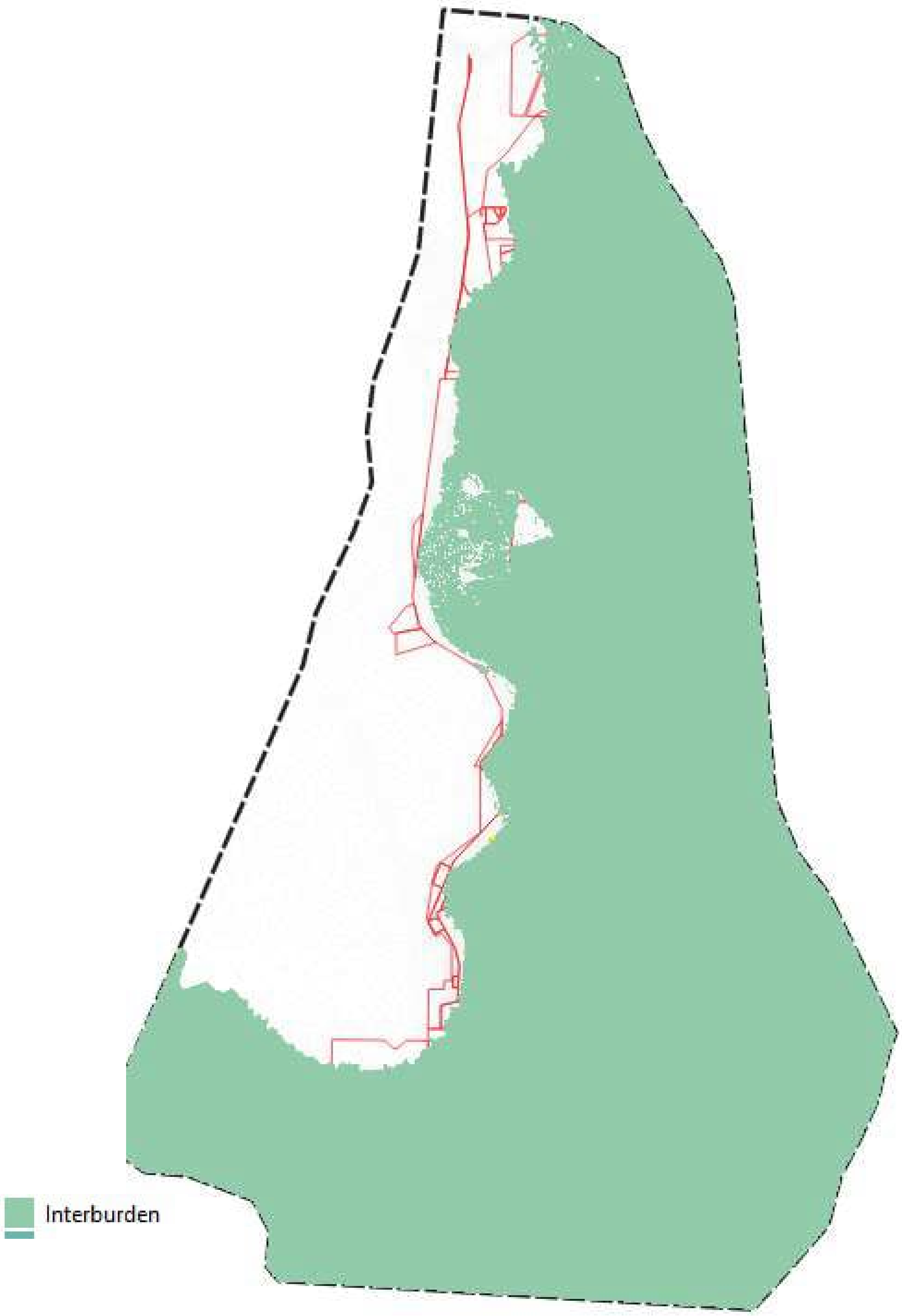

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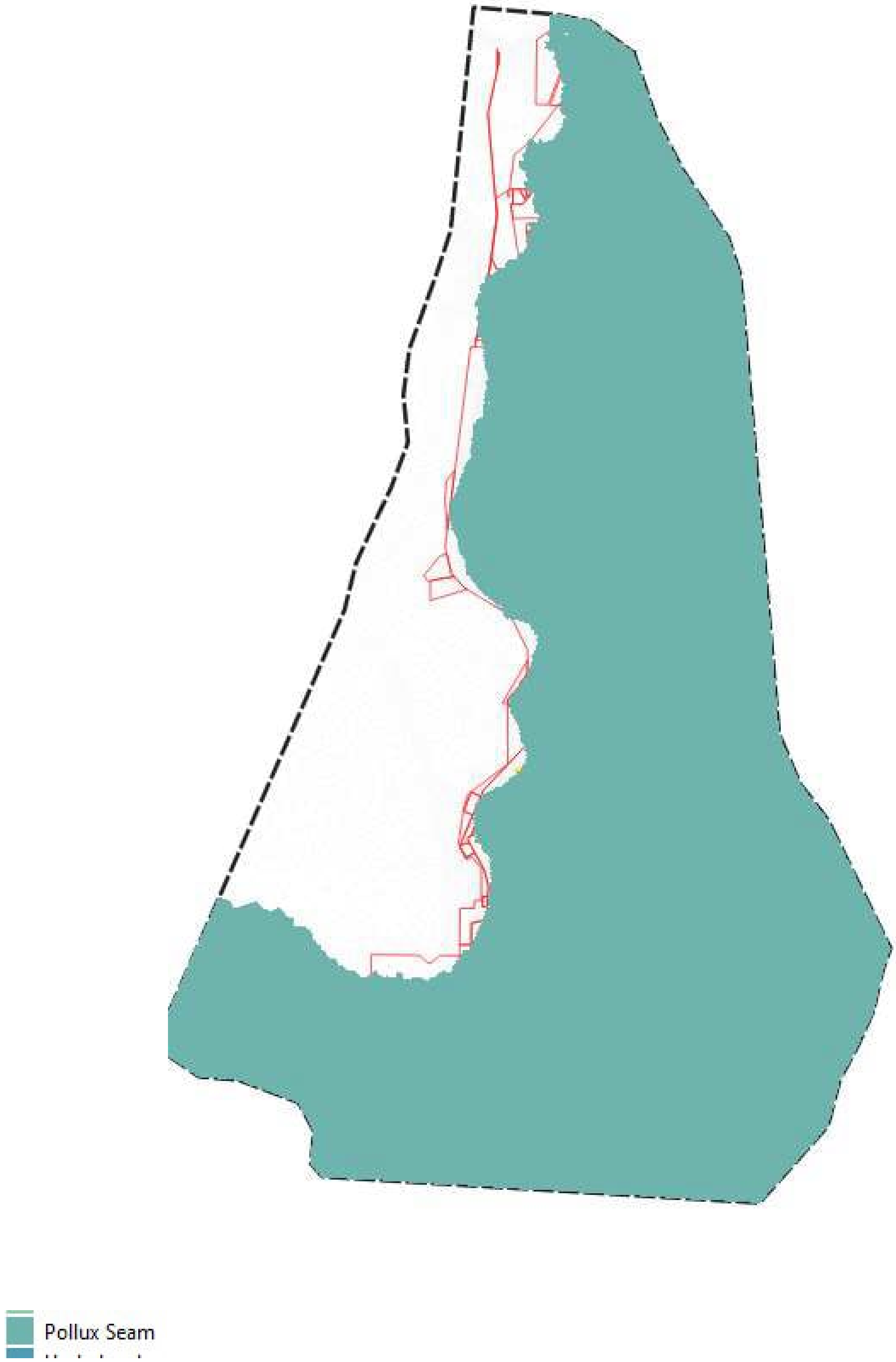

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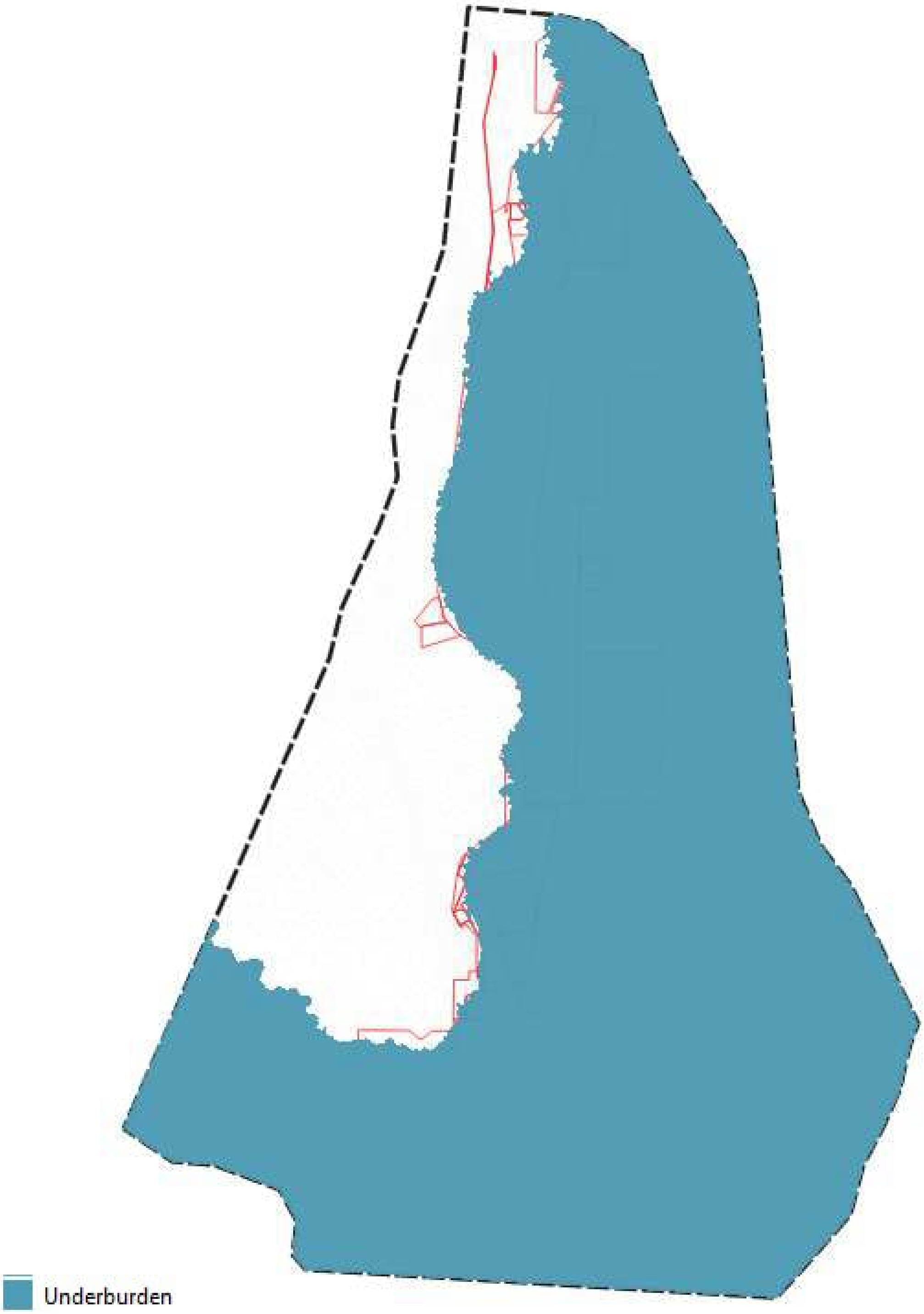

