



MINE CLOSURE PLAN

CARINA OPERATIONS REV 1.0

**TENEMENTS G15/21, L15/303,
L15/305, L15/306, L15/310,
L15/311, L15/318, L15/319,
L15/320, L15/329, L15/340,
L16/91, L16/115, L77/250,
L77/251, L77/252, L77/254,
L77/274, M77/580, M77/1244,
M77/1261, M77/1270**

30 APRIL 2024 VERSION 0

Site Name:	Carina Operations
Site Code	S0223199
Proponent:	Mineral Resources Limited
Address:	20 Walters Drive, Osborne Park, WA, 6017
Postal Address:	Locked Bag 13, Osborne Park DC, WA 6916
Corporate Contact:	Celine Mangan, Closure, Rehabilitation and Contaminated Sites Manager
Phone:	+61 8 9315 8774
Email:	Celine.Mangan@mrl.com.au
Date of Submission:	30 April 2024

DOCUMENT INFORMATION

DOCUMENT DECLARATION	
I declare that I am authorised to submit this Mine Closure Plan on behalf of Mineral Resources Limited.	
Name:	Cole Thurley
Role:	General Manager – Environment & Compliance
Signature:	
Company:	Mineral Resources Limited
Date:	30 April 2024

Revision History

Rev	Issue Date	Prepared by	Reviewed By	Approved By	Document Purpose
0.0	03/05/2019	Astron	K. Hodgson	T. Berryman	Meet compliance conditions of MS 852, MS 957 and MS 988.
1.0	30/04/2024	Pershke Consulting	Allan Renwick; Sri Lloyd; Mark Steinepreis; Adam Cross; Sai Prakash Lakkur;	Celine Mangan	This MCP has been prepared as a comprehensive update to align with the Statutory Guidelines for Mine Closure Plans

Approvals

Revision	Date	Comments	Approved by
0.0	3/05/2019	Approval for Mine Closure Plan – Yilgarn Mine Closure Plan Registration ID: 79973.	DMIRS

Acknowledgement of Country

MinRes is committed to reconciliation and recognises and respects the significance of Aboriginal and Torres Strait Islander peoples' communities, cultures, and histories. MinRes acknowledge and respect Aboriginal and Torres Strait Islander peoples as the traditional custodians of the land.

EXECUTIVE SUMMARY

The Carina Operations are located within the Central Yilgarn / Western Goldfields region of Western Australia (WA) and comprise two discrete iron-ore operations (Carina / Carina Extended and J4), a legacy gold mining site and former accommodation camp (Aurora), a haulage and rail transport hub, aerodrome and camp (Carina Southern Operations) and connecting haul roads. The operations extend from J4 in the north, approximately 100 kilometres (km) north of Southern Cross, to the Carina Southern operations approximately 100 km north-north-east of Southern Cross.

Polaris Metals Pty Ltd (Polaris), a 100% owned subsidiary of Mineral Resources Limited (MinRes), owns and operates the Carina Operations as follows:

- The Carina / Carina Extended site comprises two open pits and two Waste Rock Landforms (WRLs), which are in an active closure phase following cessation of mining by MinRes in 2016 and 2018 respectively.
- The J4 site comprises two open pits and two WRLs. The J4 operations were initially mined by MinRes from 2015 to 2018. Mining recommenced at J4 in 2023 and involves an extension of the J4 East Pit, extension of the J4 West WRL and backfill of the J4 West Pit.
- The Aurora site operated from 1995 to 2001 and was acquired by Polaris in May 2012. A regional exploration camp was constructed on the tenement and used by Polaris until 2018.
- The Carina Southern Operations comprises the East Jaurdi Aerodrome, the Mt Walton Rail Siding and the Carina Accommodation Village, all of which remain operational to support the Carina Operations and other sites within the MinRes Yilgarn hub. Crushed ore is loaded at the Mt Walton Rail Siding for transport to the Port of Esperance for shipping.
- The Carina and J4 Haul Roads connecting the sites.

This Mine Closure Plan (MCP) has been prepared as a comprehensive update to address issues raised by the Department of Mines, Energy, Industry Regulation and Safety (DEMIRS)¹ in Request for Information (RFI) issued to MinRes on 9 February 2023 (DMIRS, 2023a); aligns with the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a); includes an extension of the MCP scope to cover the expansion of the J4 East Pit and J4 West WRL; and includes the results of closure studies and updates to closure implementation plans completed since submission of previous versions of the MCP.

This revision of the MCP incorporates and supersedes:

- Yilgarn Mine Closure Plan. May 2019 (Astron, 2019).
- J4 Redevelopment Project. Mine Closure Plan. M77/1270. 18 July 2023 (MinRes, 2023b).

The key features associated with each site within the Carina Operations are summarised in Table ES-1. Based on the currently approved areas and activities and the provision of services to other MinRes operations in the region, the estimated date for completion of the Carina Operations is 2030.

¹ Formerly Department of Mines, Industry Regulation and Safety (DMIRS). Throughout this document DEMIRS has been used to refer to the Department and its guidance. Citations of guidance and guidelines use the Department name at the time the statute or guidance was written. The stakeholder consultation register uses the Department acronym applicable at the time of the consultation.

Table ES-1: Summary of Key Features

Site	Domain	Key Features
Carina Northern Operations	Pits	Carina & Carina Extended Pits (mined below water table)
	Waste Rock Landforms (WRLs)	Carina WRL & Carina Extended WRL
	Run-of-Mine (ROM) pads and stockpiles	Carina ROM Pads (x 2) & Long-term Stockpiles (LTSP) (x 3)
	Infrastructure	Dams, buildings, workshop, borefield, laydown areas, surface water bund (Carina Mine Infrastructure Area), borrow pits, roads, access tracks, and service corridors
Carina Southern Operations	Infrastructure	Carina Camp including accommodation village, reverse osmosis plant, car park, access roads, wastewater treatment plant and irrigation field.
		East Jaurdi Aerodrome including airstrip, unsealed park-up, terminal, access roads, fence and topsoil / vegetation stockpiles.
		Mt Walton Siding: workshops (2), offices, buildings, saline or process water dams, washdown bay and water treatment plant, ore-processing equipment (two stackers, one reclaimer, one train loadout, ore stockyard), substation, six generators & main electrical transformer and distribution room, transport or service infrastructure corridor (including rail loop, 3 x rail ballast areas), fire break containment tracks, communications tower, borrow pits and topsoil / vegetation stockpiles.
Mt Jackson 4 (J4)	Pits	J4 East and J4 West Pits (mined below water table)
	WRLs	J4 East WRL and J4 West WRL
	ROM pads and stockpiles	J4 ROM Pad & LTSPs (x 2)
	Infrastructure	Dams, support infrastructure, borefield, laydown areas, borrow pits, roads / access tracks, airstrip, camp and service corridors
Aurora	Pits	Aurora (open cut above water table and underground workings)
	WRLs	Aurora WRL
	Stockpiles	LTSPs (x 2)
	Infrastructure	Roads, access tracks and communications tower
Haul Route	Infrastructure	Carina and J4 sealed Haul Roads, dams, pipelines, borrow pit and vegetation / topsoil stockpiles.

Closure outcomes defined for the closure and rehabilitation of the Carina Operations are outlined in Table ES-2 along with the domains to which each outcome applies. The outcomes are broad statements of what closure of the Carina is aiming to accomplish. The specific detail of how each outcome will be measured is provided by supporting completion criteria outlined in Section 8.2 of the main body of the MCP.

Table ES-2: Closure Outcomes

Outcome	Applicable Domains
Public health and safety hazards have been mitigated.	All
The post-closure land condition is compatible with the Post-Mining Land Use (PMLU).	All
Land management requirements are commensurate with the PMLU, or formal arrangements have been made to provide for management of residual risks.	All
The post-closure landform includes provision for safe access, where required.	All
The heights of final landforms are compatible with surrounding landforms.	WRLs
Landforms are safe and geotechnically stable.	WRLs
Rehabilitated surfaces are stable and are not subject to unacceptable rates of erosion.	All
Landforms are non-polluting.	WRLs
The post-closure landform maintains the flow of surface water to key receptors.	All
Overflow from pit lakes does not adversely impact surface water receptors.	Mine pits
Contaminated sites have been identified and addressed.	All
Groundwater levels are acceptable at key receptors.	Below water table mine pits
Groundwater quality is acceptable at key receptors.	All
Suitable growth media is available to support achievement of vegetation outcomes.	All areas to be rehabilitated
Vegetation in rehabilitated areas is locally native, resilient, reflective of the reference ecosystem and supports native fauna assemblages.	All areas to be rehabilitated
Weeds or Dieback do not compromise revegetation success or surrounding vegetation.	All
Protection of heritage sites.	All
Direct and indirect impacts to conservation significant flora, vegetation and fauna habitat are minimised.	All
Pit lakes do not adversely impact native terrestrial fauna.	Below water table mine pits

The closure strategy for the WRL and Pit domains within the Carina Operations is summarised in Table ES-3 and Table ES-4 along with information on closure risks and management measures. There are several closure risks that apply site-wide, to infrastructure features or across multiple domains. These risks and the actions designed to manage the risks to acceptable levels are outlined in Table ES-5 along with the forward work programs designed to address knowledge gaps / uncertainties and progress closure approaches / designs.

The risks have been colour coded as follows, based on the risk matrix in Appendix I.



Table ES-3 and Table ES-4 provide a summary of the following information by WRL and Pit, respectively:

- Area of footprint occupied by the feature and the area that has been rehabilitated.
- An overview of the status of the feature and the key characteristics of that feature that are relevant to closure planning.
- An overview of the key risks associated with each feature. Full details of the risks considered can be found in Section 7 of the MCP.
- The measures adopted to assess and manage the identified risks.
- The current proposed post-mining land use (PMLU) for each feature. Stakeholder consultation to finalise PMLUs is ongoing.
- The closure strategy / approach proposed for each feature.
- The program of work required to address knowledge gaps and uncertainties.

Table ES-3: WRL Closure Summary

WRL	Area disturbed (ha)	Area of Rehab. (ha)	Status & Key Characteristics	Key Closure Risks		Key Risk Management Measures	PMLU	Closure Strategy	Forward Work Program
				Inherent	Residual				
Carina	41.2	90.2	- Inactive. - Outside ZOI of Carina Pit. - Partially under rehabilitation, commenced 2015. - Includes Potentially Acid Forming (PAF) encapsulation cell / landfill / evaporation ponds. Cover materials sampled were Non-Acid Forming (NAF). - Isolated areas of high salinity in cover materials. - Design non-compliances (lift height, berm widths and back-sloping on berms). - No significant flow or velocity, associated with the main PMF floodplain, reaches the WRL. - Some positive trends but rehabilitation not displaying consistent trends across all attributes.	Erosion Geotechnical stability Geochemistry (AMD)	- Materials characterisation, geotechnical stability (ZOI), berm capacity modelling and landform design assessments have been conducted. - Cover materials have been confirmed to be NAF. - Encapsulation of PAF confirmed and cover properties meet design (geotechnical properties and depth). - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water assessment indicated floodwaters are a low risk. - Rehabilitation monitoring is ongoing and, together with studies above, informs requirement for erosion / surface rectification works.	Natural Environments	- Use the recommendations from the closure studies completed during 2022 – 2024 to develop a final landform plan that addresses design non-compliances, controls surface water run-off, maintains the depth of the PAF encapsulation cell cover and, where rehabilitation is yet to be completed, minimises interaction between saline materials and the plant root zone. - Select / develop reference ecosystems suited to WRL cover characteristics and Post Mining Land Use (PMLU). - Refine completion criteria to reflect reference ecosystem characteristics.	- Develop final design for the Carina WRL informed by surface water run-off control and PAF encapsulation requirements, review of berm capacity modelling results, geochemical and geotechnical characteristics of the surface cover materials and design commitments. - Global geotechnical stability assessment. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU where supplementary seeding required. - Consider practicability of applying timber debris to rehabilitation surfaces.	
Carina Extended	0	32.5	- Inactive. - Outside ZOI of Carina Extended Pit. - Rehabilitation works completed in 2018. - Cover materials sampled were NAF. - Erosion is yet to stabilise. - Isolated areas of high to extreme salinity in cover materials. - Design non-compliances (lift 1 height, berm widths (to be confirmed) and back-sloping on berms). - No interaction with floodplain. - Some positive trends but rehabilitation structure remains different to the analogue sites.	Erosion Geotechnical stability Geochemistry (AMD)	- Materials characterisation, geotechnical stability (ZOI), berm capacity modelling and landform design assessments have been conducted. - Cover materials have been confirmed to be NAF. - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water assessment indicated floodwaters are a low risk. - Rehabilitation monitoring ongoing and, together with studies above, informs requirement for erosion / surface rectification works.	Natural Environments	- Closure strategy to address erosion to be finalised subject to review of: - berm capacity modelling recommendations - more detailed assessment of as-built berm widths - the results of additional erosion monitoring. - Seek approval via this MCP for Lift 1 height of 18 m (compared to approved design of 15 m). - Refine completion criteria to reflect reference ecosystem characteristics.	- To inform requirement for rectification: - Review the two berm capacity modelling studies to refine minimum berm width. - Review surface stability trajectory after two more monitoring periods. (Revisit this strategy if significant increase in severity of erosion after first year of additional monitoring). - Seek approval via this MCP for the height variation of Lift 1. - Global geotechnical stability assessment. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU where supplementary seeding required.	
J4 East	95.7	0	- Inactive. - ZOI to be assessed at completion of J4 East Pit development. - Cover materials predominantly NAF or UC. - Erosion observed and exacerbated where ripping not yet implemented. - Low stability materials present in some areas. - Isolated areas of high to extreme salinity in cover materials.	Erosion Geotechnical stability	- Materials characterisation, geotechnical stability (ZOI), berm capacity modelling and landform design assessments have been conducted. - Cover materials have been confirmed to be NAF or UC. - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water assessment indicated floodwaters are a negligible risk.	Natural Environments	Progress preliminary rectification plan submitted to DEMIRS at completion of mining at J4 East Pit to final design subject to the findings of forward work actions planned to address knowledge gaps (reassess interaction with ZOI interaction / mitigation approach for areas of low stability and / or high salinity cover materials present).	- Review the cover materials that have been mapped as 'low stability' to determine appropriate treatment. - Global geotechnical stability assessment to determine if WRLs meet FOS. - Assess interaction of the WRL with the ZOI of the final J4 East pit shell to inform abandonment bund location and any requirement for remedial works on the J4 East WRL.	

