

Ok Birim Tailings Storage Facility Project

Environmental and Social Impact Assessment

Appendix D

Groundwater assessment and modelling technical report





Klohn Crippen Berger

Ok Tedi Mining Limited

Ok Birim TSF Feasibility Study

Groundwater Impact Assessment

FINAL

5 June 2026

Ok Tedi Mining Ltd
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Papua New Guinea

Alan Bong
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Dear Alan,

OTML Ok Birim TSF Feasibility Study
Groundwater Impact Assessment Report | Final

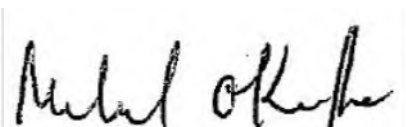
Klohn Crippen Berger is pleased to submit this Groundwater Impact Assessment Report developed as part of the Feasibility Study assessing the proposed Ok Birim Tailings Storage Facility on behalf of Ok Tedi Mining Limited.

This report is submitted as Final. Comments received from OTML and other stakeholders have been incorporated into this final version.

Thank you for the opportunity to complete this work and should you have any queries regarding this report please do not hesitate to contact the undersigned.

Yours truly,

KLOHN CRIPPEN BERGER



Michael O'Keeffe
Project Manager

JN:SL:PT:EP/SW

EXECUTIVE SUMMARY

The hydrogeological system at the Ok Birim TSF site is dominated by very high rainfall conditions, with average annual rainfall of approximately 7,400 mm driving strong recharge and relatively shallow groundwater conditions. Recharge occurs primarily on ridge crests through infiltration into residual soils and weathered rock, following topographic gradients from ridges into valleys and surface water systems. This results in:

- Strong groundwater–surface water interaction;
- Dynamic exchange with streams and springs;
- Recharge-driven groundwater flow patterns.

A hydrogeological site investigation field program was initiated in July 2025 to characterise groundwater conditions in the area surrounding the proposed Option C7 TSF. Six pairs of nested monitoring bores were installed at high-priority locations. At each location:

- Shallow boreholes (~20m depth) were drilled to assess near-surface groundwater conditions;
- Deep boreholes (~60m depth) were drilled to characterise deeper groundwater systems;
- Data were collected on groundwater levels, lithology, and subsurface conditions.

Drill log data indicate interbedded sandstone, siltstone, and mudstone units. Data from the 2014 and 2025 drill logs were used to develop a conceptual lithological model and assign material properties based on the range of values obtained from field investigations.

Measured vertical hydraulic gradients on the ridges around the proposed TSF site are predominantly downward, indicating recharge from shallow to deeper units, while groundwater levels along stream valleys are shallow, maintaining baseflow and feeding springs that are important water sources for nearby villages. Hydrogeological conditions are characterised by:

- Interbedded sandstone aquifers with hydraulic conductivity up to ~1.5 m/day;
- Siltstone and mudstone units with hydraulic conductivity as low as ~0.001 m/day;
- Significant geological heterogeneity creating local variability in flow gradients, influencing seepage migration.

Groundwater levels across the site are generally shallow, typically within about 1 to 4 m below ground level near drainage features, reflecting the high recharge environment. The shallow groundwater system, hosted in residual soils and weathered rock, is highly responsive to rainfall and characterised by rapid water level responses (both rises and subsequent declines) following precipitation events, including periodic saturation to above ground surface in lower-lying areas. In contrast, the deeper groundwater system shows more dampened response to rainfall events but remains hydraulically connected to the shallow system. Across much of the site, nested monitoring bores indicate a consistent downward vertical gradient from shallow to deep systems, confirming recharge-driven flow rather than upward discharge. In some areas, locally confined or semi-artesian conditions

have been observed in deeper units where low-permeability siltstone or mudstone layers act as confining layers. The variability in topography and hydrostratigraphic controls leads to spatially variable hydraulic gradients, with stronger vertical gradients occurring near ridges and flatter hydraulic gradients in valleys, where groundwater discharges to surface water.

Operation of the TSF is predicted to significantly alter local groundwater levels through the formation of a groundwater mound beneath the facility. Model results indicate:

- Hydraulic connection between the tailings and groundwater will occur;
- Heads within the TSF footprint will be up to ~30 m above the pre-facility groundwater elevations;
- Hydraulic gradients will allow seepage from the TSF to flow into surrounding hydrostratigraphic units.

Despite this substantial local change, the hydraulic influence from the TSF is predicted to be rapidly attenuated generally within ~500 to 800 m of the TSF embankment as a result of the hydraulic properties and high recharge that dominates the groundwater system. Beyond this distance, groundwater levels are predicted to remain largely unchanged from baseline conditions. At the villages, modelled hydrographs suggest that the TSF will have no measurable change in groundwater levels, indicating that TSF-induced hydraulic gradients do not extend to community receptors (there are local streams and creeks between the TSF and these villages) and that regional flow patterns are not affected away from the facility.

Seepage from the TSF represents the primary potential source that can influence the groundwater quality. An assessment of potential tailings seepage water (KCB, 2026) suggests that the seepage will be pH neutral to slightly alkaline (pH ~7–8) and characterised by elevated solute concentrations, including:

- Total dissolved solids of approximately 3,200 mg/L;
- Sulphate concentrations of around 2,200 mg/L;
- Copper concentrations up to 70 µg/L;
- Arsenic concentrations up to 10 µg/L.

These seepage water qualities have been used as source terms in the groundwater model. Migration of these constituents is controlled by groundwater flow gradients, hydrostratigraphic heterogeneity, and preferential pathways such as valley infill and possible structural features. Transport of dissolved constituents is predominantly advective, with reductions in concentrations due to significant dilution occurring from the extremely high recharge rates and due to the lateral dispersion that occurs as the seepage plume migrates from the TSF. Differences in the properties of materials in the TSF influence seepage behaviour:

- The fine tailings contribute limited seepage, as the fine-grained cyclone overflow material has a relatively low hydraulic conductivity (~0.006 m/day, potentially reducing to ~0.0006 m/day over time due to consolidation), thereby restricting vertical percolation into underlying formations.

- The embankment with its higher hydraulic conductivity ($\sim 0.38\text{m/d}$), from the cyclone underflow material, contributes most of the seepage flow and dissolved chemical load.

Model predictions indicate that the spatial extent of the predicted contaminant plume is limited. Elevated concentrations are generally confined to within approximately 300 to 500 m of the TSF, with more mobile parameters such as sulphate extending to about 1 km at low concentrations. Importantly, contaminant migration is predicted to occur primarily within deeper groundwater systems (typically more than 10 m below ground level), with limited upward migration in the shallow groundwater system that directly interacts with surface water and springs.

Villages in the vicinity of the TSF, including Kungembit, Birimkamba, Ambaga, and Karandimok rely heavily on natural water sources such as springs, streams, and shallow groundwater. These surface sources are sustained by baseflow from the shallow groundwater system and are therefore hydraulically connected to it. While this connectivity represents a potential exposure pathway should contaminant concentrations become elevated in these pathways, modelled outcomes indicate that the contaminant plume does not extend to the shallow groundwater at the village locations. Predicted water quality at the shallow groundwater encountered by the village observation points remains well within acceptable limits, with Total Dissolved Solids generally remaining below 1,000 mg/L (within the limits recommended by WHO, 2022), sulphate concentrations remaining low to negligible and within the Australian Drinking Water Guideline (NHMRC, 2022) of 250 mg/L for aesthetic purposes, and within the aesthetic guidelines of 400 mg/L given by the PNG Environment Act Aquatic Life guideline (Office of Legislative Counsel, 2000).

Metal concentrations at the villages are predicted to remain low. Copper concentrations are conservatively predicted to remain below approximately 0.2 $\mu\text{g/L}$, which meets the criteria of the WHO (2022) and Australian drinking water guideline of a maximum of 2 mg/L for health purposes and 1 mg/L for aesthetic purposes, and of the PNG Environment Act Aquatic Life guideline of 1 mg/L. Arsenic concentrations are predicted to remain below approximately 0.5 $\mu\text{g/L}$, which is well under the maximum limits of 10 $\mu\text{g/L}$ given by WHO (2022) and Australian drinking water guideline and of 50 $\mu\text{g/L}$ (0.05 mg/L) given by the PNG Environment Act Aquatic Life guideline.

As a result, the risk of contamination of village water supplies is assessed to be low to negligible under the modelled scenarios. This conclusion is supported by several key factors, including the limited lateral extent of the contaminant plume, strong dilution resulting from high recharge rates, and the predominance of contaminant transport within deeper groundwater systems that are not directly used by communities. In addition, the decision to exclude high-sulphur tailings from the TSF reduces the risk of acid generation, further limiting the mobility and toxicity of potential contaminants.

From a community perspective, impacts to water resources are expected to be minimal. Groundwater levels at village locations are not predicted to change, and water quality is expected to remain within acceptable limits throughout operation and closure. However, localised impacts may occur in areas immediately down-gradient of the TSF, particularly along small valleys and drainage pathways where preferential flow could concentrate seepage and lead to localised discharge to surface water systems. These areas represent the primary residual risk, although they are spatially limited and not directly associated with village water supply points based on current modelling. The seepage rates and contaminant loads from the groundwater model is included as part of the input to the surface water quality model.

Key uncertainties remain that may influence long-term risk, particularly the potential role of structural features such as faults or fracture zones, which could act as preferential pathways for groundwater flow and contaminant migration. Based on the current understanding the fault at Kungembit does not pose a risk to the village spring water supply. Additionally, the complexity of groundwater–surface water interactions in this high rainfall environment introduces uncertainty in predicting plume behaviour over long timescales. For this reason, a comprehensive monitoring program is required, including groundwater and surface water monitoring near the TSF and at village receptors, to validate model predictions and provide early warning of any changes in flow gradients, water levels, or water quality.

In summary, the hydrogeological assessment indicates that while the TSF will create a significant localised change in groundwater flow gradients and generate a seepage-derived contaminant source, these impacts are spatially constrained and strongly attenuated by natural processes. Groundwater level changes and contamination are not expected to affect nearby villages, and community water resources are predicted to remain protected. Residual risks are primarily limited to localised zones near the TSF and along preferential pathways, which can be effectively managed through targeted monitoring and adaptive management strategies.

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Appendix I:	Ok Birim Hydrogeology Factual Site Investigation Report
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CLARIFICATIONS REGARDING THIS REPORT

This report is an instrument of service of Klohn Crippen Berger (KCB). The report has been prepared for the exclusive use of Ok Tedi Mining Ltd (Client) for the specific application to the Ok Birim TSF Feasibility Study, and it may not be relied upon by any other party without KCB's written consent.

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6. This report is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

1 INTRODUCTION

Ok Tedi Mining Ltd (OTML) is proposing to develop a new tailings storage facility (TSF) and associated infrastructure to support its Ok Tedi Mine located in the Western Province of Papua New Guinea (PNG). The development of lowland facilities to store tailings is a key aspect of OTML's 2050 Vision, supports the extended life of mine and would remove the need for riverine tailings disposal into the Ok Tedi river system.

OTML is an unlisted, 100% PNG owned company, operating the Mount Fubilan Mine: the longest running open-pit copper, gold and silver mine in PNG (over 40 years). As a wholly nationally owned company, 100 % of the benefits from operations are returned to the people of Western Province and the State.

The scope of the project includes the development of materials handling facilities and an 87 km tailings pipeline to deliver tailings from the existing processing plant at Ok Tedi down to a location known as Ok Birim located on the western side of the Ok Tedi. Tailings will then be delivered to a 24 Mtpa hydrocyclone facility (cyclone house) to facilitate sand and slimes separation, with the sand fraction (cyclone underflow) utilised to construct the Ok Birim TSF embankments. The Ok Birim TSF has been designed as a twenty-year storage facility, with initial phase TSF operations supported by a starter embankment (fill) with subsequent tailing embankments constructed by sand generated by the cycloning process. Ultra fine cyclone 'overflow' tailings streams will be stored within the TSF embankments.

The proposed Ok Birim TSF will be supported by access roads and a new bridge crossing the Ok Tedi (known as Alice Bridge). Other ancillary infrastructure will also be required to support the project e.g. new camp accommodation facilities.

Building on work completed in previous prefeasibility studies (2014, 2024) (PFS) Klohn Crippen Berger (KCB) has been engaged by OTML to provide a feasibility level design of the following scopes:

- Hydrocyclone Facilities (Cyclone House);
- Ok Birim Tailings Storage Facility;
- Alice Bridge; and
- Road access.

KCB's scope forms part of the broader OTML Ok Birim TSF Feasibility Study.

This report summarises the work that KCB has completed to develop the feasibility level design for the hydrogeological conceptualisation and modelling required to predict changes in groundwater flow and quality during Project construction, operations, and closure. These predictions are necessary for evaluation of the potential impacts of the TSF location and design on the environment, including water resources, local villages and water-dependent ecosystems.

This groundwater impact assessment outlines the hydrogeological conceptualisation and numerical modelling and supports the Environmental and Social Impact Assessment (ESIA) for this facility. Information included in this report includes findings of the 2014 Prefeasibility Study, as summarised in Section 2.2, and recent site investigations conducted in 2025/2026.

1.1 Project Objectives

An initial conceptualisation and seepage assessment was conducted in 2014 based on the TSF A design and location (KCB 2014). Since then, the location and designs have changed, and the conceptual hydrogeological model was updated to include the data from the 2025/26 drilling and field campaign. The objectives of the groundwater assessment are:

- Characterise groundwater conditions within, and hydraulically downgradient, of the TSF area, including aquifer properties, recharge zones, and the relationship between groundwater and surface water flows in rivers / streams;
- Identify the groundwater values (i.e., beneficial uses) surrounding the TSF;
- Update existing groundwater modelling to predict changes in groundwater flow and quality during Project operations and post-closure;
- Predict Project-derived changes to the local groundwater regime (i.e., depth, flow and quality) and the nature and extent of impacts on groundwater values due to Project activities, including seepage from the TSFs;
- Evaluate data gaps identified during preceding phases of work, including recommendations for future phases, and collection of additional groundwater monitoring data;
- Assess residual (post-closure) impact of Project components (e.g. TSF seepage) on local and regional groundwater resources with recommendation of proposed mitigation and management measures;
- Design an appropriate monitoring program to assess Project-related impacts on groundwater, including recommendations for monitoring locations and frequency (where applicable).

1.2 Project Location and Regional Overview

The Project is located (Figure 1.1) in the remote and relatively undeveloped northwestern corner of the Western Province of PNG, south of the Bismarck Mountain Range which runs east-west along the length of PNG. The TSF is proposed on the western bank of the Ok Tedi, approximately 1.0 km southwest of the confluence of the Ok Birim and Ok Tedi. This is about 50 km directly south of the existing Ok Tedi Mine near Tabubil, or 90 km by road from the mine via the Kiunga-Tabubil Highway.

Both the Project and the existing copper and gold Ok Tedi Mine are located entirely within the Ok Tedi catchment. The Project area experiences high rainfall and is dominated by dense tropical vegetation. Terrain varies from steep-sided valleys and rugged mountains near the existing mine site, transitioning towards more gentle undulating land and low-lying floodplains around the proposed TSF site. Several hamlets and villages lie in close proximity to the proposed TSF area, and there is currently a gravel road, namely the Tax Credit Scheme Road, being constructed westwards towards the Indonesian border.

1.3 Project History

OTML engaged KCB in 2014 to undertake a Prefeasibility Study (PFS) for a TSF at Ok Birim in the PNG lowlands, updated in 2024 to align with current standards (KCB 2024). KCB, alongside OTML, conducted a multi-criteria alternatives analysis (MAA) confirming Ok Birim as the preferred site (KCB 2024a).

Following the MAA, the OTML Board approved progressing to a feasibility study (FS) starting in Q4 2024. After community engagement, the 2014 TSF location (Site A) was shifted southwest (to Site B) to avoid potential discharge to the Ok Birim catchment. A workshop in June 2025 in Brisbane reviewed implications of the location change and identified critical social and environmental concerns at Site B, including village relocation, cross-border seepage, and downstream impacts.

A hydrogeological investigation of Option C for the TSF facility commenced in July 2025. This included kick-off of site investigations with concurrent desktop studies and a preliminary groundwater numerical model which was largely based on data from the PFS (KCB 2014).

Since then, new data has become available following site investigations, and TSF designs have been reviewed. In this Groundwater Impact Assessment, the new data is presented and incorporated into the study with TSF option C7 being used for this report (hereafter referred to as the 'proposed TSF').

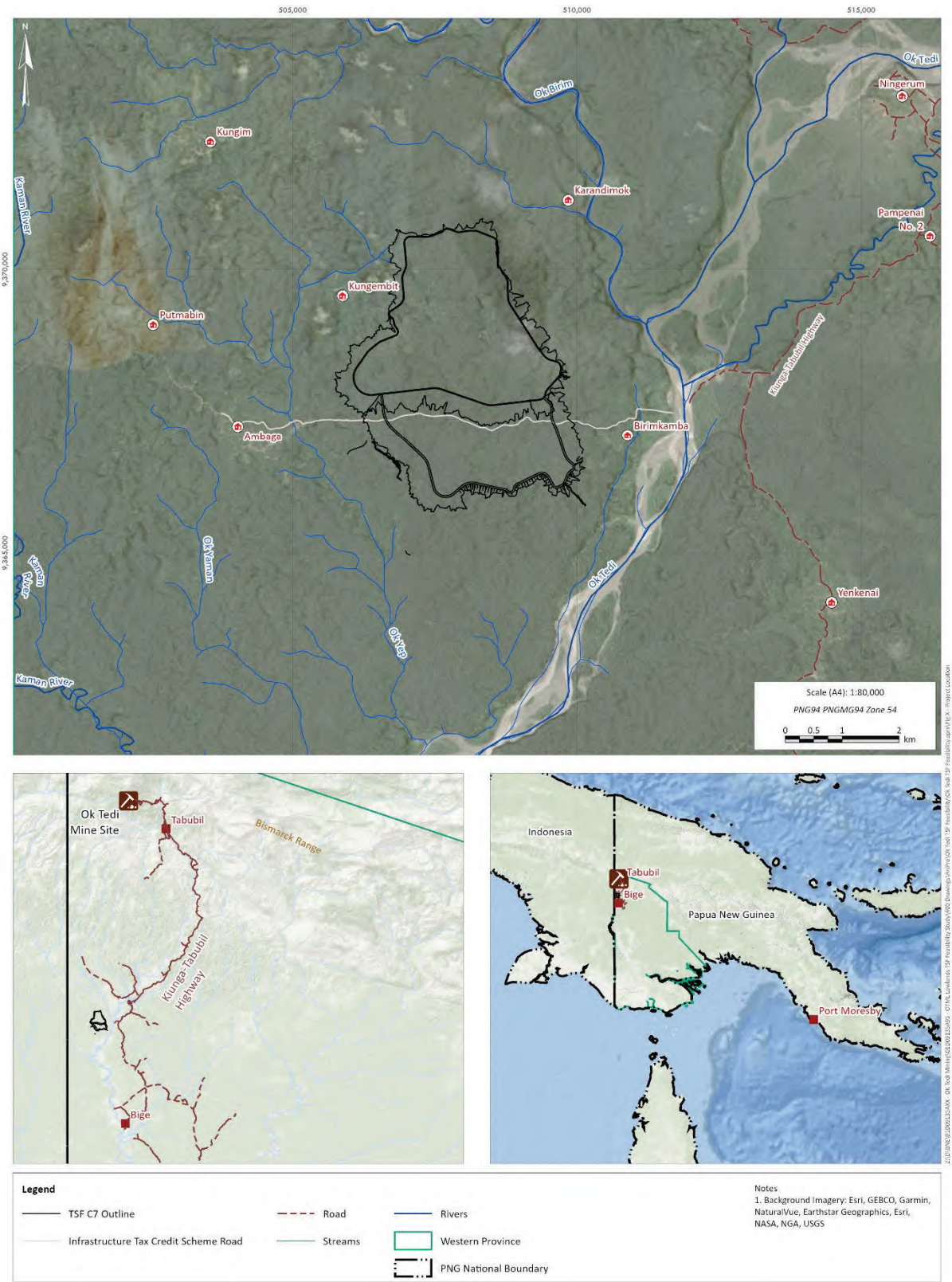


Figure 1.1 Project Location

1.4 Ok Birim Option C7 TSF Concept Design

Tailings with less than 1% on average sulphur content will be sent to the Ok Birim TSF site. Those tailings will be cycloned to generate a coarse-grained fraction (cyclone underflow) and a fine-grained fraction (cyclone overflow). Cyclone underflow will be hydraulically placed in cells to construct centreline-raised embankments, while cyclone overflow will be spigotted upstream of the embankment crest for storage within the TSF.

The operational period tailings deposition timeline of Option C7 are presented in Table 1.1 and Figure 1.2. The proposed TSF Option C7 consists of 2-cells, with Cell 1 (operated for 12 years) (Figure 1.3) located to the north of Cell 2 (operated for 8 years) (Figure 1.4). Visualisation of the cell location of Option C7 can be seen in Figure 1.3.

Clearing of the area of the starter wall is planned, but no clearing or foundation preparation for the TSF basin. A drainage blanket is proposed under the first raise of the embankment, with finger drains discharging into the collection drains, which in turn discharge to the sediment ponds.

Table 1.1 TSF C7 Assumed Operational Period

TSF Cell	Operational Period (Year)		Final Tailings Elevation (mRL)
	Start	End	
Cell 1	01/01/2030	31/12/2041	75.8
Cell 2	01/01/2042	31/12/2049	73.5

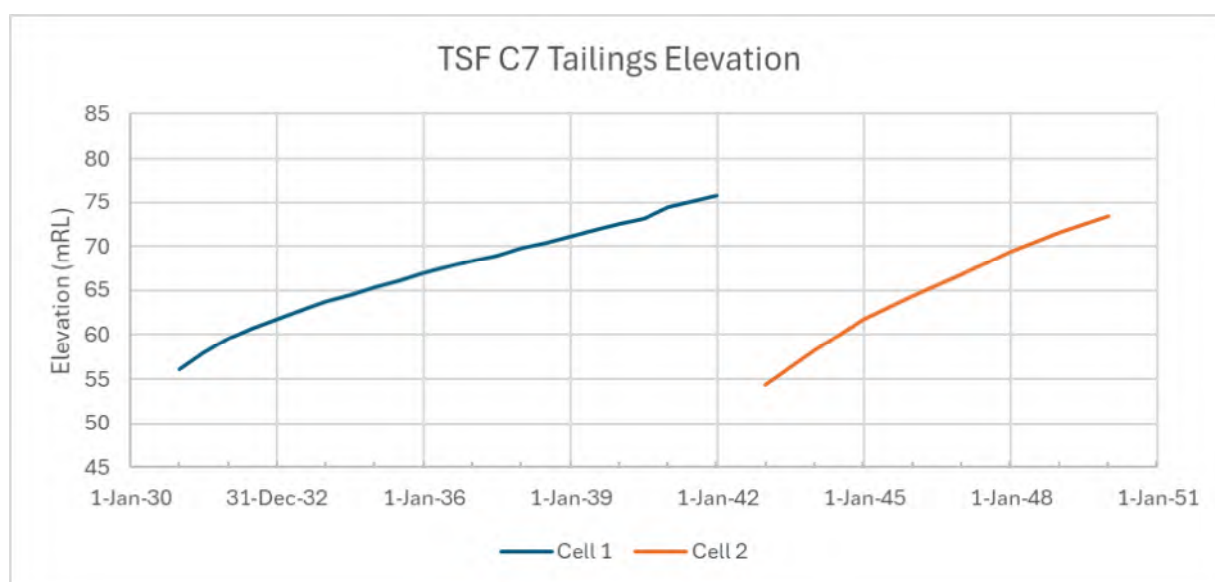


Figure 1.2 Tailings Elevation Rise with Time

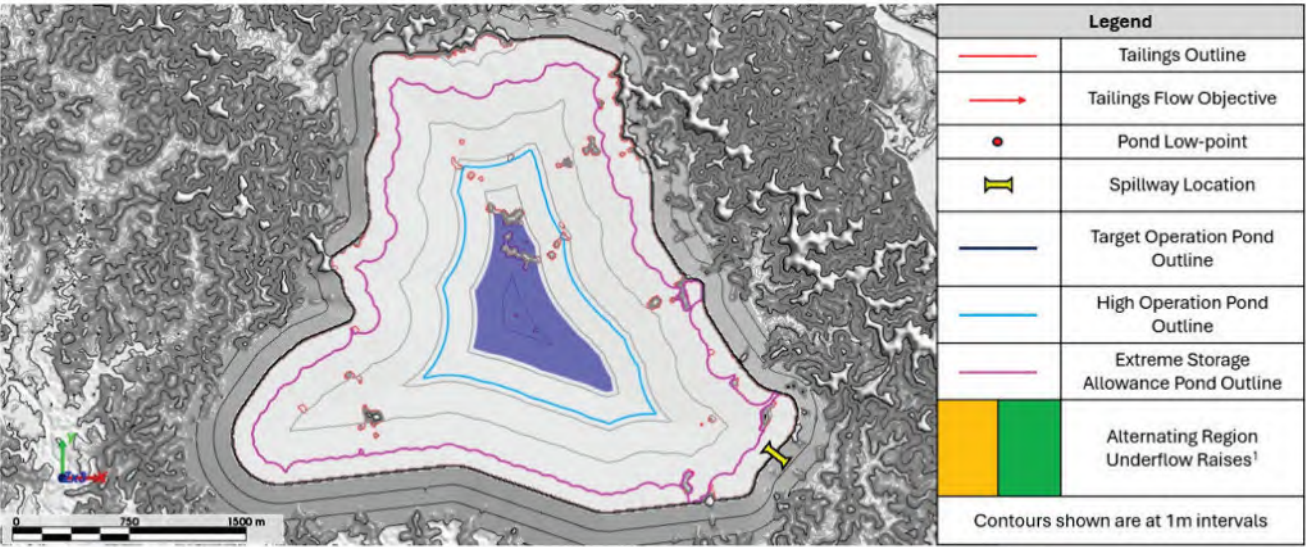


Figure 1.3 Option C7 – Cell 1 Month 144 Deposition Results (KCB 2026)

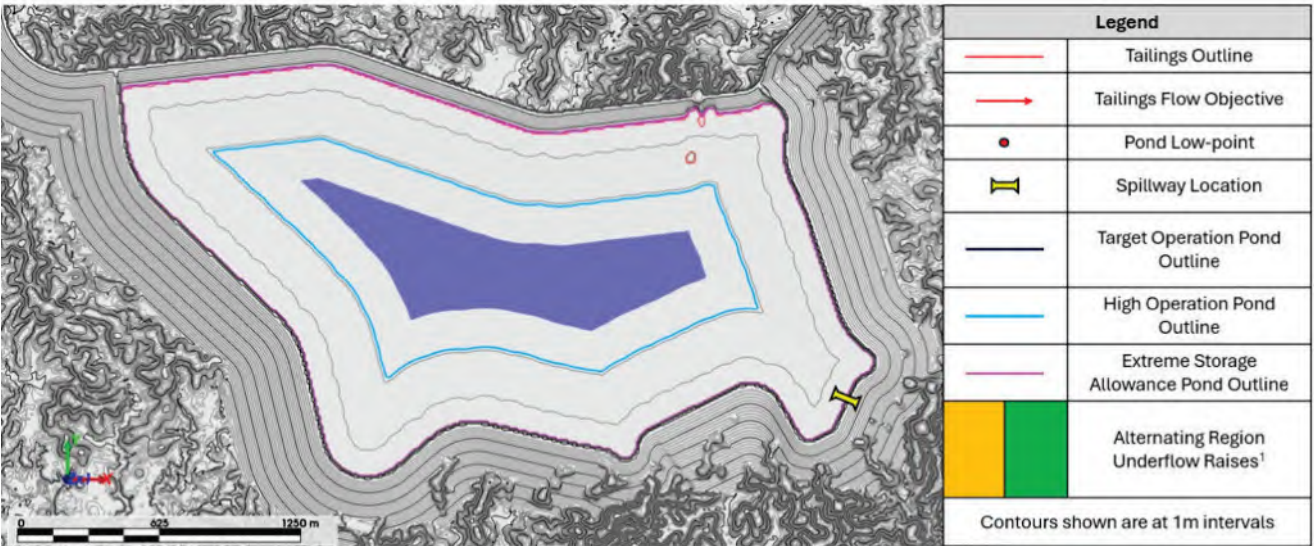


Figure 1.4 Option C7 – Cell 2 Month 96 Deposition Results(KCB 2026)

2 ASSESSMENT METHODOLOGY

2.1 Assessment Methodology

A Groundwater Impact Assessment consist of various components that, when considered collectively, provide a holistic view of the baseline site conditions (pre-TSF) and insights into how these natural conditions may be altered. Typically, an assessment of this nature consists of the following framework:

- Literature review – a review of available Project-related information (documents, reports and datasets etc);
- Desktop assessment – a review of available local and regional data to characterise the physiography (climate, topography, geomorphology etc.) and hydrogeology of the site, as well as identification of environmental values and potential receptors of groundwater impacts;
- Site investigation – collection of site-specific data to ground-truth the desktop assessment and improve quality and resolution of understanding;
- Conceptual model development – available data is assessed, first individually and then holistically, to provide a baseline understanding of the hydrogeological system and the relationship between its various components. Gaps where understanding needs to be improved become apparent in this step;
- Numerical modelling – the conceptual model is translated into a 3D numerical model (in this case using MODFLOW) which is calibrated against real data. The model is then used to predict outcomes for various operational scenarios;
- Assessment and evaluation – the model outcomes are assessed and risk is evaluated, with recommendations for mitigation, monitoring, and management being provided;
- Monitor and reiterate – conceptual understanding and outcomes of the numerical model are tested through monitoring the system response. As monitoring data is generated and understanding improves, the conceptual model and numerical model are updated so that risk and uncertainty is reduced on each iteration.

An initial desktop review, conceptualisation and numerical model was conducted in 2025 (KCB 2025), largely supported by data from field investigations undertaken during the 2014 PFS (KCB 2024). To obtain more recent and site-specific data, a hydrogeological field program was implemented in mid-2025 with the findings included in this assessment (Appendix I). Section 2.2 and Section 2.3 summarises the information and field campaigns, respectively, that have been used in the groundwater impact assessment.

2.2 Information and Data Sources

The primary sources of information used in this assessment include:

Datasets:

- 1:125 000 scale geological map for the Papua New Guinea region, including cross sections (Davies 1974);
- 2012 and 2025 OTML LiDAR data provided by Client.
- OTML. 2025. Daily Rainfall for Weather Stations Bige, PMP59, TED25, and BIR25.

Reports:

- KCB. 2014. OTML TSF Project: Prefeasibility Study – Appendix IV: Field Investigation Data Report.
- KCB. 2024. Ok Birim TSF Prefeasibility Study Design Update
- KCB. 2024a. Ok Tedi Lowlands TSF MAA
- KCB. 2026. OTML Ok Birim TSF Feasibility Study: Tailings Management Plan
- KCB. 2026a. Ok Birim Tailings Storage Facility - Feasibility Study: Tailings Storage Facility Final Landform Geochemical Model
- Tetra Tech Coffey. 2026. Social Baseline Characterisation Survey

2.3 Site-Specific Investigations

2.3.1 2014 Field Investigation

The Ok Birim TSF Site A field investigation program took place between February 21 – March 15 in 2014 with historic bore locations shown in Figure 2.1. Four bore pairs were installed to provide comparative data across shallow and deeper geological profiles within the vicinity of the initially proposed (Option C) TSF area near the Ok Birim. Deeper bores (4 total) were completed with Vibrating Wire Piezometers (VWPs) while shallow bores (4 total) were completed with standpipes as shown in Table 2.3.1 (KCB 2014). All were drilled and installed within the Awin Formation and a total of ten packer and slug tests were conducted to estimate Awin Formation K values.

Table 2.1 2014 Ok Birim Monitoring Bore and VWP Installation Details (KCB 2014)

KCB ID	Surface Elevation (mRL)	Easting (PNG94) ²	Northing (PNG94) ²	Screen (mbGL)		End Depth (mbGL)	Lithology	Installation
DH14-BIR-01A	78	509302	9370686	-	-	51	Sandstone	2 VWP (30 m and 40 m)
DH14-BIR-01B	78	509301	9370686	1.5	10.5	11	Clay and Clayey Sand	PVC Standpipe
DH14-BIR-02A	83	508193	9372309	-	-	50	Sandstone	2 VWP (20 m and 50 m)
DH14-BIR-02B	83	508194	9372309	2.5	8.5	8.5	Clay	PVC Standpipe
DH14-BIR-03A	50	507629	9368099	-	-	51	Mudstone/Sandstone	2 VWP (20 m and 40 m)
DH14-BIR-03B	50	507630	9368100	2.5	10.0	10	Sand and Sandy Clay	PVC Standpipe
DH14-BIR-04A	118	505520	9372089	-	-	60	Sand/Mudstone/Conglomerate	3 VWP (28 m, 45 m and 57 m)
DH14-BIR-04B	118	505518	9372089	10.7	16.7	20	Silt and Sandy Silt	PVC Standpipe

¹ Surface elevations are inferred from LiDAR survey.

² Coordinates estimated with handheld GPS unit.

mbGL – Metres below ground level.

mRL – Metres above reference (mean sea) level, mamsl



Figure 2.1 Historical and Recent Site Investigation Bore Locations

2.3.2 2025 Field Investigation

A hydrogeological site investigation was initiated in July 2025 to characterise groundwater conditions in the area surrounding the proposed Option C TSF (Appendix I). Six (6) nested monitoring bores were sited and drilled at high-priority locations (Priority 1 – 6) as presented in Figure 2.1 and summarised in Table 2.2. The bore locations were selected based on their proximity to nearby villages (potential receptors) and the potential for groundwater seepage from the TSF. These bores are constructed to serve as long-term monitoring wells. Borehole monitoring data would contribute to essential baseline and operational data on groundwater levels, flow direction, and water quality trends.

The information collected thus far is described in the Factual Site Investigation Report (Appendix I) and summarised in Section 4 below. This information was used to inform groundwater assessments and management, guide impact mitigation strategies, and support regulatory compliance throughout the assessment of the construction, operation, and closure phases of the Project.

At each borehole location, a deeper bore was drilled first to determine the depth to groundwater and to characterise the weathering profile. The deeper bores were typically drilled to 60m depth, with the deepest bore reaching 80.3 m depth. Once the deeper bore was completed and logged, a shallower bore was drilled and typically screened within the weathered zone below the water table. Bore construction was determined in the field, based on lithology and groundwater conditions, with screens typically installed across water bearing units or fracture zones near the terminal depth of the borehole. All bores were developed through flushing of water until they were clear of sand, mud, and drilling residues.

To protect the monitoring infrastructure, boreholes were fitted with steel covers or monuments, concreted in place, and secured with padlocks. These monitoring bores will be equipped with data loggers and telemetry and tied into the existing OTML Vista Data Vision database.

Hydraulic tests were conducted in the newly installed boreholes and along the TSF footprint. Over 50 falling/rising head tests were conducted, and the results are presented in Section 4. Tests targeted a range of lithologies and were designed to generate updated and location-specific hydraulic properties for both the weathered zone and fresh rock. The resulting data enhances the understanding of subsurface flow conditions and provides more accurate inputs to the numerical model, which is used to assess seepage potential, inform the TSF design, and inform long-term seepage management strategy.

Table 2.2 TSF Option C7 Bore Installation Details

Bore ID	Surface Elevation (mRL)	Easting (PNG94)	Northing (PNG94)	Screen Interval/VWP depth (mbGL)	Termination Depth	Unit
KCB25-BH1001-D	47.86	511206.66	9367511.56	49.3-55.3	61.00	Sandstone
KCB25-BH1001-S	47.86	511208.27	9367513.22	11.5-17.5	15.80	Siltstone/sandstone
KCB25-BH1002-D	55.11	510492.27	9367180.86	47.4-53.4	60.40	Alluvium
KCB25-BH1002-S	55.11	510489.98	9367182.09	11.5-17.51	20.20	Sandstone
KCB25-BH1003-D ¹	84.96	506292.54	9369466.46	70.5-76.5	80.30	Sandstone
KCB25-BH1003-S ¹	84.96	506293.13	9369466.51	20.0-28.4	29.50	Mudstone/sandstone
KCB25-BH1004-D	42.92	506614.76	9365708.59	47.0-53.0	56.30	Mudstone/sandstone
KCB25-BH1004-S	42.92	506616.09	9365707.83	20.0-26.0	29.70	Sandstone
KCB25-BH1005-D ²	89.13	510221.59	9369200.77	30.0; 57.0	63.20	Sandstone (30 mbGL) and Sandstone (57 mbGL)
KCB25-BH1005-S	89.13	510217.64	9369197.65	22.0-28.0	31.40	Sandstone
KCB25-BH1006-D	53.15	509503.07	9365829.55	56.2-62.2	65.20	Siltstone/sandstone
KCB25-BH1006-S	53.15	509502.87	9365827.62	14.5-20.5	24.00	Sandstone

¹ Coordinates from handheld GPS

² VWPs were installed, bore is not a standpipe

3 EXISTING ENVIRONMENT

3.1 Climate

The climate of the Project area is tropical, characterised by little to no annual temperature variation and high rainfall throughout the year (Peel et al. 2007). Data for four nearby rainfall stations have been provided, namely Bige, BIR05, TED20, and PMP59. The locations are shown in Figure 3.3 with averages summarised in Table 3.1 and Figure 3.1. BIR05 is the nearest (~2 km from the eastern embankment of the proposed TSF) and is likely most representative of on-site conditions. However, PMP59 has the most complete record, with data extending back to 2014 where water level data is available.

The average annual rainfall for BIR05 is 7464 mm/a with a daily average of 21.5 mm. This highlights the high rainfall tropical conditions. Annual rainfall averages at PMP59 are 6418.4 mm and 8439.3.0 mm at TED20. With these stations being approximately 9.5 km apart, this highlights the spatial variability of rainfall over relatively short distances.

There is no typical pattern of wet-dry seasonality as observed in non-equatorial regions, but it is clear that August and September are typically slightly wetter, while February and March are slightly drier.

Table 3.1 Average Rainfall for Stations BIR05, Ningerum, PMP59 and Bige (OTML 2025)

Month	Average Rainfall (mm)			
	BIR05	TED20	PMP59	Bige
Period of Record:	2017 to 2026	2019 to 2026	2017 to 2026	2014 to 2026
January	533.4	635.4	488.6	432.8
February	514.0	499.0	407.0	448.8
March	522.6	536.3	483.1	516.0
April	715.6	615.5	609.9	510.2
May	702.6	768.8	560.9	445.2
June	729.5	673.5	644.6	443.2
July	738.1	936.7	671.9	358.9
August	894.6	992.3	672.7	325.3
September	790.0	961.7	654.7	397.9
October	567.4	564.4	561.6	390.8
November	538.3	547.3	548.0	436.3
December	553.8	562.1	496.0	455.4
Daily Average	21.5	22.7	18.8	14.33
Monthly Average	650.0	691.1	566.6	430.1
Annual Average	7464.0	8439.3	6418.4	5067.4

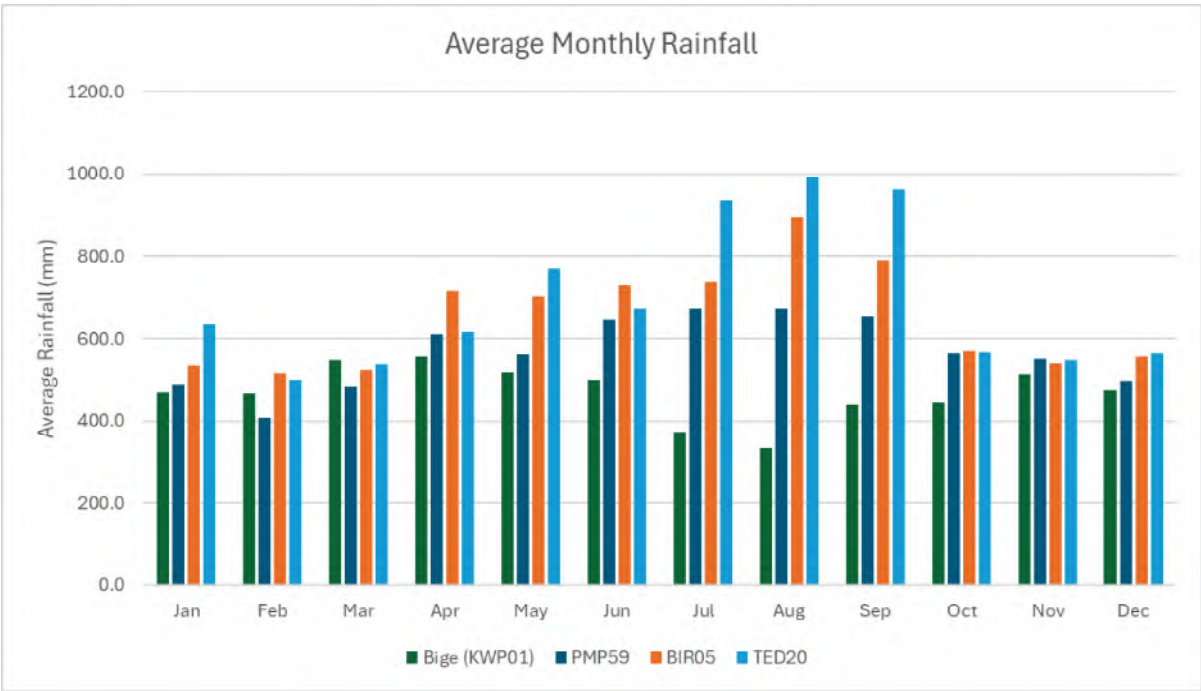


Figure 3.1 Monthly Average Rainfall for the four Weather Stations

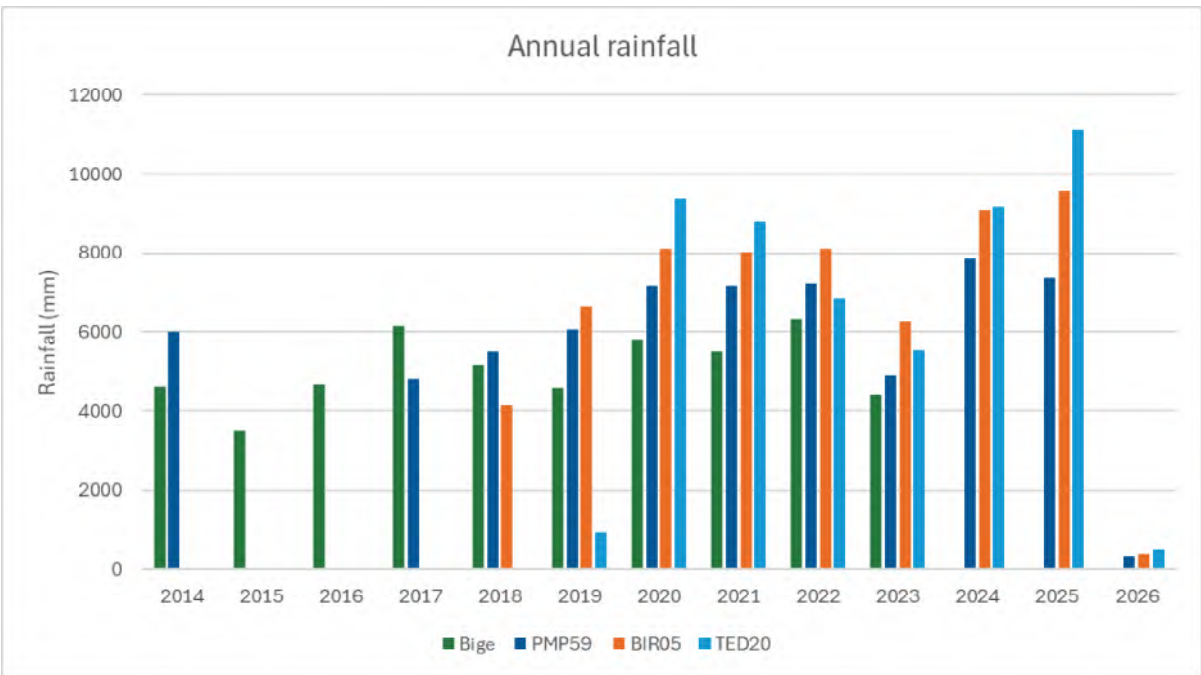


Figure 3.2 Annual Rainfall for the four Weather Stations

3.2 Topography and Hydrology

The topography of the Project area is presented in Figure 3.3. The Ok Birim and the Ok Tedi are the two major rivers of the area and have influenced the landscape through ongoing

erosion, sediment transport, and deposition processes (Figure 3.4 and Figure 3.5). These are described in more detail below:

- The Ok Tedi drains from the mountainous Bismarck Range terrain in the north, flows southwards past the proposed TSF site, and connects to the larger Fly River system further downstream. The Ok Tedi is a perennial (permanent) watercourse supported by the region's high annual rainfall, which maintains year-round flows. It is highly responsive to rainfall events, with streamflow volumes increasing rapidly during periods of heavy precipitation. This hydrological behaviour often results in flash flooding and short-duration peak flows. During drought years, some cease-to-flow periods may occur, however, non-flowing, connected pools may likely persist throughout the channel. The Ok Tedi is affected by upstream mining activities.
- The Ok Birim drains in a southeasterly direction and passes about 1 km to the north/northeast of the proposed TSF where it converges with the Ok Tedi. It is also a perennial watercourse, and a tributary to the Ok Tedi. Similar to the Ok Tedi, it is highly responsive to rainfall events, with streamflow increasing rapidly during heavy precipitation. The Ok Birim has not been influenced by mining activities.