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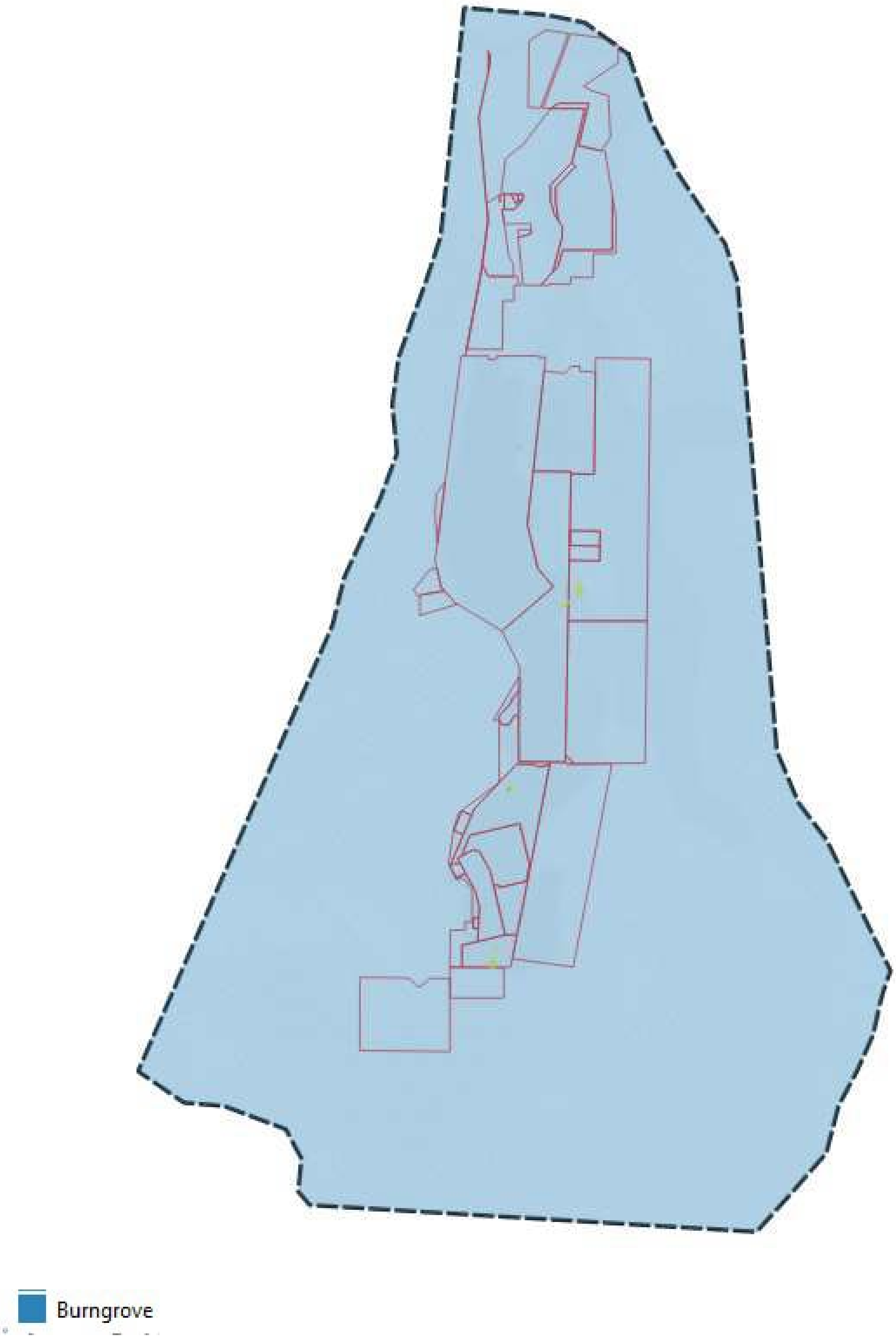


Layer 14

Appendix D Prior and posterior distribution plot (UA)

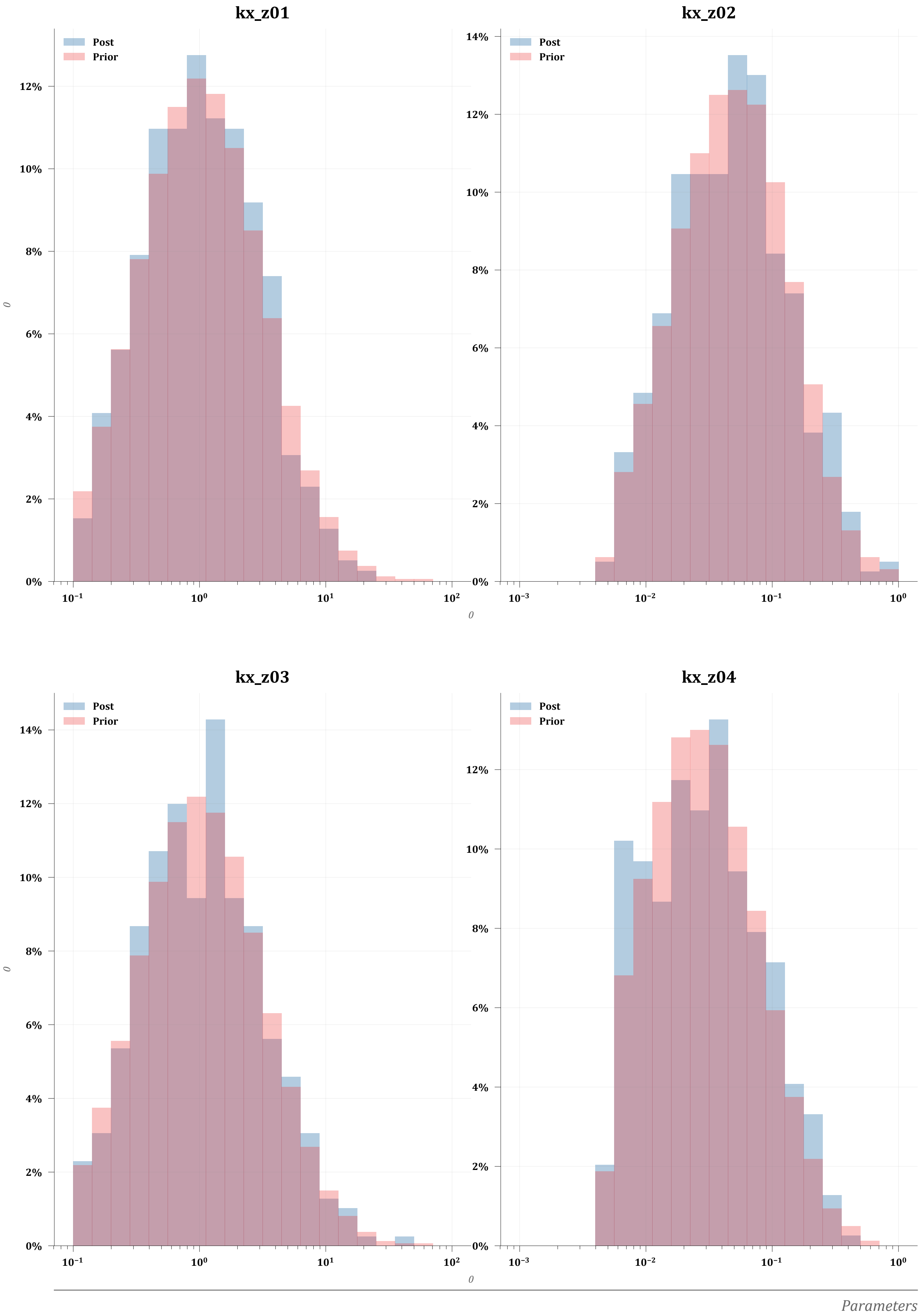
Blackwater Mine - North Extension Project