WRL	Area disturbed (ha)	Area of Rehab. (ha)	Status & Key Characteristics	Key Closure Risks		Key Risk Management Measures	PMLU	Closure Strategy	Forward Work Program
				Inherent	Residual				
			- Design non-compliances (maximum height, lift height, overall slope angle, berm widths and back-sloping, cross bunds). - Negligible flood risk.	Geochemistry (AMD) 		Erosion monitoring ongoing and, together with studies above, informs requirement for erosion / surface rectification works.		Refine completion criteria to reflect reference ecosystem characteristics.	- Investigate depth of cover material necessary to prevent OAW (salinity) from impacting on revegetation success, where cover is practicable. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.
J4 West			- Active. - ZOI not applicable as J4 West Pit planned to be backfilled to surface. - Cover materials predominantly NAF or UC. - Erosion observed and exacerbated where ripping not yet implemented. Low stability materials present in some areas. - Isolated areas of high salinity in cover materials. - Design non-compliances (maximum height, lift height, batter angle, berm widths and back-sloping, cross bunds). - Negligible flood risk.	Erosion 		- Materials characterisation, berm capacity modelling and. - Geotechnical stability (ZOI) completed for J4 East Pit extent in 2022. - Cover materials have been confirmed to be NAF or UC. - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water assessment indicated floodwaters are a negligible risk. - Erosion monitoring ongoing and, together with studies above, informs requirement for erosion / surface rectification works.	Natural Environments	- Rectification of design non-compliances will occur as part of the expansion of this WRL to achieve the design parameters outlined in the J4 East Redevelopment. - Refine completion criteria to reflect reference ecosystem characteristics.	- Address knowledge gaps to finalise the preliminary landform rectification plan for the J4 East WRL: - Interaction of the WRL with the ZOI of the final J4 East pit shell. - Re-assess cover materials mapped as 'low stability' to determine appropriate treatment / design. - Rectify design non-compliances as part of the expansion of the J4 East Pit and demonstrate compliance to plan. - Global geotechnical stability assessment to determine if WRLs meet FOS. - Investigate depth of cover material necessary to prevent OAW (salinity) from impacting on revegetation success, where cover is practicable. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.
Aurora	1.1	3.4	- Outside ZOI. - Multiple and significant erosion gullies. Observed sediment deposition beyond toe of WRL. - No materials characterisation data available. - PMF flood assessment indicates minor potential for sediment release from toe but makes no recommendation for armouring based on low risk.	Erosion 		- Landform design assessment completed. - Geotechnical stability (ZOI) assessment completed. - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water assessment indicated floodwaters are a negligible risk.	Natural Environments	- Develop and implement landform rectification plan to address surface water control requirements. - Although the Aurora WRL departs from the design criteria in that it occupies a greater footprint, the resultant lower height is a more desirable outcome for surface stability. Rectification of the landform to align with the original design geometry is not recommended. - Refine completion criteria to reflect reference ecosystem characteristics.	- Complete geochemical and geotechnical materials characterisation to inform WRL rectification plan. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.
All WRLs	-	-	As above for each WRL	Fibrous or radioactive materials 		Fibrous materials encountered during operations they are managed in accordance with Dust and Fibrous Materials Management Plan	As above	As above for each WRL	- Complete review of drill assays and conduct testing as required to confirm if fibrous or radioactive minerals are present in the waste rock or mineralised stockpile material. - Develop sampling plan based on risk assessment outcomes.

Table ES-4: Pit Closure Summary

Pit	Footprint (Ha)	Area of Rehab. (Ha)	Status & Key Characteristics	Key Closure Risks		Key Risk Management Measures	PMLU	Closure Strategy	Forward Work Program
				Inherent	Residual				
Carina	80.8	N/A	- Inactive, mining ceased 2016. - Mined Below Water Table (BWT) - partially backfilled. - Backfill potentially includes PAF. - PAF will remain exposed in some areas of pit walls. - Pit lake currently used as source of water for processing operations. - Carina Pit is located within the 1 in 2,000 and PMF event flood plains. - The north east section of the Carina Pit abandonment bund is within the conservative ZOI projection.	Groundwater drawdown		- Hydrological and hydrochemical modelling completed to predict behaviour of pit lakes and included climate change scenarios. - Groundwater monitoring to validate models. - Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Surface water management controls will be implemented (including flood protection bund incorporated into portion of abandonment bund) - Pit wall stability assessments inform abandonment bund locations. - Abandonment bund installed to meet design agreed with DEMIRS.	Extractive Industry Not in Use	- Pit lake (possible throughflow) at closure. - Undertake monitoring to validate models. - Abandonment bund installed to prevent inadvertent access and incorporates flood protection bund.	- Implement groundwater and pit lake monitoring program to validate models. - Undertake a gap analysis to determine the need for further testing / modelling (pit lake water quality). - Review interaction of abandonment bund with ZOI and if required, relocated NE section of abandonment bund in consultation with DEMIRS. - Develop geotechnical and construction specifications for the flood protection bund.
				Pit lake through flow					
				Flooding & pit lake overflow					
				Surface flow interrupted					
				Community Safety					
Carina Extended	17.37	N/A	- Inactive, mining ceased March 2018. - Mined BWT. - Potential for flow from small 6 ha catchment to interact with abandonment bund.	Groundwater drawdown (R18)		- Hydrological and hydrochemical modelling completed to predict behaviour of pit lakes and included climate change scenarios. - Groundwater monitoring to validate models. - Flood risk (from surface water perspective). - Pit wall stability assessments inform abandonment bund locations. - Abandonment bunds installed to meet design agreed with DEMIRS.	Extractive Industry Not in Use	- Pit lake (sink at closure). - Undertake monitoring to validate models. - Abandonment bund installed to prevent inadvertent access.	- Implement groundwater and pit lake monitoring program to validate models. - Undertake a gap analysis to determine the need for further testing / modelling (pit lake water quality). - Determine the location of abandonment bund in consultation with DBCA and DEMIRS. - Review interaction of PMF flood plain with abandonment bund to determine any requirement for armouring.
				Pit lake through flow					
				Community safety					
J4 East	6.42	N/A	- Active, mining recommenced 2023. - Mined BWT. - High sulfur materials (oxidised) in pit wall. - No potential for flooding to enter pits at J4.	Groundwater drawdown		- Hydrological and hydrochemical modelling completed to predict behaviour of pit lakes and included climate change scenarios. - Groundwater monitoring to validate models. - Pit wall stability assessments inform abandonment bund locations. - Abandonment bund installed to meet design agreed with DEMIRS.	Extractive Industry Not in Use	- Pit lake (sink at closure). - Undertake monitoring for the period necessary to validate models. - Abandonment bund installed to prevent inadvertent access.	- Implement groundwater and pit lake monitoring program to validate models. - Undertake a gap analysis to determine the need for further testing / modelling (pit lake water quality). - Assess J4 East ZOI at the completion of mining to inform any requirement for remedial works on the J4 East WRL and location of the abandonment bund. - Determine the location of abandonment bund in consultation with DBCA and DEMIRS.
				Pit lake through flow					

Pit	Footprint (Ha)	Area of Rehab. (Ha)	Status & Key Characteristics	Key Closure Risks		Key Risk Management Measures	PMLU	Closure Strategy	Forward Work Program
				Inherent	Residual				
				Community safety					Complete pre-clearing surveys as required and seek necessary approvals.
J4 West	20.84	0	- Inactive (mining), mining ceased March 2018. Mined BWT. - Active backfill. - No potential for flooding to enter pits at J4. - Heritage site located within the ZOI of J4 West Pit.	Groundwater drawdown		- Hydrological and hydrochemical modelling completed to predict behaviour of pit lakes and included climate change scenarios (prior to proposal to backfill) - Materials characterisation demonstrates majority of materials mined have low S content and present a low risk of acid generation. - PAF to be placed within in-pit encapsulation cell above water table. Materials balance reconciliation to ensure adequate NAF materials identified and segregated. - Modelling indicates any solutes released from J4 West pit expected to be captured within the drawdown footprint of J4 East Pit. - Pit wall stability assessment to understand potential impact on heritage site (consideration for unplanned closure event).	Natural Environments	- Backfill to surface. - PAF encapsulation cell. - In the event of unplanned closure: - Encapsulation of any exposed PAF in backfill. - Sufficient backfill will be undertaken to buttress the J4 West pit wall (if instability poses risk to heritage site). - No abandonment bund required.	- Compliance to approved plan (PAF encapsulation audit) and confirmation at end of construction. - Geotechnical assessment of J4 West pit stability in vicinity of known heritage site. - Select / develop reference ecosystems suited to backfill characteristics and PMLU.
				Backfill impacts ground water					
				Pit wall failure impacts (heritage)					
				Geochemistry (AMD)					
				Community safety					
Aurora	25.08	0	- Open pit did not intersect groundwater. - Abandonment bund within ZOI. - The proposed abandonment bund is sufficiently sized to prevent both 1 in 2,000 AEP and PMF events floodwaters from overtopping into the pit void	Flooding causes pit to fill & overflow		- Hydraulic modelling and flood analysis. - Modelling considers 1:2000 AEP and PMF events. - Abandonment bund will reduce inflow to the pit and prevent overtopping. - Pit wall stability assessments completed to inform abandonment bund location. - Abandonment bund installed to meet design agreed with DEMIRS.	Extractive Industry Not in Use	- Pit will remain as a dry void. - Abandonment bund installed to prevent inadvertent access.	- Confirm that historic underground workings have been sealed. - Determine the location of abandonment bund in consultation with DBCA and DEMIRS and finalise design informed by hydraulic modelling results. - Complete pre-clearing surveys as required and seek necessary approvals. - Materials characterisation to inform final abandonment bund design.
				Surface flow interrupted					
				Community safety					
All BWT pits	-	-	As above for each pit	Pit lake attracts feral fauna		- Operational monitoring and post-closure observations of feral animals as pit lakes establish will inform closure requirements. - Pit lake monitoring to validate models.	As above	As above for each pit	- Observe / monitor the occurrence of feral fauna. - Conduct a pit lake risk assessment.
				Pit lake impacts to native fauna					

Table ES-5: Management of Risks that Apply Across All, Multiple or Infrastructure Domains

Applicable Domains	Closure Risks Applicable to Multiple Domains		Management Measures / Closure Strategy	Forward Work Program
	Inherent	Residual		
All areas to be rehabilitated	Insufficient growth media		- Baseline soil studies determine depth of topsoil available for stripping in yet to be disturbed areas. - Stripped topsoil has been stockpiled and the quality of stockpiles assessed. A reconciliation has been conducted of the topsoil required for rehabilitation and topsoil stockpile volumes. - Rehabilitation trials have been completed and results assessed to inform surface treatment options. - Requirements for topsoil handling and storage are incorporated into mine planning for newly disturbed areas. - Progressive rehabilitation is conducted in accordance with MinRes Land Rehabilitation Procedure. - Reference ecosystem developed from baseline flora and vegetation work, with consideration to post-closure landscapes, hydrology, soil conditions, fauna habitat values and PMLU. - Local provenance species and seed are used. The timing of seed collection is managed to maximise seed viability and satisfy quantities required. MinRes has seed in storage with a commercial provider and maintains database of species and volume stored. - Conduct research, if required, into seed management practices for difficult to establish species. - Seed dispersion timed to coincide with favourable climatic conditions. - Landform scale rehabilitation monitoring and implementation of corrective actions, where required, until completion criteria are achieved. - If stressors occur prior to rehabilitation demonstrating resilience to stressors (e.g., soil seedbank and / or observed plant reproductive capacity) remedial seeding or planting will be undertaken. - Feral animals will be controlled where there is a risk of impacting rehabilitation. - Weed monitoring and weed control are conducted in accordance with MinRes Weed Hygiene and Control Procedure.	For all areas - Refine topsoil balance to account for topsoil stockpiled on WRLs, stockpiles at Carina Southern Operations and J4 East topsoil salvage. - Investigate alternate growth media if topsoil deficit confirmed. - Use landscape-scale rehabilitation monitoring data to develop completion criteria appropriate to the various post-mining landforms and PMLU. - Consult with stakeholders regarding PMLU. - Utilise aerial surveying techniques to inform and maximise the effectiveness of weed control. For WRLs - Salvage topsoil prior to WRL rectification works. - Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable. - Refine reference ecosystem (s) and species mix for WRLs with consideration to the properties of the growth substrate achieved and the PMLU. - Review potential application of Carina rehabilitation trial findings to other WRLs. - Determine if there is a practicable method of applying timber debris to rehabilitation surfaces that will achieve, but not exceed, the target cover level (10 – 20%) and not enhance erosion.
	Rehabilitation practices do not achieve completion criteria			
	Weeds			
All areas to be rehabilitated (except WRLs) For WRLs see Table ES-3.	Erosion		- Land surface will be re-profiled to accommodate drainage and erosion protection will be provided as required. - Flood modelling informs landform design and erosion protection requirements.	Complete flood modelling, hydraulic modelling and materials characterisation necessary to inform final landform design for the Infrastructure / General Disturbance domain.
Mine voids (abandonment bunds), WRLs, ROM pads / stockpiles, infrastructure including haul road.	Closure execution clearing - impacts to flora (Carina / Carina Extended)		- Exclusion / protection areas for flora, fauna and heritage sites are mapped within the MinRes GIS system and are available to planners / designers. - Land Activity Permit (LAP) & Clearing Procedure control impacts to flora, fauna habitat and heritage sites. - Pre-clearing surveys (flora, fauna habitat and heritage) will be conducted for new disturbance required for closure execution, and approval will be sought for new disturbance. - The locations of abandonment bunds will be determined in consultation with Department of Biodiversity Conservation and Attractions (DBCA) and DMIRS. - Project Environmental Management Plan will be implemented throughout the closure execution phase, as relevant. - Consultation with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys	- As closure designs progress into execution plans, consideration will be given to the potential impacts to heritage areas and W22 vegetation community arising from design changes and clearing required for construction access. - Regulatory approval for any new disturbance will be sought. - Consultation with the Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys.
	Closure execution clearing - impacts heritage areas. (Carina Northern and Carina Southern)			
	Closure execution clearing - impacts heritage areas (J4 and Aurora)			