On a more local scale, the site is drained by the Ok Yep stream. The Ok Yep contains many unnamed tributaries, many of which are present within the footprint of the proposed TSF. The Ok Yep drains southwards and flows into the Ok Tedi approximately 6 km to the south of the site. The topography is hilly to undulating, characterised by alternating ridges and valleys where elevations range from approximately 35-100 mRL (Figure 3.6).

Extremely high rainfall has contributed to the development of (often unnamed) drainage channels in most valleys that receive runoff and throughflow from surrounding ridge lines. These channels range from small non-perennial streams that can be stepped across to larger incised rivers that are several meters wide across (Figure 3.7). Many of these streams within the TSF footprint converge and drain down a valley exiting the TSF footprint in the southwestern corner of the TSF. This is hydrogeologically important because the weathered rock surrounding these streams could behave as preferential flow paths for TSF seepage once in operation.

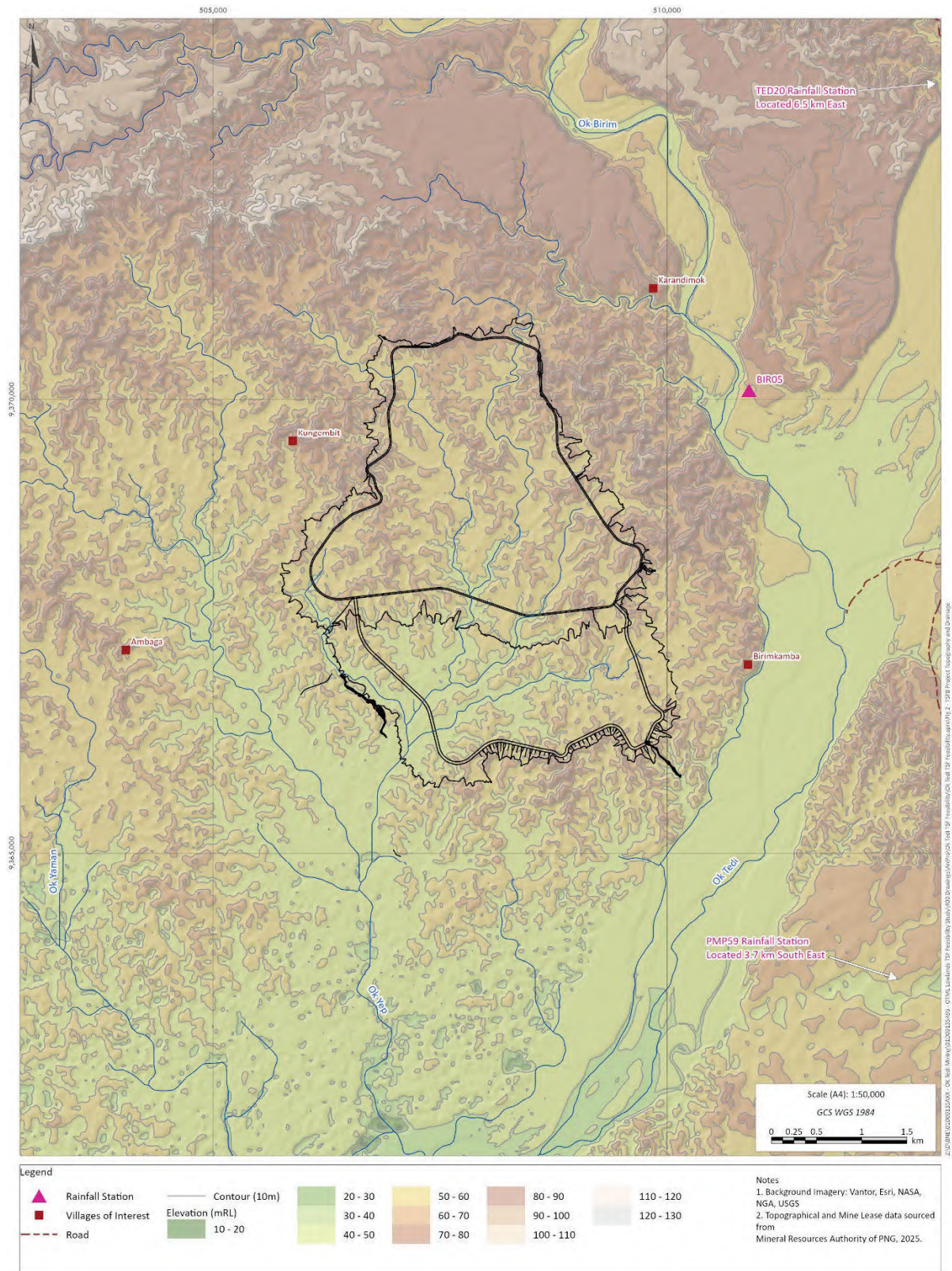


Figure 3.3 Topography and Drainage

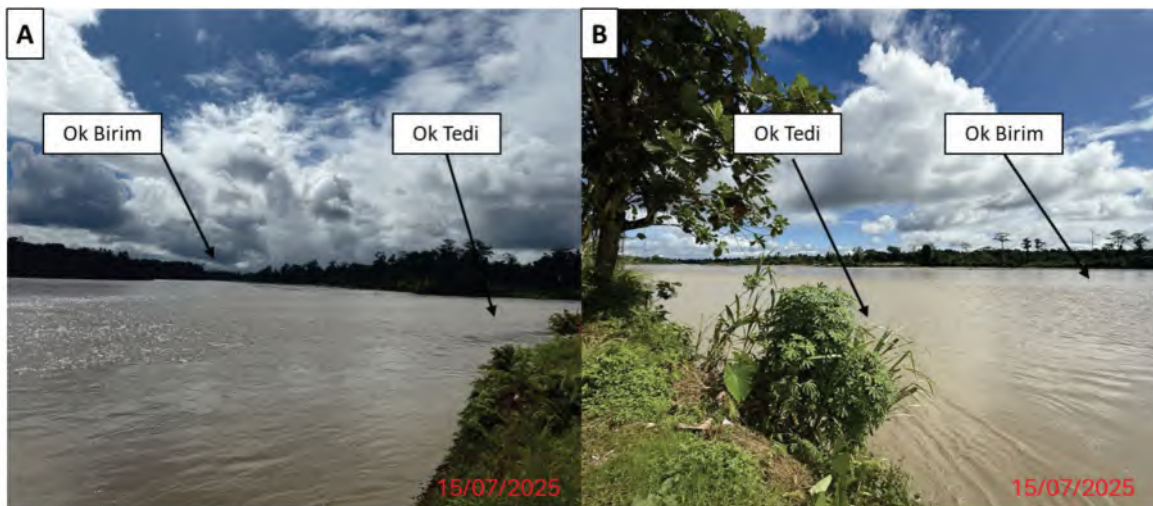


Figure 3.4 Confluence of the Ok Tedi and Ok Birim Rivers (July 2025)

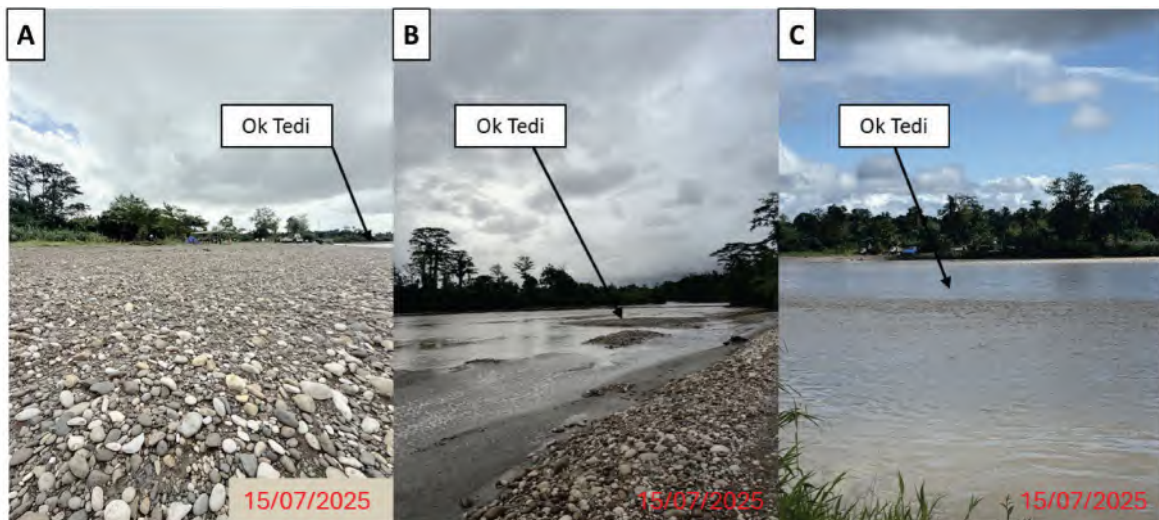


Figure 3.5 Ok Tedi River: A) Western Bank, B) Upstream of Confluence with Ok Birim, C) Eastern Bank (July 2025)



Figure 3.6 Landscape Beneath the Canopy at P6 (February 2026).



Figure 3.7 Typical Variation in Stream Flows¹

¹ Typical variation in stream flows shown by high flow (top left) and low flow (bottom left) of the same stream taken 24 hrs apart. A large, incised stream with tree trunk fallen across (right) (February 2026).

3.3 Anthropogenic Environment

The area surrounding the proposed TSF site is remote and rural. Small villages exist along the banks of the Ok Birim, Ok Tedi, and are present in the area surrounding the proposed TSF footprint as shown in Figure 1.1. As mentioned in Section 1.3, no villages exist within the TSF footprint. Villages near the TSF include Karandimok, Birimkamba, Ambaga and Kungembit.

Other than rural residence, the land is also used for small-scale subsistence farming. In the villages, the local people have planted crops for consumption, such as pineapple, coconut and bananas, with occasional roaming poultry and stock. The natural climate sustains these food sources and there appears to be limited need for irrigation. The local people rely on surface water, rainwater collection, and/or springs for drinking, cooking and hygiene.

Groundwater was found to be relatively shallow in the area (due to the high rainfall and saturation of the shallow subsurface) and is expected to contribute significantly to surface water flows through baseflow and spring discharge. An example is seen in Kungembit where the community harvest flowing spring water, as shown in Figure 3.8. Springs and surface water are commonly used at village residences and opportunistically, as locals travel between locations. Kungembit also has evidence of an abandoned rural groundwater supply scheme indicated by large steel reservoirs noted on-site (the details and history of which are unknown). Evidence of groundwater use, particularly during drought periods, has also been noted by the Social Baseline Characterisation Survey (Tetra Tech Coffey, 2026).

Groundwater is, therefore, identified as an environmental value due to its significance to both human and environmental receptors. Accordingly, the potential impacts of the TSF on groundwater resources within the area have been evaluated through the various model scenarios as presented in Section 6 of this report.



Figure 3.8 Spring Water Harvested for use in Kungembit Village

4 HYDROGEOLOGY

There is limited pre-existing hydrogeological data available for the proposed TSF site. As discussed in Section 2.3, KCB collected hydrogeological data during the 2014 field program at four locations proximal to the Option A TSF footprint. In 2025/2026 data was collected at six locations proximal to the Option C TSF footprint.

The information discussed in this section is based largely on the 2014 and 2025 field results, combined with interpretation of available climatological, topographical, hydrological, and geological information, and observations made in similar hydrogeological environments elsewhere.

4.1 Geology

A geological map and a regional cross section (representative of geological conditions 48 km to the east of the Project area) are shown in Figure 4.1 and Figure 4.2, respectively. The regional stratigraphic column is presented in Table 4.1. The cross section, only providing regional context, shows horizontal layering of geological units overlying a granite basement at depth. Similar cross section sequence of lithologies is expected at the Ok Birim site but was not confirmed with the drilling. At least 500m thick Awin Formation is expected based on the cross section.

The site lies on the border of two landforms: The hogbacks, homoclinal ridges and cuestas, typical of the Birim Formation (Tpb), give way to the low-lying plains of the Fly River system to the south, typically characterised by the Awin Formation and other quaternary deposits. The area has a relatively young geological history. The Birim Formation is ~2-5 million years old (Pliocene epoch) and consists of sandstone, conglomerate, tuff and minor agglomerate (volcanic bombs). This is overlain by the Awin Formation (Qpa) which is less than 2.5 million years old (Pleistocene epoch) and similarly consists of sandstone, conglomerate, increased siltstone, mudstone and thin lignite (low-grade coal) seams, with an absence of tuff (Davies 1974). Quaternary-aged alluvium deposits found along the major river channels, overlies the Awin Formation.

Both the Birim and Awin formations are fluvial in nature, i.e., they were produced by depositional processes relating to rivers and streams. Considering present-day processes visible in the Ok Tedi, the fluvial deposits can be highly variable with bedded, interfingered and lensed deposit of cobbles, sands, silts and clays which give rise to highly variable hydraulic properties. This heterogeneity is best displayed with a conceptual diagram as shown in Figure 4.3.

Table 4.1 Regional Stratigraphic Column

Age	Epoch	Formation	Reference
Quaternary	Quaternary	-	Qa, Qs
Quaternary	Pleistocene	Awin Formation	Qpa
Tertiary	Pliocene	Birim Formation	Tpb
Tertiary	Lower Miocene	Pnyang Formation	Tmr, Tmp
Tertiary	Upper Eocene to Middle Miocene	Darai Formation	Tr

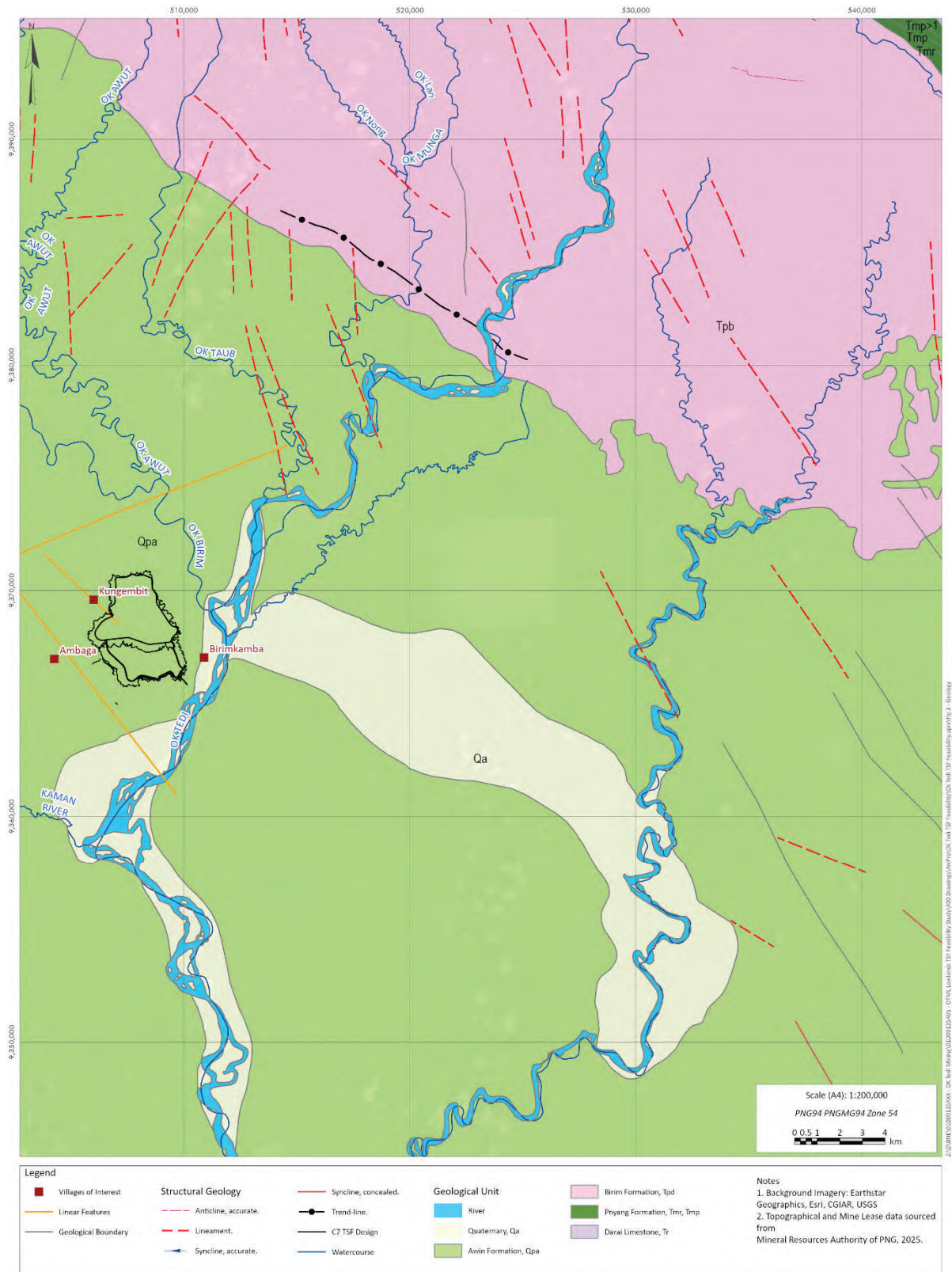


Figure 4.1 Regional Geology of Project Area

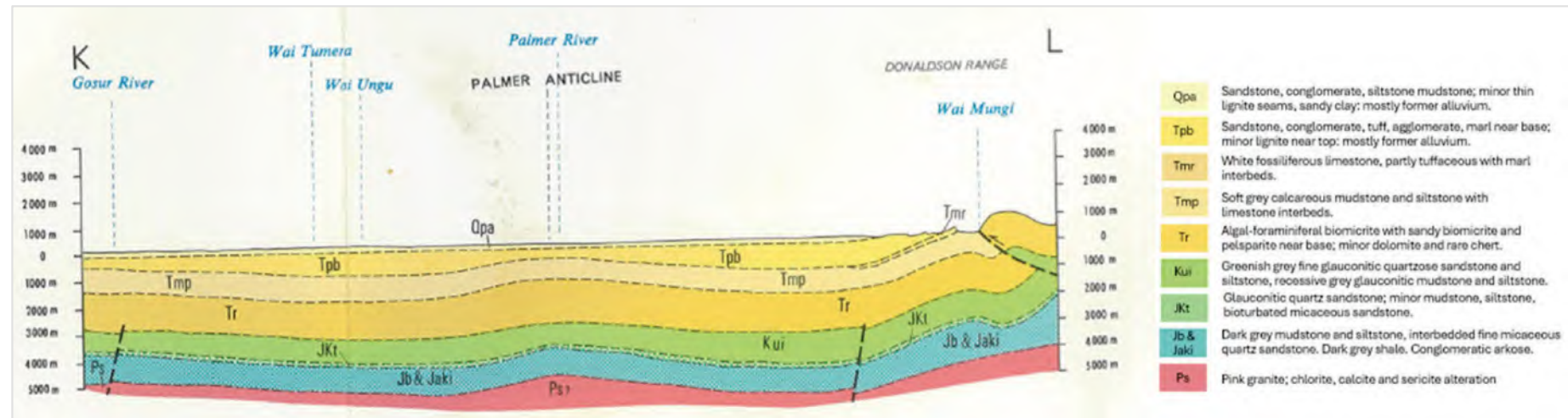


Figure 4.2 Cross Section of Regional Hydrogeology 48 km to the East of the Project Area (Davies 1974)

The TSF site is directly underlain by the Awin Formation, which is at least 80 m thick as confirmed by recent drilling programs. The Awin Formation is young, poorly lithified, and relatively undeformed with a gentle southerly dip.

Large scale structures predating the Awin Formation are mapped towards the north (Figure 4.1). Three linear features have been interpreted from aerial imagery, geological mapping and structural interpretation. These features, located to the west of the TSF near Kungembit, trend northwest–southeast and northeast–southwest in conjugate fashion and may play an important role in controlling groundwater flow in the subsurface. These structures may potentially be related to the springs observed at Kungembit, as seen in Figure 3.8.

4.2 Hydrostratigraphy

The differing units discussed above are expected to have differing hydrogeological characteristics which are likely a function of the unit's particle size and the degree of weathering. Coarser lithologies and higher degrees of weathering are expected to facilitate groundwater movement while finer lithologies and lower degree of weathering are expected to inhibit it.

The hydrogeological characteristics for the Awin lithologies encountered on-site may be summarised as follows:

- Fill materials – while only found near the Tax Credit Scheme Road, these materials may have high permeability and promote rapid ingress of water into the subsurface due to their uncompacted nature and high void ratio. An attempted constant head test in an auger hole near KCB25-BH2001 saw water infiltrate quicker than could be measured. The hydrogeological influence is anticipated to be small-scale and insignificant.
- Unconsolidated alluvium – found near the Ok Tedi, unconsolidated alluvium may have a significant hydrogeological influence in areas where it is well developed. Due to the uncompacted nature, these formations are inferred to store and transmit larger quantities of groundwater, particularly where alluvium consists of gravelly and sandy deposits. The alluvium is expected to be in direct hydraulic contact with the river and may respond to changes in river flows.
- Residual soil and weathered rock of the Awin Formation (Figure 4.3) – in-situ weathering of rock has likely led to increased porosity compared to the unweathered counterpart. Residual soils are expected to facilitate direct infiltration of rainfall. Lower infiltration (and higher runoff) is expected to occur on steeper slopes and in areas where soil is clayey, while sandy/gravelly soils are expected to have higher infiltration. Macropores, such as root zones, were seen to significantly increase infiltration (see Section 4.3.1). Residual soil and highly weathered rock are expected to behave hydrogeologically similar (due to similar hydraulic properties) and are therefore grouped as one unit. This unit was noted to be up to ~30 m thick in places.

- Sandstone and conglomerate of the Awin Formation – these formations are expected to form good aquifers. Thick sandstone deposits as seen at KCB25-BH1001-D likely promote the storage and movement of groundwater. According to drilling conducted on-site, sandstones and conglomerates may occur together and are often interbedded with siltstone and mudstone layers which may potentially cause local hydraulic separation.
- Siltstone and mudstone of the Awin Formation – are considered to behave as aquitards or aquicludes, inhibiting the flow of groundwater. Where they occur as thin and/or discontinuous layers, their influence may be less significant. Where thicker, they may create confining layers separating two hydrogeological units – confining layers are important as offer natural protection from undesirable seepage. Sub-artesian to artesian pressures may be present below these confining units, such as that seen at KCB25-BH2001 and KCB25-BH1001-D.
- Structural features – may provide preferential flow paths for groundwater. They may cause juxtapositioning of different lithologies providing hydraulic connection, or act as flow barriers between different units. The hydraulic conductivity of the single bore (KCB25-BH1003-D), drilled close to one of the interpreted lineaments, suggests hydraulic conductivity slightly higher than the mean of the other bores.

Anticipated key hydrogeological units include the residual soil and highly weathered zone, the alluvium near the Ok Tedi, and sandstone/conglomerate units, which are expected to represent the most productive and extensive aquifers.

The Birim Formation underlies the Awin Formation at considerable depths. According to the results of the site investigation, the Birim Formation was not intercepted during drilling (to depths of ~80 mbGL or elevations of -14 mRL). Although no hydrogeological data for the Birim Formation is available, this formation is not expected to play a significant role with respect to this investigation, as it is likely too deep below the proposed TSF.

The TSF construction will be conducted using cyclone separated over and under flow. The TSF embankment (overflow material) is anticipated to behave similar to sandy material (i.e., more permeable), while the TSF slurry (underflow) is anticipated to behave similar to silty or clayey material (i.e., less permeable). Hydraulic properties of the over and underflow material discussed in Section 4.3.3.

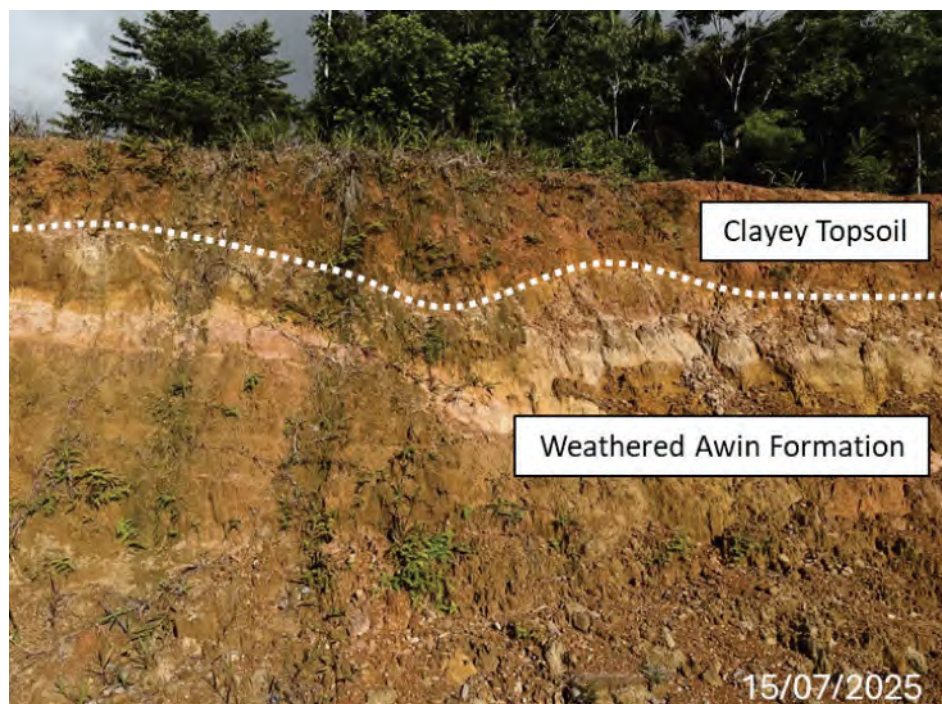


Figure 4.3 Outcrop Along the Ok Tedi Demonstrating Residual Soil and the Weathered Awin Formation

To simplify the complex geology and inform the geological layers of the numerical model (Section 6), the distribution of each geological unit across varying elevation, as per the drill logs, was assessed. Drill log data is shown in a frequency by elevation plot (Figure 4.4) which highlights elevations where various lithologies, i.e., hydrogeological units, are dominant. This is an effective visualisation because although sandstone, siltstone and mudstones often occur as interbedded layers when looking at bore logs, it identifies where each of these are dominant and therefore will control the prevailing hydrogeological characteristics. This is less obvious when looking at bore logs alone and aids in simplifying the complex geology into simpler, hydrogeologically representative 3D layers.

The simplified hydrogeological model can be summarised as follows:

- Between elevations of 76-116 mRL, residual soil is the dominant unit forming the residual soil and weathered rock aquifer. Note that residual soil (at surface) occurs as low as 28-32 mRL due to the varying topography across the site.
- This is followed by a dominance of less-weathered sandstone between 52-76 mRL, likely forming a second aquifer unit across the area. Some siltstone and mudstone are present, likely forming thinner continuous or discontinuous but less hydrogeologically significant units.
- Weathered sandstone typically transitions to siltstone/mudstone between 20-52 mRL, likely forming an aquitard unit. Sandstone is still present but less significant.
- Finally, sandstone is dominant again between 20 and -8 mRL suggesting a second deeper aquifer confined by the dominance of siltstone/mudstone above it.

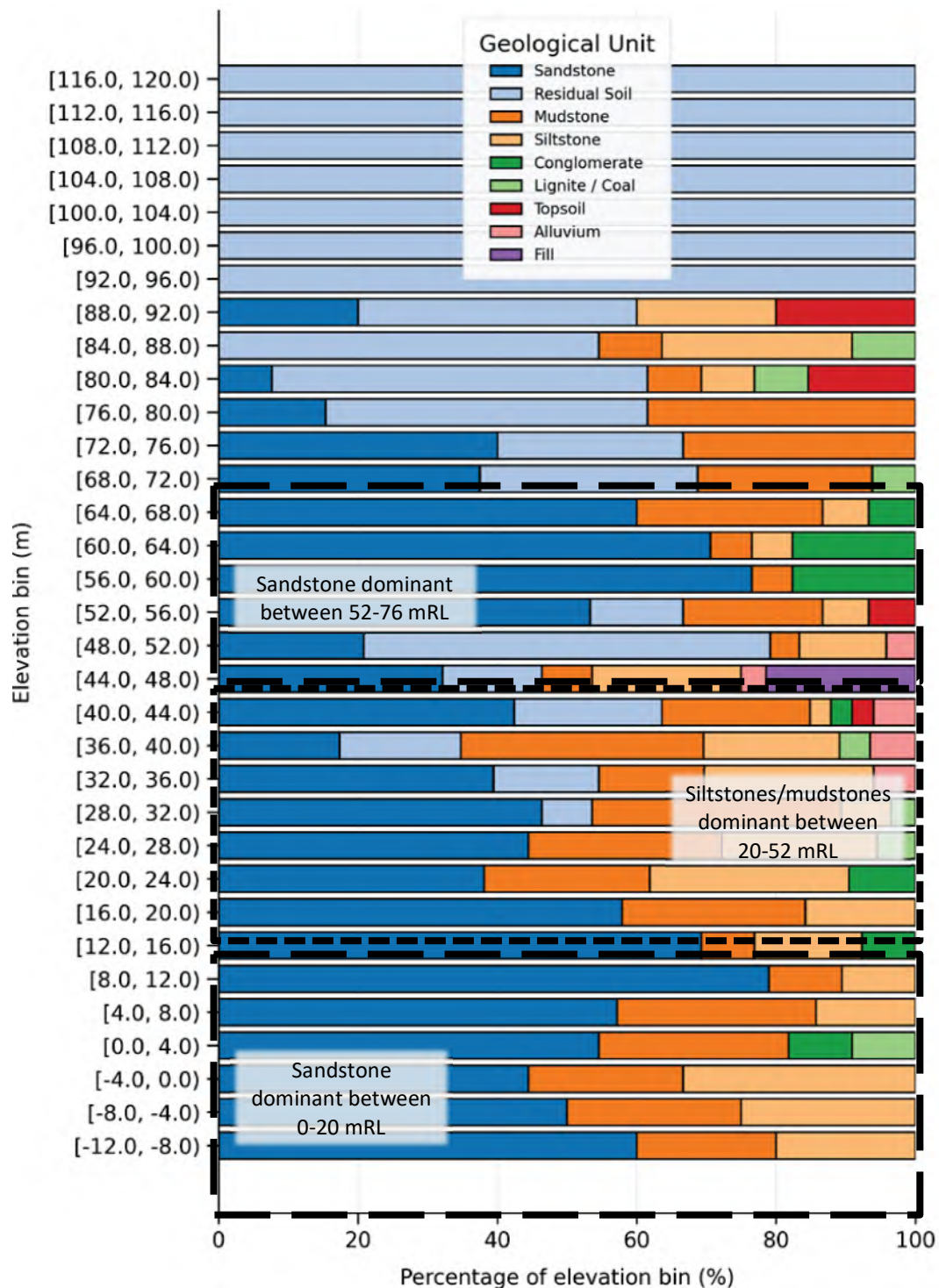


Figure 4.4 Frequency Plot (4m bins) of Geological Unit by Elevation Showing Areas where Sandstone (aquifer unit) is Dominant and where Siltstone or Mudstone (Aquitard Units) are Present

4.3 Hydraulic Properties

As mentioned in Section 2.3, KCB performed a series of hydraulic tests in the 2014 and 2025/2026 campaigns (KCB 2014 and Appendix I). The 2014 tests remain relevant because they were conducted in the Awin Formation. The results of the hydraulic testing are discussed below.

4.3.1 Hydraulic Conductivity

Table 4.2 provides a statistical summary of the hydraulic conductivity values calculated for each hydrostratigraphic unit, as logged during the 2014 and 2025 field investigations. Figure 4.5 shows the hydraulic conductivity range by depth and lithology. Note that lithology is assigned by majority, for example, if a test section is sandstone interbedded with mudstone, it is labelled as sandstone if that is the major component.

In general, results from the 2014 and 2025 field programs are relatively similar. Refer to the Factual Site Investigation Report (Appendix I) for further details regarding the hydraulic testing. The findings are summarised as:

- Residual soil and weathered rock showed an K range from 0.0002-2.294 m/day, with a geomean of ~ 0.109 m/day. This range demonstrates the highly variable nature of the shallow subsurface down to ~20 m depth. This is likely a function of rock type and degree of weathering. Auger holes where these shallow tests were conducted often encountered macropores (e.g., from roots) which have likely contributed to higher K values. Typically, those conducted on the ridges with sandy or gravelly soils showed higher K values than those conducted at the foot slopes or in valleys with clayey soils.
- K values of four locations tested in alluvium range from 0.049-0.397 m/day, with a geomean of ~0.1 m/d. As shown in Section 4.1, the alluvium is typically in the flood plain around the Ok Tedi intercepted by KCB25-BH1001-S. The lower K values are likely more typical of higher clay content while the higher K values are likely more typical of higher gravel content.
- The composition of competent sandstone to be highly variable, occurring as thick layers; interbedded with mudstones; or are even conglomeritic or carbonaceous. This variability contributes to the large range in observed K values ranging from 0.005 – 0.864 m/day and a geomean of ~0.055 m/d. Figure 4.5 shows that K values of shallower sandstone units is slightly higher than that in the deeper sandstone units.
- Conglomerate was not tested and only encountered in 2 of the bores. The K values are expected to correlate with the deeper sandstone units.
- Competent siltstone and mudstone units reflect slightly lower K values (compared to sandstone), as expected due to their finer grained nature, ranging from 0.001-0.075 m/day, with geomean of 0.021 m/d. Due to the interbedded nature of these units the vertical hydraulic conductivity is expected to contribute to semi-confined conditions to the flow of groundwater.

Table 4.2 2014 and 2025 Field Investigation Results Summary

Lithology	Min	Max	Geometric Mean	Count
2014 Field Program – K (m/day)				
Alluvium	ND	ND	ND	-
Residual Soil	ND	ND	ND	-
Weathered rock	2.66×10^{-4}	0.035	0.006	4
Sandstone	0.005	1.123	0.076	2
Conglomerate	0.052	0.130	0.082	2
Siltstone*	0.014	0.014	0.014	1
Mudstone*	0.006	0.006	0.006	1
2025 Field Program – K (m/day)				
Alluvium	0.049	0.397	0.109	4
Residual soil and Weathered rock	0.0002	2.290	0.123	14
Sandstone	0.005	0.864	0.055	7
Conglomerate	ND	ND	ND	-
Siltstone/Mudstone	0.001	0.075	0.021	2
Mixed Lithologies	0.006	0.086	0.026	4

* Only one record available
ND No data available

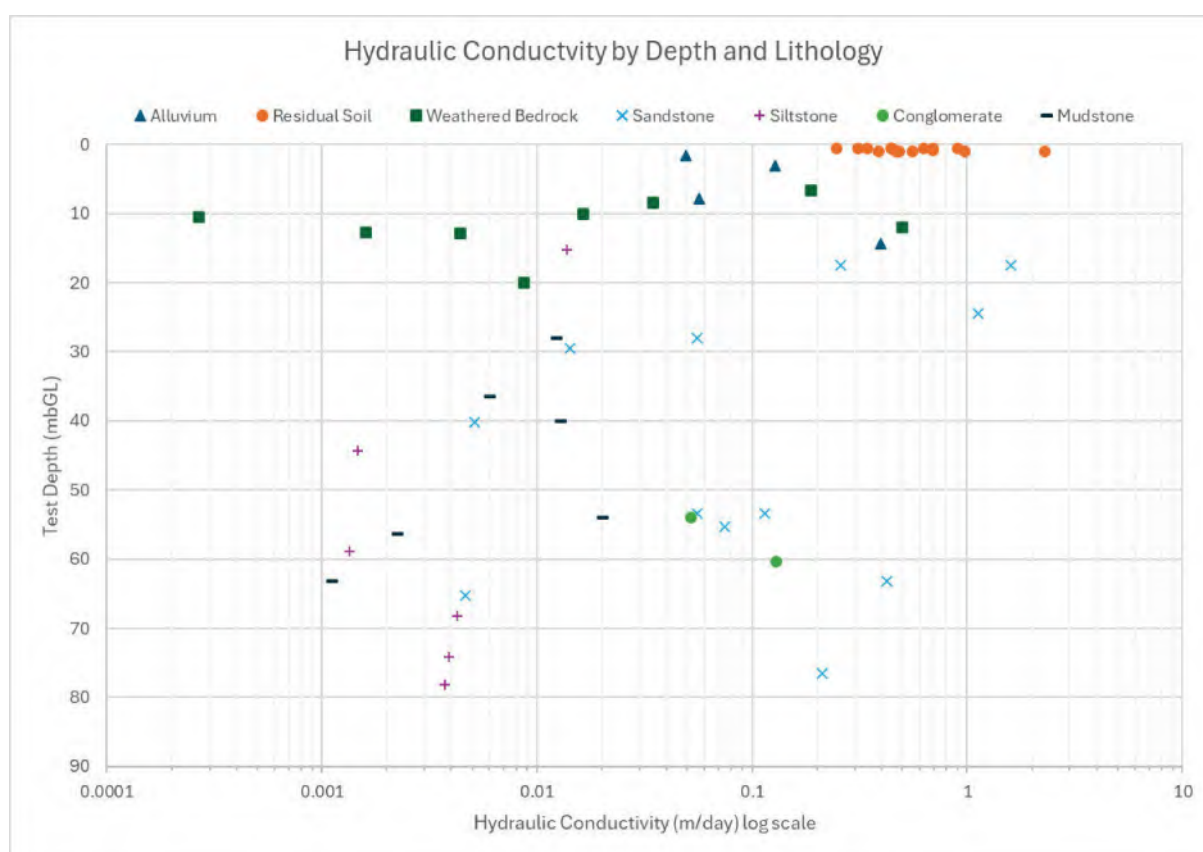


Figure 4.5 Hydraulic Conductivity (Log Scale) by Hydrostratigraphic Unit and Depth

4.3.2 Storage and Porosity

There is no information available from the Project area regarding specific yield. Generalised literature values (Johnson 1967) indicate residual soil likely has specific yields ranging from less than 5% for clayey materials to more than 30% for coarse sand and gravel. Siltstone and sandstone are reported to have specific yields ranging from 12% to 27%, though these values will vary significantly with gradation and extent of secondary porosity (weathering and/or fracturing).

Estimates of specific storage parameters for the area were obtained from typical literature values for siltstone and sandstone (Kresic 2006). Specific storage is reported to range between 1.0×10^{-4} and 1.0×10^{-5} for applicable hydrostratigraphic units of interest.

4.3.3 Tailings Material

As discussed in Section 1.4, the tailings material is split into cyclone overflow and underflow during processing. Deposited tailings material will create a separate, unique, and localised hydraulic unit that will influence the flow of groundwater in the vicinity of the TSF. During the operational phase, process water can seep vertically through deposited tailings material. These will get thicker and more compacted over time. Due to the fine-grained nature of the cyclone overflow tailings, the deposited material is expected to exhibit low permeability, limiting the rate of seepage into the underlying natural ground.

Particle size distribution (PSD) results are available from ongoing lab tests. To estimate permeability, the available results have been analysed using HydrogeoSieveXL V2.2, an Excel based program by Devlin (2015), with results shown in Figure 4.6 and Table 4.3.

