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Daunia Mine

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Daunia Mine

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
AEP	Annual exceedance probability
AHD	Australian height datum
AMD	Acid and metalliferous drainage
AQP	Appropriately qualified person
ARR	Australian Rainfall and Runoff
AWBM	Australian Water Balance Model
BMA	BHP Mitsubishi Alliance
BoM	Bureau of Meteorology
CCS	Consistent Climate Scenarios
CHPP	Coal handling and processing plant
CQCA	Central Queensland Coal Associates
CSM	Conceptual site model
DEC	Department of Energy and Climate
DESI	Department of Environment, Science and Innovation
DNM	Daunia Mine
EA	Environmental Authority
EC	Electrical conductivity
EPA	Environment Protection Agency
ERM	Environmental Resources Management
ESA	Environmentally sensitive area
EV	Environmental value
FoS	Factor of safety
FRP	Flood risk profile
FSL	Full supply level
GDE	Groundwater dependent ecosystem
GIS	Geographic information system
GLM	General Lake Model
GWDB	Groundwater Bore Database
HSE	Health, safety and environment
HVR	High value regrowth
IA	Improvement area
IPCC	International Panel on Climate Change
LOD	Land outcome document

Acronym	Description
LOR	Limit of reporting
MB	Monitoring bore
ML	Mining lease
MLA	Mining lease area
MM	Management milestone
MIA	Mine infrastructure area
n.d.	No date
NAF	Non-acid-forming
NUMA	Non-use management area
OOPD	Out of pit dump
PAF	Potentially acid forming
PMF	Probable maximum flood
pH	The negative base-10 logarithm of the hydrogen ion (H ⁺) concentration in a solution, i.e. $pH = -\log_{10}[H^+]$
PHREEQC	pH-Redox-Equilibrium in C
PMLU	Post-mining land-use
PMP	Probable maximum precipitation
PRCP	Progressive rehabilitation and closure plan
QA/QC	Quality assurance/quality control
QLD	Queensland
RCM	Rangal Coal Measure
RFI	Request for information
ROM	Run-of-mine
SCL	Stochastic Climate Library
SI	Saturation index
SILO	Scientific Information for Land Owners
SSP	Shared Socioeconomic Pathways
TDS	Total dissolved solids
VCP	Void closure plan
WBM	Water balance model
Whitehaven	Whitehaven Coal Ltd
WQO	Water quality objective
WS	Water supply (bore)

UNITS

Acronym	Description
ha	hectare
km	kilometre
kPa	kilopascal
m	metre
m ³	cubic metre
mm	millimetre
ML	Megalitre
yr	year

1 INTRODUCTION

Daunia Mine (DNM, the Mine) is an open-cut coal operation located approximately 65 kilometres (km) east of Moranbah in Queensland's Bowen Basin. Mining activities are conducted under three Mining Leases (MLs); ML1781, ML70115 and ML70116. In December 2025, ML application (MLA) MLA700085 (formerly EPC 27334; EPC 1951) was submitted for an area to the west of, and immediately adjacent to ML 1781. Activities on the new lease will comprise the construction and operation of an Out of Pit Dump (OOPD) and associated infrastructure.

DNM operates under Environmental Authority (EA) EPML00561913, held by Whitehaven Daunia Pty Ltd. Under the *Environmental Protection Act 1994 (the EP Act)*, the EA holder is required to submit a Progressive Rehabilitation and Closure (PRC) Plan.

This Void Closure Plan (VCP) has been prepared as an appendix to the PRC Plan in accordance with the Department of Environment, Tourism, Science and Innovation (DETSI) Statutory Guideline PRC Plans (version 3.01, dated 16 September 2024). The VCP addresses closure planning for the residual voids associated with the Mine. These residual voids include Titan North, Titan Central, Titan East and Pandora. Residual voids comprise both areas with a Post Mining Land Use (PMLU) and areas designated as Non-use Management Areas (NUMAs). As the Titan East and Titan Central residual voids are adjacent to each other, the NUMA for these residual voids becomes one contiguous area. Therefore, the final landform comprises four residual voids and three NUMAs.

The PRC Plan must demonstrate that the size of NUMAs and their potential for environmental harm have been minimised. The location and extent of the NUMAs within the residual voids have been refined to minimise their dimensions.

This VCP includes technical assessments led by Environmental Resources Management Australia Pty Ltd (ERM), including PHREEQC-based geochemical modelling and limnology modelling to evaluate long-term water quality of each residual void. These assessments use water balance outputs provided by WRM Water & Environment (WRM), which are summarised in this document and applied as inputs to the water quality modelling. The overall aim is to ensure the final voids are safe, stable and non-polluting.

1.1 PURPOSE AND OBJECTIVES

DNM currently contains multiple mining pits at different operational stages. At closure, these pits will be consolidated into four (4) residual voids: Titan North, Titan Central, Titan East and Pandora, within the final landform design. These voids are pre-approved as NUMAs under the PRCP framework.

The objective of this VCP is to outline an approach to achieving safe, stable and non-polluting residual voids at closure. This plan also supports the broader rehabilitation strategy by aiming to:

- Reduce environmental and safety risks associated with the residual voids and surrounding NUMA areas;
- Minimise the need for ongoing active management post-closure; and
- Prevent unmitigated access by people and livestock.

This document addresses the requirements of sections 3.4 and 3.6.3 of the PRC Plan Guideline as outlined in Table 1-1 below.

TABLE 1-1 ALIGNMENT OF VCP SECTIONS WITH REQUIREMENTS UNDER THE PRCP GUIDELINE

Reference in PRCP Guidelines	Content Summary	Section in this VCP
Section 3.4 – Voids in flood plains	Voids in flood plains must be rehabilitated to a stable condition to be approved in the PRCP schedule.	<i>Not applicable; no residual voids are situated within a flood plain.</i>
	Flood plain modelling is required in accordance with ARR 2019 and must exclude artificial features. The flood plain model report must include specific technical details (e.g. model inputs, groundwater influence, spatial data, calibration).	Section 5 – Flooding Assessment
	All voids in flood plains must have an associated PMLU and be identified in the PRCP schedule.	<i>Not applicable; no residual voids are situated within a flood plain.</i>
	Transitional arrangements apply to pre-existing NUMAs in land outcome documents.	Section 3.1 – Transitional Arrangements
	The PRC plan must demonstrate how void locations minimise environmental risk.	Section 3.1.2 – Impact of Void Location on Environmental Risks
Section 3.6.3 – Voids	Options available for minimising final void area and volume (where a final void is proposed).	Section 3.1.1 – Void Extent Minimisation
	Proposed final dimensions of the void (i.e. depth, length and width).	Section 3.2 – Designs of Voids
	Pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events.	Section 7 – Geotechnical Stability
	Proposed final slope angles of highwall, low wall and end walls of each final void.	
Void hydrology, addressing the long-term water balance and water level in the voids, stratification connections to groundwater resources and potential for overflow.	Section 4 – Groundwater and Section 5.3 – Pandora Hydraulic Assessment	

Reference in PRCP Guidelines	Content Summary	Section in this VCP
	Groundwater modelling to determine whether the void is acting as a sink or a source for groundwater.	Section 4 – Groundwater
	<p>A water balance study including an assessment of void surface and groundwater interactions such as:</p> <ul style="list-style-type: none"> • groundwater lowering/reduction in hydraulic head (from new voids); • cones of depression and associated impacts; • the drainage and flooding behaviours of surface waters in the vicinity of the void; • the potential extent of flooding and implications of interactions with the void; • a conceptual model that incorporates all projected inflows, outflows and recharge rates; • water storage and long-term water balance; • each of the major water fluxes into and out of the void; and • the sources of surface water within the mine catchment that are likely to influence the water quality in the void. 	Section 5.3 – Pandora Hydraulic Assessment
	Predicted water quality in the long-term including potential stratification.	Section 8 – Geochemical Stability
	A 3D void design plan.	Section 3.2 – Designs of Voids
	Rehabilitation strategies.	Section 9.1 – Void Rehabilitation

1.2 RELEVANT GUIDELINES AND LEGISLATIONS

This VCP has been developed in accordance with the legislative and regulatory framework applicable to mine closure and residual voids in Queensland. The following documents have informed the preparation of this plan:

- *Environmental Protection (EP) Act 1994 (Qld)*:
The primary legislation governing environmental protection, including requirements for progressive rehabilitation and mine closure.
- *Progressive Rehabilitation and Closure Plan Guideline, Version 3.01 (September 2024)*:
Provides the required structure and content for PRC plans.

- Environmental Authority (EA) (EPML00561913), dated 03 November 2025: Defines site-specific conditions for environmental management, residual voids and rehabilitation activities at DNM.
- According to Condition E9 of the EA:
- **“Residual void outcome**
- *Complete an investigation into residual voids and submit a report to the administering authority proposing acceptance criteria and landform design criteria for departmental review and comment. On acceptance of the criteria proposed in the Residual Void Management Plan, the criteria must be specified in the environmental authority.*
- *The investigation must at a minimum include the following:*
 - *a) a study of options available for minimising final void area and volume;*
 - *b) develop design criteria for rehabilitation of final voids;*
 - *c) a void hydrology study, addressing the long-term water balance in the voids, connections to groundwater resources and water quality parameters in the long term;*
 - *d) a pit wall stability study, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events;*
 - *e) a study of void capability to support native flora and fauna; and*
 - *f) a proposal/s for end of mine void rehabilitation success criteria and final void areas and volumes.*
- *These studies will be undertaken during the life of the mine and will include detailed research and modelling.”*

2 SITE OVERVIEW

DNM is an open-cut strip mining operation that uses truck, shovel and dozer fleets to produce metallurgical coal. The majority of mining activities occur within ML1781 and ML70115. ML70116, located to the west of the active pits, contains supporting infrastructure including the coal handling and preparation plant (CHPP), New Chum Creek and a rail corridor.

The mining process includes vegetation clearing, topsoil removal and stockpiling and drilling and blasting of overburden or interburden where required. Excavators, dozers and haul trucks are used to strip and relocate overburden and interburden material, most of which is backfilled into previously mined voids. Raw coal is hauled to the run-of-mine (ROM) area at the CHPP or to designated stockpile areas. Product coal is transported by conveyor to the Train Load-Out facility at the Stanmore SMC Pty Ltd Red Mountain Infrastructure area and subsequently railed to the Hay Point Coal Terminal for export. CHPP fine and coarse rejects are co-disposed within mining spoil.

DNM commenced operations in 2013. Based on the current mine plan, mining is expected to cease in 2042. The proposed final landform of DNM is shown in Figure 2-1.

A description of the site setting, climate, hydrology and geology within and around the DNM site is provided in the main PRC Plan document and is not repeated here.

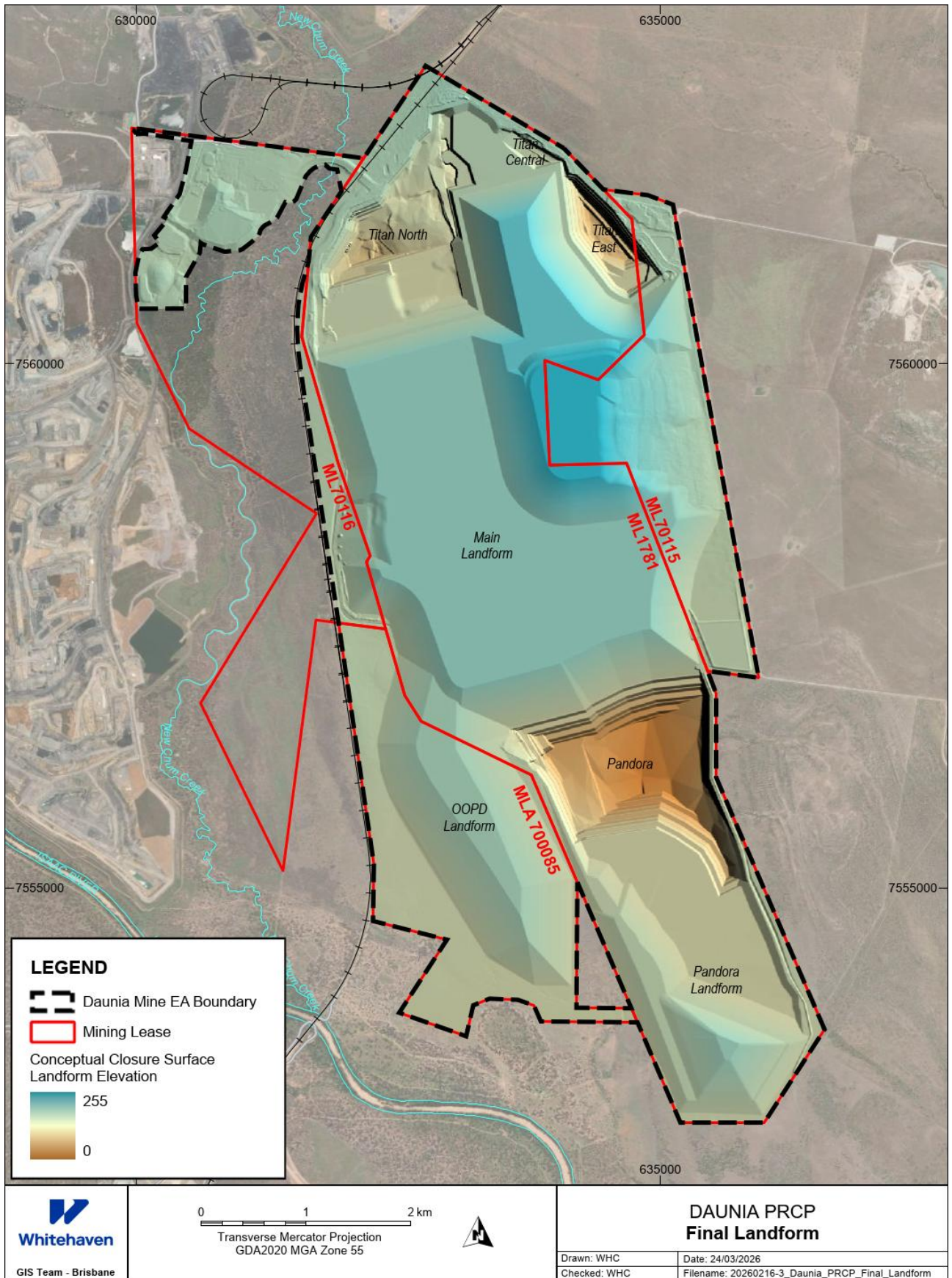


FIGURE 2-1 PROPOSED FINAL LANDFORM

3 PROPOSED RESIDUAL VOIDS

This section describes the location, dimensions and characteristics of residual voids to be retained at closure. It is required under the PRCP Guideline to justify why full rehabilitation is not feasible.

This section also addresses:

- *Options considered for minimising the final void area and volume.*
- *Proposed final dimensions of each void, including depth, length and width.*
- *A 3D design plan illustrating the final landform configuration.*
- *In addition, to support the requirement that void locations minimise environmental risk, this section includes:*
 - *A conceptual site model illustrating key environmental and geotechnical interactions.*
 - *An ecological impact assessment identifying potential impacts to flora, fauna and habitats.*
 - *An assessment of groundwater environmental values, including beneficial uses and connectivity.*
 - *An assessment of surface water environmental values, including potential impacts to downstream environments.*

This section outlines the characteristics of the residual voids at DNM that will remain post-mining. Residual voids include both areas of PMLU and NUMAs. The four residual voids to remain post-mining include:

- Titan North;
- Titan Central;
- Titan East; and
- Pandora.

Whilst there are four residual voids, the NUMA within the Titan East and Titan Central residual voids is contiguous resulting in only three NUMA areas within the final landform. This section presents a Conceptual Site Model (CSM), a summary of ecological assessment findings and a review of groundwater environmental values (EVs) relevant to the post-mining landform.

The proposed residual voids at DNM are authorised under Schedule E, Condition E9 of the EA (EPML00561913), which serves as the primary Land Outcome Document (LOD). Accordingly, these voids are being transitioned as pre-approved NUMAs under the PRC Plan.

Flood modelling indicates that the proposed residual voids are not going to be subject to inundation from floodwaters (refer to Section 5 for further detail).

3.1 TRANSITIONAL ARRANGEMENTS

EPML00561913, recorded as a Land Outcome Document (LOD), notes that residual voids are approved under NUMA provisions but does not identify their specific locations. Therefore, flood plain modelling for the DNM residual voids under the PRCP Guideline is required. The results of this modelling is presented in Section 5.

3.1.1 VOID EXTENT MINIMISATION

The total proposed NUMA area at DNM has been reduced from its original design concept of 503 ha to 431 ha. This was achieved by allowing for progressive backfilling of final voids, resulting in the complete filling of Atlas West, Atlas East, Calypso Central, Skoll and Titan West pits. Consequently, only Titan North, Titan Central, Titan East and Pandora will remain as residual voids in the final landform. Note that Titan Central and Titan East are located within a single NUMA, resulting in a total of three NUMA areas across the site.

The EA is the primary LOD for the Daunia Mine and identifies final voids as an approved outcome without prescribing their size or location. While the *Environmental Impact Statement (EIS)*, *Supplementary Environmental Impact Statement (SEIS)* and *Coordinator-General's Evaluation Report* provide historical context for the project, the EA remains the governing approval for land outcomes under the EP Act. Accordingly, the PRCP Schedule is not required to replicate information or assumptions contained in those earlier documents but must demonstrate how the total area and location of final voids have been designed to minimise environmental risks, consistent with section 754(4) of the EP Act.

Since the Coordinator-General's Report was prepared, several amendments to the Daunia EA have resulted in changes to the mine footprint over time. As mining has progressed, the previous operator developed a more refined understanding of the site's technical characteristics, which now informs ongoing final landform planning undertaken by Whitehaven.

Having regard to these developments, Whitehaven considers that the NUMAs have been designed to minimise the overall extent of the final voids and ensure the outcome minimises risks to the environment.

3.1.2 IMPACT OF VOID LOCATION ON ENVIRONMENTAL RISKS

In accordance with the PRCP guideline, this Void Closure Plan provides justification for the selected residual void locations and demonstrates how they minimise long-term risks to the environment.

The placement of each residual void has been determined through an integrated assessment of hydrology, hydrogeology, geotechnical stability, land use compatibility and environmental values. The final locations reflect a balance between operational feasibility and environmental performance, as outlined below:

- **Surface water value:** Residual voids have been positioned outside the modelled 0.1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) floodplain extents. Final landform levels are well above predicted peak flood levels, which prevents flooding risk and subsequent uncontrolled discharge to the environment.
- **Groundwater-dependent ecosystems:** Hydrogeological modelling indicates that the selected void locations do not intersect with known GDEs. This minimises the potential for degradation of connected ecological receptors.
- **PMLU compatibility:** The positioning of the voids supports landform drainage, landform surface stability and visual integration with the surrounding post-mining landscape.
- **Water quality risk management:** The geochemical stability of the Pandora void has been modelled to identify likely water quality conditions. This modelling has considered geochemistry of the highwall, geochemistry of inflow sources (groundwater, catchment

runoff), rainfall and evaporation. No off-site discharge is predicted under the proposed closure configuration.

3.1.3 ALTERNATIVE PMLUS

Residual voids at DNM are proposed to remain as long-term water bodies post-closure. Alternative PMLUs were considered as part of the closure planning process, such as partial/complete backfilling and land-based rehabilitation. These options were assessed in the context of geotechnical feasibility, available spoil volumes, final landform configuration and environmental performance.

Complete backfilling was found to be impractical due to insufficient spoil volumes, significant additional disturbance to adjoining landforms and excessive economic implications.

As such, the proposed use of voids as permanent, stable water bodies is considered the most practicable, safe and environmentally acceptable post-closure option.

3.2 DESIGNS OF VOIDS

Table 3-1 summarises the key physical characteristics and geometric configurations of the proposed residual voids based on the final landform design shown in Figure 2-1.

Three-dimensional (3D) designs of the Titan North, Titan East and Pandora residual voids are presented in Figure 3-1.

Residual voids comprise both PMLU areas and NUMA areas. The NUMA boundaries have been designed to maximise the extent of land that can be safely assigned a PMLU (Section 9.1.1). The total surface area of all NUMAs is 431 ha with the remaining residual void area allocated to a PMLU.

TABLE 3-1 RESIDUAL VOID DIMENSIONS

Attribute	Unit	Titan East	Titan North	Pandora	Titan Central
Indicative maximum length	<i>m</i>	1,085	1,048	1,680	395
Indicative maximum width		330	1,276	1,550	165
Maximum depth		104	76	134	18
Void catchment area	<i>ha</i>	185.1	513.6	827.4	38.8
Indicative surface area of void		55	192	450	6
Residual void spill level	<i>mAHD</i>	220	210	190	210

Source: WRM 2026b, Table 2-1.

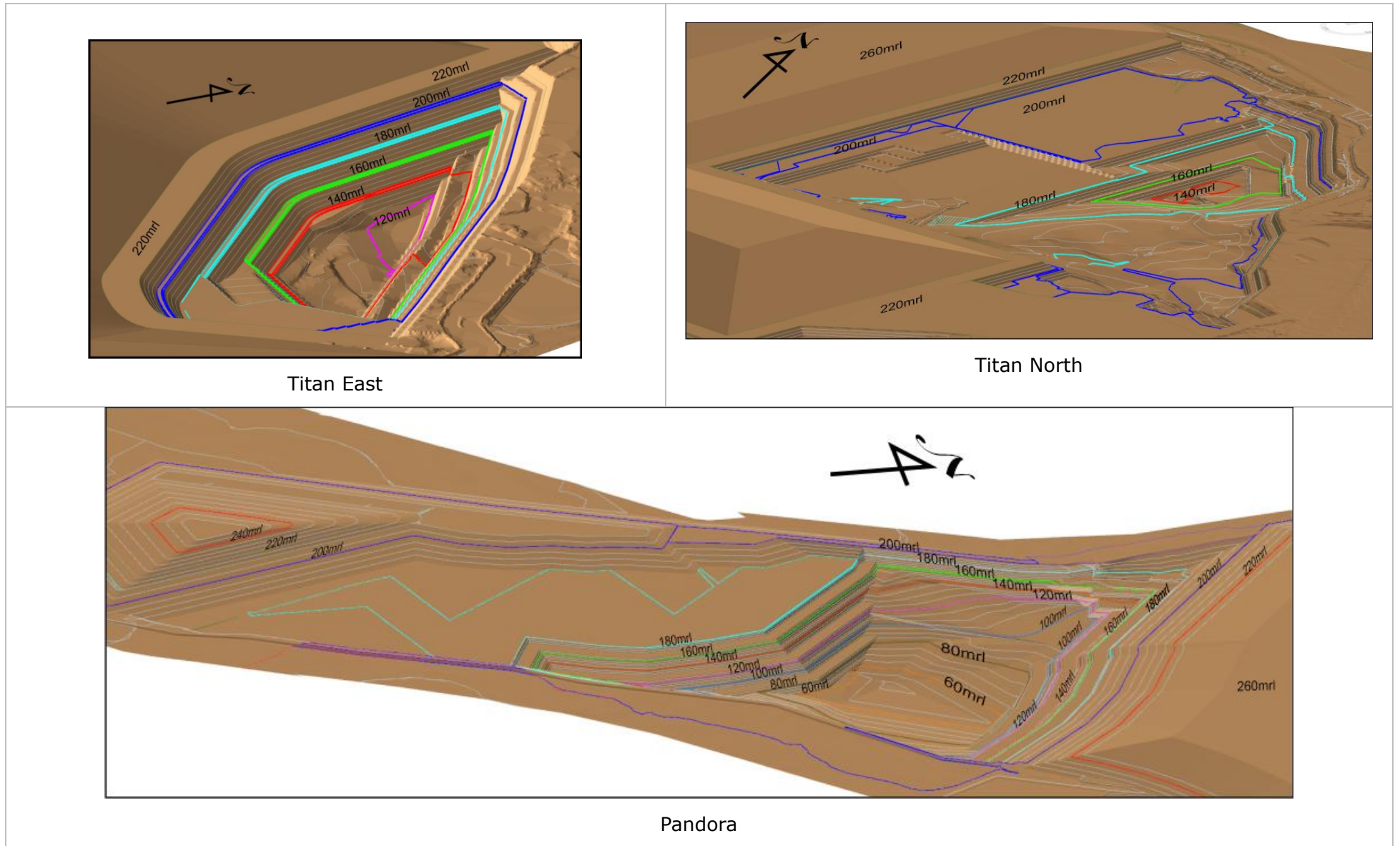


FIGURE 3-1 3D DESIGN OF DNM RESIDUAL VOIDS

3.3 CONCEPTUAL SITE MODEL

The post-closure CSM is presented in Figure 3-2 and Figure 3-3. The CSM predicts the formation of residual void lakes, with water levels stabilising below both pre-mining groundwater levels and the shallow aquifers.

The CSM shows a representation of the geological strata, groundwater flow regimes and key water balance processes. Inward hydraulic gradients into the voids will persist due to evaporation, preventing water outflow to surrounding units. The voids will capture incident rainfall, along with most seepage and catchment runoff from rehabilitated spoil. Minimal impacts are expected on surficial aquifers or environmental and human receptors after mining ends.

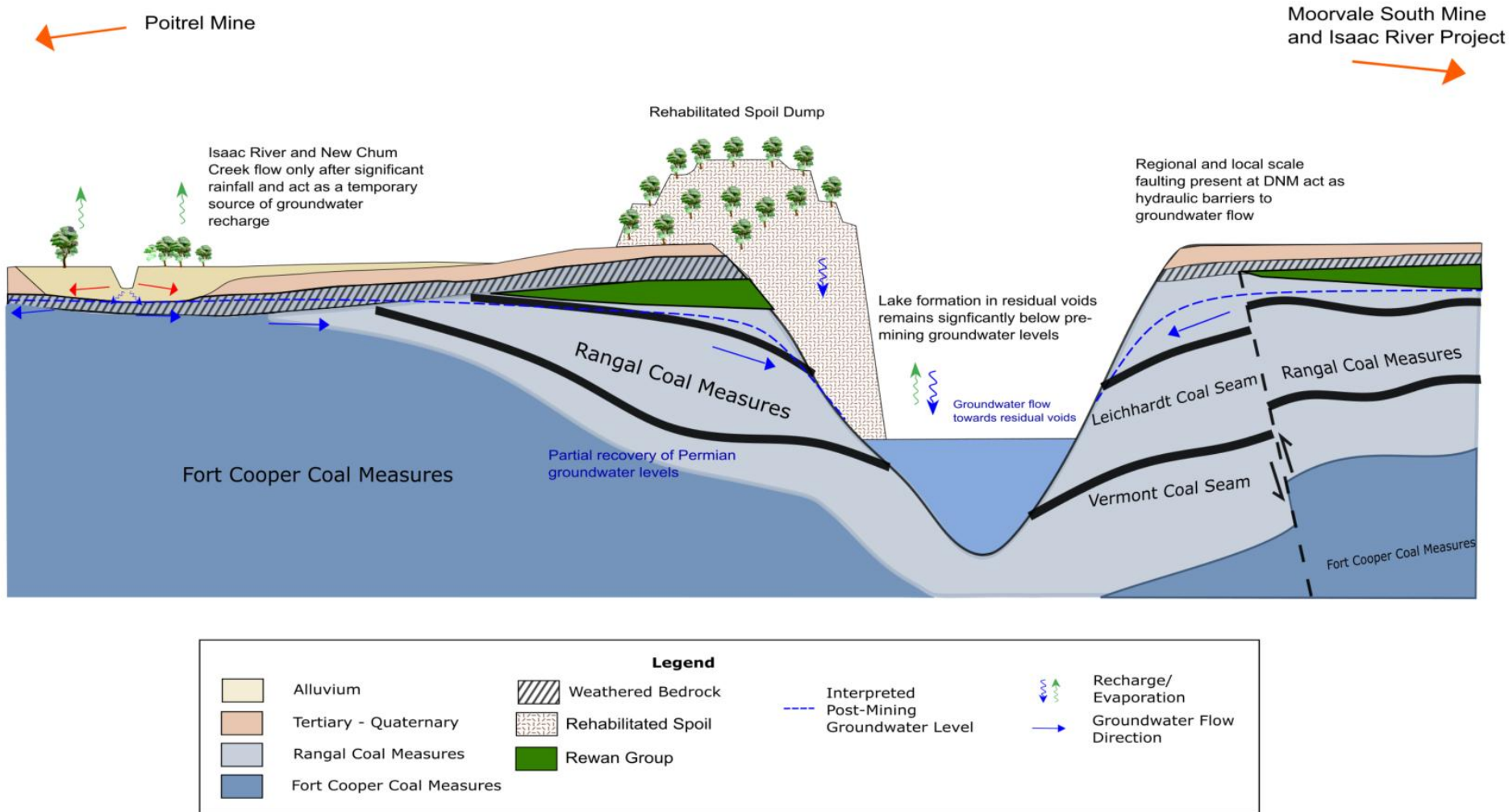


FIGURE 3-2 POST-CLOSURE CONCEPTUAL SITE MODEL OF THE GROUNDWATER SYSTEM (NORTHERN RESIDUAL VOIDS) (SLR, 2026)

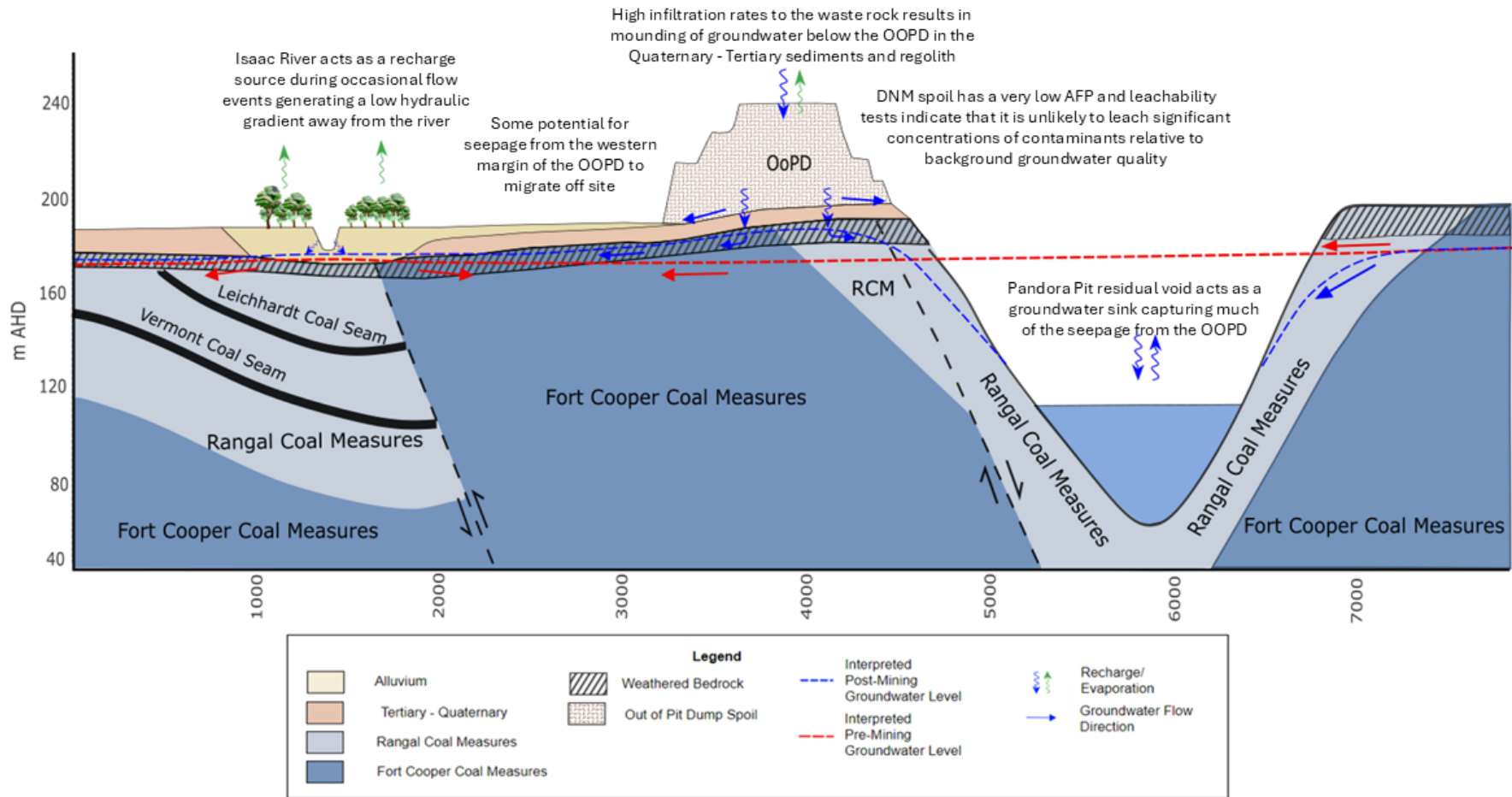


FIGURE 3-3 POST-CLOSURE CONCEPTUAL SITE MODEL OF THE GROUNDWATER SYSTEM (PANDORA RESIDUAL VOID) (SLR, 2026)

3.3.1 ECOLOGICAL ASSESSMENT

This section provides a brief ecological assessment with regards to potential impacts from the residual voids on the surrounding ecology.

3.3.1.1 FLORA ASSESSMENT

Most of DNM was cleared before mining began (SKM, 2008). Baseline Regional Ecosystem (RE) mapping is presented in Figure 3-4. At present, the landscape mostly consists of non-remnant grasslands dominated by buffel grass (*Cenchrus ciliaris*), with some regrowth of brigalow (*Acacia harpophylla*) and poplar box (*Eucalyptus populnea*) (BMA, 2024).

Recent ecological surveys undertaken between 2021 and 2025 confirm that most vegetation within the MLA700085 area remains non-remnant due to historical clearing and grazing, with approximately 308 ha of non-remnant vegetation verified within the project site (SLR, 2025).

Surveys have confirmed small patches of remnant and high-value regrowth (HVR) vegetation, mainly along the north-western edge of the site (ELA, 2015; 2016). More recent field verification surveys identified limited areas of remnant vegetation within and adjacent to the MLA700085 area, including RE 11.3.3 (*Eucalyptus coolabah* woodland on alluvial plains), with additional remnant ecosystems occurring nearby but outside the main disturbance footprint (SLR, 2025).

Two endangered REs have been identified at DNM:

- RE 11.4.9 – Brigalow shrubland on clay plains.
- RE 11.9.5 – Brigalow and Casuarina woodland on sedimentary rock.

Both are listed as Category B Environmentally Sensitive Areas (ESAs) under the Environmental Protection Regulation 2019 (QG, 2019). Notably, RE 11.9.5 is located within the Titan Central pit and has since been disturbed by mining. Additional remnant ecosystems mapped within the broader site and surrounding areas include RE 11.3.1 (brigalow open forest on alluvial plains – endangered) and RE 11.5.3 (poplar box woodland on sand plains – least concern) (SLR, 2025).

The MLA700085 area is located southwest of the existing MLs and borders the western margin of the Pandora residual void. Desktop and field assessments indicate that vegetation within the area is predominantly mapped as Category X non-remnant vegetation, although remnant ecosystems and Category B ESA vegetation occur within approximately 200 m of the area (see Figure 3-5).

3.3.1.2 FAUNA ASSESSMENT

Some state-significant fauna species are known or likely to occur on site:

- Ornamental snake (*Denisonia maculata*), found in brigalow habitat with gilgais and woody debris.
- Short-beaked echidna (*Tachyglossus aculeatus*), recorded in brigalow woodland with ephemeral wetlands.
- Rufous fantail (*Rhipidura rufifrons*), recorded in mature brigalow regrowth but typically prefers wetter forest types.
- Squatter pigeon (*Geophaps scripta scripta*), likely present due to suitable foraging habitat near permanent water.

Recent desktop and field assessments confirmed that several conservation-significant fauna species have potential to occur within the MLA700085 area. Field surveys did not record any conservation-significant fauna species; however, as outlined above, the ornamental snake, squatter pigeon and short-beaked echidna are considered highly likely to occur based on habitat availability. The koala (*Phascolarctos cinereus*) has also been identified as having a moderate likelihood of occurrence in the broader area (SLR, 2025).

3.3.1.3 ECOLOGICAL IMPACT ASSESSMENT

The residual voids are not expected to pose a risk to nearby ecological values. Reasons include:

- The pit lakes will be hydraulically isolated from the surrounding area. However, the conceptual water balance model (Section 4.2) indicates a negative hydraulic gradient through spoil from the northern voids toward Pandora in the south.
- There is no connection to shallow aquifers, the Isaac River or REs.
- Seepage from spoil will be contained within the voids.

Because RE 11.9.5 within the Titan North pit has already been mined, no direct ecological linkage remains at that location.

Remnant vegetation and fauna habitats (presented in Figure 3-6) in other parts of the site are either upslope or outside the influence of the residual voids.

The MLA700085 area and associated disturbance footprint occur primarily within previously cleared or non-remnant vegetation and do not intersect mapped protected areas, wetlands of high ecological significance or essential habitat. A regulated vegetation watercourse traverses the MLA700085 area; however, this is mapped as a low-impact (green) waterway and is not expected to be affected by residual void processes.

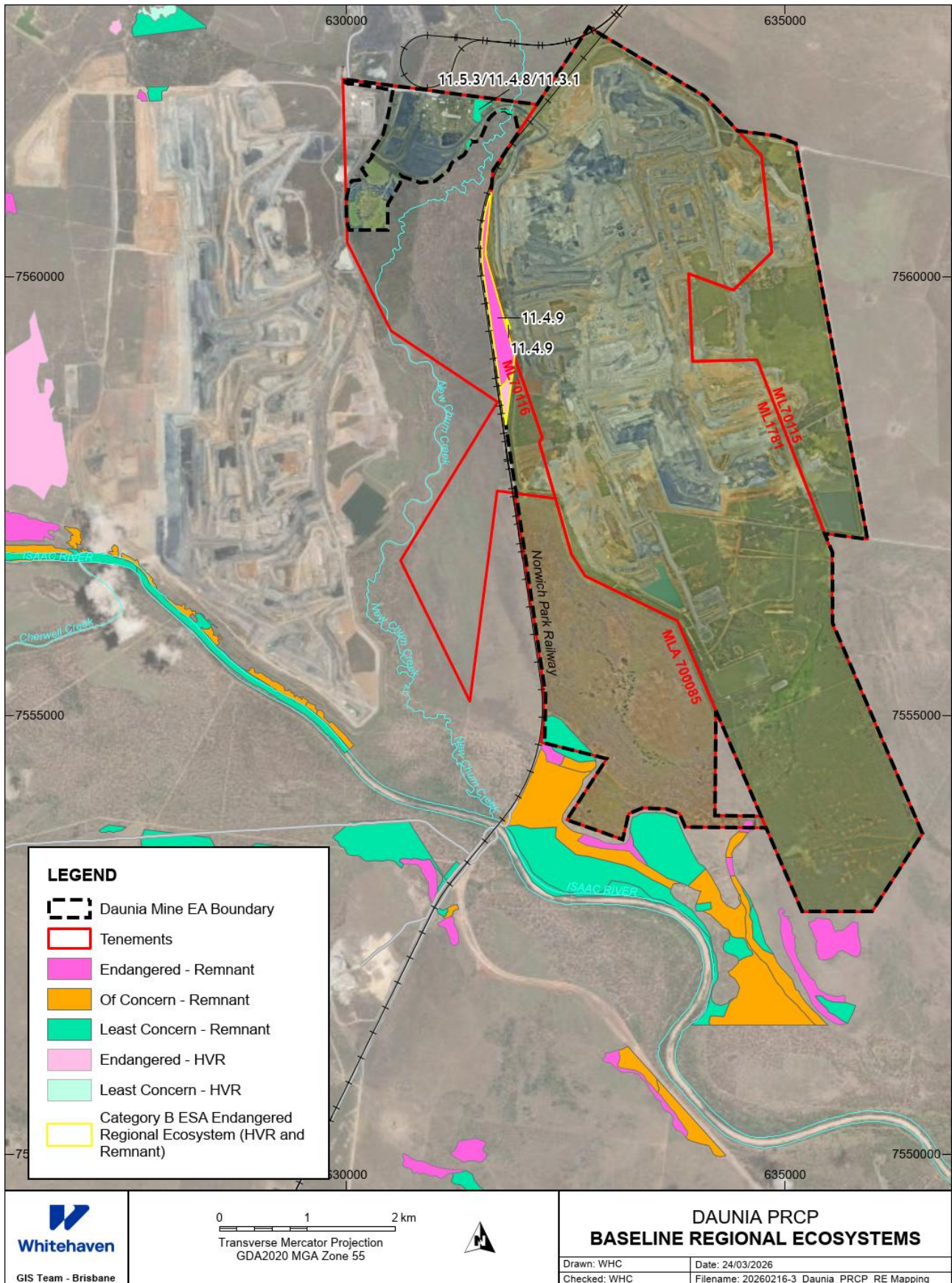


FIGURE 3-4 BASELINE REGIONAL ECOSYSTEMS (WHC, 2026)

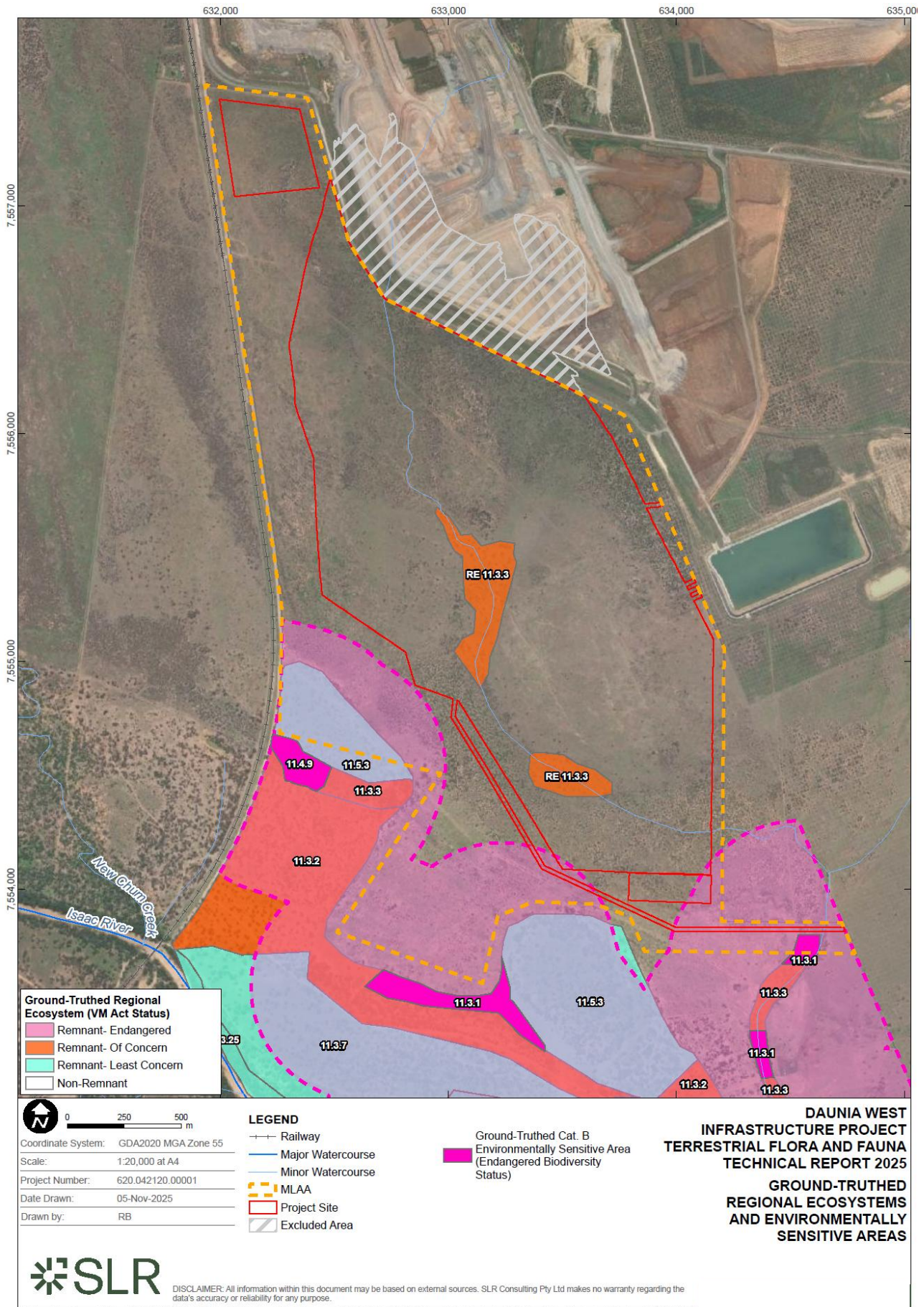


FIGURE 3-5 GROUND-TRUTHED REGIONAL ECOSYSTEMS NEAR ML700085 (SLR, 2025)

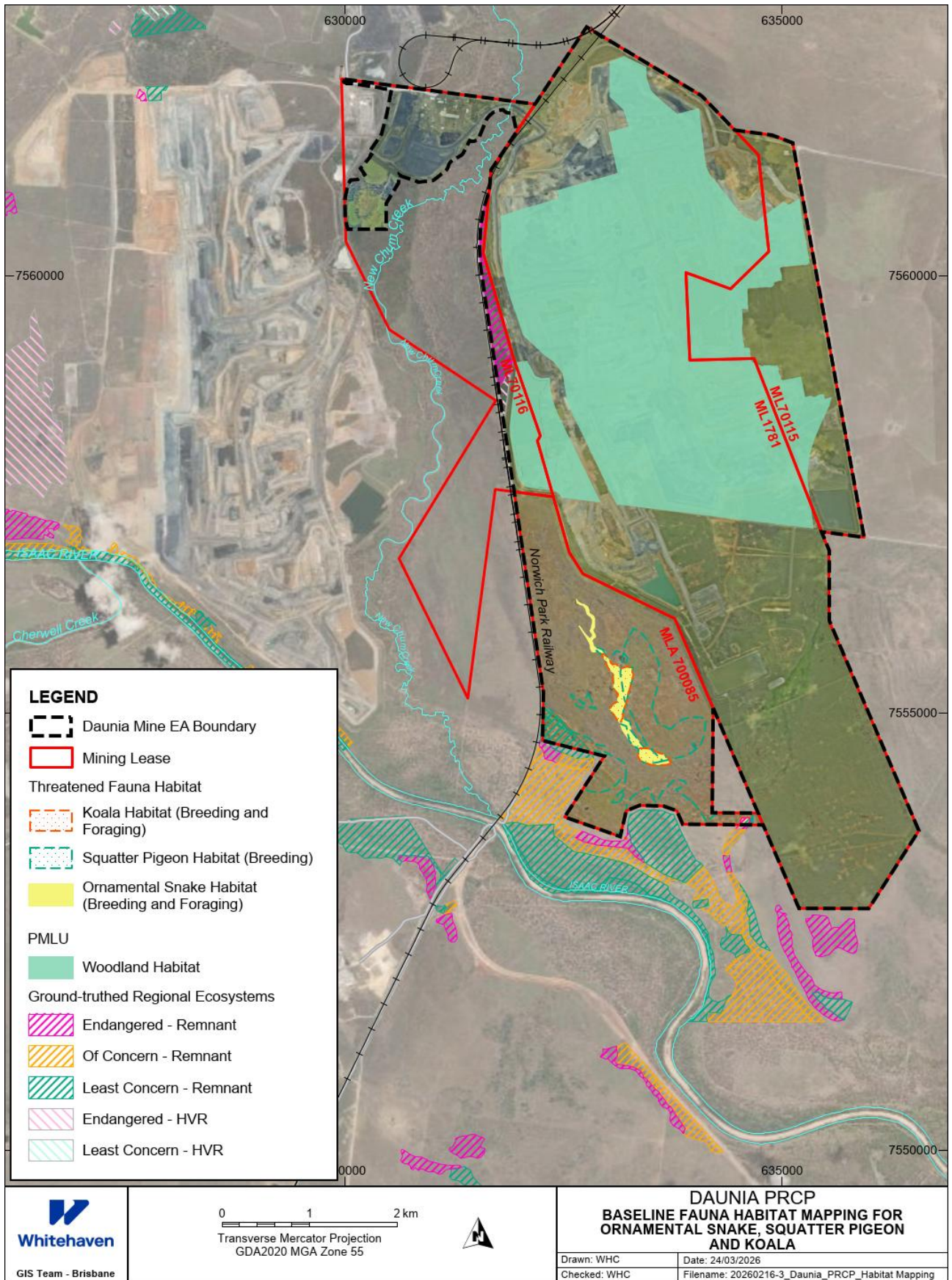


FIGURE 3-6 BASELINE FAUNA HABITAT MAPPING

3.3.2 GROUNDWATER ENVIRONMENTAL VALUES

The EVs for groundwater in the Isaac River catchment are defined under the Environmental Protection (Water) Policy 2009 (QG, 2018). These EVs help identify the uses and sensitivities of groundwater in the area. They are described in the Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP, 2011).