Applicable Domains	Closure Risks Applicable to Multiple Domains		Management Measures / Closure Strategy	Forward Work Program
	Inherent	Residual		
All domains (Mine voids, WRLs, ROM pads / stockpiles, pits backfilled to surface, infrastructure including haul road)	Impact to cultural values		- Consultation will be conducted with Traditional Owners to identify cultural values and how these might impact closure designs including safe access requirements. - Consultation with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys. - Post-mining land use managers / owners will be consulted to determine post-mining land use objectives and associated completion criteria. - Closure designs will consider safe access based on the outcomes of consultation. - Stakeholders requiring access post-closure will be consulted and commitments regarding third party access will be maintained by MinRes Land Access group. - Develop a Land Access Plan (or similar) to inform closure strategy.	- Consultation with Traditional Owners to discuss potential closure designs and outcomes. - Incorporate requirements for safe access and cultural values (where possible) in closure designs. - Consultation with the Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys. - Liaise with Land Access Group in relation to third party agreements that may include post-closure access requirements. - Develop a Land Access Plan (or similar) in consultation with all relevant stakeholders and to meet the conditions of tenements and third-party agreements.
	Access requirements not considered in closure design			
	Post-closure land condition does not meet land use requirements			
Infrastructure (All)	Operational contamination		- Preliminary site investigations have been conducted to identify areas of potential contamination. - Detailed site investigations will be conducted, and areas of confirmed contamination remediated in accordance with the <i>Contaminated Sites Act, 2003</i> as required. - Decommissioning plans include requirement to make underground infrastructure safe / non-polluting. - Closure of Landfill in accordance with site Operating Licence requirements. - Hydrocarbon and Chemical Procedure as relevant to closure.	- Prepare a Sampling and Analysis Quality Plan (SAQP) to guide a Detailed Site Investigation (DSI). Develop remediation action plans as required. - Communication with relevant stakeholders to determine applicable validation criteria.
Infrastructure (Haul Route & Access Roads)	Landform interrupts surface water flows		- Hydraulic modelling and flood analysis. - If not transferred to third party, the haul road and access roads will be removed and rehabilitated to allow appropriate drainage. - Post-closure maintenance requirements will be formally transferred to a third party as part of the transfer agreement.	- Consult with third parties regarding the requirement for the haul road post-closure and develop decommissioning / closure plans based on whether roads will be removed or retained / modified / transferred to a third party. - Where required, based on topography, hydraulic modelling informs landform design where roads are removed.
Infrastructure (All excl. Mine Voids see ES-6)	Community safety		- Decommissioning and demolition of all infrastructure that is not required by a third-party post-mining. - Responsibility for securing and maintaining infrastructure (including tracks) has been formally transferred to a third party where ownership of the infrastructure has been transferred.	- Consultation with third parties regarding the requirement for infrastructure post-closure - Detailed decommissioning and demolition plans will be developed prior to commencing demolition works.

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Appendices

Appendix A Closure Obligations Register

Appendix B Stakeholder Engagement Register

Appendix C Technical Reports

Appendix D Geochemistry

Appendix E Geotechnical Information

Appendix F Soils Information

Appendix G Groundwater

Appendix H WRL Performance

Appendix I Risk Matrices

Appendix J Maps

ABBREVIATIONS

Abbreviation	Definition
°C	Degree Celsius
ABA	Acid Base Accounting
ABCC	Acid Buffering Characterisation Curve
AC	Acid Consuming
ACA	Average Crustal Abundance
ACH Act	Western Australian Aboriginal Cultural Heritage Act 2021
AEP	Annual Exceedance Probability
AER	Annual Environmental Report
AH Act	Western Australian Aboriginal Heritage Act 1972
AHIS	Aboriginal Heritage Inquiry System
ALUM	Australian Land Use Management
AHD	Australian Height Datum
AMD	Acid and Metalliferous Drainage
ANC	Acid Neutralising Capacity
ANZG	Australian and New Zealand Guidelines for Fresh and Marine Water Quality
ANZMEC	Australia and New Zealand Minerals and Energy Council
ARC	Australian Research Council
ARI	Average Recurrence Interval
ARO	Asset Retirement Obligation
ARR	Australian Rainfall and Runoff
ASC	Australian Soil Classification
AWT	Above Water Table
BC Act	Biodiversity Conservation Act 2016
BCM	Bank Cubic Metres
BGL	Below Ground Level
BIF	Banded Iron Formation
BLT	Basalt
BMW	Department of Treasury and Finance – Building Management and Works
BOM	Bureau of Meteorology
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
BWT	Below Water Table
C	Carbon
C&M	Care and Maintenance
CALM	Western Australian Department of Conservation and Land Management
CCG	Community Consultation Group
CE	Carina Extended
CEC	Carbon Exchange Capacity

Abbreviation	Definition
CHM	Canopy Height Model
CHT	Chert
CIR	Colour Infrared
CPF	Central Processing Facility
CL	Continuing Loss
CMIA	Carina Mine Infrastructure Area
CMSR	Centre for Mine Site Restoration
CFG	Community Reference Group
CS Act	Western Australian Contaminated Sites Act 2003
CSI	Crushing Services International
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSM	Conceptual Site Model
DAA	Department of Aboriginal Affairs
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DCMS	Document Control Management System
DEMIRS	Western Australian Department of Energy, Mines, Industry Regulation and Safety
DMIRS	Western Australian Department of Mines, Industry Regulation and Safety
DOW	Department of Water
DPIRD	Western Australian Department of Primary Industries and Regional Development
DPLH	Western Australian Department of Planning, Lands and Heritage (formerly DAA)
DWER	Western Australian Department of Water and Environmental Regulation
EC	Electrical Conductivities
EMS	Environmental Management System
EP Act	Western Australian Environmental Protection Act 1986
EPA	Western Australian Environmental Protection Authority
EPBC Act	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
ERD	Environmental Review Document
ESI	Electrochemical Stability Index
ESP	Exchangeable Sodium Percentage
FOS	Factor of Safety
Ga	Giga year
GAI	Geochemical Abundance Indices
GCP	Ground Control Point
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information System
GPS	Global Positioning System
GSDM	Generalised Short Duration Method
GST	Goods and Services Tax
GWOS	Groundwater Operating Strategy

Abbreviation	Definition
ha	Hectare
HCWA	Heritage Council of Western Australia
HDPE	High Density Polyethylene
IAS	International Accounting Standard
IBRA	Interim Biogeographic Regionalisation for Australia
ID	Identification Number
IFD	Intensity-Frequency-Duration
IL	Initial Loss
J4	Jackson 4
km	Kilometre
LAP	Land Activity Permit
LOM	Life of Mine
M	Mining Lease
m	Metre
m AHD	Metres above Australian Height Datum
m bcm	Million bulk cubic metres
m bgl	Metres below ground level
MAF	Moisture Adjustment Factor
MCA	Minerals Council of Australia
MCP	Mine Closure Plan
MGA	Map Grid of Australian
MI	Migratory
MinRes	Mineral Resources Limited
ML	Megalitres
mm	Millimetres
MP	Mining Proposal
MPA	Maximum Potential Acidity
MRF	Mining Rehabilitation Fund
MRT	Mineral Resources Transport
MS	Ministerial Statement
NAF	Non-Acid Forming
NAG	Net Acid Generation Capacity
NAPP	Net Acid Producing Potential
NEPC	National Environment Protection Council
NIR	Near Infrared
NMD	Neutral Mine Drainage
NNTT	National Native Title Tribunal
NORM	Naturally Occurring Radioactive Materials
NVIS	National Vegetation Information System
OAW	Oxidised Acidity Waste

Abbreviation	Definition
OEPA	Office of the Environmental Protection Authority
OS	Other specially protected fauna
PAF	Potentially Acid Forming
PAF-HC	Potentially Acid Forming – High Capacity
PAF-LC	Potentially Acid Forming – Low Capacity
PAH	Polyaromatic hydrocarbons
PAW	Plant Available Water
PCB	Polychlorinated biphenyls
PEC	Priority Ecological Community
PEMP	Project Environmental Management Plan
PFAS	Per- and poly-fluoroalkyl substances
PGA	Peak Ground Acceleration
PI	Plasticity Index
PL	Proportional Loss
PLB	Pastoral Lands Board
PMF	Probable Maximum Flood
PMLU	Post Mining Land Use
PMP	Probable Maximum Precipitation
PSD	Particle Size Distribution
PSI	Preliminary Site Investigation
RegID	Registered Identification
RFFP	Regional Flood Frequency Procedure
RFI	Request for Information
RIWI Act	Western Australian Rights in Water and Irrigation Act 1914
RL	Reduced Level
RMR	Rocky Mid-slope / Ridgetops
RO	Reverse Osmosis
ROM	Run of Mine
RPM	Rehabilitation Performance Metrics
S	Sulfur
SAQP	Sampling and Analysis Quality Plan
SD	Saline Drainage
SGP	Sandy / Gravelly Plains
SGWA	Soil Groups of Western Australia
SILO	Scientific Information for Land Owners
SL	Salinities
SMU	Soil Management Unit
SP	Sandy Floodplains
SPR	Source-Pathway-Receptor
SRCE	Standardised Reclamation Cost Estimator

Abbreviation	Definition
SRE	Short-range Endemic
TAA	Titrateable Actual Acidity
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TRH	Total Recoverable Hydrocarbons
UAV	Unmanned Aerial Vehicle
UC	Uncertain
UCL	Unallocated Crown Land
UM	Ultramafic
USA	United States of America
UTM	Universal Transverse Mercator
VU	Vulnerable Species
WA	Western Australia
WABSI	Western Australian Biodiversity Science Institute
WEPP	Water Erosion Prediction Project
WONS	Weeds of National Significance
WRL	Waste Rock Landform
WWTP	Wastewater Treatment Plant
XRD	X-ray diffraction
XRF	X-ray fluorescence spectroscopy
YS	Yellow sandplains
ZOI	Zone of Instability

1. INTRODUCTION

Mineral Resources Limited (MinRes) has prepared this Mine Closure Plan (MCP) to document activities associated with the closure of the Carina Operations which comprise the Carina, Carina Extended, and Jackson 4 (J4) Iron Ore Projects and the Carina Southern Operations (also known as Mt Walton rail siding), East Jaurdi Aerodrome, the former Aurora mine and associated infrastructure (Carina Camp) and haul roads. Further details are provided in Section 2.

1.1 Purpose and Scope

This MCP has been prepared as a comprehensive update to address issues raised by the Department of Mines, Energy, Industry Regulation and Safety (DEMIRS)² in Request for Information (RFI) issued to MinRes on 9 February 2023 (DMIRS, 2023a). This MCP addresses the RFI and describes MinRes' strategy for:

- Decommissioning mining related infrastructure.
- Closing areas impacted by activities occurring within the Carina Operations to achieve the Post Mining Land Uses (PMLU) agreed with stakeholders.
- Addressing outstanding knowledge gaps and further refining closure designs / approaches.

This plan has been prepared in accordance with the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a) and associated Mine Closure Plan Guidance (DMIRS, 2020b), as required under the *Mining Act 1978* (Mining Act).

This MCP applies to all features associated with the Carina Operations. This revision (Revision 1):

- Is the first revision of the MCP to align with the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a).
- Includes an extension of the MCP scope to cover the expansion of the J4 East Pit and J4 West Waste Rock Landform (WRL).
- Addresses the RFI from DEMIRS (DMIRS, 2023a) and progress against items listed in Schedule 1 of DMIRS (2023b).
- Includes the results of closure studies and updates to closure implementation completed since submission of the previous version of the MCP.

This revision of the MCP incorporates and supersedes:

- Yilgarn Mine Closure Plan. May 2019 (Astron, 2019b).
- J4 Redevelopment Project. Mine Closure Plan. M77/1270. 18 July 2023 (MinRes, 2023b).

Progress against items listed in Schedule 1 of the J4 Redevelopment approval, granted on 20 October 2023 (DMIRS, 2023b) have been addressed in Section 13.3. Outstanding matters will be addressed in separate correspondence to be provided to DEMIRS by October 2024.

² Formerly Department of Mines, Industry Regulation and Safety (DMIRS). Throughout this document DEMIRS has been used to refer to the Department and its guidance. Citations of guidance and guidelines use the Department name at the time the statute or guidance was written. The stakeholder consultation register uses the Department acronym applicable at the time of the consultation.

1.2 Future Updates

This MCP will be updated to meet closure plan requirements associated with future Mining Proposals submitted for the Carina Operations (other than for Small Mining Operations), so that at any time all closure commitments are captured in a single plan. Commitments from MCPs prepared for Small Mining Operations will be incorporated in regular updates of this MCP.

Section 13.2 includes a summary of revised or unique closure commitments from two Small Mining Proposal MCPs submitted since submission of the 2019 MCP (MinRes, 2020; Polaris Metals, 2022) and how they have been incorporated in this update.