Groundwater Modelling Technical Report

BM Alliance Coal Operations Pty Ltd

SLR Project No.: 620.014601.00006

29 November 2023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kx_z02
kx_z03
kx_z04
Post
Prior
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2%
4%
6%
8%
10%
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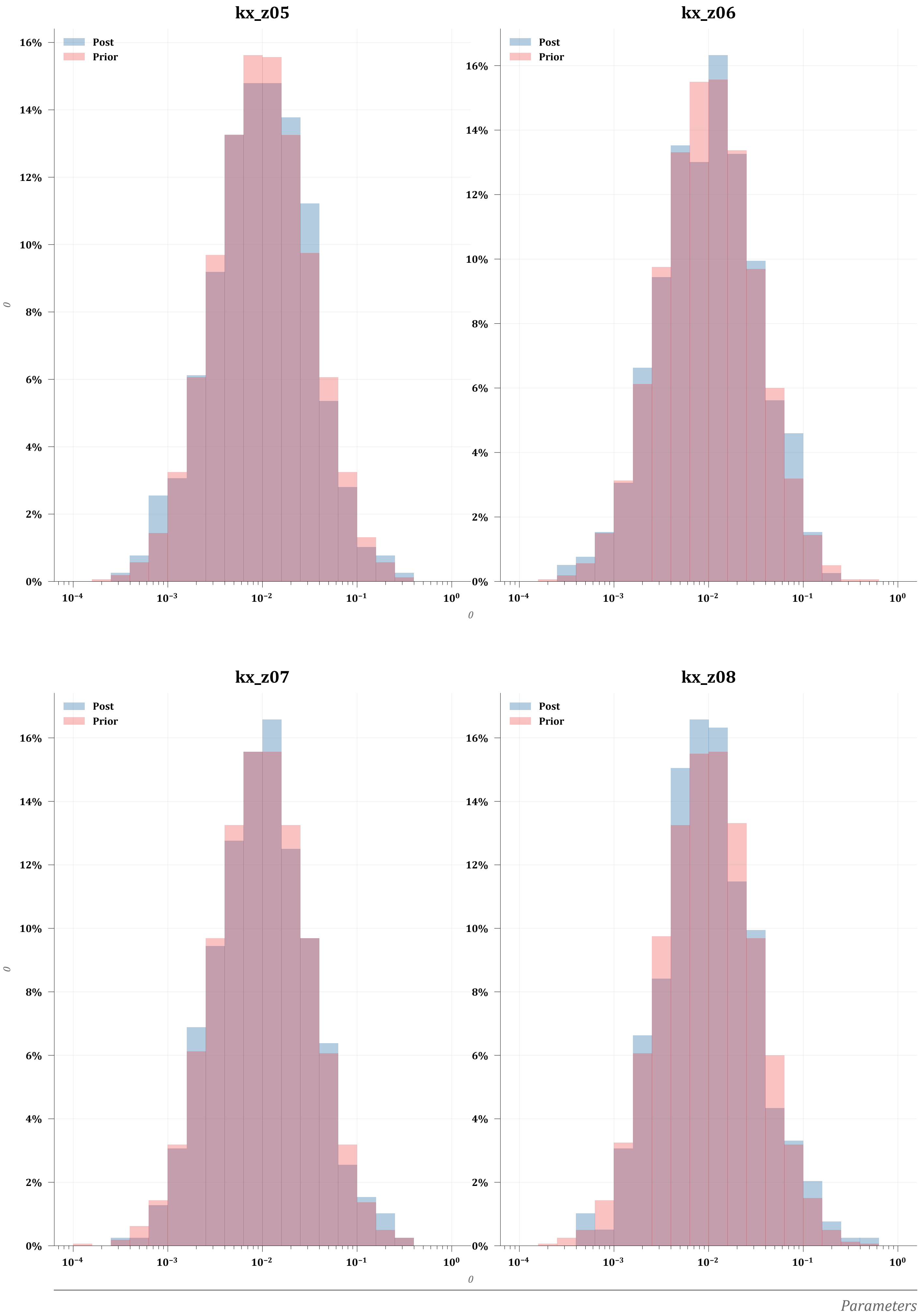
10^{-3}
10^{-2}
Parameters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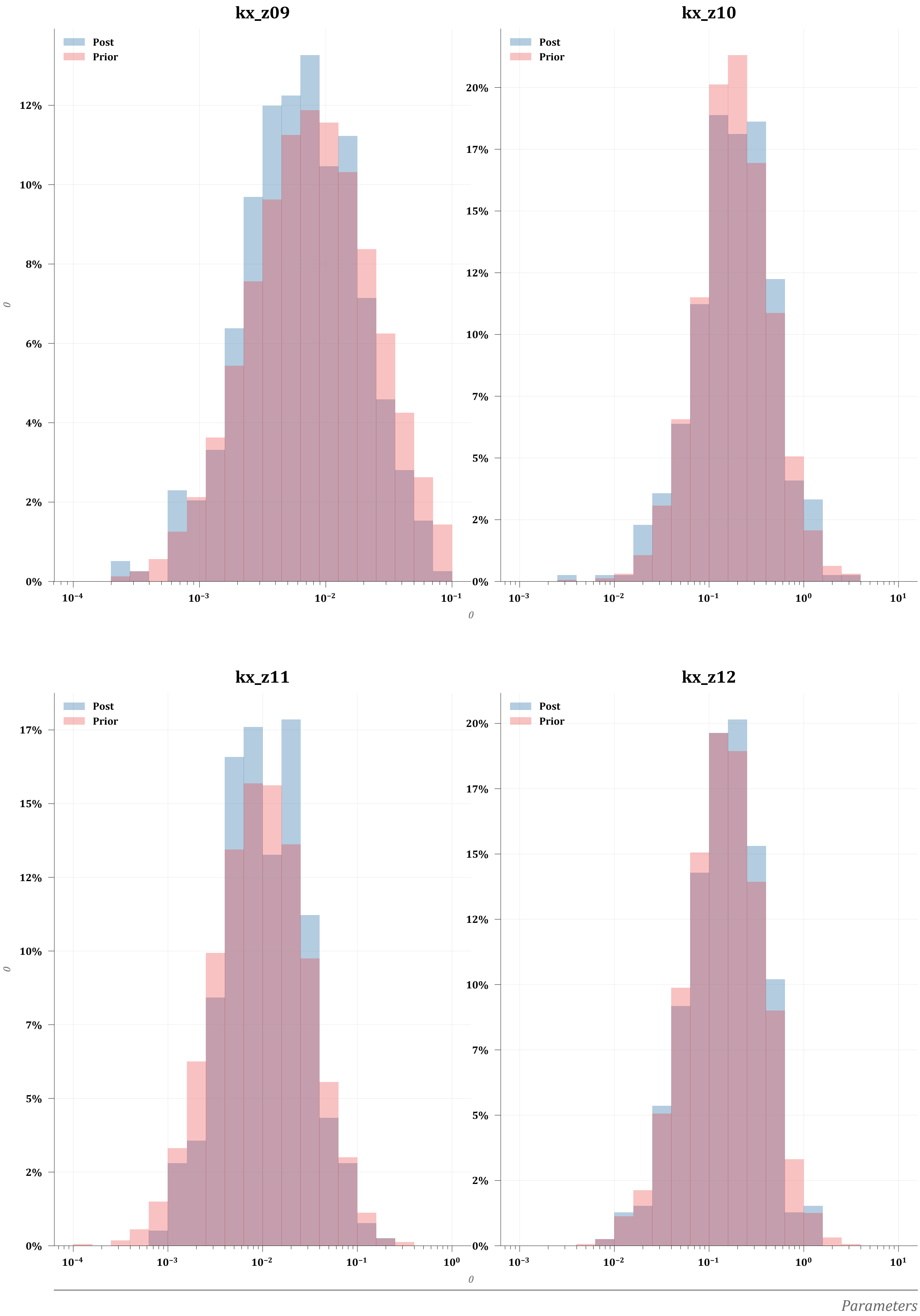
10^{-1}
10^{0}
0