Various empirical equations exist for estimating hydraulic conductivity using PSD and based on the sorting criteria only a select few are applicable (which are shown in Table 4.3). Analysis shows that the geometric mean of the hydraulic conductivity is 0.309 m/day and 0.006 m/day for the underflow and overflow respectively. K values of the coarse component are around two orders of magnitude higher than the fine component. A constant head permeability laboratory test (or Darcy test) was also conducted on underflow material as part of the Geotech Site Investigation. The laboratory permeability for this material is 0.363 m/day which aligns well with the geometric mean of 0.309 m/day estimated from the PSD calculations.

Note that these values are based on PSD and may not represent in-situ conditions. For example, they do not consider compaction of tailings over time, which will occur as the TSF deposits accumulate over time. Rowe Cell consolidation tests (a laboratory test used to measure the rate and magnitude of consolidation and permeability soft soils, such as clays and silt) on these materials indicate that compaction of tailings may result in a one order of magnitude decrease in hydraulic conductivity. This implies that vertical K of the tailings may potentially decrease from 0.006 m/day to 0.0006 m/day over time.

Table 4.3 Hydraulic Conductivity Estimates from PSD data for Underflow and Overflow

Equation	Hydraulic Conductivity (m/day)	
	Underflow	Overflow
Slichter	0.126	-
Sauerbrei	1.872	0.042
Barr	0.149	0.003
Alyamani and Sen	0.057	0.002
Krumbein and Monk	1.410	-
Geometric Mean	0.309	0.006
Arithmetic Mean	0.723	0.016

- equation not applicable

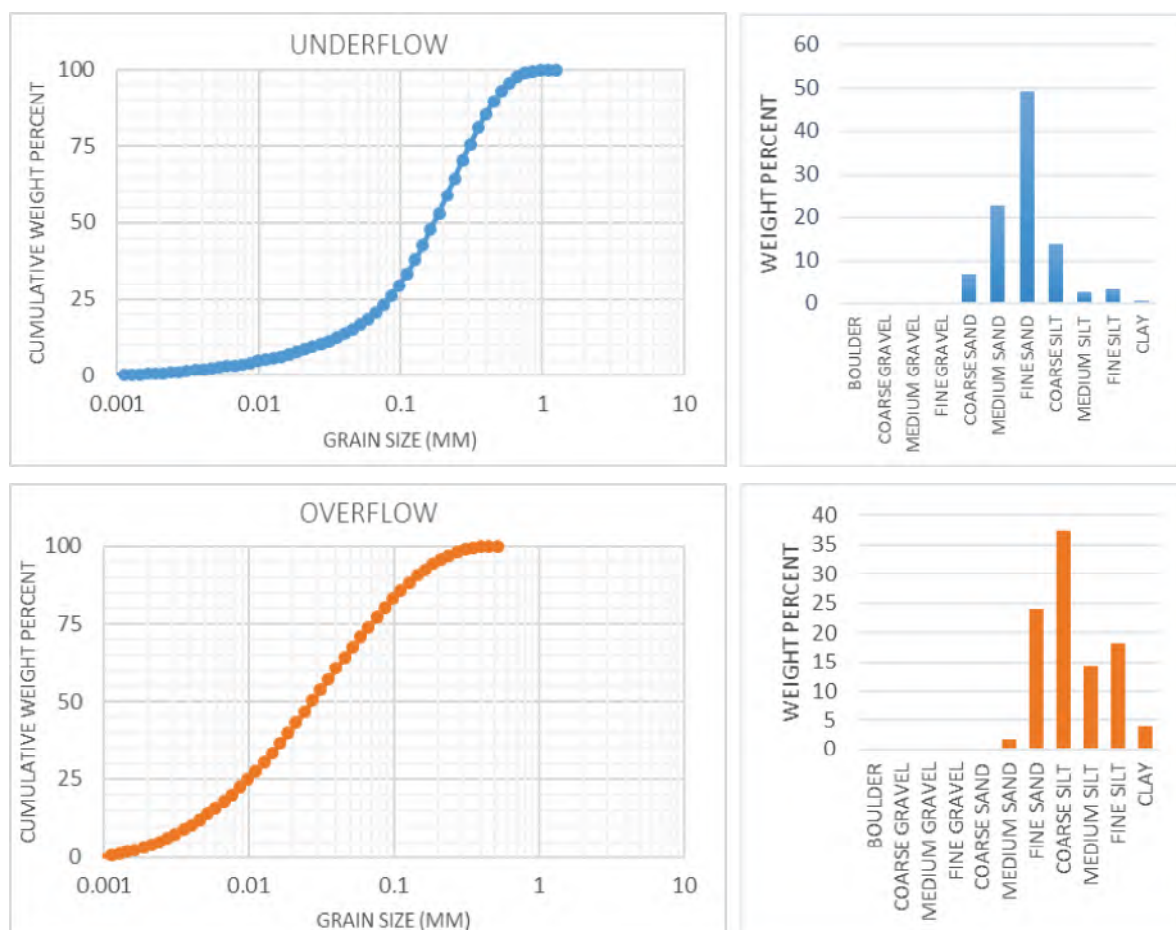


Figure 4.6 Particle Size Distribution Graph for Tailings Underflow (Top) and Overflow (Bottom)

4.4 Groundwater Levels and Flow

Regional groundwater flow is expected to be roughly north to south following the regional topography from the Bismarck Range in the north to the low-lying floodplains in the south. Regional-scale geological structures may divert this north-south flow path provide preferential flow pathways for groundwater to travel long distances over relatively rapid times. Large scale surface water features, like the Ok Tedi and Ok Birim, will play a significant role with shallow groundwater discharging along their banks, influencing the shallow groundwater flow gradients.

Loggers were installed in 2014 in the monitoring bores drilled at the time (Figure 2.1). These loggers were recovered during the 2025 campaign. It was found that the loggers ran out of battery and/or memory after a few years but that three of the four loggers recorded four years of data (2014 to 2018). In the other logger about 1.5 years of data could be retrieved (Figure 4.7).

Manual water levels are available for the 2025 bores with data logger installation still in process. The water levels are shown in Figure 4.7, Figure 4.8, and Figure 4.9 with details summarised in Table 4.4.

Groundwater contours were not generated due to poor spatial distribution of groundwater level data. A better representation of groundwater conditions and contours is provided by the numerical model as discussed in Section 6.5.

The groundwater levels have been grouped into shallow and deep systems to aid interpretation (Table 4.4). The shallow system represents the residual soil/weathered profile as described above, while the deep system corresponds to fresher rock units located at depth. Locations are shown in Figure 2.1.

Table 4.4 Bores Near Ok Birim TSF

ID	Surface Elevation (mRL)	Screen/VWP depth (mbGL)	Corresponding Lithology	System
DH14-BIR-01A VWP1	78.0	30.0	Sandstone	Deep
DH14-BIR-01A VWP2	78.0	40.0	Sandstone	Deep
DH14-BIR-01B	78.0	1.5-10.5	Residual	Shallow
DH14-BIR-02A VWP1	83.0	20.0	Sandstone	Shallow
DH14-BIR-02A VWP2	83.0	50.0	Sandstone	Deep
DH14-BIR-02B	83.0	2.5-8.5	Residual	Shallow
DH14-BIR-03A VWP1	50.0	20.0	Mudstone	Shallow
DH14-BIR-03A VWP2	50.0	40.0	Sandstone	Deep
DH14-BIR-03B	50.0	2.5-10.0	Residual	Shallow
DH14-BIR-04A VWP1	118.0	28.0	Sand	Shallow
DH14-BIR-04A VWP2	118.0	45.0	Mudstone	Deep
DH14-BIR-04A VWP3	118.0	57.0	Conglomerate	Deep
DH14-BIR-04B	118.0	10.7-16.7	Residual	Shallow
KCB25-BH1001-D	47.86	49.3-55.3	Siltstone/sandstone	Deep
KCB25-BH1001-S	47.86	11.5-17.5	Alluvium	Shallow
KCB25-BH1002-D	55.11	47.4-53.4	Sandstone	Deep
KCB25-BH1002-S	55.11	11.5-17.51	Residual	Shallow

ID	Surface Elevation (mRL)	Screen/VWP depth (mbGL)	Corresponding Lithology	System
KCB25-BH1003-D	84.96	70.5-76.5	Mudstone/sandstone	Deep
KCB25-BH1003-S	84.96	20.0-28.4	Mudstone/sandstone	Shallow
KCB25-BH1004-D	42.92	47.0-53.0	Sandstone	Deep
KCB25-BH1004-S	42.92	20.0-26.0	Mudstone/sandstone	Shallow
KCB25-BH1005-S	89.13	22.0-28.0	Siltstone/sandstone	Shallow
KCB25-BH1006-D	53.15	56.2-62.2	Sandstone	Deep
KCB25-BH1006-S	53.15	14.5-20.5	Sandstone	Shallow

Bores beginning with DH14 are 2014 bores and those beginning with KCB25 are 2025 bores.

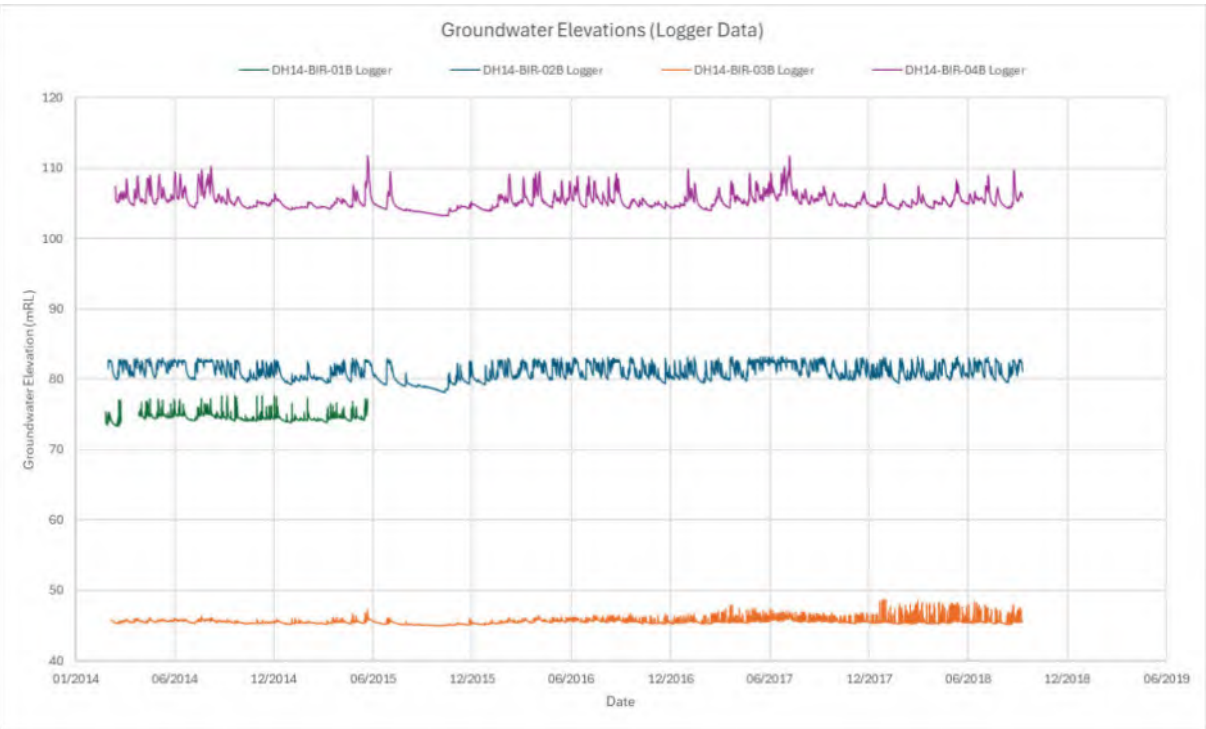


Figure 4.7 Logger Water Levels from the Shallow 2014 Bores Monitoring the Residual Soil

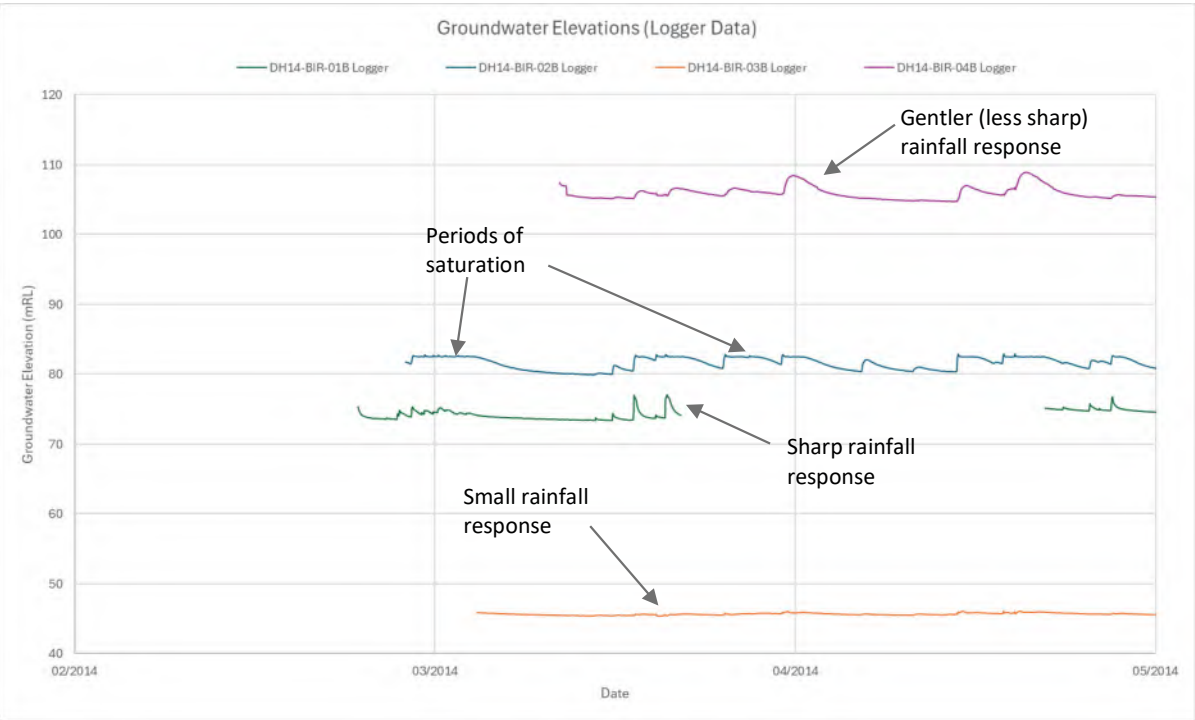


Figure 4.8 Logger Water Levels from the 2014 Bores (as above) Set to a Narrower Timescale

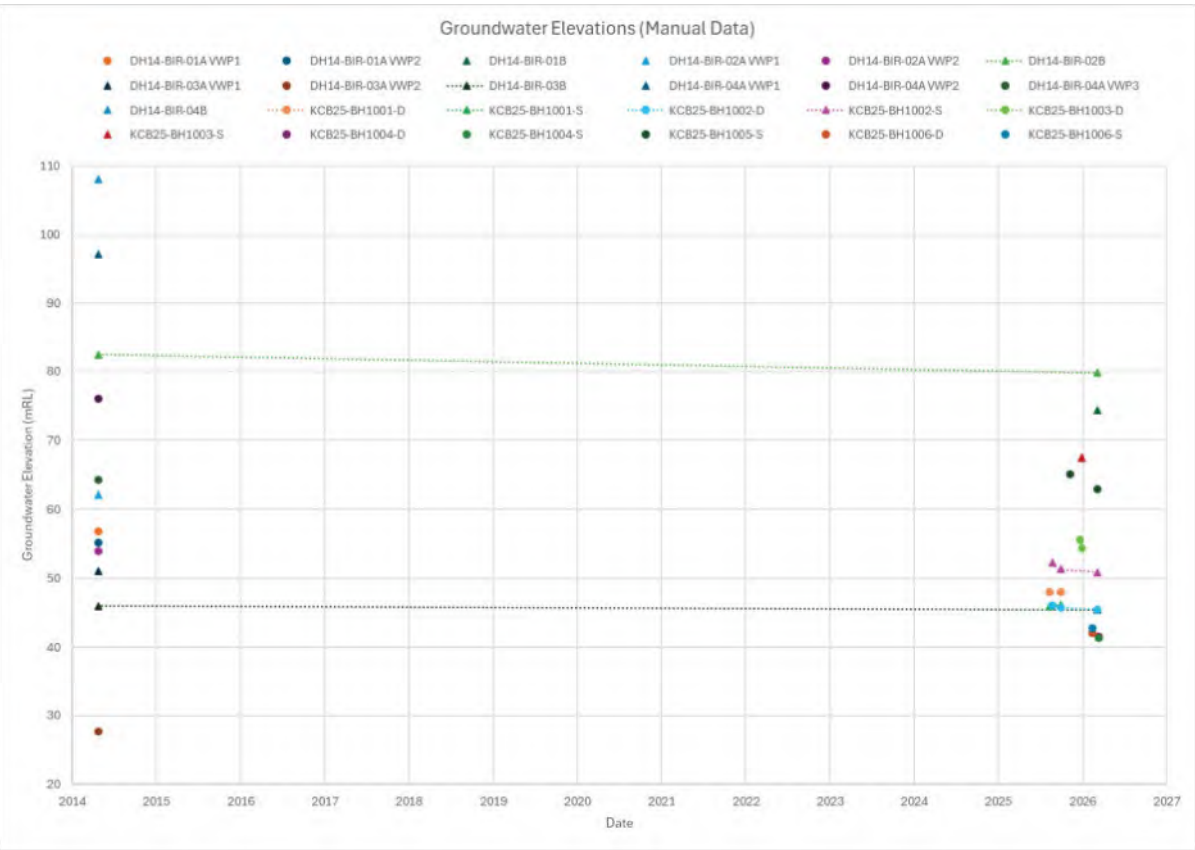


Figure 4.9 Time Series of Available Manual Groundwater Levels

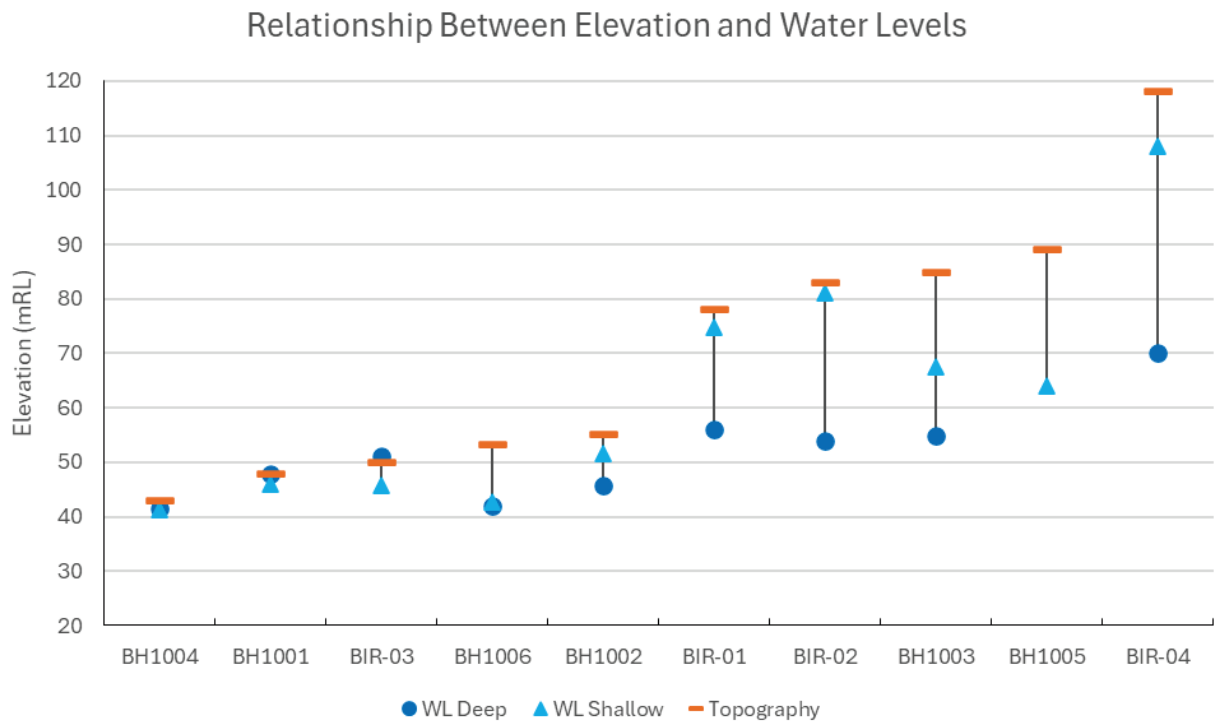


Figure 4.10 Time Series of Available Manual Groundwater Levels

Generally, groundwater elevations follow the topography, with a regional hydraulic gradient trending from north to south.

Low-permeability mudstones and shales outcrop at higher elevations to the north of the TSF, and groundwater recharge in this area is expected to be reduced. Locally, recharge is inferred to occur predominantly on sandy and gravelly ridges via surface infiltration, with a generally downward hydraulic gradient from the shallow system to deeper units (BH1002-S&D; BH1003-S&D). Groundwater discharge is expected in proximity to streams, where water levels are typically within 1 m of the ground surface (BH1004-S&D; BH1006-S&D). Semi-confined conditions with artesian water levels in the deep system are observed near large topographical changes (KCB-BH1001-S&D).

The following observations are noted from the recorded water levels.

Shallow System

- The shallow groundwater system is typically highly responsive to rainfall, although the magnitude and timing of the response vary with topography and near-surface lithology. Groundwater levels show sharp responses to rainfall events in the shallow system, with groundwater draining away in the hours and days following the rainfall event (Figure 5.11).
- BIR-01B (on a ridge line, northeast of the TSF) exhibits sharp, high-magnitude groundwater peaks that dissipate rapidly following rainfall, reflecting a highly responsive shallow zone. Groundwater levels range from approximately 74–78 mRL (0–4 mbGL).
- BIR-04B also responds strongly to rainfall but with gentler, more rounded peaks and slower recovery. This indicates lower permeability in the shallow zone, consistent with slightly deeper screening. Groundwater levels range from approximately 106–112 mRL (6–12 mbGL).
- BIR-02B (north-northeast of the TSF) shows groundwater levels rising to ground surface (~83 mRL) following rainfall after which the response flattens, indicating saturation of the residual soil/weathered zone. Once drainage occurs, groundwater levels fall to approximately 80 mRL (3 mbGL). This cyclic saturation-and-drainage behaviour repeats through the monitoring period.
- BIR-03B, located in a central valley within the TSF footprint, records relatively low groundwater elevations of ~46 mRL (4 mbGL) and exhibits a muted response to rainfall with peaks generally <0.5 m. This subdued behaviour is attributed to the deeper weathering and sandy nature of the weathered rock, resulting in higher hydraulic conductivities and better connection to the nearby stream.
- The Ok Tedi flood plain alluvial aquifer consists of a mixture of silt, sand and gravels hydraulically connected with the Ok Tedi River, with the water levels in KCB25-BH1001-S likely representative of the river levels.

Deep System

- The deeper groundwater system generally reflects recharge from the shallow system rather than independent upward pressures.
- In the southern area (BH1004-D/S and BH1006-D/S), deep groundwater levels are similar to the corresponding shallow bores, suggesting hydraulic connectivity. Differences in response timing and variability will be assessed once continuous logger data become available.
- Across the site, adjacent shallow–deep bore pairs exhibit a downward hydraulic gradient, confirming that vertical recharge from surface to depth is the dominant flow mechanism, rather than regional upward discharge.
- Although not representative of the overall groundwater regime, locally confined conditions have been observed during drilling at BH2001 at a depth of ~25 m and at BIR-03A VWP1 (at ~20 m depth), where low permeability layers resulted in artesian pressure. Recharge from the nearby ridges is most likely the source of the water pressure levels.
- Intermittent artesian pressures were also observed at BH1001-D at much greater screened depths of 49.3–55.3 mbGL, likely related to more regional groundwater flow patterns. The adjacent shallow bore (BH1001-S) drilled to a depth of ~20 m reflects non-artesian, likely river-controlled water levels, confirming that artesian pressures originate from depth.

Structural Controls

- Potential structural features near Kungembit may influence groundwater flow by acting as preferential pathways or barriers. Drilling at KCB25-BH1003-D did not intersect the fault directly, but some metamorphosed sections were encountered in the bore. Geophysical surveys also identified features suggestive of fault offsets. As geophysical interpretations are non-unique, targeted drilling is recommended to confirm the presence and hydraulic significance of any faults.

4.5 Groundwater Quality

A series of groundwater, surface water, spring water and rainwater samples have been taken across the site for hydro-chemical characterisation which aids in understanding the differences and relationships between the groundwater and surface water regimes. The sample locations are shown in Figure 4.11, and the results for key constituents are shown in Table 4.5 (See Appendix I for copies of lab results). As per Table 4.5, the results have been grouped and plotted on Piper (Figure 4.12) and Durov (Figure 4.13) diagrams. Key observations on surface and groundwater quality are outlined in the sections below.

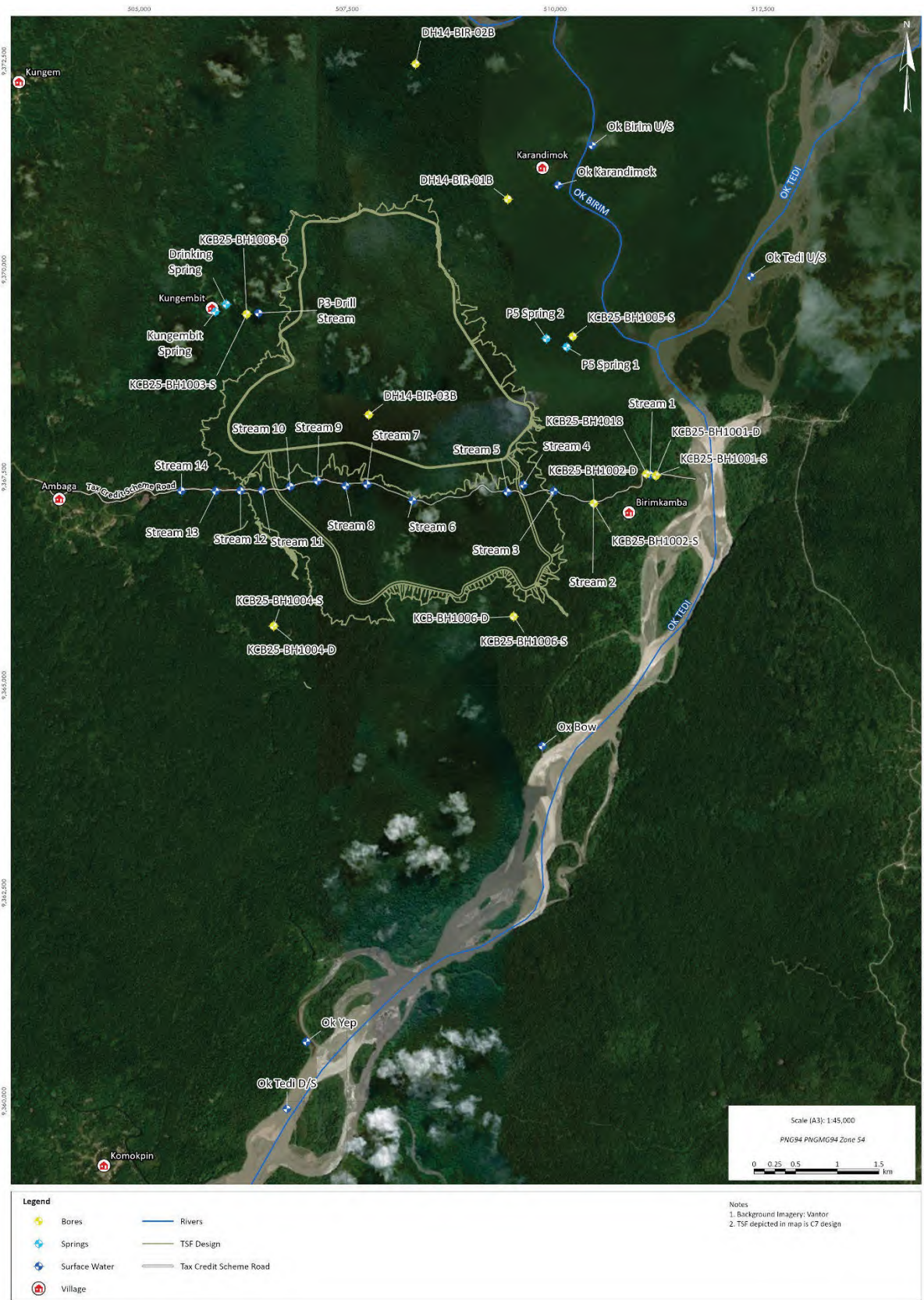


Figure 4.11 Groundwater and Surface Water Sample Locations

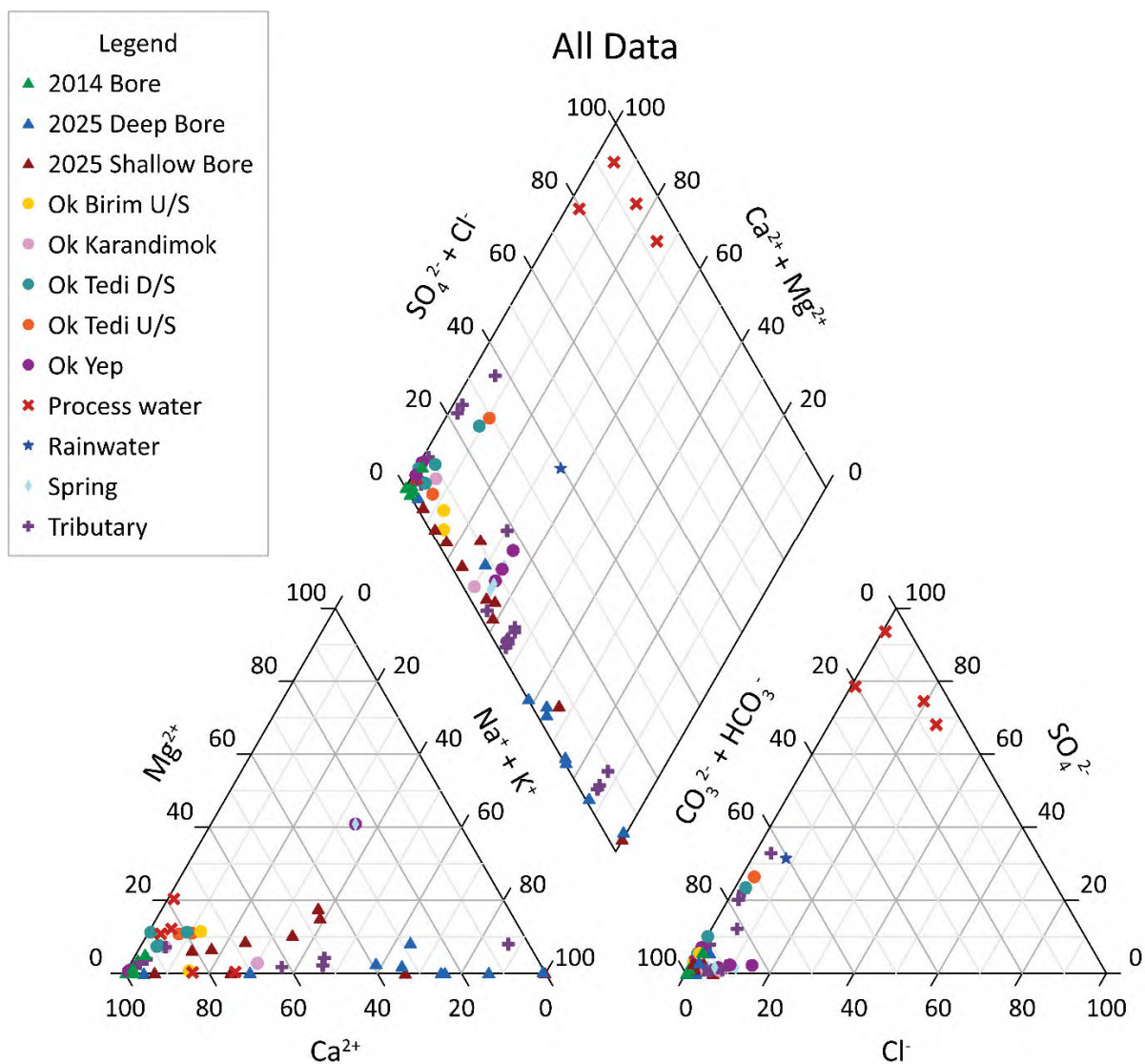


Figure 4.12 Piper Diagram of Available Water Quality

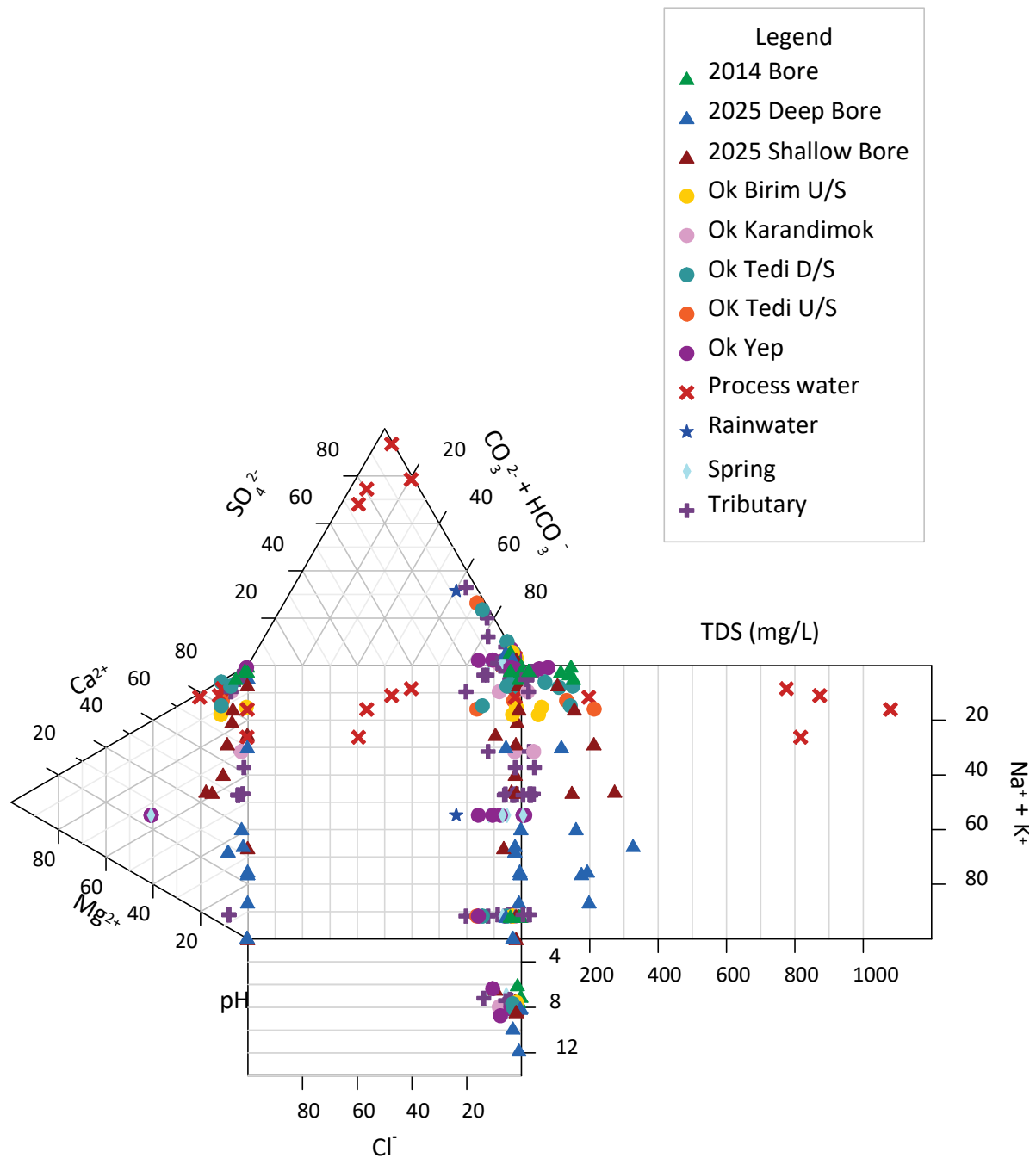


Figure 4.13 Durov Diagram of Available Water Quality

Groundwater

- pH is typically near neutral ranging from slightly acidic (pH 6) to generally around pH 7.5. The lowest pH of 6.0 was recorded at DH14-BIR-02B while the highest pH of 7.7 was recorded at KCB25-BH1002-D. An outlier of 11.75 was recorded at KCB25-BH1003-D (likely due to an influence of drilling grouts).
- Water quality is typically very good and water is fresh. Electrical conductivity (EC) is relatively low, ranging from 39.5 $\mu\text{S}/\text{cm}$ at DH14-BIR-02B to 407.2 $\mu\text{S}/\text{cm}$ at CB25-BH1002-D. Once again, an outlier of 5007.0 $\mu\text{S}/\text{cm}$ was measured at KCB25-BH1003-D.

- Groundwater typically plots from a spectrum of calcium-bicarbonate to sodium-bicarbonate water type which correlates with depth. There is little contribution of chloride and sulphate. Shallow groundwater (2014 bores screened at 1.5-10.0 m depths) is calcium-bicarbonate type, which is typical of young, fresh, shallow groundwaters with limited evaporative and mineral influence.
- Deeper groundwater (2025/2026 deep bores screened at 47-76 mbGL) plot towards the sodium-bicarbonate end member which is typical of deeper water that have higher residence time and are influenced by ion-exchange and rock-water interaction.
- Bores screened between 11.5-28.0 m depth plot in between indicating that there are some mixing and interaction of older, deeper groundwater and younger, shallower groundwater as natural recharge processes occur.
- A series of springs were sampled at Kungembit and at KCB25-BH1005-D/S. These springs cluster in the middle of the calcium-bicarbonate to sodium-bicarbonate spectrum, similar to groundwater in bores screened between 11.5-28.0 m depth.
- The groundwaters are relatively devoid of dissolved metals with most being below detection limits. This is consistent with natural waters that have little to no anthropogenic influence. Manganese and iron are common across all the bores. Furthermore, trace amounts of barium and strontium are common indicating interaction with clay and/or carbonate rich lithologies, as expected due to the abundant presence of clayey soils and rocks.

Surface Water

- pH is typically neutral to slightly alkali. Some minor streams record acidic pHs particularly those on the western half of the proposed TSF footprint, with Stream 7 and 8 recording pH of 5 (Figure 4.11). Streams at Kungembit and KCB25-BH1003 are slightly alkali with recorded values up to 8.7.
- The EC of surface water is generally low indicating fresh water particularly in unnamed non-perennial streams where values between 3.8 - 47.9 $\mu\text{S}/\text{cm}$ have been recorded. The Ok Birim and Ok Tedi sample sites show higher ECs of between 55.0-366.4 $\mu\text{S}/\text{cm}$, indicating different water sources (i.e., the highlands to the north of the site).
- Surface water quality is typically good with little dissolved constituents. The samples range from calcium-bicarbonate type to sodium-bicarbonate type on the Piper diagram. Several small unnamed tributaries to the Ok Yep were sampled along the Tax Credit Scheme Road (Figure 1.1). Streams 5, 6 and 7 (Figure 4.11) group towards the sodium-bicarbonate end (similar to the deep groundwater) indicating influence from a potentially different water source in the central TSF area.
- Streams on the western side of the TSF footprint plot centrally on the calcium-bicarbonate to sodium-bicarbonate spectrum, along with the springs and streams at Kungembit to the northwest, suggesting a potential link between surface waters and springs along the western edge.

- Generally, the smaller streams and tributaries appear to have a similar geochemical signature to groundwater which supports the conceptualisation that they are supported by baseflow, while the Ok Tedi shows similar signature to rainwater and would be largely fed by rainfall runoff and influent streams (although there is only one rainfall sample and may not be entirely representative).
- Process water (i.e., tailings water) has a distinctly different water type which is dominated by calcium-sulphate.