A review of the groundwater EVs and their applicability related to the DNM residual voids are summarised in Table 3-2.

TABLE 3-2 GROUNDWATER ENVIRONMENTAL VALUES AT DNM

EV	Description	Applicability at DNM
Aquatic ecosystems	Groundwater that supports ecological communities, such as wetlands or riparian areas.	Applicable mainly to shallow alluvium near the Isaac River (~8 km south of DNM); these areas may be supported by groundwater. Near DNM, creeks are ephemeral and generally recharge groundwater.
Irrigation	Suitability for watering crops, pastures, parks or gardens.	Potentially suitable in shallow alluvium, though no groundwater quality data is available. Deep Permian groundwater has high salinity (EC 2,600-21,000 $\mu\text{S}/\text{cm}$), limiting its suitability. No groundwater licences have been identified within 10 km of DNM.
Farm supply	Suitability for general domestic use on farms (excluding drinking water).	Potentially suitable in shallow alluvium but limited by high salinity in deeper groundwater.
Stock water	Suitability for keeping livestock healthy.	Limited potential due to elevated salinity in Permian aquifers.
Primary recreation	Water suitable for activities with direct human contact (e.g. swimming).	Not applicable. There are no permanent surface water features or springs near DNM, and groundwater salinity exceeds drinking water guidelines.
Drinking water	Water that can be used as a raw source for drinking with minimal treatment.	Not applicable due to high salinity in groundwater. No town water licences in the vicinity.
Cultural and spiritual values	The cultural, historical and aesthetic significance of water.	Applicable. Palustrine wetlands and remnant vegetation along drainage lines south of DNM may hold cultural and aesthetic significance.

Source: GHD (2022)

Among all above listed EVs, the aquatic ecosystem EV is considered the most sensitive and important to protect at DNM. While groundwater at the site is not expected to directly support baseflow to surface waters, shallow alluvial aquifers south of the site may support ecologically significant systems during wetter periods.

3.3.2.1 GROUNDWATER USERS

A review of the Queensland Government Groundwater Bore Database (GWBD) in SLR (2026) identified 70 registered bores within a 5 km radius of DNM. Of these, 57 are recorded for groundwater monitoring and investigation purposes, 4 are recorded for water supply and 9 have no recorded use.

One private landholder bore (BMB), located approximately 4 km east of the DNM, is included in the DNM groundwater monitoring network and is actively used for water supply. The bore is screened within the RCM interburden at depths of 30-50 m below ground level. Monitoring data indicates that extraction from this bore has a dominant influence on recorded water levels, with no discernible drawdown trend attributable to DNM operations. Given its distance from the mine and the absence of measurable effects in nearby monitoring bores, this bore is not considered at risk of mining-related impacts.

Four unregistered landholder bores were also identified directly south of DNM from the combined GWBD and adjacent project bore census datasets (Olive Downs 2018; Moorvale South 2019; Winchester South 2020). These include two Knob Hill bores (Tertiary), the Winnet Bore (Alluvium) and Bore 9/House Bore (Alluvium, domestic use) located approximately 1 km south of the mine near the Isaac River. Available information indicates that Bore 9 is active, while the others are either inactive or used intermittently as back-up water supplies.

A review of regional groundwater studies confirms that shallow groundwater associated with the Isaac River Alluvium is occasionally used by landholders south and southwest of DNM, primarily for stock and domestic supply. However, local DNM alluvial monitoring bores have remained dry since installation, indicating that groundwater resources in the immediate vicinity are limited and largely unsaturated.

Overall, active groundwater use near DNM is minimal and confined to isolated private supply bores. Monitoring and model results indicate negligible potential for drawdown or quality impacts to existing groundwater users under both operational and post-closure conditions.

3.3.2.2 GROUNDWATER DEPENDENT ECOSYSTEMS

Groundwater dependent ecosystems (GDEs) rely on groundwater either permanently or during dry periods to support vegetation, aquatic life and ecological functions. A GDE is defined as an ecosystem in which plant and/or animal communities depend on the availability of groundwater, either permanently or periodically, to maintain ecosystem structure and function. The Bureau of Meteorology's (BoM's) GDE Atlas maps ecosystems with high, moderate or low potential for groundwater interaction based on multiple lines of evidence. The GDE Atlas is intended as a regional-scale screening tool and represents a "first pass" indication of potential groundwater dependence rather than confirmation of GDE presence.

Figure 3-7 displays the potential GDEs in and around DNM, as mapped by SLR (2026). It shows isolated areas of low potential GDEs near the northwestern edge of DNM, and moderate to high potential GDEs along the Isaac River and New Chum Creek to the southwest.

The BoM GDE Atlas indicates that terrestrial vegetation associated with riparian zones of the Isaac River and tributaries has a high potential to be dependent on groundwater. Broader areas of the Isaac River floodplain are mapped as hosting terrestrial ecosystems with moderate to low potential to depend on groundwater, while the channel of the Isaac River and an adjacent unnamed drainage line are mapped as having a high potential to be dependent on the surface expression of groundwater. The Isaac River is ephemeral and flows approximately 26% of the time, indicating that there is no perennial groundwater-supported baseflow.

Groundwater interaction is therefore expected to occur only intermittently, such as following significant rainfall when partial saturation of the alluvium may result in short-term baseflow or surface expression of groundwater within the channel. Alluvial groundwater may also support aquatic habitat within waterholes during no-flow periods, depending on their permanence.

A remote sensing study by 2rog (2021) found no terrestrial GDEs within the DNM site. The nearest potential terrestrial GDE was located approximately 7.3 km southeast of DNM at the confluence of North Creek and the Isaac River.

Ground-truthing GDE investigations undertaken at nearby operations, including Isaac Downs (3D Environmental, 2019) and Poitrel Mine (3D Environmental, 2024), provide additional context relevant to the DNM area as they occur within the same hydrogeological setting. These studies indicate that terrestrial vegetation does not utilise groundwater from deeper confined aquifers associated with the Permian coal seams, and that interaction with groundwater is limited to shallow alluvial groundwater within riparian environments.

The studies identified that vegetation interaction with groundwater is largely restricted to mature deep-rooted riparian tree species, particularly red gum woodland communities (e.g. RE11.3.25 dominated by *Eucalyptus tereticornis* or *E. camaldulensis*) fringing drainage lines and the modern river channel. Vegetation dependence on groundwater decreases significantly with increasing distance and elevation away from the channel, with vegetation on higher alluvial terraces generally showing little to no groundwater interaction.

Other regional GDE studies, including those at Poitrel, Winchester South and Isaac Downs (Advisian, 2018; SLR, 2020; 3D Environmental, 2019), indicate that aquatic systems associated with the Isaac River are largely dependent on surface water, with any use of groundwater being facultative and short-lived. Groundwater beneath the floodplain and wetland areas occurs at depths of 10 to 20 m, and the generally high salinity of groundwater in the region limits its suitability for sensitive species. Riparian vegetation may use shallow groundwater during dry periods, but this use is likely facultative and short-lived. No stygofauna have been recorded near DNM, and the high regional groundwater salinity further limits ecological support for sensitive taxa.

No stygofauna have been recorded near DNM, and the generally high salinity of groundwater in the region further limits ecological support for sensitive taxa.

Overall, no confirmed moderate or high potential GDEs occur within the DNM site, and ecosystems in the surrounding area have only limited and localised reliance on groundwater, primarily within riparian zones immediately adjacent to the Isaac River channel.

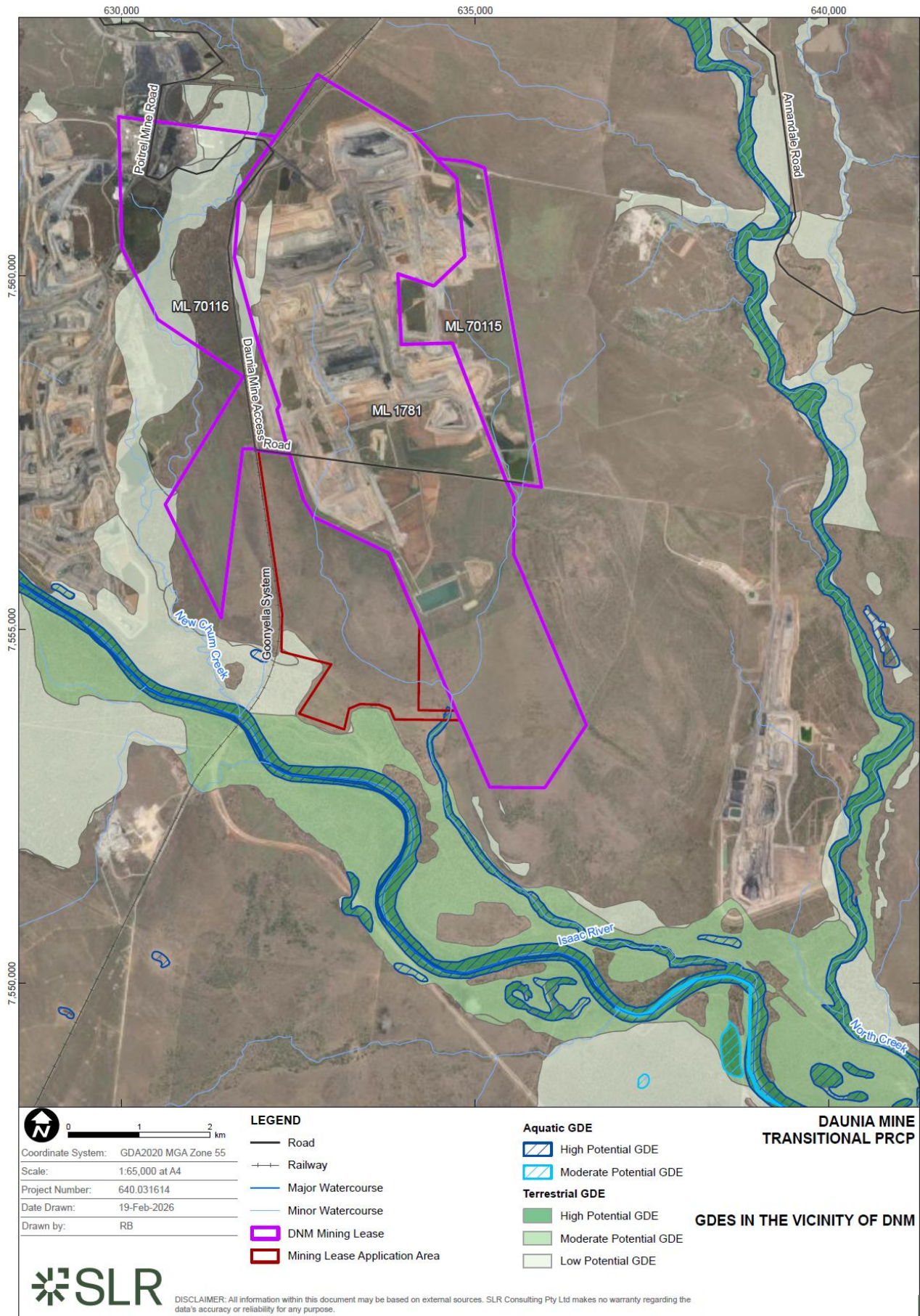


FIGURE 3-7 GROUNDWATER DEPENDENT ECOSYSTEMS NEAR DNM (SLR, 2026)

3.3.3 SURFACE WATER ENVIRONMENTAL VALUES

DNM is located within the Isaac Northern Tributaries sub-catchment of the Isaac River Sub-basin, part of the broader Fitzroy Basin, as displayed in Figure 3-8. This sub-catchment is covered under the Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (QG, 2019) and the Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP, 2011). The Isaac River ultimately flows into the Mackenzie River, then the Fitzroy River, discharging into the Coral Sea at Rockhampton.

Table 3-3 presents EVs that apply to surface waters in the sub-catchment that includes the DNM residual voids. In summary, for all listed EVs, the risk of environmental impact is low under the planned landform design and water management strategy.

TABLE 3-3 SURFACE WATER ENVIRONMENTAL VALUES IN THE VICINITY OF THE RESIDUAL VOIDS

EV	Description	Applicability Related to Residual Voids
Aquatic ecosystems	Supports freshwater habitats and biodiversity.	The Isaac River (Strahler order 6) is the only major watercourse near DNM. The Isaac River and nearby creeks (e.g. New Chum Creek, North Creek) are ephemeral and flow only after rainfall. However: <ul style="list-style-type: none"> • Site runoff is captured via sediment control structures; water releases are EA-regulated. • Pit lakes are not predicted to connect hydrologically with surface systems.
Irrigation	Water for crops, pastures, parks, gardens.	Regionally applicable, particularly along the Isaac River; however: <ul style="list-style-type: none"> • Site runoff is captured on-site; releases are EA-regulated. • Pit lakes are not predicted to connect with surface systems.
Farm supply/use	General on-farm use (excluding drinking).	Applicable in the broader catchment area; however: <ul style="list-style-type: none"> • Local surface flows are ephemeral. • Site runoff is captured on-site; releases are EA-regulated. • Pit lakes are not predicted to connect with surface systems.
Stock water	Water for livestock.	Regionally relevant; however: <ul style="list-style-type: none"> • Site runoff is captured on-site. • Pit lakes are not predicted to connect with surface systems.
Human consumption of aquatic foods	Safe consumption of aquatic organisms.	Applies downstream; however: <ul style="list-style-type: none"> • Site runoff is captured on-site. • Pit lakes are not predicted to connect with surface systems.
Primary recreation	Direct water contact (e.g. swimming).	No known suitable waterbodies near DNM; regardless: <ul style="list-style-type: none"> • Site runoff is captured on-site. • Pit lakes are not predicted to connect with surface systems.
Secondary recreation	Secondary contact (e.g. boating).	
Visual recreation	Non-contact appreciation (e.g. bushwalking near creeks).	Regionally applicable; however: <ul style="list-style-type: none"> • Site runoff is captured on-site. • Pit lakes are not predicted to connect with surface systems. • Low potential for adverse visual or aesthetic impacts.

EV	Description	Applicability Related to Residual Voids
Drinking water	Source for potable use with minimal treatment.	Regionally applicable in the broader Fitzroy Basin; however: <ul style="list-style-type: none"> No potable surface water sources are located near DNM. Site runoff is captured on-site. Pit lakes are not predicted to connect with surface systems.
Industrial use	Water for processing or cooling.	May be relevant downstream; however: <ul style="list-style-type: none"> Site runoff is captured on-site. Pit lakes are not predicted to connect with surface systems.
Cultural and spiritual values	Cultural or historical significance.	Wetlands and riparian zones in the Isaac catchment may hold cultural significance; however: <ul style="list-style-type: none"> Site runoff is captured on-site. Pit lakes are not predicted to connect with surface systems.

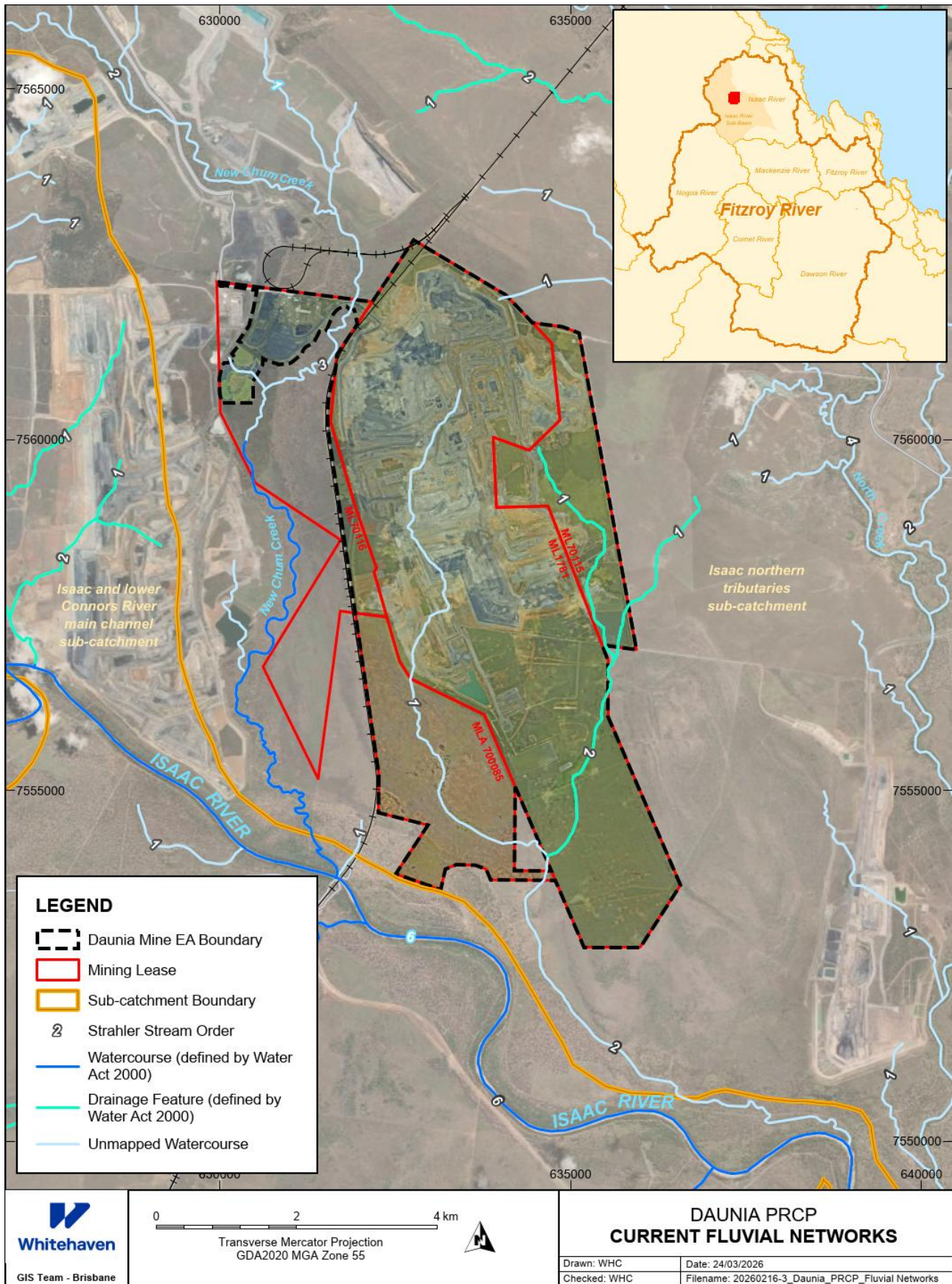


FIGURE 3-8 FLUVIAL NETWORKS AS OF 2025 (WHC, 2026)

4 GROUNDWATER

This section assesses how residual voids interact with groundwater systems post-mining, supporting the PRCP requirements to evaluate containment, recovery and risks to environmental values.

It includes groundwater modelling to determine whether each residual void will function as a sink (drawing in groundwater) or a source (discharging to the surrounding aquifer), and assess the implications for:

- *Groundwater flow paths and hydraulic gradients.*
- *Connectivity with surrounding aquifers and surface water systems.*
- *Potential for contaminant migration or dilution.*
- *Long-term changes in groundwater levels and quality.*

Groundwater assessments have been undertaken to evaluate the potential interactions between the DNM residual voids and the surrounding groundwater system, and to assess the potential for long-term contaminant transport (SLR, 2026).

A calibrated regional numerical groundwater model (BMA Bowen Basin MODFLOW-USG model) was developed to predict the relationships between the final closure landform and groundwater behaviour. The model incorporated the four proposed residual voids and associated spoil placements. The key objectives of the modelling were to confirm the following:

- That the final landform is non-polluting with respect to groundwater.
- Final voids are demonstrated to be sinks for groundwater, including groundwater contained within spoil.
- Final void lake levels remain below shallow groundwater-bearing units, i.e. sufficient freeboard exists to negate any risk of void water discharge to shallow groundwater.
- That there are minimal additional impacts to groundwater receptors post-closure caused by the final landform beyond those resulting from approved mining, including:
 - Little to no additional groundwater drawdown at potential GDE locations.
 - Little to no additional groundwater drawdown at existing private bore users.

The model was configured to commence at the projected end-of-mining date and simulate a 2,000-year post-closure period across 67 stress periods. The starting condition was defined using predicted groundwater levels at the end of mining.

To address climate variability, three climate scenarios were used: Wetter-R1, Mid-R4 and Drier-R6. These scenarios were based on results from the water balance modelling (refer to Section 5.3). The mid-climate scenario (Mid-R4) forms the basis of groundwater recovery predictions, while the wetter and drier cases were used for the sensitivity analyses.

Under the mid-climate scenario, the model predicts that long-term groundwater levels near the residual voids will stabilise below pre-mining groundwater elevations. This is due to continued discharge of groundwater into the void lakes, governed by lake water levels, thereby maintaining long-term inward hydraulic gradients to the voids (Figure 4-1).

Groundwater gradients are steepest northeast of the site near the Titan East residual void. Less steep gradients are seen near the Pandora void and north and west of the Titan North and Titan Central voids. Modelled drawdown associated with the residual voids extends approximately 1 km east of the mining lease boundary and remains confined within the RCM, with no predicted influence on the alluvial aquifer or off-site receptors.

Model results indicate that groundwater levels near the Isaac River and other potential GDE areas remain within natural pre-mining variability. Consequently, impacts to groundwater-dependent ecosystems and private bores are expected to be negligible under all modelled closure scenarios.

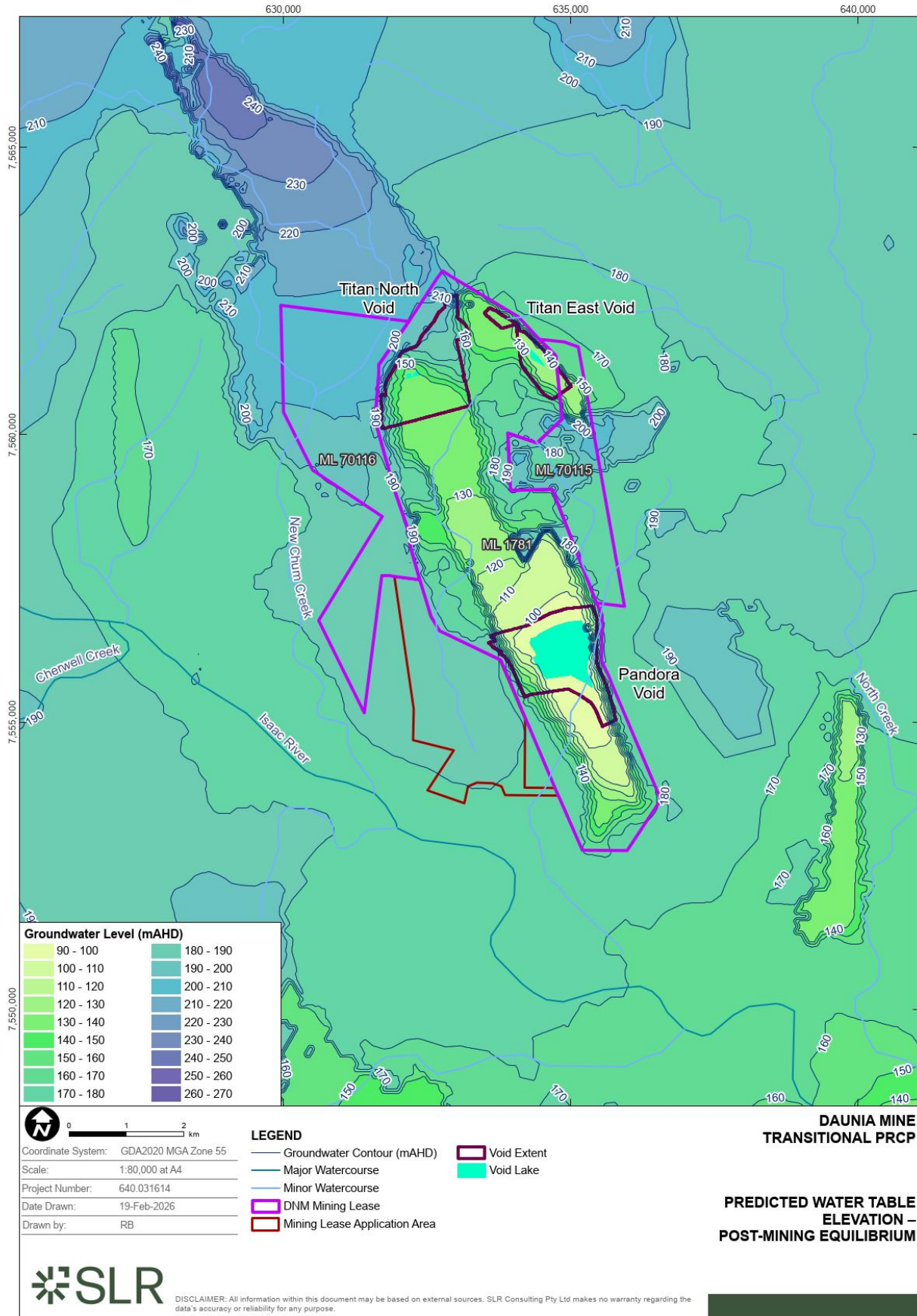


FIGURE 4-1 PREDICTED GROUNDWATER TABLE ELEVATION AT POST-MINING EQUILIBRIUM (SLR, 2026)

4.1 POST-MINING RECOVERY AND FLUX DYNAMICS

The groundwater recovery model (SLR, 2026) simulates post-mining inflows and outflows between the residual voids and the surrounding groundwater system over a 977-year period. Recovery stress periods commenced following the end of mining at DNM in 2041 and were simulated over 977 years to 3019 using 125 model stress periods of variable duration to represent long-term system recovery.

Predicted groundwater inflows exhibit temporal variability across all residual voids during the early recovery phase. Short-term flux reversals occur where residual spoil remains unsaturated immediately following mine dewatering. Modelled inflows and outflows are driven by differences between local groundwater recovery rates and the gradual filling of the residual voids via rainfall, runoff and infiltration.

Model results show that inflow and outflow behaviour differs between voids:

- At Titan North, early outflow from the void to adjacent backfilled spoil is predicted, with stabilisation after approximately 220 years.
- All outflows occur through backfilled spoil, and none extend to natural geological formations.
- At Titan East and Pandora, inflows from spoil dominate throughout the recovery period, stabilising after ~220 years.

Model results indicate 99% of the long-term inflows to the voids are from the backfilled spoil, originating as mainly as local recharge applied to the spoil. The groundwater inflow rates developed by SLR (2026) were used in the development of the void water balance model (WRM, 2026b). Section 7.5.2 of SLR (2026) outlines the iterative modelling approach undertaken to achieve agreement between the SLR groundwater recovery model and the void water balance model. Overall, groundwater recovery is characterised by slow re-establishment of heads within the Rangal Coal Measures and negligible hydraulic connection to shallow systems. The residual voids ultimately stabilise as permanent groundwater sinks governed by lake level elevations and ongoing evaporative loss.

4.2 GROUNDWATER CONTAINMENT AND FLOW PATHWAYS

Modelled groundwater levels in the Leichhardt and Vermont seams indicate that post-mining recovery remains incomplete over the 977-year simulation, with the water table persistently depressed relative to pre-mining conditions and controlled by residual void lake levels. Long-term inward gradients toward the residual voids are maintained, with the steepest gradients occurring near Titan East and shallower gradients around Titan North and Pandora.

Flow path simulations undertaken using the mod-PATH3DU code (S.S. Papadopoulos & Associates, Inc., 2018) displayed in Figure 4-2 show that the majority of particles originating within or adjacent to the voids move progressively toward deeper model layers representing the Permian coal measures or backfilled spoil, ultimately converging at the void lakes. The particle tracking results indicate the following:

- Particles originating within or adjacent to the residual voids migrate toward the void lakes and remain captured for the duration of the simulation, confirming hydraulic containment.
- Particles released within the voids themselves remain within the void lakes for the duration of the simulation.

- Particles released from shallow saturated zones at the Mine Infrastructure Area (MIA) on the north-western side of DNM generally show limited movement, migrating southwards within the DNM footprint. Some particles located within the MIA to the west-northwest of Titan North are not captured within the final landform during the simulation and migrate southwards approximately 2 km over the simulation period, marginally leaving the DNM. This behaviour is attributed to hydraulic influence from the adjacent Poitrel Mine represented within the groundwater model.
- A clear groundwater divide is predicted beneath the OOPD (Figure 4-2):
- Particles released from the eastern 65% of the OOPD footprint migrate eastwards and are captured by the Pandora residual void.
- Particles along the western margin of the OOPD initially move away from the Pandora residual void while travelling through shallow model layers before descending into deeper Permian units. Most particles subsequently turn eastwards, or south then eastwards, and are captured by the Pandora residual void.
- Three particles on the western margin of the OOPD continue to move south and away from DNM over the simulation period. These particles move to the deeper Permian strata and are not predicted to impact the shallow groundwater system.

Particles entering the voids remain captured for the duration of the simulation, confirming hydraulic containment.

These results confirm that the residual voids at DNM will act as long-term groundwater sinks. Predicted outflows during early recovery are temporary and restricted to adjacent backfilled spoil. Once groundwater levels stabilise, inflows to the voids dominate, limiting off-site migration of water or solutes to the deeper Permian strata from a small area along the western margin of the OOPD.

Predictive hydrographs for the Permian Coal Measures (Figure 4-3, Figure 4-4, Figure 4-5 and Figure 4-6) show the relationship between residual void lake levels and groundwater levels in the Leichhardt and Vermont seams adjacent to each residual void.

Groundwater levels recover gradually after mining but remain below pre-mining elevations. Void lake levels stabilise early and stay lower than surrounding groundwater levels, confirming that all residual voids act as long-term groundwater sinks.

Across Titan North, Titan East and Pandora (East and West), groundwater recovery occurs within the first 50-100 years, after which stable inward gradients are maintained and groundwater-void interactions remain confined to the mine footprint.

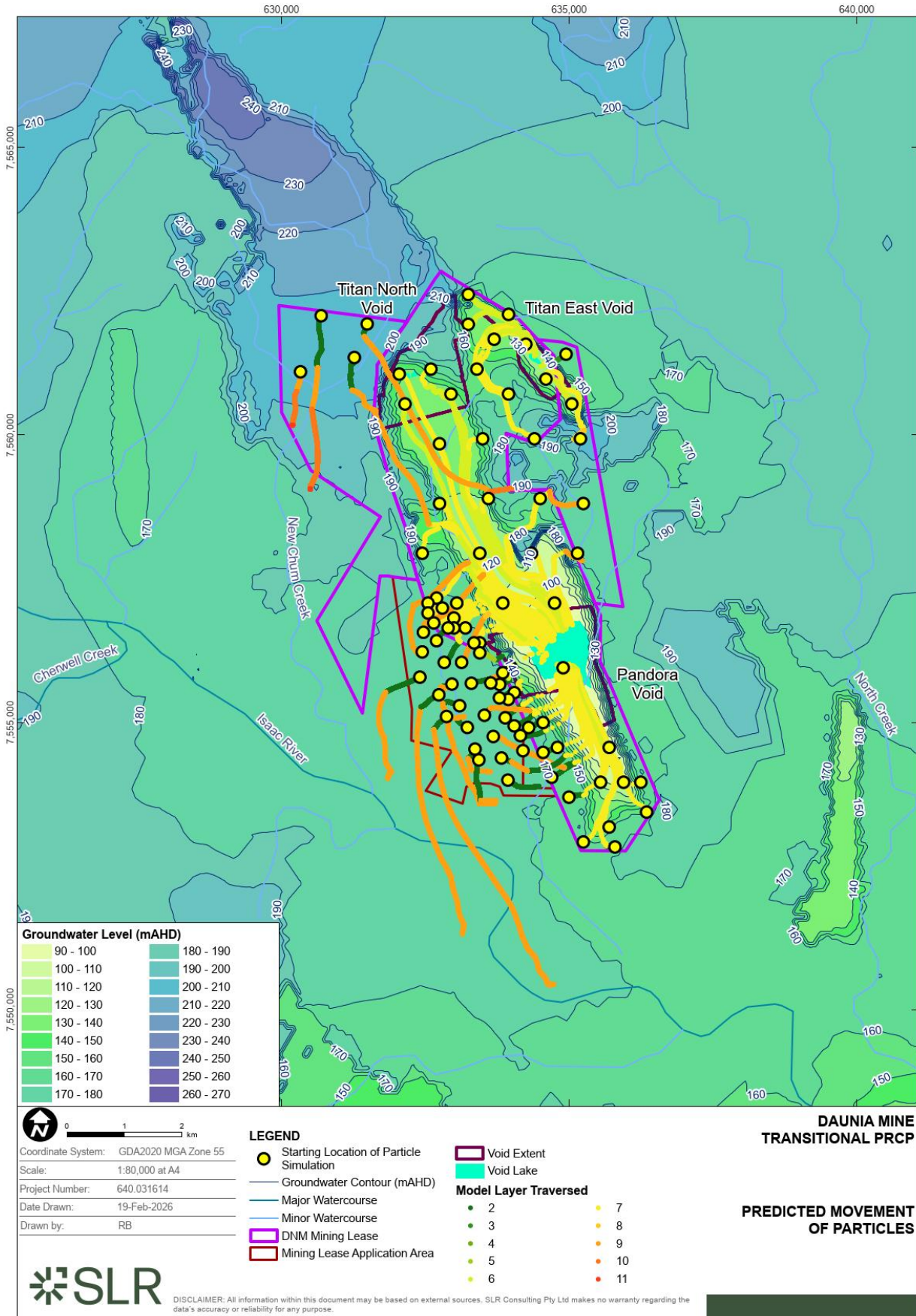


FIGURE 4-2 PREDICTED MOVEMENT OF PARTICLES (SLR, 2026)

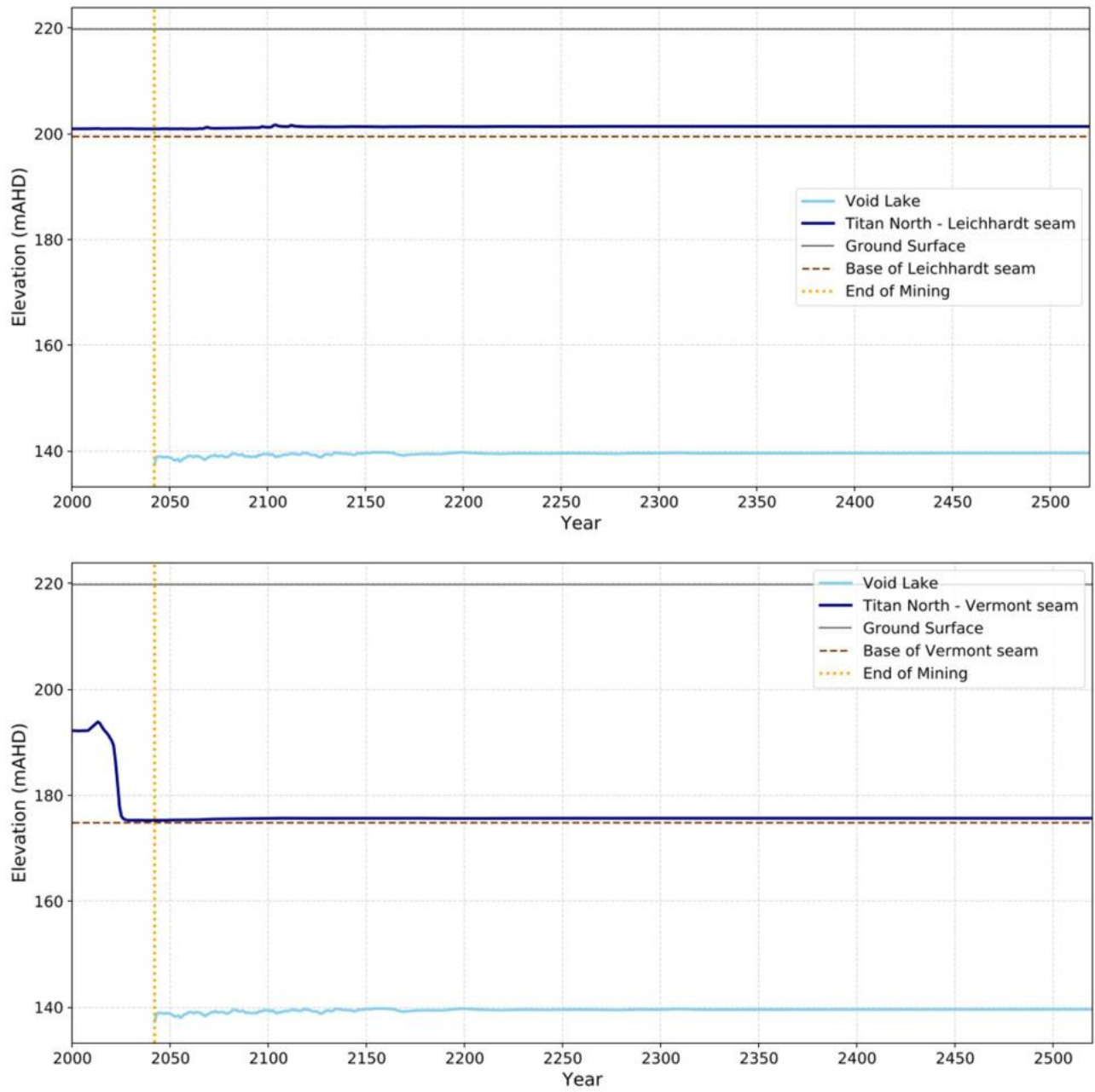


FIGURE 4-3 PERMIAN COAL MEASURES PREDICTIVE HYDROGRAPHS ADJACENT TITAN NORTH (SLR, 2026)

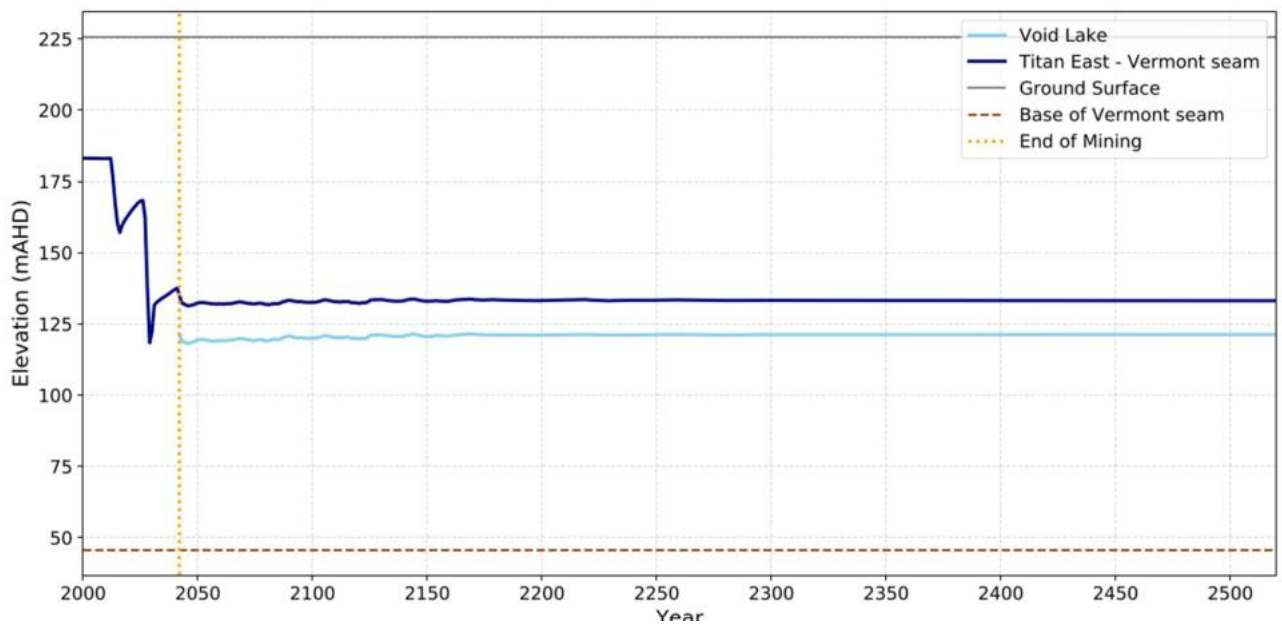
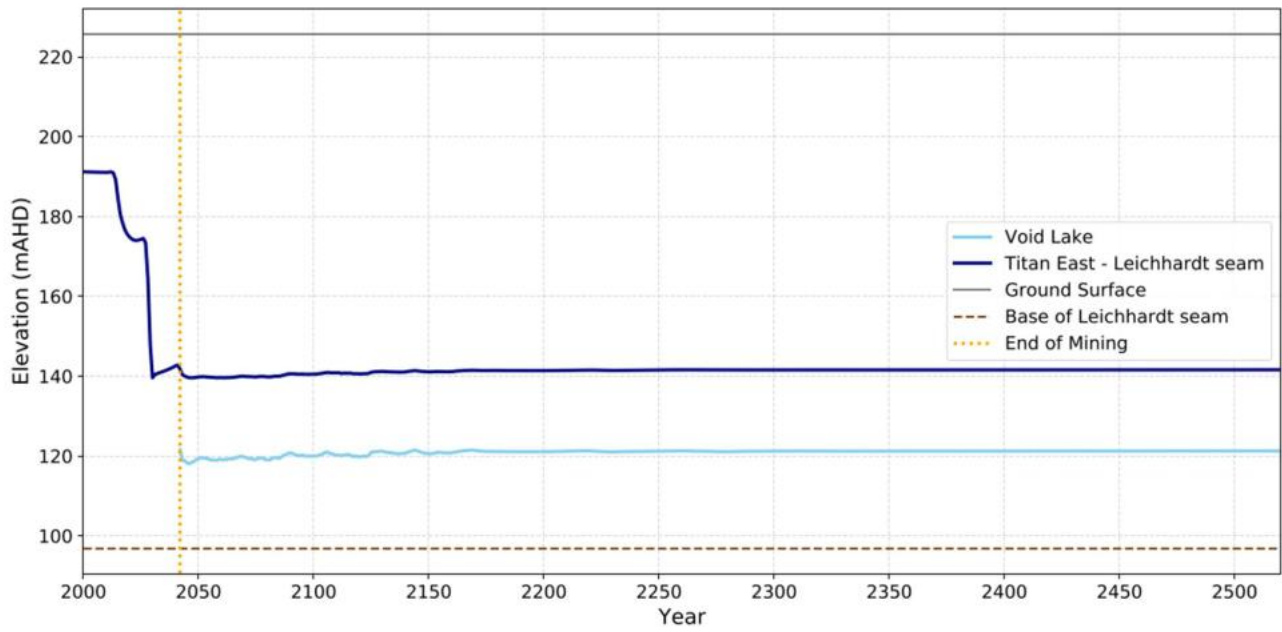