Parameters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Prior
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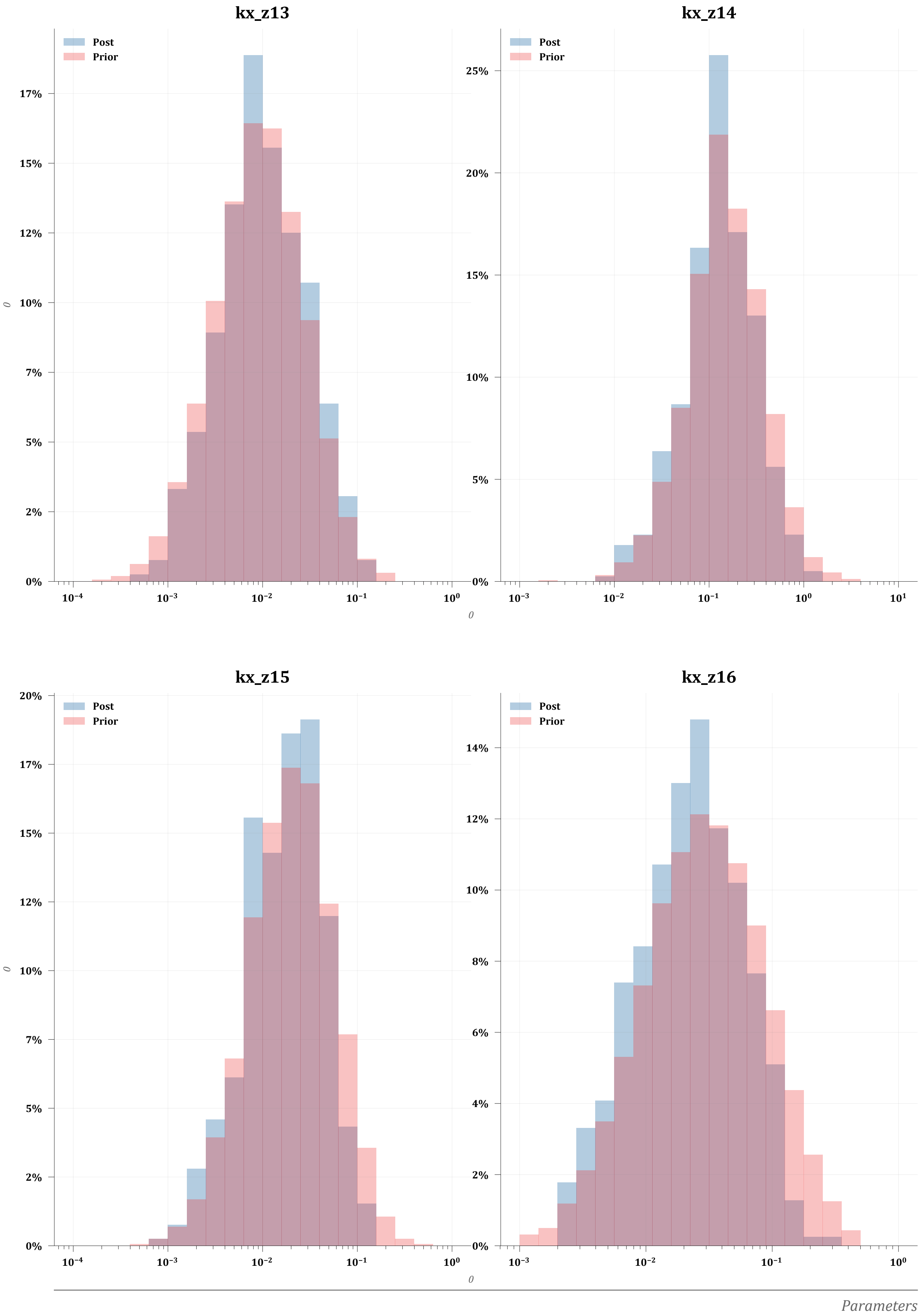
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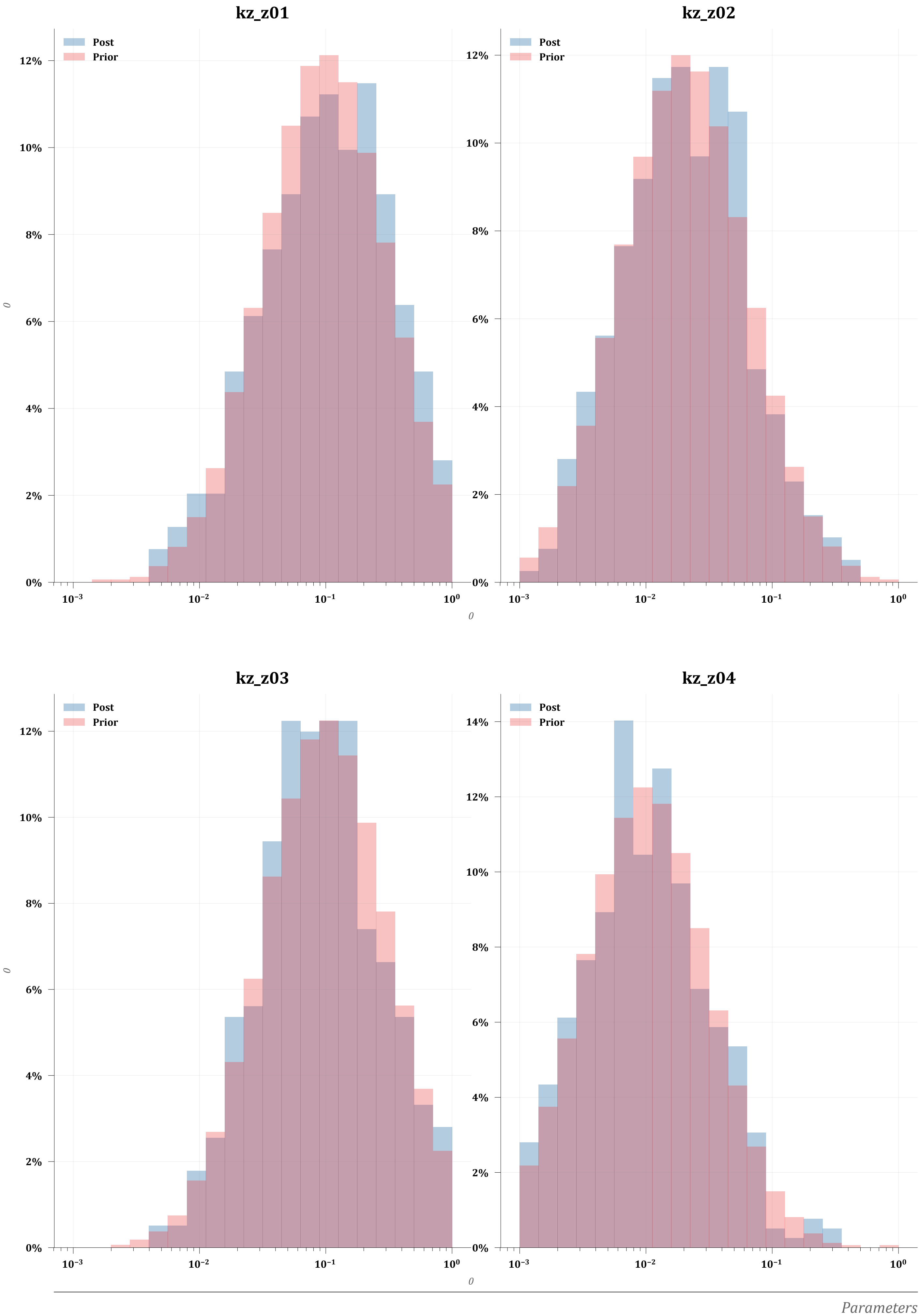
Prior
kx_z14
Post
Prior
kx_z15
Post
Prior
kx_z16
Post
Prior
0
Parameters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10%
8%
6%
4%
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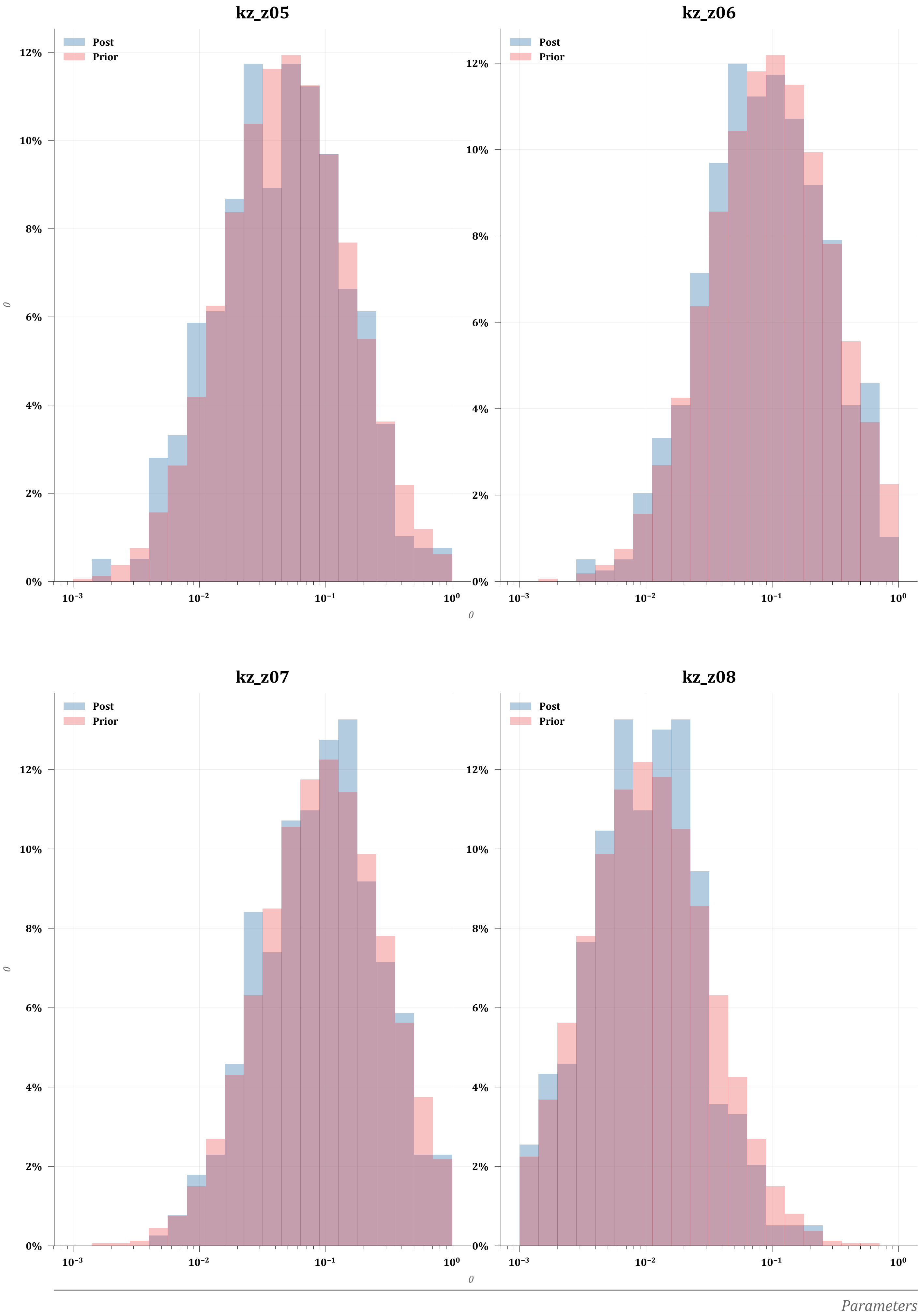
10⁻²
10⁻¹
10⁰
kz_z02
kz_z03
kz_z04
14%
Parameters