Table 4.5 Water Quality Results

Bore ID	Piper Diagram Group	Sample date	pH (field)	EC (Field)	pH (Lab)	Electrical Conductivity @ 25°C	Total Dissolved Solids @180°C	Total Alkalinity as CaCO3	Sulfate as SO4 - Turbidimetric	Chloride	Fluoride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Arsenic	Barium	Copper	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Strontium	Zinc	Iron
		Unit:	pH unit	µS/cm	pH unit	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		LOR:	-	-	0.01	1	10	1	1	1	0.01	0.1	1	1	1	1	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.005
Groundwater																											
DH14-BIR-02B	2014 Bore	11/12/2025	6.02	39.50	6.37	34.00	21	18.00	<1	0.17	<0.1	6.00	<1	<1	<1	<0.01	<0.001	0.008	<0.001	<0.001	0.015	<0.001	<0.001	<0.001	0.020	<0.005	<0.05
DH14-BIR-01B	2014 Bore	11/03/2026	6.63	40.40	8.22	289.00	153	152.00	2.00	0.14	<0.1	59.00	2.00	1.00	1.00	0.07	<0.001	0.138	0.002	<0.001	0.299	<0.001	<0.001	0.004	0.282	0.025	0.16
DH14-BIR-01B	2014 Bore	11/12/2025	7.47	250.00	7.37	223.00	140	123.00	2.00	0.14	<0.1	43.00	1.00	<1	1.00	0.02	<0.001	0.068	<0.001	<0.001	0.104	<0.001	<0.001	0.006	0.205	<0.005	<0.05
DH14-BIR-02B	2014 Bore	11/03/2026	7.71	311.40	6.23	31.00	22	17.00	1.00	0.15	<0.1	6.00	<1	<1	<1	<0.01	<0.001	0.049	<0.001	<0.001	0.017	<0.001	<0.001	<0.001	0.022	0.025	<0.05
DH14-BIR-03B	2014 Bore	10/03/2026	6.94	235.10	8.18	211.00	115	110.00	<1	0.15	<0.1	43.00	<1	1.00	<1	<0.01	<0.001	0.046	<0.001	<0.001	0.152	<0.001	<0.001	<0.001	0.122	0.01	0.62
DH14-BIR-03B	2014 Bore	11/12/2025	7.03	258.00	7.23	221.00	145	123.00	<1	0.17	<0.1	46.00	<1	<1	<1	<0.01	<0.001	0.015	<0.001	<0.001	0.154	<0.001	<0.001	<0.001	0.133	<0.005	0.75
KCB25-BH1001-D	2025 Deep Bore	12/12/2025	8.07	289.00	7.63	266.00	176	151.00	<1	0.42	<0.1	14.00	<1	50.00	2.00	<0.01	0.001	0.013	<0.001	0.003	0.025	0.003	<0.001	0.004	0.139	<0.005	0.05
KCB25-BH1001-D	2025 Deep Bore	08/03/2026	8.40	301.60	8.35	289.00	193	150.00	1.00	0.24	0.1	15.00	<1	51.00	2.00	<0.01	0.001	0.065	<0.001	0.003	0.024	0.002	<0.001	0.004	0.143	<0.005	<0.05
KCB25-BH1001-S	2025 Shallow Bore	12/12/2025	8.23	243.00	7.50	219.00	153	120.00	2.00	0.62	<0.1	37.00	2.00	9.00	1.00	0.08	<0.001	0.013	<0.001	<0.001	0.081	0.003	<0.001	0.003	0.164	<0.005	0.12
KCB25-BH1001-S	2025 Shallow Bore	08/03/2026	7.65	252.30	8.25	238.00	155	122.00	1.00	0.41	<0.1	42.00	2.00	7.00	1.00	<0.01	<0.001	0.082	<0.001	<0.001	0.098	<0.001	<0.001	0.002	0.170	0.012	0.13
KCB25-BH1002-D	2025 Deep Bore	12/12/2025	7.79	394.70	7.35	338.00	349	154.00	<1	7.57	<0.1	28.00	<1	63.00	2.00	0.04	0.001	0.015	<0.001	0.008	0.083	0.01	<0.001	0.006	0.095	<0.005	0.19
KCB25-BH1002-D	2025 Deep Bore	09/03/2026	7.69	407.20	8.36	379.00	327	198.00	<1	3.34	<0.1	27.00	1.00	60.00	1.00	0.01	<0.001	0.095	<0.001	0.001	0.112	0.004	<0.001	0.003	0.082	0.01	0.11
KCB25-BH1002-S	2025 Shallow Bore	12/12/2025	7.55	188.00	7.42	185.00	168	90.00	2.00	0.87	0.1	11.00	2.00	27.00	3.00	<0.01	<0.001	0.011	<0.001	0.001	0.065	0.001	<0.001	0.004	0.139	0.006	0.09
KCB25-BH1002-S	2025 Shallow Bore	09/03/2026	7.63	222.60	8.24	210.00	148	107.00	2.00	0.7	<0.1	20.00	4.00	17.00	4.00	0.02	<0.001	0.057	<0.001	0.001	0.138	0.001	<0.001	0.005	0.240	0.013	0.16
KCB25-BH1003-D	2025 Deep Bore	10/03/2026	7.36	153.00	7.80	185.00	117	86.00	5.00	1.94	<0.1	23.00	<1	7.00	7.00	0.02	<0.001	0.146	0.004	0.04	0.178	<0.001	0.001	0.021	0.157	0.344	<0.05
KCB25-BH1003-S	2025 Shallow Bore	31/12/2025	6.40	204.30	7.43	204.00	143	82.00	2.00	5.43	<0.1	29.00	<1	10.00	2.00	0.02	<0.001	0.221	<0.001	0.004	0.127	0.001	<0.001	0.007	0.174	0.016	<0.05
KCB25-BH1003-S	2025 Shallow Bore	10/03/2026	7.47	204.60	8.06	191.00	106	98.00	1.00	0.33	<0.1	37.00	<1	2.00	2.00	<0.01	<0.001	0.202	<0.001	0.002	0.100	<0.001	<0.001	0.005	0.137	0.026	<0.05
KCB25-BH1004D	2025 Deep Bore	16/03/2026	9.82	178.00	9.27	139.00	104	70.00	2.00	0.90	0.07	2.00	<1	31.00	<1	0.17	0.003	0.086	<0.001	<0.001	0.001	0.003	<0.001	<0.001	0.013	<0.005	<0.05
KCB25-BH1004S	2025 Shallow Bore	16/03/2026	8.37	180.00	7.64	155.00	114	73.00	2.00	0.27	0.03	11.00	<1	24.00	<1	<0.01	<0.001	0.061	<0.001	<0.001	0.032	0.001	<0.001	0.002	0.035	<0.005	<0.05
KCB25-BH1005-S	2025 Shallow Bore	12/12/2025	7.35	218.00	7.54	216.00	170	115.00	4.00	0.43	<0.1	26.00	3.00	17.00	3.00	<0.01	0.001	0.015	<0.001	0.002	0.091	0.002	0.002	0.003	0.285	<0.005	<0.05
KCB25-BH1005-S	2025 Shallow Bore	09/03/2026	7.68	280.60	7.95	288.00	212	324.00	4.00	3.39	0.1	38.00	3.00	14.00	3.00	0.02	<0.001	0.156	0.001	0.003	0.232	0.001	0.003	0.004	0.430	0.031	<0.05
KCB25-BH1006-D	2025 Deep Bore	17/02/2026	8.56	285.5	8.31	255.00	198	139.00	<1	0.92	<0.1	7.00	<1	51.00	1.00	0.02	<0.001	0.009	<0.001	0.004	0.035	0.002	<0.001	0.003	0.045	<0.005	<0.05
KCB25-BH1006-S	2025 Shallow Bore	18/02/2026	6.75	234.7	7.48	207.00	273	103.00	4.00	1.36	<0.1	21.00	5.00	18.00	3.00	0.1	0.001	0.029	<0.001	0.002	0.282	0.002	<0.001	0.005	0.261	<0.005	0.64
KCB25-BH4018	2025 Deep Bore	5/10/2025	----	----	8.21	290.00	160	164.00	<1	0.22	0.1	24.00	1.00	40.00	2.00	<0.01	<0.001	0.004	<0.001	<0.001	0.032	<0.001	<0.001	0.004	0.129	<0.005	<0.05
Surface Water																											
Drinking Spring	Spring	11/10/2025	8.70	3.78	6.20	6.00	<10	3.00	<1	0.14	<0.1	<1	<1	<1	<1	0.01	<0.001	0.019	<0.001	<0.001	0.012	<0.001	<0.001	<0.001	0.007	<0.005	<0.05
Drinking Spring	Spring	10/03/2026	8.03	12.50	5.74	6.00	<10	3.00	<1	0.14	<0.1	<1	<1	<1	<1	<0.01	<0.001	0.052	<0.001	<0.001	0.013	<0.001	<0.001	<0.001	0.009	0.032	<0.05
Indo Road Stream 1	Tributary	10/12/2025	7.41	30.40	6.35	27.00	30	12.00	1.00	0.17	<0.1	5.00	<1	<1	<1	0.01	<0.001	0.011	<0.001	<0.001	0.046	<0.001	<0.001	0.002	0.038	<0.00.	

Bore ID	Piper Diagram Group	Sample date	pH (field)	EC (Field)	pH (Lab)	Electrical Conductivity @ 25°C	Total Dissolved Solids @180°C	Total Alkalinity as CaCO3	Sulfate as SO4 - Turbidimetric	Chloride	Fluoride	Calcium	Magnesium	Sodium	Potassium	Aluminium	Arsenic	Barium	Copper	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Strontium	Zinc	Iron
		Unit:	pH unit	µS/cm	pH unit	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		LOR:	-	-	0.01	1	10	1	1	1	0.01	0.1	1	1	1	1	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.005
Ox Bow	Ok Tedi D/S	8/03/2026	6.55	275.40	8.19	232.00	150	111.00	12.00	0.17	<0.1	40.00	2.00	2.00	<1	<0.01	<0.001	0.063	0.003	<0.001	0.173	0.002	<0.001	0.002	0.198	0.015	<0.05
P3 - Drill Stream	Ok Yep	31/12/2025	6.36	4.35	6.16	5.00	<10	2.00	<1	0.15	<0.1	<1	<1	<1	<1	0.01	<0.001	0.008	<0.001	<0.001	0.027	<0.001	<0.001	<0.001	0.005	<0.005	0.14
P3 - Drill Stream 2	Ok Yep	31/12/2025	8.74	10.00	6.28	7.00	10	3.00	<1	0.16	<0.1	<1	<1	<1	<1	<0.01	<0.001	0.013	<0.001	<0.001	0.057	<0.001	<0.001	0.001	0.009	0.006	0.46
P3 - Rainwater	Rainwater	31/12/2025	----	----	6.31	6.00	<10	2.00	1.00	0.19	<0.1	<5	<5	<5	<5	<0.50	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.250	<0.50	
P5 Spring 1	Spring	17/10/2025	6.76	8.25	6.34	8.00	<10	3.00	<1	0.27	<0.1	<1	<1	<1	<1	0.02	<0.001	0.009	<0.001	<0.001	0.006	<0.001	<0.001	0.001	0.007	<0.005	<0.05
P5 Spring 2	Spring	18/10/2025	6.88	8.65	6.48	9.00	<10	5.00	<1	0.19	<0.1	<1	<1	<1	<1	0.02	<0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.012	0.012	<0.05
Unnamed Stream 1	Ok Karandimok	10/12/2025	7.95	11.70	6.28	13.00	18	7.00	<1	0.42	<0.1	1.00	<1	<1	<1	0.02	<0.001	0.004	<0.001	<0.001	0.007	<0.001	<0.001	<0.001	0.015	<0.005	<0.05
Unnamed Stream 1	Ok Karandimok	8/03/2026	6.95	20.80	7.11	18.00	36	10.00	<1	0.16	<0.1	2.00	<1	1.00	<1	0.02	<0.001	0.068	<0.001	<0.001	0.02	<0.001	<0.001	<0.001	0.029	0.018	0.17

Note: The sample from KCB25-BH1003-D of 31/12/2025 was not included in this table as the sample was likely contaminated by drilling fluids.

4.6 Tailings Leachate Quality

Based on the Closure Cover and Geochemical Model (KCB 2026a), it is predicted that the pH in the tailings will not acidify. For the purposes of this hydrogeological assessment, this assumption is considered reasonable given that the high-sulphur pyrite concentrate will be disposed of at the Bige TSF.

TSF supernatant and embankment seepage water quality ranges were modelled as part of the geochemical characterisation of the TSF seepage water quality (KCB 2026a). These concentrations are not expected to reduce significantly during closure (KCB 2026a) with the values used as input concentrations for the groundwater model listed in Table 4.6.

Table 4.6 Modelled TSF Seepage Water Quality (KCB 2026a)

Parameter	TSF Underflow Seepage	Modelled Embankment Seepage Water Quality
pH	7-10	7-8
TDS (mg/L)	1600	3200
SO ₄ (mg/L)	1000	2200
As (ug /L)	6.2	10
Cu (ug /L)	10	70

4.7 Groundwater Recharge

4.7.1 Rainfall Recharge Mechanisms

The nature and magnitude of groundwater recharge and discharge is expected to vary spatially and temporally across the Project area, and is controlled by several factors, including climate, topography, soil and rock permeability, and vegetation. Actual recharge is a difficult parameter to quantify due to the complexities and relationships between these influencing factors.

Nonetheless, the total recharge is expected to be high due to the high rainfall, nature of material at surface, and shallow groundwater levels.

The potential groundwater recharge mechanisms that may be active in the area include:

- Localised recharge beneath drainage features such as rivers and streams, and free-draining unconsolidated sedimentary cover, such as alluvium – it is anticipated that most streams and rivers in the area can be classified as gaining, meaning that groundwater discharges into the rivers as baseflow, maintaining river flows when rainfall is low. However, in times of flooding, and at non-perennial streams in the upper reaches of the catchment, surface water may recharge into groundwater systems as surface water levels rise above groundwater levels. Hence, there is likely to be a continuum of recharge and discharge between rivers/streams and groundwater in the surrounding hyporheic zone.

Diffuse recharge from the shallow to deeper groundwater systems primarily occurs during periods of high-intensity and/or sustained rainfall, where infiltration exceeds soil storage capacity, leading to percolation under gravity to deeper aquifer zones. This

process is spatially and temporally variable and is influenced by topography and the hydraulic properties of the intervening hydrostratigraphic units. Recharge rates may be reduced in areas of steeper slopes or where low-permeability strata are present, resulting in increased surface runoff and limited downward infiltration:

- Low-permeability mudstones and shales outcrop at higher elevations to the north of the TSF, and groundwater recharge in this area is expected to be reduced.
- Locally, recharge is inferred to occur predominantly on sandy and gravelly ridges via surface infiltration, with a generally downward hydraulic gradient from the shallow system to deeper units.
- Vertical leakage into and through semi-confined units, where present, groundwater may move from one aquifer system to another through a less permeable confining layer. This can occur both upwards and downwards depending on the hydraulic gradient and it is a function of contrasting permeabilities (discussed in Section 4.3.1) of different lithologies that are in contact, or where confining layers, such as siltstone and mudstone, exist.
- Interflow and throughflow: the lateral movement of rainwater through the shallow subsurface under varying degrees of saturation, typically within the soil profile or highly weathered zones, occurring above the regional water table and driven by gravity. Interflow and throughflow either reach the groundwater (as diffuse recharge) or moves downgradient and discharges into streams and springs. Interflow typically occurs due to the presence of underlying rock or sediments of lower permeability (in comparison to surface units), that result in the preferential lateral movement of water.

Actual recharge is a difficult parameter to quantify due to the associated complexities. The Cromer constant head tests and shallow falling head tests (discussed in Section 2.3.2 and 4.3) conducted on hilltops showed higher infiltration rates up to 1.06×10^{-3} m/day while those conducted at the base of slopes showed infiltration rates as low as 3.70×10^{-5} m/day. As discussed in Sections 4.3.1, 4.4 and 4.5 this is expected as the valleys typically have saturated clayey soils, while drier silty/sandy or gravelly clays exist at the ridges.

4.7.2 Tailings Infiltration and Embankment Recharge Mechanisms

Tailings deposition will alter the groundwater infiltration and recharge regime in the following ways:

- The embankment (cyclone underflow) will be constructed using comparatively coarse underflow material which will likely enhance recharge across the embankment's footprint. Rain falling on the embankment may be expected to infiltrate at relatively higher rates (per unit surface area). This will be supplemented by lateral seepage of water from the saturated overflow material deposited within the TSF into the embankment. The bulk of this water will drain out the toe of the embankment and become surface water. However, some contribution is expected to flow vertically into the subsurface and contribute to groundwater recharge. The embankment material has similar K values to that of the residual soil (see Table 4.2 and Table 4.3).
- At commencement of deposition, only a small tailings pond is expected to be present. This pond will progressively expand as a) deposition volumes increase, and b) low

permeability overflow tailings accumulate across the TSF footprint. Consequently, it is anticipated that a persistent ponded water surface (hydraulic head) will form within the TSF – supplemented by direct rainfall – which will likely result in sustained infiltration and recharge, and the development of a groundwater mounding effect beneath the TSF.

The vertical infiltration and recharge from the pool will initially be controlled by properties of the natural ground (as mentioned above). However, as low permeability overflow tailings accumulate and compact within the TSF, it will offer some resistance to vertical flow and seepage. The fine overflow material is expected to have lower K values than the natural ground, as shown in Table 4.2 and Table 4.3.

5 SUMMARY OF HYDROGEOLOGICAL CONCEPTUAL MODEL

With the data and findings presented above, an improved conceptual hydrogeological model has been developed – this includes the current natural state as well as the influence of the proposed TSF facility. This improved conceptual model was used to update the numerical groundwater model and ultimately increases confidence in the numerical model results.

5.1 Surface Setting

The Ok Birim TSF is located in a humid equatorial climate characterised by consistently high rainfall and minimal temperature variability. Mean annual rainfall recorded by the weather station nearest to site is 7464 mm. This climatic regime results in persistently high soil moisture, frequent groundwater recharge, and generally shallow groundwater levels.

Topographically, the site lies at a transition between the upland foothills draining southwards from the Central Cordillera and the low-lying floodplains of the Fly River system. Elevations across the Ok Birim TSF site range from approximately 90 mRL along the northern edge to 30 mRL along the southwestern edge. Major perennial rivers in the region include the Ok Tedi and Ok Birim, while the immediate TSF area is drained by the Ok Yep catchment through numerous small to medium, unnamed tributaries occupying incised valleys. Flows vary greatly depending on intensity of rainfall and baseflow input.

All the unnamed drainage lines on the TSF site converge in the southwestern corner of the proposed TSF. These drainage features are hydraulically important and represent potential preferential pathways for shallow groundwater flow and seepage expression. It is likely that local groundwater flows similarly converge in this area and may become a focal point for expression of seepage from the TSF.

5.2 Hydrogeological Framework

The site is underlain by the Awin Formation, a young, poorly lithified, fluvial sedimentary sequence comprising interbedded sandstone, siltstone, mudstone, conglomerate, and minor lignite. The formation displays strong vertical and lateral heterogeneity typical of fluvial deposits, resulting in highly variable hydraulic properties. The four main hydrostratigraphic units recognised are:

- **Unconsolidated alluvium** comprising quaternary-aged gravels to clays found along the banks of the Ok Tedi. These generally form transmissive units, with hydraulic conductivity ranging between 0.05-0.40 m/day. Alluvium appears to be in direct hydraulic contact with the river and responds to changes in river flows.
- **Residual soil and weathered rock** (of the Awin Formation) cover most of the site extending to depths 10-30 mbGL. This unit has increased porosity compared to the deeper, less-weathered rock units and, therefore, higher hydraulic conductivity up to 2.3 m/day. This unit facilitates infiltration of rainfall. Groundwater movement typically follows slope/topography with interflow and throughflow seeps commonly occurring. Groundwater levels can be shallower than 1 mbGL.

- **Sandstone and conglomerate** form the aquifers of the Awin Formation. They occur as thick units in some areas or are interbedded with siltstone/mudstone in other areas. These units promote the storage and movement of groundwater and show hydraulic conductivity values of up to 1.6 m/day. Groundwater levels suggest that these units may be confined with artesian to sub-artesian pressures.
- **Siltstone and mudstone** form the aquitard units of the Awin Formation and may form confining units that hydraulically separate the aquifer units. Where they occur as thin and/or discontinuous layers, this confining influence may be less significant. These inhibit the flow of groundwater and have upper range hydraulic conductivity values as low as 0.02 m/day.

Other features of relevance to the conceptual model include:

- **Structural Features** in the Kungembit area were interpreted from aerial imagery and structural interpretation, and their presence was supported by geophysical survey results. Although their presence and hydraulic behaviour need to be confirmed with targeted drilling, these features have been included in the conceptual model and numerical model at this stage as a conservative precaution due to their potential significance as preferred groundwater pathways.
- **The TSF and its Embankments** will influence the hydrogeological regime once constructed. The resulting impact is conceptualised as a local groundwater high from which groundwater will flow radially outwards. It will also serve as a source for contaminants which will leach into the groundwater over time. The numerical model discussed in Section 6 serves to quantify these impacts.

5.3 Cross Sections

Cross sections of the study area were developed to inform and refine the hydrogeological conceptual model of the site. Interpretation was supported by the depth-frequency plot in Figure 4.4, and an integrated assessment of lithological logs from the 2014 and 2025 drilling programs. Lithological horizons were interpreted by correlating key stratigraphic units across boreholes to honour both the spatial continuity of units and the conceptual understanding of subsurface conditions.

The lithological units vary in thickness and lateral extent across the site, consistent with the inherent heterogeneity of the geological profile. Together, these interpreted layers form a three-dimensional representation of subsurface conditions, which provides the basis for the numerical model stratigraphy. The conceptual layering also incorporates the proposed TSF footprint and thickness as a discrete unit, recognising its importance in influencing site hydrogeological behaviour.

Cross sections that demonstrate the conceptual hydrogeological understanding are presented in Figure 5.2 to Figure 5.6. Locations of cross sections are shown in Figure 5.1. Boreholes, water levels and hydraulic parameters for screened intervals have been included in the cross sections.



Figure 5.1 Location of Conceptual Cross Section Lines

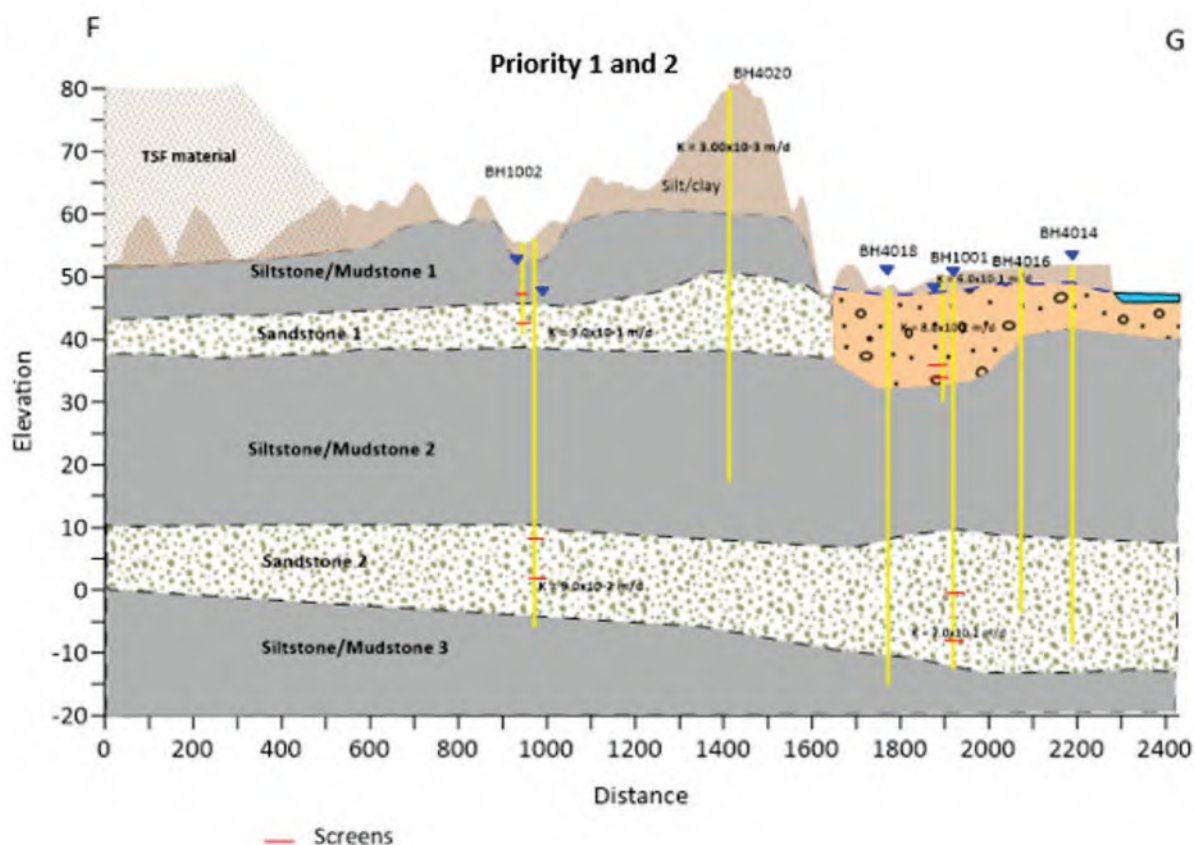


Figure 5.2 Conceptual Cross Section along Line F-G in Figure 5.1

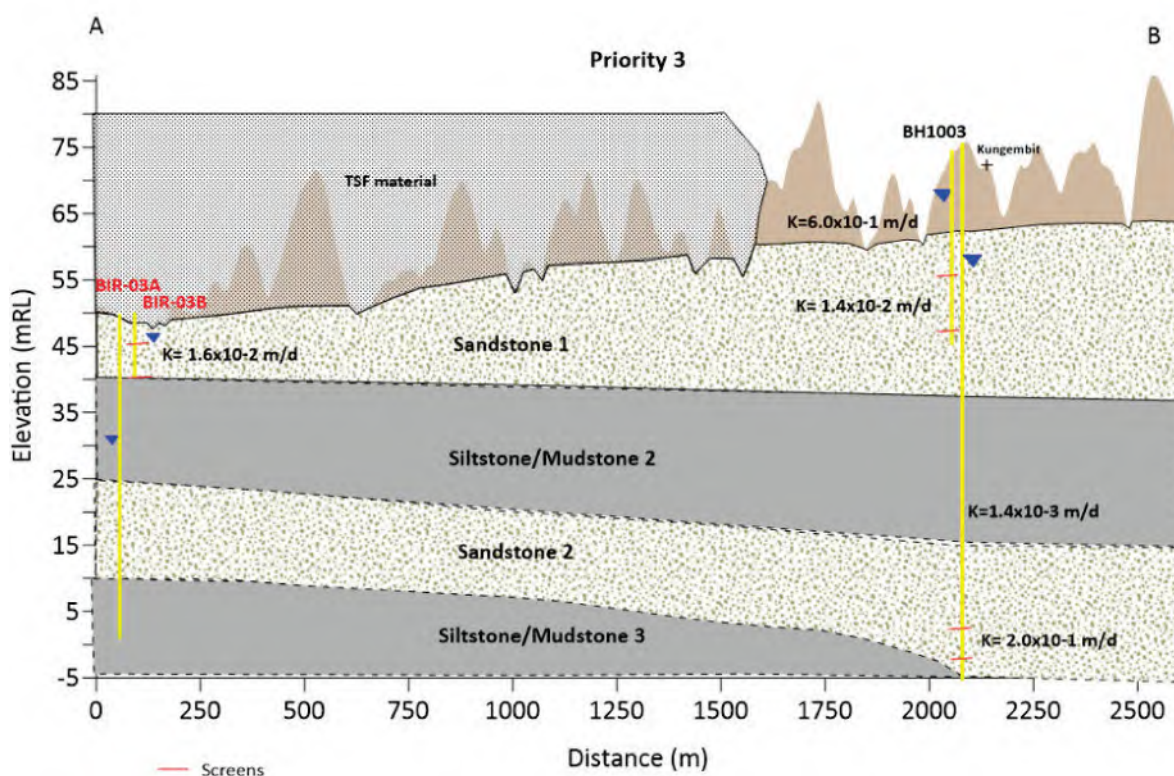


Figure 5.3 Conceptual Cross Section along Line A-B in Figure 5.1

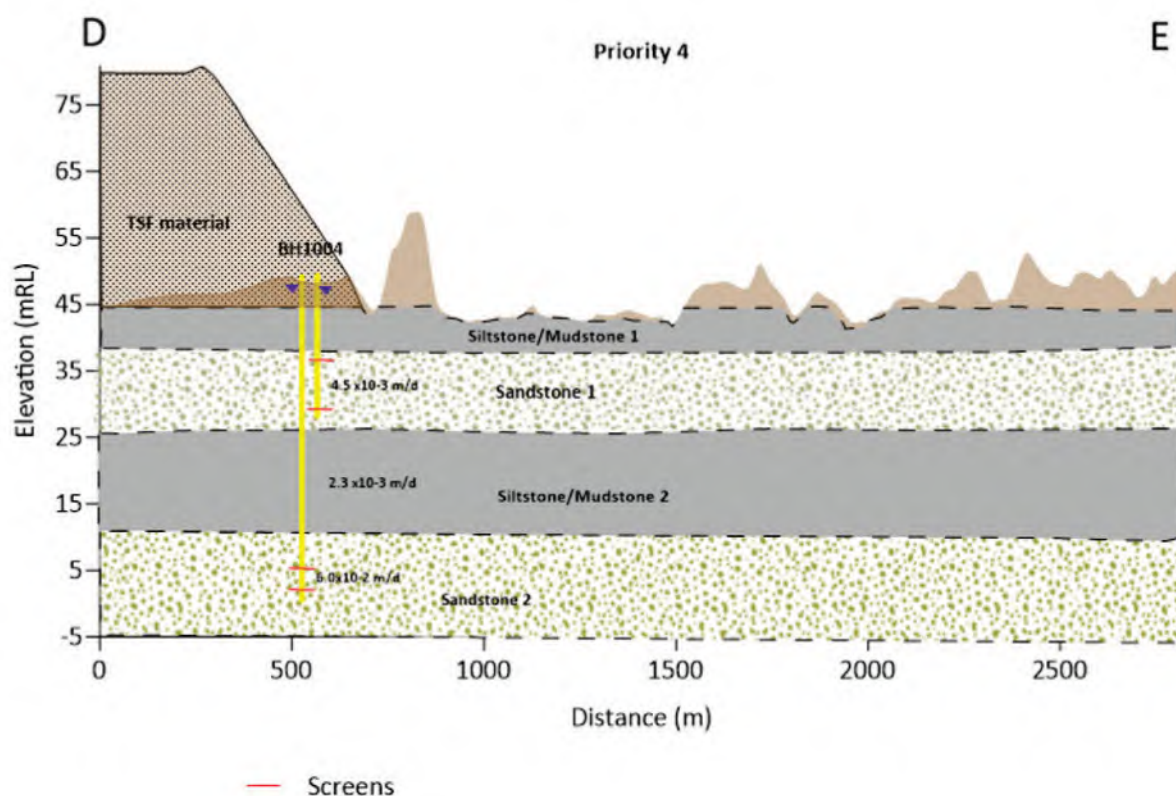


Figure 5.4 Conceptual Cross Section along Line D-E in Figure 5.1

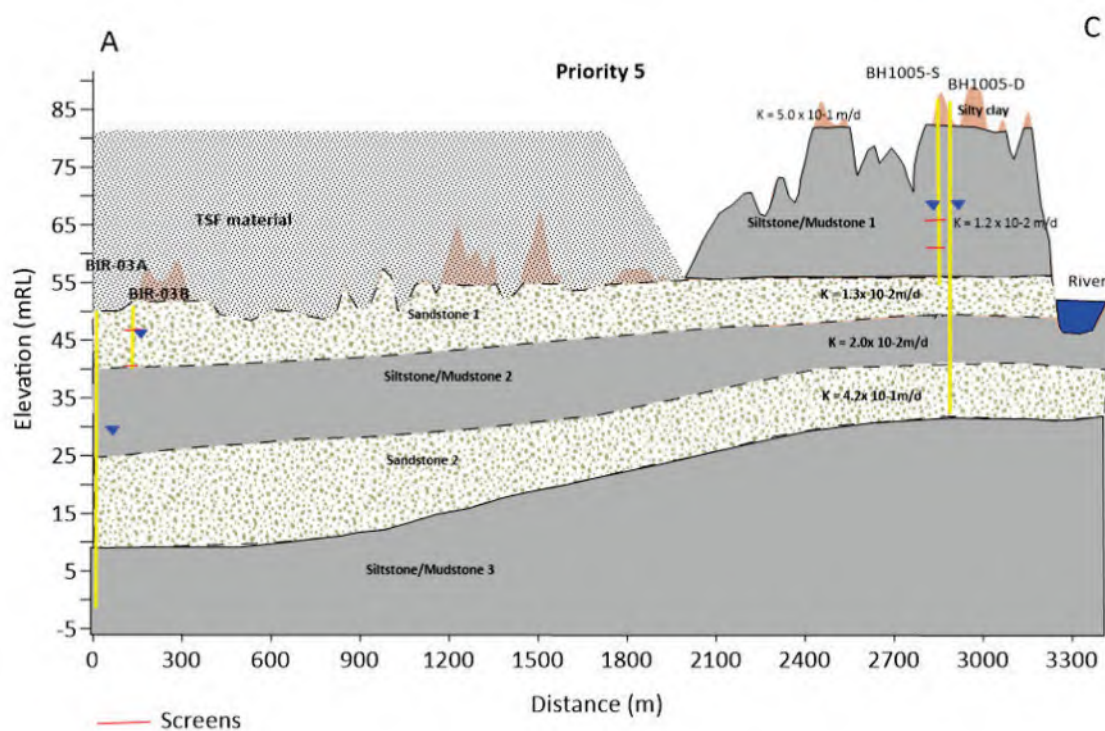


Figure 5.5 Conceptual Cross Section along Line A-C in Figure 5.1

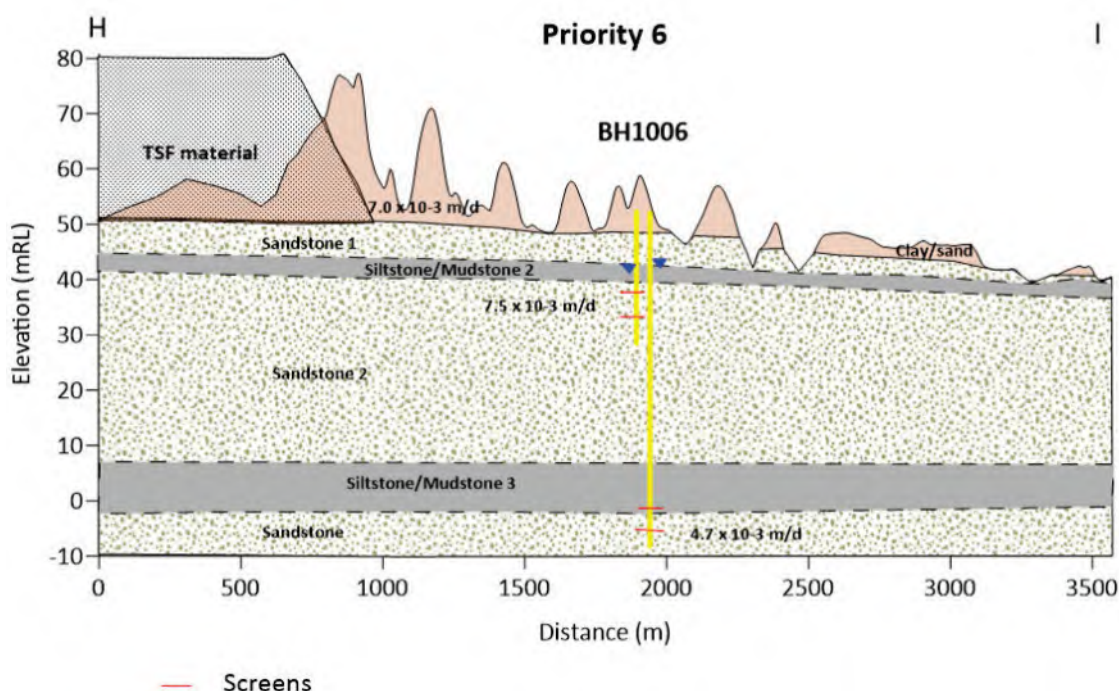


Figure 5.6 Conceptual Cross Section along Line H-I in Figure 5.1

5.4 Groundwater Levels and Flow

Groundwater is generally encountered at shallow depths across the site, commonly encountered at depths of 1-4 mbGL. Regional groundwater flow is from north to south, broadly following topography from the highlands toward the Ok Tedi floodplain. Locally, groundwater flow is strongly influenced by ridge–valley topography, lithological heterogeneity and rainfall.

Analysis of groundwater levels has identified three groundwater systems, as supported by the lithological analysis described above. These are:

- The **alluvial system** being in direct connection to the Ok Tedi responding to changes in flow of the major river.
- A **shallow system** within residual soils and weathered rock, displaying rapid and often sharp responses to rainfall, particularly on ridges.
- A **deeper system** within fresh rock units, locally confined and at times artesian where sandstone units are overlain by low-permeability siltstone or mudstone.

Hydraulic connection between groundwater and surface water systems is likely widespread across the investigation area, with perennial valley-floor streams expected to be representative of groundwater levels.

Generally, vertical hydraulic gradients are downward, indicating dominant recharge from surface to depth, although upward gradients and artesian pressures occur locally.

5.5 Groundwater Quality

Baseline groundwater quality is generally good, with pH values typically slightly acidic to neutral and low electrical conductivity. Shallow groundwater tends to exhibit calcium-bicarbonate water types, while deeper groundwater transitions toward sodium-bicarbonate compositions, reflecting increasing residence time and water–rock interaction. Dissolved metals are generally low, with iron and manganese commonly present.

Springs sampled near Kungembit show geochemical signatures intermediate between shallow and deep groundwater systems, indicating potential vertical connectivity. Surface water quality is similarly fresh, although chemistry varies between minor tributaries and the larger perennial rivers.

5.6 Tailings Water Quality

Geochemical modelling (KCB2026a) has indicated that pH in the tailings will not acidify. TSF water quality is expected to have higher TDS with a Ca-SO₄ character. The groundwater surrounding the TSF are likely to be influenced by the TSF water. Potential source concentrations are listed in Table 4.6.

5.7 Groundwater Recharge

Groundwater recharge and discharge are spatially and temporally variable across the Project area, controlled by climate, topography, and hydrostratigraphy.

Low-permeability mudstones and shales outcrop at higher elevations to the north of the TSF, and groundwater recharge in this area is expected to be limited. Recharge at a local scale is anticipated to be higher on ridges and mid-slopes with sandy or gravelly soils and lower in clay-rich valley floors where the shallow subsurface is generally saturated. Additional potential recharge mechanisms include vertical leakage through semi-confining units, and episodic riverbed recharge during flood events.

Construction and operation of the TSF will significantly modify the natural recharge regime. The presence of a permanent or semi-permanent water body (hydraulic head) within the TSF, coupled with infiltration through embankment materials, is expected to induce groundwater mounding beneath the facility and result in local radial groundwater flow from the TSF.

5.8 Environmental Values

Groundwater is a key environmental value at the site due to its role in sustaining springs, supporting baseflow to streams, and providing water resources for local communities. The local communities rely primarily on surface water and springs for domestic use, and the hydraulic connection between groundwater and surface water marks the importance of protecting groundwater quality and flow.

6 NUMERICAL GROUNDWATER MODEL

6.1 Model Design

In 2025, KCB built a three-dimensional (3D) numerical groundwater flow and transport model to assess groundwater flow paths and resulting TSF seepage at the Ok Birim site. A structured model grid was used with the MODFLOW-USG solver within the Groundwater Vistas 9.07 modelling software graphical user interface. The model included the following phases:

- Calibration phase (February-2014 to September-2018);
- Operational phase (2030 to 2049);
- Closure phase (1000 years after the end of operations).

The most recent hydrogeological data collected by the KCB drilling program (Appendix I) finished in Q1 2026, and the updated hydrogeological conceptual model (see Section 5), has been used to update the model structure and predictive scenario results. The aspects updated in the model were:

- Hydrostratigraphy (Section 4.2);
- Inclusion of extended water level monitoring data for bores BIR-01B, BIR-02B, BIR-03B and BIR-04B, in the calibration period. New bores drilled in 2025 was included in the Steady-State calibration verification and used as initial conditions for the transient predictions;
- Hydraulic conductivity and storage parameters. Those were revised during model calibration to better represent the updated hydrogeological conceptual model;
- Inclusion of the TSF Design Option C7 (raising schedule and hydraulic parameters) in the prediction modelling phase to represent the TSF operational phase.

The updated model design, calibration and results of the operational and post-closure prediction scenarios are presented in subsections below.

6.2 Model Domain

The model domain follows catchment boundaries and covers an active area of approximately 199 km², delimited by no-flow boundaries. Boundaries fully enclose the proposed TSF (Figure 6.1).

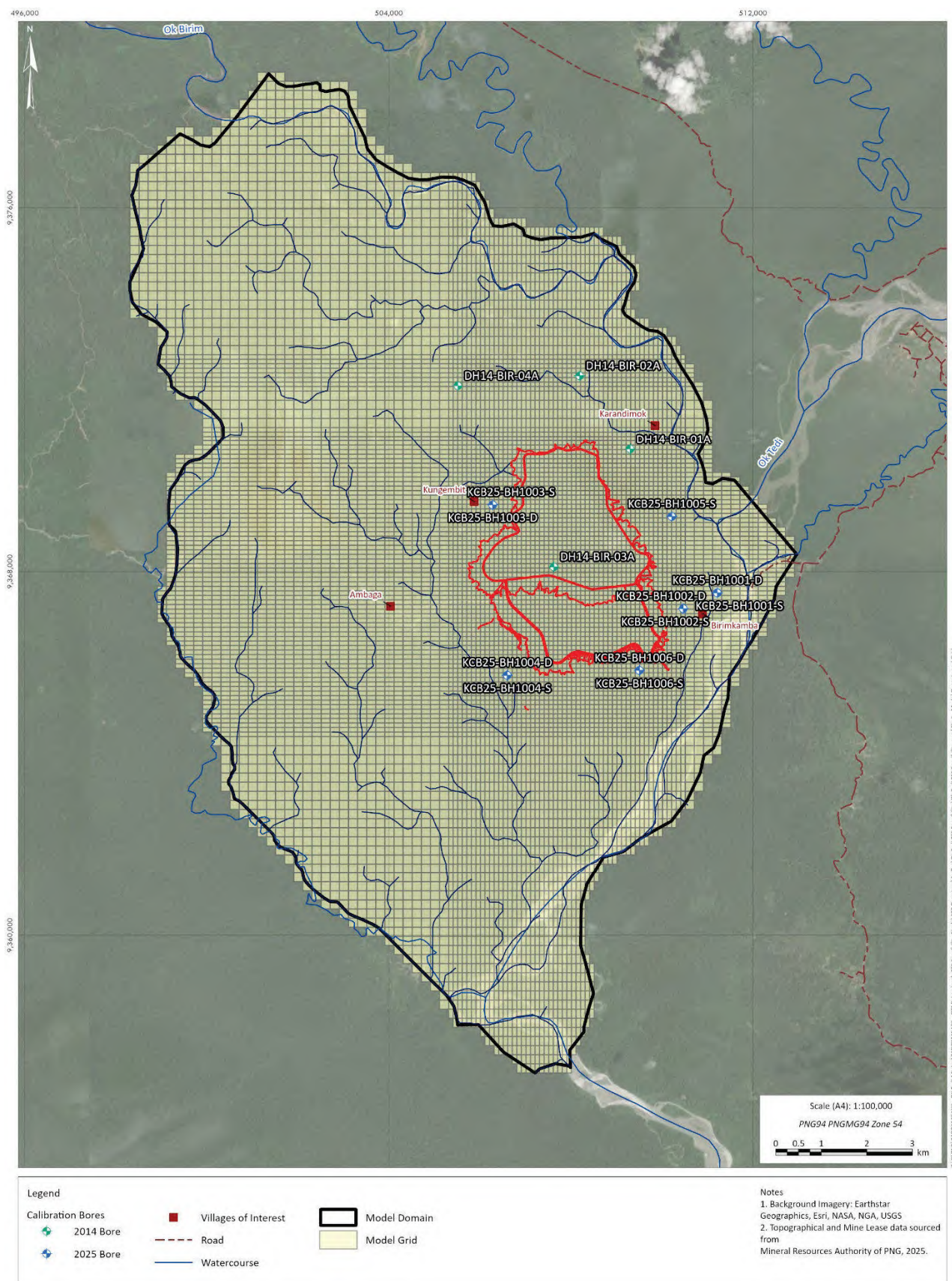


Figure 6.1 Model Domain and Grid

6.3 Model Discretisation

6.3.1 Grid Cell Size

A structured grid was defined with a 200 m-grid cell size and further refinement was applied to the proposed TSF area (Figure 6.2). A 100 m-grid cell size was adopted in the TSF area in the calibration model. Another refinement was adopted in the operational and closure models, with a grid cell size reduced to 50m in the TSF area, to allow better performance in contaminant transport model simulations.