FIGURE 4-4 PERMIAN COAL MEASURES PREDICTIVE HYDROGRAPHS ADJACENT TITAN EAST (SLR, 2026)

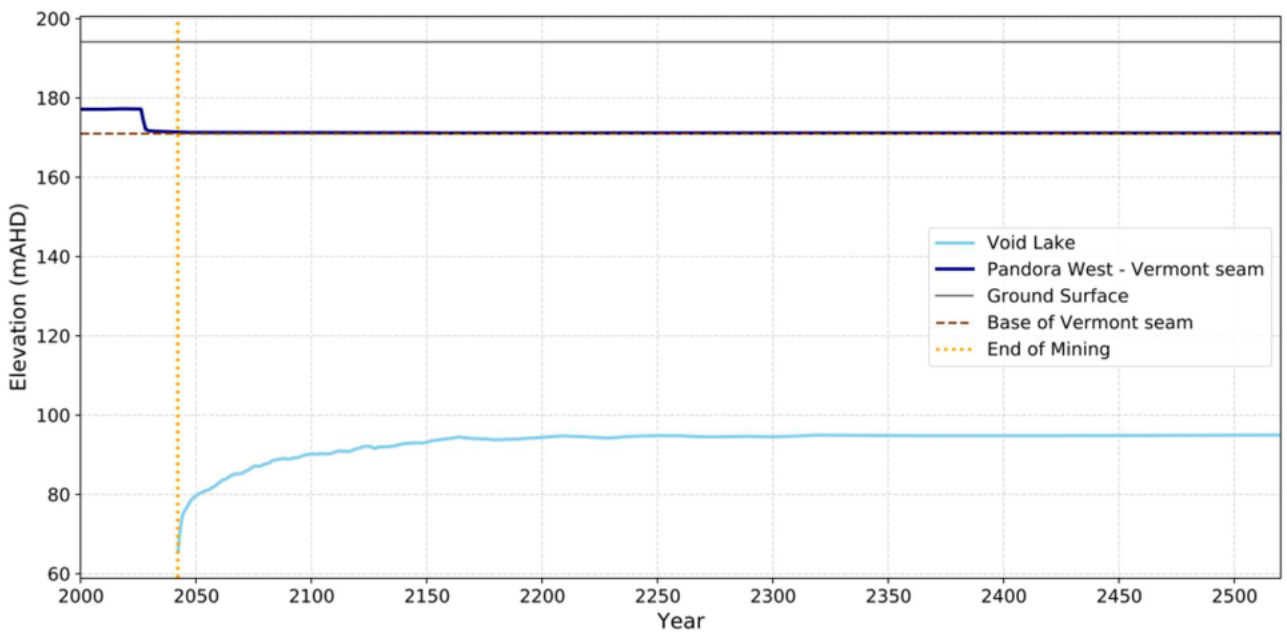
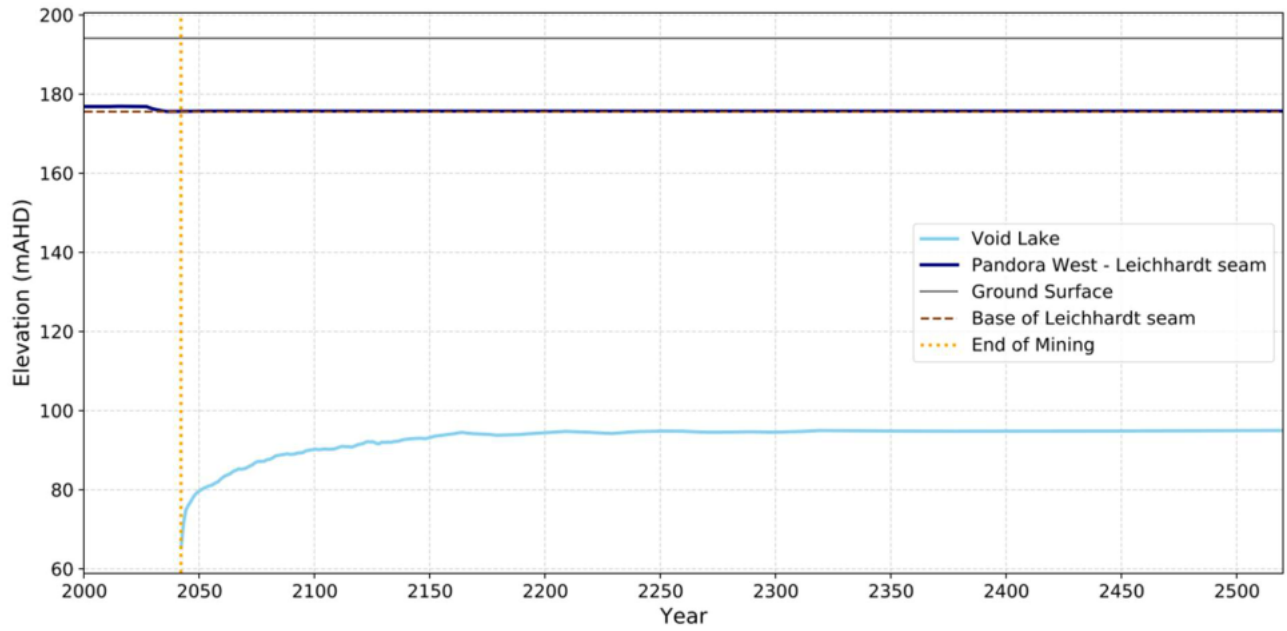


FIGURE 4-5 PERMIAN COAL MEASURES PREDICTIVE HYDROGRAPHS ADJACENT PANDORA (WEST) (SLR, 2026)

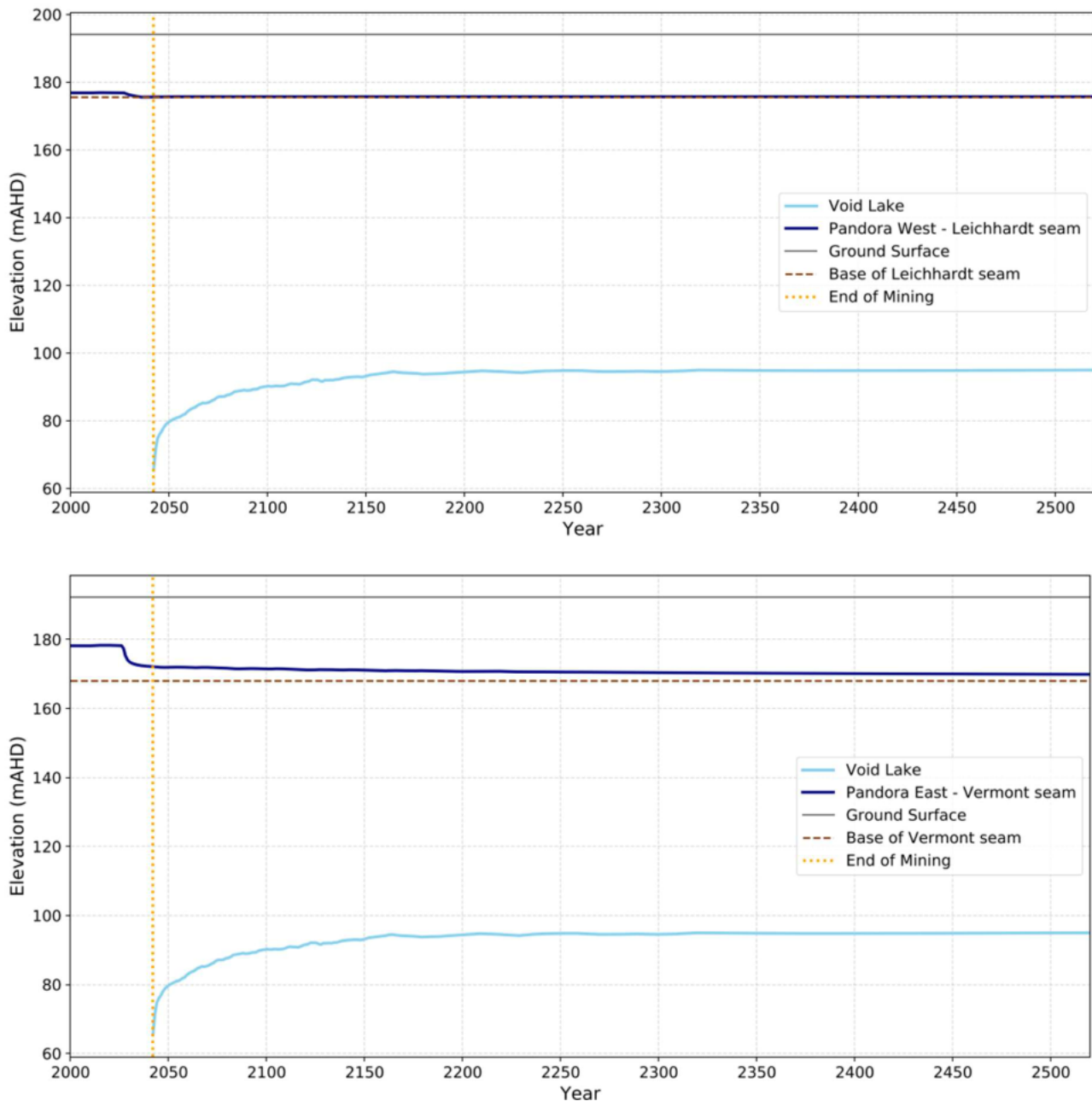


FIGURE 4-6 PERMIAN COAL MEASURES PREDICTIVE HYDROGRAPHS ADJACENT PANDORA (EAST) (SLR, 2026)

4.2.1 TITAN NORTH AND TITAN CENTRAL REPRESENTATION IN GROUNDWATER MODELLING

The regional groundwater model (BMA Bowen Basin MODFLOW-USG model) used to support closure assessments in SLR (2026) was configured with a model cell size and layering scheme appropriate for regional-scale simulations. Within this framework, the Titan North and Titan Central voids were represented as a single hydraulic feature due to their close spatial proximity and hydraulic connectivity at the post-mining landform scale. The combined representation was adopted to ensure numerical stability and to allow consistent simulation of groundwater flow and storage behaviour within the broader Rangal Coal Measures domain.

Although the model geometry depicts a single water body in the Titan North/Central area, the closure design distinguishes these as two physically separate voids with individual catchments,

pit geometries and surface water inflow characteristics. The joint representation in the model therefore reflects a conservative simplification for groundwater behaviour, in which the combined void is assumed to operate under a shared hydraulic head. This configuration is conservative because it assumes hydraulic connectivity between the two voids, increasing predicted groundwater inflow and drawdown extent compared to modelling them separately, thereby ensuring the assessment remains precautionary and protective.

This approach does not materially affect the predicted post-closure groundwater regime for the following reasons:

- Groundwater levels within the Rangal Coal Measures are predicted to equilibrate below the base of both Titan North and Titan Central, indicating long-term hydraulic containment of the voids and the absence of any potential for groundwater exchange with the surrounding system.
- The difference in final pit floor elevations between Titan North and Titan Central is small relative to the regional groundwater gradient, such that both are predicted to act as hydraulic sinks throughout recovery.
- Modelled equilibrium lake levels are controlled primarily by local water balance inputs (groundwater inflow, rainfall, evaporation, runoff) rather than inter-void exchange.

Given the hydraulic separation of spoil masses and the limited permeability of intervening materials, no significant interconnection or differential groundwater mounding is expected between the two voids under closure conditions.

Accordingly, the single-void representation in the groundwater model provides an appropriate and conservative approximation of post-closure groundwater-void interactions at Titan North and Titan Central.

4.3 IMPACT ASSESSMENT

A predictive assessment of post-mining groundwater levels and drawdown was undertaken by SLR (2026). The assessment evaluated potential impacts to registered third-party bores and groundwater behaviour under long-term closure conditions, including the presence of the Titan North, Titan East and Pandora residual voids.

The predicted drawdown is confined to the Rangal and Fort Cooper Coal Measures in the immediate DNM mining area (ref. Section 4.2). Drawdown does not extend into shallow alluvial systems or surface water–groundwater interaction zones. Groundwater responses in all bores reflect recovery from historical dewatering rather than new effects from the final landform.

Post-mining groundwater levels remain below pre-mining conditions but stabilise progressively through the 977-year simulation. Long-term inflows to residual voids are balanced by evaporation, maintaining inward hydraulic gradients. These conditions prevent lateral migration of water or solutes beyond the mine footprint.

Residual void lakes at Titan North, Titan East and Pandora are predicted to stabilise below the regional groundwater table and act as long-term groundwater sinks. Residual drawdown within the Permian coal measures reflects historical mine dewatering rather than effects of the final landform.

4.3.1 SEEPAGE FROM THE OUT OF PIT DUMP

The majority of seepage generated from the OOPD is predicted to migrate toward and be captured by the adjacent Pandora residual void due to a strong inward hydraulic gradient. However, seepage from the western margin of the OOPD is predicted to descend into the Permian coal measures and migrate south and away from the DNM residual voids.

The permeable nature of waste rock within the OOPD may result in higher infiltration rates and minor groundwater mounding beneath the dump. Groundwater flow is nevertheless predicted to be directed predominantly toward the Pandora void, with only limited migration to the west and south controlled by the groundwater divide beneath the OOPD (Figure 3-3).

Waste rock geochemical characterisation (MWM, 2026) indicates spoil is overwhelmingly non-acid forming (NAF) with negligible risk of acid and metalliferous drainage (AMD). Leachability testing returned concentrations within the Water Quality Objectives (WQO) for Isaac Groundwaters (Zone 34), indicating low risk to groundwater quality. Mixed Plant Rejects will not be disposed of in the OOPD.

Groundwater potentially migrating from the western margin of the OOPD is predicted to remain within deeper Permian coal measures and not expected to enter the shallow Quaternary-Tertiary sediments of the Isaac River alluvial aquifer. Consequently, off-site groundwater movement at depth is not expected to affect shallow groundwater users or riparian ecosystems.

4.3.2 IMPACTS TO GROUNDWATER-DEPENDENT ECOSYSTEMS

Predictive hydrographs for potential GDE sites in SLR (2026) indicate up to 11 m of additional post-mining drawdown along the Isaac River (maximum at GDE4) and up to 3 m along North Creek (maximum at GDE5), with the latter response primarily influenced by the adjacent Moorvale South Project. Upstream North Creek sites (GDE8-GDE10) remain unsaturated before and after mining, confirming no groundwater availability to support vegetation.

Given that groundwater depths along the Isaac River and North Creek exceed 10 m, vegetation is not expected to rely on groundwater discharge for survival. The modelled drawdowns are consistent with the approved mining footprint and do not represent new or additional impacts attributable to the final landform. Consequently, no adverse effects on potential groundwater-dependent ecosystems are expected under any climate scenario.

4.3.3 OVERALL IMPACT ASSESSMENT

The groundwater modelling results by SLR (2026) indicate that the final landform configuration is not expected to cause any new or unacceptable groundwater impacts. Predicted hydraulic behaviour of the residual voids, surrounding spoil and regional aquifers is consistent with the closure objectives established for DNM.

Residual void lake levels are predicted to stabilise below pre-mining groundwater elevations and beneath all shallow post-Permian strata under all climate scenarios (Wetter-R1, Mid-R4 and Drier-R6). This confirms that no upward hydraulic connection will form between the voids and shallow groundwater systems such as the alluvium or regolith. Consequently, there is no pathway for interaction between the residual void lakes and surface water or near-surface ecosystems.

Within the Rangal Coal Measures, residual drawdown reflects the historical dewatering footprint of the approved mining operation. Ongoing evaporative loss from the residual void lakes maintains inward hydraulic gradients in the long term, ensuring groundwater and seepage inflows remain largely contained within the final landform.

With the exception of seepage generated from the western margin of the OOPD, the DNM residual voids will capture seepage from surrounding spoil emplacements, reinforcing hydraulic containment. Groundwater beneath the MIA may remain partially influenced by the adjacent Poitrel Mine, although this influence is localised and unrelated to the final landform design. Limited seepage from the western margin of the OOPD may migrate towards within deeper Permian coal measures and away from the Pandora residual void; however, this groundwater remains at depth and does not interact with shallow groundwater receptors.

Predicted drawdown and recovery trends confirm that post-mining impacts are minor and restricted to the Permian coal measures. Groundwater levels progressively stabilise during the 977-year simulation, with no influence on surficial aquifers, environmental receptors or third-party bores. At external receptors, predicted drawdown ranges from negligible to approximately 8 m, remaining within the expected envelope of residual mining effects.

Overall, the post-mining groundwater regime is largely hydrologically contained and stable. Residual voids act as long-term groundwater sinks under all simulated climate scenarios. The final landform is therefore assessed to have no significant residual impact on environmental or anthropogenic receptors and is hydrogeologically suitable for the intended post-mining land uses.

5 FLOODING ASSESSMENT

This section evaluates flood risk to residual voids under current and future climate conditions. It aims to ensure voids are protected from inundation, in line with PRCP Guideline sections 3.4 and 3.6.3.

In accordance with the Mined Land Rehabilitation Policy and relevant provisions of the EP Act and EP Regulation, the assessment must demonstrate that residual voids are not located within flood plains, or if they are, that they will be rehabilitated to a stable, safe, and sustainable condition.

The flood plain modelling must:

- *Be undertaken in accordance with Australian Rainfall and Runoff (2019) (ARR) guidelines.*
- *Exclude artificial features within the tenure boundary.*
- *Include hydrologic and hydraulic modelling, calibration, sensitivity analysis and spatial mapping.*
- *Identify all relevant watercourses, diversions and potential groundwater influences.*
- *Assess impacts of 0.1% AEP flood levels to determine floodplain extent.*

Where floodwaters may interact with voids or backfilled areas, assessments must consider:

- *Erosion risks and wall instability from floodwater ingress.*
- *The hydraulic properties of backfilled material.*
- *Design modifications required to maintain long-term stability.*

This section evaluates flood risk to the DNM residual voids under existing and post-mining conditions, based on the PRCP Flood Modelling Report prepared by WRM (2026a). The assessment confirms that the residual voids are not at risk of inundation from the Isaac River or local drainage systems under any modelled event, including the Probable Maximum Flood (PMF).

The flood assessment was undertaken using updated hydrologic and hydraulic models consistent with Australian Rainfall and Runoff (ARR, 2019) guidance. Hydrologic modelling was updated from the previous XP-RAFTS framework and converted to URBS, and the model was recalibrated and reconciled to an updated Flood Frequency Analysis (FFA) at the Deverill gauge incorporating five additional years of recorded flow data. Modelling was completed using the URBS rainfall-runoff and TUFLOW hydrodynamic software packages, incorporating the latest ARR climate-change factors to represent both present-day ('existing') and post-mining design hydrology and additional flow data recorded since 2019. The updated modelling assesses flooding for existing, pre-mining and post-mining scenarios and incorporates the proposed final landform ('version 3.1'), including the OOPD located west of ML1781.

5.1 VOIDS IN FLOODPLAINS

The location of the four (4) residual voids at DNM are not explicitly stated in EA EPML00561913. Therefore, in accordance with Section 3.4 of the DESI PRC Plan Guideline Transitional Provisions, an assessment of voids in floodplains has been completed.

Previous assessments presented in WSP (2023) were based on preliminary and outdated void extents. At the time, hydraulic modelling of the pre-mining landform indicated that the Pandora void intersects the Isaac River floodplain under the 0.1% AEP event. Since then, the location of the Pandora pit has moved further north, and it is no longer in a floodplain (WRM, 2026a). The Titan East, Titan Central and Titan North voids remain outside the 0.1% AEP and PMF extents.

For the final landform at DNM, void extents have been reduced and repositioned through landform reshaping and strategic placement of spoil dumps to reduce environmental risk and preclude surface water interactions from the flood plain.

5.2 FLOOD MODELLING OF FINAL LANDFORM

A TUFLOW hydrodynamic model was originally developed and calibrated by WRM (2019) to simulate flood behaviour in the Isaac River floodplain near DNM. The model was updated in WRM (2026a) to version 2025.0.0 (BMT, 2025) with enhanced modelling capabilities. The model was recalibrated using updated hydrologic inputs and applied to simulate the 0.1% AEP and PMF events under three scenarios:

- Existing conditions – Present-day hydrology and current topography at DNM (used to inform final landform planning).
- Pre-mining conditions (Figure 5-1) – Existing hydrology and pre-mining topography within DNM (used to define the PRCP floodplain).
- Post-mining conditions (Figure 5-2 and Figure 5-3) – Final landform and ultimate hydrology (used to assess residual void flood risk).

For each scenario, the model outputs included predicted flood extents, levels and depths in the DNM area.

In addition to the topographic data used in the WRM (2019) study, updated LiDAR data acquired on 22 January 2025 was provided for the DNM site. Review of the datasets indicated no material differences between the 2019 and 2025 LiDAR data within the Isaac River floodplain. Proposed final landform topographic data (Rev3.1.1) was also provided for DNM and forms the basis for the modelling assessment. Information on proposed final landforms for nearby mines was obtained from the relevant PRCPs, where available, and through data sharing agreements between proponents.

Climate change factors in Table 5-1 were obtained from the ARR Datahub portal (Geoscience Australia, 2024) for the existing and post-mining design scenarios. In line with ARR2019 guidance, uplift factors were applied to all design events, including Probable Maximum Precipitation (PMP) depths.

TABLE 5-1 ADOPTED CLIMATE CHANGE SCENARIO FACTORS

Scenario	Projected Temperature Change (°C)	Rainfall Depth Uplift Factor	IL Uplift Factor	CL Uplift Factor
Existing Conditions (Yr 2030, SSP5-8.5)	+1.3	1.11	1.03	1.05
Post-mining Conditions (Yr 2100, SSP2-4.5)	+2.5	1.41	1.05	1.10

IL = initial loss
CL = continuing loss
SSP = shared socioeconomic pathway

Source: WRM (2026a)

To specifically assess post-mining landform flood risk, results were summarised in terms of predicted peak flood levels, velocities and available freeboard relative to the proposed final landform elevations (Table 5-2).

TABLE 5-2 PREDICTED FLOOD LEVELS, VELOCITIES AND FREEBOARD FOR THE POST-MINING LANDFORM

Event	Post-Mining Landform Elevation ¹	Peak Flood Level	Peak Flood Velocity	Freeboard ²
<i>Unit</i>	<i>mAHD</i>	<i>mAHD</i>	<i>m/s</i>	<i>m</i>
Flood protection landform				
0.1% AEP	200	192.8	0.4	>7
PMF	200	196.5	1.1	3.5
OOPD				
0.1% AEP	240	194.2	1.7	N/A
PMF	240	198.4	3.2 ³	N/A

Notes:
¹ Minimum proposed final landform level at locations with predicted adjacent Isaac River flooding.
² Indicative minimum available freeboard.
³ Localised high velocity near southwestern corner of the OOPD. Elsewhere in this area, velocities generally reach between 2.1-2.8 m/s at peak.

Source: WRM (2026a)

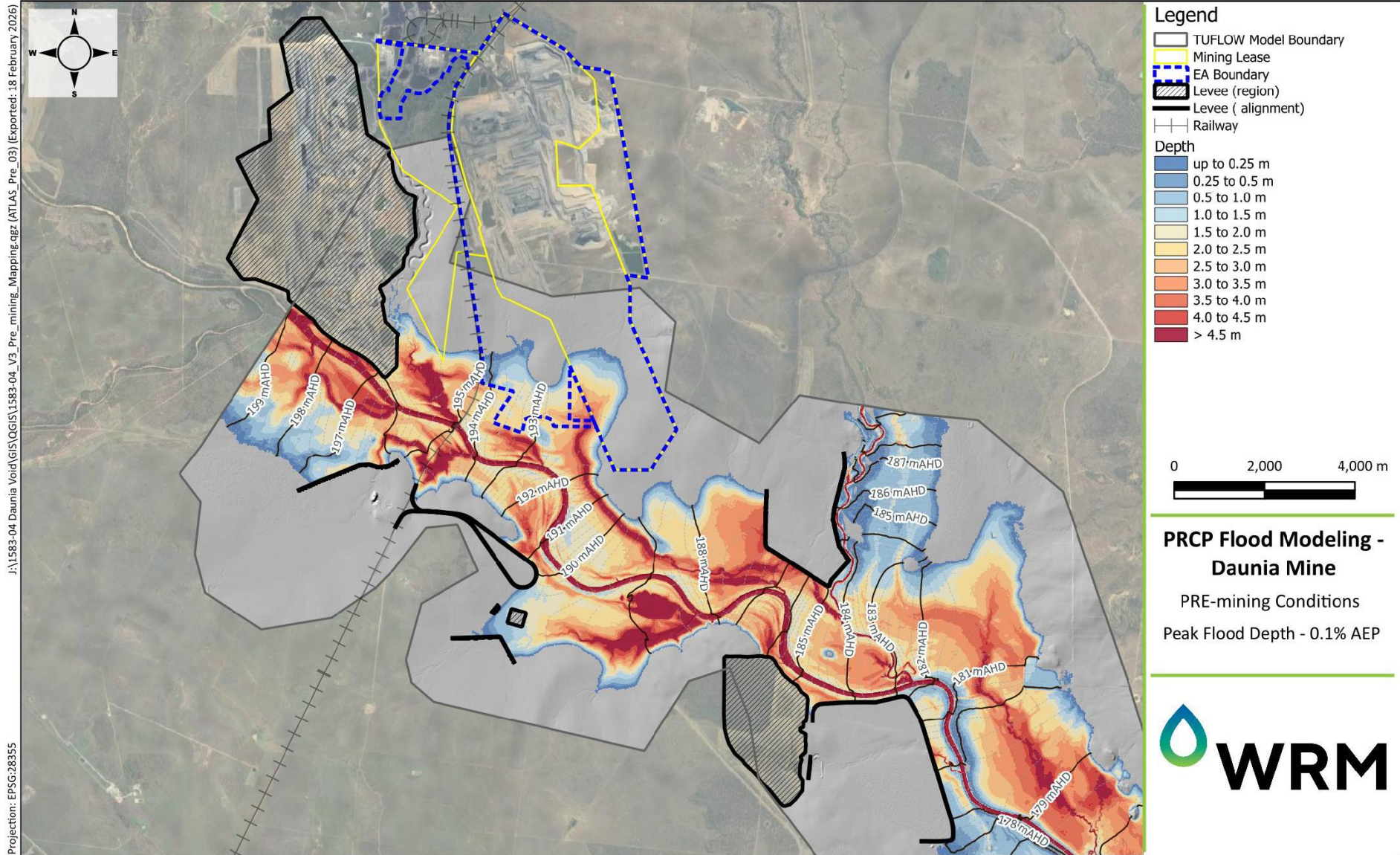


FIGURE 5-1 PEAK FLOOD DEPTH – PRE-MINING CONDITIONS 0.1% AEP (WRM, 2026A)

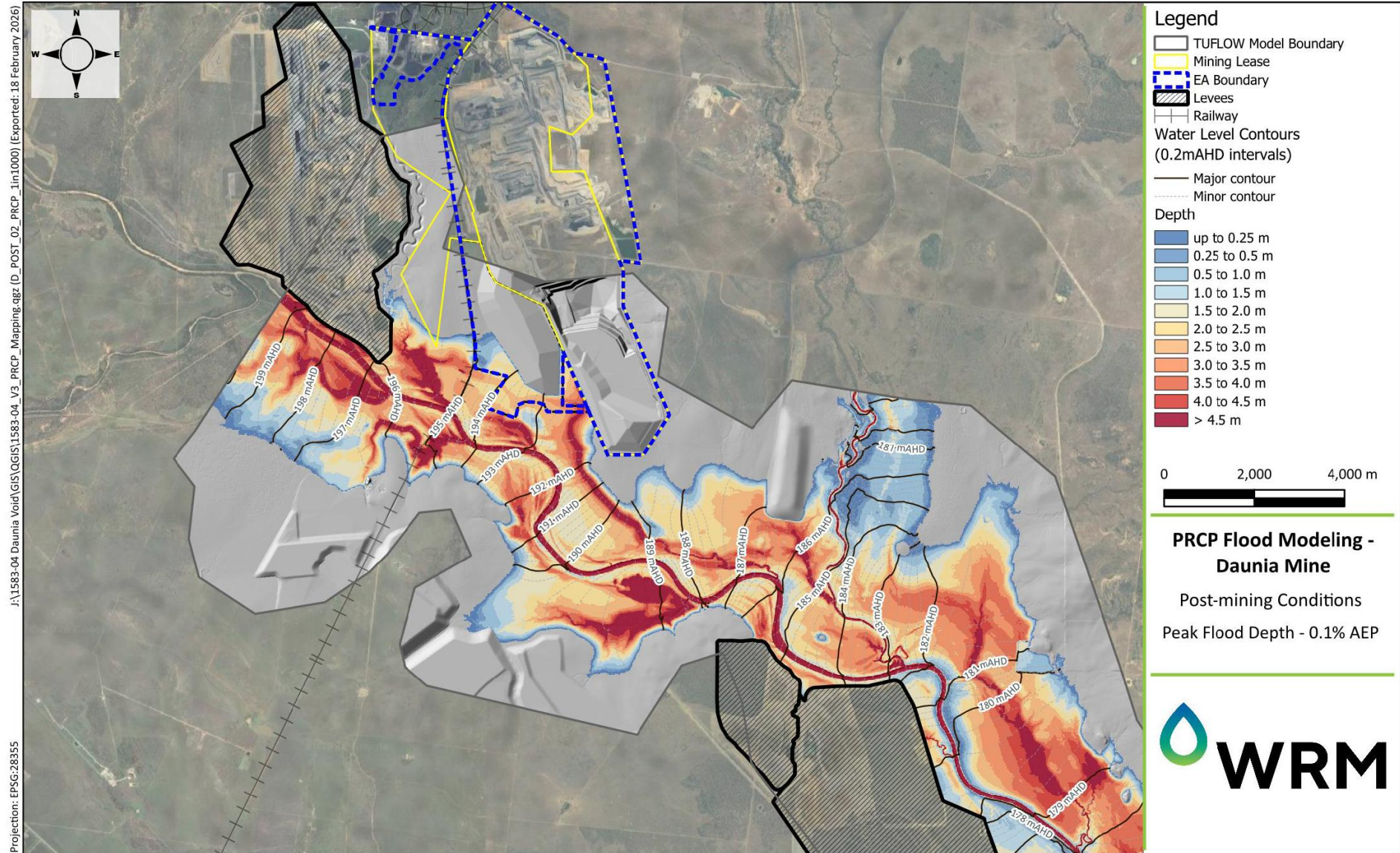


FIGURE 5-2 PEAK FLOOD DEPTH - POST MINING CONDITIONS 0.1% AEP EVENT (WRM, 2026A)

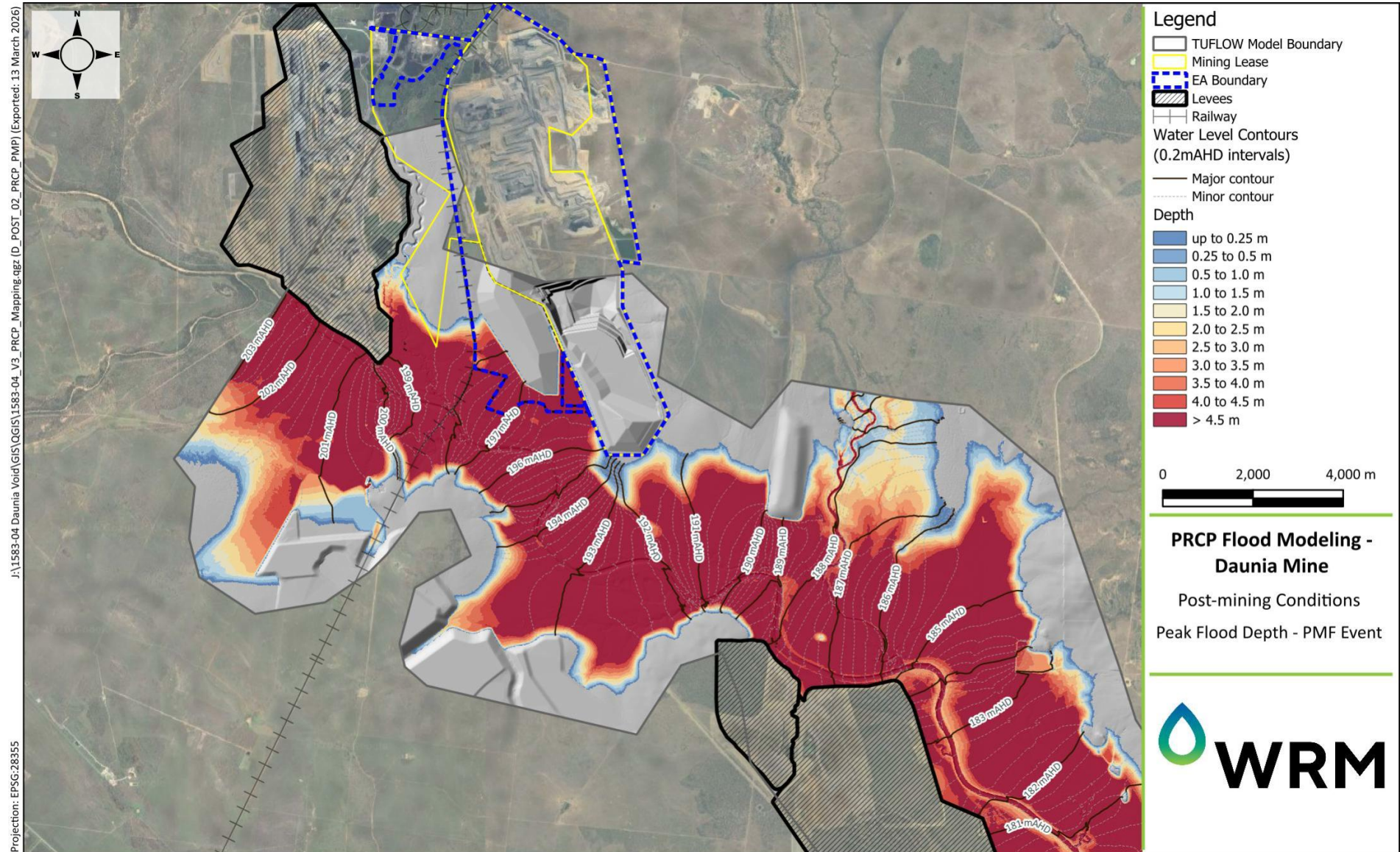


FIGURE 5-3 PEAK FLOOD DEPTH- POST-MINING CONDITIONS PMF EVENT (WRM, 2026A)

5.3 PANDORA HYDRAULIC ASSESSMENT

The updated flooding assessment results demonstrate that the Pandora residual void is entirely outside the Isaac River floodplain under both the 0.1% AEP and PMF events (Figure 5-2 and Figure 5-3). As the void is not hydraulically connected to the floodplain, no inundation, overtopping or flood-related erosion is expected.

5.4 PANDORA FLOOD PROTECTION AND FLOODPLAIN STATUS

Following refinement of the final landform and updated hydrologic and hydraulic modelling by WRM (2026a), the Pandora residual void is confirmed to be outside the 0.1% AEP floodplain. Earlier versions of the mine layout indicated partial intersection of the Isaac River floodplain; however, the revised post-mining topography places the void further north, above the modelled flood extent.

The updated TUFLOW model predicts peak flood levels of 193 mAHD (0.1% AEP) and 197 mAHD (PMF) adjacent to the Isaac River. The minimum crest elevation at Pandora is 200 mAHD, providing at least 7 m freeboard under the 0.1% AEP event and 3.5 m under the PMF.

Modelled flood velocities are low (0.6 m/s for 0.1% AEP; 1.3 m/s for PMF), indicating negligible potential for erosion or hydraulic instability of adjacent landforms.

No floodwater interaction with the Pandora void is predicted under any modelled event. Accordingly, there is no requirement for additional flood protection structures, and the closure configuration achieves full hydraulic separation between the Isaac River floodplain and the residual void.

5.5 CLIMATE CHANGE CONSIDERATIONS

As described above, climate-adjusted rainfall and loss parameters were incorporated into the WRM (2025) flood modelling in accordance with Australian Rainfall and Runoff (ARR, 2019) methodology.

The climate-adjusted simulations show only marginal increases in predicted flood levels and velocities. The minimum available freeboard to the Pandora crest remains ≥ 3 m under the PMF and ≥ 7 m under the 0.1% AEP event, confirming that the landform maintains full flood immunity under projected future climate conditions.

6 VOID WATER BALANCE

This section presents predicted long-term void water balance behaviour of the proposed residual voids. It also aims to support the assessment of geotechnical and geochemical stabilities over time.

As required under the PRCP framework, this section addresses:

- *Long-term water balance modelling results of inflows, outflows and equilibrium lake levels of the residual voids.*
- *Interactions with groundwater, including drawdown, hydraulic head reduction and potential cones of depression.*
- *Potential for stratification and connection to surrounding groundwater systems.*
- *Flooding and drainage behaviours of nearby surface waters, and potential void interactions.*
- *Conceptual water balance model incorporating all projected inflows, outflows and recharge rates.*
- *Assessment of each major water flux into and out of the voids.*
- *Identification of catchment surface water sources likely to influence void water quality.*

A water balance assessment was carried out by WRM (2026a) to evaluate the behaviour of the residual voids in their final closure state.

The assessment outcomes supported separate evaluations of the residual voids' geotechnical and geochemical stabilities over time, presented in Sections 7 and 8, respectively.

6.1 CONCEPTUALISATION

A WBM was developed for the DNM residual voids to predict long-term water level recovery and assess interactions with the surrounding aquifers. The model was constructed in GoldSim and incorporated the key hydrological processes influencing the void water balance. These processes include:

- Inflows:
 - Runoff from local catchments, including pit walls and rehabilitated spoil;
 - Seepage through backfilled spoil material;
 - Direct rainfall inputs; and
 - Groundwater inflows.
- Storage:
 - Water retained within the void; and
 - Temporary storage within backfilled spoil.
- Outflows:
 - Evaporation from the water surface; and
 - Discharge into backfilled spoil.

Two conceptual models of the void water balance have been developed, one representing an evaporative sink (Figure 6-1), and one representing a flow-through system (Figure 6-2)

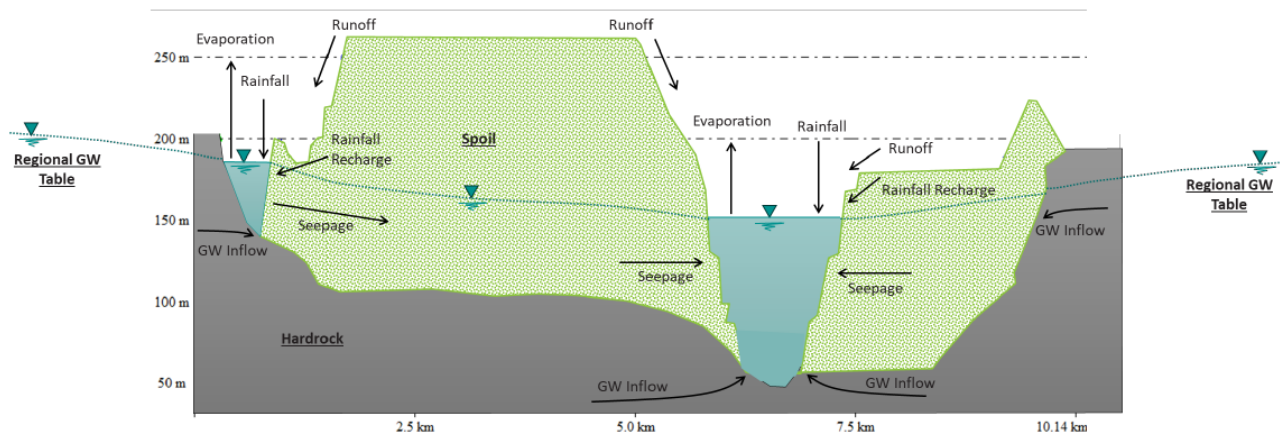


FIGURE 6-1 CONCEPTUAL VOID WATER BALANCE MODEL - INFLOW DOMINANT CONDITIONS (WRM, 2026a)

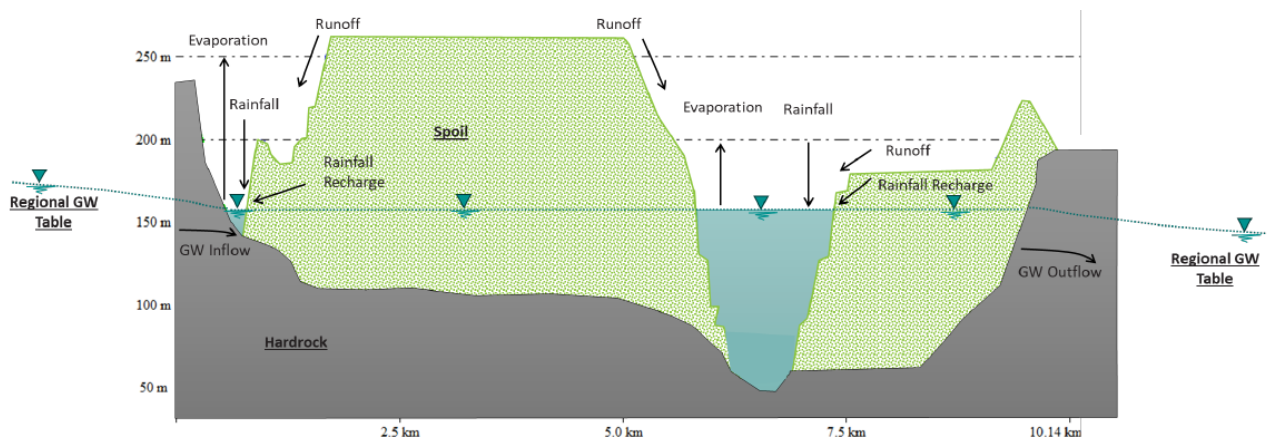


FIGURE 6-2 CONCEPTUAL VOID WATER BALANCE MODEL – FLOW-THROUGH CONDITIONS (WRM, 2026a)

6.2 MODEL SUMMARY

The WBM was developed to simulate daily water quantity and quality over a 500-year period. The simulation begins at closure year 1 in 2045 and includes 250 stochastic realisations.

6.2.1 CATCHMENT AREAS

The conceptual closure landform at DNM was designed to limit the area of catchment reporting to each void to primarily rehabilitated low wall areas. Using the final landform terrain, catchment areas were defined using spatial software and categorised based on PMLU type (Figure 6-3). The catchment types identified for each residual void is included in Table 6-1.

TABLE 6-1 RESIDUAL VOID CATCHMENT AREAS

Catchment Type	Titan North	Titan Central	Titan East	Pandora
Natural (ha)	0	0	0	0
Void (ha)	81.3	8.4	35.0	145.4
Rehabilitated (ha)	432.3	29.9	150.1	682.0
Total (ha)	513.6	38.3	185.1	827.4

Source: WRM (2026b)

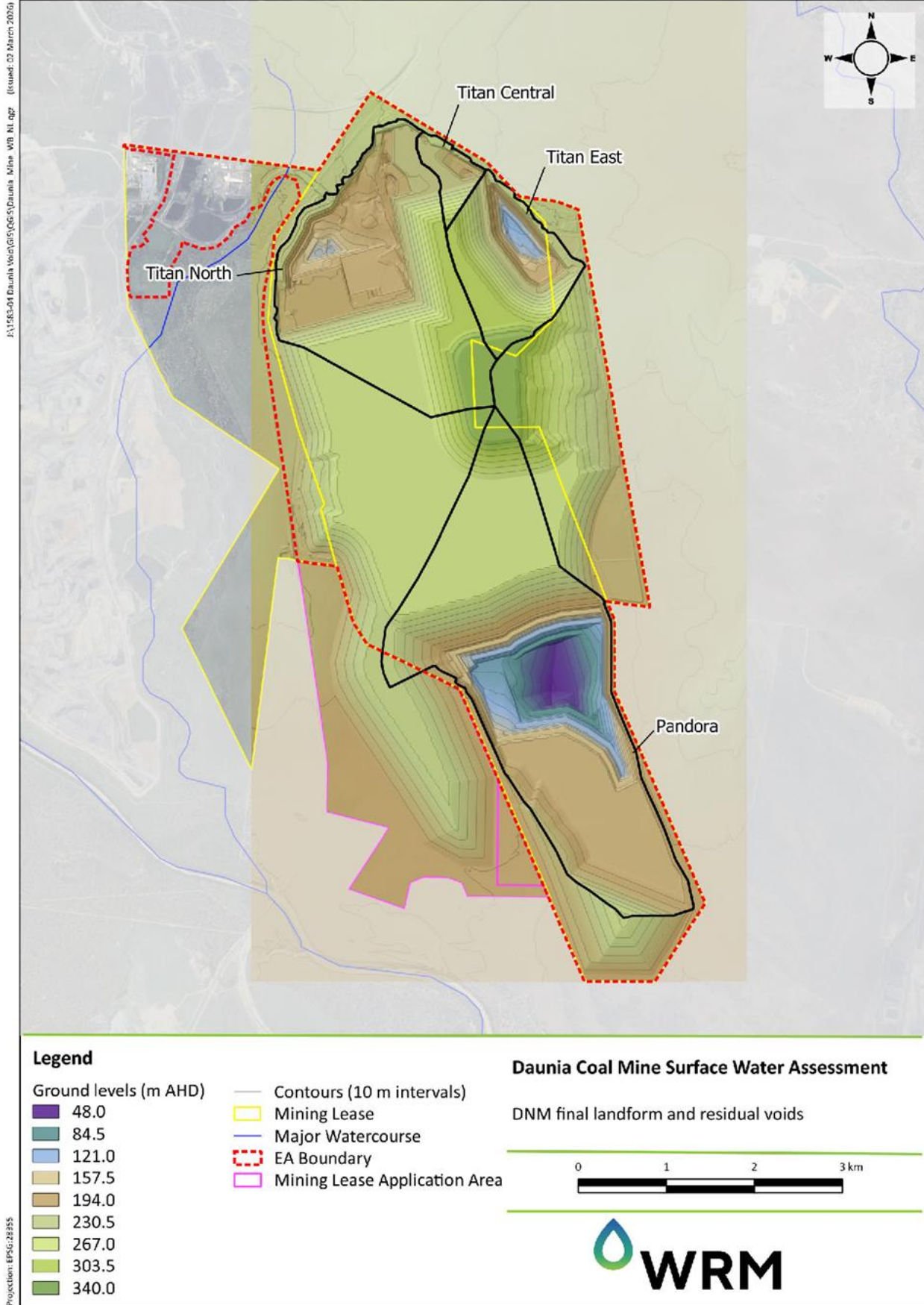


FIGURE 6-3 RESIDUAL VOID CATCHMENT AREAS (2026B)

6.2.2 CATCHMENT RUNOFF

The Australian Water Balance Model (AWBM) (Boughton, 2004) was used to estimate surface water runoff from rainfall for each catchment area. The model relates daily rainfall and evapotranspiration to runoff using a system of three surface storages with different capacities (small, medium, large). Projected climate data, including rainfall, temperature and evaporation, were sourced from the SILO database (DESI, 2024) and applied to the model. Storage capacities are presented in Table 6-2.