kz_z05
kz_z06
kz_z07
kz_z08
Post
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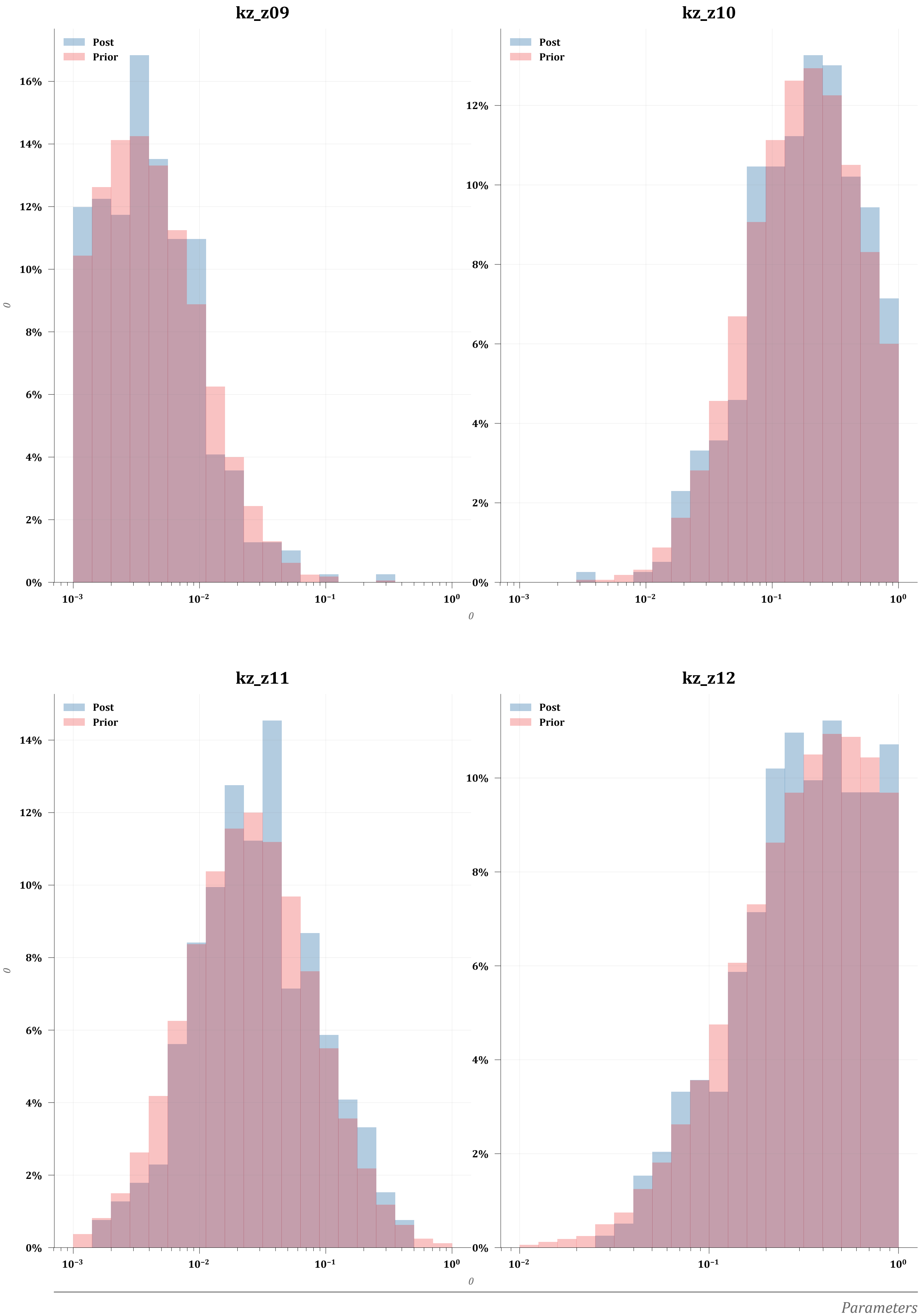
8%
6%
4%
2%
0%
10⁻³
10⁻²
10⁻¹
10⁰
0
Parameters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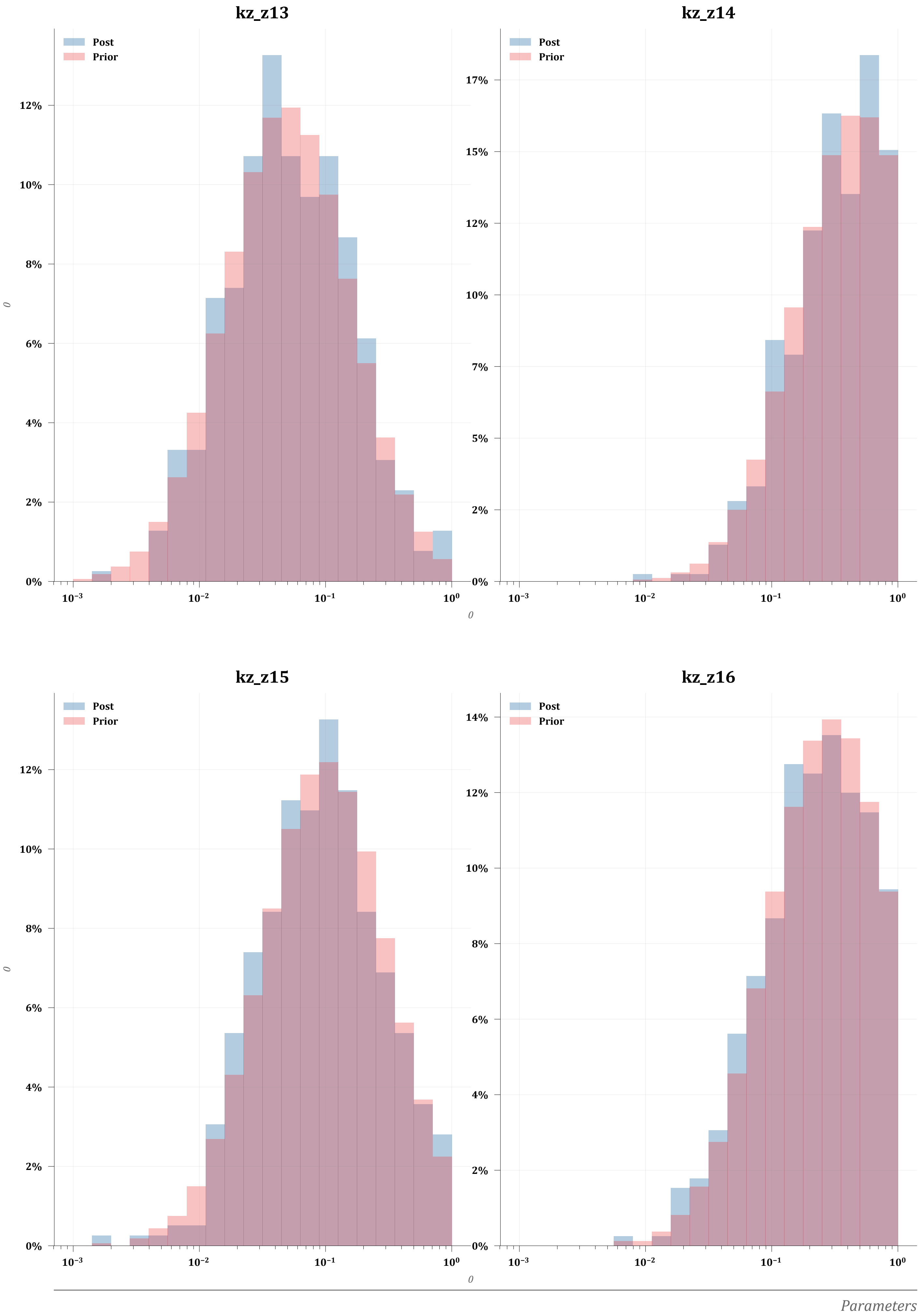
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Prior
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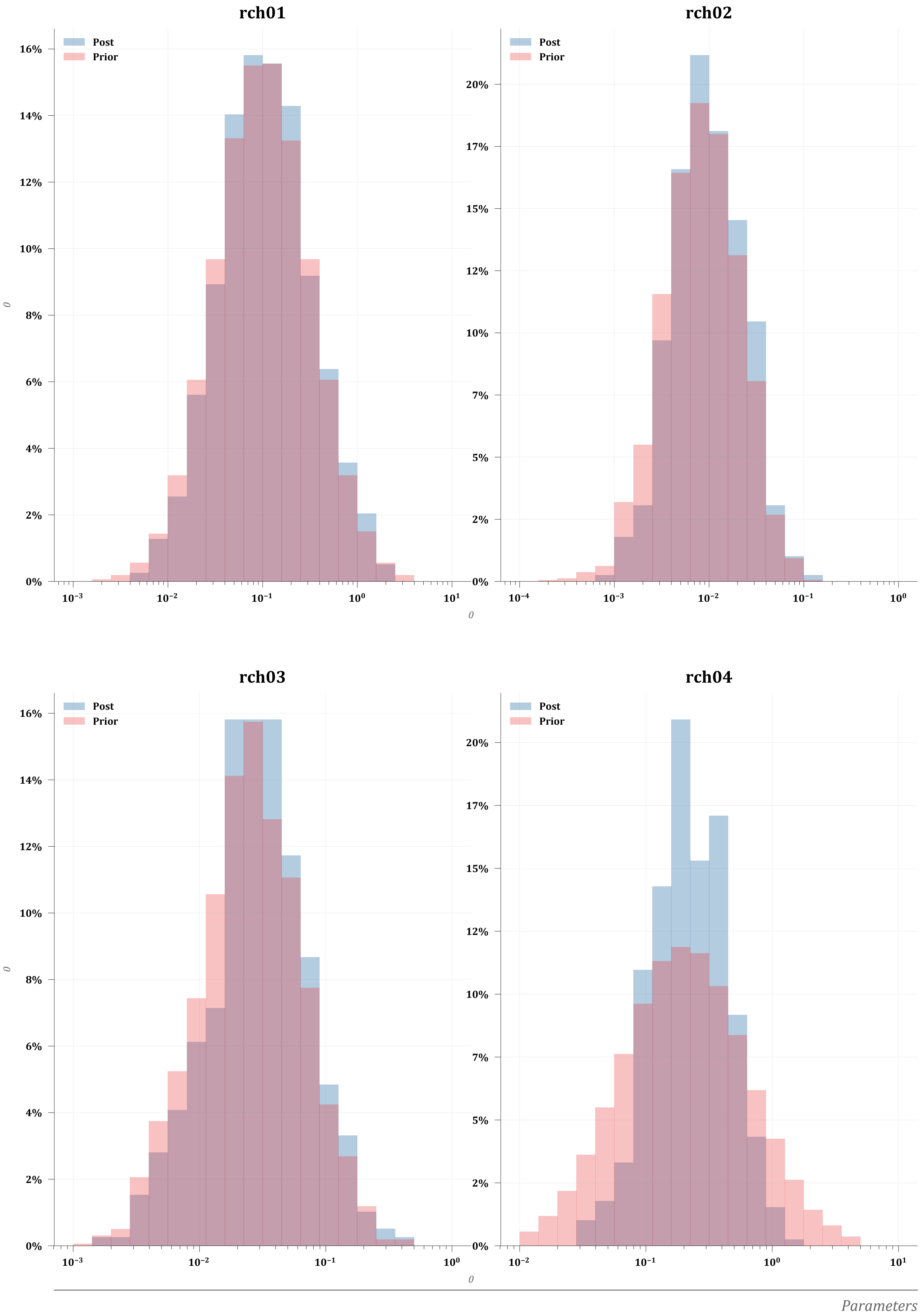
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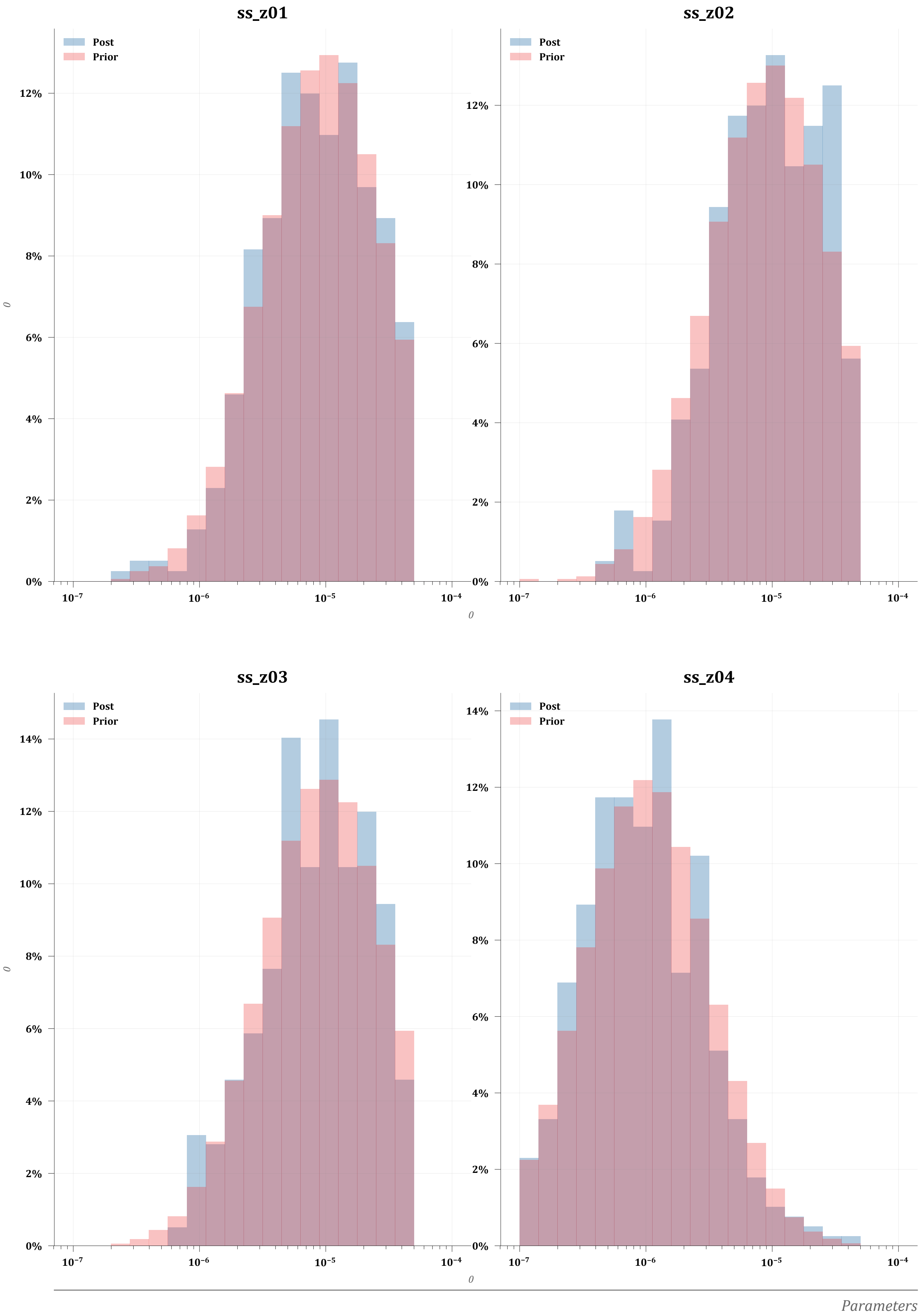
rch02
rch03
rch04
Post
Prior
Parameters