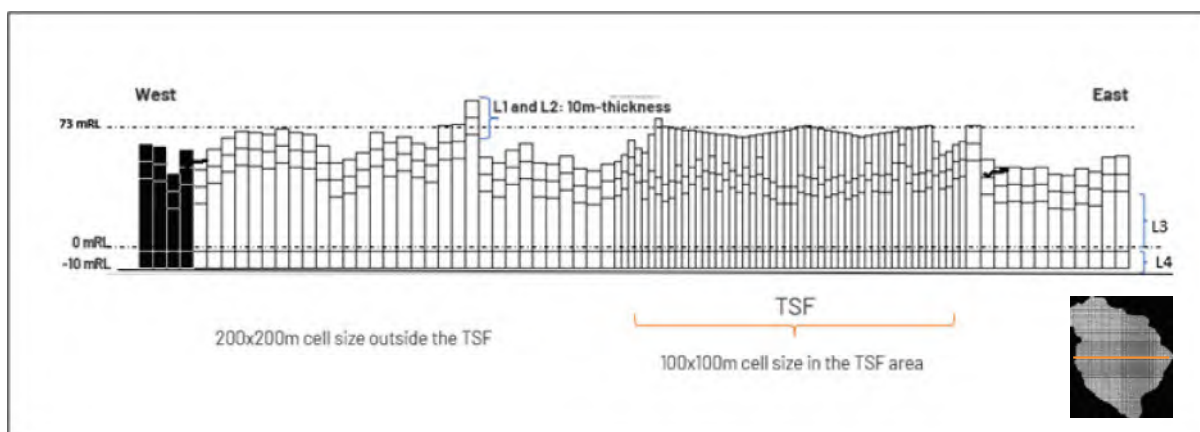


Figure 6.2 East-West Cross Section Showing the Vertical Grid Distribution in the Calibration Model

6.3.2 Hydrostratigraphy

The lithological analysis and cross sections presented in the hydrogeological conceptual model (Section 4.2 and Section 5) were used to define hydrostratigraphic layers for the numerical model, using The Minimum Curvature Method in Surfer version 29.3.307. The elevation points identified for each lithology defined in the cross sections were used as inputs for the method, which allowed the creation of six stratigraphic layers:

- Layer 1: Weathering zone (including residual soil) and alluvium (and TSF following development)
- Layer 2: Siltstone/Mudstone 1 (and TSF following development)
- Layer 3: Sandstone 1
- Layer 4: Siltstone/mudstone 2
- Layer 5: Sandstone 2
- Layer 6: Siltstone/Mudstone 3

The proposed TSF was included in Layers 1 and 2 in the Operational and Closure models.

6.3.3 Hydraulic Property Zones

6.3.3.1 Hydraulic Conductivity and Storage

The hydrostratigraphic layers in the calibrated model, as described above, were further discretised into eight zones with distinct properties, representing hydraulic conductivity and storage. The spatial distribution of the zones is shown in Figure 6.3. The lithologies defined by each zone are listed in Table 6.1.

The initial hydraulic conductivity properties assigned to each of the zones are within the range of values given by the field investigation conducted in 2014 and 2025 (Table 4.2). In the model, the hydraulic conductivity for each of the model property zone represents bulk properties, and small-scale variations within the model layers are included in the bulk response, with the impact of these variations on groundwater flows considered negligible at the scale of the model.

Table 6.1 Hydraulic Property Zones Defined in the Transient Calibration Model

Zone number	Lithology	Colour in model
1	Weathering zone	
2	Sandstone	
3	Alluvium	
4	Structural Features/Faults	
5	Weathered Zone, clayey	
6	Siltstone/Mudstone	
7	Sandy Material	
8	Weathered Zone, Sandy	

6.3.3.2 Recharge

Two recharge zones were defined in the model as shown in Figure 6.4. Zone 2 is assumed to have lower recharge than the rest of the model domain, as it is located in an area with shale and low permeability clay which contribute to higher runoff and higher interflow (and lower recharge rates). This is consistent with the landforms and elevation changes described in Section 3.2.

Available rainfall data from PMP59 station was applied to calculate recharge inputs to the model, and data from TED20, BIR05 and Bige station was used to fill the data gaps where data from PMP59 was unavailable. The BIR05 station did not exist in 2014 to 2018 where the calibration data for the model is available and therefore the next closest station with data (PMP59) was used.

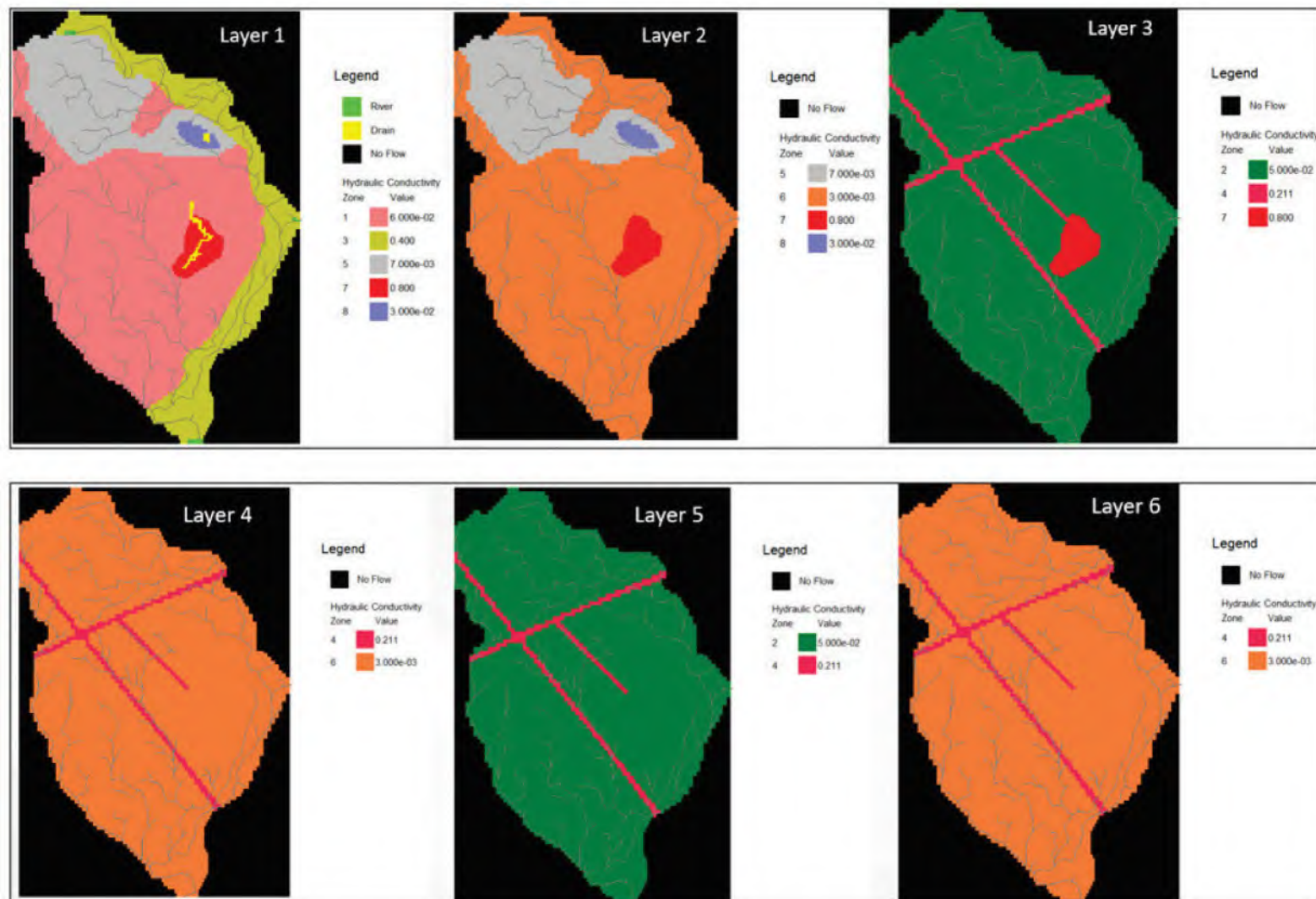


Figure 6.3 Property Zones (K and S) Adopted in the Transient Calibration Model (m/d)

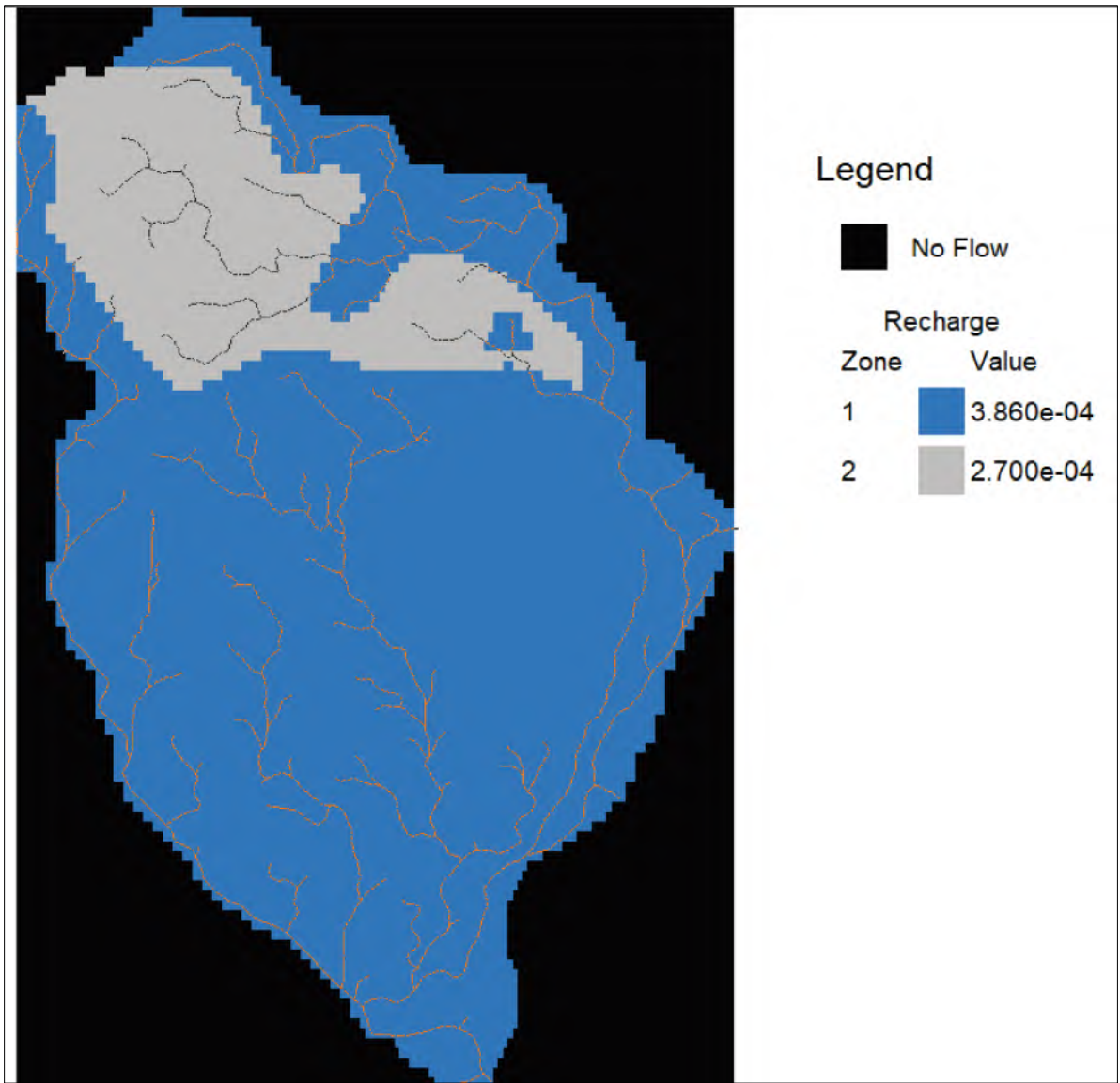


Figure 6.4 Calibration Model Recharge Zones (m/day)

6.4 Boundary Conditions

For this assessment, the boundary conditions were selected to plausibly represent the local groundwater processes in a manner that is consistent with the conceptual model, while allowing simulation of the influence of the TSF on the groundwater system.

Boundary conditions were applied to simulate surface water bodies, recharge, and seepage faces. The local topographic low areas were used to define boundaries correlating with surface water drainage systems.

Connected Linear Networks (CLNs) were used to represent the stream network across the model domain, and drain cells were placed at the catchment outlet.

Table 6.2 summarises the adopted model boundary conditions specified in the groundwater model.

Table 6.2 Adopted Model Boundary Conditions

Model Boundary Condition	Boundary Description
MODFLOW Recharge Package (RCH)	Rainfall Recharge.
MODFLOW Evapotranspiration Package (EVT)	Evapotranspiration. Extinction depth = 2.0 m.
No-flow	Catchment limits.
CLNs, River Boundary, Drain boundaries.	CLNs and drain boundaries represent the stream network. River control points were placed at the start of the river network in the North, East and South of the model domain.
Time-Variant Specified-Head (CHD). (Applied only in the operational and closure models).	TSF cells. Tailings elevation for TSF cells 1 and 2, given by the raising schedule for the C7 TSF model design.

6.5 Solute Transport Model

MODFLOW-USG Transport was used to simulate solute transport. Sulphate and Total Dissolved Solids were selected as parameters of interest (POI) and were representative of salinity, while copper and arsenic were selected as indicators of metal POI.

No geochemical reactions were incorporated into the numerical model and computed concentrations presented in this report therefore represent a conservative groundwater contaminant transport scenario (predicted concentrations were governed solely by physical transport processes, including advection, hydrodynamic dispersion and molecular diffusion).

The following constant source terms were adopted in the operational model for the TSF embankment and Inner TSF respectively (as informed by the estimated TSF seepage water quality presented in Table 4.6):

- Sulphate (SO₄): 2200 and 1000 mg/L
- Total Dissolved Solids (TDS): 3200 and 1600 mg/L
- Arsenic (As): 10 and 6.2 ug/L
- Copper (Cu): 70 and 10 ug/L

Modelling assumed that the source terms would remain constant during the post-closure period, and that the TSF will not acidify (as discussed in Section 4.6).

6.6 Model Calibration

The following model calibration criteria were considered to assess the calibration performance, based on the Australian Groundwater Modelling Guidelines (Barnett et al. 2012):

- Model convergence.

- Water balance error <1%.
- Scaled root mean square (RMS) of <10%.
- Realistic surface water discharge rates (baseflow).
- Realistic simulated potentiometric surfaces match the conceptual understanding of groundwater flow regime.

6.6.1 Steady-State Calibration (2014)

The steady-state model was calibrated to the average water levels at each of the four available monitoring bores (DH14-BIR-01B, DH14-BIR-02B, DH14-BIR-03B and DH14-BIR-04-B) using averaged water levels available in 2014, to simulate the pre-TSF period. Figure 6.5 shows the correlation between modelled and observed heads. In the case of absolute conformity, the points should create a 45-degree straight line (line of perfect fit). As indicated in Figure 6.5, the level of conformity is tolerable and consistent with the level of assessment at this stage of the Project, especially when considering heterogeneity of hydraulic properties. A correlation coefficient of 98% was achieved, which indicates a good calibration fit.

Table 6.3 presents the steady-state calibration statistics. The RMS error is below 0.1 and the water balance error is below 1%, which meets the requirements defined by Barnett et al. (2012).

Water level elevations at the end of the steady-state calibration are illustrated in Figure 6.6, with groundwater flow indicated towards the southeast, generally decreasing in the direction of the Ok Tedi. The final heads of the steady-state calibrated model were used as initial conditions for the transient model.

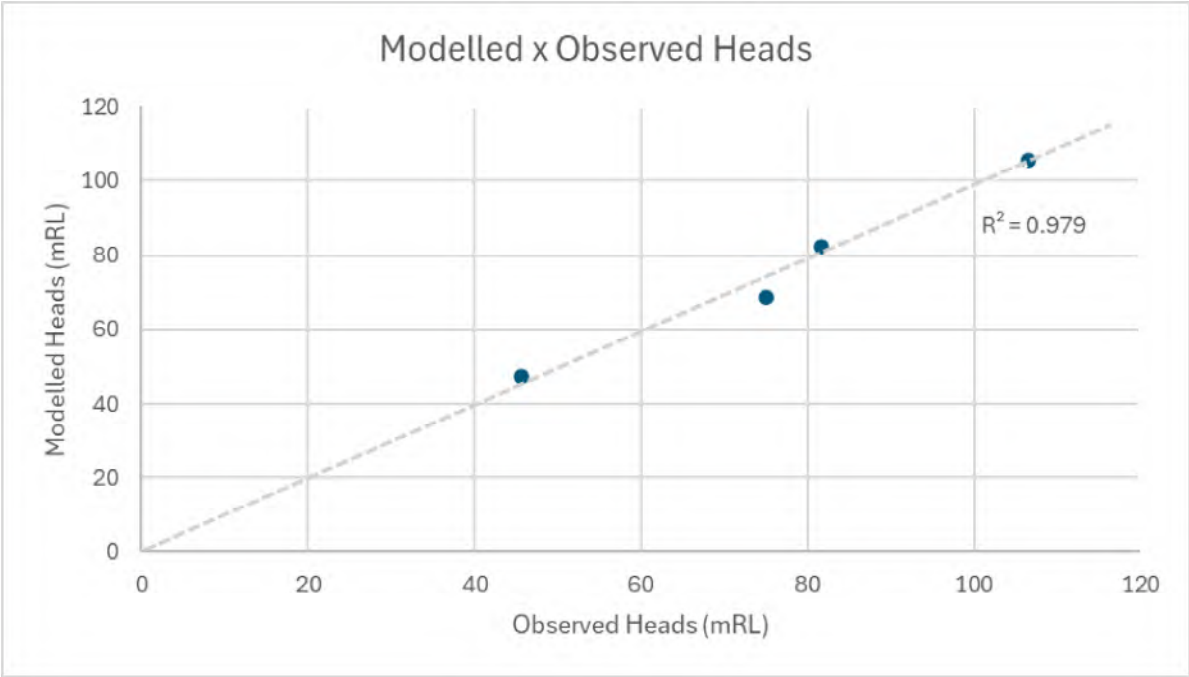


Figure 6.5 Steady-State Calibration Correlation – Modelled and Observed Heads

Table 6.3 Steady-State Model Calibration Statistics

Statistical Metric	Calibration Results
Number of Observations	4
Residual Mean	1.28 (m)
Scaled Absolute Residual Mean	4%
Root Mean Square (RMS) Error	3.40 (m)
Scaled RMS Error	6%
Water balance Error	0.0 %

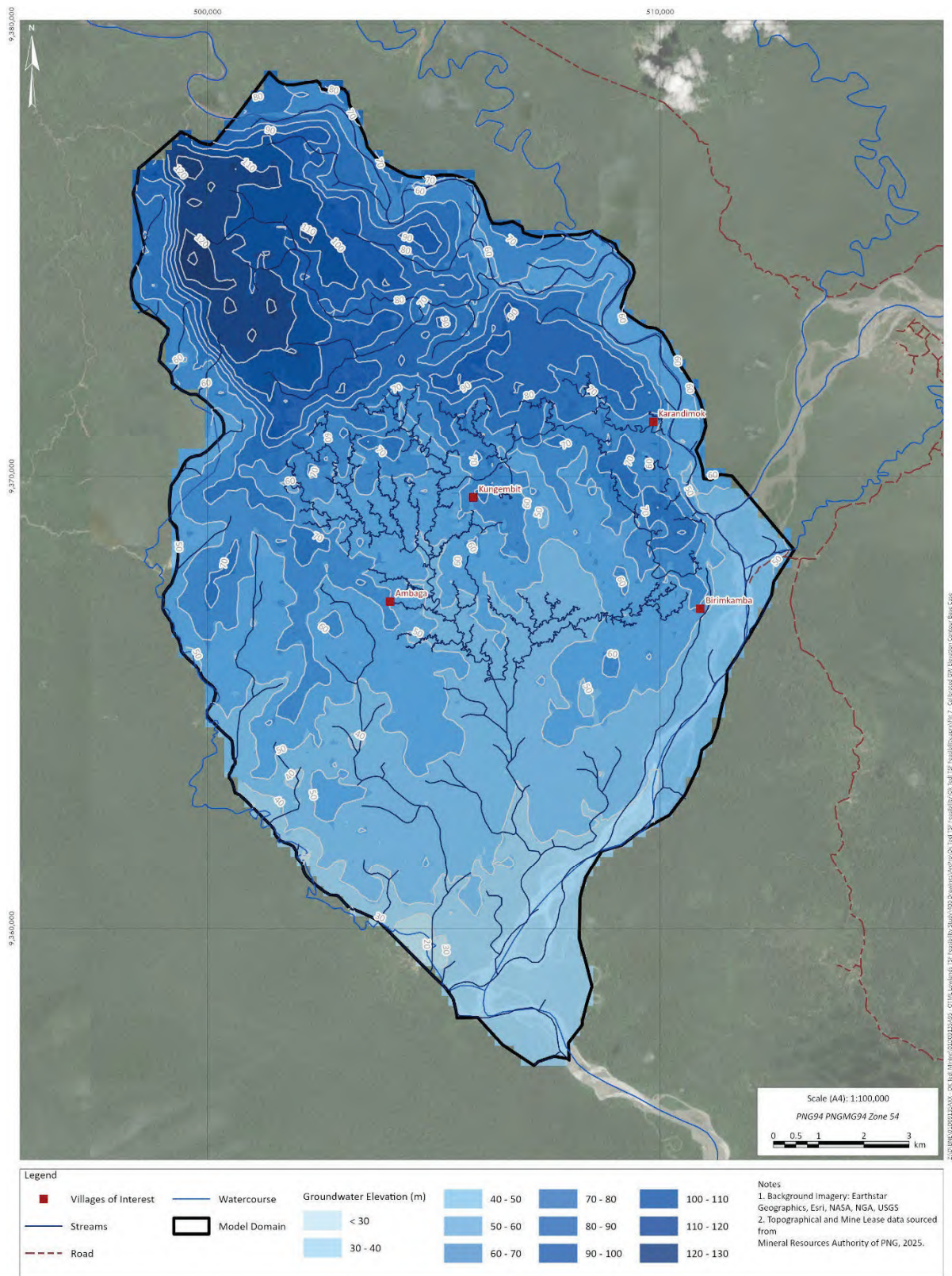


Figure 6.6 Calibrated Steady-state Groundwater Elevation Contour Map (Pre-TSF)

6.6.2 Transient Calibration (2014 to 2018)

The dataset used for calibration included monitoring water levels from the period between February 2014 and September 2018. The calibration process was divided into the following two phases:

- Short-term calibration from mid-February 2014 to late April 2014, using daily stress periods.
- Longer-term calibration from mid-February 2014 to September 2018, using weekly stress periods.

Both calibration models adopted the final heads of the steady-state model as initial conditions, and the same hydraulic conductivity and storage properties were applied to both calibration models. Similar rainfall/recharge coefficients were applied to both calibration models.

Figure 6.7 and Figure 6.8 show the calibration hydrographs for the short and longer-term calibrations, respectively. The patterns of change in heads modelled across the calibrated period match the patterns in the observed data, which indicates a satisfactory calibration fit. Calibration metrics achieved during the short-term and longer-term calibrations are presented in Table 6.4. Model convergence was obtained during calibration with a scaled RMS error below 10%, and a water balance error below 1%.

The level of conformity (calibration) is acceptable and consistent with the level of assessment at this stage of the Project, especially when considering heterogeneity of hydraulic properties.

Table 6.4 Transient Calibration Statistics

Statistical Metric	Calibration Results	
	Short-Term Calibration	Longer-Term Calibration
Number of Observations	177	792
Residual Mean (m)	-0.24	-0.19
Scaled Absolute Residual Mean	1%	2%
RMS Error (m)	1.04	2.14
Scaled RMS Error %	2%	3%
Water Balance Error	0.00	0.00

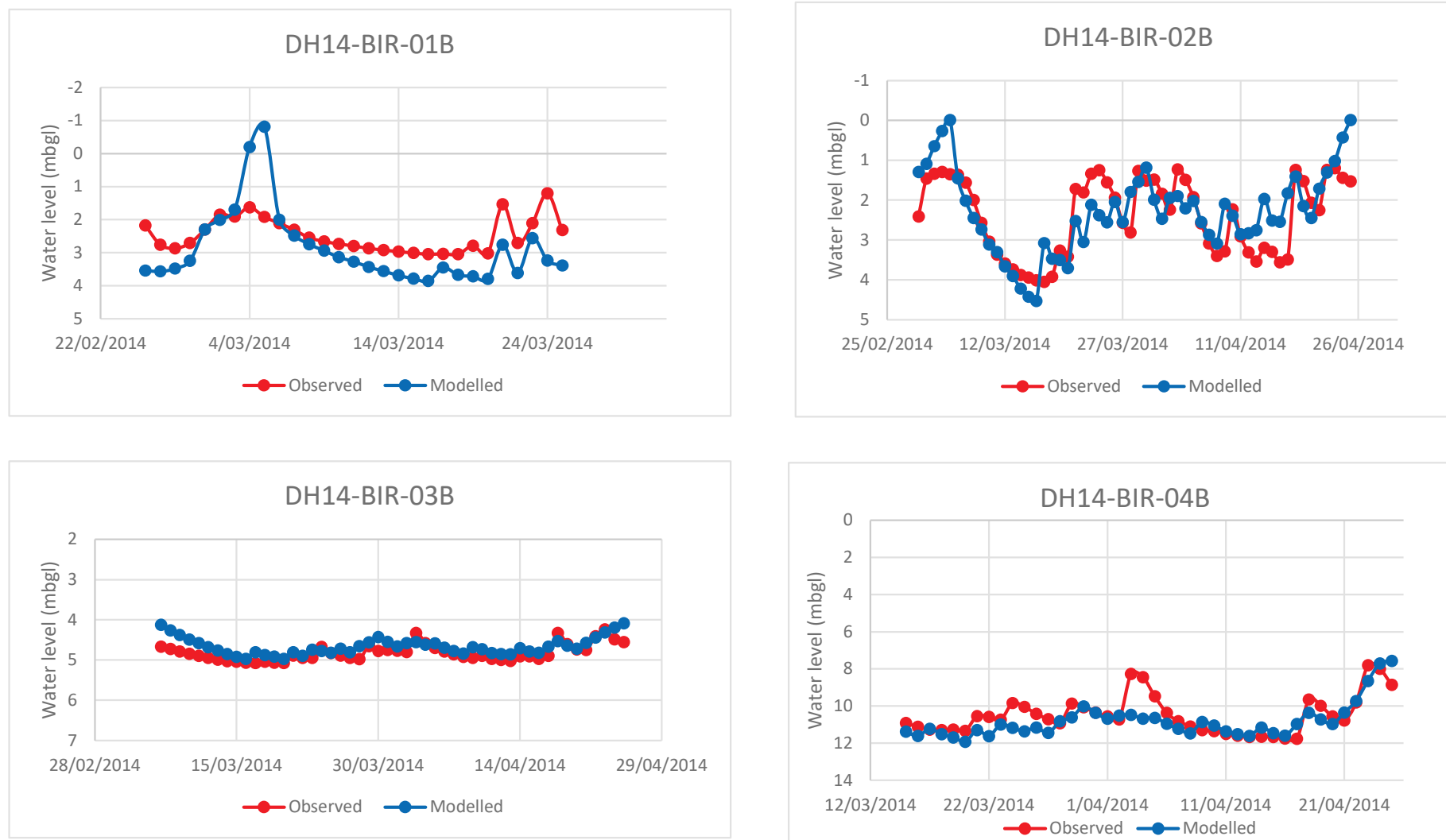


Figure 6.7 Calibration Hydrographs for Short-Term Transient Calibration

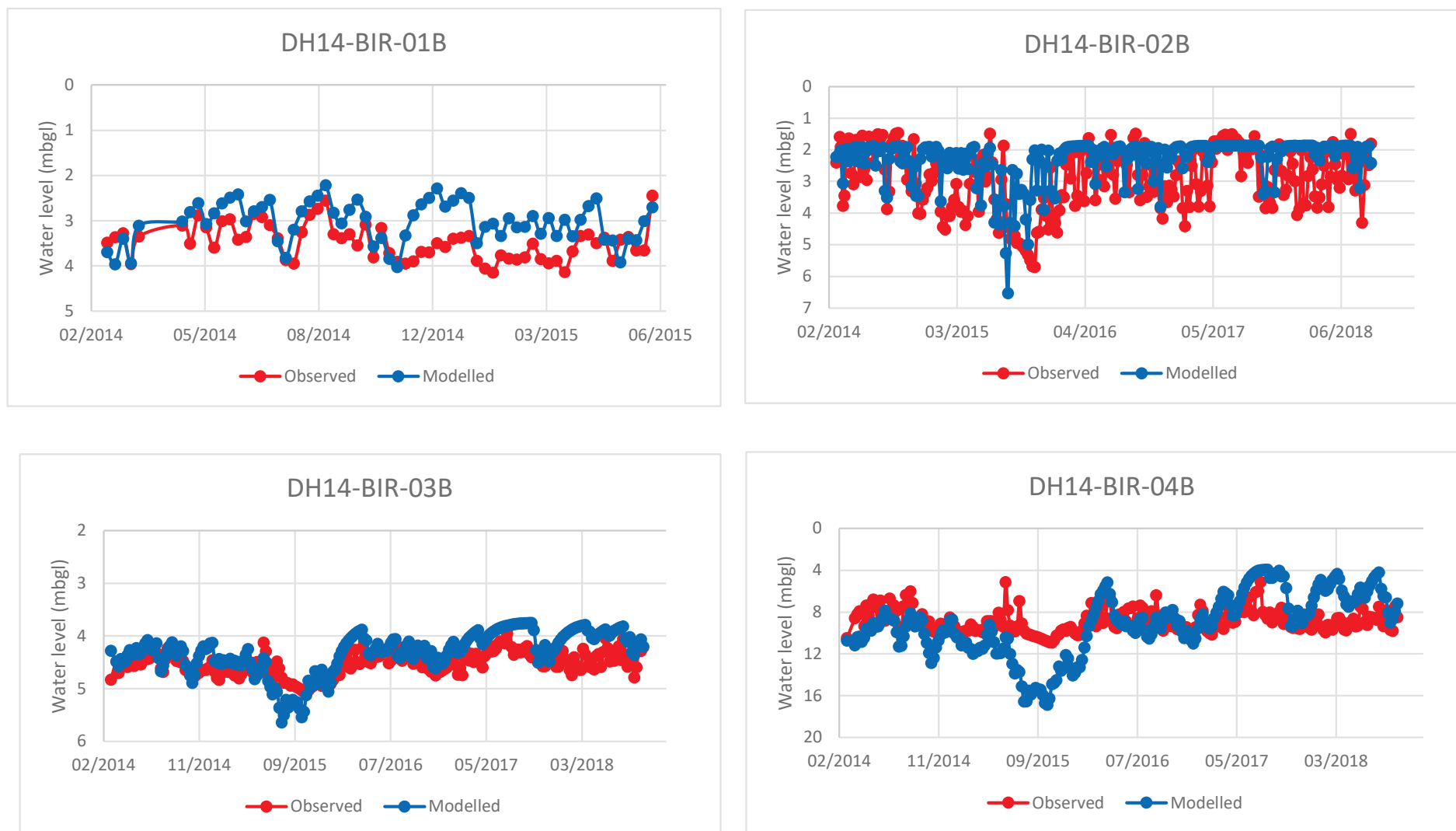


Figure 6.8 Calibration Hydrographs for Longer-Term calibration

The flux drained by the CLNs (stream cells) located in the proposed TSF area was compared between the short-term and long-term calibrated models for the period from late February to late April 2014 (Figure 6.9). It is observed that the volume drained by the CLNs in both models are broadly consistent, indicating that the duration of the stress periods (daily or weekly) does not result in significant discrepancies.

A stress period is a user defined period over which boundary conditions (e.g., recharge, river levels, TSF discharge rates or TSF height) of a model remain constant. It splits the total simulation into segments where external stresses are “constant” before potentially changing the magnitude of an external stress into the next stress period, i.e., allowing for transient conditions.

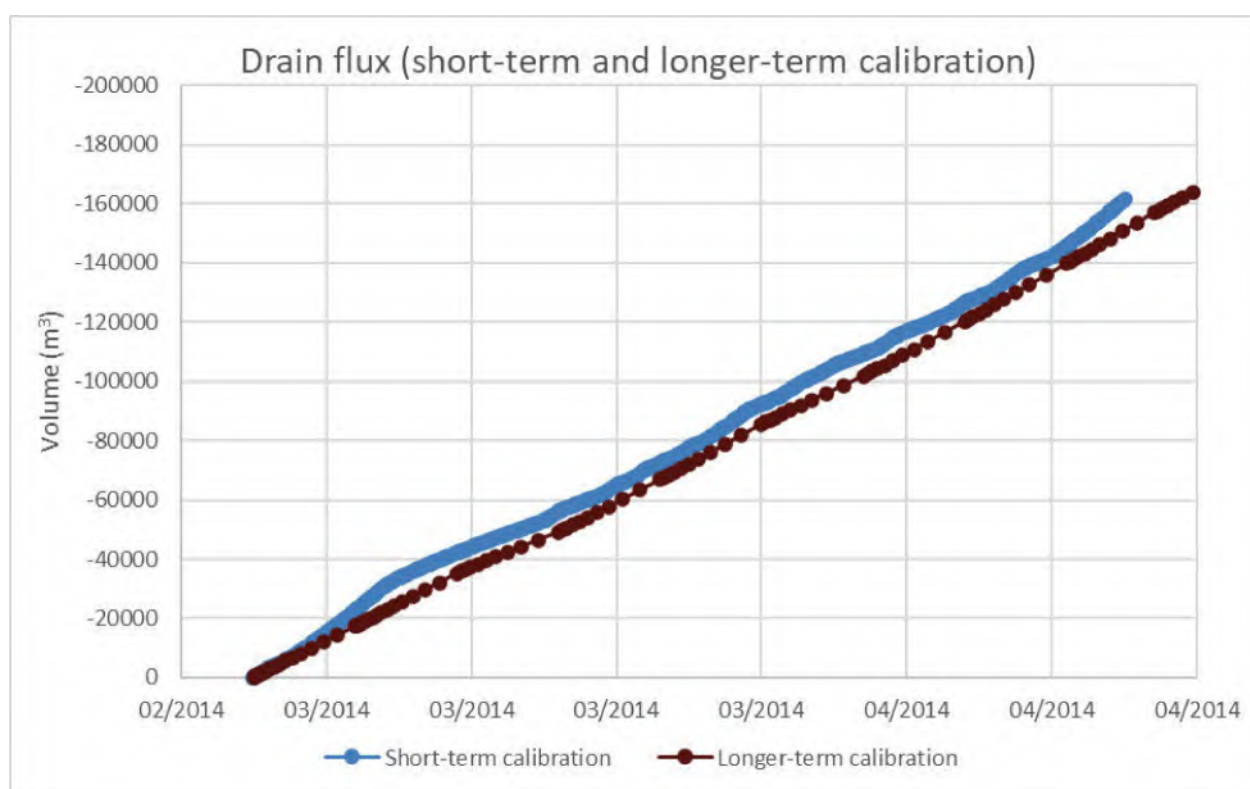


Figure 6.9 Drain Flux: Comparison for Short-Term Calibration and Longer-Term Calibration

6.6.3 Verification 2025/26 bore data

The model calibration was verified with a steady-state run using the water levels collected during the 2025/26 field campaign. Figure 6.5 shows the correlation between modelled and observed heads for the 2025/26 water levels. An acceptable correlation was achieved, and the 2025/26 steady-state was used as initial condition for the transient predictions.

Table 6.3 presents the steady-state verification statistics. The RMS error is below 0.1 and the water balance error is below 1%, which meets the requirements defined by Barnett et al. (2012).

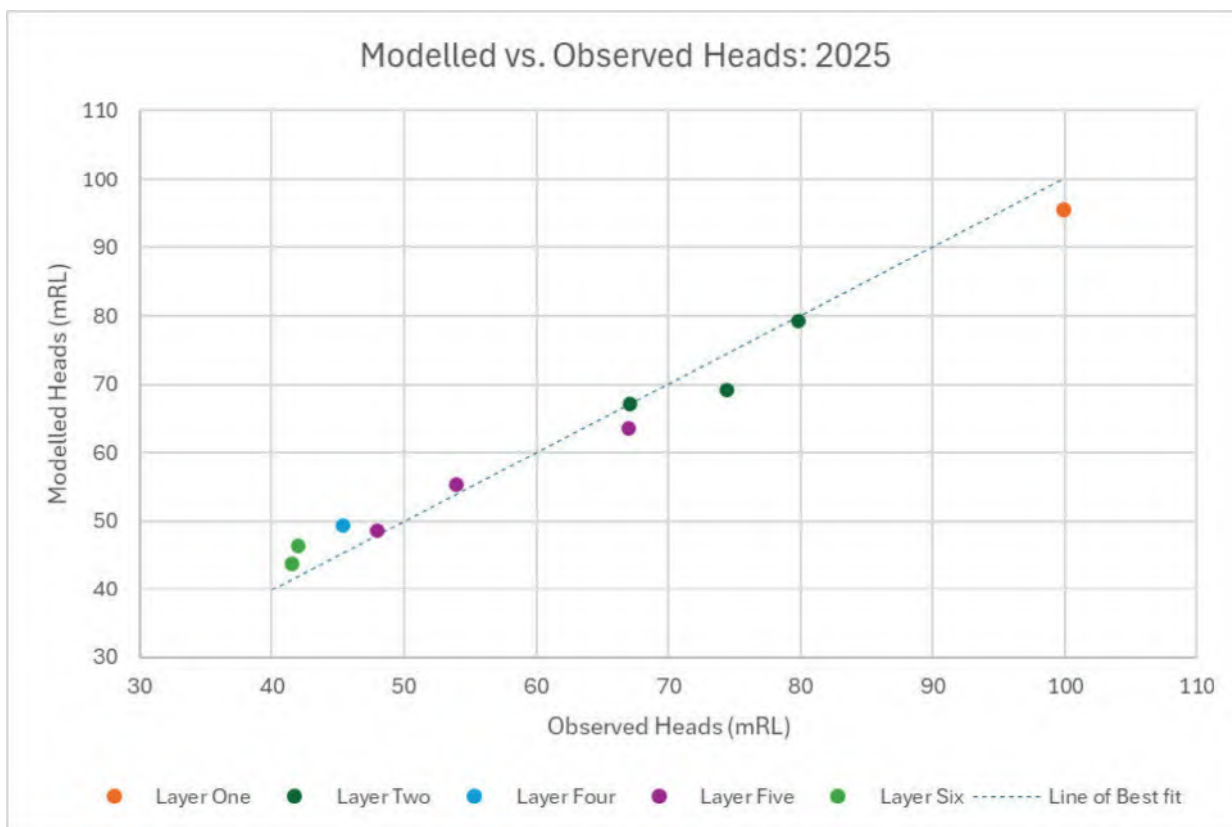


Figure 6.10 Steady-State Verification Using 2025/26 Data – Modelled and Observed Heads

Table 6.5 Steady-State Verification Statistics (2025/26 Data)

Statistical Metric	Calibration Results
Number of Observations	10
Residual Mean	0.14 (m)
Scaled Absolute Residual Mean	4.5 %
Root Mean Square (RMS) Error	3.18 (m)
Scaled RMS Error	5.4 %
Water Balance Error	0.0 %

6.7 Calibrated Properties

6.7.1 Recharge

The transient calibrated recharge rates for the short and long-term calibration models are listed in Table 6.6. The rates for each recharge zone were very similar for both models.

Table 6.6 Calibrated Recharge Rates

Zone	Recharge rate (% of Rainfall)	
	Short-term calibration	Long-term calibration
1	10.5	10.0
2	7.0	7.0

6.7.2 Hydraulic Conductivities and Storage

The transient calibrated hydraulic properties for the various zones as discussed in Section 6.3.3 are listed in Table 6.7. The rates for each recharge zone were very similar for both models.

Table 6.7 Transient Calibrated Hydraulic Conductivity and Storage Parameters

Zone number	Lithology	Kx (m/d)	Ky (m/d)	Kz (m/d)	Ss	Sy	Colour
1	Weathering zone	0.060	0.060	0.0600	5.00E-06	0.005	
2	Sandstone	0.050	0.050	0.0050	1.00E-05	0.010	
3	Alluvium	0.400	0.40	0.4000	1.00E-05	0.010	
4	Structural features/Faults	0.211	0.211	0.2110	1.00E-05	0.010	
5	Weathered zone, clayey	0.007	0.007	0.0070	2.00E-06	0.002	
6	Siltstone/Mudstone	0.003	0.003	0.0003	1.00E-05	0.010	
7	Sandy material	0.800	0.800	0.8000	8.00E-06	0.008	
8	Weathered zone, sandy	0.030	0.030	0.0300	1.00E-06	0.001	

6.8 Overall Transient Calibration Performance

The model has been appropriately calibrated to transient conditions based on the following criteria:

- The conceptual model for groundwater flow has largely been honoured by the calibration;
- Calibration-optimised hydraulic data for the key hydrostratigraphic units are within the range of values measured during field campaigns and derived during independent studies;
- Quantitative calibration metrics (e.g. residual errors) are within guideline-recommended ranges (e.g. Barnett et al., 2012); and
- The relative contributions of recharge/discharge processes in the model water balance are within the ranges expected and are supported by independent calculations and field observations.

The calibrated model is therefore deemed to be a suitable tool for assessing the TSF seepage contribution to the surrounding environment. The predictive scenarios based on the calibrated model are presented in the following sections.