2. PROJECT SUMMARY

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes:

- *A description of the mining operation (Section 2.1)*
- *A map(s) of the location of the mining operation (Section 2.1, Figure 1) showing all relevant mine activities, land disturbances (Section 2.4, Figure 10 to Figure 9), tenements and other land tenure (Section 2.3, Figure 2 to Figure 5).*
- *An estimated Project completion date is included (Section 2.2).*

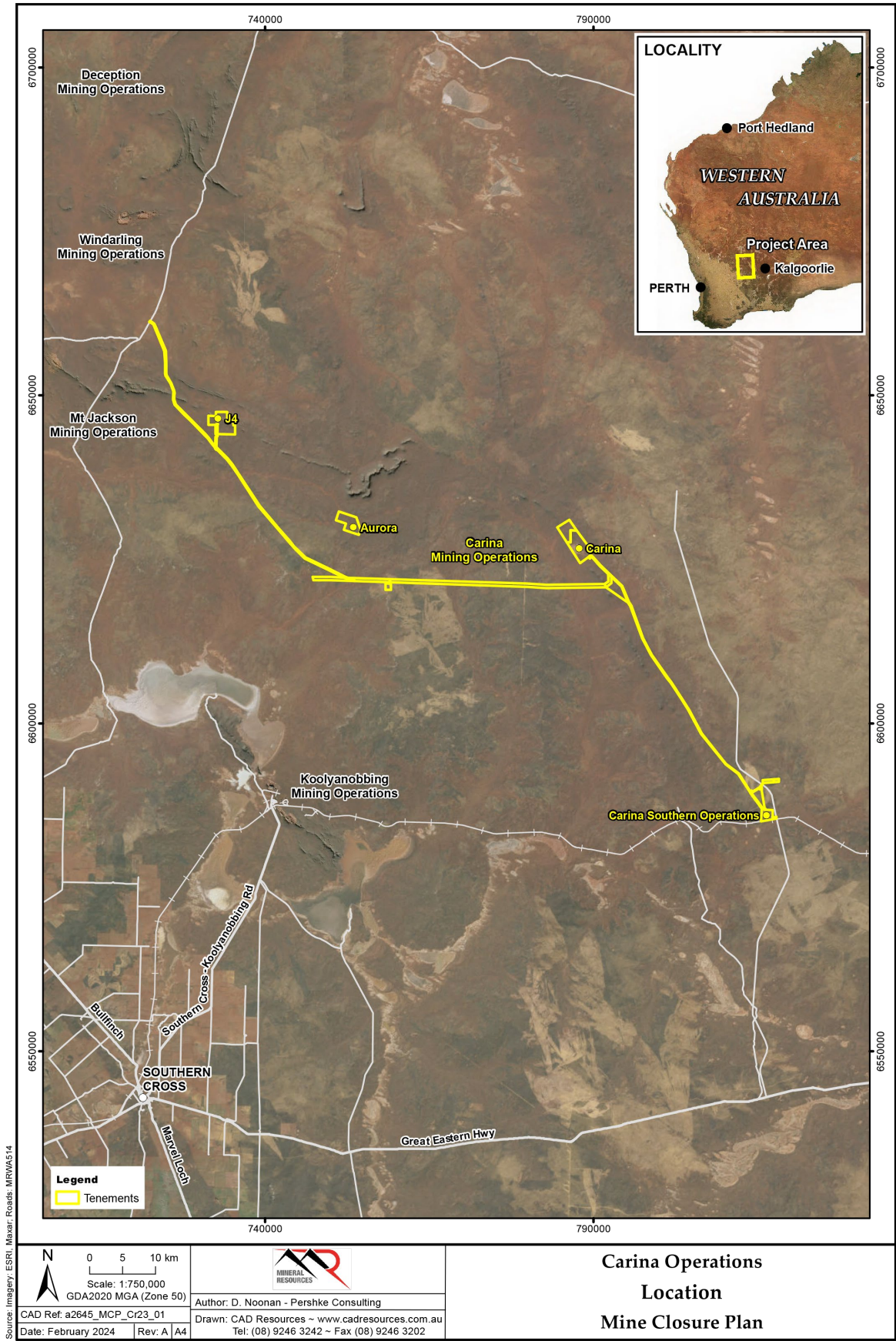
2.1 Project Overview

The Carina Operations, comprise two discrete iron-ore operations (Carina / Carina Extended and J4), a legacy gold mining site and former accommodation camp (Aurora), a haulage and rail transport hub, aerodrome and camp (Carina Southern Operations) and connecting haul roads, located within the Central Yilgarn / Western Goldfields region of Western Australia (WA). The operations extend from J4 in the north, approximately 100 kilometres (km) north of Southern Cross, to the Carina Southern operations approximately 100 km north-north-east of Southern Cross (Figure 1). Polaris Metals Pty Ltd (Polaris), a 100% owned subsidiary of MinRes owns and operates the Carina Operations as follows:

- The Carina / Carina Extended site, comprising two open pits and two WRLs, which are in an active closure phase since cessation of mining by MinRes in 2016 and 2018 respectively. The Carina Pit Lake is currently used as a source of water for the Carina Southern operations.
- The J4 site comprises two open pits and two WRLs. Mining recommenced at J4 in 2023 and involves an extension of the J4 East Pit, extension of the J4 West WRL and backfill of the J4 West Pit. The J4 operations were initially mined by MinRes from 2015 to 2018.
- The Aurora site was operated from 1995 to 2001 by Amalg Resources who subsequently purchased Breakaway in 2004 and adopted that name. Polaris acquired the tenement from Breakaway in May 2012. A regional exploration camp was constructed on the tenement and used by Polaris until 2018. The camp has now been decommissioned and the site, which includes one pit and one WRL, is in the closure phase. Prior to demobilising from the site, Breakaway, constructed an abandonment bund around the open pit and placed topsoil on the profiled WRL slopes (Polaris Metals, 2013c) but these works require rectification. It was also reported that the underground shaft was sealed (Polaris Metals, 2013c) but this requires confirmation.
- The Carina Southern Operations consist of the East Jaurdi Aerodrome, the Mt Walton Rail Siding and the Carina Accommodation Village, all of which remain operational to support the Carina Operations and other sites within the MinRes Yilgarn hub. Crushed ore is loaded at the Mt Walton Rail Siding for transport to the Port of Esperance for shipping.
- The Carina Southern Operations are connected to the Carina and J4 sites by sealed haul roads.
- Access to the Carina Southern Operations includes a portion of the existing Mt Walton intractable waste facility access road, Reserve 44102, from the Great Eastern Highway to the Trans-Australian Railway. Polaris obtained agreement from the Department of Treasury and Finance – Building Management and Works (BMW) to use this section of road for mine support traffic.
- The Aurora site is accessed via the Carina / J4 Haul Road and the Mt Dimer access with permission of the Department of Biodiversity, Conservation and Attractions (DBCA).

The iron ore operations are mined using conventional open pit mining methods. Drill and blast techniques are used to fragment the ore and overburden material. Blasted rock is mined using hydraulic excavators. Ore and low-grade stockpile material from J4 is transported to MinRes' Koolyanobbing site for crushing and screening.

Further details of each closure domain are provided in Section 2.4.



Refer to Appendix J for pdf version
Figure 1 Carina Operations Location Plan

2.2 Estimated Date for Completion of Operations

The Carina Operations are managed as a hub for the purposes of closure planning and implementation, based on their proximity and connectivity of access. The estimated completion date for the Carina Operations is 2030 based on the following:

- The Carina Southern Operations, including the Carina Camp and East Jaurdi Aerodrome, form a critical part of the long-term regional strategy for MinRes. Currently the East Jaurdi Aerodrome and sealed haul road network are being used to also transport personnel to the adjacent Koolyanobbing operations. The crushing facility at the Carina Southern Operations is currently being used to process ore from MinRes' Parker Range Operations.
- Financially viable blending stock located at J4, and ore being mined from the J4 East Pit expansion are hauled to the Koolyanobbing Crusher.
- Water from the Carina Pit Lake is being utilised for processing operations at Carina Southern Operations.
- Progressive closure activities are occurring at all the mine sites, including trials and investigations.
- The estimated date of completion for the MinRes Yilgarn Operations (2030).

2.3 Land Tenure and Ownership

2.3.1 Mining Tenure

All mining tenure occupied by the Carina Operations (Table 1) is held by Polaris Metals Pty Ltd, a wholly owned subsidiary of MinRes. All but the two undisturbed tenements (L15/310 and L15/329) have conditions requiring submission of an MCP. Figure 2 provides an overview of tenement locations for the Carina Operations.

Table 1 Tenement Details

Tenement	Activity	Area (ha)	Grant Date	Expiry
G15/21	Carina Southern Operations (incl. Mt Walton rail siding)	280.2	01/10/2010	30/9/2031
L15/303	Carina Village (Reverse Osmosis Plant and Waste Water Treatment Plant)	9.0	15/06/2010	14/6/2031
L15/305	Carina haul road	707.0	14/05/2010	13/5/2031
L15/306	Carina Village access road	22.0	06/05/2010	05/05/2031
L15/310	Undisturbed	1.87	02/07/2010	01/07/2031
L15/311	Mt Walton rail siding access road	1.72	02/07/2010	01/07/2031
L15/318	Power line and access corridor	12.1	06/04/2011	05/04/2032
L15/319	East Jaurdi Aerodrome	32.18	19/05/2011	18/05/2032
L15/320	East Jaurdi Aerodrome	71.34	19/05/2011	18/05/2032
L15/329	Undisturbed	1.35	01/06/2012	31/05/2033
L15/340	Haulage contractor yard	4.49	05/04/2013	04/04/2034
L16/91	Carina Northern Operations	10.4	09/12/2011	08/12/2032
L16/115	J4 haul road	600	21/05/2015	20/05/2036

Tenement	Activity	Area (ha)	Grant Date	Expiry
L77/250	J4 haul road	77.8	30/10/2014	29/10/2035
L77/251	Undisturbed	451.8	15/07/2015	14/07/2036
L77/252	J4 haul road	597	05/12/2014	04/12/2035
L77/254	J4 haul road	2,325	13/10/2014	12/10/2035
L77/274	Cleared for construction of J4 camp but it was not built	87.05	13/10/2014	12/10/2035
M77/580	Aurora Mine	702.45	15/06/1993	14/06/2035
M77/1244	Carina Mine	999.5	07/12/2009	06/12/2030
M77/1261	Carina Extended Mine	491.25	15/05/2012	14/05/2033
M77/1270	J4 Mine	994.5	20/08/2014	19/08/2035

2.3.2 Underlying Land Tenure

The tenure underlying the Carina Operations is shown in Figure 2, with detailed maps provided in Figure 3 to Figure 6, and described for each of the operations below.

2.3.2.1 Carina

2.3.2.1.1 Carina Northern Operations

The Carina Northern Operations (the Carina and Carina Extended mine sites and supporting infrastructure) and the majority of the Carina haul road are located within the former Jaurdi Pastoral Station, which was purchased by the Department of Conservation and Land Management (CALM) (now the DBCA) in 1989. The station was destocked and is now managed for conservation. The former Jaurdi Pastoral Station was proposed for inclusion in the Yilgarn conservation reserve system based on landscape and biodiversity values (EPA, 2007). The area is currently part of the DBCA - Lands of Interest data set, which shows all land to which DBCA is recognised as the manager, but which are not vested under any Act that is administered by DBCA.

2.3.2.1.2 Carina Southern Operations, Carina Camp and East Jaurdi Aerodrome

The Carina Southern Operations are located on UCL and Crown Land (DP 68972 and DP 409173).

2.3.2.2 J4

The J4 mining operations are located on the Mt Jackson Pastoral Station which is managed by Red Dirt Pastoral Pty Ltd. The operations are immediately south of an area (ex-Diemals Pastoral Station) that is proposed to be a Conservation and Mining Reserve under section 5(1)(h) of the *Conservation and Land Management Act 1984*.

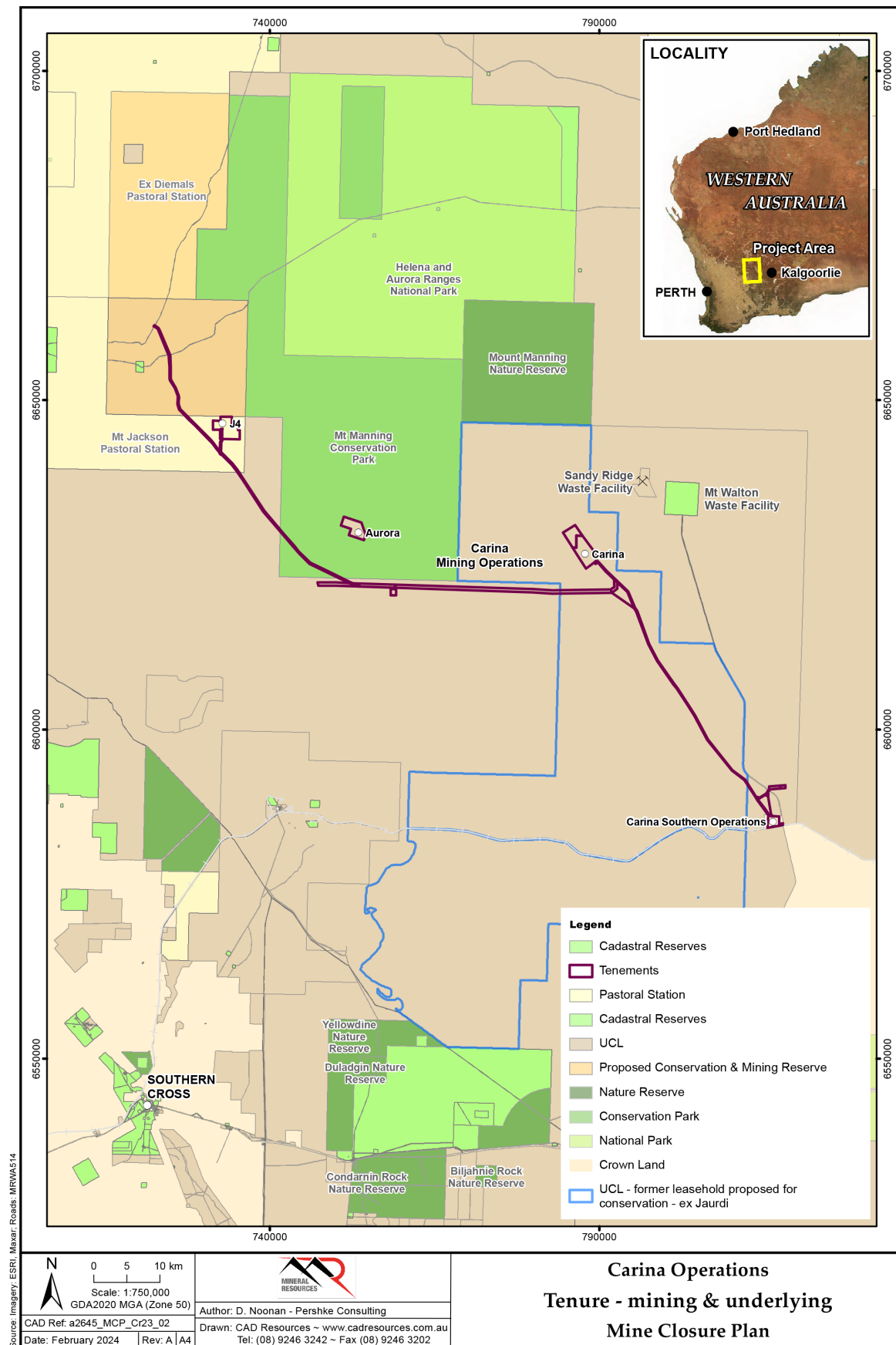
The J4 haul road (a 72 km extension of the Carina haul road network west to J4) traverses the Mt Jackson Pastoral Lease, UCL and the southeast corner of the Mount Manning Conservation Park.