TABLE 6-2 AWBM SURFACE STORAGE CAPACITIES AND PROPORTIONS

Land-Use Type	Small		Medium		Large	
	Capacity (mm)	Proportion	Capacity (mm)	Proportion	Capacity (mm)	Proportion
Natural	30	0.134	180	0.433	250	0.433
Void	10	0.3	40	0.4	75	0.3
Spoil	20	0.134	120	0.433	180	0.433
Rehabilitated	20	0.134	110	0.433	170	0.433

Source: WRM (2026b)

The AWBM baseflow and channel parameters for the different land-use types at DNM are in Table 6-3. The baseflow index represents the proportion of total streamflow that is contributed by groundwater or subsurface flow, as opposed to direct surface runoff. A higher baseflow index indicates a greater contribution from slow, sustained groundwater inputs.

The channel coefficient defines the rate at which water moves through the channel network. It influences how quickly surface runoff is routed to the outlet, with higher values indicating faster movement.

The baseflow coefficient determines the rate at which groundwater contributes to baseflow. It controls how rapidly groundwater is released to the stream, affecting the persistence of flow during dry periods.

The model operates on a daily timestep and does not account for high-intensity, short-duration rainfall events, as all surface runoff is represented as daily averages.

TABLE 6-3 WBM BASEFLOW AND CHANNEL PARAMETERS OF THE LAND-USE AREAS

Land-Use Area	Baseflow Index	Baseflow Coefficient (1/day)	Channel Coefficient (1/day)
Natural	0	0	0
Void	0	0	0
Spoil	0.35	0.7	0
Rehabilitated	0.8	0.7	0

Source: WRM (2026b)

6.2.3 STAGE, AREA AND VOLUME

The stage-storage relationships for each residual void, linking void volume, surface area, and elevation, were derived from the final landform topography. These relationships are shown in Figure 6-4, Figure 6-5, Figure 6-6 and Figure 6-7.

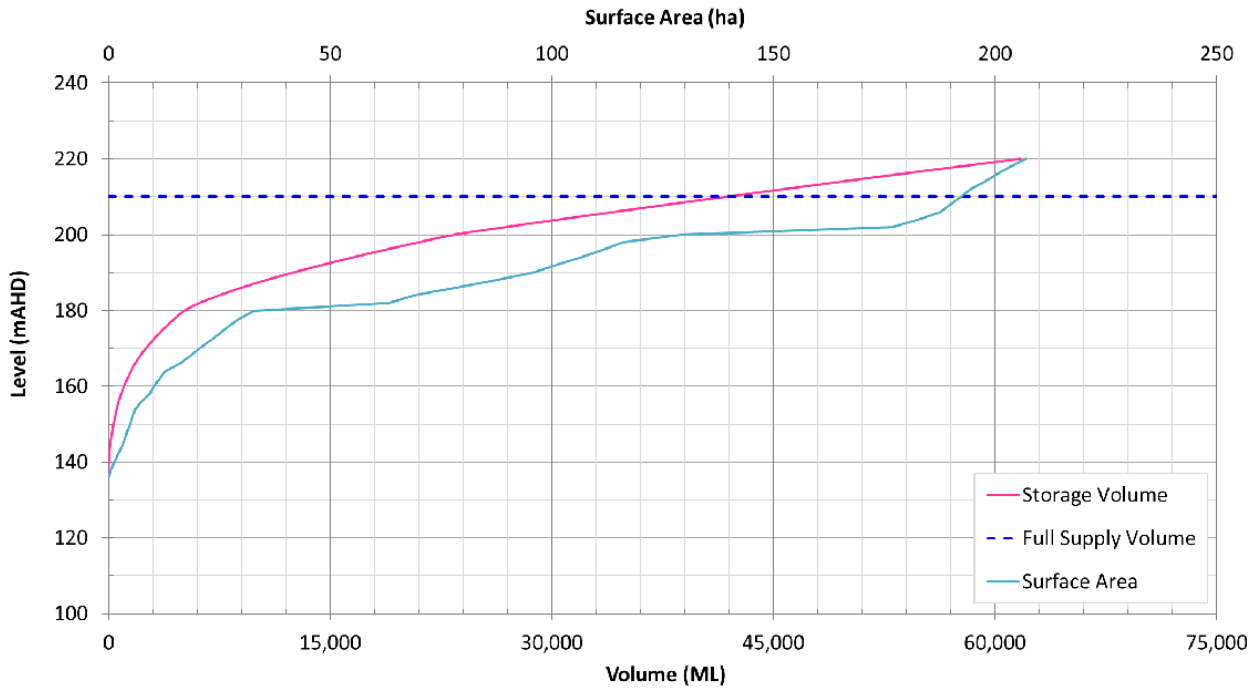


FIGURE 6-4 TITAN NORTH STAGE-STORAGE RELATIONSHIP (WRM, 2026B)

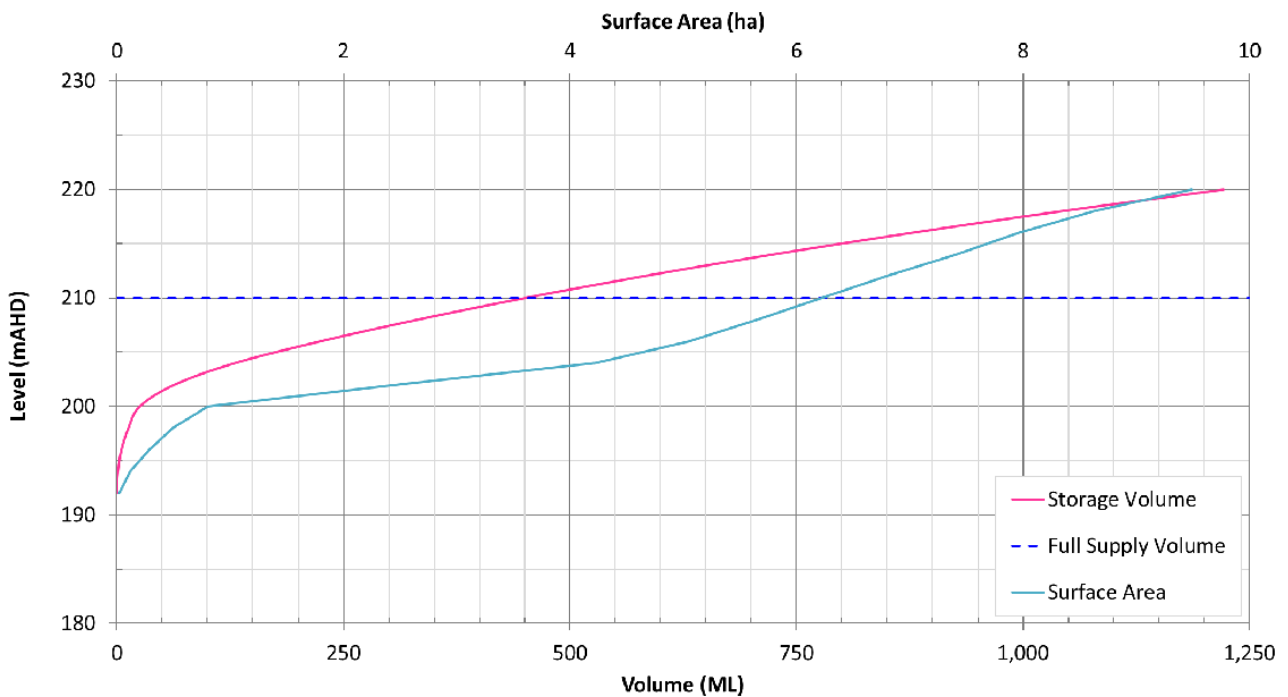


FIGURE 6-5 TITAN CENTRAL STAGE-STORAGE RELATIONSHIP (WRM, 2026B)

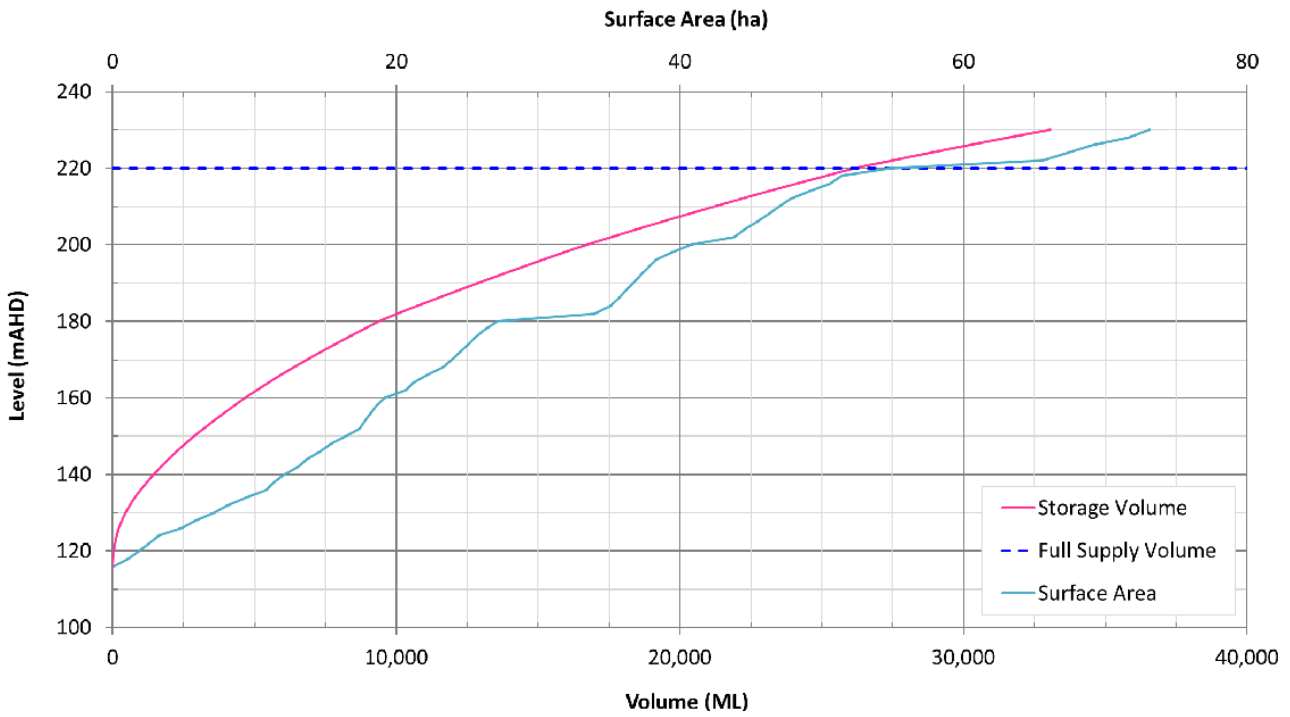


FIGURE 6-6 TITAN EAST STAGE-STORAGE RELATIONSHIP (WRM, 2026B)

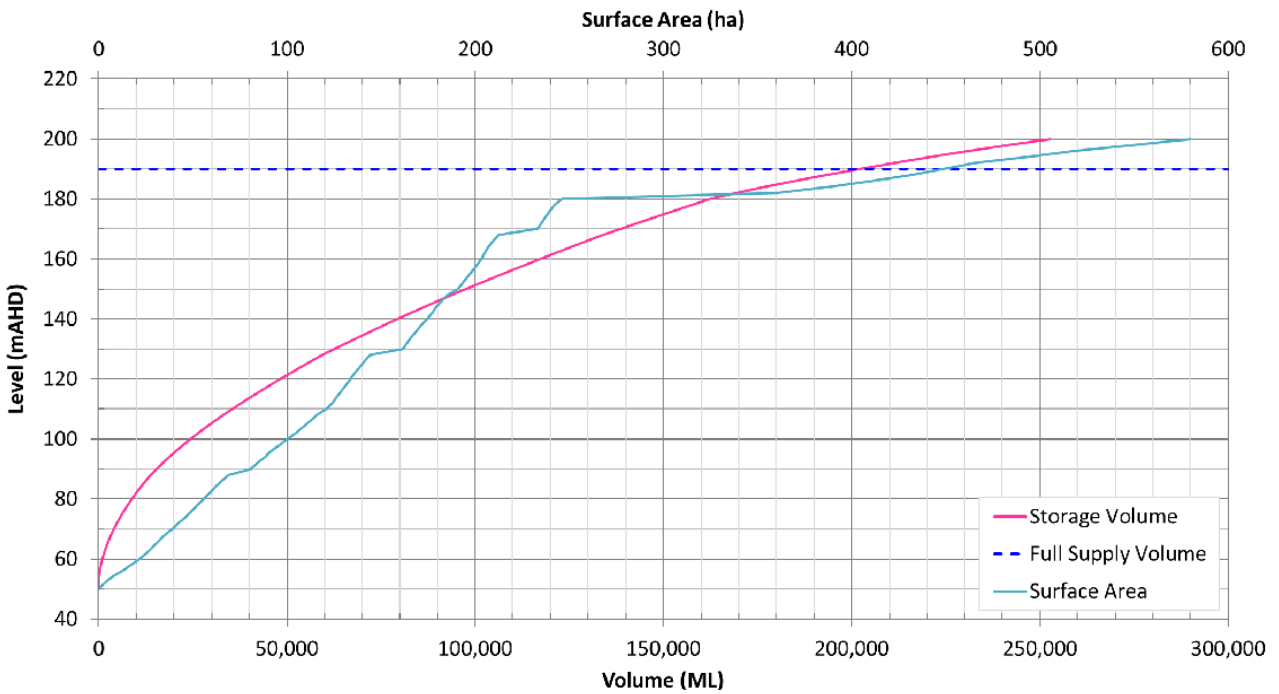


FIGURE 6-7 PANDORA STAGE-STORAGE RELATIONSHIP (WRM, 2026B)

6.2.4 INITIAL VOID LAKE LEVELS

Initial lake levels for each proposed residual void were selected to reflect plausible water levels at the time of mine closure. Spill levels were determined by analysing the final landform topography of each void. Table 6-4 presents the initial lake levels, spill levels and corresponding water storage capacities at full supply level (FSL).

TABLE 6-4 INITIAL LAKE LEVELS, SPILL LEVELS AND WATER STORAGE CAPACITIES FOR RESIDUAL VOIDS

Residual Void	Initial Lake Level	Spill Level	Storage Capacity at FSL
<i>Unit</i>	<i>mAHD</i>		<i>ML</i>
Titan North	139.0	210.0	41,810
Titan Central	193.1	210.0	450
Titan East	118.5	220.0	26,200
Pandora	70.4	190.0	201,850

Source: WRM (2026b)

6.2.5 RAINFALL AND EVAPORATION

Annual rainfall data from 1957 to 2024 is shown in Figure 6-8, along with the historical average annual rainfall of 584 mm. Rainfall over this period exhibits moderate year-to-year variability, with a minimum of 262 mm recorded in 1982 and a maximum of 1,082 mm in 2010.

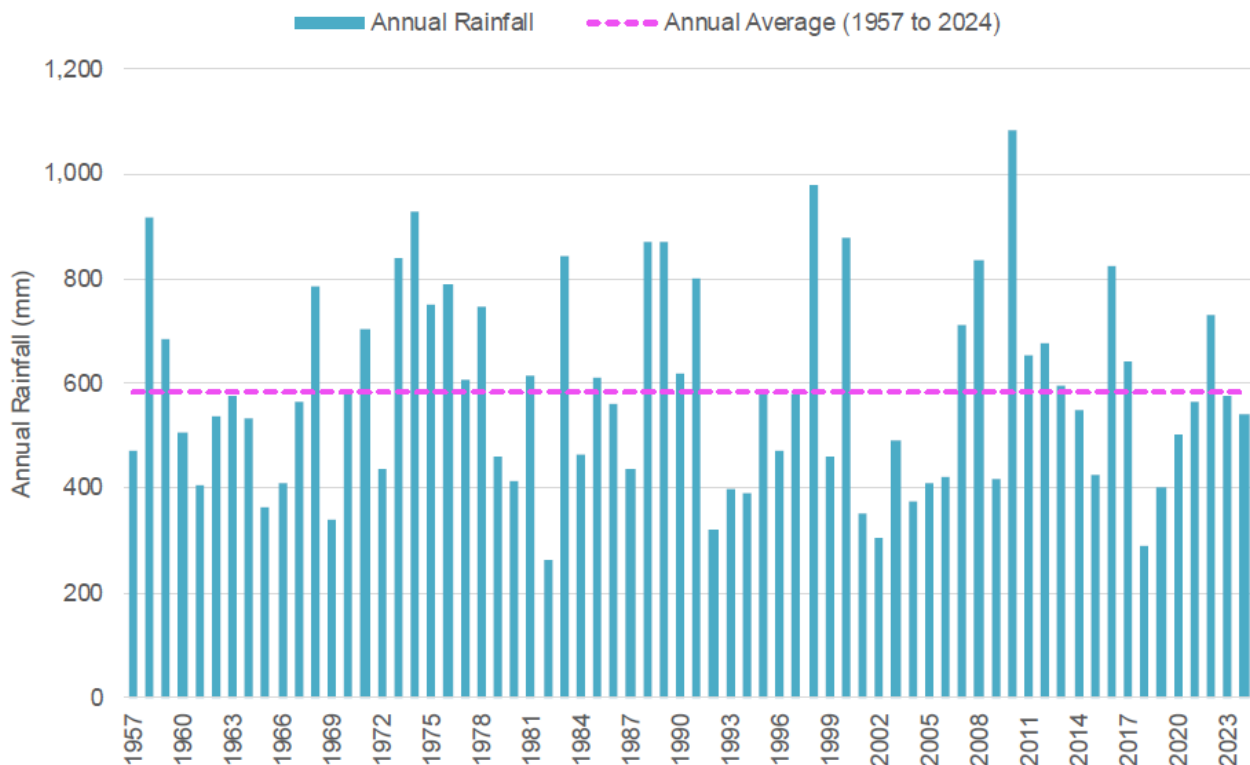


FIGURE 6-8 ANNUAL RAINFALL DATA (1957-2024) (WRM, 2026B)

Monthly rainfall and Class A pan evaporation data for the period 1957-2024 are summarised in Table 6-5 and Figure 6-9. Class A pan evaporation provides a standardised measure of potential evaporative loss from open water surfaces and is commonly used to estimate evaporation from lakes and reservoirs. Average annual pan evaporation is approximately 2,005 mm, with rates peaking during the warmer months from October to January.

TABLE 6-5 SUMMARY OF AVERAGE ANNUAL RAINFALL AND EVAPORATION DATA

Month	Average Rainfall (mm)	Pan Evaporation (mm)
January	102	216
February	91	179
March	65	179
April	35	146
May	31	117
June	23	94
July	22	104
August	22	134
September	11	173
October	31	215
November	61	225
December	90	233
Annual	584	2,015

Note: All data was derived from SILO drill climate information (1957-2024).

Source: WRM (2026b)

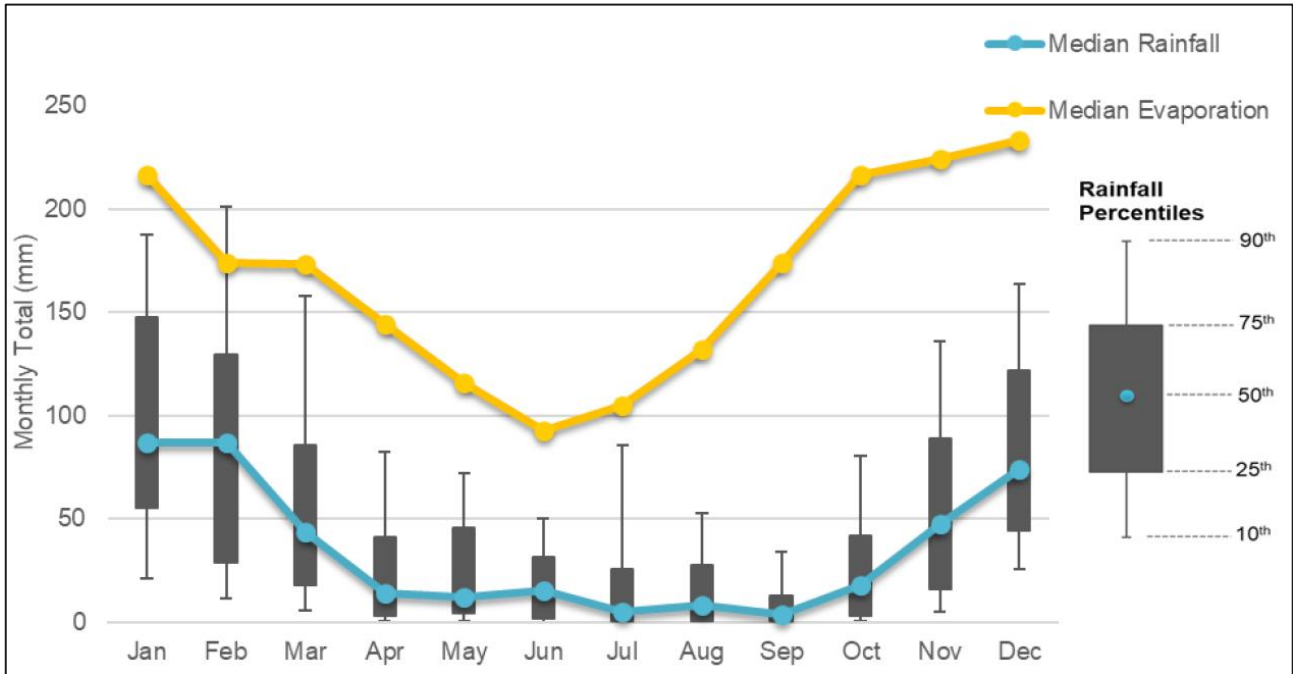


FIGURE 6-9 MONTHLY SILO RAINFALL AND EVAPORATION DISTRIBUTION SUMMARY (WRM, 2026B)

6.2.5.1 CLIMATE CHANGE ADJUSTMENTS

By 2030, climate change is expected to have a relatively minor effect on surface runoff compared to natural variability. However, by 2070, more substantial reductions are projected, with modelled declines in average runoff of up to 25% in the southern Murray-Darling Basin. This level of reduction is comparable to the Millennium Drought (1997 to 2009), a prolonged and severe dry period that significantly affected water resources, agriculture and ecosystems across southeastern Australia (van Dijk et al. 2013). Such changes could have serious implications for water security, environmental flows and long-term land use planning.

To assess future climate impacts, the Shared Socioeconomic Pathways (SSPs) developed by Riahi et al. (2017) were used. The base case for modelling adopted SSP2-4.5 from the IPCC AR5 framework, which assumes a continuation of current global trends and results in moderate emissions with radiative forcing of 4.5 W/m² by 2100.

Two alternative pathways were included for sensitivity testing of the WBM:

- SSP1-2.6 ("Sustainability") represents a low-emissions future focused on inclusive development and environmental stewardship. It aligns with the Paris Agreement (UNFCCC, 2015) and limits radiative forcing to 2.6 W/m².
- SSP5-8.5 ("Fossil-fuelled development") reflects a high-emissions scenario driven by rapid economic growth and fossil fuel reliance, with minimal climate mitigation, leading to radiative forcing of 8.5 W/m² by 2100.

Climate change-adjusted rainfall and evaporation sequences were sourced from the Australian Government's SILO Consistent Climate Scenarios (CCS) project, which modified historical data from 1960 to 2024 to reflect future conditions. Projections were based on the following:

- High climate warming sensitivity.
- "HP" climate cluster, representing a high global warming scenario (*H = high temperature increase; P = decrease in precipitation*).

Gridded daily time-series data were generated using the Q5 v3 Quantile Matching method and are available for over 4,700 stations or at 0.05° (approximately 5 km) resolution across Australia. These projections were processed using the Stochastic Climate Library (SCL) software to produce 250 iterations of daily rainfall, evaporation and temperature data over a 500-year simulation period (eWater n.d.).

Monthly climate change adjustment factors used to scale average values in the model are in Table 6-6.

TABLE 6-6 MONTHLY CLIMATE CHANGE ADJUSTMENT FACTORS FOR PRECIPITATION AND EVAPORATION

Month	Precipitation Change (%)	Evaporation Change (%)
January	-12.5	13.4
February	-9.9	11.3
March	1.1	11.5
April	-5.6	14.1
May	18.6	19.0

Month	Precipitation Change (%)	Evaporation Change (%)
June	-17.6	19.3
July	-6.1	6.5
August	-9.9	16.5
September	24.2	18.2
October	-23.6	17.5
November	-17.3	16.3
December	-10.2	14.0
Annual	-9.1	15.2

Source: WRM (2026b)

6.2.5.2 PIT WATER SALINITY

As pit lake water evaporates over time, salinity increases, which in turn reduces the evaporation rate (Salhotra et al., 1985). This occurs because dissolved salts lower the vapour pressure of water, making it more difficult for water molecules to escape into the atmosphere. In addition, higher salinity increases water density and surface tension, further inhibiting evaporation.

This effect can be estimated using the following evaporation adjustment equation:

$$FE = 1.025 - 0.0246 * \exp(0.0087 * \text{salinity})$$

where FE is the evaporation factor and salinity is expressed in g/L.

This relationship shows that evaporation becomes negligible at extremely high salinity levels, with evaporation effectively ceasing around 430,000 mg/L. However, the equation is applicable only up to about 300,000 mg/L, assuming sodium chloride is the dominant salt and begins to precipitate at that concentration.

The model assumes the pit lake remains fully mixed and applies a salt balance approach based on mass conservation. Salinity inputs from runoff and other sources were derived from earlier studies and groundwater modelling data, with TDS values converted from electrical conductivity values as shown in Table 6-7.

TABLE 6-7 ADOPTED RUNOFF SALINITY CONCENTRATIONS

Water Source/Land-Use	EC (µS/cm)	TDS (mg/L)
Groundwater inflows	2,630	1,845
Natural/undisturbed	260	185
Rehabilitated	400	280
Void runoff	2,630	1,845

Source: WRM (2026b)

6.2.6 GROUNDWATER INFLOW

Groundwater inflow to the voids would change over time as the water level in the void increases to the equilibrium level. Groundwater inflow rates applied in the water balance model were sourced directly from the SLR (2026) groundwater recovery model to ensure consistency.

6.3 WATER BALANCE RESULTS

Table 6-8 and Table 6-9 present the modelled annual average water balance for the residual voids. The groundwater inflow values shown are dynamic fluxes from the WRM water balance model and therefore differ from the static equilibrium inflows reported in Section 4. The results show clear differences in the hydrological behaviour of each void.

- Titan Central receives no measurable groundwater or backfilled spoil seepage inflows, and its water balance is controlled by surface water runoff inputs (0.12 ML/day) and seepage outflows to backfilled spoil. Inflows and outflows balance, indicating a steady-state condition throughout the simulation.
- Titan North similarly receives no measurable inflows from backfilled spoil seepage or groundwater. All inflows come from surface water runoff (1.16 ML/day). Evaporation and outflows of seepage to backfilled spoil during the initial 50 years are slightly lower than inputs, leading to development of the pit lake (increase in storage of ~0.01 ML/day). Evaporation increases during the latter 450 years of the simulation to balance out the inflows and achieve equilibrium.
- Titan East receives groundwater inflows (\approx 0.18-0.20 ML/day) and surface water runoff of 0.44 ML/day. Outflows comprise evaporation and seepage to backfilled spoil that are approximately 0.01 ML/day less than inflows during the first 50 years of the simulation, increasing to 0.02 ML/day during the remaining 450 years.
- Pandora has the largest fluxes, with groundwater inflow ranging between 0.8-1.0 ML/d, seepage from backfill spoil inflow of 1.5 ML/d, and surface water runoff of 2.3-2.6 ML/d. Total inflow (\approx 4.7-5.2 ML/d) exceeds total outflow by a small margin, producing a net positive water balance that diminishes over time as equilibrium is approached.

Comparison of the two model periods (2045-2095 and 2095-2545) shows that the hydrologic behaviour of all residual voids remains stable, with only minor changes in the magnitude of inflows and outflows.

For Titan Central and Titan North, average inflows and outflows are effectively constant, confirming that both voids reach equilibrium early in the post-mining period. Titan East shows a slight increase in groundwater inflow (from 0.18 to 0.20 ML/d) and evaporation (from 0.17 to 0.20 ML/d), resulting in a marginally higher total flux but no material change in stored volume.

Pandora exhibits the greatest temporal variability, with small increases in surface runoff (from 2.31 to 2.58 ML/d) and groundwater inflow (from 0.83 to 1.03 ML/d), accompanied by a rise in evaporation (from 3.87 to 5.05 ML/d). This results in a gradual reduction of its net positive water balance (from +0.80 to +0.11 ML/d) as the system stabilises.

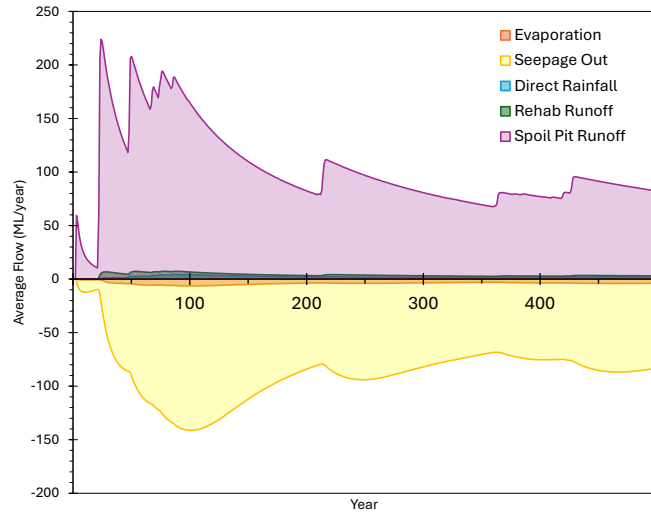
Average annual water balance data for the residual voids over 500 years for the mid rainfall scenario is displayed in Figure 6-10 and Figure 6-11.

TABLE 6-8 AVERAGE VOID INFLOW AND OUTFLOW FOR YEARS 2045 TO 2095 (250 REALISATIONS)

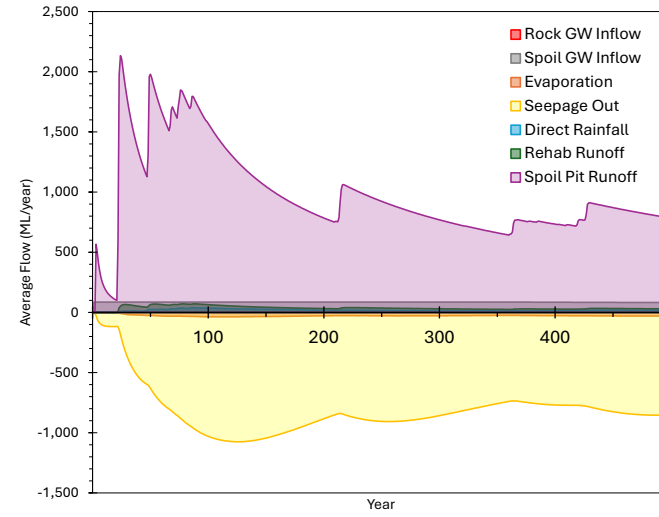
Void	Surface Water Runoff	GW Inflow	Spoil Seepage Inflow	Total Inflow	Evaporation	GW Outflow	Spoil Seepage Outflow	Total Outflow	Change in Water Volume
<i>Unit</i>	<i>ML/day</i>								
Titan North	1.16	0.00	0.00	1.16	0.12	0.00	1.03	1.15	0.01
Titan Central	0.12	0.00	0.00	0.12	0.01	0.00	0.11	0.12	0.00
Titan East	0.44	0.18	0.00	0.61	0.17	0.00	0.43	0.60	0.01
Pandora	2.31	0.83	1.53	4.67	3.87	0.00	0.00	3.87	0.80
Spoil	-	-	1.57	1.57	-	-	1.53	1.53	0.05
<i>Source: WRM (2026b)</i>									

TABLE 6-9 AVERAGE VOID INFLOW AND OUTFLOW FOR YEARS 2095 TO 2545 (250 REALISATIONS)

Void	Surface Water Runoff	GW Inflow	Spoil Seepage Inflow	Total Inflow	Evaporation	GW Outflow	Spoil Seepage Outflow	Total Outflow	Change in Water Volume
<i>Unit</i>	<i>ML/day</i>								
Titan North	1.17	0.00	0.00	1.17	0.14	0.00	1.03	1.17	0.00
Titan Central	0.12	0.00	0.00	0.12	0.01	0.00	0.11	0.12	0.00
Titan East	0.44	0.20	0.00	0.64	0.20	0.00	0.42	0.62	0.02
Pandora	2.58	1.03	1.55	5.16	5.05	0.00	0.00	5.05	0.11
Spoil	-	-	1.56	1.56	-	-	1.55	1.55	0.01
<i>Source: WRM (2026b)</i>									



Titan Central



Titan North

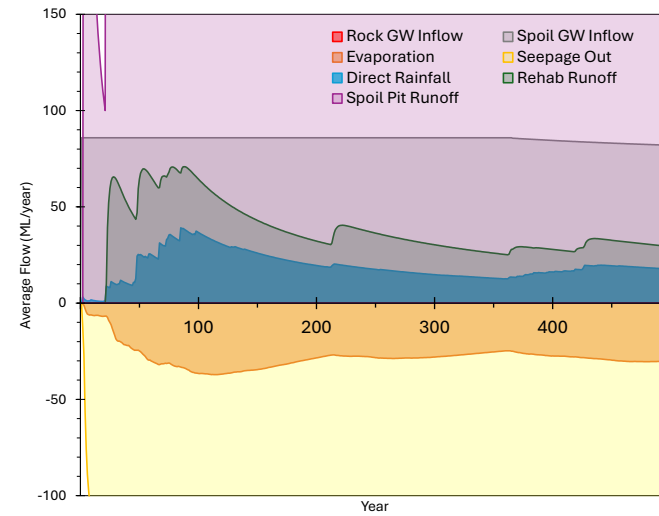
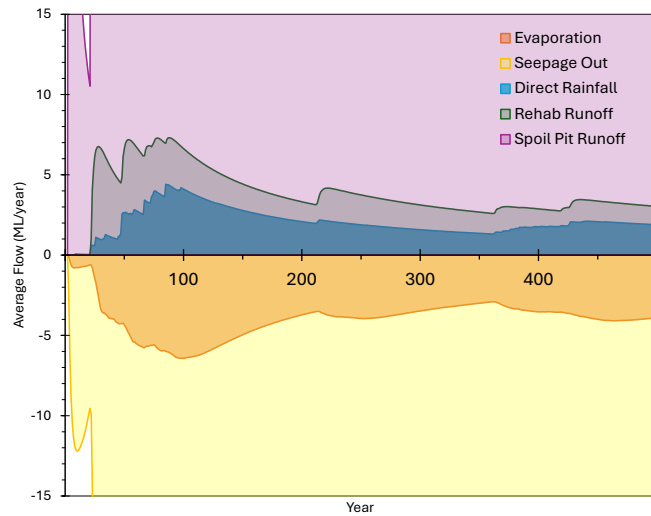
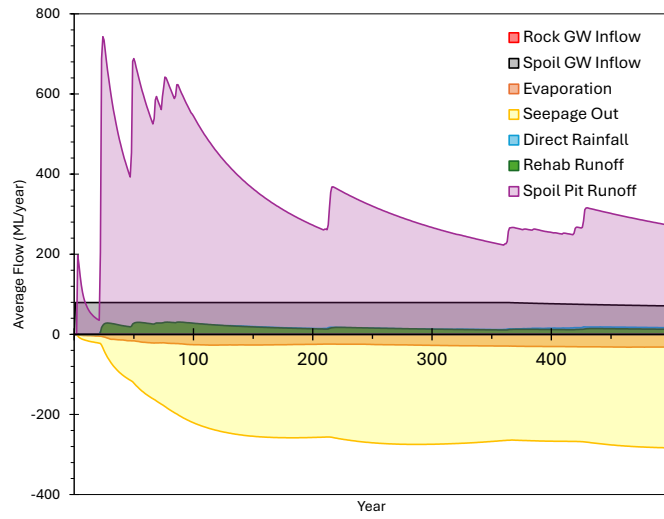
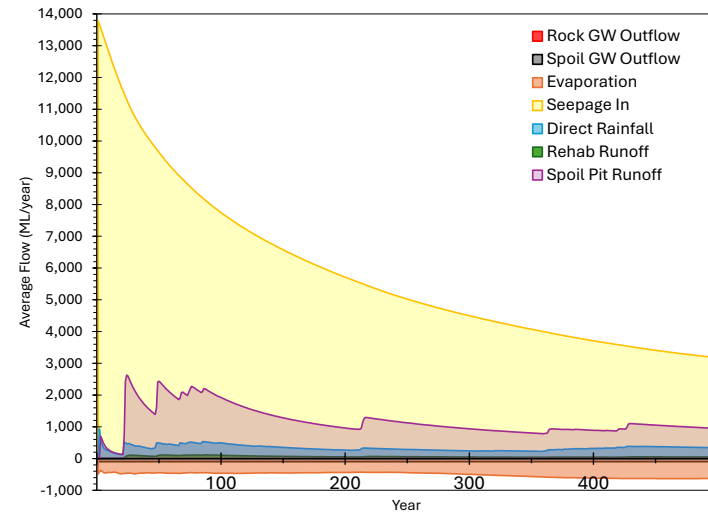


FIGURE 6-10 ANNUAL AVERAGE VOID WATER BALANCES FOR TITAN CENTRAL AND TITAN NORTH OVER 500 YEARS – MID RAINFALL



Titan East



Pandora

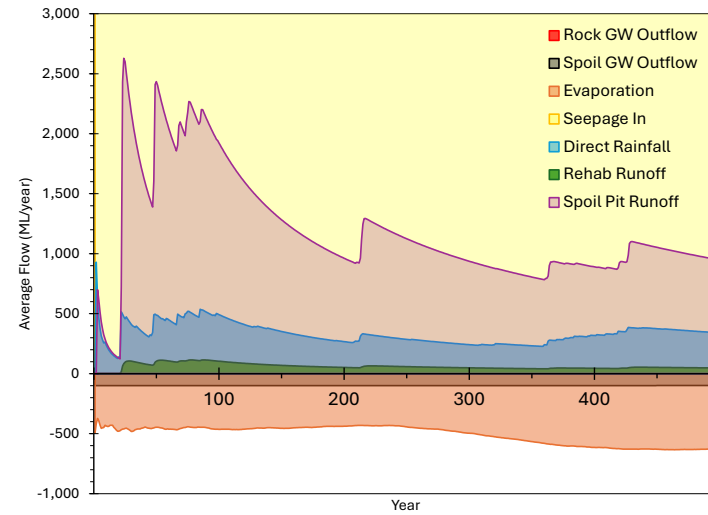
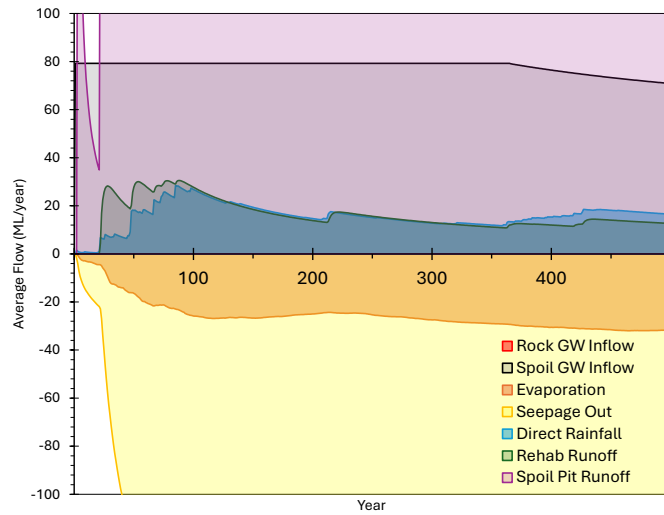


FIGURE 6-11 ANNUAL AVERAGE VOID WATER BALANCES FOR TITAN EAST AND PANDORA OVER 500 YEARS – MID RAINFALL

6.3.1 RESIDUAL VOID WATER LEVELS

Table 6-10 below summarises the projected water levels of each residual void over the 500-year modelling period (2045 to 2545), including pit floor levels, initial levels, mean levels and the 5th and 95th percentile (%ile) water levels at 2545. These are compared against the spill level for each void to assess long-term water balance behaviour and the risk of overtopping. Average monthly void lake levels are shown in Figure 6-12 to Figure 6-15.

TABLE 6-10 SUMMARY OF PROJECTED VOID LAKE WATER LEVELS (2045-2545)

Residual Void	Pit Floor Level ¹	2045	2545			Spill Level
		Initial Level	Mean Level	5th %ile	95th %ile	
<i>Unit</i>	<i>mAHD</i>					
Titan Central	192	193.1	193.2	192.2	195.2	210.0
Titan North	134	139.5	139.5	136.7	146.7	210.0
Titan East	116	119.0	120.4	116.9	125.8	220.0
Pandora	56	70.6	91.9	69.8	102.2	190.0

Note:

¹ Pit floor levels calculated by subtracting the indicative maximum depth of voids from residual void spill levels (Table 3-1).