7 GROUNDWATER MODEL PREDICTIONS

7.1 Operational Model Predictions

The operational prediction model was set up to simulate the operational period of the TSF, and mass transport associated with seepage from the TSF. For this purpose, a transient flow and transport model was built, with constant head boundaries applied to represent the saturated water level of the proposed TSF, using the design water level data and tailings concentrations. The model timeline was from the start of 2030 to the end of 2049 (20 years), and monthly stress periods were applied in the model.

This model adopted the calibrated hydraulic parameters of the transient model as presented in Table 6.7 above. In this case, the TSF is presented with two additional zones (9 and 10), with the hydraulic parameters summarised in Table 7.1. Porosity values from literature (as discussed in Section 4.3) were assumed in the contaminant transport simulation (Kresic 2006). Specific Storage (Ss) and Specific Yield (Sy) values were applied to the same zones used for hydraulic conductivity.

The model was run for 241 stress periods (SPs). Cell 1 was activated on 01/01/2031 and Cell 2 was activated on 01/01/2042, according to the TSF layout described in Section 1.4. Once Cells 1 and 2 were activated, they remained active to the end of simulation.

Parameters of interest (POI) and source concentrations relevant to the mass transport model are discussed in Section 6.5. SO₄, TDS, Cu and As were selected as POI for the operational mass transport model.

The heads of the last time step of the transient calibration model were used as initial conditions for the operational prediction model. Constant head boundary conditions were applied to simulate the transient heads at each TSF cell, as defined by the TSF operation timeline (refer to Section 1.4).

Table 7.1 Hydraulic Parameters for the Operational Prediction Model

Zone	Lithology	Kx (m/d)	Ky (m/d)	Kz (m/d)	Ss	Sy	Porosity
1	Weathering zone	0.060	0.060	0.060	5.00E-06	0.005	0.005
2	Sandstone	0.050	0.050	0.005	1.00E-05	0.010	0.010
3	Alluvium	0.400	0.400	0.400	1.00E-05	0.010	0.010
4	Structural features/Faults	0.211	0.211	0.211	1.00E-05	0.010	0.010
5	Weathered zone, clayey	0.007	0.007	0.007	2.00E-06	0.002	0.002
6	Siltstone/Mudstone	0.003	0.003	0.0003	1.00E-05	0.010	0.010
7	Sandy material	0.800	0.800	0.800	8.00E-06	0.008	0.008
8	Weathered zone, sandy	0.030	0.030	0.030	1.00E-06	0.001	0.001
9	TSF zone (fines)	7.90E-3	7.9E-3	7.9E-4	5.00E-4	0.050	0.200
10	TSF embankment	0.340	0.340	0.34	2.0E-3	0.200	0.350

7.1.1 Predicted Water Levels in Operation

A contour map reflecting the computed groundwater level before commissioning of the TSF (2029) and at the end of TSF operations (2049) for Layer 3 (the layer beneath the TSF) is illustrated in Figure 7.1. Contour maps showing the groundwater elevation of Layers 1 (surface of TSF and shallow weathered aquifer outside TSF) and Layer 3 (competent rock layer for most of model domain, including below TSF) at the end of TSF Cell 1 (2042) and Cell 2 (2049) are presented in Figure 7.2 and Figure 7.3 respectively. Computed hydrographs for the operational period are presented in Figure 7.4 to Figure 7.6 at TSF Option C's groundwater monitoring bores. The following is observed:

- Operation of the TSF will result in elevated hydraulic levels within the confines of the facility, which will result in radial seepage from the facility to the surrounding environment.
- Although the groundwater level within the TSF is predicted to extend up to 30 m above the groundwater levels in the aquifers surrounding the TSF, the extent of influence is limited to within ~ 800 m from the toe of the embankment.
- A slight increase in computed groundwater levels (of approximately 0.5 – 1 m) is observed at monitoring bores KCB25-BH1006S/D and KCB25-1002S/D during the operational period of Cell 2. These bores are located downgradient of the TSF, at approximately 400 m and 650 m, respectively, from the toe of the TSF embankment.

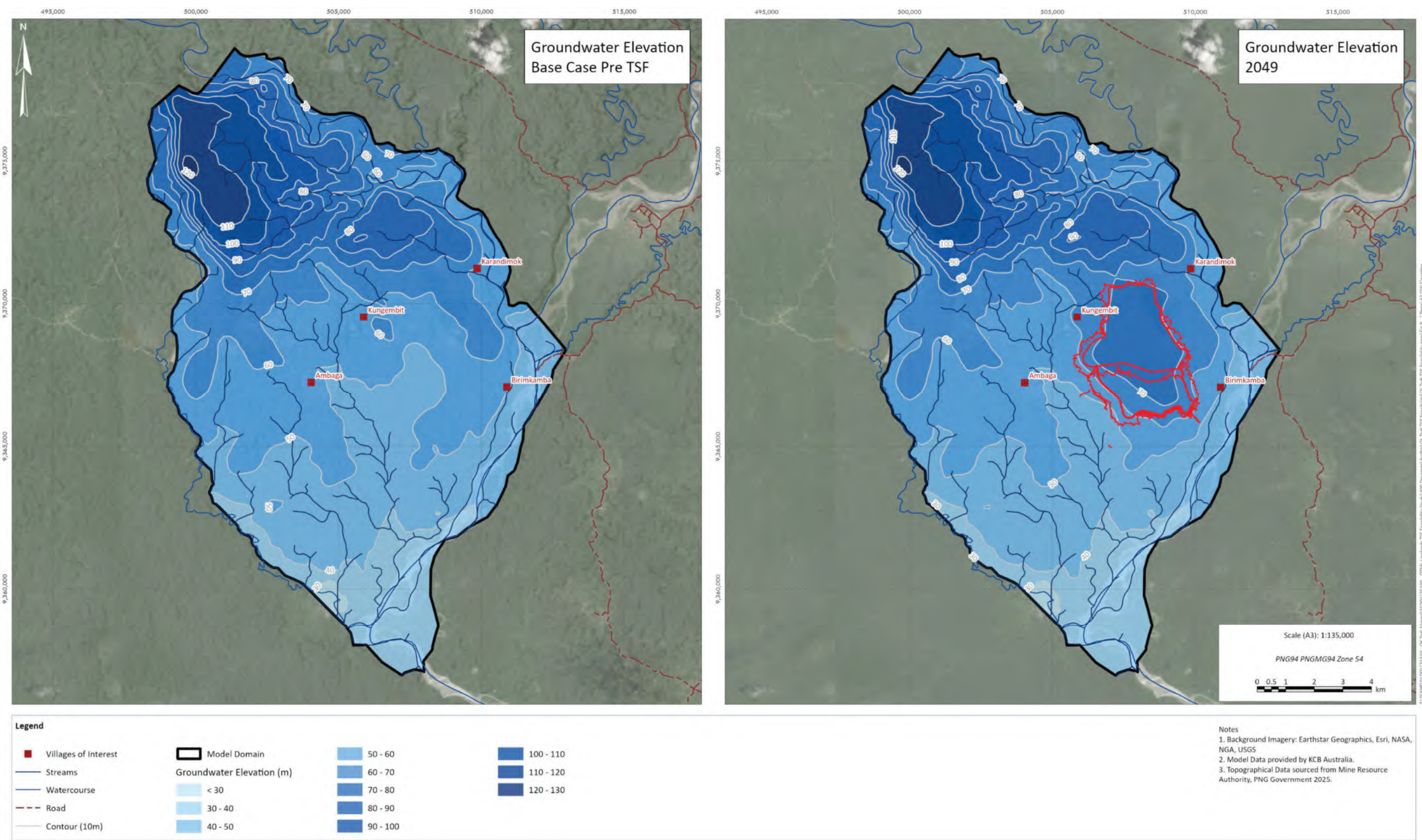


Figure 7.1 Groundwater Elevation Contour Map: pre-TSF and at End of Operations (2049) (Model Layer 3)

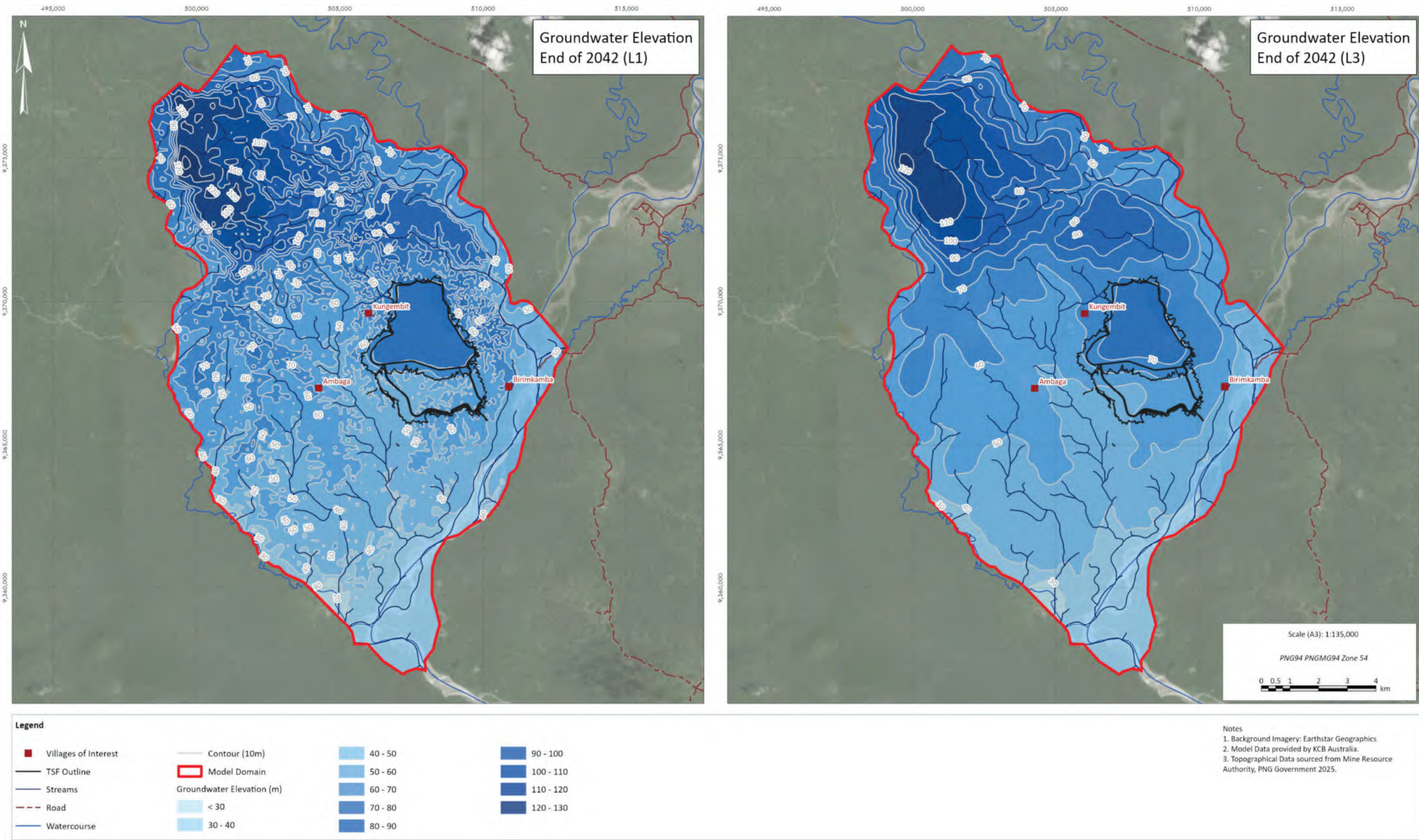


Figure 7.2 Groundwater Elevation Contour Map: Operations, End of Cell 1 (2042)

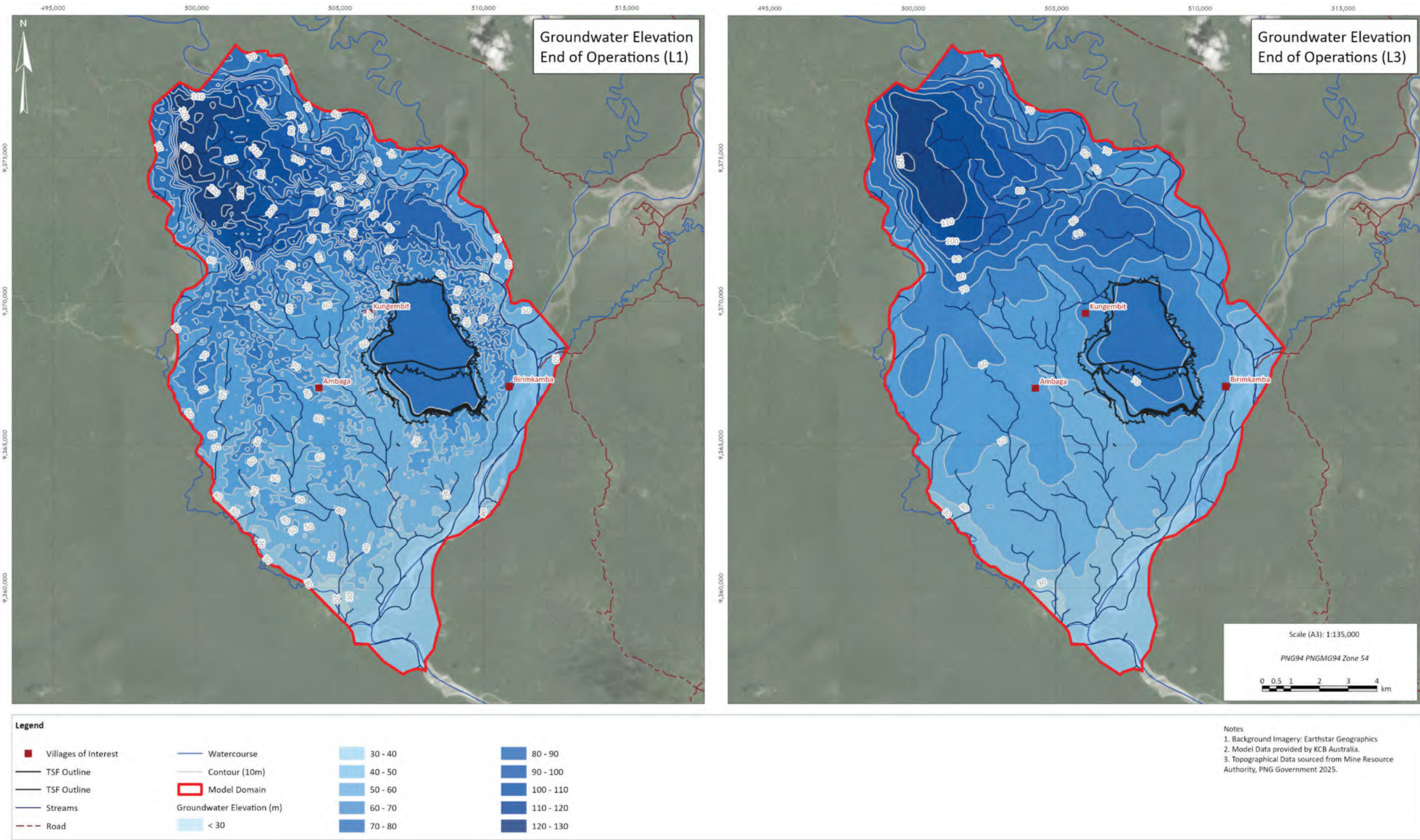


Figure 7.3 Groundwater Elevation Contour Map: Operations End of Cell 2 (2049)

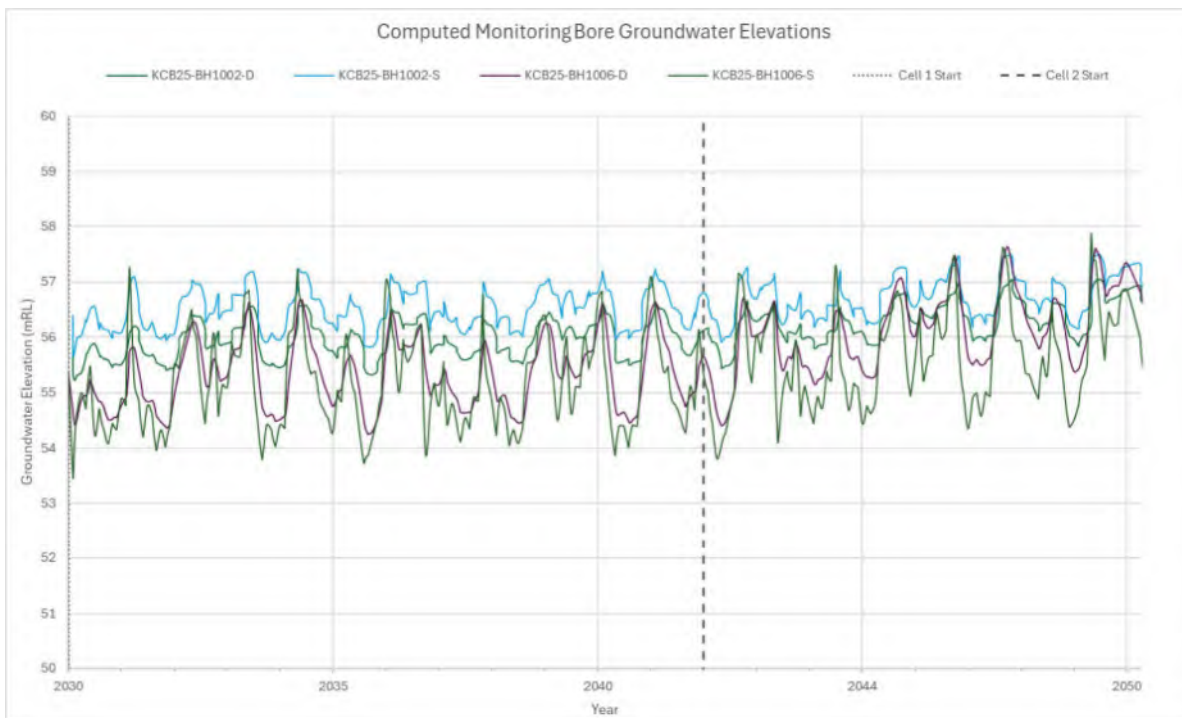


Figure 7.4 Computed Hydrographs: KCB25-BH1002 and KCB25-BH1006

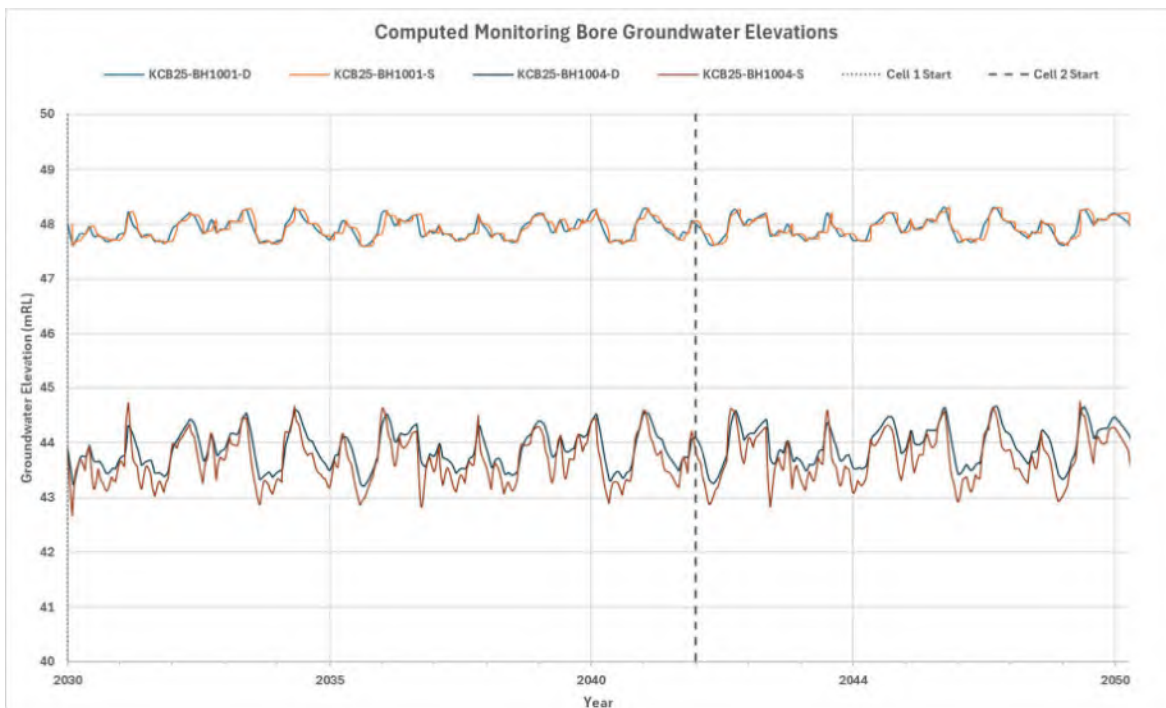


Figure 7.5 Computed Hydrographs: KCB25-BH1001 and KCB25-BH1004

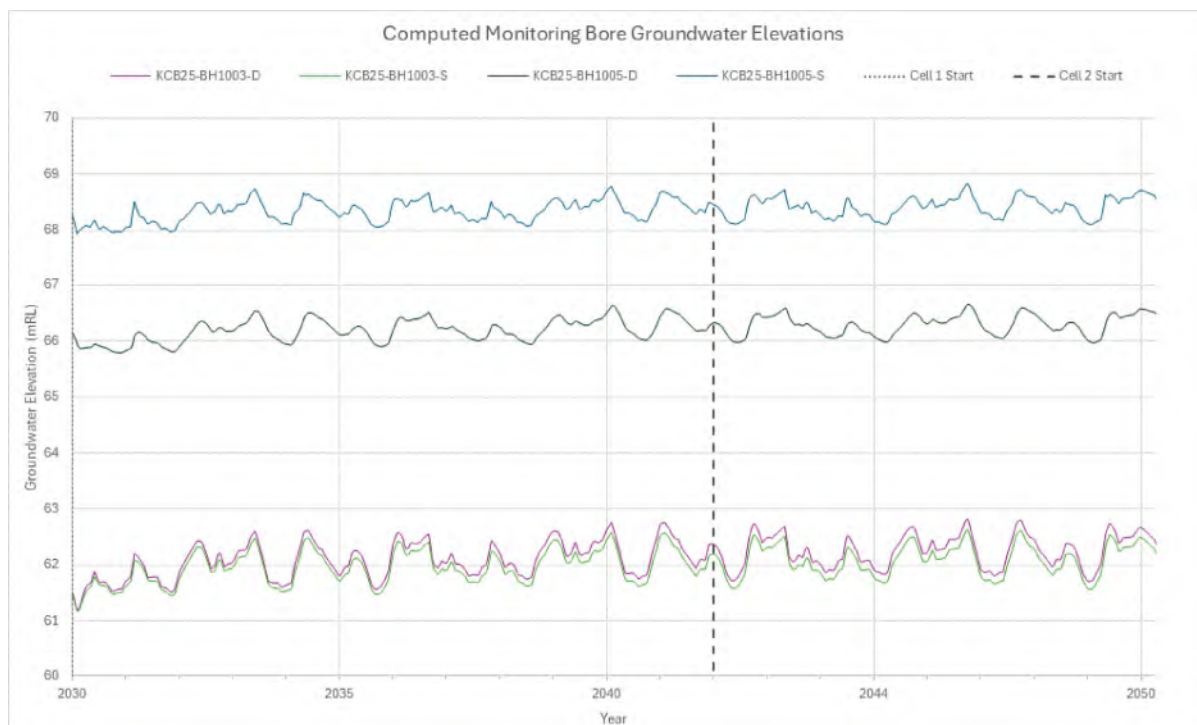


Figure 7.6 Computed Hydrographs: KCB25-BH1003 and KCB25-BH1005

For the purpose of this assessment, it was assumed that groundwater receptors are present in the vicinity of identified villages and along drainage lines in the area surrounding the TSF. Observation points have been included in the model at Kungembit, Ambaga, Birimkamba and Karandimok villages (as shown in Figure 1.1) to represent potential groundwater receptors at these locations. Observation points were assigned in the model layer immediately beneath the TSF.

Predicted water levels at village groundwater observation points are presented in Figure 7.7. The following is observed:

- Groundwater levels in the vicinity of Birimkamba village is shallow with a potential for baseflow contribution of groundwater to surface waters along the streams after periods of higher rainfall.
- Village groundwater observation points do not reflect systemic increases following commissioning of the TSF.

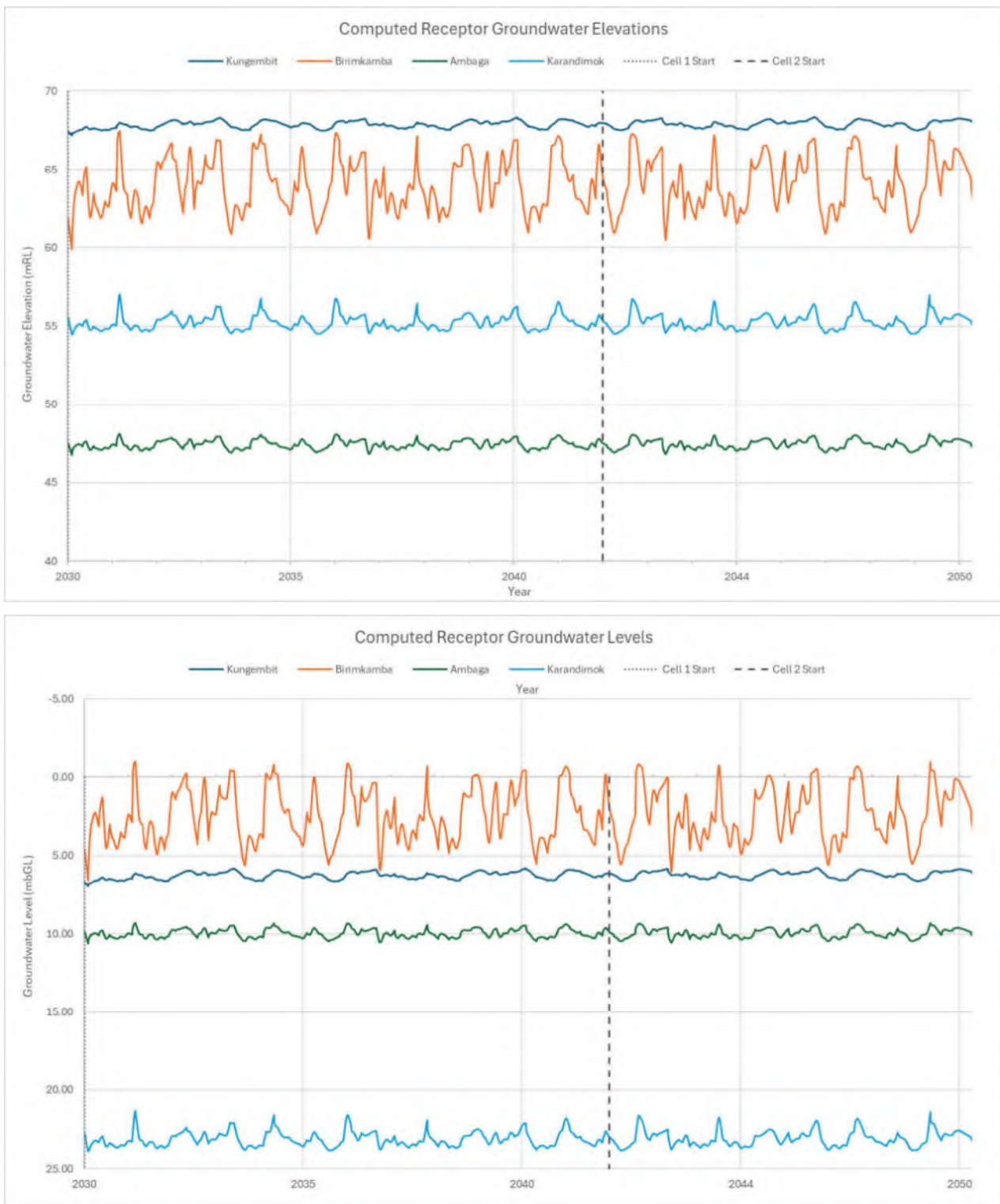


Figure 7.7 Computed Hydrographs at Village Observation Points (in mRL and mbGL).

7.1.2 Predicted Water Quality

Contour maps that represent the predicted sulphate concentrations at the end of operations is presented in Figure 7.8. The predicted increase in sulphate concentrations resulting from TSF seepage is presented as time-series plots for TSF Option C groundwater monitoring bores and for village groundwater observation points in Figure 7.9 and Figure 7.10. The following is observed:

- Sulphate concentrations are elevated in the immediate vicinity of the TSF during operations and decrease rapidly with distance from the TSF.
- A slight increase (of between 2 – 12 mg/L) is noted at a KCB25-BH1003 S and D and KCB25-BH1006S toward the end of the operational phase (after 2044). These bores are located slightly closer to the TSF in comparison to the villages (Figure 7.9).
- Computed sulphate concentrations during operations were approximately 0 mg/L at boreholes KCB25-BH1001-D, KCB25-BH1001-S, KCB25-BH1002-D, KCB25-BH1002-S, KCB25-BH1004-D, KCB25-BH1004-S, KCB25-BH1005-D and KCB25-BH1005-S.
- An increase in sulphate concentration is not predicted to occur at groundwater observation points associated with the villages during the operational phase. The computed sulphate concentrations at the villages are approximately 0 mg/L. (Figure 7.10).

Sulphate concentrations illustrate that the extent of contaminant transport during the operational phase is limited and that village groundwater observation points will remain unaffected. Post-closure water quality predictions are discussed in Section 7.2.2, and include water quality predictions of other POI as discussed in Section 6.5.

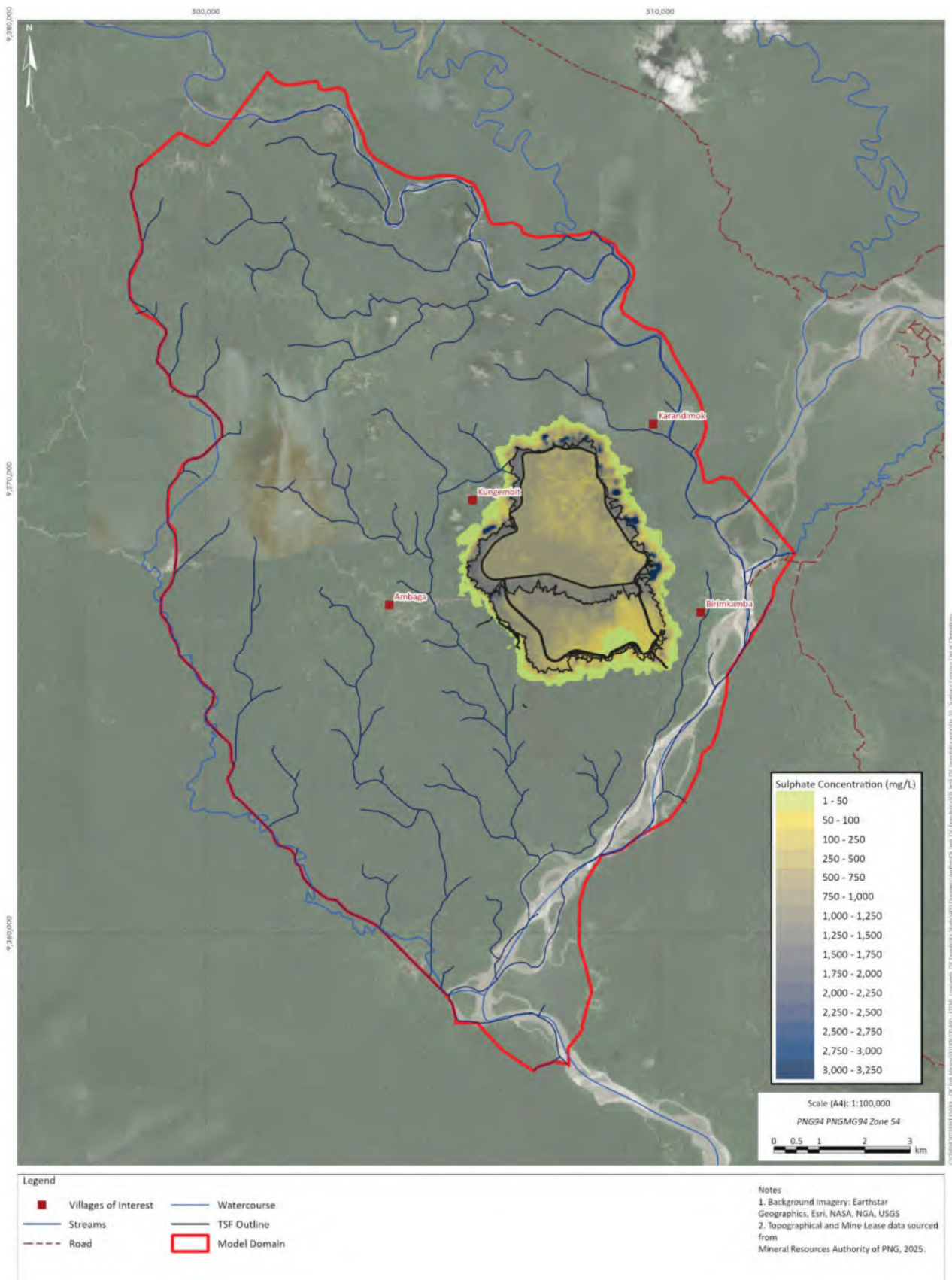


Figure 7.8 Sulphate Contour Map at End of Operations (2049)

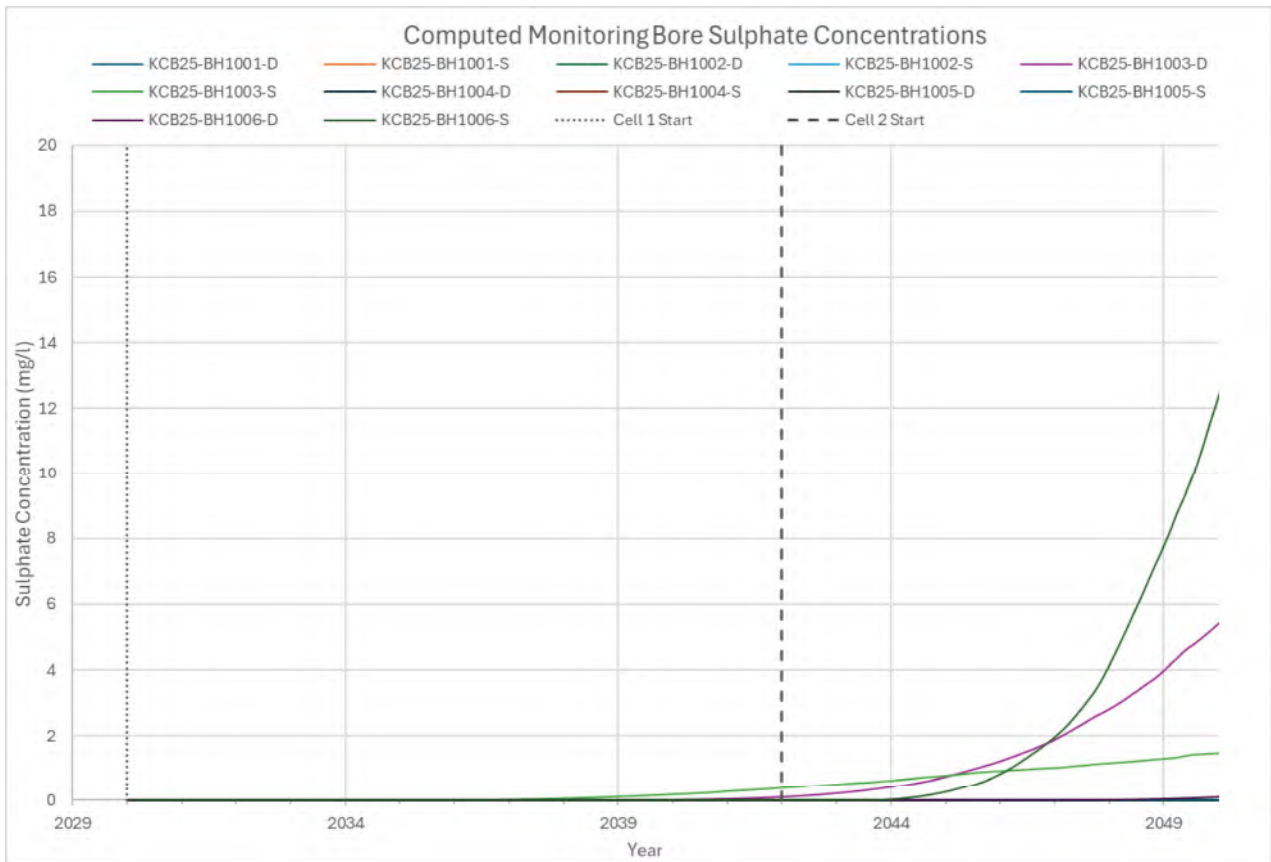


Figure 7.9 Modelled Sulphate Concentrations at TSF Option C Groundwater Monitoring Bores

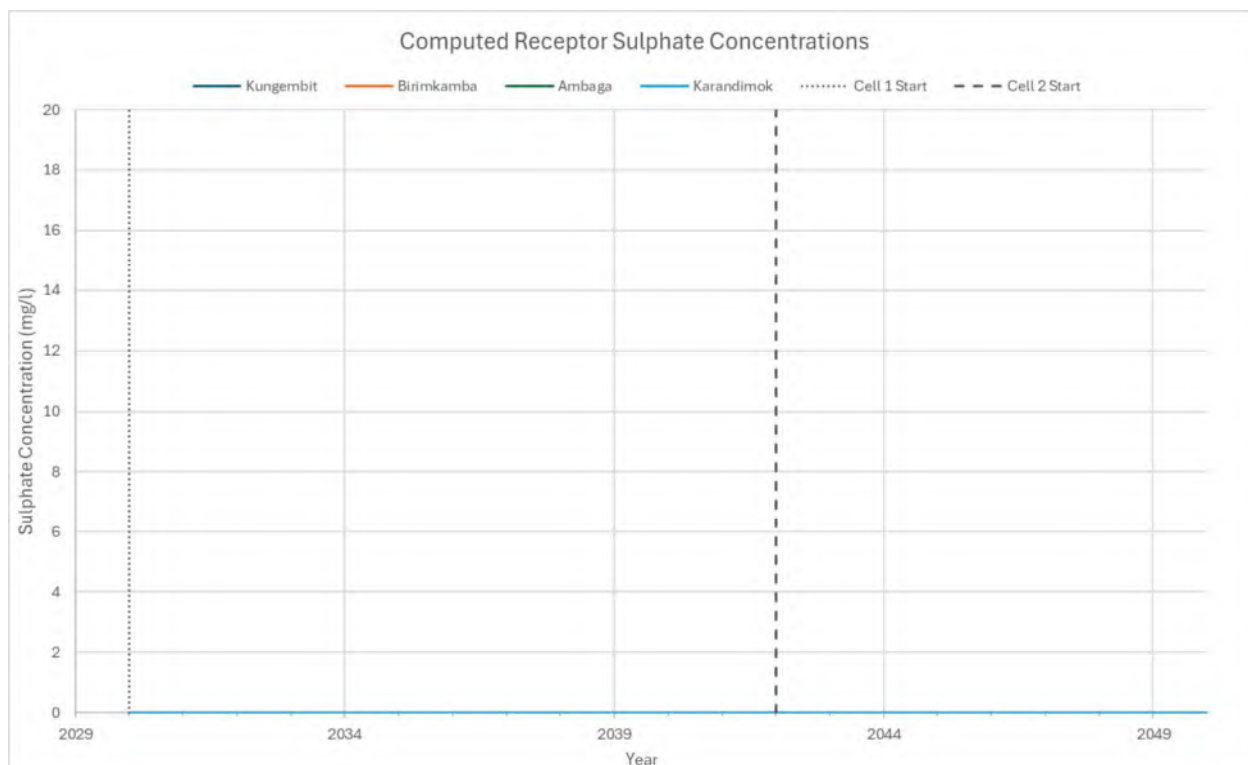


Figure 7.10 Computed Sulphate Concentrations at Village groundwater Observation Points

7.1.3 Operational Water Balance

Water Balance outputs for the model were assessed to evaluate the interaction between the various boundary conditions and the model's behaviour to the imposed stresses. The overall model water balance is shown in Figure 7.11 and illustrates that:

- The water balance error is below 1% for the individual stress periods, as well as for the overall model water balance showing that the finite difference equation was solved within acceptable error bounds.
- The water balance is dominated by recharge inflows and evaporation outflows. Release of water from storage is observed after high rainfall periods.
- The groundwater flow fluxes show a seasonal response (see Section 7.1.1) based on recharge as anticipated and is consistent with observations made in Section 4.4.