2.3.2.3 Aurora

The Aurora site is located on Unallocated Crown Land (UCL) surrounded by tenure hosting the Mt Manning Conservation Park.

The surrounding tenure is part of the proposed Helena and Aurora Ranges National Park. Stage one of the creation of this national park has been completed with the upgrade of the existing non-class A Mount Manning Range Nature Reserve to class A national park. The next stage involves the conversion of the Mount Manning Conservation Park to class A national park and requires the development of an Indigenous Land Use Agreement with the Marlinyu Ghoorlie native title claimants (DBCA, 2022).

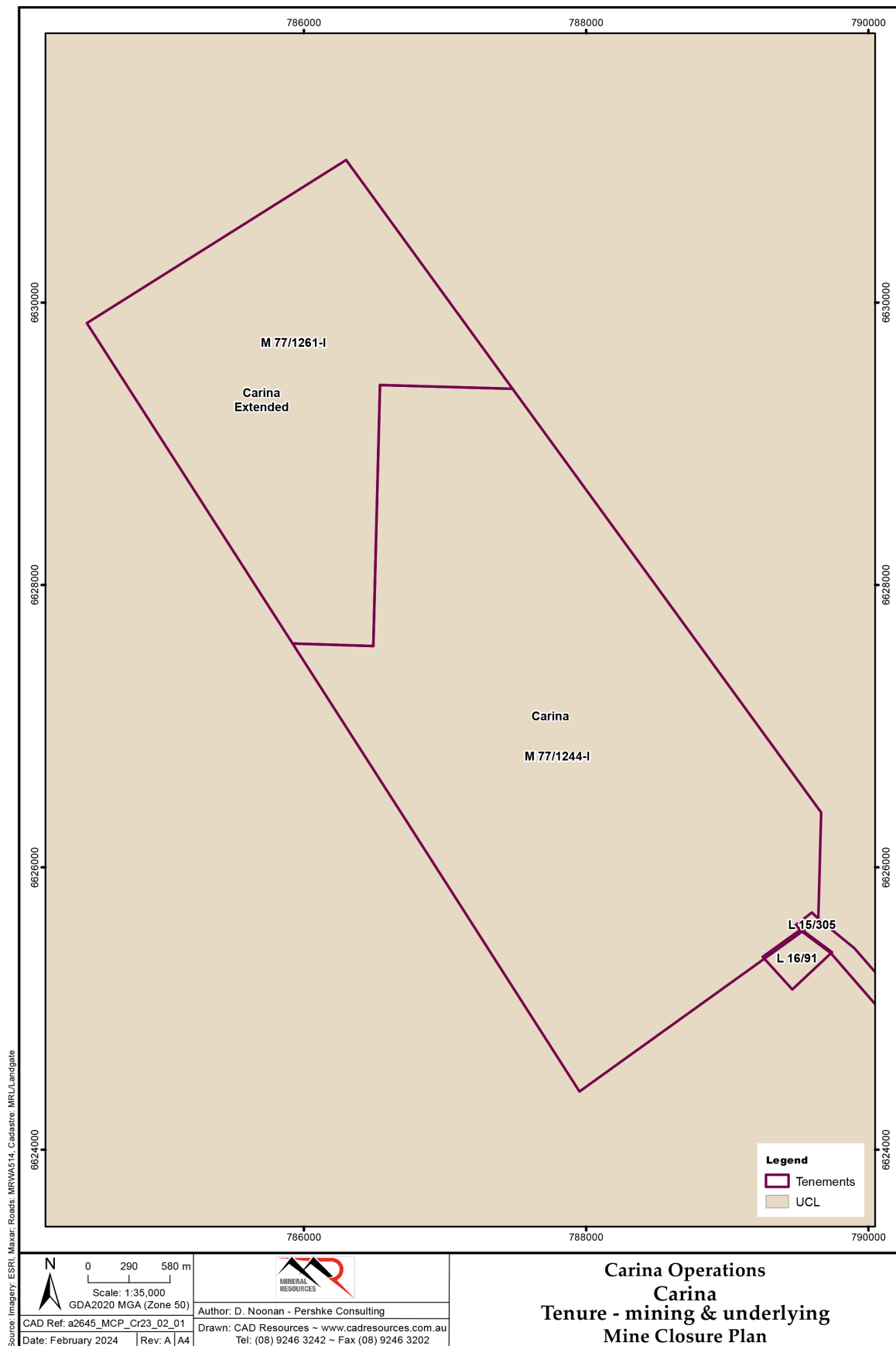
Access to the Aurora site is via existing tracks within the Mt Manning Conservation Park, as approved by the DBCA.



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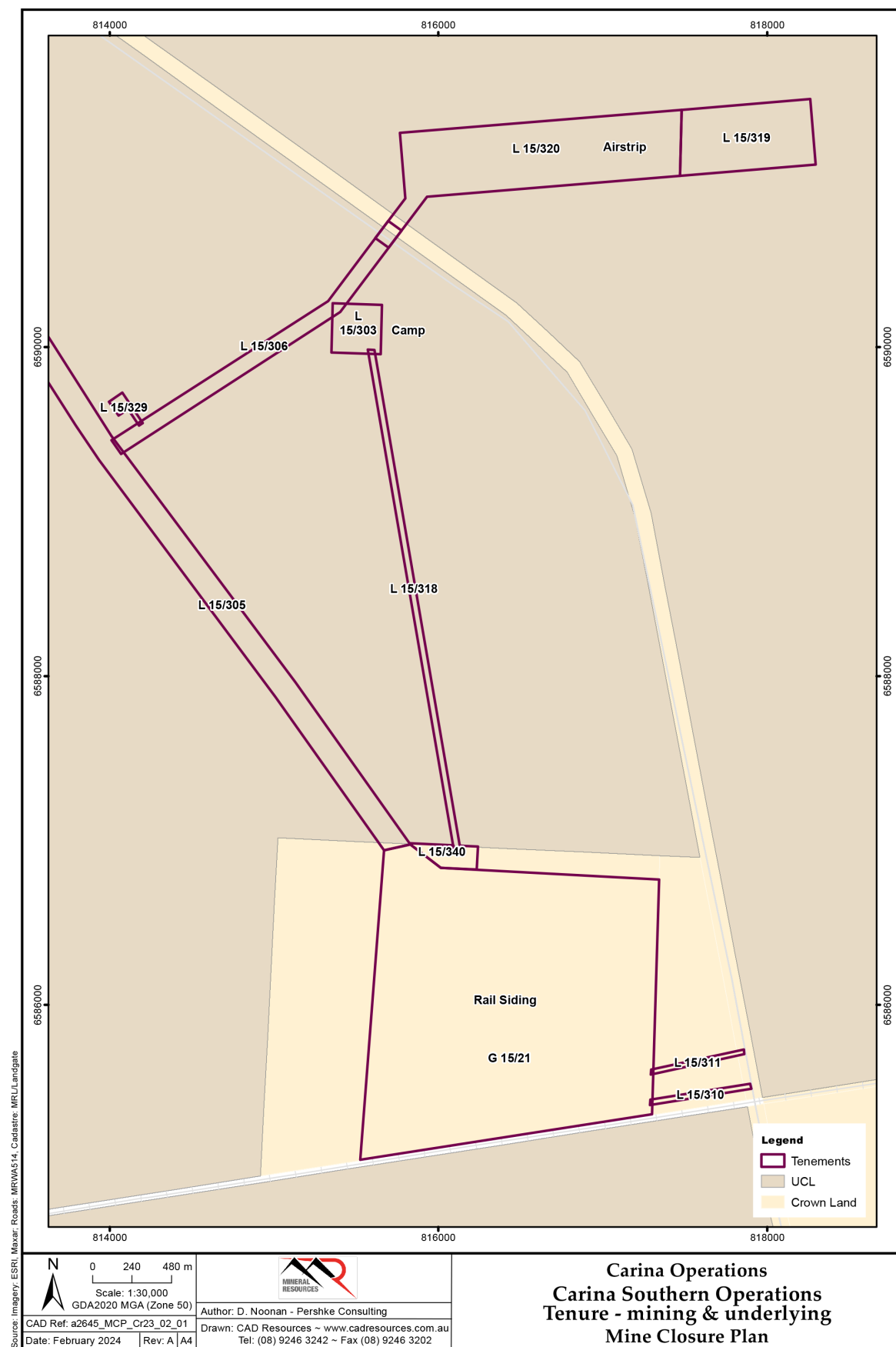
Figure 2 Carina Operations Tenure Overview

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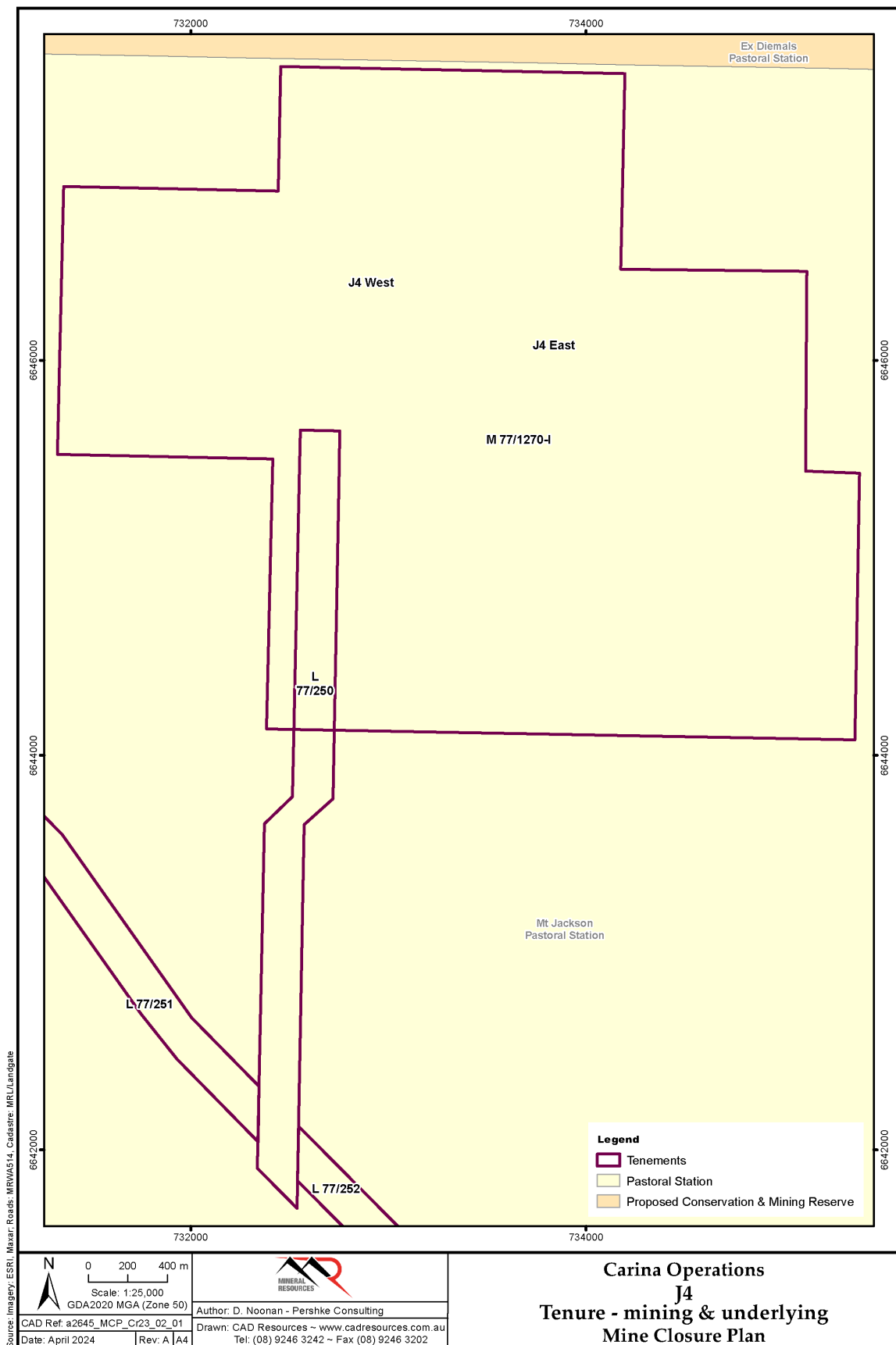
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Figure 3 Tenure – Carina and Carina Extended