Source: WRM (2026b)

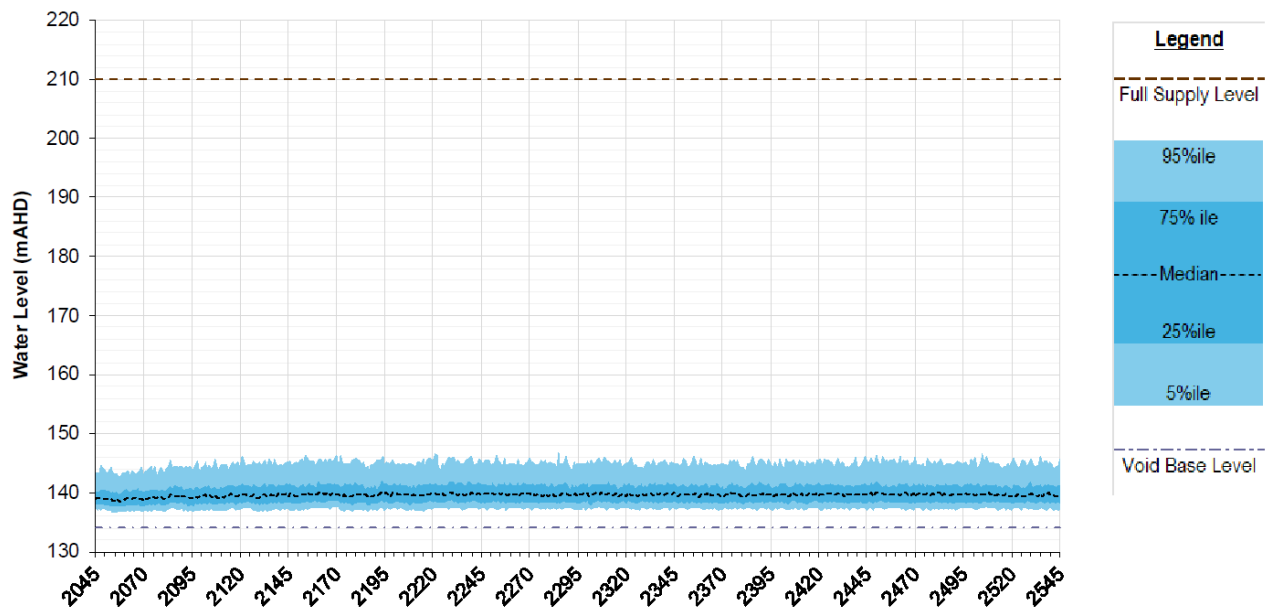


FIGURE 6-12 AVERAGE MONTHLY WATER LEVELS FOR THE TITAN NORTH RESIDUAL VOID (WRM, 2026B2025A)

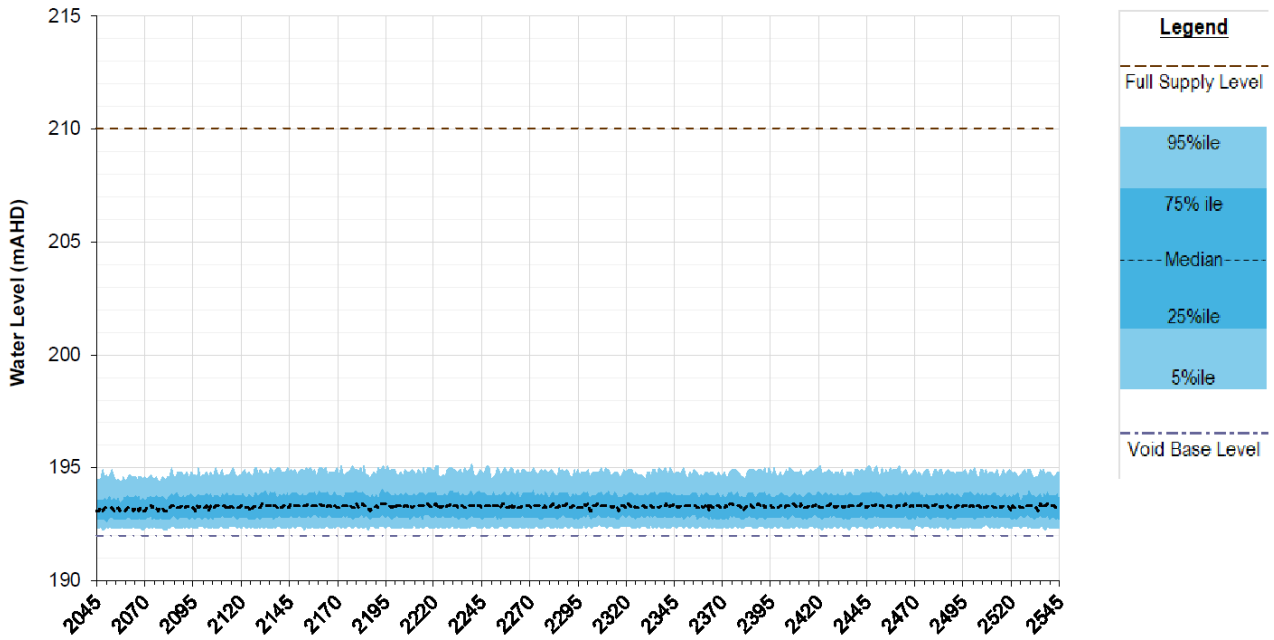


FIGURE 6-13 AVERAGE MONTHLY WATER LEVELS FOR THE TITAN CENTRAL RESIDUAL VOID (WRM, 2026B)

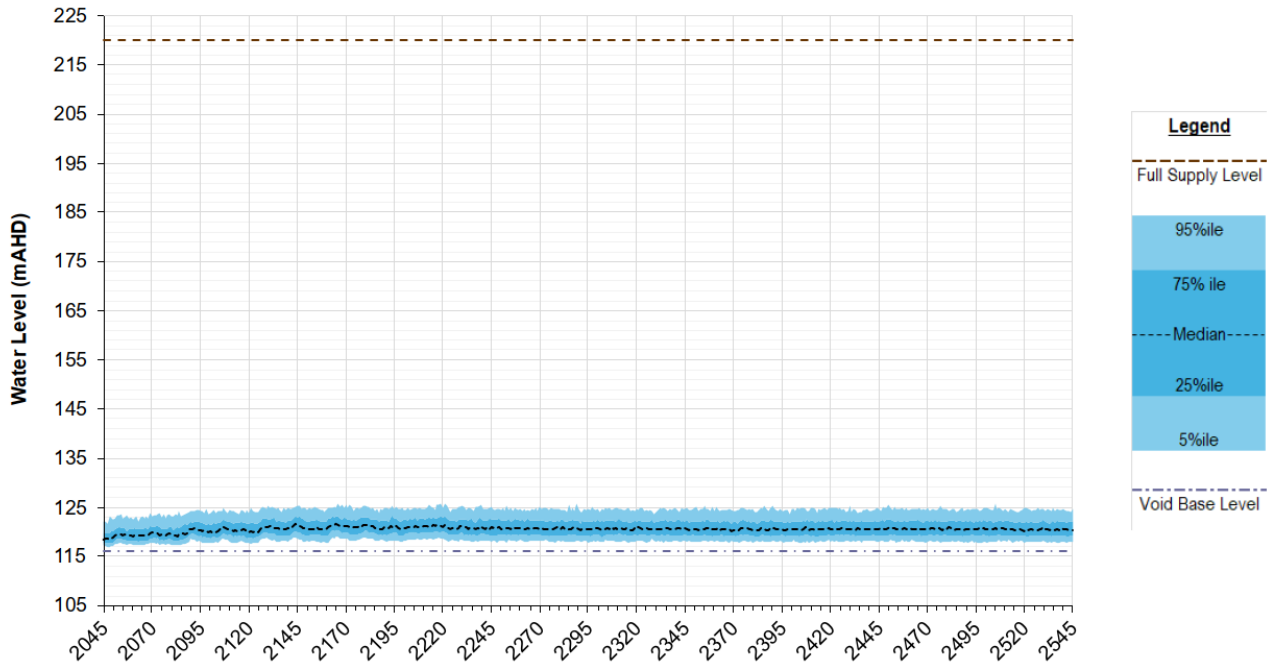


FIGURE 6-14 AVERAGE MONTHLY WATER LEVELS FOR THE TITAN EAST RESIDUAL VOID (WRM, 2026B)

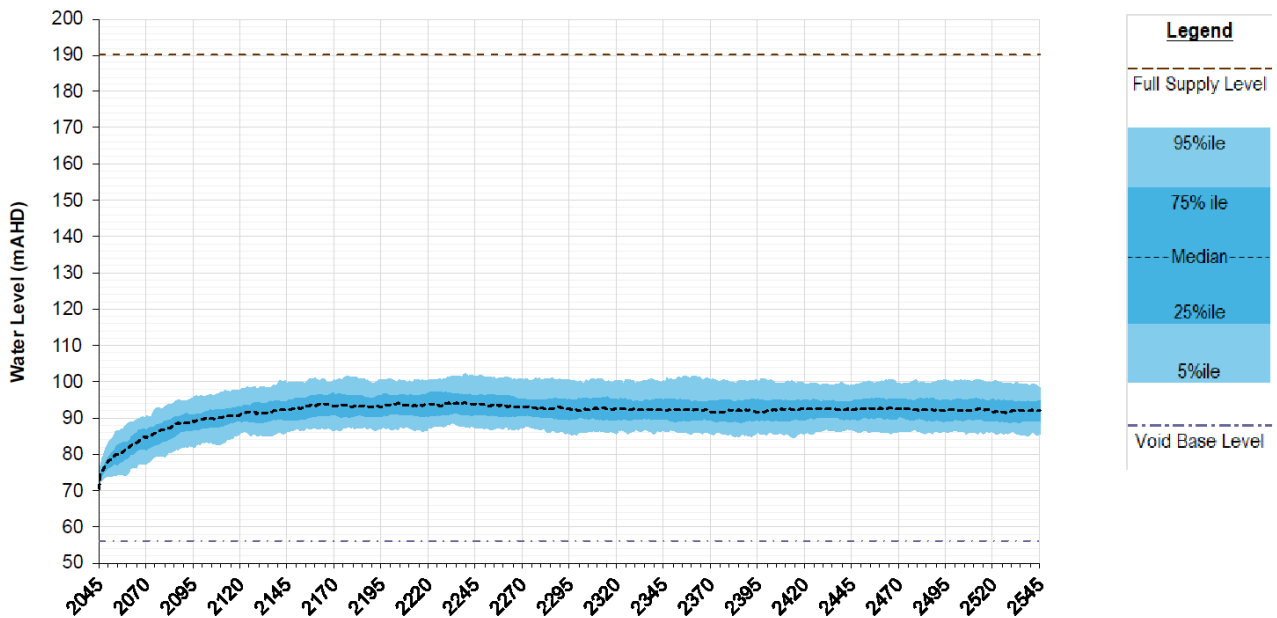


FIGURE 6-15 AVERAGE MONTHLY WATER LEVELS FOR THE PANDORA RESIDUAL VOID (WRM, 2025B)

6.3.2 GROUNDWATER INFLOW

Table 6-11 summarises the modelled groundwater inflows to each residual void at the start and end of the 500-year simulation period, along with the estimated time required for inflows to stabilise. Stabilisation reflects the point at which inflow rates level off as void lake levels approach equilibrium.

TABLE 6-11 GROUNDWATER INFLOWS TO RESIDUAL VOIDS (2045-2545)

Residual Void	Equilibrium Groundwater Inflow			Flow Direction/ Behaviour	Time Until Stable Groundwater Inflow
	Spoil	Natural geological formations	Total		
<i>Unit</i>	<i>m³/day</i>			-	<i>Years</i>
Titan North	-77.6	0.2	-77.4 (net outflow)	Outflow to spoil. Minimal inflow from natural formations.	≈220
Titan East	201.7	0.003	201.7	Inflow via spoil from local recharge.	
Pandora	916.2	4.5	921.1		

Source: SLR (2026)

6.3.3 SALINITY

Pit lakes at DNM will exhibit different salinity behaviours depending on their hydrological setting. The northern voids (Titan North, Titan Central and Titan East) operate as flow-through systems, while Pandora functions as the terminal sink within the system. As seepage from the northern voids is predicted to migrate toward Pandora, salts do not accumulate in these voids to the same extent as in Pandora.

The following classifications are used to describe salinity levels based on total dissolved solids (TDS):

- Freshwater: <500 mg/L.
- Brackish water: 500 to 10,000 mg/L.
- Moderately hypersaline: 10,000 to 100,000 mg/L.
- Highly hypersaline: Above 100,000 mg/L (e.g. Dead Sea, Great Salt Lake).
- Extremely hypersaline: Around or above 300,000 mg/L, where salt (NaCl, halite) may begin to precipitate.

Table 6-12 summarises the modelled mean salinity concentrations of each residual void at the end of the 500-year simulation period (2545), along with the salinity category based on TDS. These values reflect the simulated solute concentrations within each void as calculated in WRM (2026b) using a salt balance model. This method applies representative TDS inputs and adjusts evaporation rates as salinity increases, assuming complete mixing within the void water column.

The northern voids (Titan North, Titan Central and Titan East) remain below the hypersaline threshold due to their flow-through behaviour, with seepage migrating toward the Pandora void. As a result, solute concentrations in these voids remain broadly consistent with assumed surface runoff concentrations. Modelled concentrations remain below 2,000 mg/L, which aligns with the water quality objective for stock watering (ANZECC & ARMCANZ, 2000).

In contrast, Pandora functions as the terminal sink within the system. Progressive accumulation of salts results in a moderately hypersaline classification and unsuitable for future beneficial use.

Unlike the PHREEQC modelling presented in Section 8.2, which simulates geochemical reactions and mineral equilibria, the WRM approach is purely mass-balance based and does not simulate geochemical interactions.

TABLE 6-12 PROJECTED AVERAGE PIT LAKE SALINITY AT 2545

Residual Void	TDS (mg/L)	Hypersalinity Category
Titan North	2,000	Brackish water
Titan Central	1,900	
Titan East	1,200	
Pandora	59,000	Moderately hypersaline

Source: WRM (2026b)

6.3.4 CLIMATE CHANGE SENSITIVITY

The climate change sensitivity assessment compares the impact of three emission scenarios on long-term pit lake water levels: SSP1-2.6 (low), SSP2-4.5 (moderate, base case) and SSP5-8.5 (high). These scenarios represent progressively higher greenhouse gas emissions and associated changes in temperature, rainfall and evaporation.

The results in Table 6-13 indicate that void water levels generally decrease as emissions increase (from SSP1-2.6 to SSP5-8.5), reflecting the combined influence of reduced recharge and increased evaporation under higher-emission climate projections.

Across all climate scenarios, changes in rainfall and evaporation only marginally affect long-term water levels in Titan North and Titan East, while Titan Central remains particularly stable due to ongoing seepage toward the Pandora residual void. The Pandora residual void shows a more pronounced, but still contained response as it functions as the terminal catchment receiving runoff and seepage from surrounding voids.

Even under SSP5-8.5, water levels stabilise well below crest elevations and no scenario indicates any loss of containment or change in groundwater-sink behaviour.

TABLE 6-13 PROJECTED AVERAGE PIT LAKE WATER LEVELS UNDER DIFFERENT CLIMATE SCENARIOS

Residual Void	SSP1-2.6 ("Sustainability")	SSP2-4.5 (Base)	SSP5-8.5 ("Fossil-fuelled Development")	Change (Range)
<i>Unit</i>	<i>mAHD</i>			<i>m</i>
Titan Central	193.5	193.3	193.3	-0.2
Titan North	140.8	140.1	139.6	-1.2
Titan East	121.6	120.8	120.0	-1.6
Pandora	95.7	92.0	87.6	-8.1

Source: WRM (2026b)

7 GEOTECHNICAL STABILITY

This section assesses the geotechnical stability of the final void landforms. It is required to demonstrate that the landform is safe and stable over time under PRCP Section 3.6.3.

In summary, this section covers the following:

- *How post-closure void slopes will be stable and consistent with closure planning objectives.*
- *Measures to achieve geotechnical stability (e.g. backfilling, regrading, buttressing, benching).*
- *Techniques for creating safe slope configurations must be specified where relevant.*
- *Potential effects of long-term erosion, weathering and hydrological impacts.*
- *Proposed final slope angles of highwalls, low walls and end walls of each residual void.*

Geotechnical stability assessments have been undertaken by Henderson Geotech (2026) to confirm that the conceptual highwall, end wall and low wall slopes of the DNM residual voids will remain stable in the long-term following closure. This section outlines the key findings of the assessment relevant to void closure at DNM.

7.1 APPROACH

7.1.1 MODEL SUMMARY

Seven cross-sections intersecting the residual voids and surrounding final landform at closure were selected for the stability analysis. The sections were selected to intersect the maximum void depth and greatest spoil height, represent the typical highwall in each void, and capture local natural features such as New Chum Creek. The location of the seven cross-sections are shown in Figure 7-1.

Titan North and Titan Central were considered as one void in the geotechnical analysis because they are separated only by an internal spoil landform rather than a distinct geological barrier. Titan Central is also shallower and narrower, with lower wall heights and limited independent stability risk.

The Slide2 Modeler, 2D Limit Equilibrium Analysis for Slopes was used to perform the analyses. The analytical methods used were Morgenstern/GLE - Vertical Slices - Circular Surfaces and Sarma - Vertical Slices - Non-Circular Surfaces. Generally, the Sarma method produces lower minimum Factors of Safety (FoS) due to better being able to generate potential slip surfaces that ran along strata interfaces.

The limit equilibrium method was used to assess the stability of the DNM residual void highwalls and end walls. Instability along potential slip surfaces was evaluated in terms of Factor of Safety (FoS), which represents the ratio of resisting to driving forces. Typical FoS values adopted for slope design range from 1.2 to 1.5, with higher values applied where model uncertainty or the consequence of failure is greater. Given the geotechnical model was assessed as having high uncertainty and considering the consequence levels outlined in Table 7-2, the minimum FoS criteria adopted for design acceptance are those listed in Table 7-3.

The chosen FoS depends on the potential consequences of failure. For long-term civil structures like roads or dams, a FoS of 1.5 is typically used. For mine pit walls, lower values like 1.2 to 1.3 are common due to shorter design lives and lower exposure risks.

7.1.2 MODEL INPUTS

7.1.2.1 GEOLOGY AND GEOTECHNICAL PROPERTIES

In the Bowen Basin, coal-bearing sedimentary rocks from the Permian period are common. These are overlain by younger sediments, mainly from the Tertiary period. In some areas, early Tertiary basalt is also present, which is laterally confined and occurs within the younger sediments.

The geotechnical parameters used in the DNM slope stability analyses are shown in Table 7-1.

TABLE 7-1 GEOTECHNICAL PARAMETERS USED IN STABILITY ANALYSES

Material Type	Weight	Cohesion	Friction Angle	Coefficient of permeability	kv/kh Ratio
<i>Unit</i>	<i>kN/m³</i>	<i>kPa</i>	<i>°</i>	<i>m/s</i>	<i>-</i>
Unsaturated spoil (down dip spoil)	18	40	30	5e-5	0.25
Saturated spoil (down dip spoil)	20	23	25	5e-5	0.25
Unsaturated Tertiary overburden	20	50	30	7.1e-7	0.01
Saturated Tertiary overburden	20	15	30	7.1e-7	0.01
Weathered Permian overburden	24	75	30	4.5e-6	0.02
Fresh Permian over/interburden	24	450	42	1.9e-9	0.01
Fresh coal	15	30	35	1.1e-7	0.01

Source: Henderson Geotech (2026)

7.1.2.2 GROUNDWATER

At the end of each of the seven cross-sections, piezometric heads from the groundwater model were extracted and applied as total head boundaries. The water levels within each void from WRM (2026) were also used. This hydrogeological information was used in highwall and low wall stability for three scenarios:

- end-of mining;
- 20 years after end of mining; and
- 100 years after end of mining.

It is noted that groundwater conditions change over time after the end of mining; however, the rate of such change is slow enough that steady state analysis was considered sufficiently accurate.

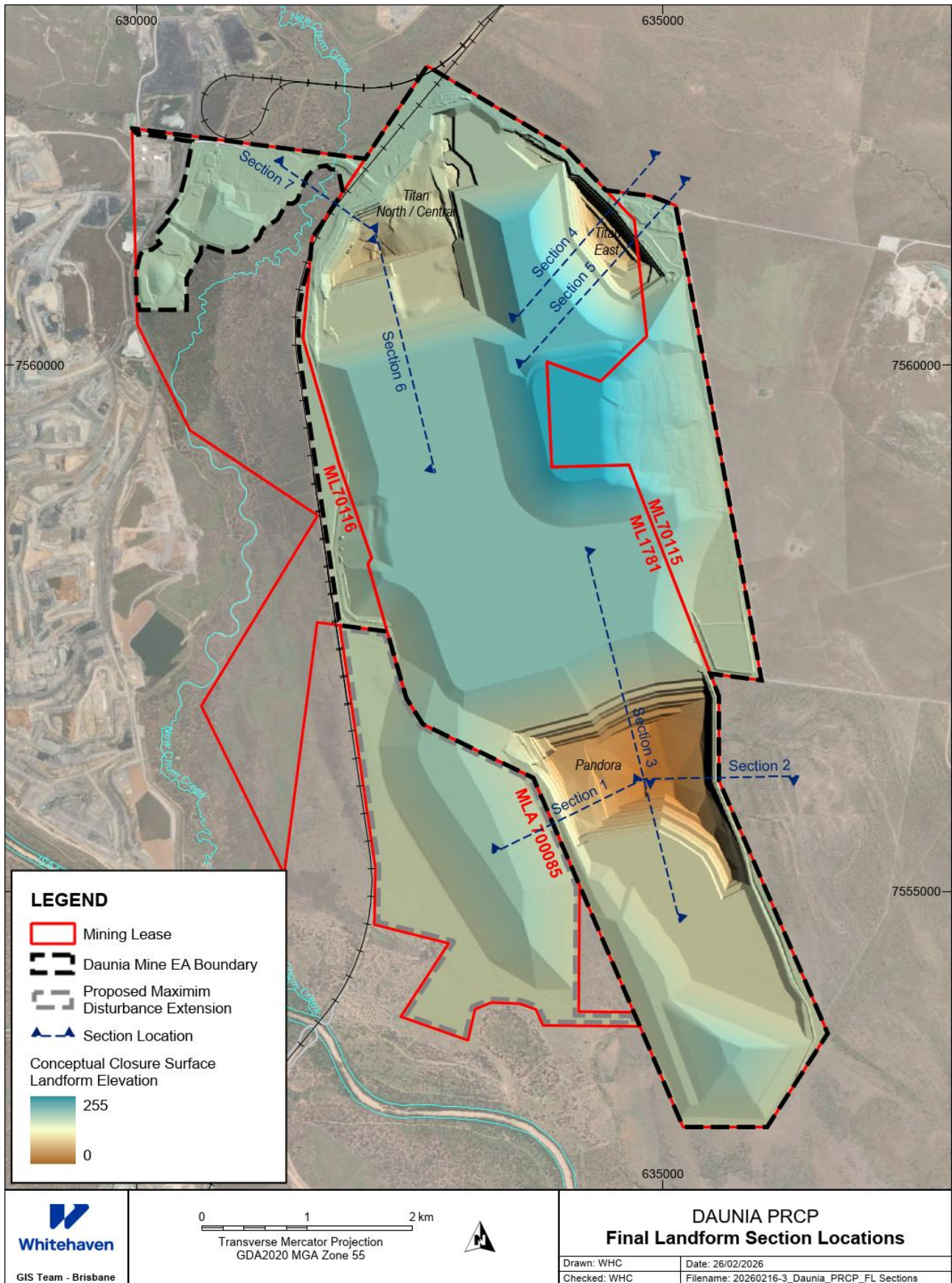


FIGURE 7-1 LOCATIONS OF CROSS-SECTIONS USED IN THE GEOTECHNICAL ASSESSMENT

7.1.3 POTENTIAL GEOTECHNICAL INSTABILITY MECHANISMS

7.1.3.1 WEATHERING

Weathering naturally reduces rock strength over time. However, weathering that occurred over geological time before pit wall excavation is already accounted for in the strength parameters used for operational wall design. As a result, it does not pose any additional risk to rehabilitation or post-mining landforms.

Therefore, only weathering that occurs after mining stops could affect long-term stability. Weathering happens in two main phases: physical degradation and chemical decomposition.

Physical degradation begins soon after the rock face is exposed and involves large fragments breaking into smaller pieces. This process, known as slaking, is often driven by salts or clays that absorb moisture and expand. Cementing minerals can also dissolve in water. Rainfall or in-pit water storage causes rapid slaking in susceptible materials. Even humidity alone can cause slaking over a few years.

Because slaking relies on water, it mostly affects the surface of pit walls and rarely extends deep enough to cause structural instability. One exception is if moisture-sensitive rock lies below the long-term water level. In such cases, saturated strength values are used in design, so no extra consideration is needed.

Chemical decomposition alters rock minerals at the molecular level, typically forming clays. This process happens where water can reach, mostly on surfaces and along joints or bedding planes. However, this process is very slow.

Both weathering phases occur fastest in hot and wet climates. At DNM, the climate is hot but relatively dry. Therefore, only "very slight" ongoing weathering is expected.

In rare cases, minor weathering could affect geotechnical stability post-closure. For example, if weak, degradable rock lies beneath stronger layers, the weaker material may break down and fall away, leaving the stronger layer unsupported. This could lead to localised failures. These situations are generally only discovered during excavation. They cannot be fully predicted during planning but will be assessed and managed at the detailed design stage once mining ends. Further weathering on highwalls and end walls is unlikely to penetrate deeply enough to cause anything more than surface fretting that is not geotechnically significant.

7.1.3.2 LONG-TERM EROSION

Erosion is the process where solid particles are detached from soil or rock and transported away from their original position. Detachment usually happens through mechanical forces, such as raindrop impact or the energy of flowing water. Transport of the detached particles is driven by flowing water.

The severity of erosion depends on the material's properties – specifically, how easily particles can be detached. Erosion becomes more significant with increasing catchment size and steeper slopes, as both increase the volume and speed of runoff.

In dispersive materials, detachment can also occur chemically. In these cases, the internal bonds and ionic charges allow clay particles to disperse into still water, even without any mechanical energy. However, water movement is still required to transport the particles.

On highwalls and end walls in the Bowen Basin, erosion in fresh rock is generally minimal. Most erosion is limited to slaked or weathered material, as fresh, intact rock is too strong to break apart easily. Above the base of weathering, particles are more easily detached, and erosion can occur along flow paths.

Erosion tends to follow the direction of water flow, which is usually perpendicular to the pit wall. In contrast, slip failures generally occur along surfaces that are sub-parallel to the wall. Because of this, erosion rarely leads to geotechnical instability.

In rare cases, intersecting erosion gullies could form a wedge-type failure. However, these are managed using surface water and erosion control measures, not by altering slope design.

Exclusion bunds and/or flood protection landforms will limit the movement of surface water runoff over highwalls and end walls. The available data reviewed did not indicate strong overburden strata underlain by weaker strata that could be susceptible to undercutting. For the low walls, rainfall runoff will predominantly flow down the batters, with vegetation in the grazing and woodland PMLU areas limiting runoff. On this basis, erosion is not likely to materially affect long-term geotechnical stability.

7.1.3.3 SIGNIFICANT HYDROGEOLOGICAL EVENTS

In Bowen Basin coal mines, weathered overburden is typically prone to softening when saturated, especially if it contains significant clay content. In contrast, unweathered (fresh) coal measure rocks usually retain their strength when wet. This is supported by the many inactive pits in the region that hold water without showing signs of wall instability.

Some claystones or mudstones may be more moisture sensitive. These materials often begin slaking soon after exposure to humid air, making them identifiable during active mining. In such cases, wall designs can be modified in real time to reduce stability risks.

Water balance modelling for the DNM residual voids (see Section 6.3) indicates that long-term steady state void water levels will remain well below the base of weathering. Therefore, water is only expected to contact fresh rock or spoil. As a result, no adverse impact on pit wall stability is anticipated from long-term water storage in the voids.

The greatest potential risk from rainfall would be an extreme event causing floodwater to rush into the void. In theory, this could create a new drainage path or channel, increasing the volume and speed of inflow. Flood modelling (see Section 5) confirms that all DNM residual voids, including Pandora, are fully protected from flood inundation. The Pandora void lies outside the Isaac River floodplain under both the 0.1% AEP and PMF events under future climate scenarios (RCP 8.5 P90), with at least 7 m freeboard and low adjacent flow velocities. The voids are hydraulically disconnected from the river and New Chum Creek, and no flood protection works are required under the final closure design.

Another water-related failure mode is drawdown instability. This occurs when pore pressures in the surrounding rock have adjusted to a stable water level, and that level is then lowered too quickly for the rock to drain. The resulting imbalance can reduce slope stability. However, this is not likely to be a concern at DNM. The voids will only lose water slowly through evaporation or small capacity pumps, which are not capable of lowering water levels fast enough to cause drawdown failure. Drawdown stability would only need to be considered if PMLUs involved significant water movement, such as pumped hydro storage or large-scale irrigation. These uses are not proposed for the DNM residual voids.

7.1.4 DESIGN ACCEPTANCE CRITERIA

Design acceptance criteria for slope stability were determined with reference to both the assessed level of model uncertainty and the potential consequences of instability. The combined geotechnical and groundwater pressure model has a reliability score of 49/100, placing it at the boundary between medium and high uncertainty (Simmons et al., 2024). This rating does not reflect the reliability of the assessment itself but provides a framework for selecting suitable minimum FoS.

Accordingly, higher FoS values were applied to scenarios with greater potential consequence (refer to Table 7-2), as summarised below:

- 1.50 for medium-consequence scenarios, including highwall instability extending into grazing PMLUs or watercourses/flood protection structures behind the crest.
- 1.35 for low-consequence scenarios, including highwall or low wall instability extending into woodland or grazing PMLUs.
- 1.25 for negligible-consequence scenarios, where instability is contained wholly within a NUMA and poses no external risk.

7.2 CONSEQUENCE ASSESSMENT

Summary outcomes from the consequence assessment, which considered harm to humans, environmental harm, and property loss and damage, are presented in Table 7-2. The full assessment is presented in Henderson Geotech (2025).

The assessment concluded that for the four highwall scenarios, the ratings ranged from negligible to medium. For the three low wall scenarios, the ratings ranged from negligible to low.

TABLE 7-2 CONSEQUENCE CATEGORY ASSESSMENT FOR GEOTECHNICAL STABILITY

Scenario	Consequence of Geotechnical Stability
Highwall instability that extends into grazing PMLU behind crest	Medium
Highwall instability that extends to watercourse channels or flood protection structures behind crest	Medium
Highwall instability that extends into woodland PMLU behind crest	Low
Highwall instability that does not extend outside NUMA	Negligible
Low wall instability that extends into grazing PMLU	Low
Low wall instability that extends into woodland PMLU	Low
Low wall instability that does not extend outside NUMA	Negligible

7.3 ASSESSMENT RESULTS

7.3.1 HIGHWALL STABILITY

Geotechnical stability assessment results for the highwalls are summarised in Table 7-3. These results show that the minimum FoS for the scenarios was achieved for all cross-sections and for each assessment stage. The cross sections representing the FoS for the void highwalls under each scenario are presented in Figure 7-2 to Figure 7-5.

The initial revised final landform for the Pandora void eastern highwall did not achieve the FoS for the area within the NUMA due to the coal seams dipping steeply out of the wall, which provided a potential path for sliding failure. The geometry of the highwall was revised (cross-section 2*) to replace the upper coal seam and overburden above it with spoil. This resulted in an improved FoS above the acceptance criteria.

For the Titan North void highwall on the northern side of the void, the assessment identified an area of potential localised geotechnical instability in the event of water ponding in the drain and saturating the weathered overburden. The final landform was revised to remove the drain (cross-section 7*). This resulted in an improved FoS value above the acceptance criteria.

TABLE 7-3 GEOTECHNICAL STABILITY FoS RESULTS FOR RESIDUAL VOID HIGHWALLS

Location/Scenario	NUMA	Grazing/Creek PMLU	Woodland PMLU
<i>Design acceptance criteria</i>	1.25	1.50	1.35
<u>Pandora</u>			
Section 1 highwall			
End-of-mining	1.62	1.62	n/a
Interim pit lake			n/a
Long-term pit lake			n/a
Section 2* highwall			
End-of-mining	1.38	1.52	n/a
Interim pit lake			n/a
Long-term pit lake			n/a
<u>Titan East</u>			
Section 4 highwall			
End-of-mining	1.87	1.87	n/a
Interim pit lake			n/a
Long-term pit lake			n/a
Section 5 highwall			
End-of-mining	2.22	2.22	n/a
Interim pit lake			n/a
Long-term pit lake			n/a
<u>Titan North</u>			
Section 7* highwall			
End-of-mining	2.01	2.93	n/a
Interim pit lake			n/a
Long-term pit lake			n/a
<i>Note: *minimum FoS values based on revised landform design</i>			
<i>Source: Henderson Geotech (2026)</i>			

7.3.2 LOW WALL STABILITY

Low wall geotechnical stability assessment results are summarised in Table 7-4. The minimum FoS for NUMA (1.25) and woodland PMLU (1.35) was achieved for all cross-sections and for all assessment stages.

TABLE 7-4 GEOTECHNICAL STABILITY FOS RESULTS FOR FINAL VOID LOW WALLS

Location/Scenario	NUMA	Grazing/Creek PMLU	Woodland PMLU
<i>Design acceptance criteria</i>	1.25	1.50	1.35
<u>Pandora</u>			
Section 3 northern low wall			
End-of-mining	1.58	n/a	2.07
Interim pit lake	1.60	n/a	1.81
Long-term pit lake	1.39	n/a	1.70
Section 3 southern low wall			
End-of-mining	1.54	n/a	1.94
Interim pit lake	1.59	n/a	1.75
Long-term pit lake	1.38	n/a	1.70
<u>Titan East</u>			
Section 4 low wall			
End-of-mining	1.65	n/a	1.65
Interim pit lake		n/a	
Long-term pit lake		n/a	
Section 5 low wall			
End-of-mining	1.60	n/a	1.60
Interim pit lake	1.64	n/a	1.64
Long-term pit lake	1.64	n/a	1.64
<u>Titan North</u>			
Section 6 low wall			
End-of-mining	1.60	n/a	1.60
Interim pit lake		n/a	
Long-term pit lake		n/a	
<i>Source: Henderson Geotech (2026)</i>			

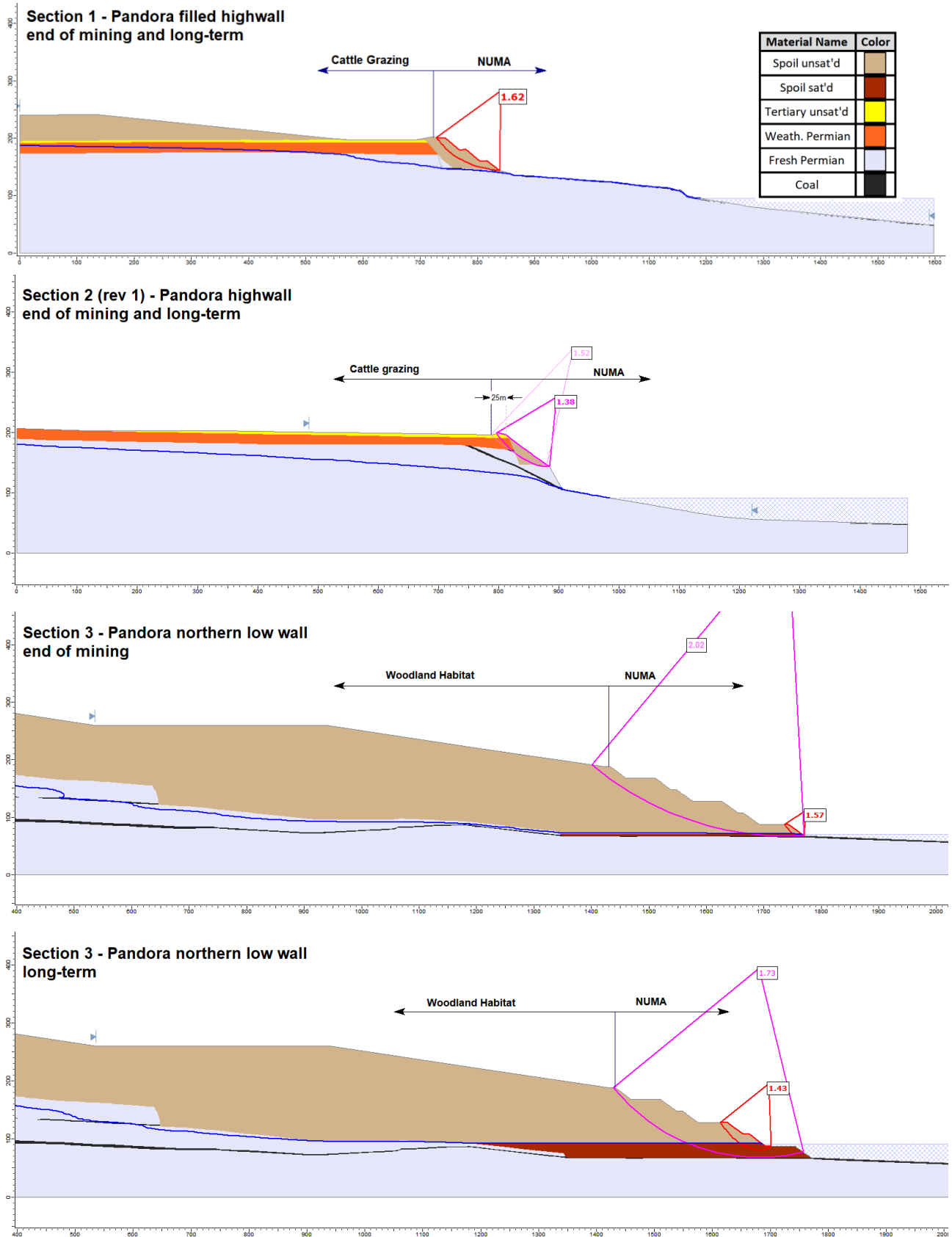


FIGURE 7-2 PANDORA VOID STABILITY ANALYSES CROSS SECTIONS (PART 1)

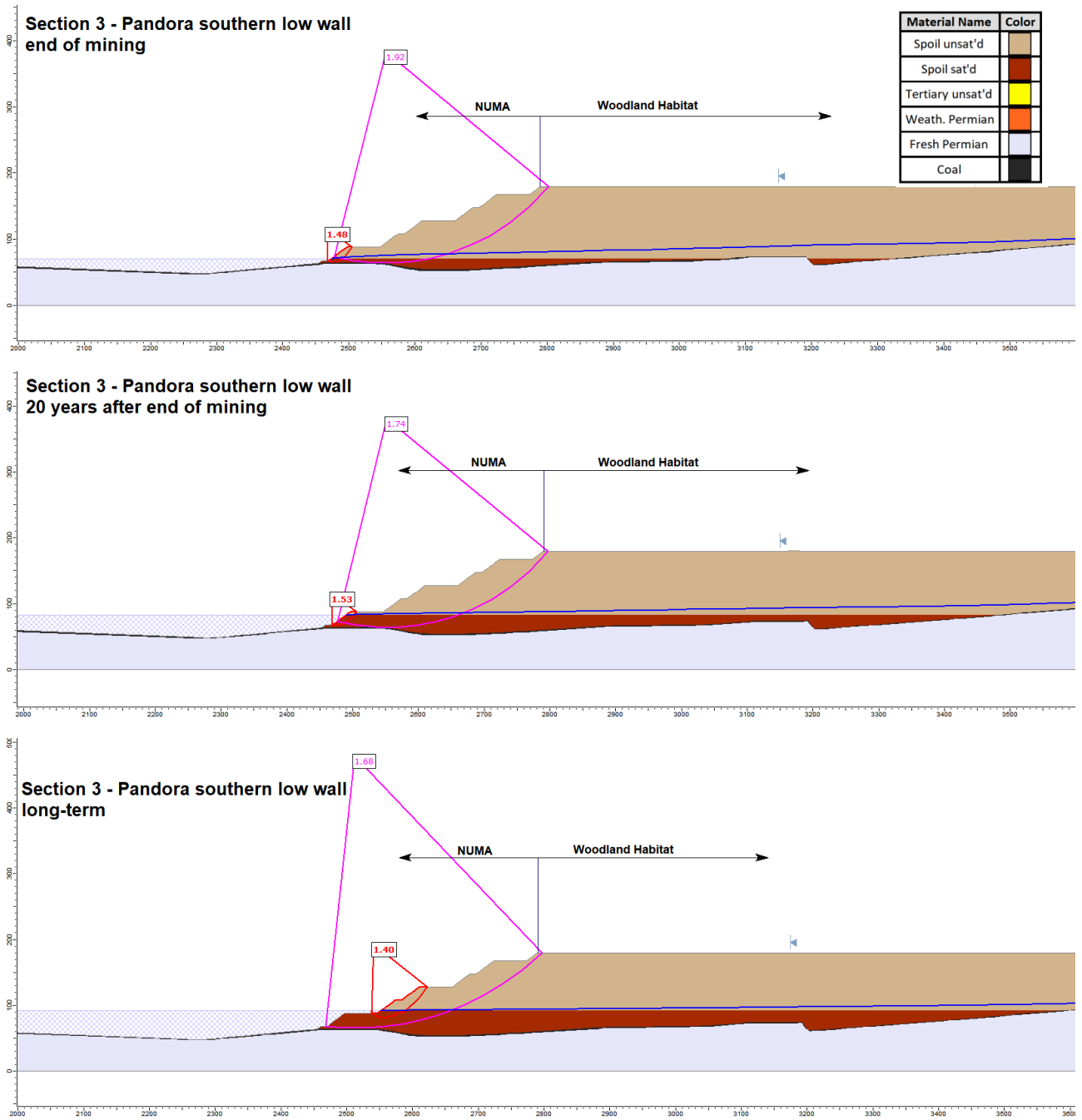


FIGURE 7-3 PANDORA VOID STABILITY ANALYSES CROSS SECTIONS (PART 2)

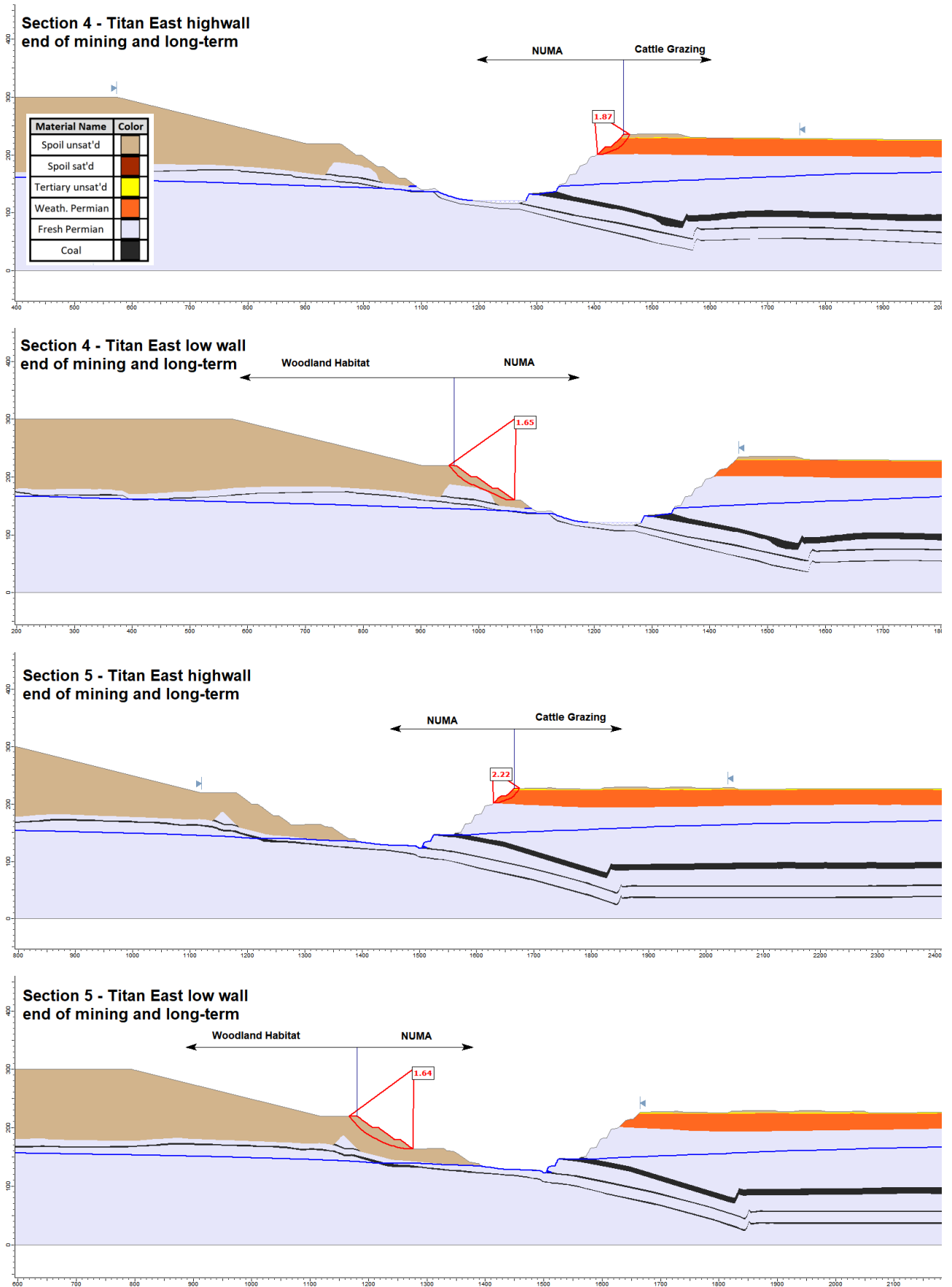


FIGURE 7-4 TITAN EAST VOID STABILITY ANALYSES CROSS SECTIONS

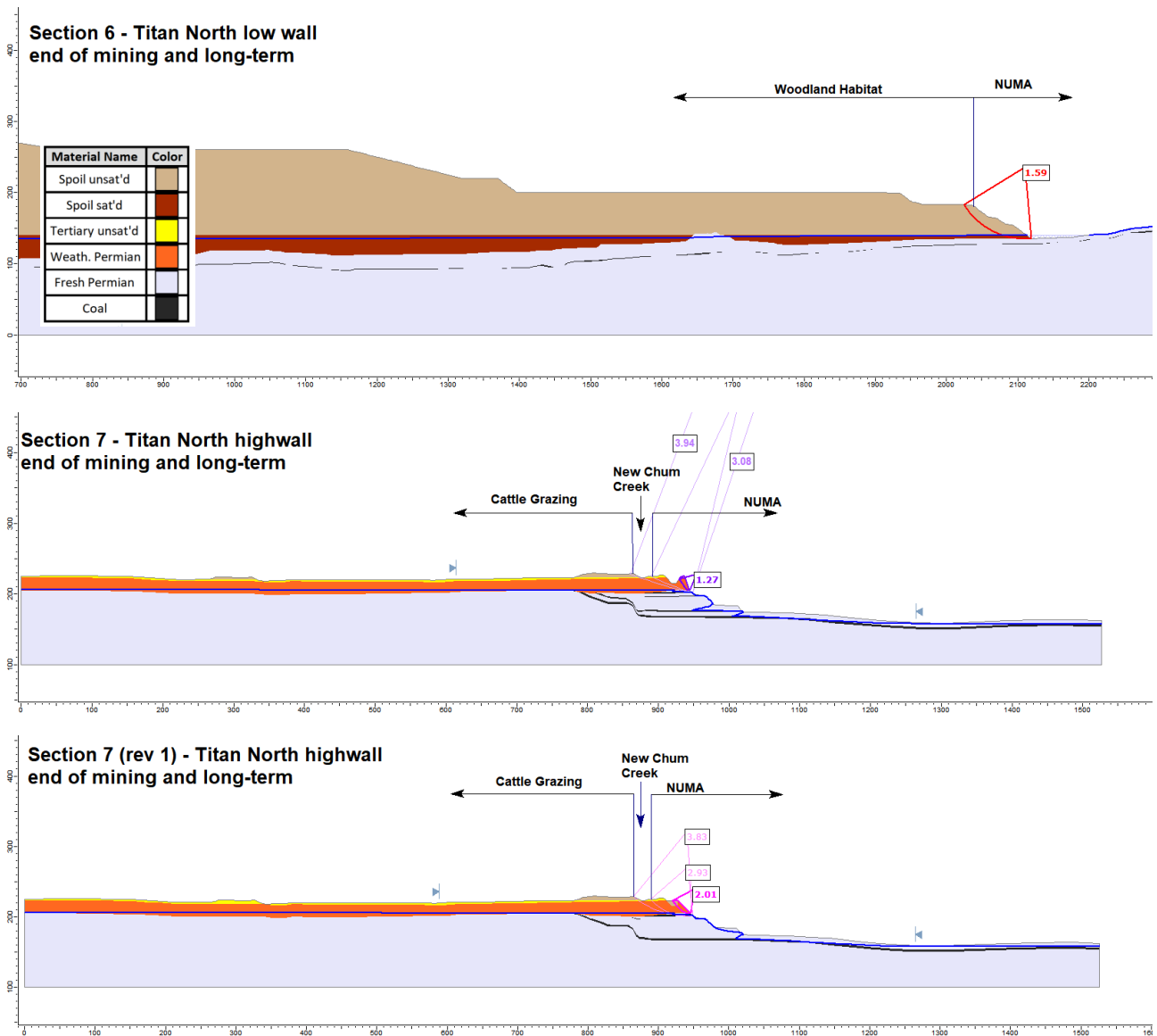


FIGURE 7-5 TITAN NORTH VOID STABILITY ANALYSES CROSS SECTIONS

7.4 CONCLUSION

Geotechnical stability assessment of the final landform void walls and slopes has been undertaken. The assessment did identify that some local iterations to the Pandora and Titan North highwalls were required to meet appropriate design acceptance criteria. The revised landforms at these two locations, and the final landform geometry represented in the modelled cross-sections have identified that the proposed void highwall and low wall slopes will meet appropriate design acceptance criteria (i.e. the relevant FoS).