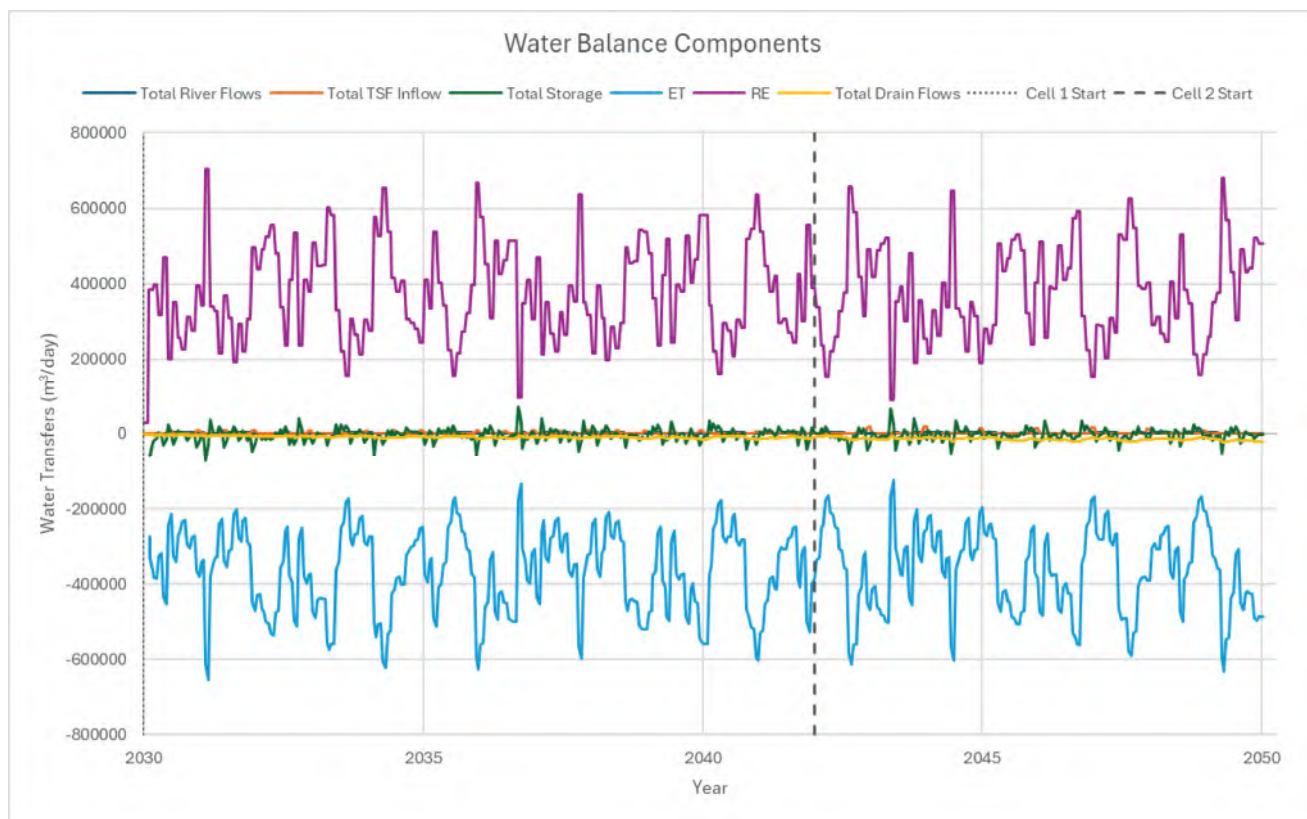


Figure 7.11 Water Balance Components for the TSF in the Prediction Model

7.1.4 Seepage Prediction

The flow exchange, i.e., water balance, between the TSF and the underlying natural ground in the base case prediction model is shown in Figure 7.12 (inner TSF) and Figure 7.13 (TSF embankment). Areas where surface expression of seepage may occur are shown in Figure 7.14.

Predicted seepage rates during peak operations are approximately 3,500 m³/day from the inner TSF and up to 20,000 m³/day from the embankments. The proposed design incorporates engineered drainage infrastructure to collect seepage exiting the embankments.

Seepage from the TSF may result in limited surface expression to the northeast and south of the facility over its operational life. Figure 7.14 illustrates the predicted areas of surface seepage expression at the end of the TSF operational period. The proposed diversion along the northeastern embankment is expected to facilitate effective drainage of any seepage in this area. No seepage expression is predicted to occur within nearby village areas.

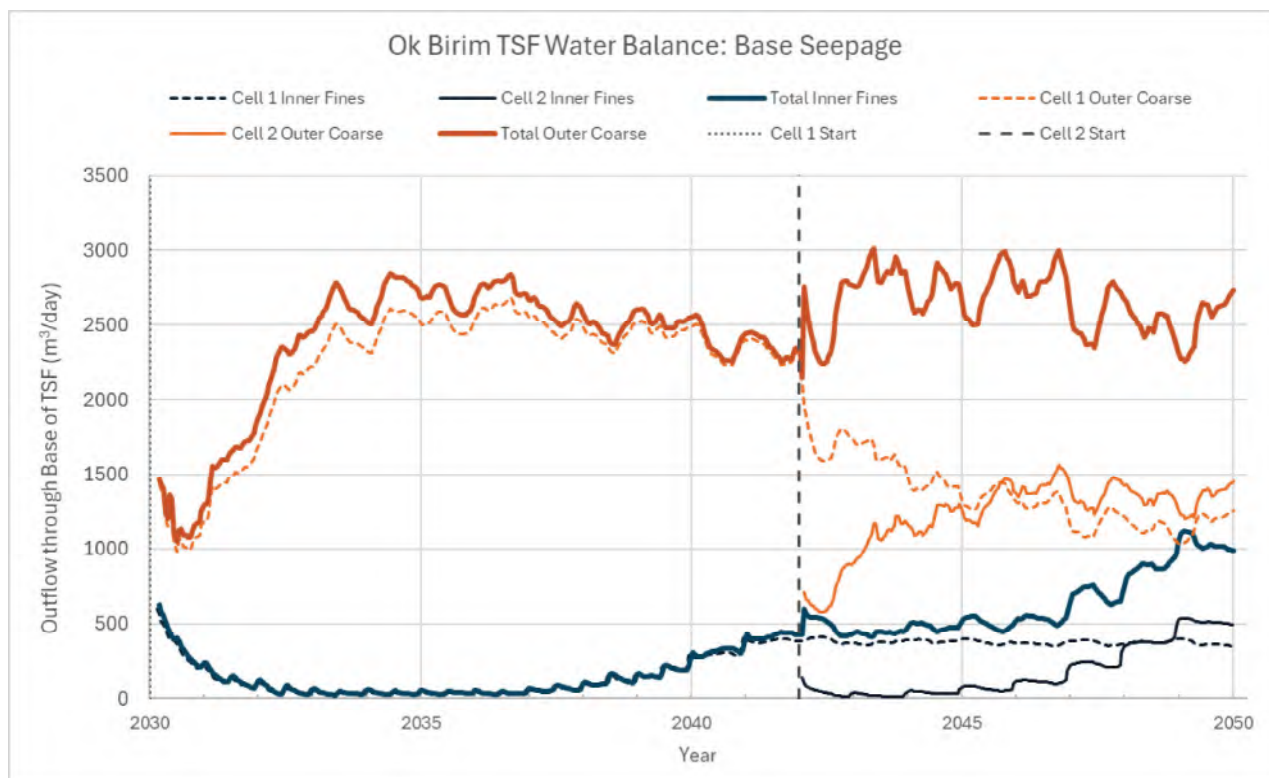


Figure 7.12 Water Balance Components for Inner TSF in the Prediction Model

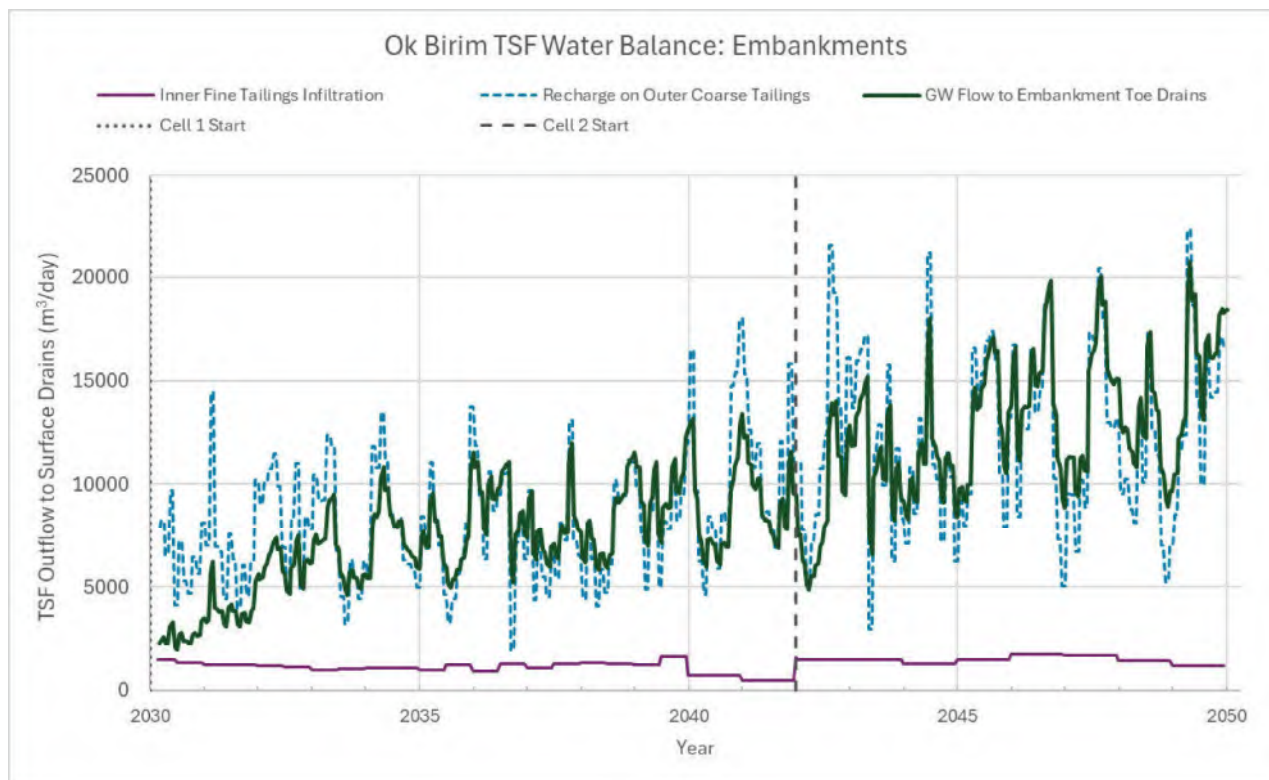


Figure 7.13 Water Balance Components for TSF Embankments in the Prediction Model

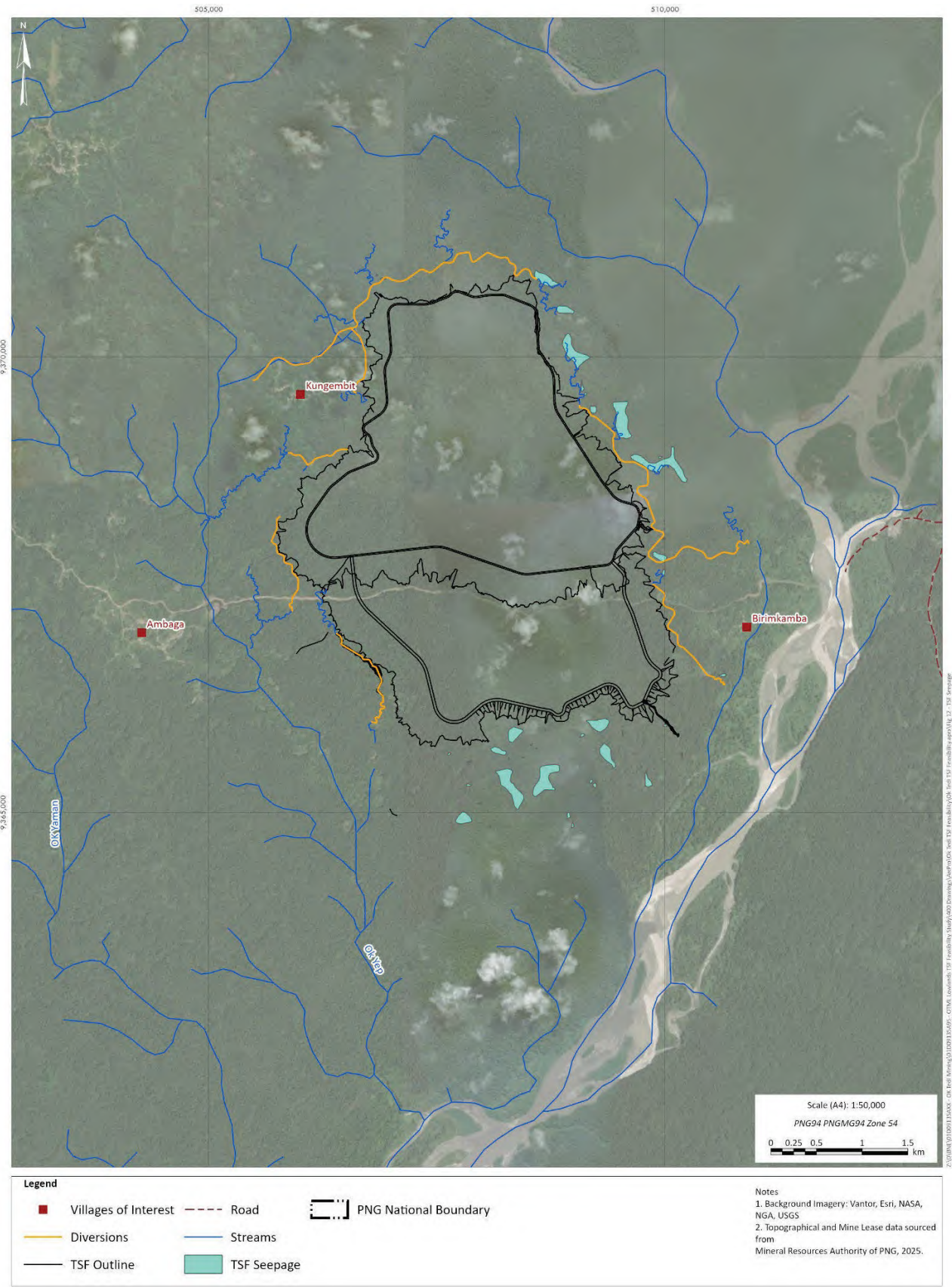


Figure 7.14 Predicted Surface Expression Areas

7.2 Closure Model Predictions

The prediction model was amended to enable simulation of conditions for 1,000 years following closure of the TSF. Heads and concentrations of the last timestep of the operational prediction model was adopted as initial conditions for this model. To represent closure conditions, a conservative assumption was adopted whereby the TSF source concentration was maintained at the same concentration used during operations, and the TSF water levels was assumed to be at the top of the tailings. The timesteps of the post-closure model was selected to replicate the timesteps used during calibration.

7.2.1 Closure: Predicted Water Levels

Computed groundwater level elevations at 100, 250, 500 and 1000 years post-closure are illustrated in Figure 7.15. The location of cross sections showing groundwater elevations for various model layers during closure are shown in Figure 7.16, while the cross sections are depicted in Figure 7.17. Post-closure hydrographs are presented in Figure 7.18 to Figure 7.21.

The following is observed from the predictions:

- Groundwater levels near the TSF are not predicted to change significantly during closure (Figure 7.15). The TSF will continue to influence local groundwater levels in its immediate vicinity during closure, as expected for a facility characterised by low-permeability tailings materials and subject to high rainfall conditions.
- The cross sections illustrate the natural topography, the elevation of the completed TSF in relation to the surrounding environment and the computed groundwater elevation of various model layers following closure of the TSF (Figure 7.17).
- Groundwater elevations computed for all model layers are observed to decline steeply as distance from the TSF increases.
- The cross sections (Figure 7.17) also reflect the influence of surface topography and groundwater discharge (baseflow contribution) to local streams on groundwater elevations in the shallow hydrogeological system. The semi-confined to confined nature of deeper geological units is also apparent, with artesian conditions indicated in valley floor areas (where Layer 3 and 4 groundwater elevations are shown to extend above the topographical surface).
- Water level fluctuations (Figure 7.18 to Figure 7.21) show relatively stable water levels; these fluctuate due to seasonal variation in rainfall. No changes in the long-term flow gradients are predicted.

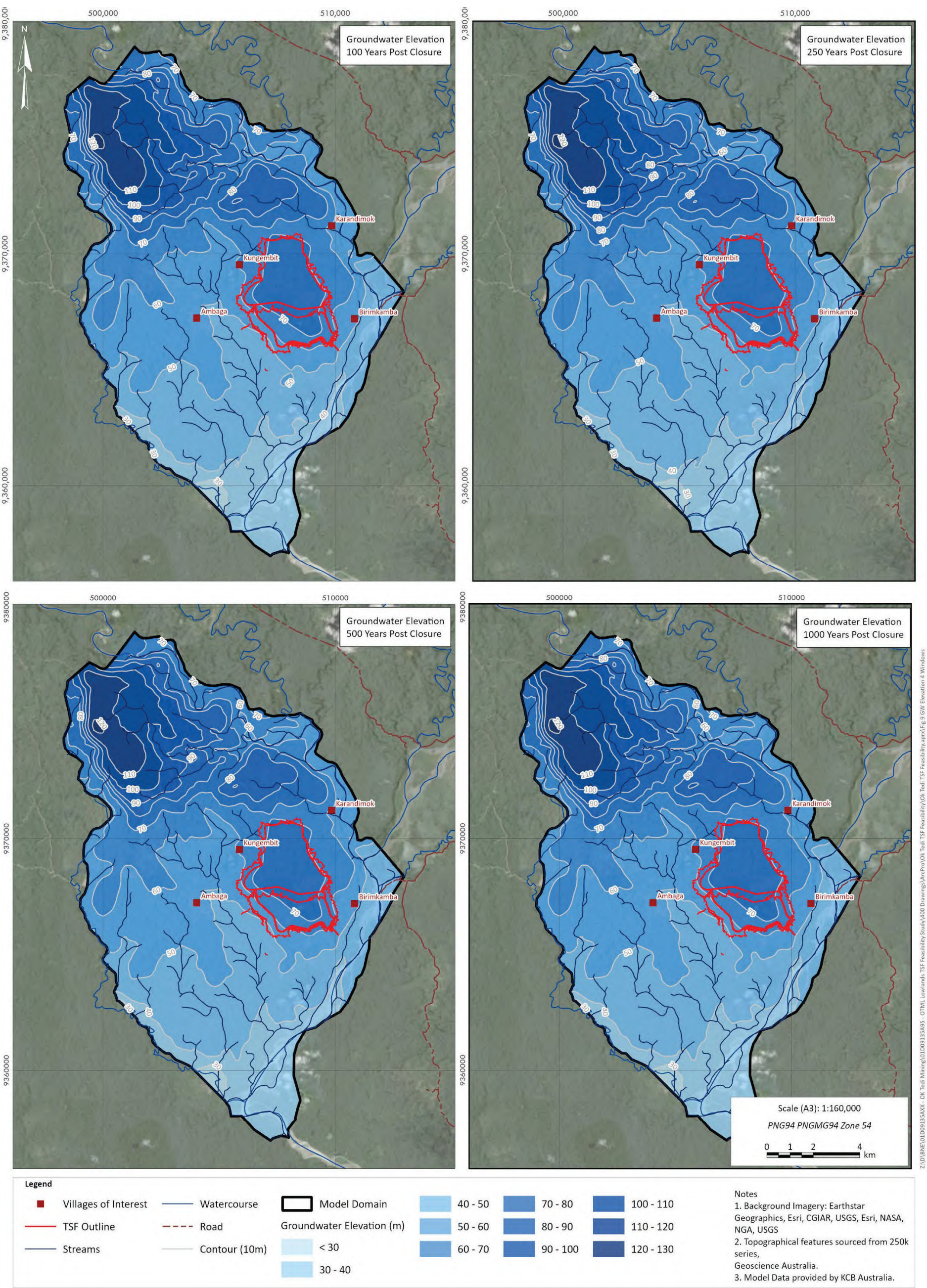


Figure 7.15 Groundwater Elevation Contour Map – 100, 250, 500, 1000 Years Post-Closure



Figure 7.16 Location of Computed Groundwater Elevations Cross Sections Shown in Figure 7.17

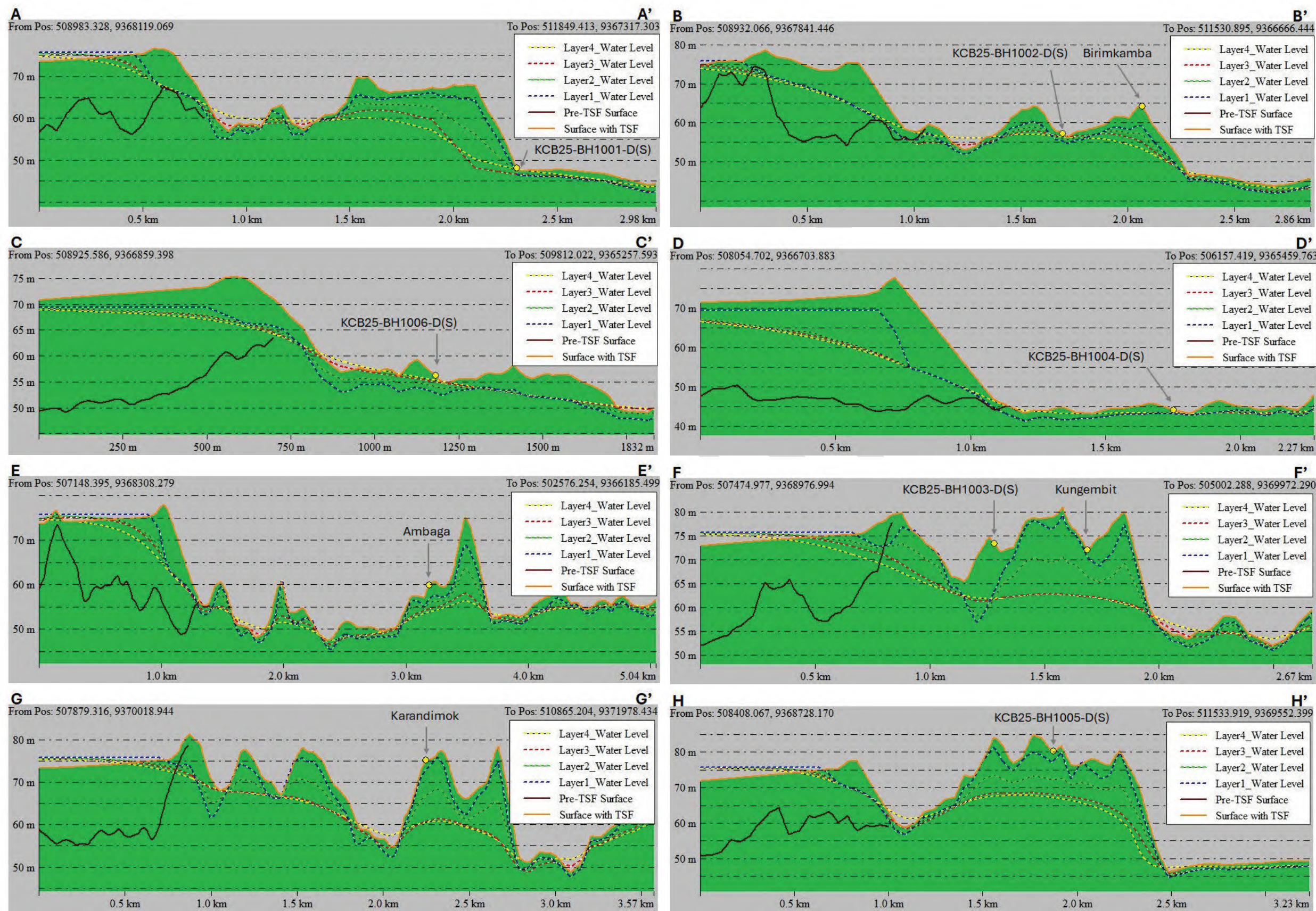


Figure 7.17 Cross Sections of Computed Post-Closure Groundwater Elevations for Various Model Layers

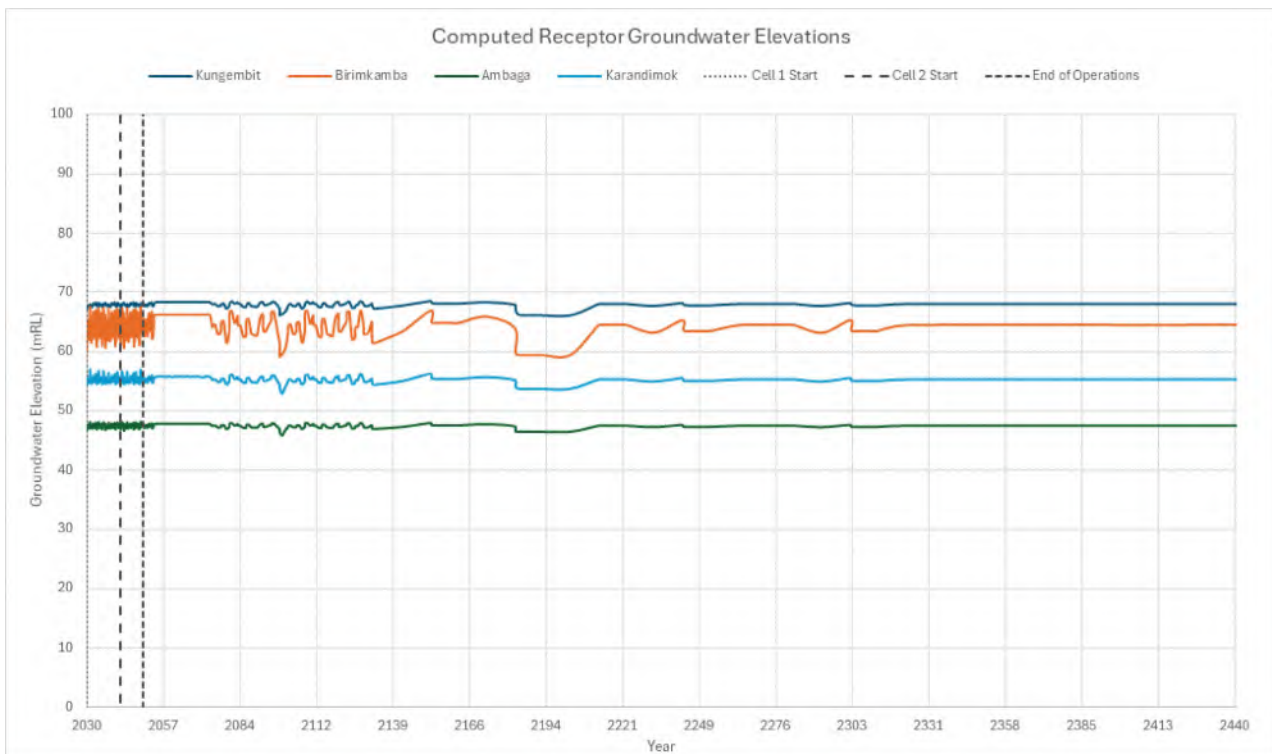


Figure 7.18 Post-Closure Computed Hydrographs: Village Observation Points

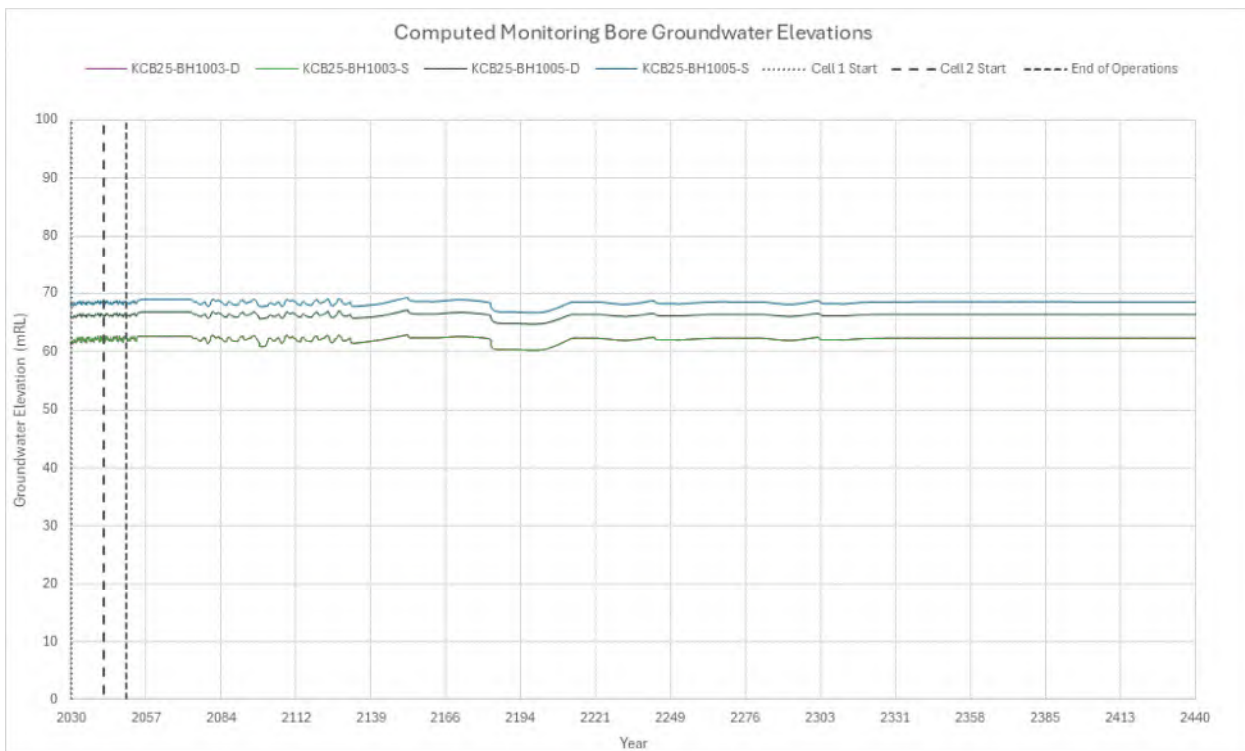


Figure 7.19 Post-Closure Computed Hydrographs: KCB25-BH1003 and KCB25-BH1005

Figure 7.20 Post-Closure Computed Hydrographs: KCB25-BH1002 and KCB25-BH1006

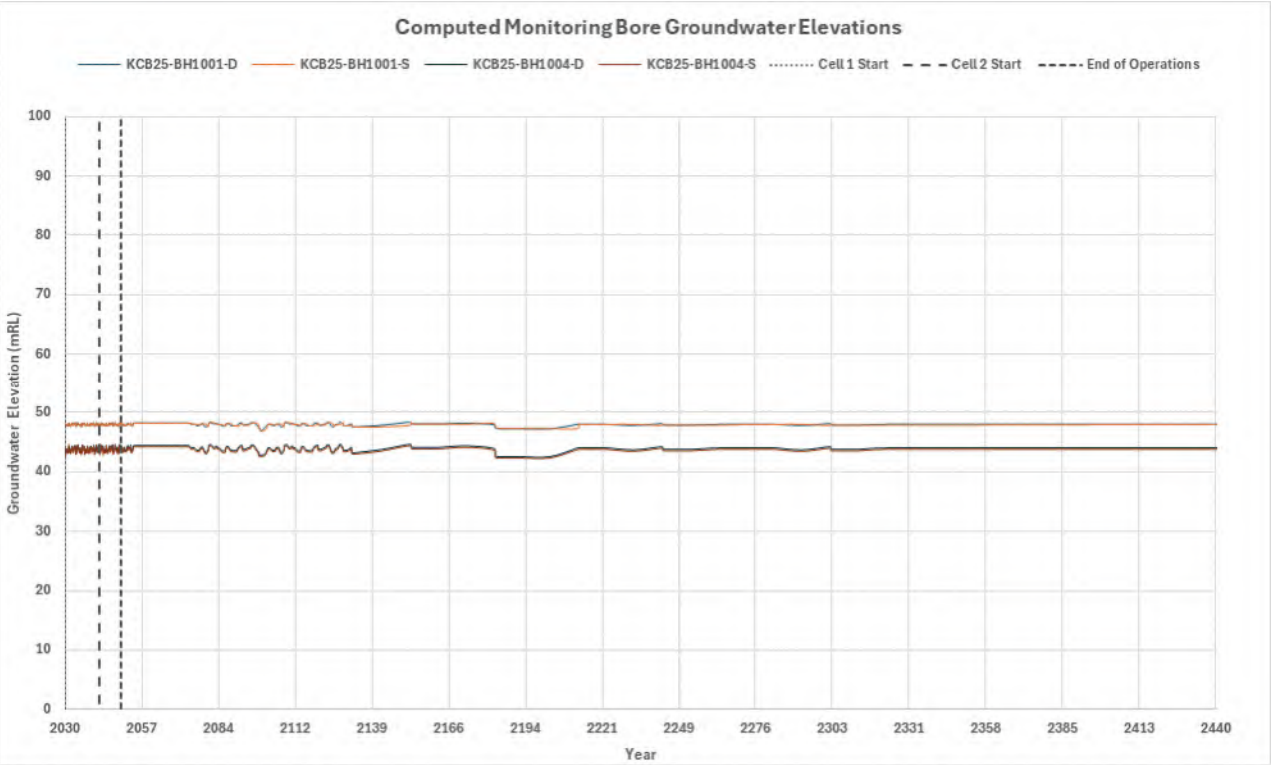


Figure 7.21 Post-Closure Computed Hydrographs: KCB25-BH1001 and KCB25-BH1004

7.2.2 Closure: Predicted Water Quality

As discussed in Section 6.5, total dissolved solids and sulphate were selected as POI representative of saline mine drainage while copper and arsenic were selected as indicators of metal POI.

Total Dissolved Solids

TDS concentrations at 100, 250, 500 and 1,000 post-closure for the shallow hydrogeological system (the model layer beneath the TSF) are illustrated in Figure 7.22. Computed TDS concentrations at village observation points and Option C TSF monitoring bores for the operational and closure periods are presented in Figure 7.23.

The following is observed:

- TDS migration above background concentrations during the post-closure phase is shown to extend to the area immediately surrounding the TSF and extends the furthest along valley lines in a hydraulically downgradient direction to the south of the TSF (in the direction of the Ok Yep and Ok Tedi River).
- TDS concentration increases are predicted to remain low to negligible in groundwater at the village observation points, and well below the WHO drinking water guideline (WHO, 2022) (1,000 mg/L).
- Elevated TDS concentrations are predicted at monitoring bore location KCB2025-BH1006S and D (located 300 m to the south of Cell 2). Concentrations of up to 2,500 mg/L are predicted.
- Baseflow contributions to surface water features in areas where groundwater quality is affected, may result in a corresponding influence on stream water quality.

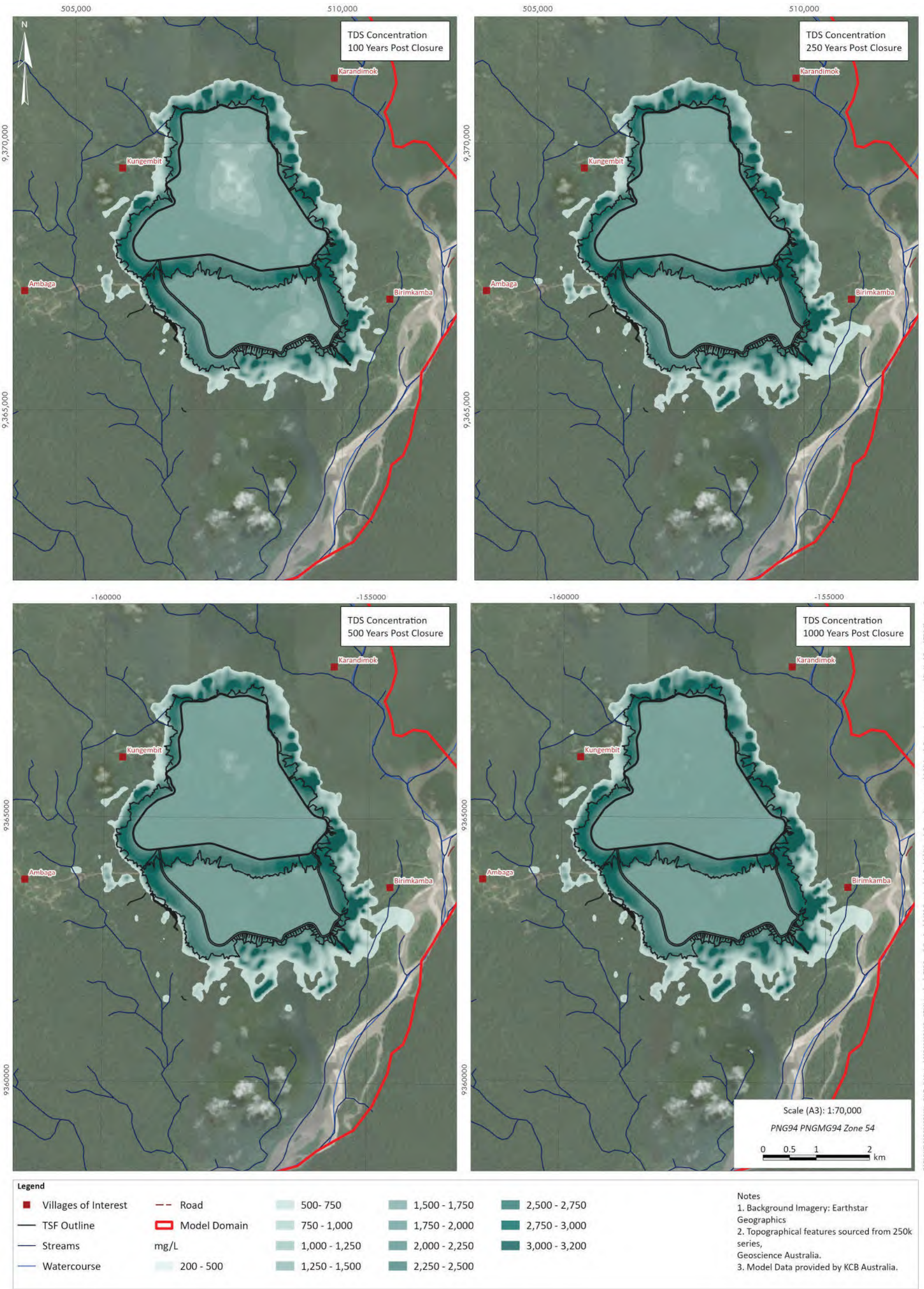


Figure 7.22 TDS Concentrations: 100, 250, 500, 1000 Years Post-Closure (Model Layer 3)



Figure 7.23 TDS Time Series: Computed Concentrations at Village Observation Points and Option C TSF Monitoring Bores

Sulphate

Sulphate concentrations at 100, 250, 500 and 1000 post-closure for the shallow hydrogeological system (the model layer beneath the TSF) are illustrated in Figure 7.24. Computed sulphate concentrations at village observation points and Option C TSF monitoring bores for the operational and closure periods are presented in Figure 7.25.

The following is observed:

- Sulphate migration during the post-closure phase is shown to extend to the area immediately surrounding the TSF, with concentration increases to more than 250 mg/L (Aesthetic limit for WHO (2022) and Australian Drinking Water Guideline), indicated at distances up to 1 km from the TSF, and extending further along valley lines in a hydraulically downgradient direction to the south of the TSF (in the direction of the Ok Yep and Ok Tedi River).
- Sulphate concentration increases are predicted to remain low to negligible in the shallow groundwater at the village observation points. The predicted water quality for the village water sources (Figure 7.25) are from the shallow aquifers (Layer 1 and 2 in the model), while the predicted migration of sulphate shown in Figure 7.24 is for the sediments just below the TSF (Layer 3 and deeper).
- Sulphate concentrations are predicted to increase to above the PNG Environment Act Aquatic Life guideline (Office of Legislative Counsel 2000) aesthetic guideline value of 400 mg/L at monitoring bore locations located hydraulically downgradient of, and closer to the TSF (at between 300 – 500 m).
 - The greatest increase is predicted at KCB2025-BH1006-S and D (located 300 m to the south of Cell 2) at 1000 - 2000 mg/L.
 - Notable increases are also predicted at KCB2025-BH1002S and D (located 400 m to the east of Cell 2) and KCB2025-BH1003 D (located 470 m to the west of Cell 1 near Kungembit Village) where concentration increases between 300 – 600 mg/L is predicted. The sulphate concentration in shallow bore KCB2025-BH1003 S is however predicted to remain low.