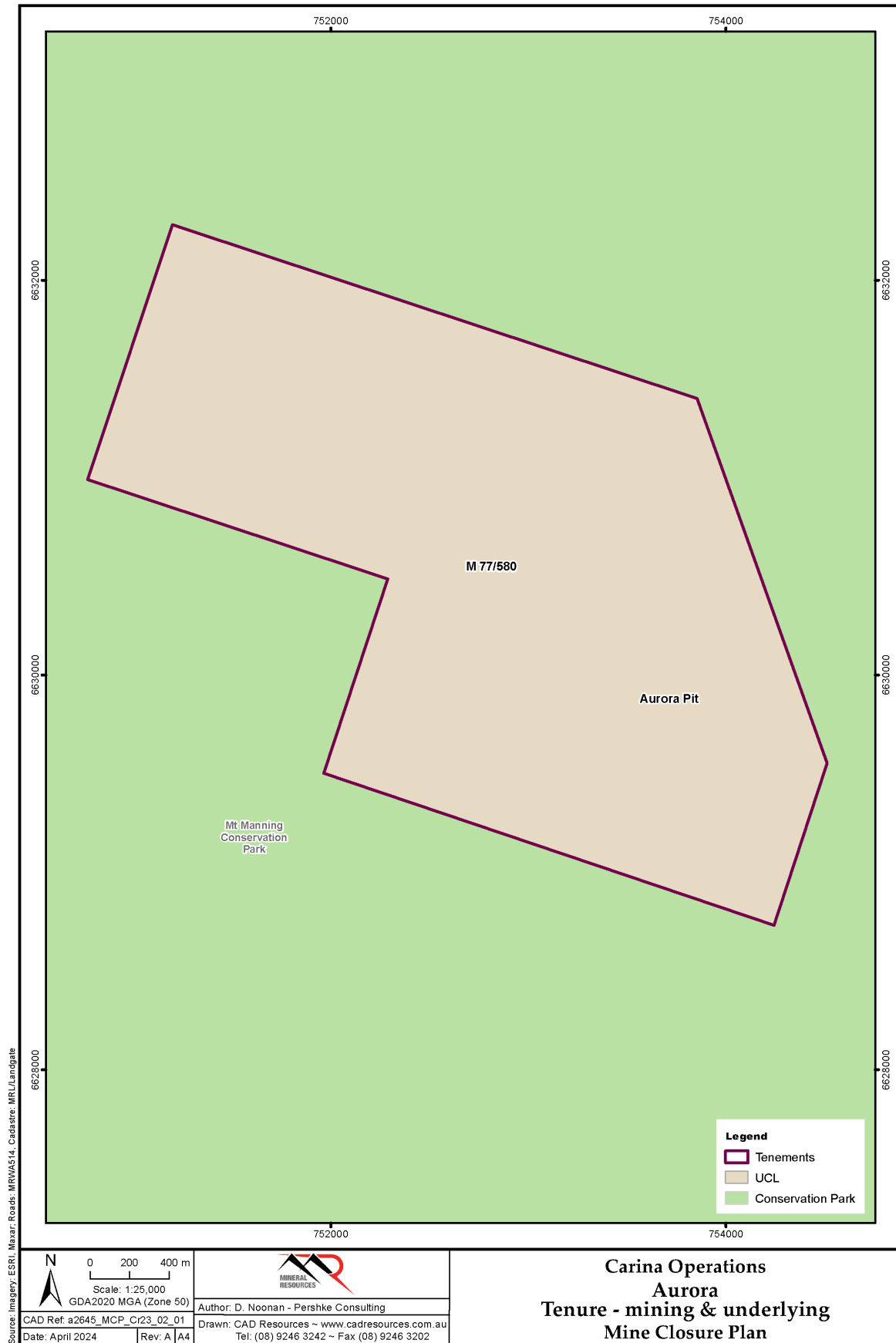
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Figure 4 Tenure – Carina Southern Operations



Refer to Appendix J for pdf version

Figure 5 Tenure – J4



Refer to Appendix J for pdf version

Figure 6 Tenure – Aurora

2.4 Major Mine Components and Closure Domains

Consistent with the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a), all mine and infrastructure features covered by this MCP have been classified into domains of similar characteristics and closure work programs including:

- Mine pits.
- Waste Rock Landforms (WRLs).
- Run of Mine (ROM) pads and stockpiles.

Infrastructure, excluding exploration, which is covered by separate programs of work, encompasses the following features and are shown on Figure 7 to Figure 10:

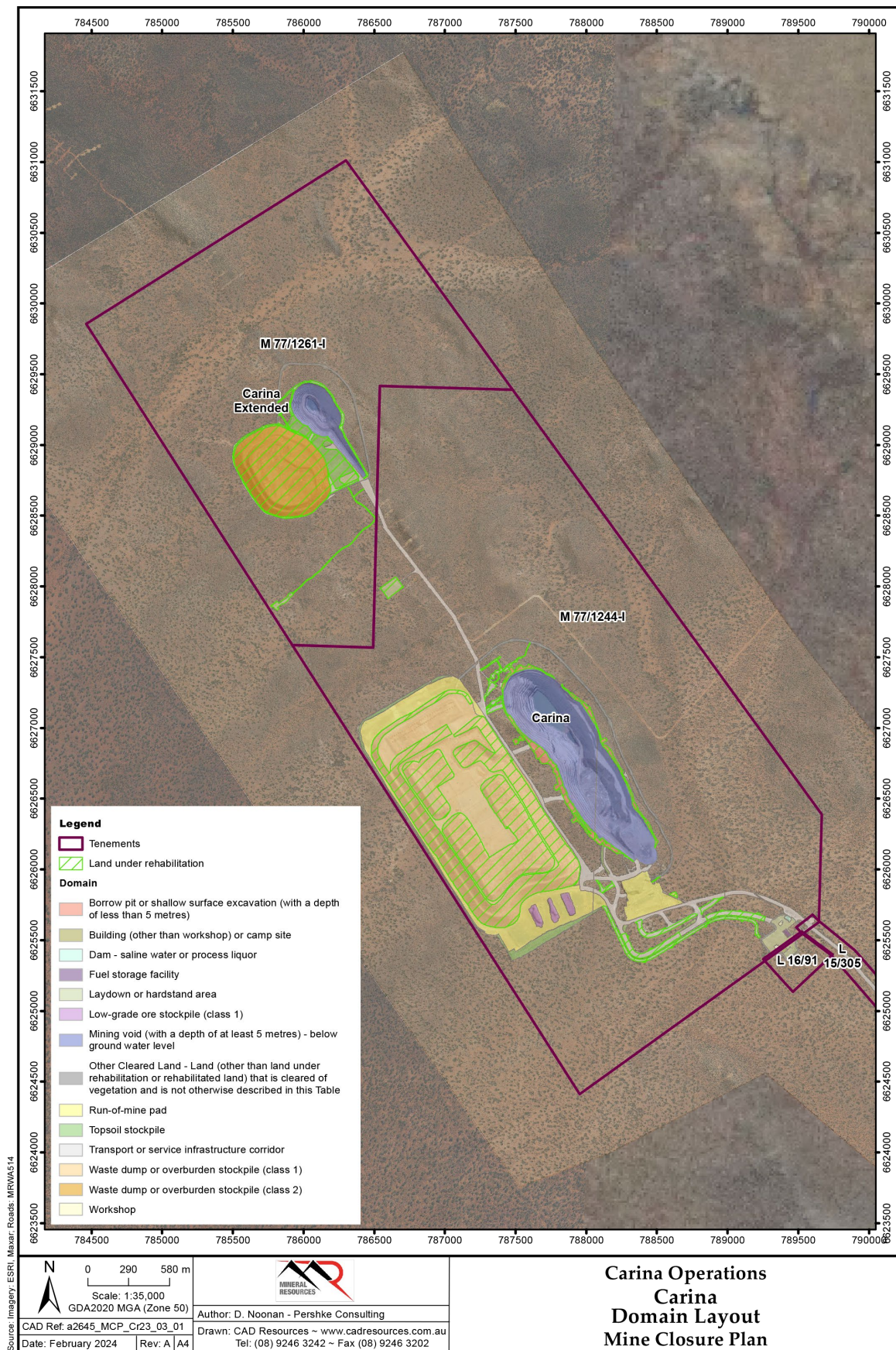
- Borrow pits.
- Buildings and camp sites.
- Workshops.
- Fuel storage.
- Dams.
- Sewage pond.
- Drains.
- Laydown / hardstand areas.
- Plant site.
- Transport and service infrastructure corridors.
- Other cleared land.
- Topsoil stockpiles.

Figures covering the length of the haul road are provided in Appendix J.

The features included in these domains are listed in Table 2 and Table 3 and have been categorised according to Mining Rehabilitation Fund (MRF) categories (see also Figure 7 to Figure 10) provided in the Mining Rehabilitation Fund Regulations 2013 (WA).

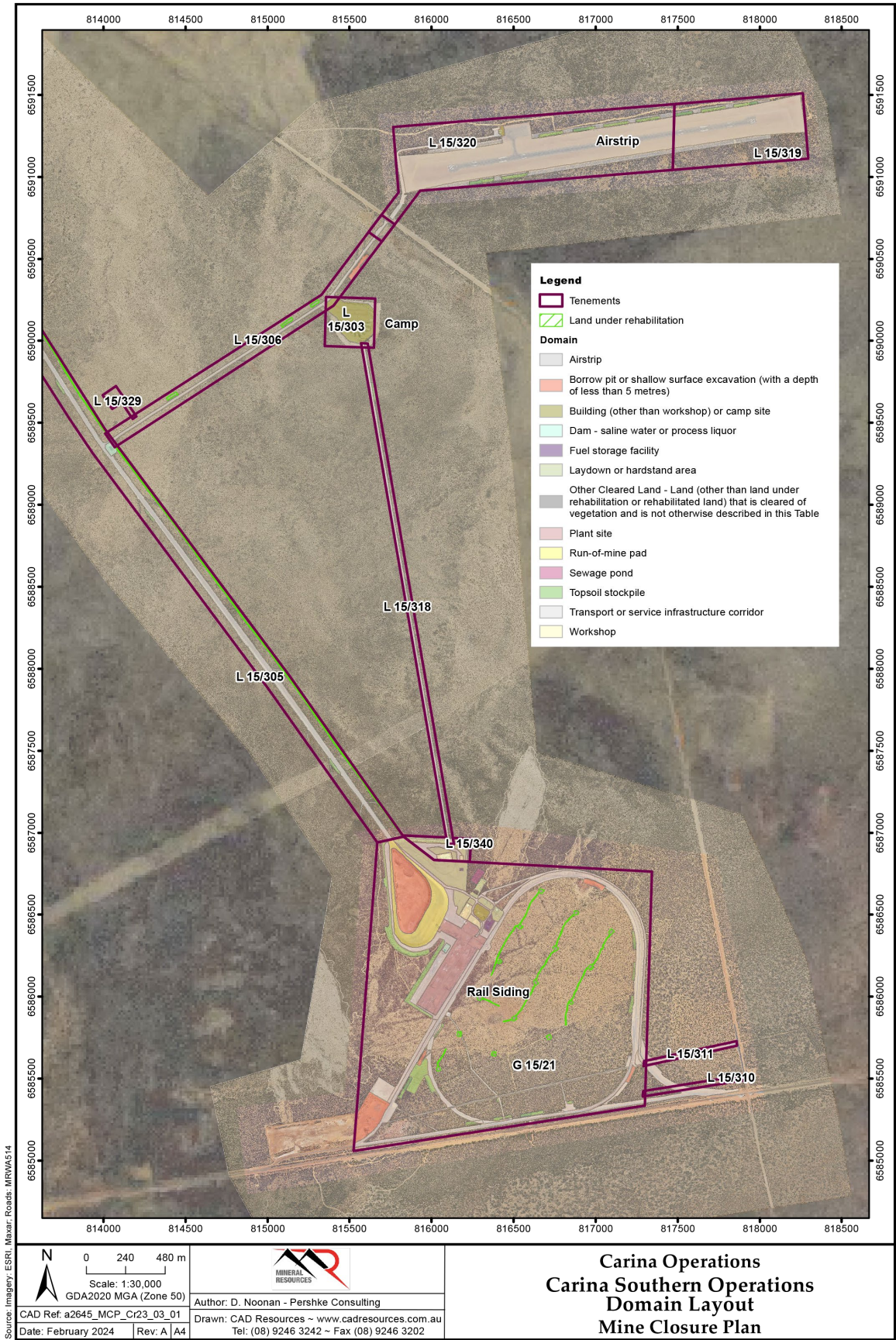
Table 2 and Table 3 includes operating and non-operating features, features where closure and rehabilitation are underway, and features where closure and rehabilitation work are complete, but monitoring is ongoing.

The areas of disturbance and rehabilitation provided in the Figures and Table that follow are based on the 2023 MRF data.



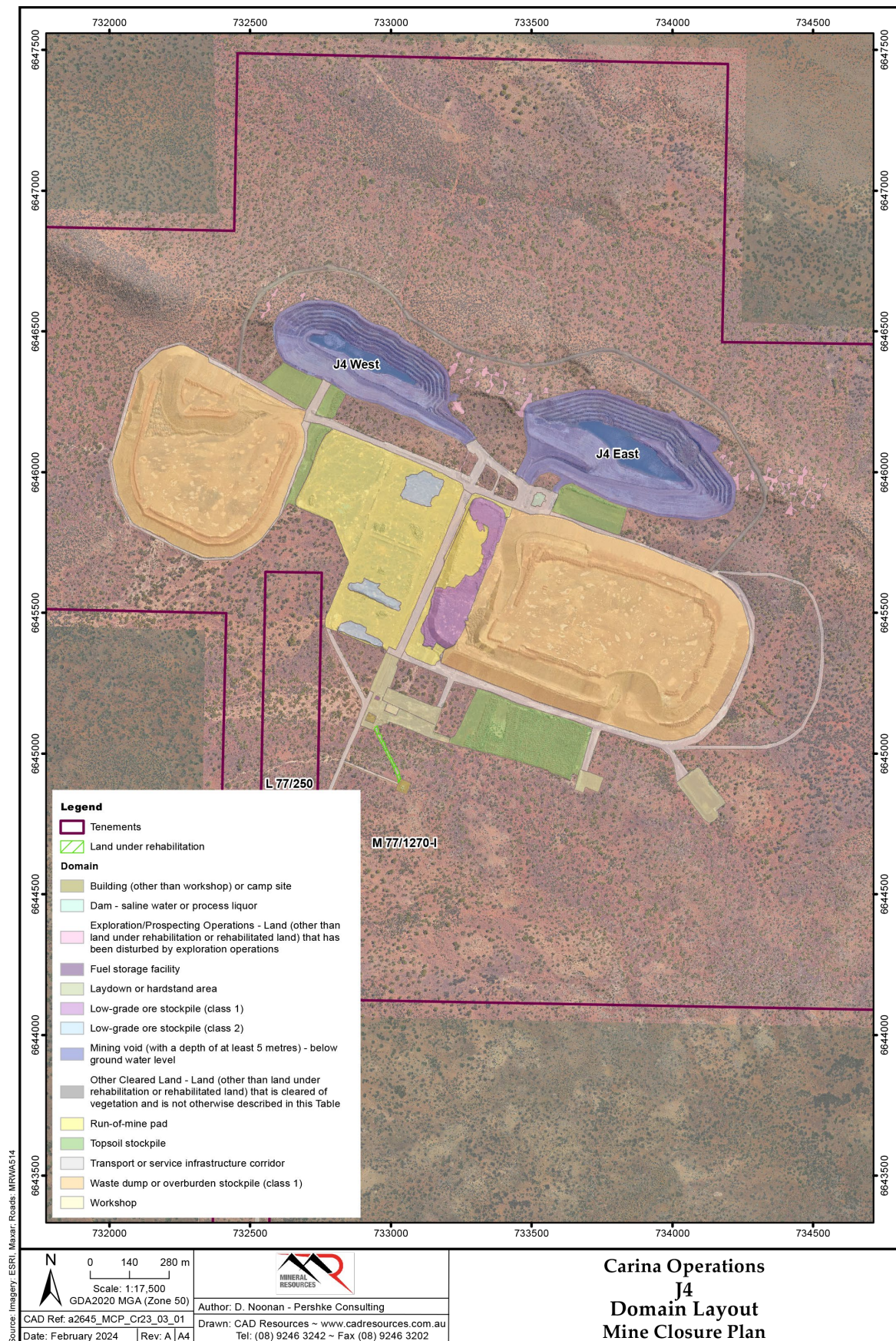
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Figure 7 Domains – Carina Northern Operations