ss_z01
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14%
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10^{-6}
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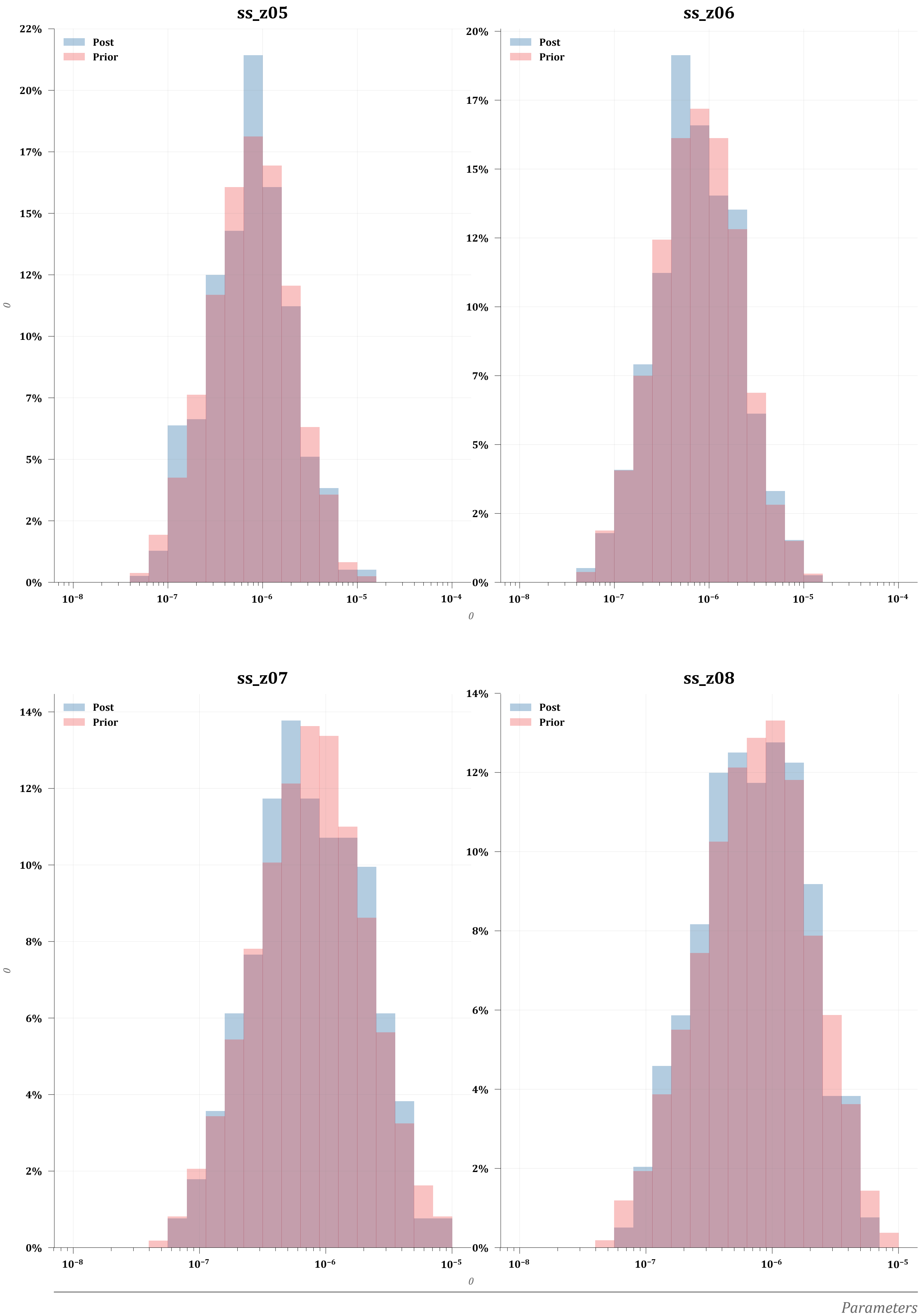
0
Parameters