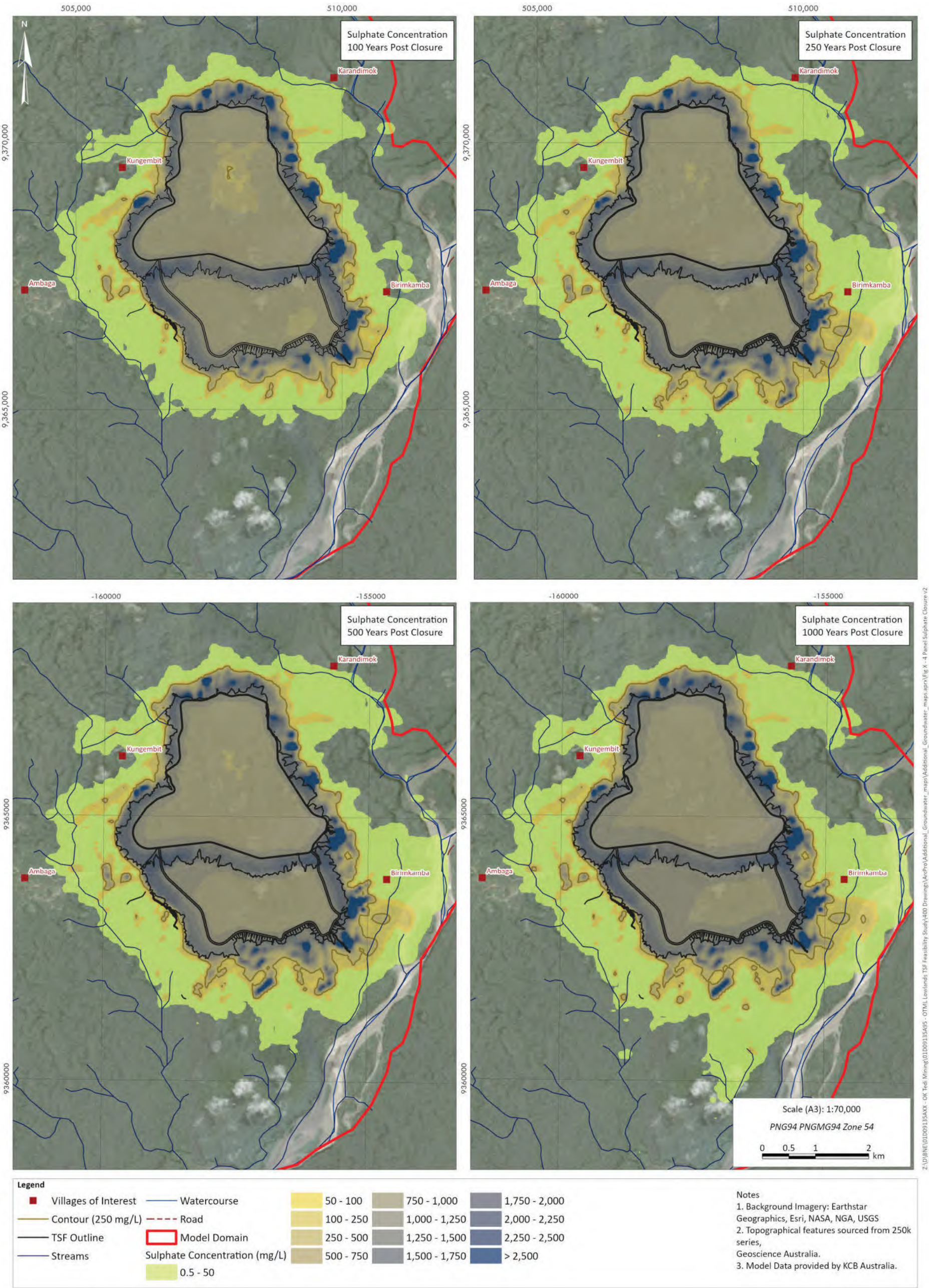


Figure 7.24 Sulphate Concentrations: 100, 250, 500, 1000 Years Post-Closure (Model Layer 3)

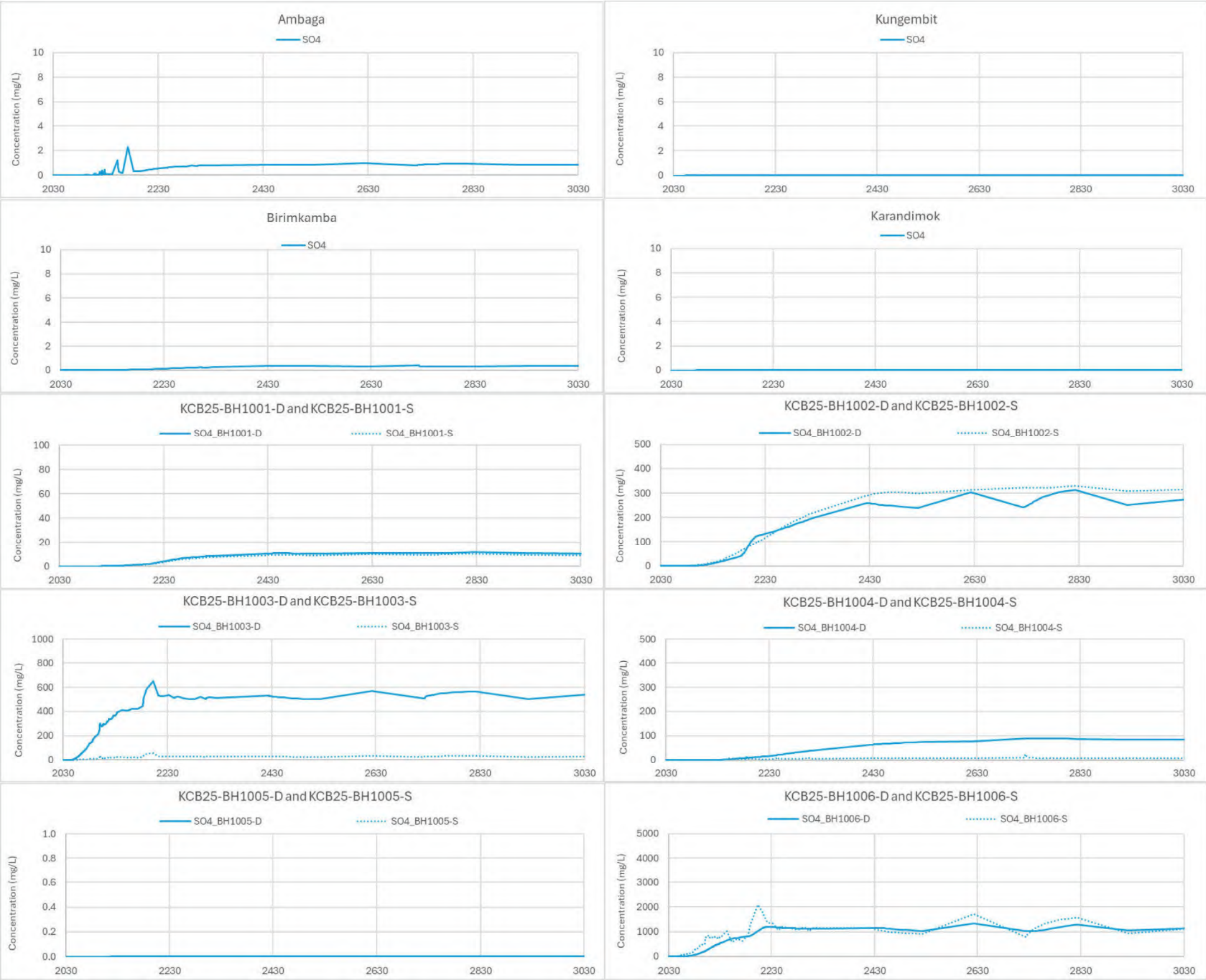


Figure 7.25 Sulphate Time Series: Computed Concentrations at Village Observation Points and Option C TSF Monitoring Bores

Copper

Copper concentrations at 100, 250, 500 and 1000 post-closure for the shallow hydrogeological system (the model layer beneath the TSF) is illustrated in Figure 7.26. Computed copper concentrations at village observation points and Option C TSF monitoring bores for the operational and closure periods are presented in Figure 7.27. The following is observed:

- The extent of copper migration above background concentrations is limited to the immediate vicinity of the TSF, and similar to TDS, extends slightly along valleys to the south and southeast of the TSF.
- Copper concentration increases are predicted to remain low in groundwater at the village observation points. The highest concentration increase is predicted to be less than 0.2 µg/L (0.0002 mg/L).
- Copper concentrations are not predicted to increase to above the WHO (2022) or Australian drinking water guideline (NHMRC 2022), nor the PNG Environment Act Aquatic Life guideline (Office of Legislative Counsel 2000) of 1000 µg/L (1 mg/L), at any of the village observation points or TSF Option C monitoring bore locations.
- The draft Australian water quality guidelines for irrigation and general water uses (ANZG, 2023) indicate that water containing less than 200 µg/L (0.2 mg/L) is unlikely to cause plant toxicity (minimal risk of adverse effects). Copper concentrations at observation points are not indicated to exceed these guidelines.
- Most notable increases in copper concentrations are observed at KCB2025-BH1006S and D (located 300 m to the south of Cell 2), where concentrations are predicted to increase to a maximum of between 25 – 50 µg/L (0.025 – 0.050 mg/L).

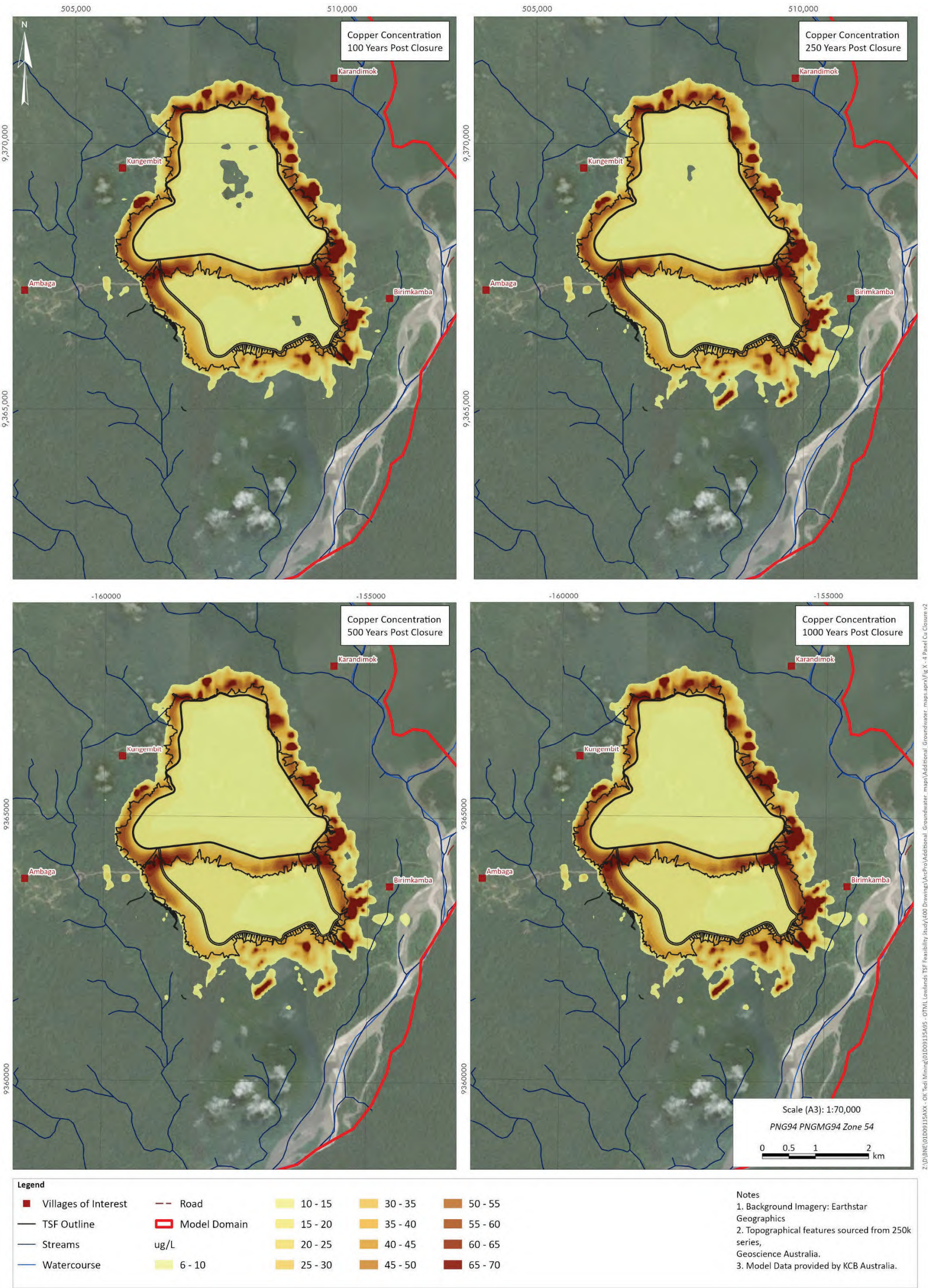


Figure 7.26 Copper Concentrations: 100, 250, 500, 1000 Years Post-Closure (Model Layer 3)



Figure 7.27 Copper Time Series: Computed Concentrations at Village Observation Points and Option C TSF Monitoring Bores

Arsenic

Arsenic concentrations at 100, 250, 500 and 1000 post-closure for the shallow hydrogeological system (the model layer beneath the TSF) is illustrated in Figure 7.28. Computed arsenic concentrations at village observation points and Option C TSF monitoring bores for the operational and closure periods are presented in Figure 7.29.

The following is observed:

- Arsenic concentration contours exhibit a similar spatial distribution pattern to that observed for copper.
- Arsenic concentration increases are predicted to remain low in groundwater at the village observation points. The highest concentration increase is predicted to be less than 0.5 µg/L (0.0005 mg/L).
- Arsenic concentrations are not predicted to increase to above the Australian drinking water guideline (NHMRC 2022) of 10 µg/L (0.01 mg/L), nor the PNG Environment Act Aquatic Life guideline (Office of Legislative Counsel 2000) of 50 µg/L (0.05 mg/L) at any of the village observation points or TSF Option C monitoring bore locations.
- Most notable increases in arsenic concentrations are again observed at KCB2025-BH1006S and D, where concentrations are predicted to increase to a maximum of between 4 - 8 µg/L (0.004 – 0.008 mg/L).

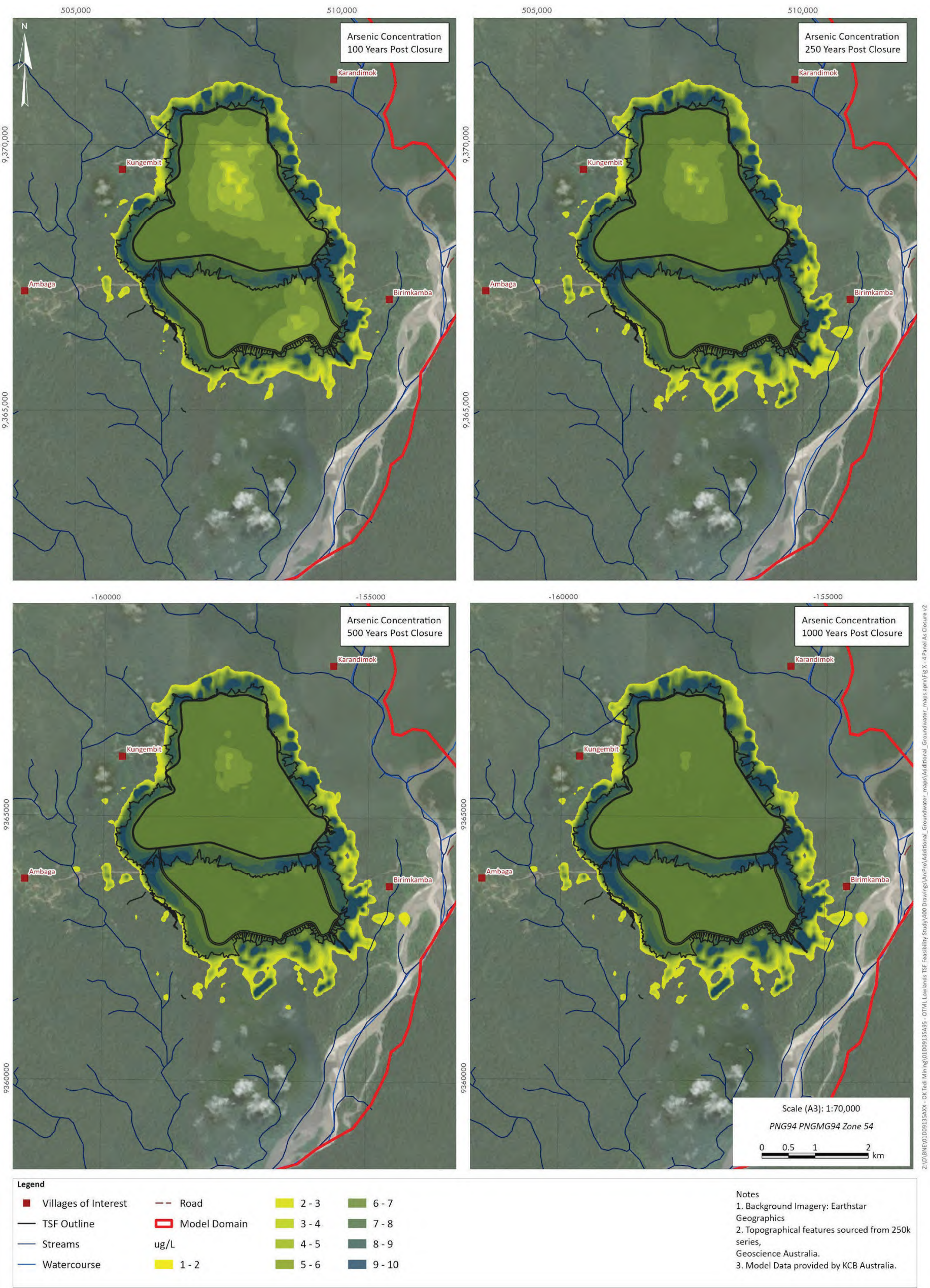


Figure 7.28 Arsenic Concentrations: 100, 250, 500, 1000 Years Post-Closure (Model Layer 3)

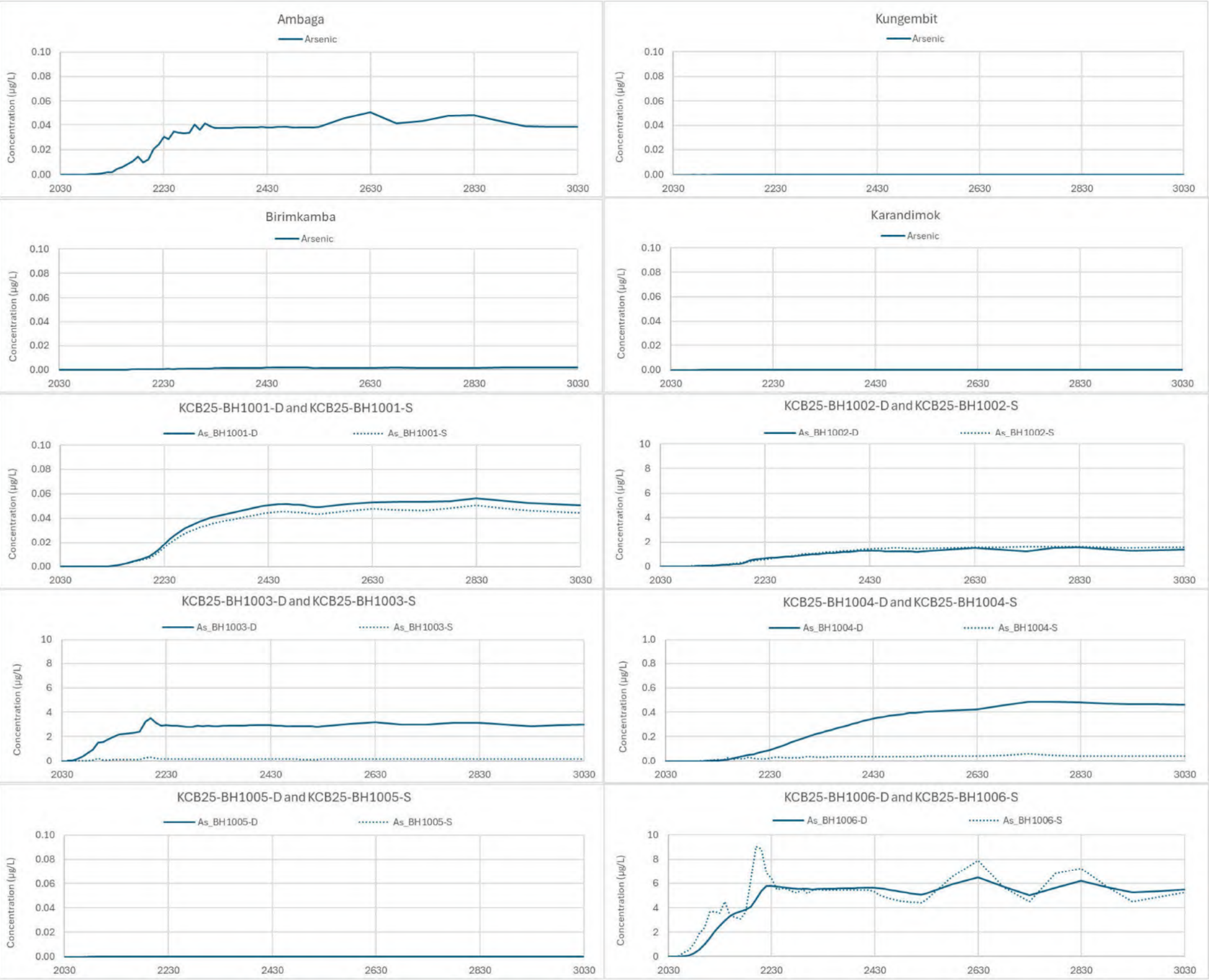


Figure 7.29 Arsenic Time Series: Computed Concentrations at Village Observation Points and Option C TSF Monitoring Bores

7.3 Particle Tracking

Particle tracking was undertaken as part of the groundwater modelling to better understand groundwater flow pathways, travel times, and potential contaminant migration within the model domain. This approach simulates the movement of hypothetical particles through the computed velocity field, providing insight into advective transport processes under calibrated conditions.

The particle tracking map presented in Figure 7.30 shows particle progression in terms of years since closure and depth (mbGL), allowing visualisation of both the temporal evolution of groundwater movement and its vertical distribution within the subsurface. This enables identification of flow paths, migration rates, and the depth intervals through which groundwater and potential contaminants travel, supporting interpretation of post-closure conditions and receptor connectivity within the system.

Figure 7.30 shows that most particles remain in the immediate vicinity of the TSF at depths exceeding 10 mbGL, while very limited shallow migration is indicated to the southeast, south and east of the TSF.

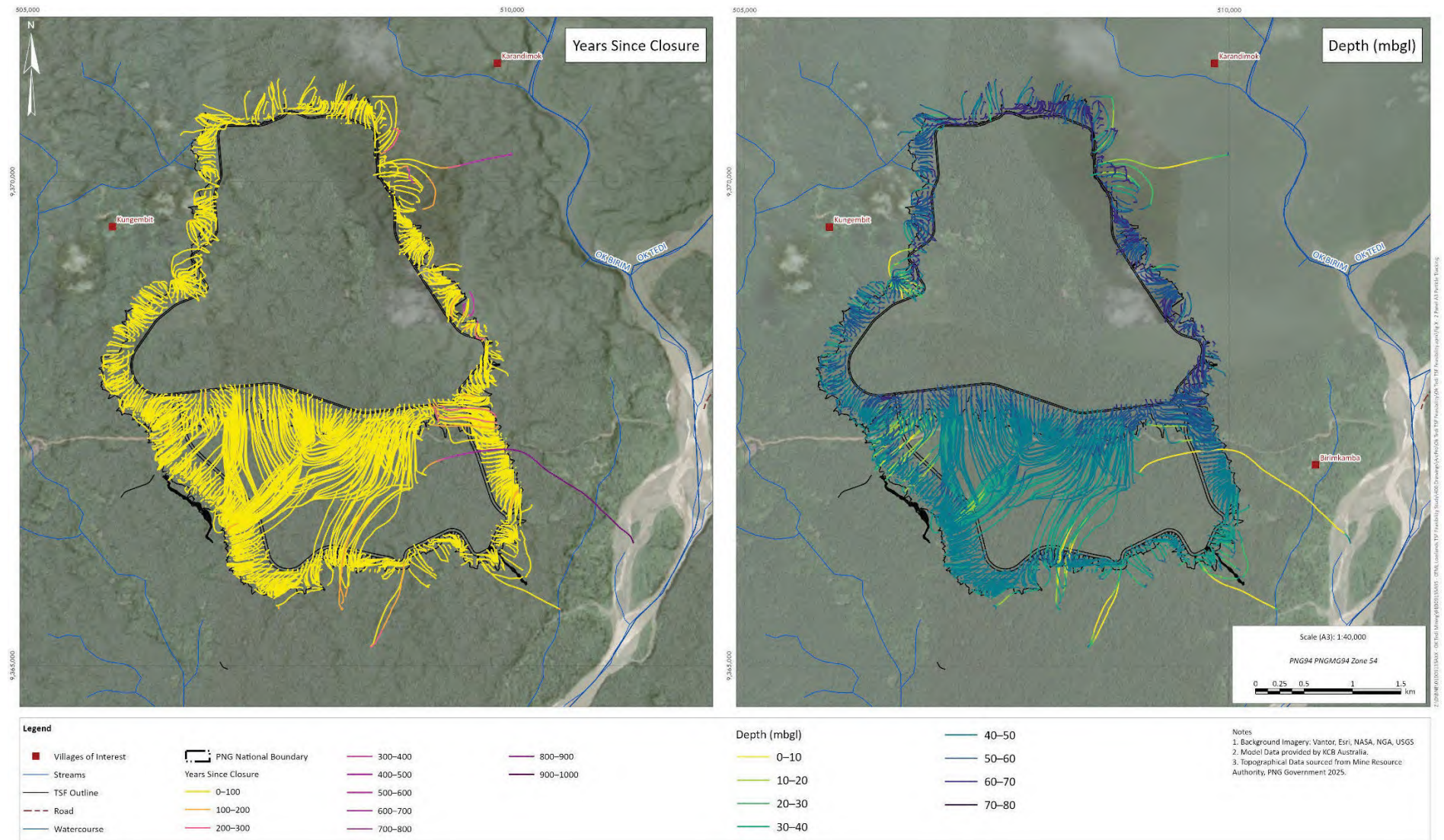


Figure 7.30 Particle Tracking: Years Since Closure and Depth (mbgl)

7.4 Prediction Uncertainty

The potential influence of uncertainty pertaining to hydraulic parameters was represented by varying properties in the model, producing different model output scenarios:

- **Base Case Scenario:** Adopts the transient state calibrated hydraulic parameters and the parameters as adopted for the operational prediction model. This represents the 'most likely' scenario based on available site and literature data.
- **Porosity Scenarios:** Two uncertainty scenarios were run with porosities increased by 25% and decreased by 25%, respectively.
- **Hydraulic Conductivity Scenarios:** Two uncertainty scenarios were run with hydraulic conductivities increased by 25% and decreased by 25%, respectively.

The range in sulphate concentrations for the TSF's operational and closure phases at village observation points and TSF Option C monitoring bores associated with these scenarios are displayed in Figure 7.31. It is observed that the increased hydraulic conductivity (K+25%) and reduced porosity (Porosity -25%) results in the earlier arrival of the breakthrough curve (as would be expected from fundamental considerations of contaminant transport in groundwater). The maximum concentrations predicted at observation points are, however, not overly sensitive to changes in the porosity or hydraulic conductivity. Predicted concentration trends generally plot within a narrow band.

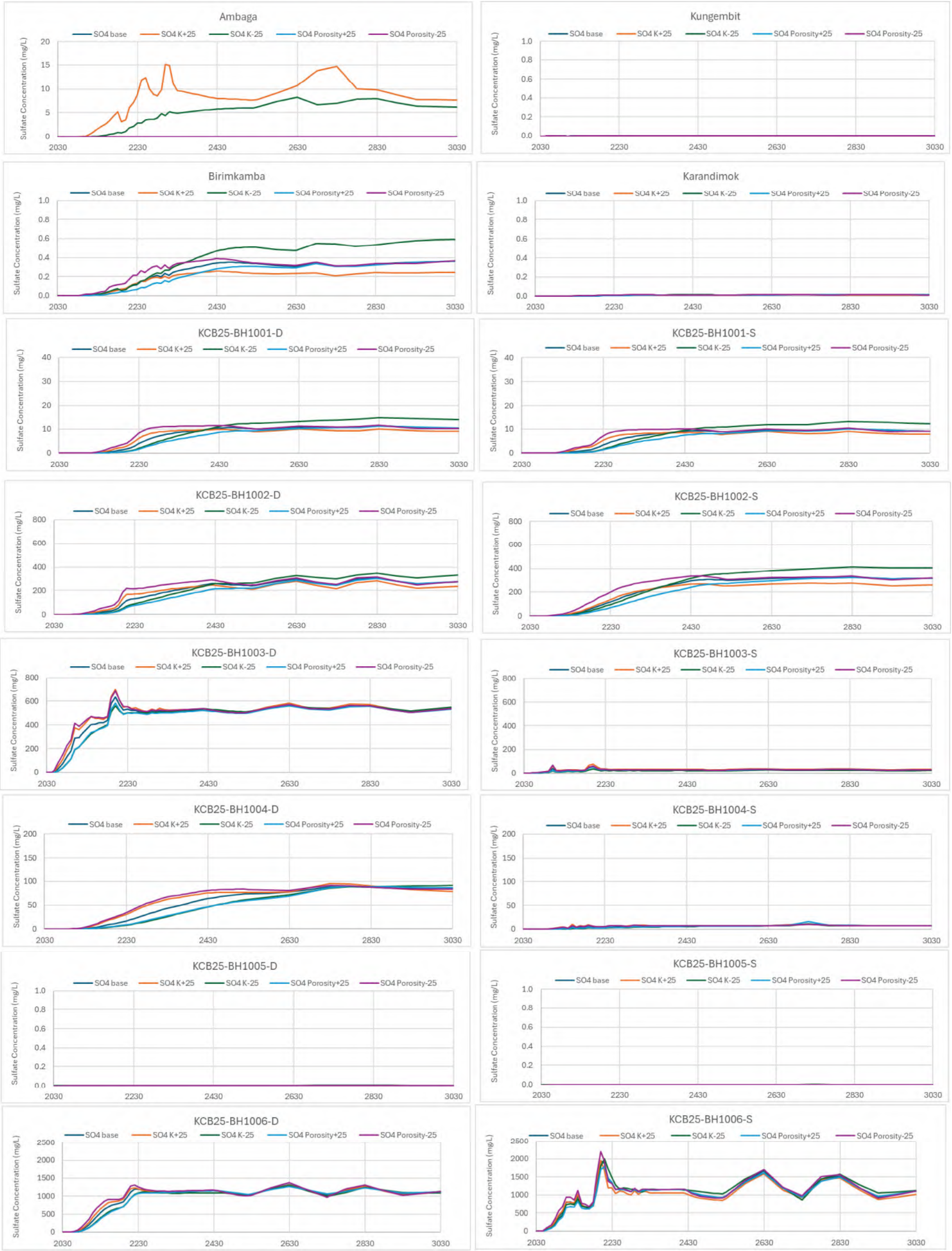


Figure 7.31 Prediction Uncertainty: Sulphate Concentrations in Groundwater

7.5 Model Assumptions and Limitations

The groundwater impact assessment and associated numerical modelling are subject to a number of limitations and uncertainties inherent to the available data, conceptual understanding, and modelling approach.

Groundwater data are limited in both spatial and temporal extent, with relatively few monitoring locations and incomplete long-term datasets. As a result, interpretation of groundwater levels, flow directions, and hydraulic gradients is constrained, and baseline conditions may not be fully characterised.

The hydrogeological system is highly heterogeneous due to interbedded lithologies and variable weathering. This complexity has been simplified in the conceptual and numerical models through the use of generalised hydrostratigraphic units and bulk hydraulic properties, which may not fully represent local scale variability or preferential flow pathways.

Hydraulic parameters, including hydraulic conductivity, storage, and recharge, are derived from a limited number of field tests and supplemented by literature values. Similarly, tailings material properties are based on laboratory testing and may change over time due to consolidation and operational factors.

The numerical model applies simplified boundary conditions and discretisation, and does not explicitly represent small-scale geological features, such as fractures or faults, which may locally influence groundwater flow and contaminant transport.

Solute transport modelling is conservative, based only on advection–dispersion processes with constant seepage source concentrations, and does not account for geochemical reactions (e.g. sorption, precipitation, degradation) that would likely reduce predicted plume concentrations.

Calibration of the model is constrained by the limited monitoring dataset, and while calibration targets are met at a regional-scale, uncertainty remains at local scales and for predictive scenarios.

Long-term predictions of groundwater levels and water quality are subject to uncertainty related to climate variability, operational conditions, and subsurface heterogeneity. Model results should therefore be considered indicative of general trends rather than precise forecasts.

Ongoing groundwater and surface water monitoring is required to validate model predictions, reduce uncertainty, and support adaptive management of potential impacts.

8 IMPACT AND RISK ASSESSMENT

The construction of the proposed TSF is expected to influence the local groundwater regime. Groundwater modelling has been undertaken to predict Project-induced changes in groundwater depth, flow direction, and quality.

8.1 Groundwater Levels and Flow

Operation of the TSF will result in elevated hydraulic levels within the confines of the facility, which will result in radial seepage from the facility to the surrounding environment.

Although the groundwater level within the TSF is predicted to extend up to 30 m above the groundwater levels in the aquifers surrounding the TSF, the extent of influence is limited to the immediate vicinity of the TSF (within ~ 800 m from the toe of the embankment).

Village groundwater observation points do not reflect systemic increases following commissioning of the TSF.

8.2 Water Quality

Seepage from the TSF is expected to exhibit elevated salinity and may contain metals that are elevated compared to the natural groundwater. TDS and sulphate were selected as POI representative of salinity (soluble salts) while copper and arsenic were selected as indicators of metals.

High natural recharge in the area means that natural dilution processes are continuous and high concentrations of contaminants are not expected to be found at significant distances away from the TSF. An influence on groundwater quality is predicted in the immediate proximity of, and to the south and southeast of the TSF (up to a distance of ~500 m). Baseflow contributions to surface water features in this area may result in an influence on stream water quality.

Predicted concentrations at the points of interest (POIs) were assessed against the Papua New Guinea water quality criteria for aquatic life protection (Office of Legislative Counsel 2000), the Australian Drinking Water Guideline (NHMRC 2022) and the WHO drinking water guideline (WHO, 2022) for selected determinants as presented in Table 8.1. Predictions indicate that no concentrations exceeding the Table 8.1 criteria would reach the local communities.

Table 8.1 Summary of Water Quality Criteria for Selected Parameters

Parameter	PNG Environment Act 2000 Aquatic Life	Australian Drinking Water Guideline
pH	Not given by guideline	6.5 – 8.5
TDS	-	1000 mg/L *
Sulphate (SO ₄ ²⁻) (mg/L)	400	250 mg/L for Aesthetic purpose
Cadmium (Cd) (mg/L)	0.01	0.002
Chromium (Cr) (mg/L)	0.05	0.05 mg/L for Cr ⁶⁺
Copper (Cu) (mg/L)	1	2 mg/L for Health and 1 mg/L for Aesthetic purpose
Iron (Fe) (mg/L)	1	0.3 mg/L for Aesthetic purpose
Nickel (Ni) (mg/L)	1	0.02
Lead (Pb) (mg/L)	0.005	0.01
Zinc (Zn) (mg/L)	5	3
Arsenic (mg/L)	0.05	0.01

* WHO (2022) drinking water guideline value. The maximum limit for TDS is not available in the Australian Drinking Water Guideline.

9 MITIGATION, MANAGEMENT AND MONITORING

This section provides details mitigation, management and monitoring practices proposed for the Project that will be adopted to manage the risk of impacting water resources.

9.1 Mitigation

The Option C7 TSF has been optimised to reduce the TSF's potential impact on sensitive receptors.

Mitigation measures inherent to the C7 design include:

- High-sulphur/pyrite concentrate will not be stored at the Option C7 TSF.
- A drainage blanket will be installed under the first raise of the TSF embankment, with finger drains discharging into a collection drain to facilitate active management of process water.
- The TSFs footprint has been amended to reduce the potential for impact on sensitive receptors (including nearby villages).

Adverse impact to water quality at the villages is not predicted to be associated with the Option C7 TSF. While groundwater quality is predicted to be affected in the immediate proximity of, and to the south and southeast of the TSF, the extent of quality impacts is anticipated to be limited.

It is predicted that seepage from the TSF may cause limited surface expression, specifically to the northeast and south of the TSF (Figure 7.14). It is recommended that the surface water diversion proposed along the north-eastern embankment of the TSF be designed to include effective interception and drainage of groundwater expression in this area. Seepage expression is not predicted to occur at nearby village areas.

Confirmation of predicted water quality and level impacts should be undertaken as part of the ongoing groundwater monitoring program as discussed in the section below.

9.2 Groundwater Monitoring

The groundwater monitoring network presented in Table 9.1 and in Figure 2.1 comprises boreholes installed up-gradient and downgradient of the Option C TSF site to establish baseline groundwater conditions and enable detection of potential Project-related changes in groundwater quality and flow regimes over time.

It is recommended that the monitoring network be extended with the installation of additional monitoring bores at Kungembit, Birimkamba, Karandimok and Ambaga Villages. The springs used by the communities should also be included in this monitoring.

Groundwater quality monitoring will focus on key physical and chemical parameters relevant to drinking water and aquatic ecosystem environmental values. All monitoring bores are recommended to be sampled quarterly for 3 years to establish a baseline and characterise potential seasonal fluctuations. A review of the data is then recommended to consider if data collection could be reduced to bi-annually. Samples must be analysed for the OTML surface water quality analyte suite as a minimum:

- pH;

- Total dissolved solids;
- Major ions (including alkalinity);
- Dissolved heavy metals;
- Acidity.

It is recommended that groundwater level monitoring be performed using data loggers connected to the OTML telemetry system, for both level and electrical conductivity prior to establishment of the TSF.

The collection of robust baseline data will provide the statistical foundation for developing site-specific trigger values, which will function as early warning thresholds within the broader groundwater management framework. Baseline data could also be used to validate and further refine the groundwater model, reducing the risk of any unwanted influence on the surrounding communities.

Table 9.1 Proposed Groundwater Monitoring Network

KCB Bore ID	Surface Elevation (mRL)	Coordinates (PNG94) ¹		Screen Interval/VWP depth (mbGL)	Lithology	Installation and Purpose
		Easting (m)	Northing (m)			
KCB25-BH1001-D	47.86	511206.66	9367511.56	49.3-55.3	Residual	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1001-S	47.86	511208.27	9367513.22	11.5-17.5	Siltstone/sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1002-D	55.11	510492.27	9367180.86	47.4-53.4	Alluvium	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1002-S	55.11	510489.98	9367182.09	11.5-17.51	Sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1003-D ¹	84.96	506292.54	9369466.46	70.5-76.5	Residual	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1003-S ¹	84.96	506293.13	9369466.51	20.0-28.4	Mudstone/sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1004-D	42.92	506614.76	9365708.59	47.0-53.0	Mudstone/sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1004-S	42.92	506616.09	9365707.83	20.0-26.0	Sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1005-D	89.13	510221.59	9369200.77	30.0; 57.0	Sandstone (30 mbGL) and Sandstone (57 mbGL)	<ul style="list-style-type: none">Two VWPsBaseline monitoring & long-term monitoring
KCB25-BH1005-S	89.13	510217.64	9369197.65	22.0-28.0	Sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1006-D	53.15	509503.07	9365829.55	56.2-62.2	Siltstone/sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
KCB25-BH1006-S	53.15	509502.87	9365827.62	14.5-20.5	Sandstone	<ul style="list-style-type: none">PVC Standpipe and Slotted ScreenBaseline monitoring & long-term monitoring
DH14-BIR-01A	78.00 ²	509302.00	9370686.00	2 x VWP (30 m and 40 m)	Sandstone	<ul style="list-style-type: none">Baseline monitoring & long-term monitoring
DH14-BIR-01B	78.00 ²	509301.00	9370686.00	1.5 – 10.5	Clay and Clayey Sand	<ul style="list-style-type: none">PVC StandpipeBaseline monitoring & long-term monitoring
New Birimkamba S + D ³		510009.92	9367778.86	20 + 60	To be determined	<ul style="list-style-type: none">Early warning for community
New Kungembit S + D ³		506573.81	9369392.90	20 + 60	To be determined	<ul style="list-style-type: none">Early warning for community
New Ambaga S + D ³		505431.58	9367660.67	20 + 60	To be determined	<ul style="list-style-type: none">Early warning for community
New Karandimok S + D ³		508522.33	9370945.43	20 + 60	To be determined	<ul style="list-style-type: none">Early warning for community
Kungembit Drinking Spring		506046.80	9369585.00	Surface	Sandstone/ shale contact	<ul style="list-style-type: none">Early warning for community
Kungembit Spring		505917.60	9369497.00	Surface	Sandstone/ shale contact	<ul style="list-style-type: none">Early warning for community
P5 Springs		510141.00	9369070.00	Surface	Sandstone/ shale contact	<ul style="list-style-type: none">Early warning for community

¹ Coordinates estimated with handheld GPS unit.

² Surface elevations are inferred from LiDAR survey.

³ Target location within 100m

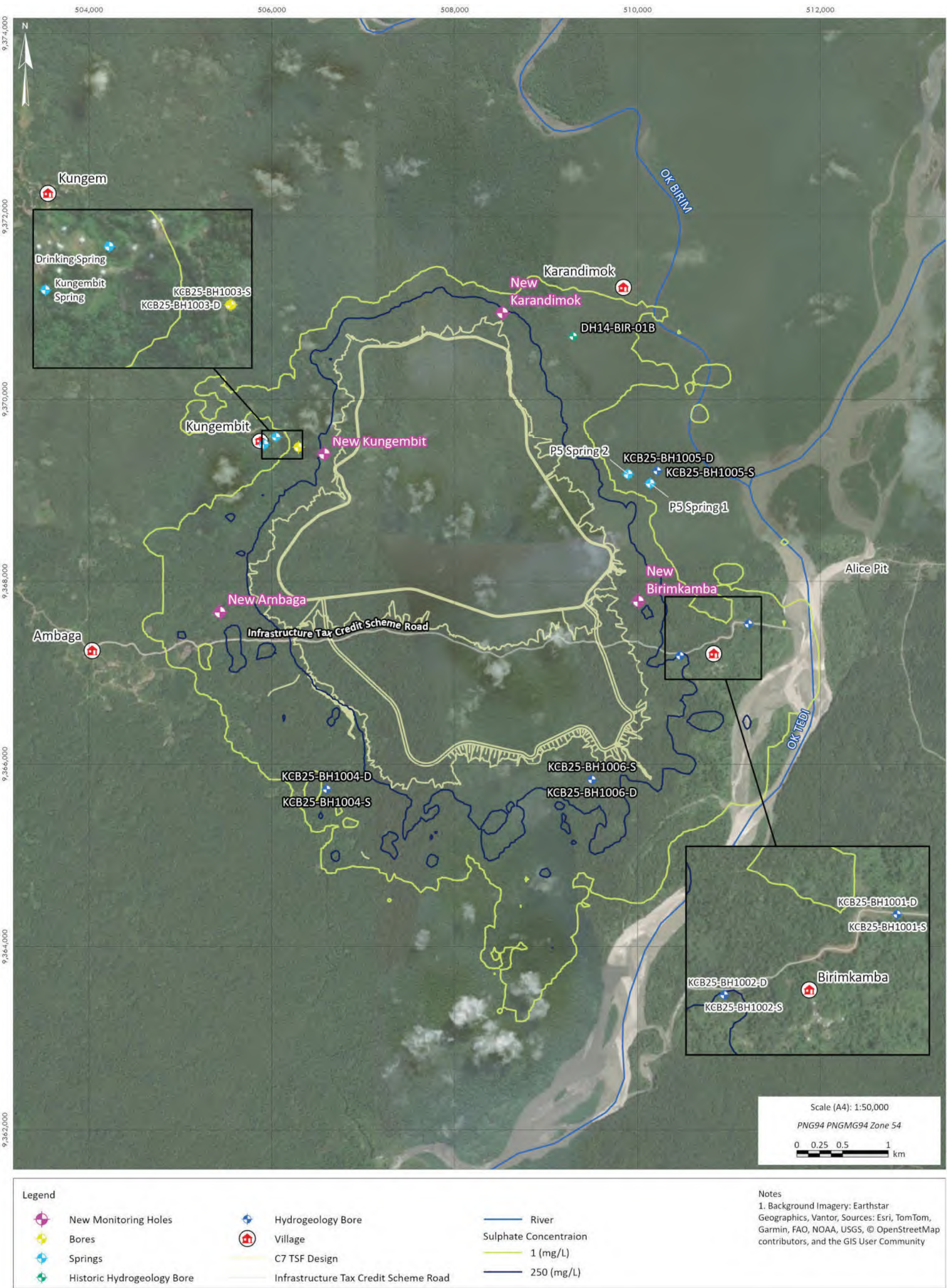


Figure 9.1 Existing and Proposed New Groundwater Monitoring Sites

10 CLOSING

We would like to thank you for the opportunity to work on this assignment. Should you have any questions, please do not hesitate to contact the undersigned.

Yours truly,

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