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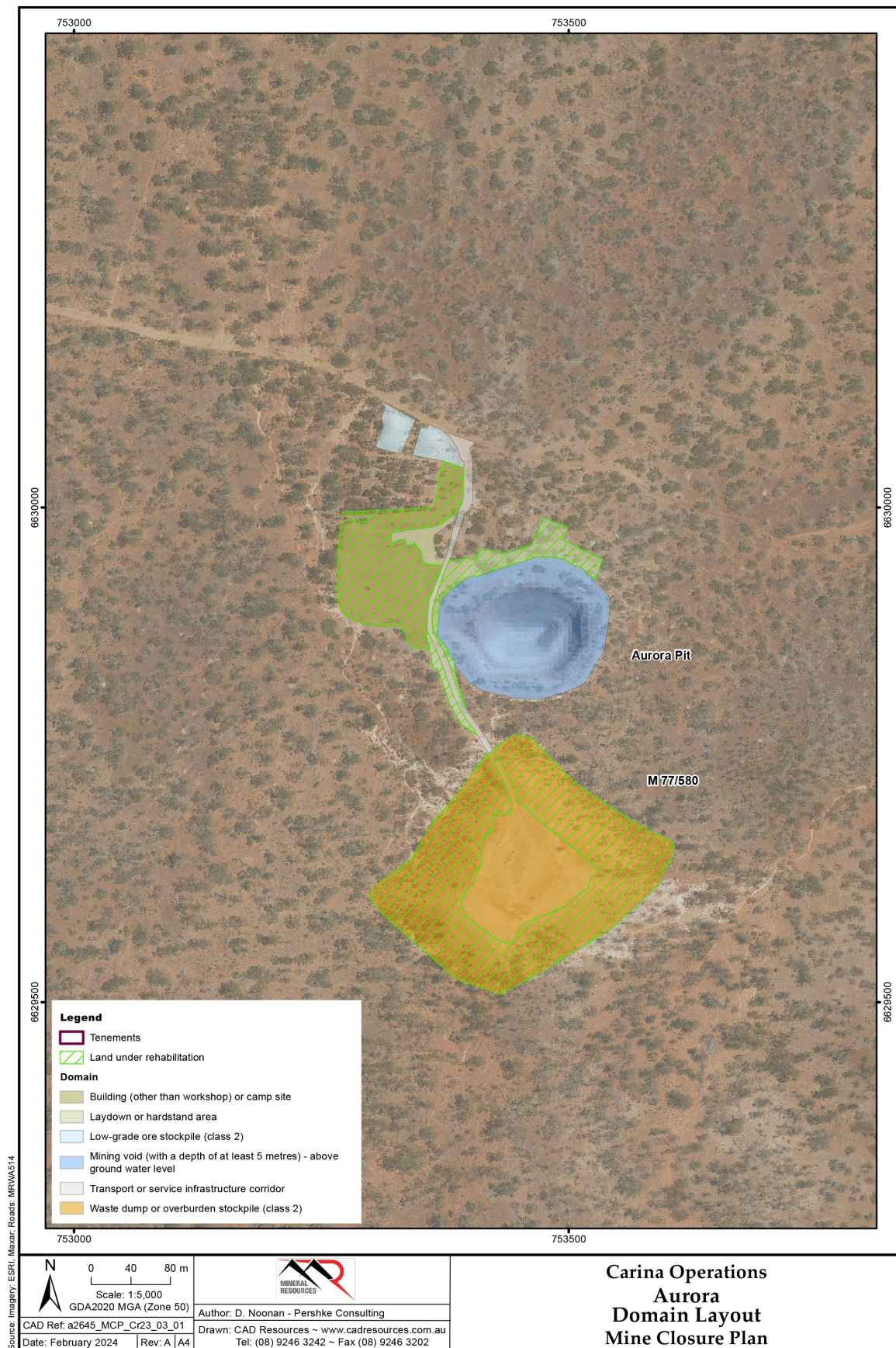
Figure 8 Domains – Carina Southern Operations



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Figure 9 Domains – J4

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Refer to Appendix J for pdf version

Figure 10 Domains – Aurora

Table 2 Mine Pit and WRL Features

Domain	Site	Feature (s)	Tenement	Status	Closure Strategy	MRF Category	Area Disturbed (ha)	Area Under Rehabilitation (ha)
Waste Rock Landforms	Carina	Carina WRL	M77/1244	- Inactive. - Outside ZOI of Carina Pit. - Partially under rehabilitation, commenced 2015. - Includes Potentially Acid Forming (PAF) encapsulation cell / landfill / evaporation ponds. Cover materials sampled were Non-Acid Forming (NAF). - Isolated areas of high salinity in cover materials. - Design non-compliances (lift height, berm widths, back-sloping). - No interaction with floodplain.	- Use the recommendations from the closure studies completed during 2022 – 2024 to develop a final landform plan that addresses design non-compliances, controls surface water run-off, maintains the depth of the PAF encapsulation cell cover and, where rehabilitation is yet to be completed, minimises interaction between saline materials and the plant root zone. - Select / develop reference ecosystems suited to WRL cover characteristics and Post Mining Land Use (PMLU).	A / E	41.24	90.21
		Carina Extended WRL	M77/1261	- Inactive. - Outside ZOI of Carina Extended Pit. - Rehabilitation works completed in 2018. - Cover materials sampled were NAF. - Erosion is yet to stabilise. - Isolated areas of high to extreme salinity in cover materials. - Design non-compliances (lift 1 height, berm widths (to be confirmed) and back-sloping on berms). - No interaction with floodplain.	- Closure strategy to address erosion to be finalised subject to review of: - berm capacity modelling recommendations - more detailed assessment of as-built berm widths - the results of additional erosion monitoring. - Seek approval via this MCP for Lift 1 height of 18 m (compared to approved design of 15 m). - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU where supplementary seeding required.	E	0	32.46
	J4	J4 East WRL	M77/1270	- Inactive. - ZOI to be assessed at completion of J4 East Pit development. - Cover materials predominantly NAF or UC. - Erosion observed and exacerbated where ripping not yet implemented. Low stability materials present in some areas. - Isolated areas of high to extreme salinity in cover materials. - Design non-compliances (maximum height. Lift height, overall slope angle, berm widths and back-sloping, cross bunds). - Negligible flood risk.	- Progress preliminary rectification plan submitted to DEMIRS at completion of mining at J4 East Pit to final design subject to the findings of forward work actions planned to address knowledge gaps (reassess interaction with ZOI interaction / mitigation approach for areas of low stability and / or high salinity cover materials present). - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.	A	95.71	0
		J4 West WRL	M77/1270	- Active. - ZOI not applicable as J4 West Pit planned to be backfilled to surface. - Cover materials predominantly NAF or UC. - Erosion observed and exacerbated where ripping not yet implemented. Low stability materials present in some areas. - Isolated areas of high salinity in cover materials. - Design non-compliances. - Negligible flood risk.	- Rectification of design non-compliances will occur as part of the expansion of this WRL to achieve the design parameters outlined in the J4 East Redevelopment MP (MinRes, 2023a) (which are consistent with the MCP 2019 and the original J4 Mining Proposal (MP) Registered Identification (REG ID) 56760 (Polaris Metals, 2015). - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.	A		
	Aurora	Aurora WRL	M77/580	- Outside ZOI. - Multiple and significant erosion gullies. Observed sediment deposition beyond toe of WRL. - No materials characterisation data available. - PMF flood assessment indicates minor potential for sediment release from toe, no recommendation for armouring based on low risk.	- Develop and implement landform rectification plan to address surface water control requirements. - Complete materials characterisation to inform WRL rectification plan. - Select / develop reference ecosystems suited to WRL cover characteristics and PMLU.	B	1.13	3.37
Mine Pits	Carina	Carina Pit	M77/1244	- Inactive, mining ceased 2016. - Mined Below Water Table (BWT) – partially backfilled. - Backfill potentially includes PAF. - PAF will remain exposed in some areas of pit walls. - Pit lake currently used as source of water for processing operations.	- Pit lake (expected sink at closure). - Complete studies necessary to refine pit lake modelling inputs and undertake monitoring to validate models. - Abandonment bund installed to prevent inadvertent access and incorporates flood protection bund.	B	58.69	0
	Carina	Carina Extended Pit	M77/1261	- Inactive, mining ceased March 2018. - Mined BWT.	- Pit lake (possible throughflow at closure). - Undertake monitoring to validate models. - Abandonment bunds installed to prevent inadvertent access.	B	12.4	0
	J4	J4 East Pit	M77/1270	- Active, mining recommenced 2023. - Mined BWT. - High sulfur materials (oxidised) in pit wall.	- Pit lake (sink at closure). - Undertake monitoring to validate models. - Abandonment bund installed to prevent inadvertent access.	B	42.22	0
	J4	J4 West Pit	M77/1270	Inactive (mining), mining ceased March 2018. Mined BWT.	Backfill to surface.	B		0

Domain	Site	Feature (s)	Tenement	Status	Closure Strategy	MRF Category	Area Disturbed (ha)	Area Under Rehabilitation (ha)
				Active backfill.	Select / develop reference ecosystems.			
	Aurora	Aurora Pit	M77/580	- Open pit did not intersect groundwater. - Abandonment bund within ZOI.	- Pit void at closure - Relocate abandonment bund.	C	1.95	0

Table 3 ROM, Stockpiles, and Infrastructure Features

Domain	Site	Feature (s)	Status	Tenement	MRF Category	Area Disturbed (ha)	Area Under Rehabilitation (ha)
ROM Pads & Stockpiles	Carina	Carina ROM Pads (2)	Inactive	M77/1244	C	36.24	0.117
		3 x low grade ore stockpiles - Class 1	Inactive	M77/1244	A	2.42	0
	Carina Southern Operations	Carina Southern Operations ROM Pad	Active	G15/21	C	7.09	0
	J4	J4 ROM Pad	Active	M77/1270	C	28.56	0
		J4 East low-grade ore stockpile – Class 1	Inactive	M77/1270	A	5.11	0
		J4 East low-grade ore stockpiles – Class 2	Inactive	M77/1270	B	2.65	0
	Aurora	Two low-grade stockpiles – Class 2	Inactive	M77/580	B	0.25	0
Infrastructure & General Disturbance Excluding Exploration	Aurora	Former Aurora accommodation village (rehabilitated footprint)	Under rehabilitation	M77/580	E	0	1.185
		Unsealed access road	Active	M77/580	C / E	0.236	0.083
		Hardstand area & communications tower	Inactive	M77/580	C / E	0.114	0.395
	Carina Northern Operations	Buildings - light vehicle shed, medic building, communications tower	Active	L16/91	C	0.093	0
		Carina heavy vehicle workshop	Inactive	M77/1244	B	0.176	0
		Carina washdown bay and reverse osmosis plant – partly decommissioned	Active	M77/1244	C	0.142	0
		Generators (2)	Inactive	M77/1244	C	0.2	0
		Carina former explosives magazine	Under rehabilitation	M77/1244	C	0.037	0
		Surface water management flood bund (Carina Mine Infrastructure Area)	Active	L16/91 & M77/1244	B	0.347	0
		Saline or process water turkeys nest	Inactive	M77/1244	B	0.142.	0
		Piezometers and monitoring bores	Active	M77/1244	C	0	0
		Unsealed haul road	Active	M77/1244	C / E	24.827	9.12
		Unsealed access roads including unsealed public access road around Carina Extended WRL	Active	M77/1261	C / E	2.953	3.4
			Active	L16/91	C	0.021	0
		Topsoil and / or vegetation stockpiles	Inactive	M77/1244	E	7.325	0.184
				M77/1261	E	0.202	5.462
			Inactive	State Agreement	E	1.907	0
		State Agreement - Transport or Service infrastructure corridor	Active	State Agreement	E	12.117	0

Domain	Site	Feature (s)	Status	Tenement	MRF Category	Area Disturbed (ha)	Area Under Rehabilitation (ha)
		Laydown, hardstand, unsealed parking	Active	L16/91	C	1.038	0
		Former Hardstand (under rehabilitation)	Under rehabilitation	M77/1261	E	0	1.579
		Hardstand	Inactive/ under rehabilitation	M77/1244	C / E	3.217	1.216
		Borrow pit (1) (under rehabilitation)	Under rehabilitation	M77/1244	E	0	7.28
		Workshop - Mineral Resources Transport (MRT) Haulage	Active	L15/340	B	0.471	0
Infrastructure & General Disturbance Excluding Exploration	Carina Southern Operations	Offices / Buildings - MRT Haulage	Active	L15/340	C	0.461	0
		Washdown bay and water treatment plant – MRT Haulage	Active	L15/340	C	2.03	0
		Unsealed access road, park-up & drains - MRT Haulage	Active	L15/340	C	1.429	0
		Workshop - Crushing Services International (CSI) Crushing	Active	G15/21	B	0.864	0
		Offices / Buildings - Plant site & Laboratory	Active	G15/21	C	0.687	0
		Waste water treatment plant	Active	G15/21	C	0.461	0
		Fuel storage facility: three x 110,000 L double skinned fuel tanks (rail) & two x 110,000 L double skinned fuel tanks.	Active	G15/21	B	0.429	0
		Processing equipment comprising (G15/21): two stackers, one reclaimer, one train loadout, ore stockyard, substation, six generators and main electrical transform and distribution room (G15/21).	Active	G15/21	B	9.166	0
		Transport or service infrastructure corridor including rail loop, 3 x rail ballast areas, fire break containment tracks & communications tower.	Active	G15/21	C	14.052	0
		Transport or service infrastructure corridor	Active	Crown Lease	C	16.615	0
		Laydown	Active	G15/21	C	7.211	0
		Saline or process water turkeys nests x 2	Active	G15/21	A	0.171	0
		Fresh water dam	Active	L15/305	B	0.532	0
		Saline or process water turkeys nests x 2	Active	L15/305	A	0.772	0
		Sealed Haul Road	Active	L15/305	C	131.765	6.415
		Unsealed access road	Active	L15/306	C	4.227	0
		Unsealed access road & boom gate control building	Active	L15/311	C	1.044	0
		Unsealed access road & buried pipeline	Active	L15/318	C	4.134	0
		Topsoil and / or vegetation stockpiles	Inactive / under rehabilitation	G15/21	E	4.965	0
				L15/305	E	14.58	0
				L15/306	E	0	0.34
				L15/318	E	0.213	0
		Borrow pits	Inactive / under rehabilitation	G15/21	C	8.94	0
				L15/305	C / E	18.17	14.68
				L15/306	C	0.46	0
				Crown Lease	C	3.603	0