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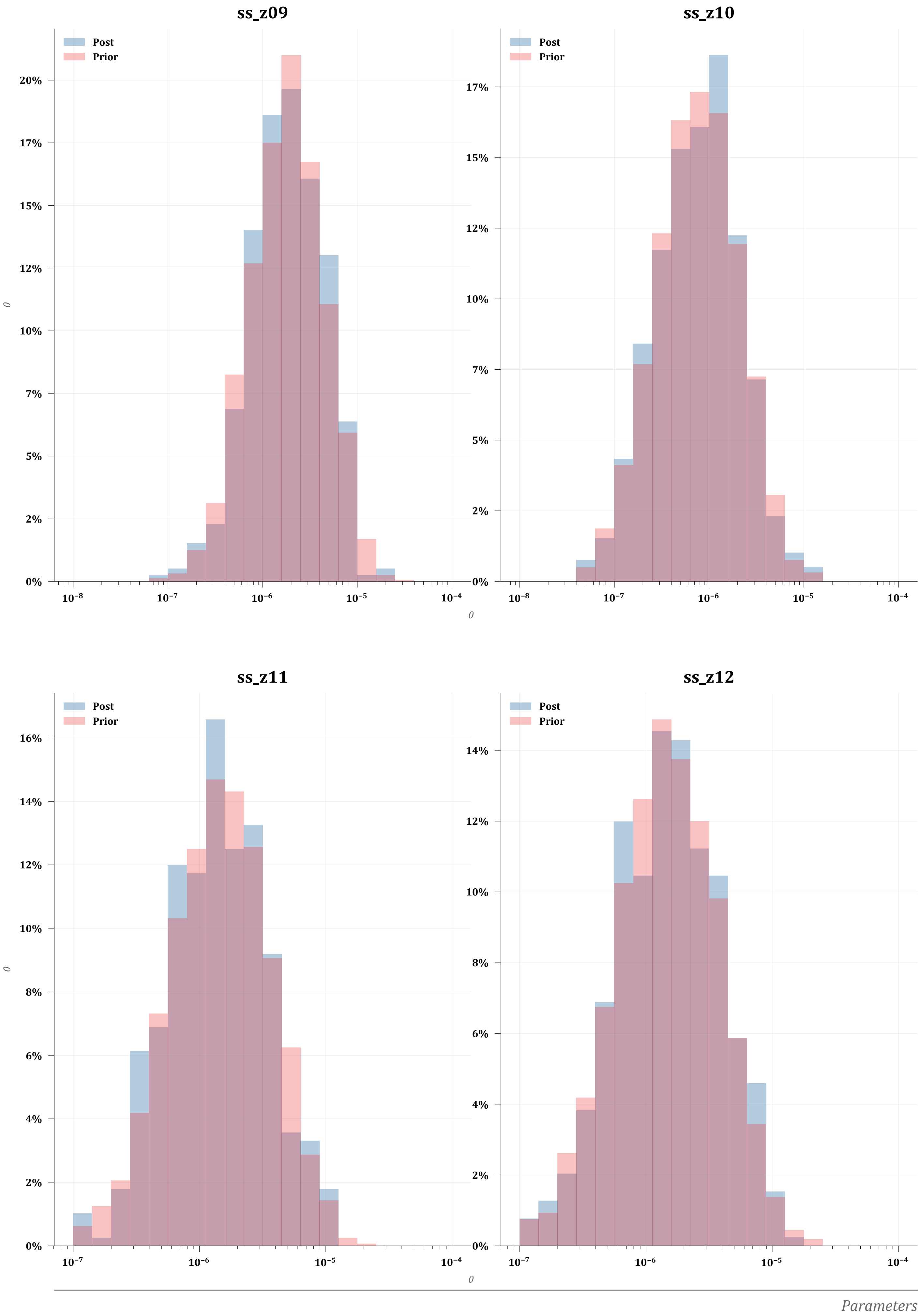
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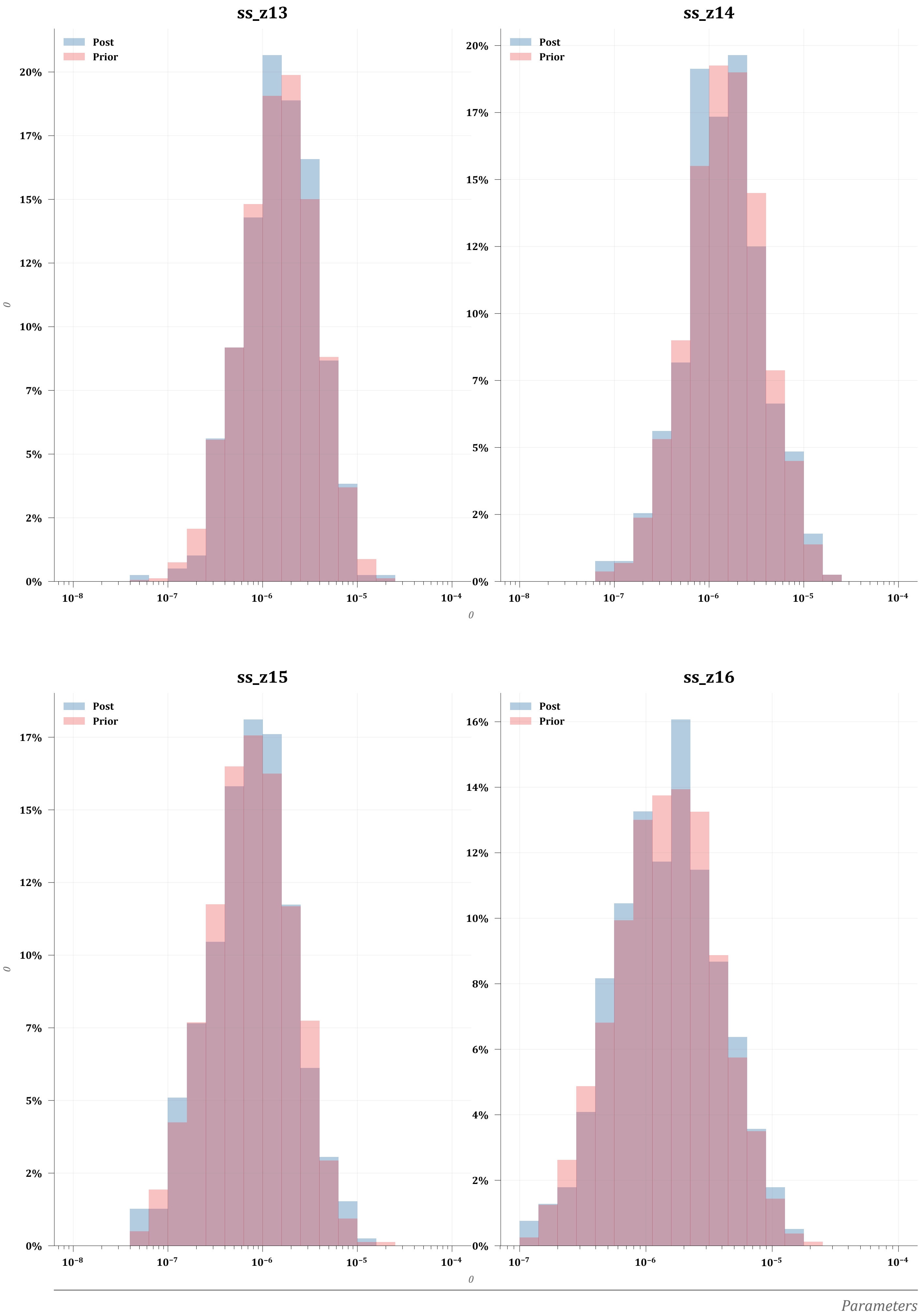
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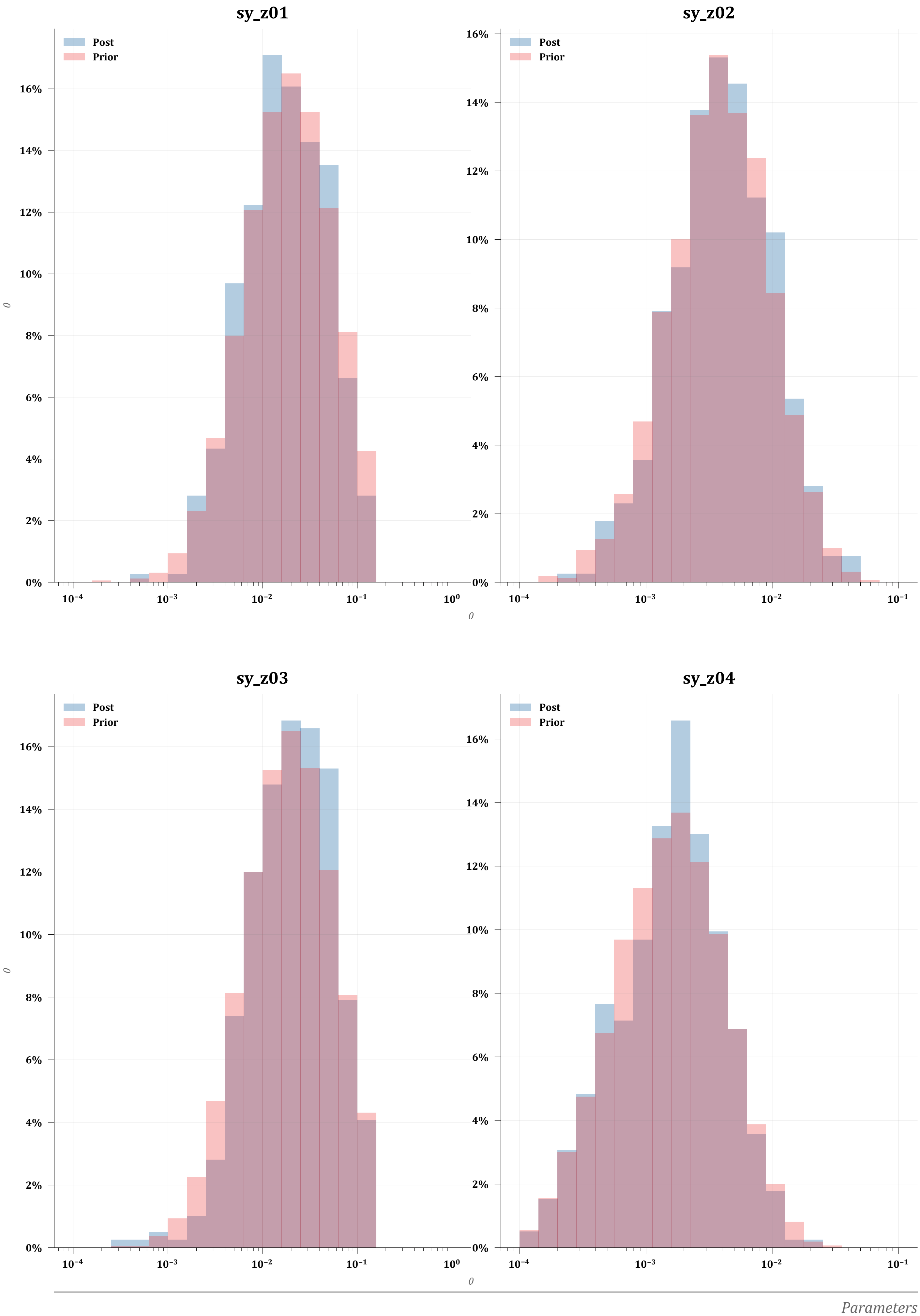
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Prior
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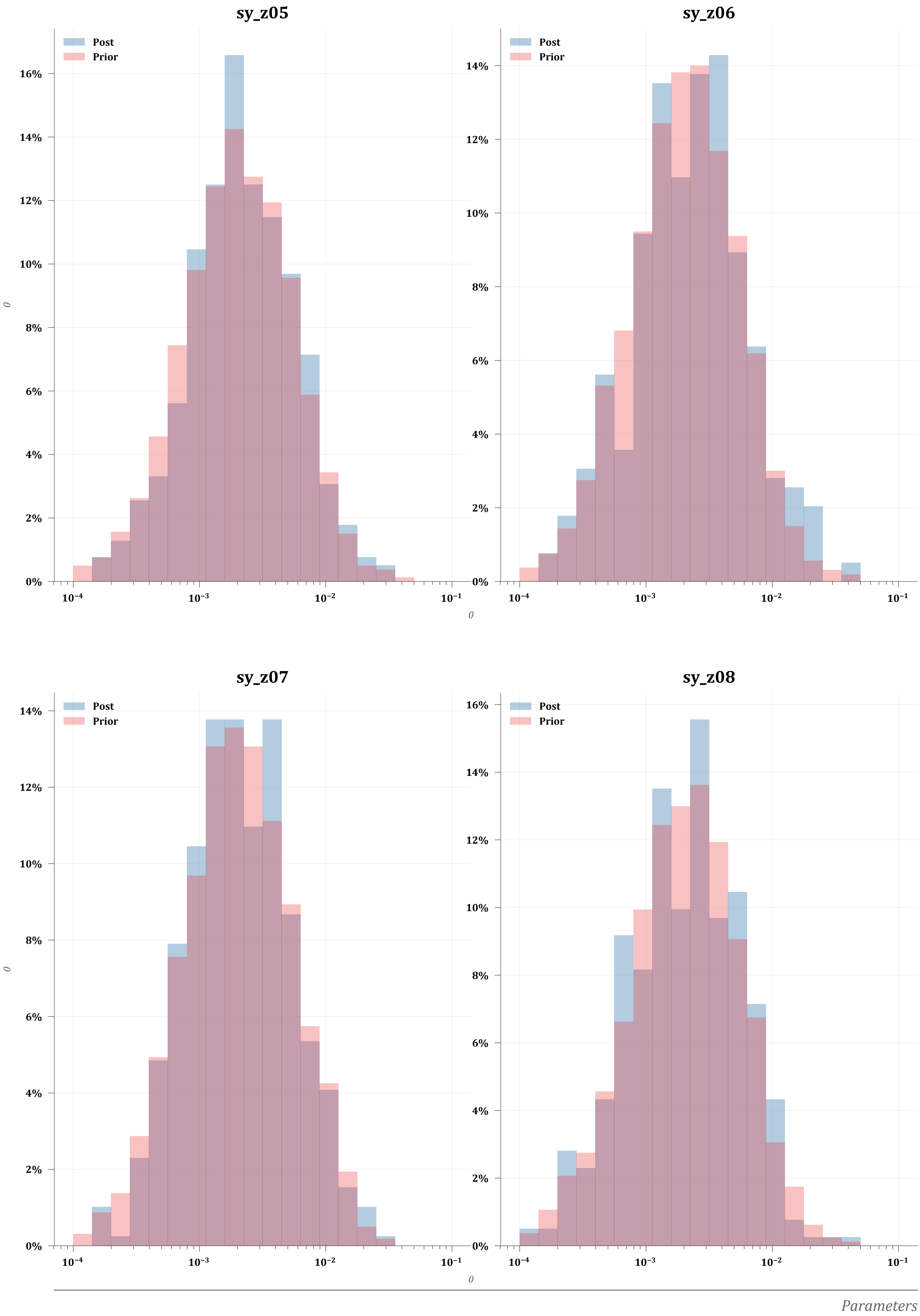