8 GEOCHEMICAL STABILITY

This section evaluates long-term water quality in the void lakes, including potential stratification. It supports the PRCP requirements in Section 3.6.3 to assess potential environmental risks from salinity and contaminants.

A geochemical assessment was conducted to understand the geochemical risk of the void walls and evaluate long-term water quality in the DNM residual voids under closure conditions. The assessment aimed to:

- Predict the long-term evolution of void lake water quality;
- Assess the potential for environmental impact by comparing predicted water quality to EA groundwater trigger values; and
- Identify whether stratification may develop within the voids.

The PHREEQC modelling was based on water balance modelling outputs developed by WRM (2025) and covered a 500-year period (2045-2545)¹.

Limnology modelling was undertaken for a 110-year period due to model processing requirements. The period modelled is adequate as it evaluates the voids for numerous seasons after the water level in the void has stabilised.

Since completion of the original assessment presented in ERM (2025), updated water balance and groundwater modelling have been undertaken to reflect revisions to the final landform design. While these updates slightly modify the magnitude and timing of water inflows to the voids, they do not materially change the geochemical source terms, chemical weathering processes or dominant hydrochemical controls influencing void water quality. As such, the predicted long-term geochemical behaviour of the void lakes is not expected to change significantly.

8.1 GEOCHEMICAL STABILITY OF VOID WALLS

The geochemical characteristics of the materials that make up the residual void walls have been assessed to understand geochemical stability risks associated with the void walls. The assessment results are presented in full in MWM & TES (2025).

The materials within the highwall comprise weathered and fresh materials, with fresh materials making up most of the exposure material. As a conservative estimate, approximately 3-4% of the void highwalls for all residual voids were assumed to be PAF (see Table 8-3).

Overall, the assessment undertaken found that AMD generation from the highwalls of the residual voids is unlikely. The proportions of each material type estimated to be exposed in each residual void are shown in Figure 8-1 to Figure 8-3.

¹ Note: Section 6 presents updated void water balance modelling undertaken in 2026 following revisions to the final landform design to incorporate the OOPD. The geochemical modelling presented here is based on the WRM (2025) outputs as there was no material change to residual void lake levels in the 2026 void water balance model.

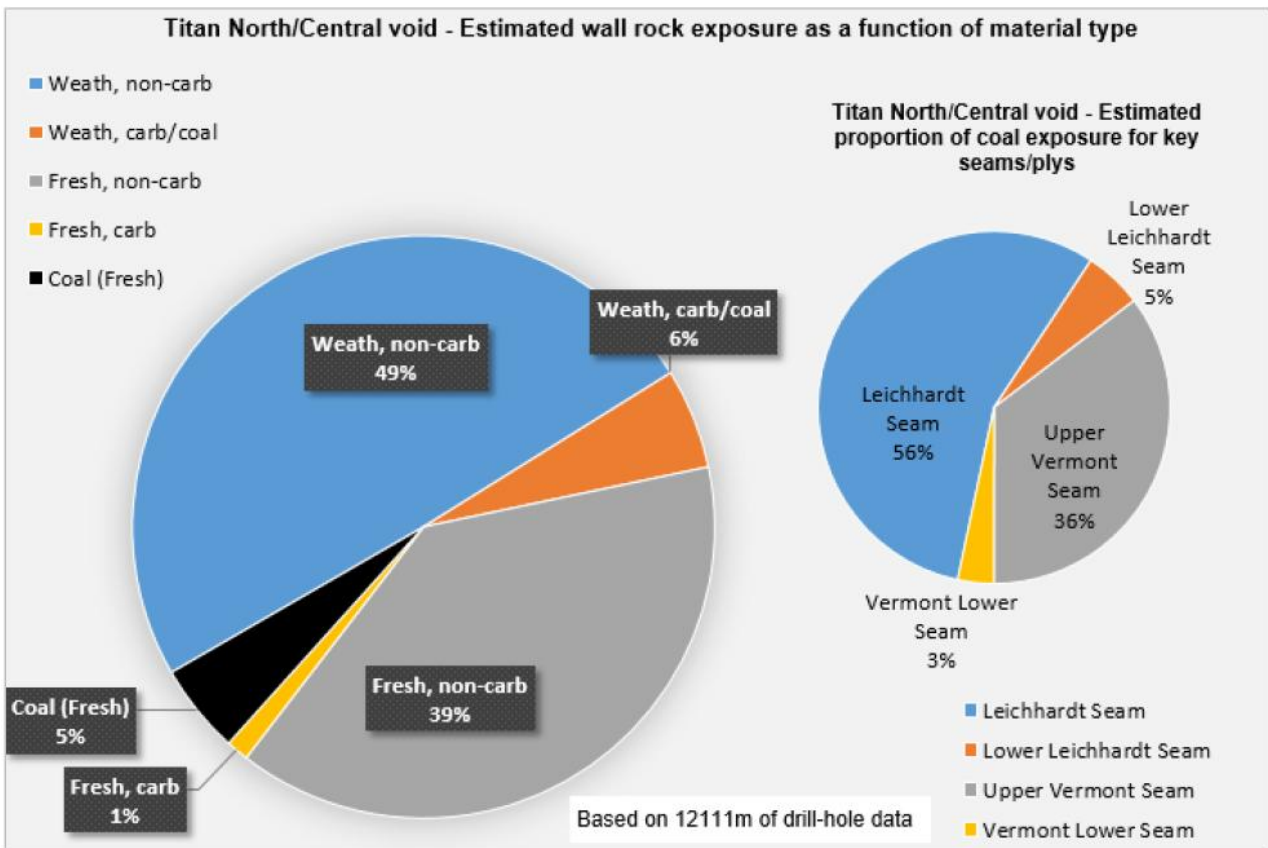


FIGURE 8-1 ESTIMATED TITAN NORTH/CENTRAL RESIDUAL VOID HIGHWALL EXPOSURE BY MATERIAL TYPE (MWM & TES, 2025)

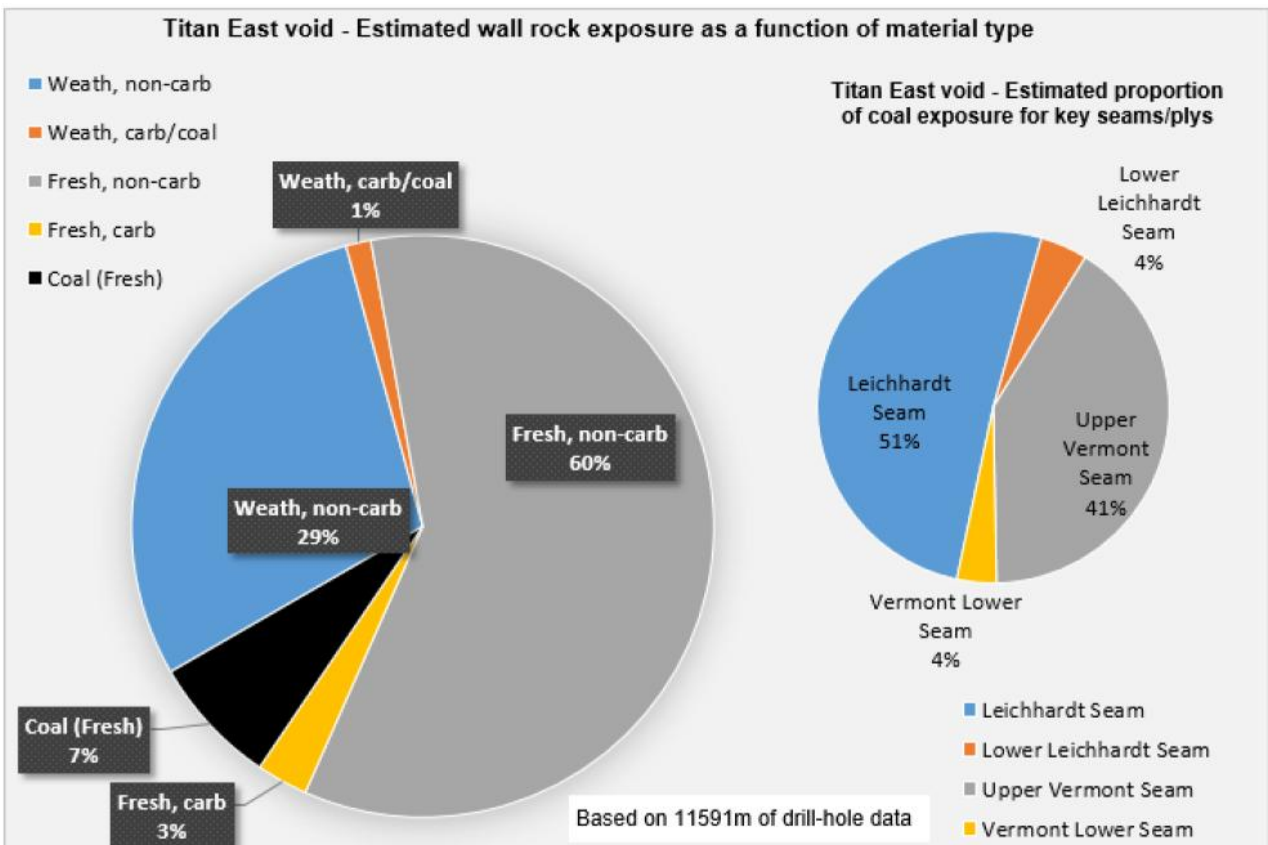


FIGURE 8-2 ESTIMATED TITAN EAST RESIDUAL VOID HIGHWALL EXPOSURE BY MATERIAL TYPE (MWM & TES, 2025)

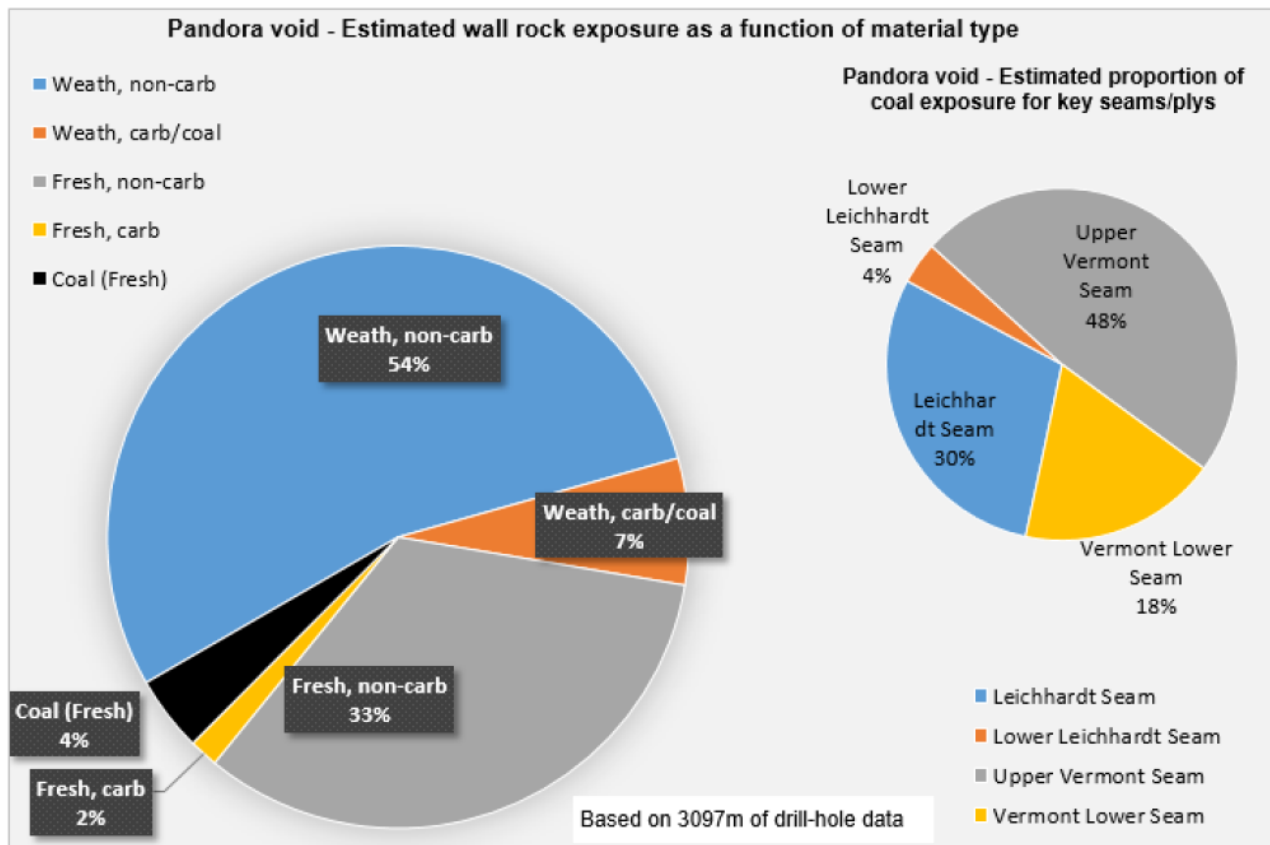


FIGURE 8-3 ESTIMATED PANDORA RESIDUAL VOID HIGHWALL EXPOSURE BY MATERIAL TYPE (MWM & TES, 2025)

8.2 GEOCHEMICAL VOID WATER QUALITY

A geochemical water quality model was developed using PHREEQC (Parkhurst, 2013) with the minteq.v4 thermodynamic database. The Pandora residual void lake was modelled to simulate the evolution of pH, major ions and selected metal(loid)s in monthly timesteps over 500 years and the results were compared to EA trigger levels.

Key features:

- Sources of water were combined at monthly timesteps based on GoldSim-derived water balance in- and outflows (WRM, 2026b).
- Modelling was incremental, using each previous timestep's pit water composition as input for the next.
- The effect of geochemical processes on void lake water quality was investigated: mineral precipitation/dissolution, gas exchange (O_2 and CO_2) and sorption on ferrihydrite.

The assumptions in Table 8-1 were applied in the PHREEQC modelling to represent long-term equilibrium behaviour. These are standard for pit lake geochemical simulations and are designed to isolate chemical processes from hydrodynamic and biological effects.

TABLE 8-1 PHREEQC MODEL ASSUMPTIONS AND IMPLICATION

Assumption	Description and Rationale	Potential Implications
Fully mixed water column	<ul style="list-style-type: none"> The model assumes a single, well-mixed lake with uniform chemistry. This is standard in equilibrium modelling, as PHREEQC does not simulate physical stratification. Mixing and layering are addressed separately in the GLM limnology model (Section 8.4). 	<ul style="list-style-type: none"> Reasonable and typical assumption. Physical stratification is treated elsewhere, so this does not affect the chemical equilibrium interpretation.
Instant (equilibrium) geochemical reactions	<ul style="list-style-type: none"> Reactions are assumed to occur rapidly enough to reach equilibrium each timestep. This isolates equilibrium trends without the complexity of kinetic rate data. 	<ul style="list-style-type: none"> Conservative assumption. Real systems may react more slowly, meaning actual chemical change would occur more gradually than modelled.
No initial mineral solids	<ul style="list-style-type: none"> The model begins with dissolved inputs only, allowing minerals to precipitate or dissolve dynamically based on evolving water chemistry. 	<ul style="list-style-type: none"> Ensures secondary mineral formation is simulated directly.
No solute release from submerged wall rock or spoil	<ul style="list-style-type: none"> Once submerged, wall rock and spoil are assumed to have negligible ongoing leaching. Any early solute release is represented through the inflow source terms. 	<ul style="list-style-type: none"> Reasonable for closure conditions. Supported by low PAF proportions (<5 %) and realistic neutralising capacity of bulk spoil. Minor early leaching would have limited long-term impact.
Methane release negligible	<ul style="list-style-type: none"> Anaerobic methane generation is excluded due to low organic content and strongly oxidising conditions expected in the lake. 	<ul style="list-style-type: none"> Very low likelihood of significant methane production; exclusion has negligible influence.
No biological processes simulated	<ul style="list-style-type: none"> Microbial reactions (e.g. sulfate reduction, iron oxidation) are not included, as PHREEQC does not handle biological kinetics. 	<ul style="list-style-type: none"> Typical for long-term models. Biological effects may locally alter redox conditions but are unlikely to change the overall geochemical trajectory.

A sensitivity analysis was conducted to examine the influence of geochemical controls on predicted water quality (Table 8-2).

TABLE 8-2 PHREEQC SENSITIVITY ANALYSIS PARAMETERS

Simulation	Atmospheric CO ₂ Equilibrium	Oxic/Anoxic Conditions	Mineral Precipitation	Surface Sorption
Geochemical controls (C)	Equilibrium at partial pressure 10 ^{-3.37} atm (~430 ppm) ¹	O ₂ equilibrium at partial pressure 10 ⁻¹¹ atm (pe ≈ 8.5; Eh ≈ 0.5 V)	Equilibrium	Adsorption onto precipitated ferrihydrite (Fe(OH) ₃) particle surfaces with specific surface area of 60 m ² /g.
No geochemical controls (NC)	No CO ₂ equilibrium	No O ₂ equilibrium	No equilibrium	No sorption

¹ 430 ppm is representative of 2025 atmospheric CO₂ concentrations. Any future change of CO₂ levels in the atmosphere is not included in current model scenarios.

8.2.1 MODELLING APPROACH

Geochemical modelling was undertaken only for the Pandora residual void, as it represents the hydraulically and geochemically dominant feature within the post-closure landform.

Groundwater and water balance modelling (Sections 4 and 6) indicate that the surrounding residual voids are subject to high rates of seepage through spoil material toward Pandora, resulting in predicted lake depths of approximately 5 m or less at the voids in the northern portion of the site. These voids therefore act as transient or ephemeral depressions rather than persistent waterbodies and are unlikely to sustain stable water columns or distinct geochemical evolution over time.

In contrast, the Pandora void is predicted to retain permanent water, remain a terminal sink, and control long-term water quality dynamics within the system. Consequently, detailed geochemical modelling of Pandora provides a representative and conservative assessment of post-closure water quality outcomes for the broader void complex.

8.2.2 VOID WALL MATERIAL COMPOSITION

The geochemical assessment considered how different geological and mine waste materials at DNM may interact with water and influence solute release or immobilisation. Key interactions included rainfall and runoff contacting highwall lithologies, spoil, rejects, tailings and natural catchments. Infiltration into wall rock and spoil pore water was not modelled explicitly, as any associated solute release is represented within the source term chemistry for seepage and runoff.

Table 8-3 presents the proportion of excavated highwall exposure by lithology grouping for each residual void. In addition, an estimation of PAF material content for each void is included. Their distributions for each residual void were estimated using stratigraphic data from drill holes. Materials with unknown classifications were reassigned to carbonaceous or non-carbonaceous groups based on estimated carbonaceous content.

TABLE 8-3 ESTIMATED PERCENTAGES OF EXPOSED LITHOLOGIES AND PAF MATERIAL IN THE RESIDUAL VOID HIGHWALLS

Lithology Grouping	Titan East	Titan North/Central	Pandora	PAF Content
Weathered non-carbonaceous	29.1%	49.5%	54.0%	<2%
Weathered carbonaceous/coal	1.4%	5.6%	7.0%	5%
Fresh non-carbonaceous	59.5%	38.7%	33.2%	<2%
Fresh carbonaceous	2.9%	1.2%	1.6%	5%
Fresh coal	7.2%	5.0%	4.2%	44%
Total PAF (by proportion)	2.5%	3.5%	4.0%	-
<i>Source: WSP (2023) and MWM (2025)</i>				

8.2.3 GEOCHEMICAL SOURCE TERMS

Presented in Table 8-4 are the types of water inflows considered in the pit lake model, along with their associated source term assumptions and data sources. These inputs are used to characterise the geochemical behaviour of each inflow type contributing to the residual voids.

TABLE 8-4 SUMMARY OF DATA USED TO CALCULATE GEOCHEMICAL SOURCE TERMS

Water Inflow Type	Comment	Data Source
Rehabilitated catchment/in-pit spoil runoff	Represented by leachate data from fresh non-carbonaceous drill core samples.	DNM drill core database
Highwall runoff	Based on exposed lithological domains on the highwall. Drill core databases were used to derive source terms for each lithological domain/grouping.	
Groundwater inflow	Median water quality from the DNM groundwater database during the time period 2009-2025.	DNM groundwater database
Seepage inflow	Represents water infiltrating spoil and co-disposed rejects before entering the void. Chemistry derived from combined tailings/reject leachate and groundwater data to account for mixing and solute enrichment during subsurface flow.	DNM groundwater database and DNM spoil and rejects analytical results by ALS in 2024
Direct rainfall	Characterised using rainfall chemistry data from the Newcastle region (77 samples from 11 rainfall events), adjusted for charge balance.	Evans (2006)

PHREEQC source terms used in the Pandora geochemical assessment are in Table 8-5. The water types in the column headings represent the chemical compositions used for each inflow source in the PHREEQC model. These correspond directly to the flow pathways identified in the GoldSim water balance (Section 6) and define the solute chemistry for each contributing water type entering the Pandora void:

- **Groundwater (rock and spoil):** Represents groundwater inflows predicted by the hydrogeological model. "Rock" refers to flow through natural geological formations, while "spoil" reflects groundwater that has migrated through spoil material and therefore exhibits slightly elevated alkalinity and salinity due to interaction with reactive minerals.
- **Seepage:** Represents near-surface water moving laterally or vertically through spoil and co-disposed rejects before discharging to the void. Unlike groundwater inflow, seepage originates from rainfall infiltration and has a shorter residence time, often showing greater solute variability due to interaction with fine-grained or carbonaceous materials.
- **Rainfall:** Represents direct precipitation onto the pit lake surface, derived from regional rainfall chemistry data. Rainfall contributes minimal solute load and acts primarily as a dilution source.
- **Runoff (rehabilitated and highwall):** Represents surface runoff entering the pit lake. Chemistry varies depending on the contributing land surface: rehabilitated catchments (typically low salinity, slightly alkaline) and exposed highwall lithologies. The highwall runoff is further subdivided into lithological groupings (weathered/fresh, carbonaceous/non-carbonaceous, and coal) to capture the range of expected solute compositions.
- **Highwall composite:** A weighted average of the individual highwall runoff chemistries, representing the combined inflow from all wall types in the overall pit lake mass balance.

TABLE 8-5 PHREEQC GEOCHEMICAL SOURCE TERMS FOR GROUNDWATER, DIRECT RAINFALL AND LITHOLOGIES (HIGHWALL RUNOFF) FOR PANDORA

Solution	Unit	Groundwater		Seepage	Rainfall	Runoff						
		Rock	Spoil			Rehabilitated	Highwall				Highwall Composite	
Description	-	Based on PZ04 monitoring data	Based on 1:1 rock and seepage geochemistry	From tailings/reject geochemistry + groundwater chemistry	Evans (2006)	Fresh non-carbonaceous	Weathered non-carbonaceous	Weathered carbonaceous	Fresh non-carbonaceous	Fresh carbonaceous	Fresh coal	Weighted composite
pH	-	7.60	8.00	8.00	5.00	9.20	8.50	8.20	9.20	9.20	8.00	8.70
pe	-	4.00	6.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
C(4) as CaCO ₃	mg/L	332 ¹	1,220 ¹	2,110 ¹	-	80.0	67.5	74.3	80.0	23.0	23.0	69.5
S(6) as SO ₄		400	429	458	8.00	18.0	9.00	12.0	18.0	19.0	24.5	13.0
Cl		6,580	6,588	6,600	14.0	75.1	109	85.6	75.1	74.3	67.4	93.7
Ca		542	549	556	3.00	3.00	7.50	11.6	3.00	0.75	14	6.46
Mg		437	440	443	-	2.00	4.80	8.80	2.00	0.50	7.00	4.17
Na		3,040	3,060	3,080	9.00	68.0	73.2	47.0	68.0	62.0	30.5	67.7
K		15.0	16.0	17.0	-	6.00	2.00	2.40	6.00	3.00	2.00	3.37
Fe(II)		2.09	2.09	2.09	-	-	-	-	-	-	-	-
Mn		-	-	0.02	-	-	-	-	-	-	-	-

Note: ¹ as HCO₃

8.3 WATER QUALITY RESULTS

Table 8-6 compares simulated water quality results from the controlled (C) and no-controls (NC) runs against ANZG (95% species protection) guidelines and PZ04 EA trigger levels (Table I2 in EPML0056193) over the 500-year simulation period. Results are presented at 100-year intervals for the key parameters Fe, Mn, NO₃, SO₄, pH and EC. The table highlights when exceedances occur and illustrates the distinct geochemical trajectories produced by the two model configurations.

Note that the comparison to the PZ04 EA groundwater trigger levels is provided for context only, as the Pandora void is a NUMA and not subject to specific water quality criteria. The triggers offer a relevant local reference point given the proximity of PZ04 to the void and help illustrate how predicted water quality compares with surrounding groundwater conditions, rather than representing compliance requirements.

With geochemical controls, the system evolves toward increasingly saline, acidic and oxidising conditions, where sulfate is almost entirely removed and trace metals remain largely immobilised. The low Fe and Mn levels indicate strong mineral buffering and secondary phase formation that limit metal mobility despite declining pH. Over time, the system approaches geochemical stability as redox potential remains high and mineral equilibria constrain further changes in solute composition. The persistence of strongly oxidising conditions promotes formation of ferric oxyhydroxides and other secondary minerals that sequester Fe, Mn, and sulfate, leading to a self-regulating water chemistry dominated by steady-state ion balances. Although salinity continues to rise, the chemical evolution slows as the system nears equilibrium.

As detailed in Table 8-2, the term controlled refers to a conceptual scenario where geochemical reactions and mineral equilibria are allowed to influence solute behaviour, representing natural self-regulation processes that may develop over time. The uncontrolled case represents a purely conservative condition with no geochemical feedbacks, used to illustrate the potential chemical trajectory if such reactions did not occur. These scenarios are not management options, but simplified representations used to illustrate the possible range of pit lake behaviour under different geochemical conditions.

In contrast, the uncontrolled system maintains near-neutral pH and moderate redox potential, allowing continued accumulation of dissolved salts and sulfate and leading to elevated Fe and Mn concentrations.

Overall, the controlled system achieves greater geochemical stability through mineral precipitation and redox control but at the cost of higher salinity and lower pH, whereas the uncontrolled system remains more alkaline but chemically dynamic, with ongoing solute accumulation and limited internal buffering.

Note that PHREEQC reports total dissolved solids (TDS) instead of electrical conductivity (EC). To calculate EC, the ionic conductivity method was applied: final ion concentrations (Na, K, Ca, Mg, Cl, SO₄, HCO₃, NO₃, Fe) were converted from mg/L to mol/L, then multiplied by their known molar ionic conductivities at infinite dilution (Λ^0 , unit: Siemens (S) cm²/mol at 25°C). These contributions were summed and converted to $\mu\text{S}/\text{cm}$.

TABLE 8-6 PANDORA PHREEQC RESULTS SUMMARY – EA TRIGGER-LEVEL AND GUIDELINE COMPARISON

Run		Fe	Mn	SO ₄	pH	EC	pe
<i>Unit</i>		<i>mg/L</i>	-			<i>μS/cm</i>	-
<i>ANZG Guideline (Freshwater Aquatic Ecosystem 95% Protection)</i>		<i>0.28</i>	<i>1.9</i>	-	-	-	-
<i>EA Trigger Level for the PZ04 Groundwater Monitoring Bore</i>		<i>4.2</i>	-	<i>490</i>	<i>6.5-8.5</i>	<i>20,100</i>	-
Geochemical Controls (C)	Year 100	0.00273	0.0175	0.162	6.17	31,100	12.1
	Year 200	0.00536	0.0297	0.0327	5.90	54,100	12.4
	Year 300	0.00903	0.0438	0.0114	5.70	80,800	12.6
	Year 400	0.0140	0.0585	0.00503	5.52	109,000	12.8
	Year 500	0.0201	0.0740	0.00231	5.35	139,000	12.9
No Geochemical Controls (NC)	Year 100	2.68	0.0174	595	7.99	33,100	8.43
	Year 200	4.65	0.0294	1,030	7.88	57,300	8.55
	Year 300	6.84	0.0429	1,520	7.79	84,500	8.71
	Year 400	9.08	0.0564	2,020	7.71	112,000	8.81
	Year 500	11.3	0.0699	2,520	7.63	140,000	8.89

Note: Values outside reference levels are marked in **bold**.

8.3.1 RESULTS DISCUSSION

This section presents an interpretation of the simulated geochemical evolution of the Pandora residual void over the 500-year modelling period, comparing outcomes from the geochemical control and no-controls scenarios. The discussion focuses on the major parameters of interest, i.e. pH, total dissolved solids and key ionic and redox species (Fe, Mn, SO₄) and evaluates these results against applicable EA trigger levels. Note that, for the analysis of predicted Mn concentrations, ANZG (95% freshwater species protection) guidelines were used as reference criteria, as no specific EA trigger levels for manganese are available.

Potential for thermal and chemical stratification within the Pandora residual void lake, and its influence on mixing and water quality, is assessed separately using the General Lake Model (GLM) limnological model (see Section 8.4).

8.3.1.1 ELECTRICAL CONDUCTIVITY AND IONS

The major ion data in Table 8-7 show that both the control and no-control runs display a progressive increase in salinity over the 500-year simulation.

Overall, both runs evolve toward hypersaline conditions, but their dominant chemistries diverge: the NC run remains enriched in sulfate and bicarbonate under near-neutral pH conditions, whereas the C run becomes dominated by NaCl and Mg, with progressive loss of alkalinity and sulfate under more acidic conditions. These differences represent simplified modelling cases rather than distinct physical outcomes, as the actual pit lake would likely show

a mix of oxidised surface water and reducing deep water that changes over time with stratification and mixing.

TABLE 8-7 PANDORA PHREEQC RESULTS – MAJOR IONS AND TDS

Run	Year	Na	K	Ca	Mg	Cl	SO ₄	HCO ₃	TDS
Unit	-	mg/L							
Geochemical Controls	100	4,040	21.5	422	556	8,610	0.16	0.83	13,600
	200	7,050	37.5	731	974	15,000	0.03	0.46	23,800
	300	10,500	55.8	1,090	1,450	22,400	0.01	0.30	35,500
	400	14,200	75.2	1,460	1,960	30,200	0.01	0.20	47,900
	500	18,100	95.8	1,860	2,500	38,500	0.00	0.14	61,000
No Geochemical Controls	100	4,030	21.4	720	572	8,590	595	185	14,600
	200	6,990	37.1	1,250	993	14,900	1,030	289	25,300
	300	10,300	54.7	1,840	1,460	22,000	1,520	372	37,300
	400	13,700	72.5	2,440	1,940	29,100	2,020	421	49,500
	500	17,100	90.5	3,050	2,420	36,400	2,520	436	61,800

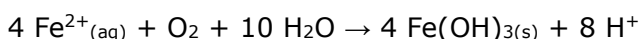
8.3.1.2 PH, IRON AND FERRIHYDRITE FORMATION

The pH response differed markedly between runs: in the NC run pH remained stable within the EA trigger range, whereas in the C run pH decreased after 200 years and remained below the trigger for the rest of the simulation, indicating progressive acidification.

Iron also followed different patterns. In the NC run, Fe concentrations increased steadily over time, exceeding guideline and trigger levels after 200 years. In the C run, Fe concentrations remain low.

The different pH and Fe trends reflect the behaviour of Fe(III) phases such as ferrihydrite under varying conditions. In the NC run, EQUILIBRIUM_PHASES was not applied, so minerals were not allowed to precipitate or dissolve. Fe concentrations therefore increased directly according to inflow chemistry and solubility.

In the C run, ferrihydrite precipitation was enabled. This kept Fe concentrations low as ferrihydrite was formed. However, this reaction is acid-generating as ferrihydrite, containing Fe(III), is formed from aqueous Fe(II) ions in the following redox reaction:



This reaction consumes oxygen but releases protons, contributing to the progressive decrease in pH. In a real pit lake, these processes would occur predominantly in the oxidised surface layer, while deeper waters may remain reducing until periodic destratification re-oxygenates the column.

8.3.1.3 COMPARISON OF SCENARIOS WITH AND WITHOUT GEOCHEMICAL CONTROLS

Figure 8-4 and Figure 8-5 show PHREEQC model results for the mid- rainfall scenario, comparing pit lake chemistry with and without geochemical controls. Both systems show

increasing solute concentration under evaporative conditions; however, but their pH, redox and metal behaviour trends differ significantly. The main outcomes are summarised below.

In the NC scenario, pH remains near-neutral and substantially while redox potential increases only slightly, indicating a moderately oxidising but chemically unbuffered system. Dissolved Fe and Mn concentrations increase steadily through time, while sulfate remains high due to the persistence of soluble Fe(II) and SO_4^{2-} in the absence of mineral equilibria. Total dissolved solids continue to rise throughout the simulation. Without mineral precipitation or redox buffering, the system does not approach equilibrium and remains chemically reactive.

In the C scenario, early equilibration with atmospheric oxygen produces rapid acidification and a substantial increase in redox potential, creating strongly oxidising conditions dominated by Fe(III) species. Extensive Fe(II) oxidation drives ferrihydrite formation, which removes Fe from solution and stabilises redox conditions. Although Mn and sulfate are not directly incorporated into ferrihydrite, their concentrations decline through secondary processes. Manganese oxidises to insoluble Mn(III/IV) oxides that co-precipitate with or adsorb onto ferrihydrite surfaces, while sulfate becomes partly immobilised through adsorption or incorporation into Fe(III) secondary minerals. These reactions collectively reduce dissolved Mn and sulfate, reinforce redox buffering and promote long-term chemical stability.

As ferrihydrite formation peaks and reactive Fe becomes depleted, the controlled system reaches a stable chemical state. Redox potential and pH remain relatively constant, and further changes in ionic composition are limited to gradual increases in salinity through evaporation. Although total dissolved solids continue to rise, the proportions of major ions become internally balanced and self-regulated, indicating that near-equilibrium conditions have been achieved.

Overall, both systems evolve toward more saline and oxidising conditions through time, but the controlled scenario better represents long-term behaviour, as redox and mineral equilibria would naturally develop over hundreds of years. In reality, the void lake would exhibit a dynamic balance between oxidised and reducing zones, with oxic surface waters and periodically anoxic deep layers that mix during destratification events. The uncontrolled results therefore serve only as a conservative comparison, illustrating how the chemistry might evolve in the absence of these natural buffering processes.

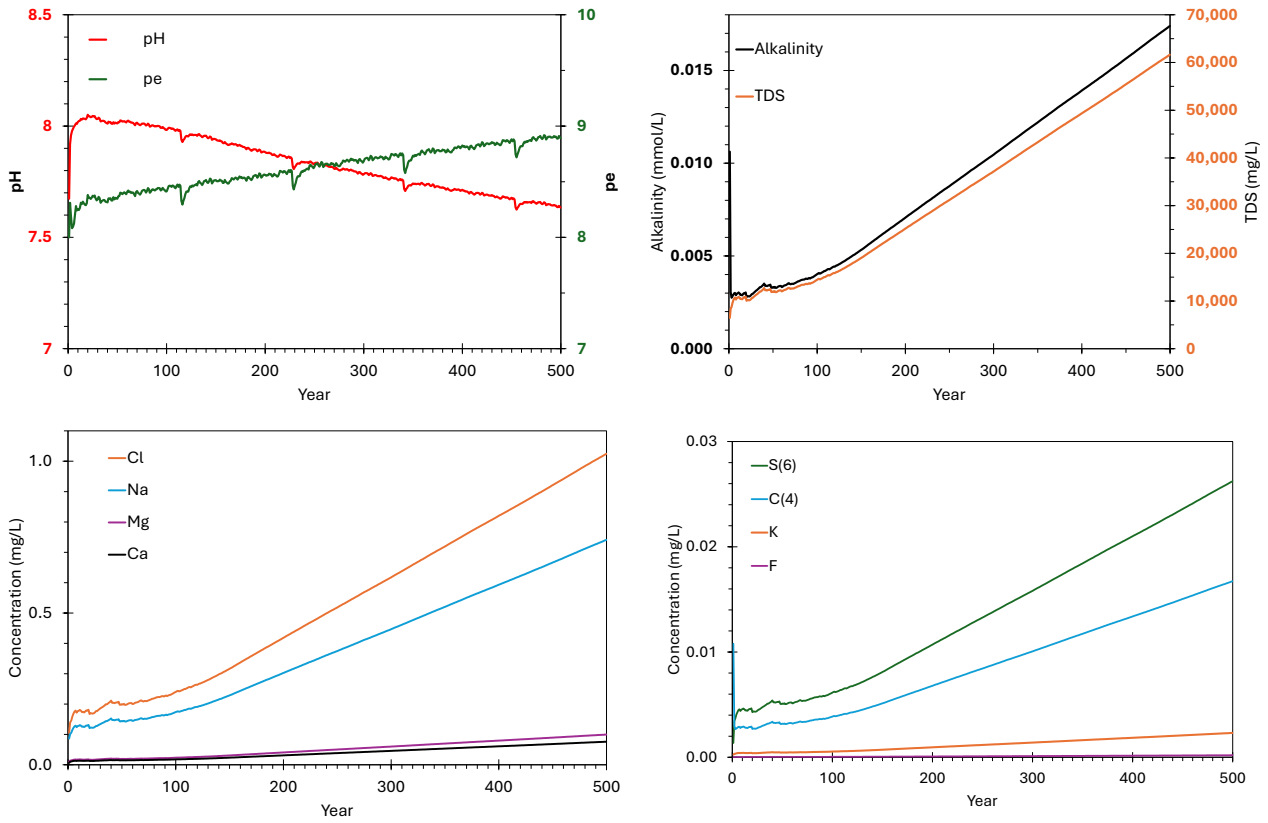


FIGURE 8-4 PHREEQC OUTPUT DATA – MID RAINFALL WITH **NO** GEOCHEMICAL CONTROLS

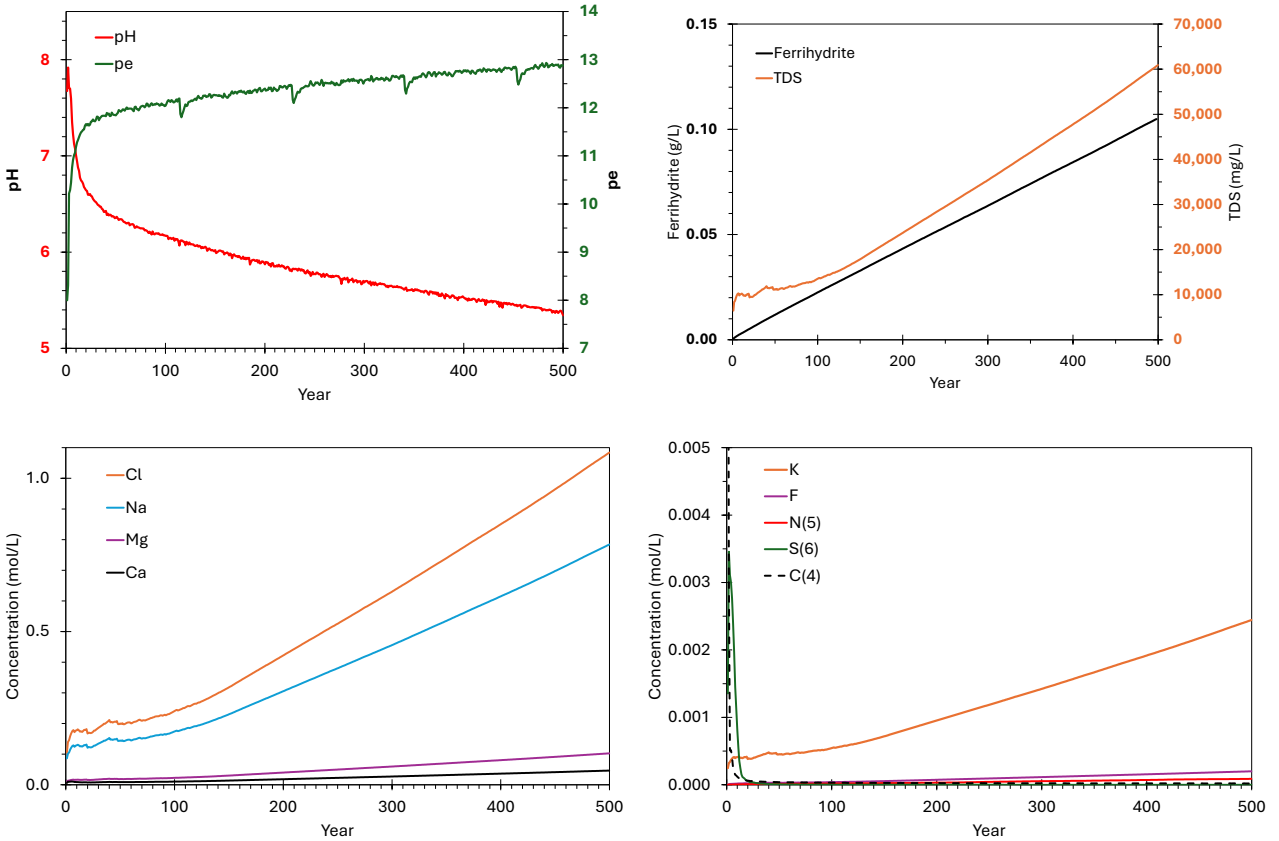


FIGURE 8-5 PHREEQC OUTPUT DATA – MID RAINFALL **WITH** GEOCHEMICAL CONTROLS

8.3.2 MODEL QUALIFICATIONS AND LIMITATIONS

- The geochemical model represents equilibrium conditions; kinetic effects and microbial redox reactions were not simulated.
- Input parameters were based on available groundwater chemistry and predicted inflow compositions; future data could refine these results.
- Void hydrodynamics were not explicitly simulated within PHREEQC; instead, mixing and aeration assumptions were informed by analogue post-mining lakes and supported by separate limnological modelling (see Section 8.4).
- Screening against EA criteria used the PZ04 groundwater trigger levels and ANZG 95% species protection values for context only, as the Pandora void is a NUMA and not required to meet specific water quality criteria.

8.4 LIMNOLOGY RESULTS

This section presents the limnology results from GLM modelling of the Pandora residual void over a 110-year period. Pandora was selected for detailed limnological modelling as it represents the only residual void expected to form a substantial pit lake, with a final water level of approximately 92 mAHD and a mean water depth of around 40 m. In contrast, the Titan North, Titan Central and Titan East voids are predicted to stabilise at much shallower depths (typically less than 10 m) and will behave as small, evaporation-dominated water bodies. Given the consistent climatic and hydrogeological setting across the Daunia site, the Pandora results provide a suitable analogue for understanding the general limnological behaviour of the other voids, noting that stratification and redox cycling will be less pronounced in the shallower systems.

8.4.1 CLIMATE SCENARIOS

Numerical limnology modelling was undertaken for the Pandora pit lake under three rainfall scenarios (low, mid and high) over the simulation period. Each scenario was assessed for thermal, salinity and density stratification and evolution. A summary of the results is provided below.

Figure 8-6, Figure 8-7 and Figure 8-8 display thermal, salinity and density stratification over the entire simulation period for each rainfall scenario.

8.4.1.1 THERMAL STRATIFICATION

Across all scenarios, the lake develops strong seasonal thermal stratification, with surface waters warming above 30-35°C during summer while hypolimnetic waters remain cooler (15-20°C) and relatively stable. A thermocline generally forms at 10-20 m depth, with its depth and strength varying seasonally in response to surface heating and cooling. Thermal stratification weakens in winter but typically re-establishes rapidly with the return of warmer conditions, and the overall extent and intensity are broadly similar between rainfall scenarios. This indicates that rainfall variability has limited effect on the lake's temperature profile compared to other factors, such as regional weather patterns and seasonal solar heating.

8.4.1.2 SALINITY STRATIFICATION

Salinity increases progressively throughout the 110-year simulation period, reflecting the combined influence of saline groundwater and seepage inflow, catchment runoff and

evaporative concentration. Early in the simulation, strong vertical stratification develops as saline groundwater accumulates at depth while fresher surface inflows occupy the upper layers. This initial halocline weakens as the lake deepens and seasonal mixing intensifies, resulting in full vertical mixing by approximately 30 years.