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16%
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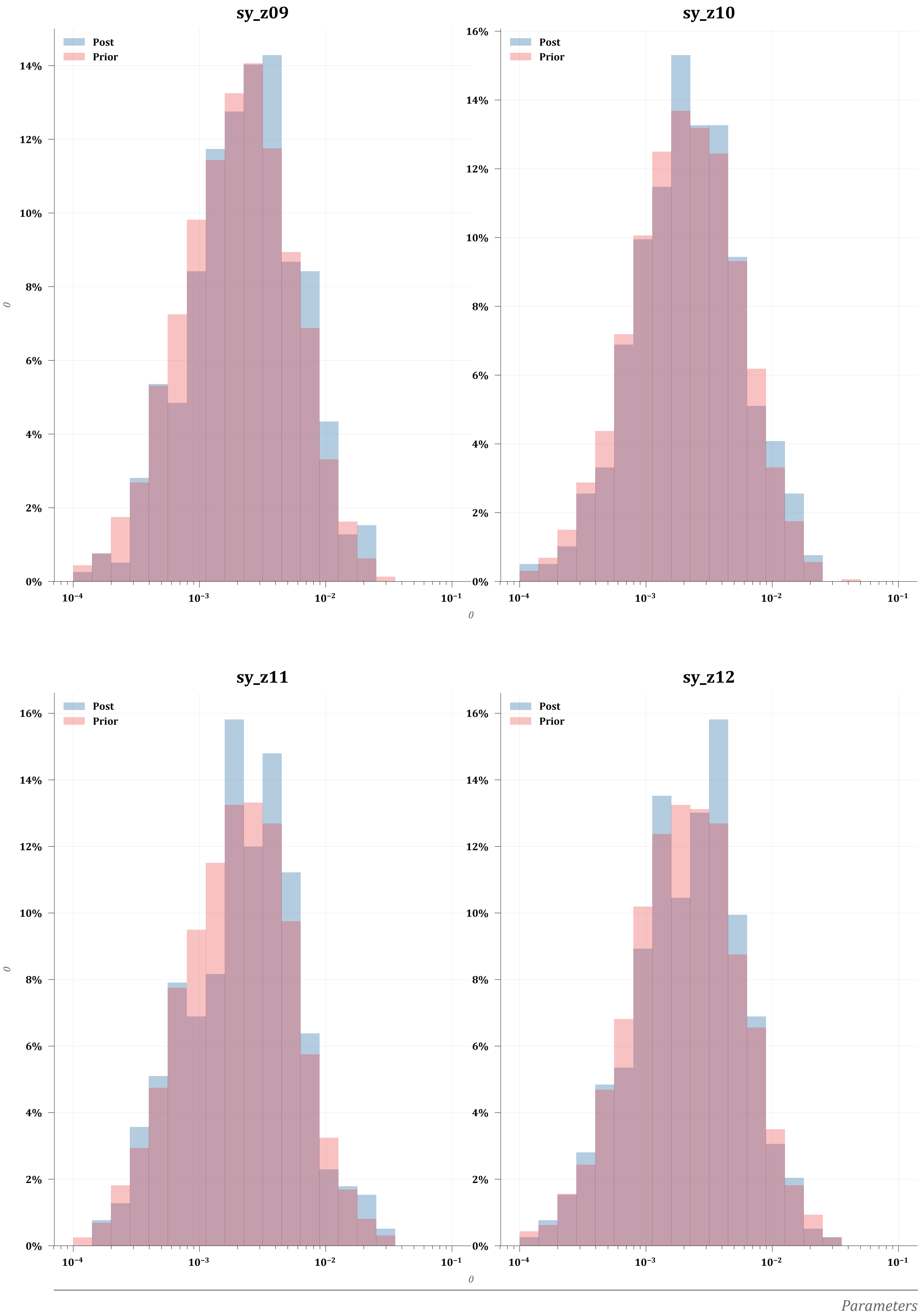
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16%
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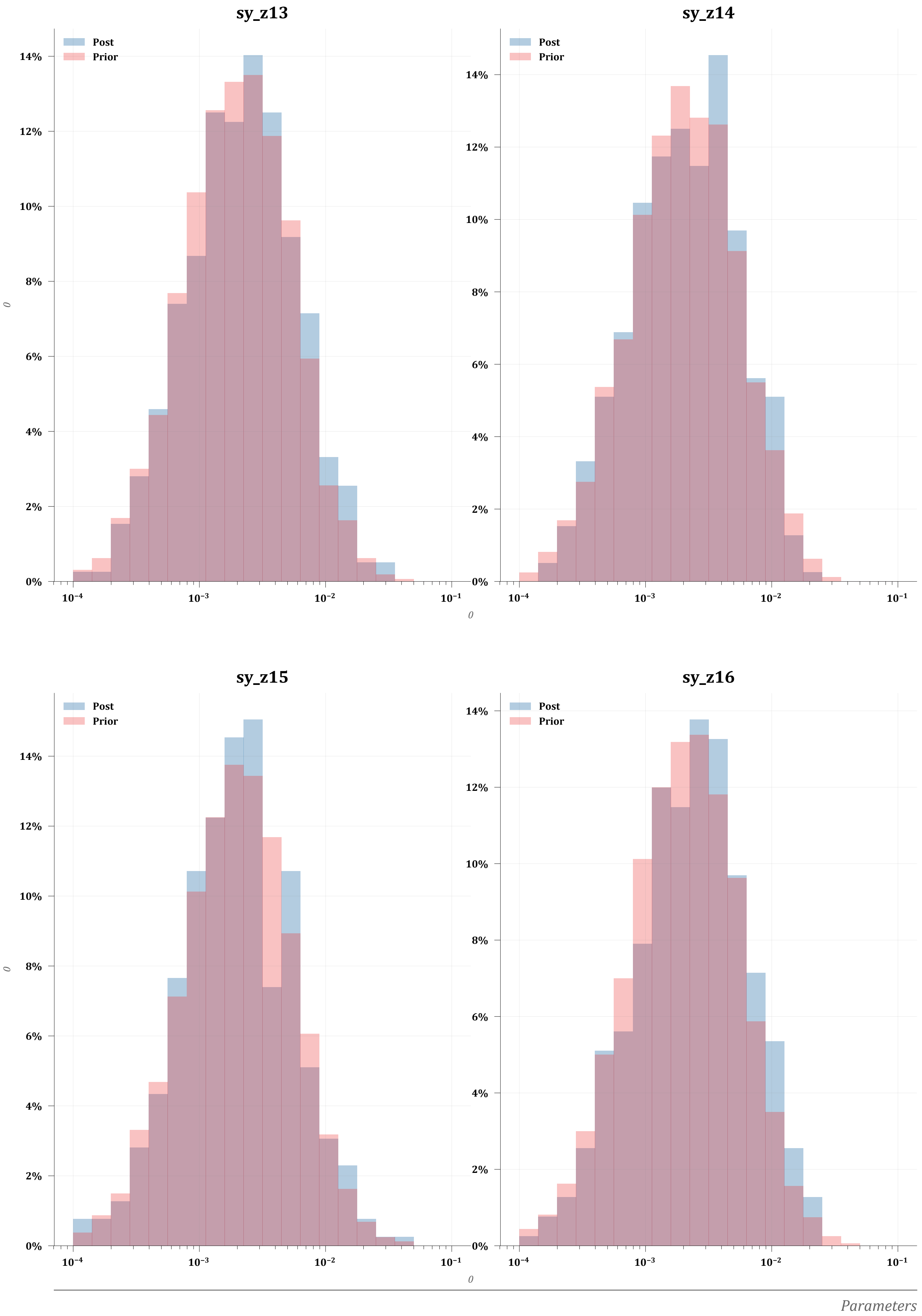
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4%
6%
8%
10%
12%
14%
10⁻⁴
10⁻³
10⁻²
10⁻¹
0
Parameters

Making Sustainability Happen

Making Sustainability Happen