Beyond this period, the water column remains well mixed, with salinity increasing gradually and uniformly across all depths. By year 110, deep-water salinity (30 m depth) reaches approximately 9.4 g/L under low rainfall, 10.5 g/L under mid rainfall, and 9.8 g/L under high rainfall. Differences between scenarios are minor and primarily reflect variations in evaporative concentration rather than rainfall volume. Overall, the model results indicate limited potential for long-term salinity stratification, with the lake maintaining a vertically homogeneous salinity profile over the long term.

8.4.1.3 DENSITY STRATIFICATION

Density stratification persists under all rainfall scenarios, driven by the combined influence of temperature and salinity. In the low rainfall case, density differences between surface and deep waters increase steadily, promoting long-term stability of the density gradient and limited deep mixing. Under mid and high rainfall conditions, periodic partial overturns are indicated, particularly during cooler winter periods when the density gradient weakens substantially. These seasonal mixing events temporarily reduce stratification and allow partial homogenization of the upper and mid-depth layers, although complete and sustained mixing is not achieved.

8.4.1.4 SUMMARY

Overall, thermal effects exert the dominant control on short-term stratification, with surface heating generating strong seasonal density contrasts. However, over the long term, salinity accumulation becomes increasingly important in reinforcing the density gradient - particularly under drier conditions - resulting in a progressively stronger and more persistent stratification. As a result, the Pandora pit lake is expected to remain meromictic under low rainfall conditions, weakly meromictic or monomictic under mid rainfall, and largely holomictic under high rainfall, with rainfall intensity and inflow regime exerting a key influence on long-term mixing behaviour and water quality outcomes.

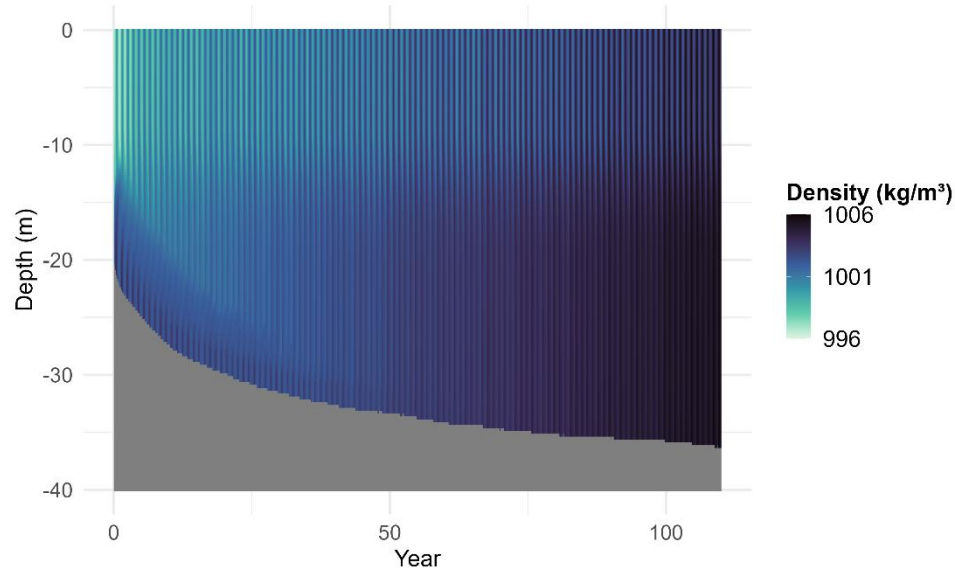
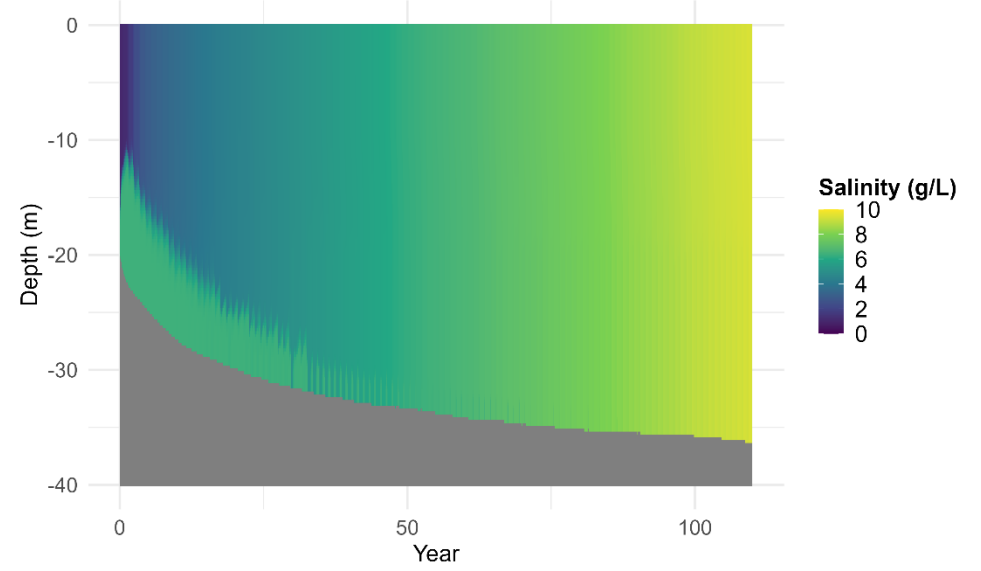
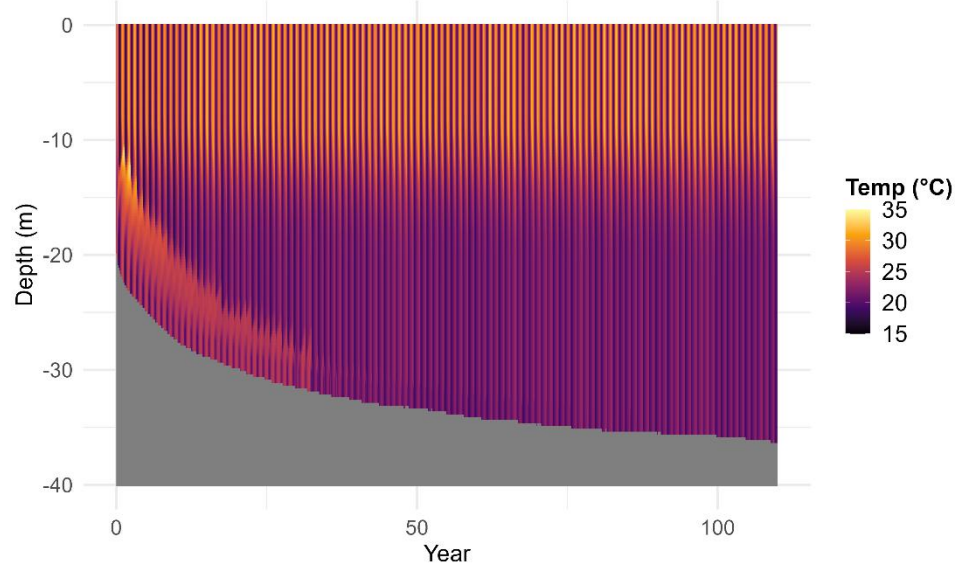


FIGURE 8-6 PANDORA THERMAL, SALINITY AND DENSITY STRATIFICATION OVER 110 YEARS – LOW RAINFALL

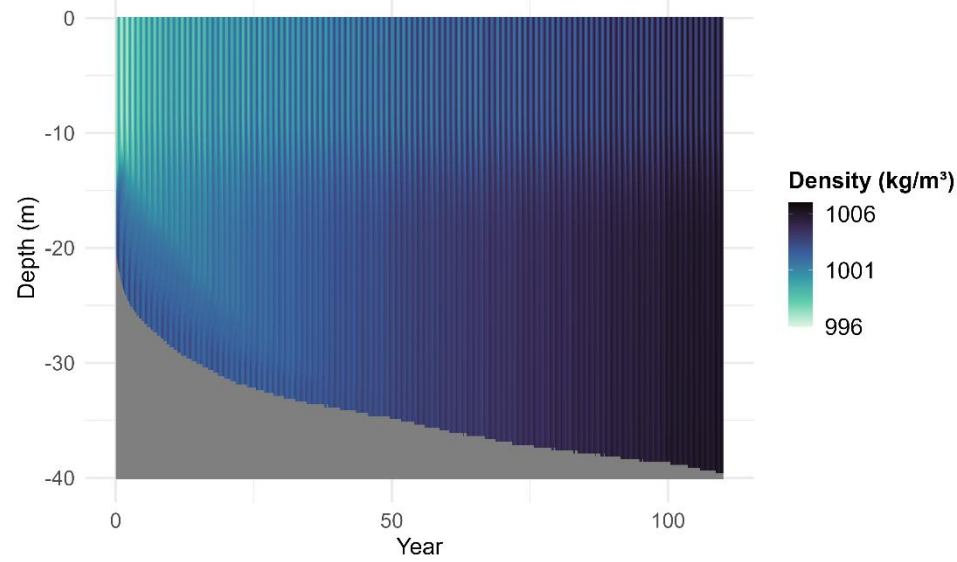
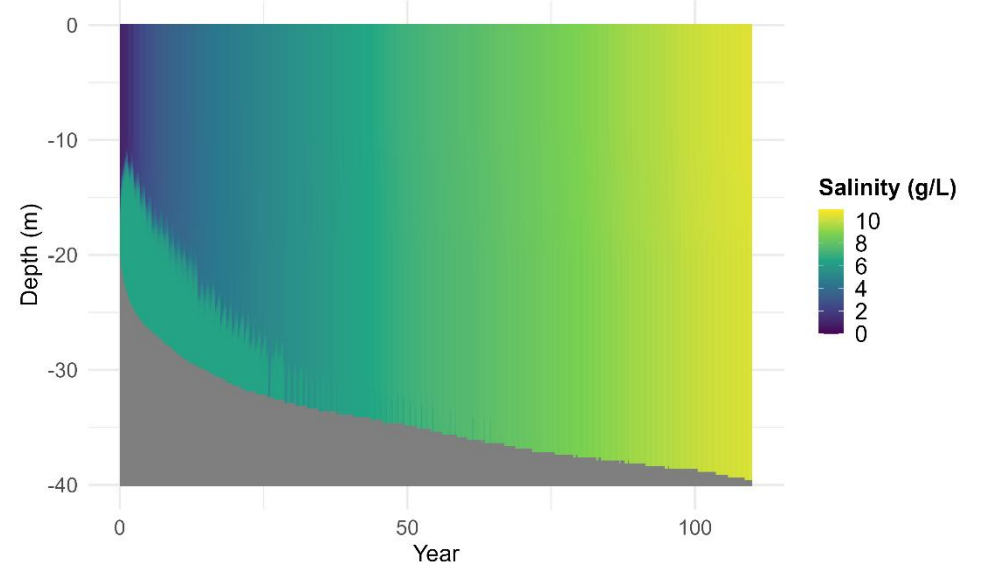
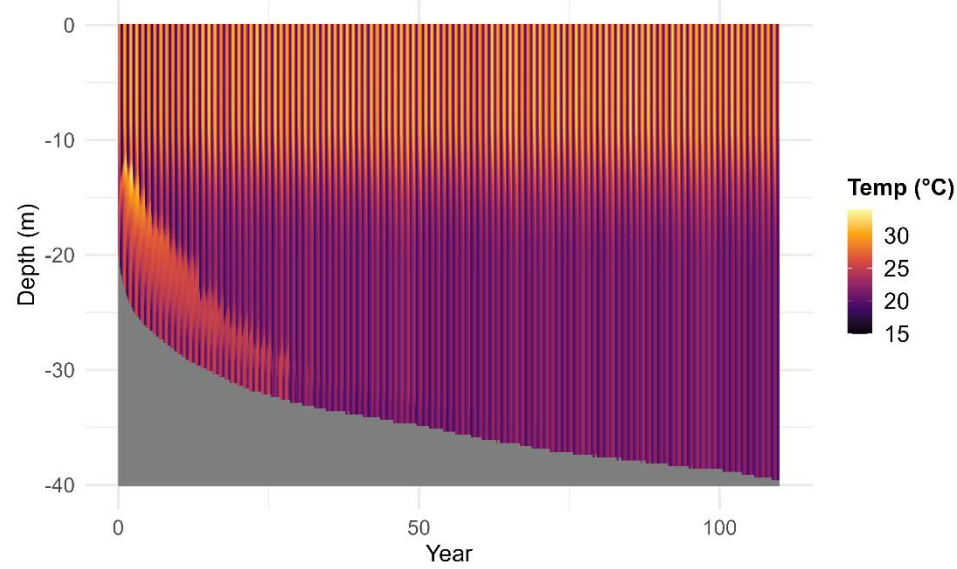


FIGURE 8-7 PANDORA THERMAL, SALINITY AND DENSITY STRATIFICATION OVER 110 YEARS – MID RAINFALL

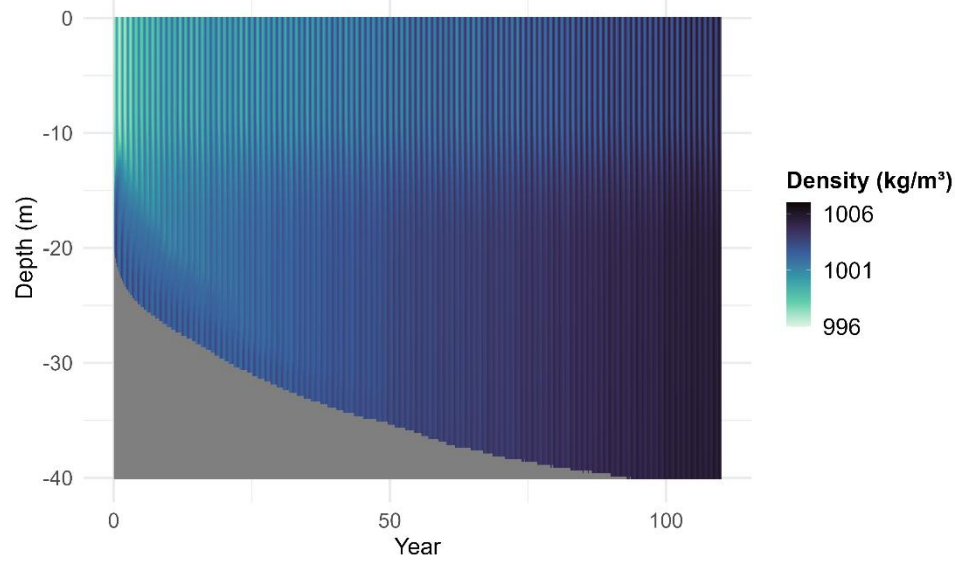
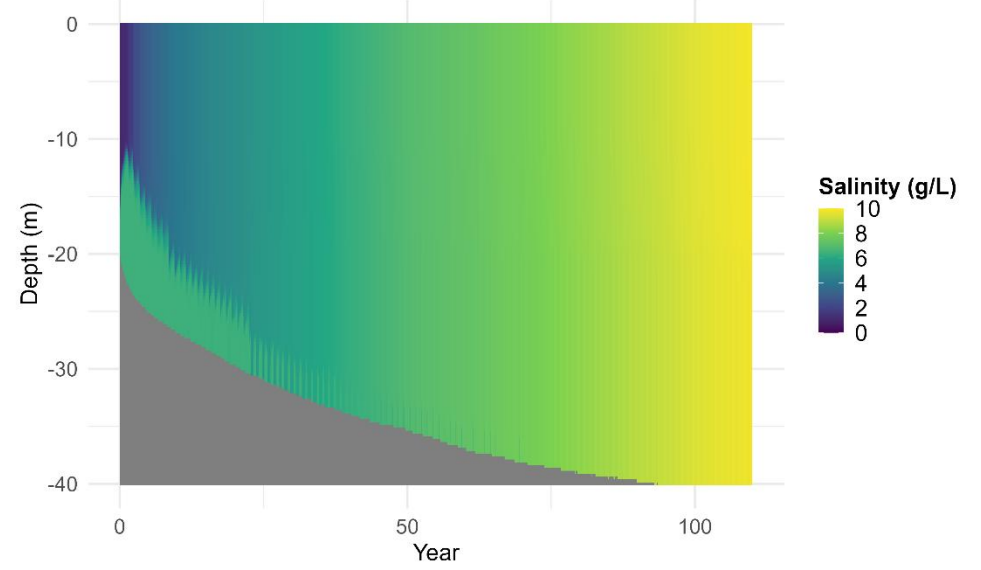
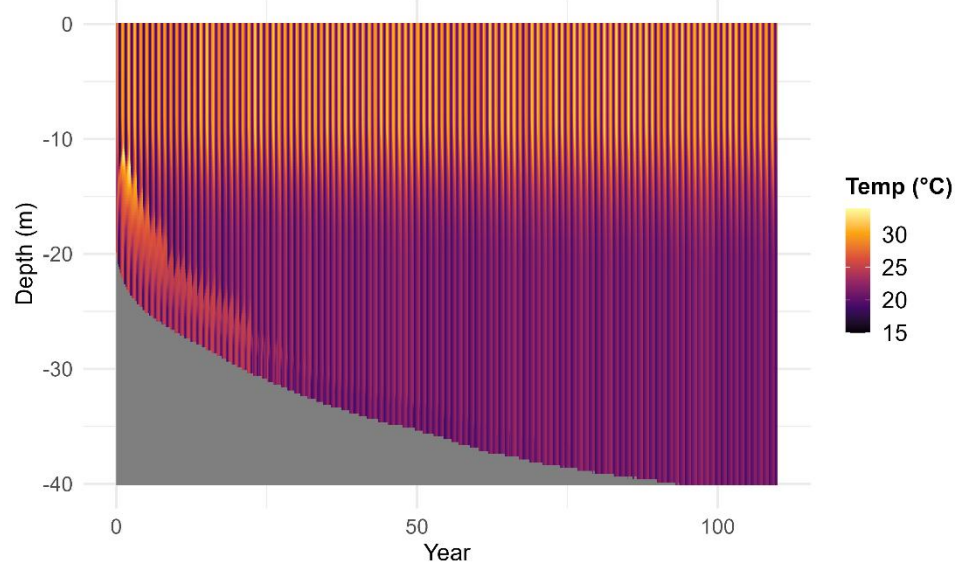


FIGURE 8-8 PANDORA THERMAL, SALINITY AND DENSITY STRATIFICATION OVER 110 YEARS – HIGH RAINFALL

8.4.2 TEMPORAL LIMNOLOGICAL EVOLUTION

This section examines the development of limnological conditions over time within the Pandora pit lake over the simulation period. The analysis was undertaken to understand how temperature, salinity and density stratification behaviours evolve over time, and to determine whether persistent stratification, seasonal mixing or long-term stability is likely to occur.

The primary aim of this assessment is to characterise the timing and progression of key physical processes that influence water column behaviour. This includes the onset and breakdown of stratification, the establishment of seasonal overturn and the approach toward long-term equilibrium.

Table 8-8 summarises the simulated temporal variations across the 110-year period during significant decades, representing early filling, mid-term transition and long-term equilibrium stages of pit lake development. As rainfall scenario differences have minimal influence on the overall limnological behaviour, Figure 8-9, Figure 8-10 and Figure 8-11 present results for the mid-rainfall scenario during the significant decades to illustrate the representative depth-dependent trends in temperature, salinity and density through time.

TABLE 8-8 SUMMARY OF PANDORA LIMNOLOGY RESULTS – TEMPORAL VARIATIONS

Aspect	Significant Decade	Results Summary
Thermal	Years 0-10	<ul style="list-style-type: none"> • Strong, seasonal thermal stratification forms each summer. • Warm surface waters overlies cooler deep waters. • The thermocline appears around 10-20 m, occasionally deepening toward 25 m. • Each winter, the water column mixes nearly to the bottom, showing complete or near-complete overturn.
	Years 20-30	<ul style="list-style-type: none"> • The same seasonal pattern continues, but the gradient becomes more consistent and slightly deeper. • Surface heating remains strong, but cooling penetrates deeper, indicating annual monomictic cycling (one main mixing period per year). • The lower layer (~30-35 m) stays relatively stable and cool.
	Years 100-110	<ul style="list-style-type: none"> • Surface warming and winter mixing persist. • No evidence of long-term thermal isolation or stratification. • The lake behaves as a monomictic system with recurring seasonal stratification that fully mixes each winter. • Deep temperature remains steady (~17-18°C).
Salinity	Years 0-10	<ul style="list-style-type: none"> • Strong stratification develops immediately, with high salinity accumulating at depth due to saline groundwater inflow. • The lower 20-30 m becomes distinctly more saline, while surface water remains fresh. • The gradient strengthens rapidly during this period.
	Years 30-40	<ul style="list-style-type: none"> • The salinity gradient collapses. • Colours become nearly uniform from surface to bottom, i.e. clear evidence of complete vertical mixing. • Seasonal variations appear minor and limited to near-surface layers.
	Years 100-110	<ul style="list-style-type: none"> • The entire water column is uniformly saline (yellow shading ~9-10 g/L). • No evidence of any stratification or layering. • Salinity increases gradually over time due to evaporation and solute accumulation.
Density	Years 0-10	<ul style="list-style-type: none"> • Clear density stratification develops during early filling. • Dense (dark blue) water accumulates below ~20 m due to saline groundwater inflow and cooler temperatures. • The upper layer (teal-green) is less dense, forming a distinct two-layer system.
	Years 30-40	<ul style="list-style-type: none"> • The vertical density gradient weakens but remains visible, with surface and mid-depth layers mixing each winter. • Colours show minor but persistent vertical variation, indicating that a weak density contrast persists below ~25-30 m. • The system undergoes seasonal overturn, with mixing extending to near the bottom each winter but not achieving complete full-depth mixing.

Aspect	Significant Decade	Results Summary
	Years 100-110	<ul style="list-style-type: none"> • Density remains high and nearly uniform through the column, with only minor differences between surface and bottom waters. • Seasonal density fluctuations occur in the upper 10-15 m, consistent with annual thermal mixing. • The system exhibits stable monomictic behaviour; nearly full mixing each winter, with a weak residual gradient persisting below ~30 m.

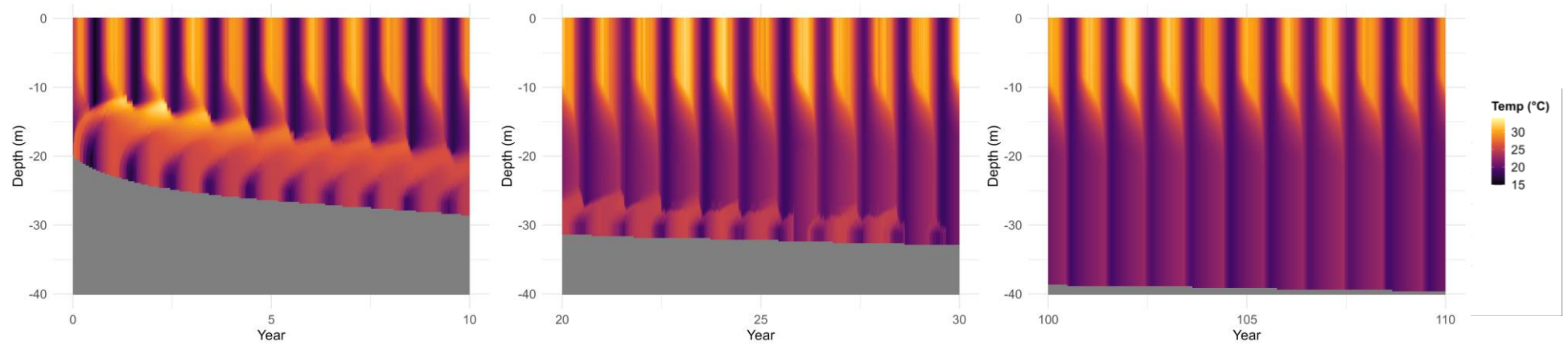


FIGURE 8-9 PANDORA THERMAL STRATIFICATION OVER SIGNIFICANT DECADES – MID RAINFALL

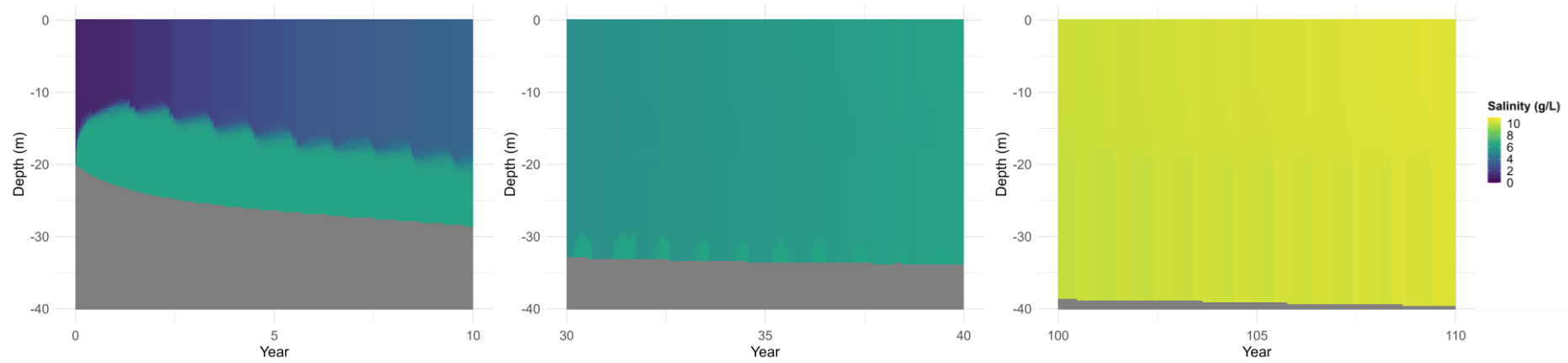


FIGURE 8-10 PANDORA SALINITY STRATIFICATION OVER SIGNIFICANT DECADES – MID RAINFALL

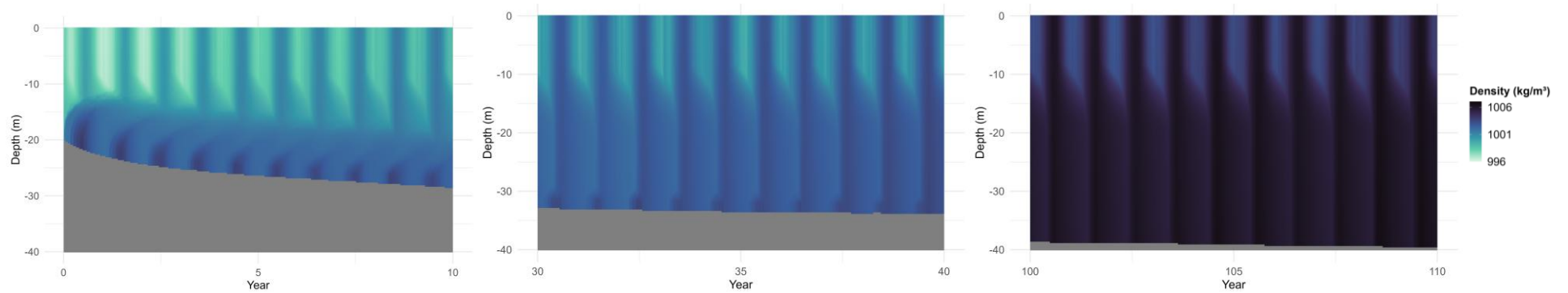


FIGURE 8-11 PANDORA DENSITY STRATIFICATION OVER SIGNIFICANT DECADES – MID RAINFALL

8.5 CONCLUSIONS

The combined geochemical and limnological modelling indicates that the Pandora pit lake will stabilise as a saline, chemically self-regulating waterbody under closure conditions. The geochemically controlled PHREEQC scenario is considered the most realistic representation of long-term behaviour, as it accounts for mineral buffering, redox reactions and secondary mineral formation that will naturally occur over centuries. This configuration results in a stable, moderately acidic but low-metal system dominated by NaCl-type salinity.

Limnology modelling shows that Pandora will behave as a monomictic lake, with strong seasonal thermal stratification that breaks down each winter through full mixing. Early in filling, salinity stratification develops as denser groundwater accumulates at depth, but this gradient collapses within the first few decades as the lake deepens and annual overturn becomes established. Over the long term, the water column remains well mixed, and salinity increases uniformly through gradual evaporative concentration. Temperature is the primary driver of stratification, with density reflecting its seasonal influence rather than persistent salinity layering.

Overall, the results indicate that Pandora, and by extension the shallower Titan voids, will remain hydraulically closed and seasonally stratified, with the water column mixing fully each winter. The lake will undergo predictable annual cycles of thermal and density stratification driven by surface heating, but no long-term or permanent stratification is expected. Water quality evolution will be controlled primarily by evaporation and mineral equilibria rather than rainfall variability.

9 RESIDUAL VOID MANAGEMENT

This section outlines proposed monitoring and management measures for the residual voids. It ensures that residual risks are controlled post-closure, as required under the PRCP framework.

Specifically, this section contains strategies to address:

- *Monitoring during construction through supervision, verification and auditing of engineering works.*
- *Development and use of 'as built' profiles to assess consistency with design surfaces.*
- *Comparison of key earthworks criteria (e.g. compaction, settlement) against design specifications, with rectification of any shortcomings.*
- *Post-construction assessment of landform stability through visual inspection and survey.*
- *Documentation of exclusion measures (if applicable) as part of ongoing post-closure management.*

The residual voids at DNM are proposed to remain as permanent water bodies post-closure. In general, potential long-term risks associated with residual voids include water quality degradation, geotechnical instability and interaction with surrounding groundwater or surface water systems. These risks will be managed through appropriate design measures, long-term monitoring and adaptive management planning.

- Geotechnical stability modelling (Section 7) indicates satisfactory FoS values for all highwall, end wall and low wall slopes, confirming the long-term structural stability of the final landform.
- Flood modelling (Section 5) confirms that no voids are located within the 0.1% AEP or PMF floodplains.
- Groundwater modelling (Section 4) shows that the final landform, including both spoil dumps and residual voids, functions as a terminal sink for groundwater. Groundwater inflows from most surrounding spoil and coal-measure strata ultimately converge toward the Pandora void, which acts as the terminal groundwater sink in the mining lease area. The northern residual voids (Titan North, Titan Central, Titan East) behave as flow-through features that drain toward Pandora but do not discharge off-site.
- Water balance (Section 6.3) and geochemical (Section 8) modelling predict that salinity conditions will differ between the northern voids and Pandora. Titan North, Titan Central and Titan East are predicted to remain relatively low in salinity due to their flow-through behaviour and ongoing seepage toward Pandora, while the Pandora residual void is expected to become moderately hypersaline over time due to evaporative concentration and its role as the terminal sink within the system. Despite increasing salinity in the Pandora residual void, the inward hydraulic gradient and absence of any surface discharge pathways mean these conditions are not expected to affect surrounding groundwater quality.
- Predicted void water levels stabilise below surrounding groundwater elevations, confirming no risk of upward seepage, overflow, or overtopping under current or future climate scenarios.

Based on these findings, ongoing management requirements of the NUMA areas of residual voids are expected to be minimal. A tailored monitoring program will be developed to confirm the stability of lake levels, water quality trends and void wall integrity over time. Monitoring results will be reviewed periodically against closure performance criteria. If significant deviations are observed, adaptive management principles will be adopted, and an adaptive management program will be developed closer to closure execution.

9.1 VOID REHABILITATION

Void rehabilitation at DNM will primarily involve shaping and stabilising pit walls to ensure long-term geotechnical stability and safe integration into the final landform. All final slopes have been designed in accordance with site-specific geotechnical investigations, and reshaped where necessary to meet minimum stability criteria.

The rehabilitation process will include:

- Completion of final earthworks to meet design surface levels and slope geometry.
- Construction QA/QC, including compaction testing and topographic validation against the final landform model.
- Erosion control measures (e.g. surface roughening, contour drains) where needed on accessible benches and batters.
- Installation of safety or exclusion infrastructure, such as fencing, bunding or signage where public access or fauna hazard is identified.
- Documentation of the final constructed condition, including 'as built' survey data and photographic records.

9.1.1 LOW WALL REVEGETATION

The area and layout of the NUMAs for each residual void have been reviewed in line with *Management of Coal Mine Voids as Non-Use Management Areas*, published by the Queensland Mine Rehabilitation Commissioner. This guidance explains that voids approved under transitional arrangements may be retained as NUMAs under the EP Act. It also notes that some areas of a void, such as ramps or low walls, may be suitable for rehabilitation to stable condition and excluded from the NUMA footprint.

At DNM, the NUMA boundaries have been designed to maximise the extent of land that can be safely assigned a PMLU. NUMAs are limited to the pit floor, slopes that are too steep to enable effective rehabilitation and long-term water level. All practicable areas where slope geometry, geotechnical stability and safety allow are included in the PMLU footprint for future rehabilitation.

The final NUMA and PMLU boundaries, including areas to be revegetated, are shown in Figure 9-1. No revegetation will occur within the NUMA footprint itself. This approach ensures that:

- Only stable, accessible and safely reprofiled surfaces are revegetated.
- NUMA low walls and pit floors are excluded from rehabilitation activities due to safety, geotechnical and access constraints.
- The PMLU areas contribute to long-term landform stability and minimisation of environmental harm by establishing vegetation in all practicable locations above the residual void.

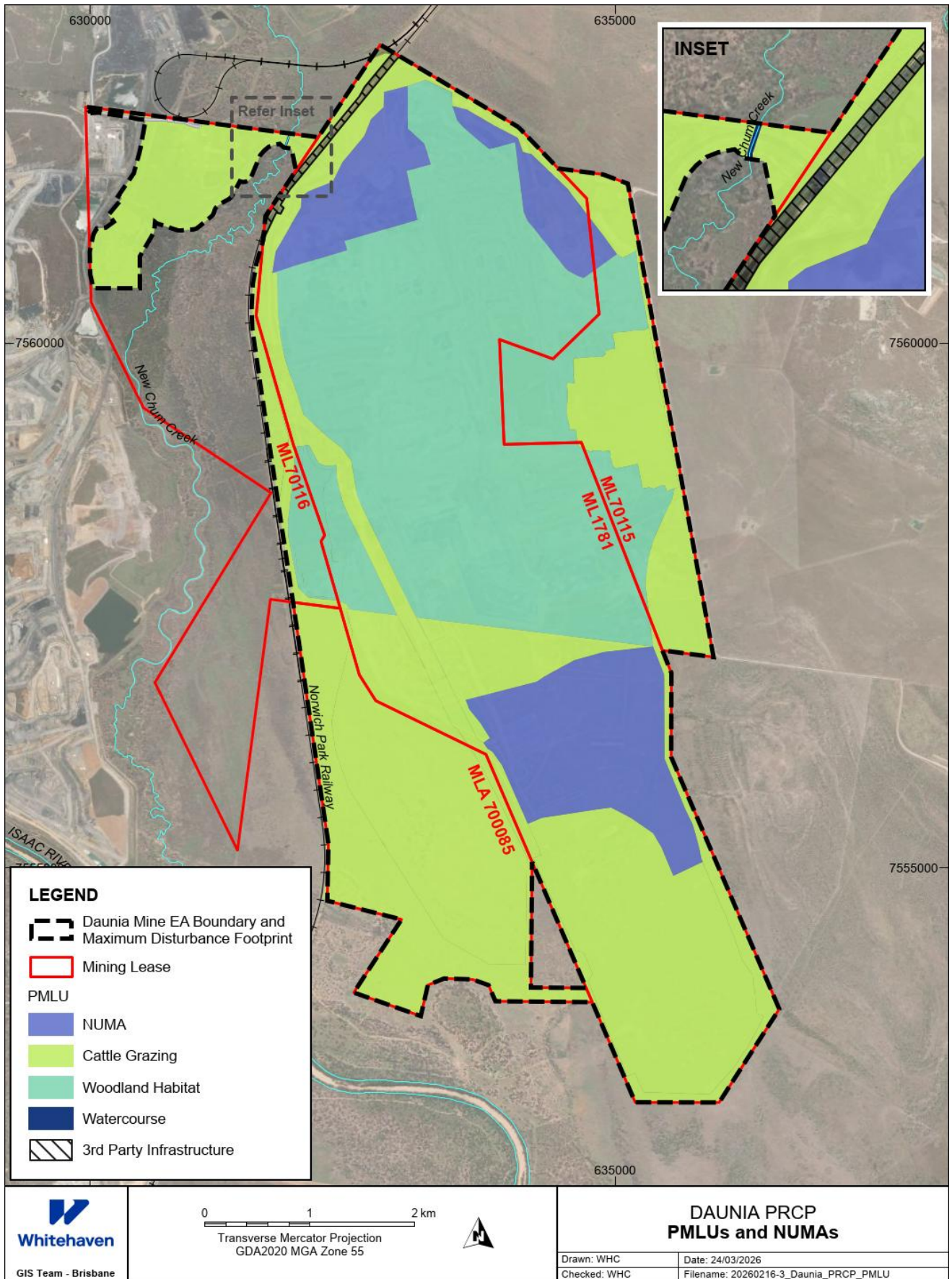


FIGURE 9-1 DNM PMLU AND NUMA LAYOUT

9.2 MONITORING AND MANAGEMENT

A residual void monitoring program will be implemented post-closure, consistent with the site's overall rehabilitation monitoring framework.

Table 9-1 summarises the residual void monitoring program for Improvement Area (IA) 1 under the PRCP Schedule. The program is structured to demonstrate progressive achievement of the PRCP management milestones of IA1:

- MM1 (structural stability);
- MM2 (surface requirements); and
- MM3 (sufficient improvement).

Monitoring activities are designed to verify post-closure performance against model predictions, confirm compliance with these milestone criteria, and provide data to support adaptive management and certification by an appropriately qualified person (AQP).

TABLE 9-1 RESIDUAL VOIDS MONITORING PROGRAM

Monitoring Element	Description	Relevant PRCP Milestone(s)
Void water levels	<ul style="list-style-type: none"> • Automated or manual dip readings and groundwater bores to confirm modelled water balance and hydraulic sink behaviour. • Monitoring will verify predicted trends and confirm the void acts as a groundwater sink post-closure. • Data should be reviewed quarterly by the environmental team and certified by an AQP. 	MM3.5-MM3.6
Water quality	<ul style="list-style-type: none"> • Periodic sampling and laboratory analysis to track salinity, pH, metals, major ions and other parameters relevant to closure performance and environmental harm criteria. • Results compared against model predictions and closure performance targets. • Bi-annual monitoring during the initial decade post-closure, then annual. 	MM3.5
Slope and wall stability	<ul style="list-style-type: none"> • Visual inspections to confirm structural stability, erosion or slumping, and compliance with design FoS. • Inspections undertaken annually and after major rainfall events by a geotechnical engineer or AQP. 	MM1.5-MM1.7
Safety bunds, fencing and signage	<ul style="list-style-type: none"> • Periodic inspection of bunds, fencing and safety signage to confirm integrity and continued effectiveness of exclusion controls in accordance with Australian Standards. • Includes annual maintenance and post-storm verification. 	MM2.1-MM2.3 and MM3.7
Wildlife use and safety	<ul style="list-style-type: none"> • Visual and photographic monitoring to identify fauna interaction or hazard potential and guide mitigation measures. • Findings inform adaptive controls to ensure the NUMA remains safe to humans and fauna. 	MM3.4
Adaptive management	<ul style="list-style-type: none"> • Engineering interventions-bench reshaping, erosion control, drainage improvements-plus model recalibration and revision of closure performance criteria or safety controls if monitoring shows deviation from predictions. 	MM3.5-MM3.8

Monitoring Element	Description	Relevant PRCP Milestone(s)
	<ul style="list-style-type: none"> • Actions should be implemented under AQP direction. 	
Certification and review	<ul style="list-style-type: none"> • All monitoring and inspection outcomes reviewed by an AQP to certify achievement of MM1-MM3 and confirm compliance with PRCP Schedule requirements. 	MM3.8

If monitoring results show deviations from predicted trends (e.g. unexpected groundwater mounding, water quality degradation, wall instability, etc.), the following adaptive management responses may be considered:

- Engineering interventions (e.g. bench reshaping, additional erosion control);
- Update of predictive models or assumptions;
- Recalibration of closure performance criteria; and
- Revision of exclusion or safety controls.

9.3 RESIDUAL VOID OVERVIEW TABLES

Table 9-2 through Table 9-5 summarise the results of the modelling and design work detailed in the above sections for the relevant residual voids at DNM. It contains the following information:

- Pit design parameters – refer Section 3.
- Hydrogeology and particle tracking – refer Section 4.
- Flooding risk – refer Section 5.
- Pit lake water balance – refer Section 6.
- Geotechnical stability – refer Section 7.
- Geochemical stability, geochemistry and limnology predictions – refer Section 8.

TABLE 9-2 TITAN EAST PROPERTIES

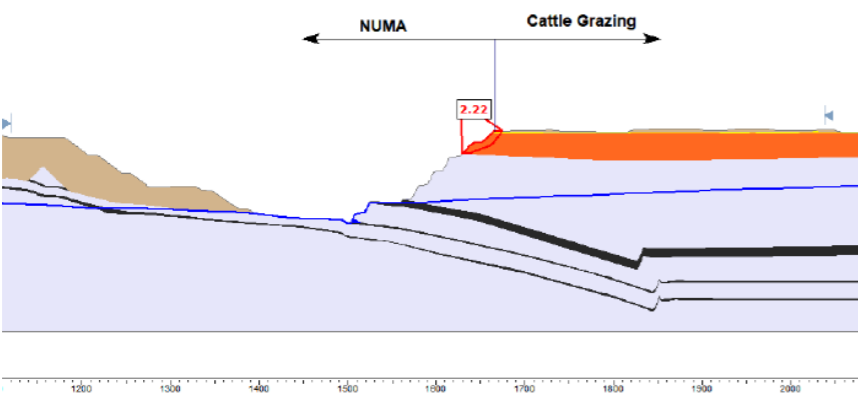
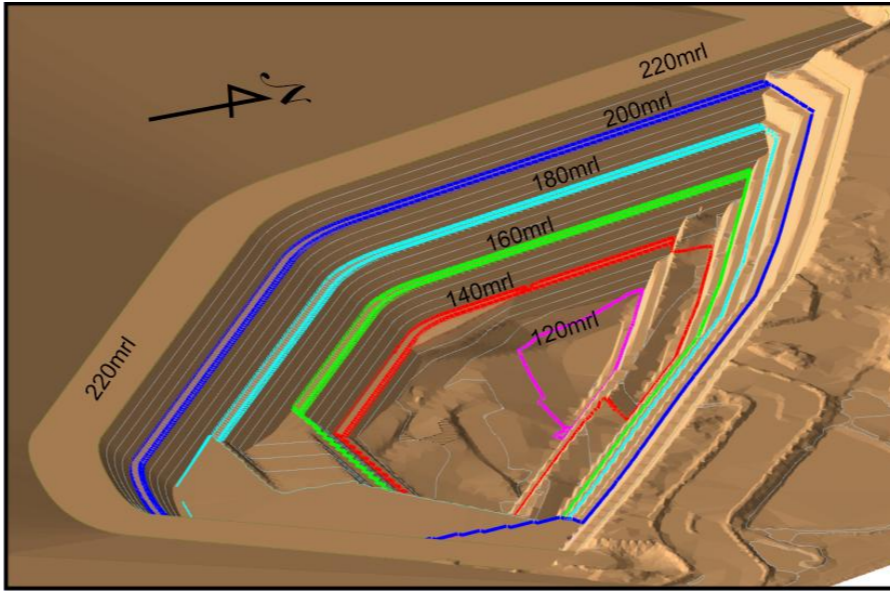
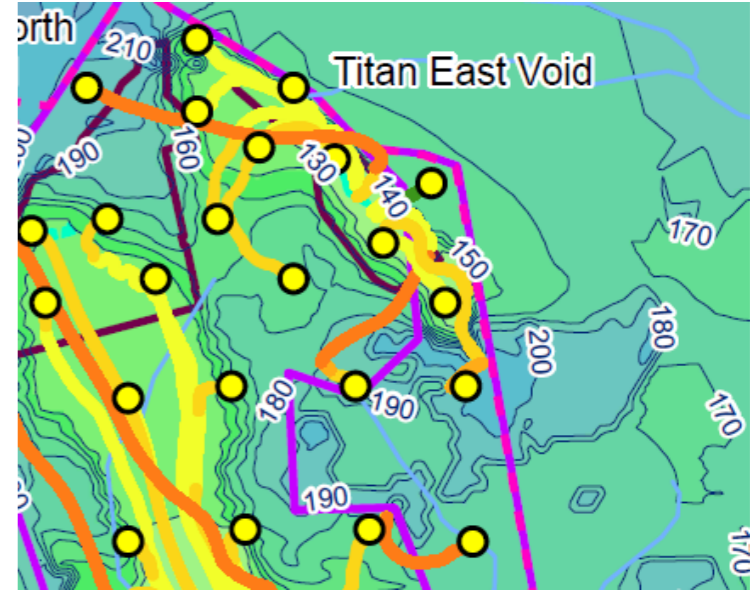
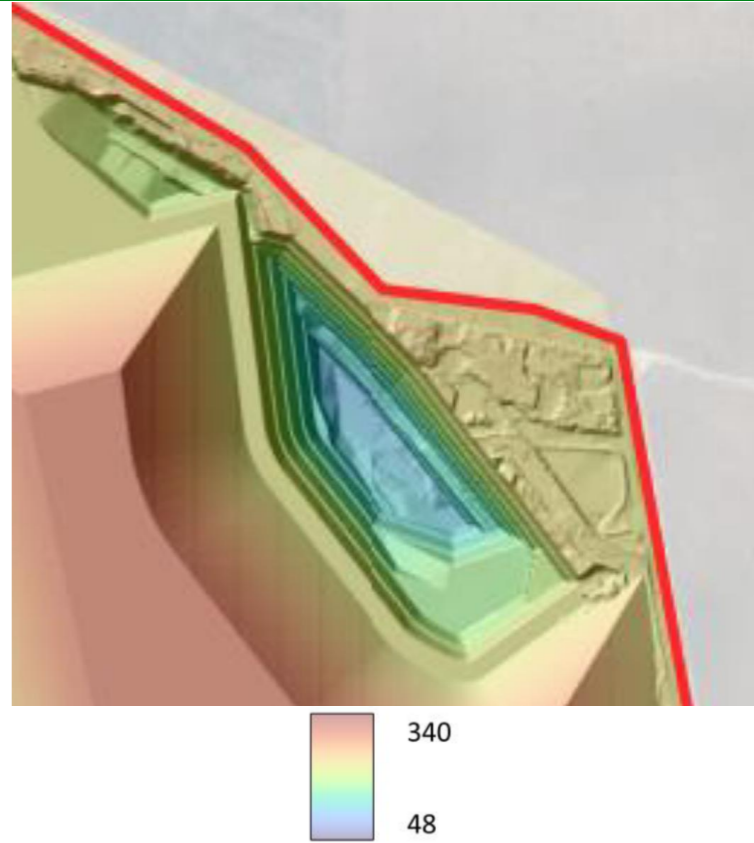
Titan East				
Overview				
End of Mining Cross-Section 		3D View 		Particle Tracking 
Design Parameters				
Indicative Dimensions	Elevation	NUMA Slope Grades (overall)		
Max. Length: 1,085 m Max. Width: 330 m Max. Depth: 104 m Surface area: 55 ha	Void crest/Spill Level: 220 mAHD Indicative void floor: 116 mAHD	Highwall: ~63-78% Low wall: ~50%		
Hydrology				Final Landform Design
Catchment Area	Average Filling Rate	Equilibrium Water Level	Post-Mining Flooding Risk	
Void: 35 ha Rehabilitated: 150 ha <u>Total: 185 ha</u>	2045 to 2095: 0.01 ML/day 2095 to 2545: 0.02 ML/day	Median: 120.8 mAHD Median Max. water depth: 4.8 m	Outside 0.1% AEP design and PMF events.	
Water Balance				
Inflows		Outflows		
2045 to 2095	2095 to 2545	2045 to 2095	2095 to 2545	
Runoff: 0.44 ML/day Groundwater: 0.18 ML/day Seepage to spoil: 0 ML/day	Runoff: 0.44 ML/day Groundwater: 0.20 ML/day Seepage to spoil: 0 ML/day	Seepage to spoil: 0.43 ML/day Evaporation: 0.17 ML/day Groundwater: 0 ML/day	Seepage to spoil: 0.42 ML/day Evaporation: 0.20 ML/day Groundwater: 0 ML/day	
Geotechnical Stability				
Geotechnical Risks		Long-term FoS	Offset to FoS ≥ 1.5	
<ul style="list-style-type: none"> Highwall and low wall meet acceptance criteria under all scenarios <ul style="list-style-type: none"> New Chum Creek floodplain does not extend to the void Model uncertainty rated High-Medium, with low overall geotechnical risk Minor residual risks limited to potential surface weathering or local saturation near crest drains, managed by exclusion bunds and fencing 		NUMA areas Highwall: 1.87 Low wall: 1.60 Grazing/creek PMLU Highwall: 1.87 Woodland PMLU Low wall: 1.60	N/A	
				

TABLE 9-3 TITAN NORTH PROPERTIES

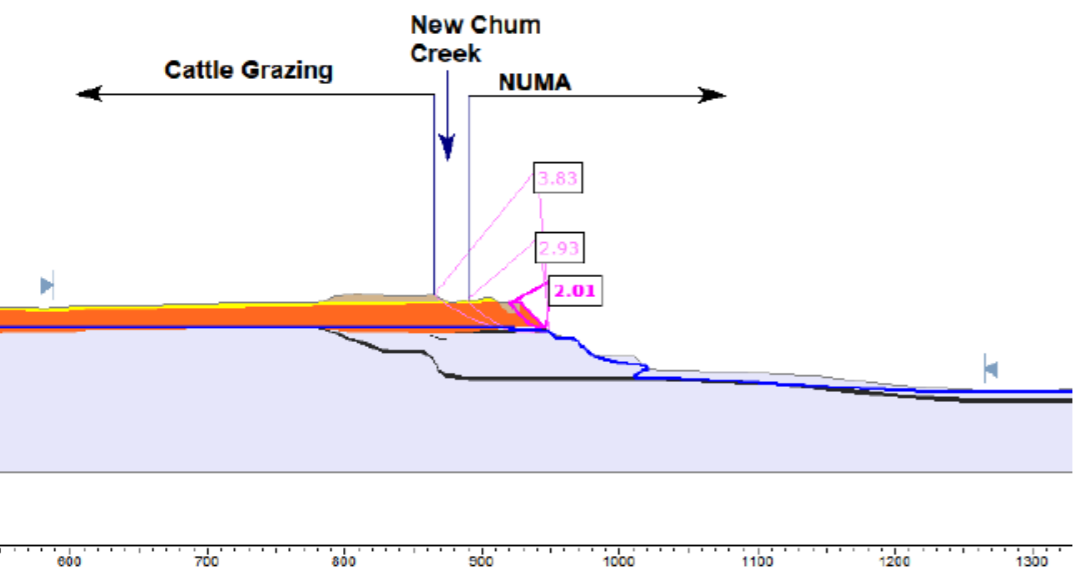
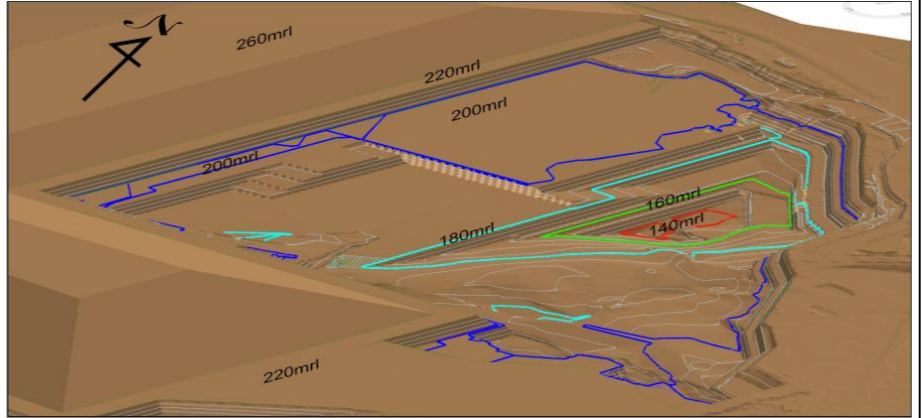
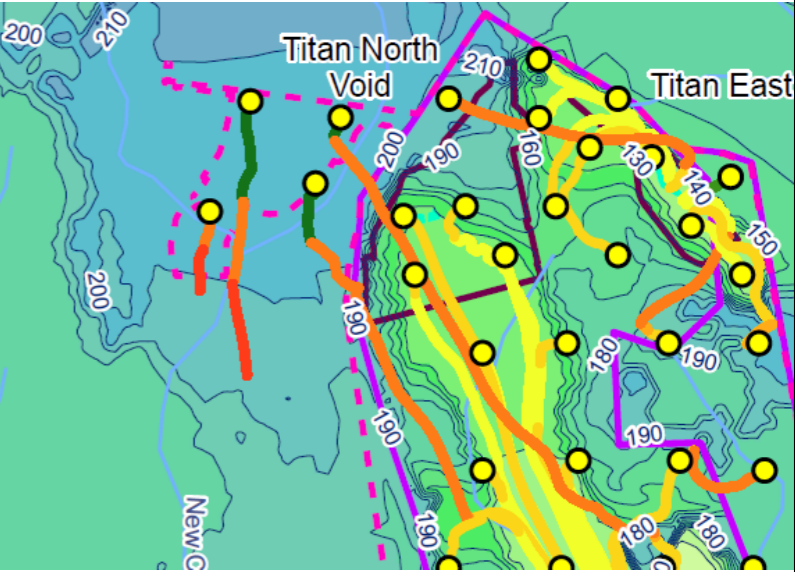
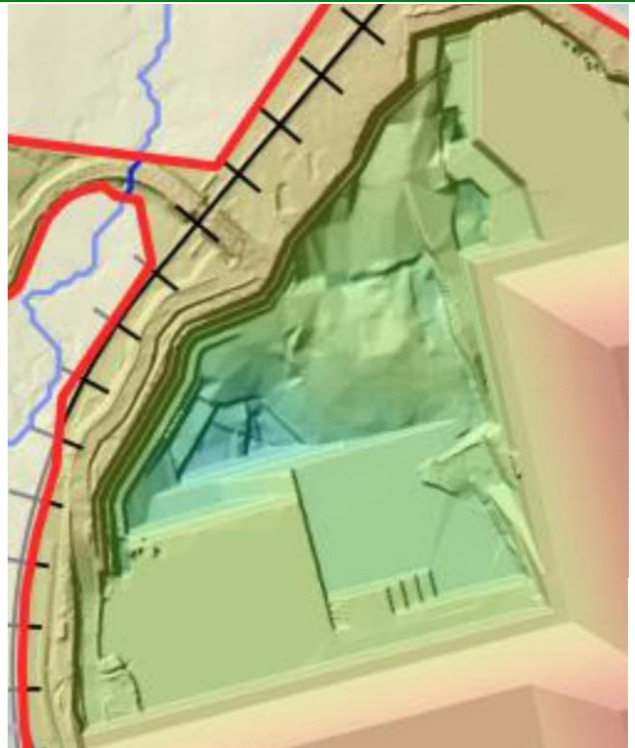
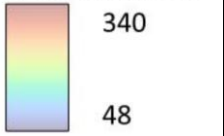
Titan North				
Overview				
End of Mining Cross Section		3D View		Particle Tracking
				
Design Parameters				
Indicative Dimensions	Elevation	NUMA Slope Grades (overall)		
Max. Length: 1,048 m Max. Width: 1,276 m Depth: 76 m Surface area: 192 ha	Void crest/Spill Level: 210 mAHD Indicative void floor: 134 mAHD	Highwall: 63% Low wall: 35%		
Hydrology				Final Landform Design
Catchment Area	Average Filling Rate	Equilibrium Water Level	Post-Mining Flooding Risk	
Void: 81 ha; Rehabilitated: 432ha; Total: 514 ha	2045 to 2095: 0.01 ML/day 2095 to 2545: 0.00 ML/day	Median: 140.1 mAHD Median Max. water depth: 6.1 m	Outside 0.1% AEP design and PMF events.	
Water Balance				
Inflows		Outflows		
2045 to 2095	2095 to 2545	2045 to 2095	2095 to 2545	
Runoff: 1.16 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	Runoff: 1.17 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	Seepage to spoil: 1.03 ML/day Evaporation: 0.12 ML/day Groundwater: 0 ML/day	Seepage to spoil: 1.03 ML/day Evaporation: 0.14 ML/day Groundwater: 0 ML/day	
Geotechnical Stability				
Geotechnical Risks		Long-term FoS	Offset to FoS ≥ 1.5	
<ul style="list-style-type: none"> Highwall and low wall meet acceptance criteria under all scenarios <ul style="list-style-type: none"> New Chum Creek floodplain does not extend to the void Model uncertainty rated High-Medium, with low overall geotechnical risk Minor residual risks limited to potential surface weathering or local saturation near crest drains, managed by exclusion bunds and fencing 		NUMA areas Highwall: 2.01 Low wall: 1.60 Grazing/creek PMLU Highwall: 2.93 Woodland PMLU Low wall: 1.60	N/A	
				Final Landform 

TABLE 9-4 TITAN CENTRAL PROPERTIES

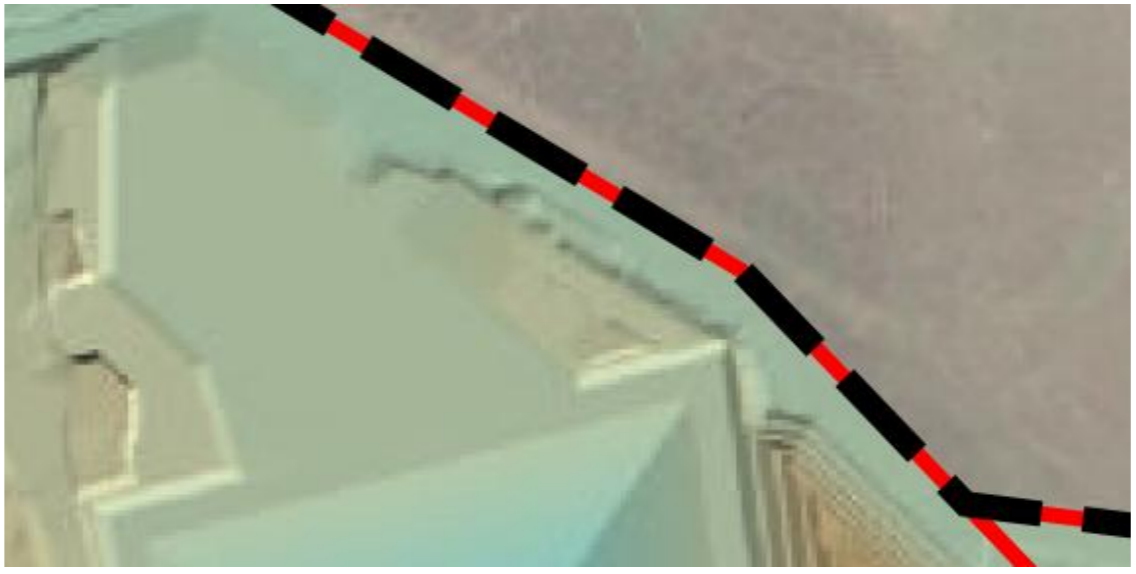
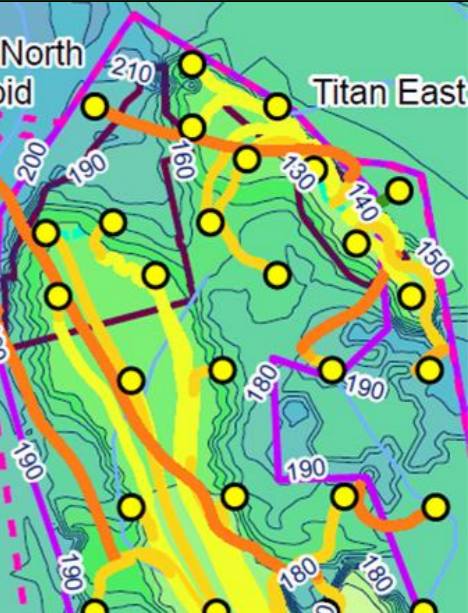
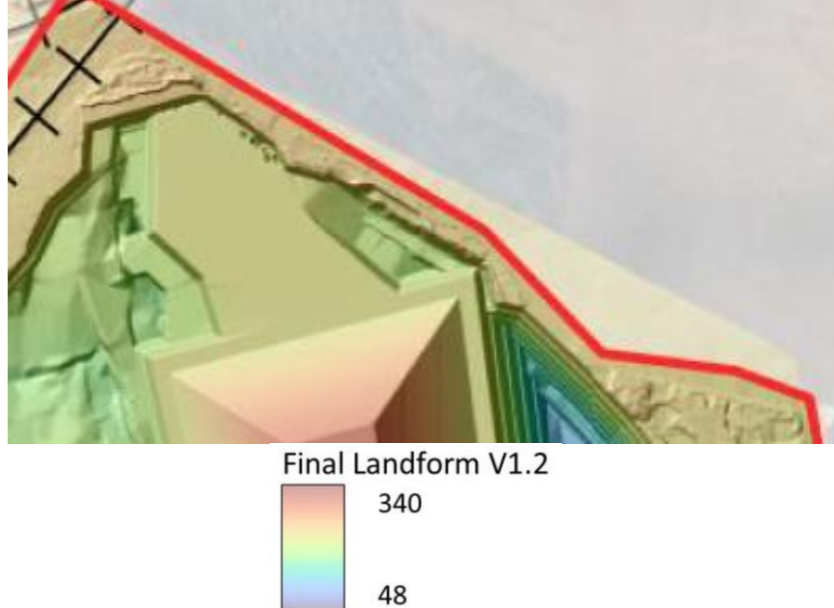
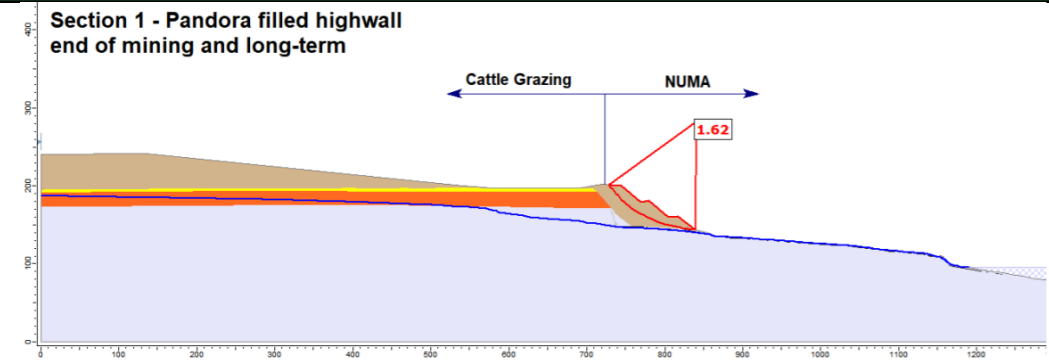
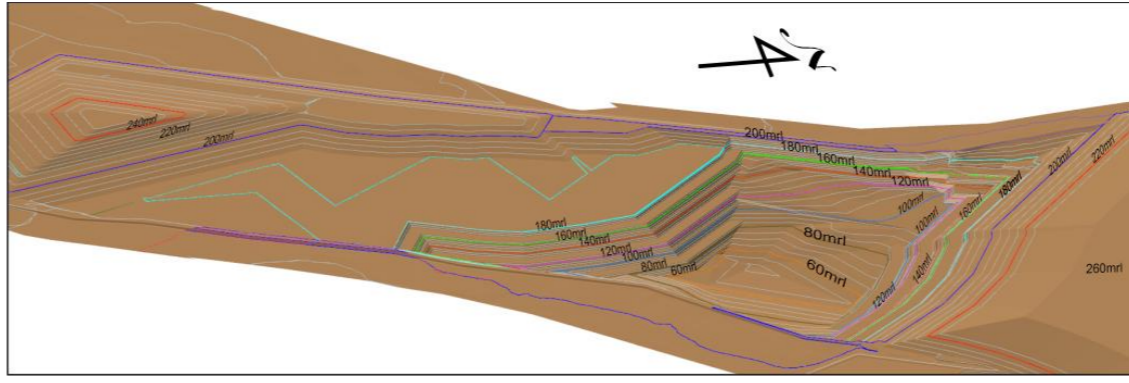
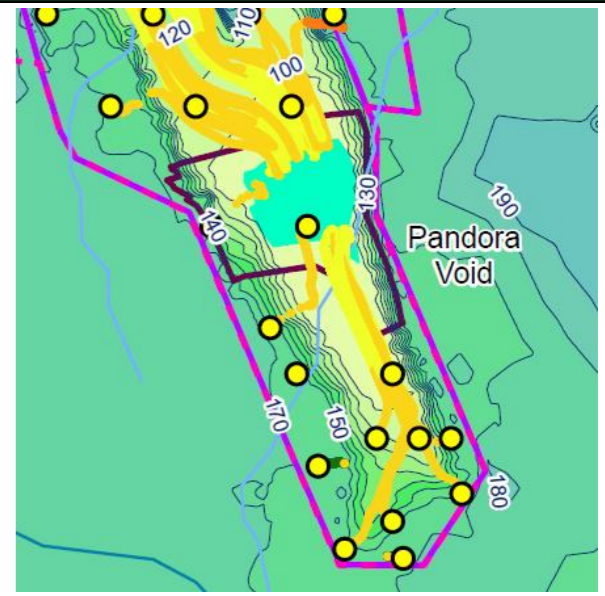
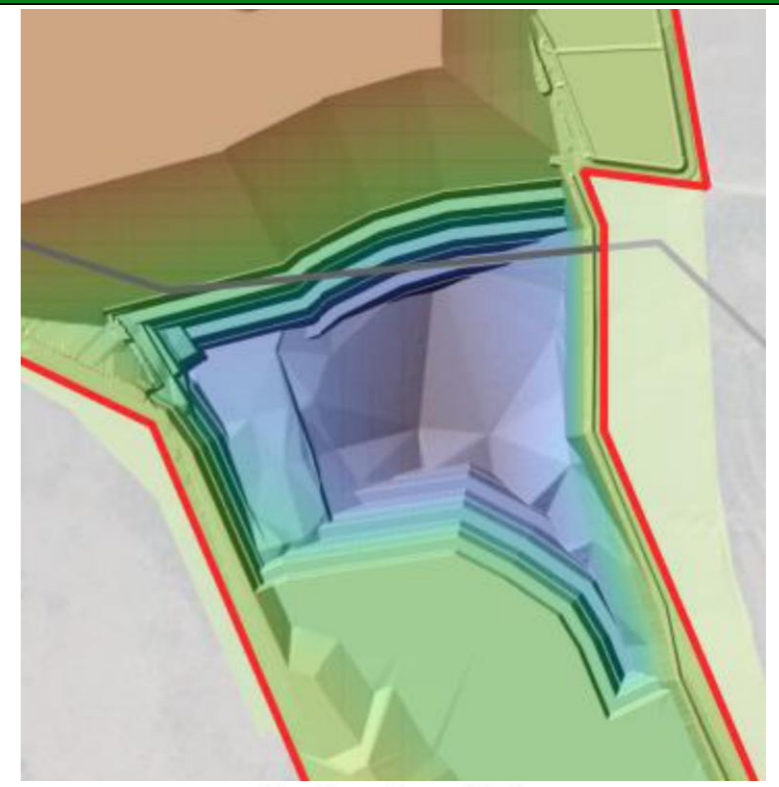
Titan Central				
Overview				
Design Parameters			3D View	Particle Tracking
Indicative Dimensions	Elevation	NUMA Slope Grades (overall)		
Max. Length: 395 m Max. Width: 165 m Max. Depth: 18 m Surface area: 56 ha	Void crest/Spill Level: 210 mAHD Reshaped floor: 192 mAHD	Highwall: As mined Low wall: As dumped angle of repose		
Hydrology				Final Landform Design
Catchment Area	Average Filling Rate	Equilibrium Water Level	Post-Mining Flooding Risk	
Void: 8 ha; Rehabilitated: 30 ha; Total: 38 ha	2045 to 2095: 0 ML/day 2095 to 2545: 0 ML/day	Median: 193.3 mAHD Median Max. water depth: 1.3 m	Outside 0.1% AEP design and PMF events.	
Water Balance				
Inflows		Outflows		
2045 to 2095	2095 to 2545	2045 to 2095	2095 to 2545	
Runoff: 0.12 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	Runoff: 0.12 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	Evaporation: 0.01 ML/day Groundwater: 0 ML/day Seepage to spoil: 0.11 ML/day	Evaporation: 0.01 ML/day Groundwater: 0 ML/day Seepage to spoil: 0.11 ML/day	

TABLE 9-5 PANDORA PROPERTIES

Pandora				
Overview				
End of Mining Cross Section 		3D View 		Particle Tracking 
Design Parameters				
Indicative Dimensions	Elevation	Slope angles		
Max. Length: 1,680 m Max. Width: 1,550 m Max. Depth: 134 m Surface area: 450 ha	Void crest/Spill Level: 190 mAHD Reshaped floor: 56 mAHD	Highwall: 62% (west) 115% (east) Low wall: 33% (south) 36% (north)		
Hydrology				Final Landform Design
Catchment Area	Average Filling Rate	Equilibrium Water Level	Post-Mining Flooding Risk	
Void: 145 ha; Rehabilitated: 682 ha; Total: 827 ha	2045 to 2095: 0.80 ML/day 2095 to 2545: 0.11 ML/day	Median: 92.0 mAHD Median Max. water depth: 36.0 m	Outside 0.1% AEP design and PMF events.	
Water Balance (WRM Model Outputs)				
Inflows		Outflows		
2045 to 2095	2095 to 2545	2045 to 2095	2095 to 2545	
Runoff: 2.31 ML/day Groundwater: 0.83 ML/day Seepage to spoil: 1.53 ML/day	Runoff: 2.58 ML/day Groundwater: 1.03 ML/day Seepage to spoil: 1.55 ML/day	Evaporation: 3.87 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	Evaporation: 5.05 ML/day Groundwater: 0 ML/day Seepage to spoil: 0 ML/day	
Geotechnical Stability				
Geotechnical Risks		Min. Long-term FoS	Offset to FoS ≥ 1.5	
<ul style="list-style-type: none"> Highwall and low wall meet acceptance criteria under all scenarios following revision of Section 2 <ul style="list-style-type: none"> No major structural or flood risks; spoil landform south of Pandora prevents inundation <ul style="list-style-type: none"> Model uncertainty rated High-Medium, with low overall geotechnical risk Minor residual risks limited to surface weathering or local saturation near crest drains, managed by exclusion bunds and fencing 		Highwall NUMA: 1.38 Grazing/Creek PMLU: 1.52 Low wall NUMA: 1.38 Woodland: 1.70	Highwall NUMA: 25 m (Section 2)	
Geochemistry				
Predicted Water Quality	Chemicals of Concern	Hypersalinity Onset	Limnology	
Increasingly saline (pH ~5.3 by year 500), acidic and oxidising; sulfate removed and Fe/Mn stabilised by ferrihydrite formation; system approaches equilibrium over time.	By year 500: <ul style="list-style-type: none"> TDS: 61,000 mg/L Fe: 0.02 mg/L Mn: 0.07 mg/L Other metals below LOD.	Becomes moderately hypersaline after ~5 years.	<ul style="list-style-type: none"> Strong seasonal thermal and density stratification; mixes fully each winter. Early salinity halocline forms then collapses by ~30 years; uniform salinity thereafter. 	
				

10 DISCUSSION

This section summarises the findings across all assessments. It identifies key risks, uncertainties and implications for closure and residual risk management.

The modelling and evaluations presented in this VCP demonstrate that the final landform will be safe, stable and non-polluting under the proposed closure configuration:

- Water balance and groundwater modelling show that the overall final landform, including most spoil dumps and residual voids, will function as a terminal groundwater sink. The northern residual voids (Titan North, Titan Central and Titan East) behave as flow-through features that drain toward Pandora, which acts as the terminal receptor in the system. No voids are predicted to discharge off-site or overtop under any climate scenario.
- Water quality modelling indicates that Pandora pit lakes will rapidly become hypersaline over time, consistent with evaporative concentration and the absence of outflows.
- Although increasing salinity presents ecological limitations, the pit lakes remain hydrologically contained within the mine footprint and are not expected to affect surrounding groundwater or surface-water systems.
- Geotechnical assessments confirm that the final void slopes achieve the required FoS for closure stability.
- Flood modelling confirms that no residual voids are located within the modelled 0.1 % AEP or PMF floodplains.

10.1 RISK AND UNCERTAINTY

While the assessment outcomes in this VCP support the long-term stability and containment of the residual voids, some level of uncertainty remains due to the nature of predictive modelling and future climate conditions. Key sources of uncertainty include:

- Climate variability and change, particularly the timing and intensity of rainfall and evaporation under different SSP scenarios.
- Catchment hydrology assumptions, including long-term performance of rehabilitated surfaces and erosion control measures.
- Void water quality evolution, especially under extreme salinity conditions.
- Material properties, such as variability in spoil geochemistry or uncharacterised lithologies within final wall exposures.

To manage these uncertainties, adaptive management strategies will be implemented as part of residual risk management. These may include long-term monitoring of water levels, salinity trends, and slope stability, along with predefined trigger levels and response actions. The residual void management approach will be reviewed periodically and refined based on updated monitoring data or changes in closure assumptions.

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APPENDIX A VCP METHODOLOGY

A 1 MODEL OBJECTIVES

Table A-1 summarises the analytical tools and modelling platforms applied for assessment of the Daunia residual voids. Each model was selected to address a specific closure discipline, with consistent use of shared inputs such as landform geometry, hydrology, and climate data to ensure integrated outcomes across the flood, water balance, geotechnical, geochemical and limnological assessments.

TABLE A-1 SUMMARY OF MODELLING METHODS AND KEY INPUTS/OUTPUTS

Model	Primary Tool/Platform	Key Inputs	Key Outputs
Flooding Assessment	<ul style="list-style-type: none"> TUFLOW for hydraulic model; XP-Rafts for hydrological model 	<ul style="list-style-type: none"> Design rainfall events (e.g. 0.1% AEP, PMF) Topography and landform design Catchment delineations Hydrological 	<ul style="list-style-type: none"> Predicted flood levels and extents Freeboard to void crest Void inundation risk
Water Balance	GoldSim	<ul style="list-style-type: none"> Catchment runoff Groundwater inflow Highwall runoff Rainfall and evaporation Surface water management infrastructure 	<ul style="list-style-type: none"> Annual/long-term water volumes to voids Changes in pit lake water level over time Flow volumes to/from key sources
Geotechnical Stability	Slide2 (Rocscience)	<ul style="list-style-type: none"> Seven cross-sections through each residual void and surrounding landform Final landform geometry and material properties Geological structure and stratigraphy Shear strength parameters (friction angle, cohesion) Groundwater conditions 	<ul style="list-style-type: none"> FoS for highwalls and end walls Identification of potential circular and non-circular failure mechanisms Assessment of slope stability under closure conditions
Geochemistry	PHREEQC using the minteq.v4 database with added surface sorption terms	<ul style="list-style-type: none"> Groundwater inflow volumes (from water balance model) Source terms of historical water chemistry (monitoring data, spoil leachate, etc.) Mineral phases Redox, pH, temperature Evaporation rates 	<ul style="list-style-type: none"> TDS, pH and major ion trends over time Mineral saturation indices (SIs) Predicted concentrations of chemicals of concern, e.g. metals/metalloids
Limnology	GLM3 in R (custom script)	<ul style="list-style-type: none"> Void bathymetry and geometry Daily climate data (temperature, radiation, wind, rainfall) 	<ul style="list-style-type: none"> Thermal, salinity and density stratification and mixing patterns Lake stability dynamics

Model	Primary Tool/Platform	Key Inputs	Key Outputs
		<ul style="list-style-type: none"> Water inputs (from water balance) 	

A.1.1 GEOCHEMISTRY MODEL

A groundwater geochemistry model was developed to evaluate the long-term evolution of water quality within the proposed residual voids at DNM. The modelling was undertaken using PHREEQC, a widely recognised geochemical modelling code developed by the U.S. Geological Survey. The software allows for the simulation of complex geochemical interactions under varying hydrochemical and hydrological conditions.

The model simulates the progressive development of pit lakes within the residual voids, accounting for key geochemical processes such as mineral dissolution and precipitation, sorption, redox reactions and mixing of different water sources. The purpose of the model is to assess whether the quality of water in the residual voids is likely to stabilise within acceptable ranges for environmental and potential future land use considerations.

Hydrological inputs to the geochemical model were derived from WRM's water balance modelling for the post-mining landform. These include:

- Annual volumes of groundwater inflow.
- Surface runoff contributions from catchments and highwall runoff.
- Direct rainfall and evaporation losses.

The model uses representative source water chemistry for each inflow component, based on site-specific monitoring data and available geochemical characterisation studies. These inputs enable the simulation of cumulative solute loading and concentration changes over time.

Modelling was conducted over a 500-year period to represent the long-term steady-state behaviour of the residual void lakes. Key outputs include:

- Predicted trends in salinity in terms of total dissolved solids (TDS), pH and major ion concentrations.
- Mineral SIs.
- Potential for contaminant mobilisation or attenuation (e.g. metals, metalloids).

A 1.1.1 GEOCHEMICAL CONTROLS

Geochemical controls were incorporated into the PHREEQC modelling framework to simulate key processes influencing water quality evolution in the pit lake over time. These controls include equilibrium with atmospheric CO₂, mineral precipitation/dissolution and surface sorption. The inclusion of these processes provides a more realistic representation of long-term geochemical behaviour under the conditions in the residual voids.

A.1.1.1.1 ATMOSPHERIC CO₂ AND O₂ EQUILIBRIUM

Equilibration with atmospheric carbon dioxide (CO₂) and oxygen (O₂) was included in each simulation step to account for gas exchange at the void lake surface. This process is important for regulating both pH and redox conditions, influencing carbonate speciation, iron oxidation and the stability of secondary mineral phases.

In PHREEQC, this was implemented using the EQUILIBRIUM_PHASES block, with CO_{2(g)} and O_{2(g)} included at a fixed partial pressures representative of equilibrium with the atmosphere.

For CO₂, a partial pressure of 10^{-3.37} atm (430 ppm), representative of equilibrium with the atmosphere in 2025, was used. This allowed the model to simulate the dynamic balance between dissolved inorganic carbon species (CO_{2(aq)}, HCO₃⁻, CO₃²⁻) and their influence on mineral stability and metal solubility.

For O₂, a partial pressure of 10⁻¹¹ atm was used, corresponding to a pe of ~8.5 and an Eh of ~0.5 V.

A.1.1.1.2 MINERAL PRECIPITATION

Mineral precipitation and dissolution were incorporated into each MIX step using the EQUILIBRIUM_PHASES block. This allowed PHREEQC to simulate passive geochemical processes that influence long-term water quality, such as mineral buffering, scaling and trace metal attenuation.

In the context of pit lake modelling, scaling refers to the precipitation of dissolved minerals, such as calcite or gypsum, onto surfaces when water becomes oversaturated. This can influence both water quality and geochemical interactions with pit walls or sediments. Trace metal attenuation describes the reduction of dissolved metal concentrations through processes like mineral precipitation, sorption and co-precipitation.

A suite of relevant mineral phases was included based on the initial water chemistry and saturation indices calculated in preliminary simulations. These phases were selected to represent geochemically plausible reactions likely to occur under pit lake conditions, including:

- Carbonates (e.g. calcite, siderite) for acid-buffering and metal co-precipitation;
- Sulfates (e.g. gypsum, barite) to control sulfate, calcium and barium concentrations;
- Hydroxides (e.g. ferrihydrite, gibbsite) for aluminium, iron and trace metal control; and
- Silicates and evaporites, if thermodynamically favourable.

All mineral reactions were treated as equilibrium-controlled, with no kinetic constraints applied. This approach provides a conservative, upper-bound estimate of the potential for mineral precipitation over time in the absence of biological or operational intervention.

A.1.1.1.3 SURFACE SORPTION

To account for sorption processes in the geochemical modelling, a surface complexation approach was applied using ferrihydrite as the sorbent phase. Ferrihydrite was selected due to its high surface area, strong sorption capacity and widespread occurrence in natural systems, particularly in iron-rich environments. It is commonly used in predictive geochemical modelling to represent reactive iron oxide surfaces that bind trace metals and metalloids.

The model employed the Dzombak and Morel (1990)² diffuse-layer surface complexation model, which is widely accepted for simulating the sorption behaviour of ferrihydrite in environmental systems.

In the PHREEQC model, ferrihydrite was included as an equilibrium phase in each MIX block, with a surface area and site density representative of natural conditions.

² Dzombak, D. A. & Morel, F. M. M., 1990. *Surface complexation modeling: Hydrous ferric oxide*. Wiley-Interscience. ISBN: 0-471-63731-9.

This setup allows the model to account for competitive sorption of dissolved species such as arsenic, molybdenum, selenium, antimony, etc., improving the accuracy of long-term water quality predictions in the residual voids.

A.1.2 LIMNOLOGY MODEL

Limnological modelling was undertaken to assess the potential for thermal stratification and mixing behaviour within the Pandora residual void at DNM. Note that the other residual voids were not modelled, as they are predicted to contain only shallow water and would not sustain persistent stratification.

The modelling was implemented in R using the GLM3 framework together with the packages GLM3r, glmtools, rLakeAnalyzer and custom scripts containing the required input data. The model configuration was based on site-specific climatic and hydrological inputs and incorporated the following elements:

- Void bathymetry and geometry derived from the final landform design and represented as depth-area relationships.
- Daily climate data from the Bureau of Meteorology, including rainfall (m/day), air temperature (°C), relative humidity (RH%) and shortwave solar radiation (W/m²). Wind speed and longwave radiation were calculated using empirical formulations (see Section 0 below).
- Hydrological inputs from WRM's water balance model, including pit lake levels, groundwater inflows and surface runoff.
- Initial and inflow water quality conditions derived from:
 - BoM for rainfall and runoff daily temperature averages;
 - Evans (2009)³ for rainfall chemistry;
 - Groundwater monitoring data provided by the client for groundwater and seepage chemistry.

The GLM model was run at an hourly timestep, accounting for:

- The development and breakdown of thermal stratification driven by seasonal weather patterns; and
- The frequency and depth of vertical mixing, which influences transport of solutes in the water column.

Model outputs included:

- Temporal profiles of temperature and salinity through the water column; and
- Identification of periods of stratification versus mixing.

The limnology model complements the geochemical modelling by identifying potential constraints to water quality arising from physical lake dynamics in the Pandora void.

³ Evans, C. A., Coombes, P. J., & Dunstan, R. H. (2006). *Wind, rain and bacteria: The effect of weather on the microbial composition of roof-harvested rainwater*. *Water research*, 40(1), 37-44.

A.1.2.1 WIND SPEED AND LONGWAVE RADIATION ESTIMATION

As direct measurements of wind speed and longwave radiation were not available for the site, these parameters were derived from calculations using available BoM climate records (i.e. T and RH).

Hourly wind speed data was generated to reflect typical Central Queensland conditions, with a diurnal cycle and seasonal modulation:

$$U(t) = U_{base} + U_{amp} \times \sin\left(2\pi \times \frac{H}{24}\right) + U_{season} \times \cos\left(2\pi \times \frac{D}{365}\right)$$

Where U(t) = wind speed at time t (m/s); H = hour of day (0-23); D = day of year (1-365); U_{base} = baseline daily minimum wind speed (m/s); U_{amp} = diurnal amplitude (m/s); U_{season} = seasonal adjustment (m/s).

This produces winds of about 2 m/s at night, increasing to around 5-7 m/s in the afternoon, consistent with BoM regional climatology.

Incoming longwave radiation was calculated from air temperature and vapour pressure derived from BoM temperature and relative humidity records. Atmospheric emissivity (ϵ_a) was calculated using the Brutsaert (1975) formulation:

$$\epsilon_a = 1.24 \left(\frac{e_a}{T_a}\right)^{\frac{1}{7}}$$

Hourly incoming longwave radiation was then estimated as:

$$L = \epsilon_a \sigma T_a^4$$

Where ϵ_a = effective clear-sky emissivity; e_a = vapour pressure (kiloPascal (kPa)); σ = Stefan-Boltzmann constant ($5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$); T_a = air temperature (Kelvin (K)).

A.1.2.2 INPUT DATA SUMMARY

A.1.2.2.1 GLM SETTINGS

Key GLM input data are summarised in Table A-2

TABLE A-2 KEY GLM INPUT DATA FOR PANDORA PIT LAKE LIMNOLOGY MODELLING

Category	Parameter/Variable	Value(s)/Description	Source/Notes
Morphometry	Crest elevation	195 mAHD	Final landform design
	Basin length × width	2330 m × 1471 m	
	Hypsography (H, A)	H = 50-195 m (1 m steps between 50-100, then 110, 130, 150, 170, 195 m); A = 0-4,446,000 m ²	
Simulation time	Start date	1900-01-01 00:00:00	Model setup
	Stop date	2013-01-01 00:00:00	
	Time step	3,600 s (hourly)	

Category	Parameter/Variable	Value(s)/Description	Source/Notes
Initial profile	Lake depth	20 m	Initialisation
	Temperature profile	25°C at surface to 20°C at 20 m (linear gradient, 18 depths)	
	Salinity profile	1.0 g/L throughout (uniform with depth, 18 depths)	

A.1.2.2.2 HYDROLOGICAL SETTINGS

A summary of the hydrological inputs used in the limnology modelling for low, mid and high rainfall scenarios (as directed by WBM outputs) are in Table A-3, Table A-4 and Table A-5

The scenarios primarily differ in rainfall and runoff inputs, which scale with climatic conditions and drive variability in total inflows.

- The low scenario represents dry conditions with reduced rainfall.
- The mid scenario reflects historical long-term averages in the region, with moderate rainfall.
- The high scenario captures wet conditions, with slightly higher rainfall extremes and runoff.

Seepage inflows are consistent across all scenarios (mean $\sim 0.025 \text{ m}^3/\text{s}$, salinity 6.4 g/L), but show considerable temporal variability ($0.020\text{-}0.437 \text{ m}^3/\text{s}$). Given its higher salinity relative to rainfall and runoff, seepage remains the dominant solute source in all scenarios. Outflows (spoil and rock groundwater) are minor compared to total inflows.

TABLE A-3 SUMMARY OF HYDROLOGICAL INFLOWS – LOW RAINFALL SCENARIO

Source	Mean Flow	Flow Range	T Range	Mean T	Salinity
<i>Unit</i>	m^3/s		$^{\circ}\text{C}$		g/L
Surface runoff including direct rainfall	2.30×10^{-7}	2.12×10^{-7} - 3.82×10^{-7}	6.8-33.8	22.4	0.643 (range 0-0.85)
Seepage inflow	5.83×10^{-4}	5.37×10^{-4} - 6.28×10^{-4}	21.6-27.3	22.4	6.4 (calculated from groundwater monitoring data)
Groundwater spoil inflow	3.30×10^{-4}	2.30×10^{-4} - 3.51×10^{-4}			
Groundwater rock inflow	2.30×10^{-7}	2.12×10^{-7} - 3.82×10^{-7}			

TABLE A-4 SUMMARY OF HYDROLOGICAL INPUTS – MID RAINFALL SCENARIO

Source	Mean Flow	Flow Range	T Range	Mean T	Salinity
<i>Unit</i>	m^3/s		$^{\circ}\text{C}$		g/L
<u>Inflows</u>					
Runoff	0.015	0-0.086	21.6-27.3	22.4	0.64 (range: 0-0.85)
Seepage in	0.025	0.020-0.44	21.6-27.3	22.4	6.4 (calculated from groundwater monitoring data)

Source	Mean Flow	Flow Range	T Range	Mean T	Salinity
Direct rainfall	0.015	0-1.66	6.8-33.8	22.4	0.036 (Evans, 2006)
<u>Outflows</u>					
Spoil GW Outflow	0.009	0.003-0.010	-	-	-
Rock GW Outflow	8×10^{-6}	Constant	-	-	-

TABLE A-5 SUMMARY OF HYDROLOGICAL INPUTS – HIGH RAINFALL SCENARIO

Source	Mean Flow	Flow Range	T Range	Mean T	Salinity
<i>Unit</i>	m^3/s		$^{\circ}C$		g/L
<u>Inflows</u>					
Runoff	0.016	0-0.018	6.8-33.8	22.4	0.644 (range: 0-0.85)
Seepage In	0.026	0.022-0.437	6.8-33.8	22.4	6.4 (calculated from groundwater monitoring data)
Direct rainfall	0.015	0-1.664	6.8-33.8	22.4	0.036 (Evans, 2006)
<u>Outflows</u>					
Spoil GW Outflow	0.009	0.003-0.010	-	-	-
Rock GW Outflow	8×10^{-6}	Constant	-	-	-

A 1.2.2.3 METEOROLOGICAL SETTINGS

Meteorological inputs for the Pandora pit lake simulation were derived from BoM datasets and processed to an hourly timestep for use in GLM. Daily observations of air temperature, relative humidity, and solar radiation were interpolated to hourly values using sinusoidal functions that capture diurnal variability.

Air temperature was interpolated between daily minimum (T_{min}) and maximum (T_{max}) values using a sinusoidal function:

$$T(h) = T_{min} + (T_{max} - T_{min}) \times \sin[\pi \times (h - h_{min}) / (h_{max} - h_{min})]$$

Where h is the hour of day, h_{min} is the time of T_{min} (typically around 06:00), and h_{max} is the time of T_{max} (typically around 15:00).

Relative humidity was derived as the inverse of air temperature, with maxima aligned to night-time hours and minima to midday, using a complementary sinusoidal function:

$$RH(h) = RH_{max} - (RH_{max} - RH_{min}) \times \sin[\pi \times (h - h_{min}) / (h_{max} - h_{min})]$$

Solar radiation (shortwave, SW) was distributed across daylight hours using a clear-sky sinusoidal curve constrained by observed totals of daily averages:

$$SW(h) = SW_{max} \times \sin[\pi \times (h - h_{sunrise}) / (h_{sunset} - h_{sunrise})]$$

with zero SW radiation assigned at night.

Table A-6 summarises the key statistics of the meteorological inputs, including ranges, means and variability.

TABLE A-6 METEOROLOGICAL INPUT SUMMARY FOR GLM

Variable	Range (min-max)	Mean±SD	Unit	Interpretation
Shortwave	0.0-1150	234±299	<i>W/m²</i>	Strong daily and seasonal cycle, with peaks in summer driving surface heating.
Longwave	200-552	362±47.6		Moderate variability reflecting the influence of cloud cover, air temperature and humidity.
T _{air}	-1.50-46.2	22.4±6.80	°C	Typical subtropical range, with hot summers and occasional winter lows near 0.
RH	8.80-100	70.4±19.9	%	Varies from very dry to saturated, strongly influencing evaporation.
Wind speed	2.30-12.9	4.80±2.50	<i>m/s</i>	Generally moderate winds, with occasional stronger events affecting mixing at the lake surface.

A.1.3 FLOODING MODEL

Flood modelling methodology is described in WRM (2025b).

A.1.4 WATER BALANCE MODEL

Water balance modelling methodology is described in WRM (2025a).

A.1.5 GEOTECHNICAL MODEL

Geotechnical modelling methodology is described in Henderson Geotech (2025).



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