Domain	Site	Feature (s)	Status	Tenement	MRF Category	Area Disturbed (ha)	Area Under Rehabilitation (ha)
	Carina Camp	Accommodation village comprising (L15/303): accommodation buildings, reverse osmosis plant, gym and recreation court, storage shed, standby generator, light vehicle access, unsealed car park, fire break, wastewater treatment plant and irrigation field.	Active	L15/303	C	5.424	0
	East Jaurdi Aerodrome	Sealed airstrip, unsealed apron and plane park up area, fence.	Active	L15/319	C	18.233	0
				L15/320	C	40.992	0
		Aerodrome terminal	Active	L15/320	C	0.172	0
		Unsealed access road	Active	L15/320	C	2.134	0
		Topsoil and / or vegetation stockpiles	Inactive	L15/319	E	0.763	0
				L15/320	E	1.73	0
Infrastructure & General Disturbance Excluding Exploration	J4	Building other than workshop / communications towers (2)	Active	L77/254	C	1.456	0
		Former Workshop - heavy vehicle (building removed)	Inactive	M77/1270	B	0.135	0
		Building (medic building)	Active	M77/1270	C	0.29	0
		Fuel storage facility: one 110,000 L double skinned fuel tank (M77/1270)	Active	M77/1270	B	0.021	0
		Laydown / hardstand including former J4 explosives magazine	Inactive	M77/1270	C	6.079	0
		Saline or process water turkeys nest	Inactive / under rehabilitation	M77/1270	B	0.175	0
				L77/252	B / E	0.638	0.251
				L77/254	B	1.337	0
		Dewatering bores	Inactive	M77/1270	C	0	0
		Sealed haul road and above ground pipeline, communications tower and laydown / hardstand.	Active (except pipeline)	L16/115	C / E	3.288	0.56
				L77/250	C	6.774	0
				L77/252	C	56.533	0
				L77/254	C	73.265	0
		Unsealed access roads / communications tower and building	Active	M77/1270	C	19.764	0.189
		J4 resource definition drilling	Inactive	M77/1270	D	2.973	0
		Topsoil and / or vegetation stockpiles	Inactive	L16/115	E	0.466	0
				L77/250		1.012	0
				L77/252		5.539	0
				L77/254		15.056	0
				M77/1270		15.91	
		Borrow pits	Inactive / under rehabilitation	L77/252	E	0	13.2
				L77/254	C / E	3.6	13.17
		Building (other than workshop) or campsite (area cleared for J4 camp, but camp not built)	Under rehabilitation	L77/274	C	0	7.639

3. IDENTIFICATION OF CLOSURE OBLIGATIONS AND COMMITMENTS

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a), the mine closure plan details all legal obligations for rehabilitation and closure that will affect the post-mining land use and closure outcomes, as provided in:

- *Section 3: Sources of Closure Obligations and Commitments*
- *Appendix A: Register of Closure Obligations and Commitments.*

Mine closure planning at the Carina Operations is governed by the legal frameworks in which the projects operate including, various Commonwealth and State legislation (Section 3.1) and site-specific conditions arising from approvals, tenements, third-party agreements and proponent commitments made in submissions as outlined in Sections 3.2 to 3.5 and detailed in Appendix A.

Obligations can also arise from commitments made during stakeholder consultation which is discussed in Section 4 with a detailed stakeholder engagement register provided in Appendix B.

One environmental management plan has been prepared for the Carina Operations operating phase (Polaris Metals, 2023). Some of the requirements of this plan may extend into the closure execution phase and / or inform closure monitoring and maintenance as discussed in Section 3.6.

Section 3.7 lists industry guidelines that have been considered, where applicable, in the preparation of the MCP.

3.1 Legislation and Regulation

Commonwealth legislation applicable to mine closure and considered in the preparation of this MCP are listed below:

- *Native Title Act 1993.*
- *Aboriginal and Torres Strait Islander Heritage Protection Act 1984.*
- *Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act).*

State legislation and regulations applicable to mine closure are listed below:

- *Environmental Protection Act 1986 (EP Act) and associated regulations.*
- *Mining Act 1978 and Mining Regulations 1981.*
- *Mines Safety and Inspection Act 1994 and Mines Safety and Protection Regulations 1995.*
- *Rights in Water Irrigation Act 1914 (RIWI Act).*
- *Contaminated Sites Act 2003 (CS Act) and Contaminated Sites Regulations 2006.*
- *Aboriginal Heritage Act 1972 (AH Act).*
- *Land Administration Act 1997.*
- *Biosecurity and Agricultural Management Act 2007.*
- *Biodiversity Conservation Act 2016 (BC Act) and Biodiversity Conservation Regulations 2018.*
- *Soil and Land Conservation Act 1945.*
- *Dangerous Goods Safety Act 2004.*

- *Conservation and Land Management Act 1984.*
- *Waterways Conservation Act 1976.*

3.2 Mining Act 1978 and Tenement Conditions

The Carina Operations are implemented on the mining tenements listed in Table 1. Mining tenement conditions applicable to closure are listed in Appendix A-1.

Numerous Mining Proposals (MPs), MP Addendum documents and Notices of Intent (NOI) have been submitted under the *Mining Act 1978* for sites within the Carina Operations. Since the last MCP revision, closure related statements from 29 MPs, MP Addendums and NOIs, approved and listed as Environmental Registrations under the *Mining Act 1978*, have been collated into a working register. A list of the documents reviewed is provided in Appendix A-2 and the full register is provided in Appendix A-3.

MinRes will progressively review and update this working register, which includes duplicate and potentially superseded statements, for currency and applicability to the MCP. The register includes the ability to search statements by closure domain, aspect and activity and has been used to provide background to relevant sections throughout this MCP and will continue to inform future revisions of the MCP. Where there are potential conflicts between historic statements and current plans, this has been identified and addressed in the relevant sections of this plan.

3.3 Environmental Protection Act 1986 Part IV

The Carina Operations are subject to three approvals under Part IV of the EP Act:

- Ministerial Statement (MS) 852 which applies to the Carina Iron Ore Mine (including Carina Southern Operations [haul road, rail siding, accommodation village] and Carina Extended) and was published on 28 January 2011.
- MS 957 which also applies to the Carina Operation documented in MS 852 and was published on 12 December 2013.
- MS 988 which applies to the Jackson 4 (J4) Iron Ore Mine and Haul Road and was published on 24 October 2014.

The conditions of these Ministerial Statements relevant to closure are provided in Appendix A-4 and approval boundaries shown in Figure 11.

The Aurora operation was approved in 1994 and 1995, prior to the EP Act 1986 and so is not subject to a Ministerial Statement.

3.4 Environmental Protection Act 1986 Part V

Licences issued under Part V of the EP Act 1986, to regulate processing or beneficiation of ore (Category 5), crushing and screening of waste rock material (Category 12), putrescible landfill (Category 89), Class II or III putrescible landfill (Category 64) used tyre storage (Category 57), sewage facility (Category 54) and mine dewatering (Category 6) at the Carina Operations, are detailed in Table 4. While the licences pertain to the operating phase, they contain conditions of potential relevance to closure which are summarised in Appendix A-5.

Table 4 Carina Operating Licences

Licence No	Issued	Last amended	Expiry date	Premises
L8596/2011/1	18/11/2011	16/05/2022	20/11/2016	Carina Iron Ore Project and General Purpose Lease Mount Walton Road
L8837/2014/1	23/10/2014	16/05/2022	23/10/2019	Carina Iron Ore Project – Northern Operations
L8945/2016/2	03/03/2016	16/05/2022	06/03/2026	J4 Iron Ore Project

3.5 Native Title Act 1993

Native Title applications and determinations are maintained by the National Native Title Tribunal (NNTT) and the Federal Court of Australia in accordance with the *Native Title Act 1993* (Commonwealth).

The Carina Operations fall within the boundaries of the Marlinyu Ghoorlie Registered Native Title Claim (WAD647/2017, WC2017/007), Brian Champion and Ors, State of Western Australia (Marlinyu Ghoorlie). MinRes is currently progressing an Indigenous Land Use Agreement with the Marlinyu Ghoorlie.

MinRes will continue to engage with all relevant Traditional Owners and knowledge holders in relation to mine closure activities pertaining to the Carina Operations.

3.6 Environmental Management Plan

The Carina and Jackson 4 Project Environmental Management Plan (PEMP) (Polaris Metals, 2023) has been prepared to satisfy Condition 9 of MS 852 and Condition 6-2 of MS 988 and is updated at 3-yearly intervals.

To satisfy the MS conditions, the PEMP outlines the management measures that will be implemented to protect terrestrial flora, vegetation, and fauna from the project operations generally and to manage the potential impacts of the J4 Haul Road. Management measures outlined in the most recently approved PEMP will be implemented as applicable to the closure execution phase at the Carina Operations as discussed in Section 9.1.

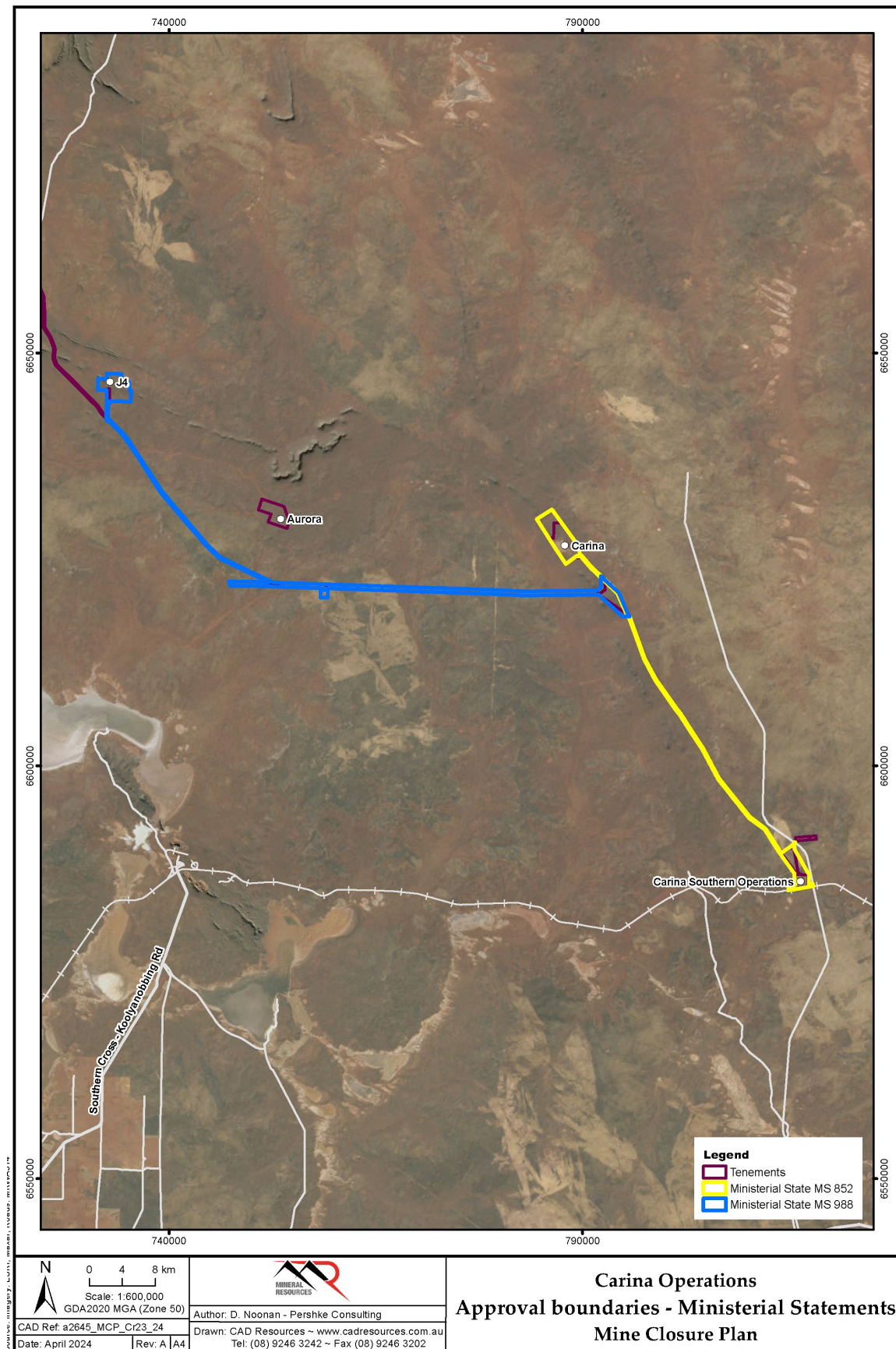
3.7 Industry Guidelines

In addition to the DEMIRS statutory MCP Guidelines (2020a) and Mine Closure Plan Guidance (DMIRS, 2020b), other industry guidelines have also been considered in the preparation of this MCP (Table 5).

Table 5 Industry Guidelines Considered for this MCP

Management Aspect	Guidelines
Closure, Rehabilitation & Risk	- Strategic Framework for Mine Closure (Australian and New Zealand Minerals and Energy Council (ANZMEC) and Minerals Council of Australia (MCA) (ANZMEC & MCA, 2000) - Mine Closure: Leading Practice Sustainable Development Program for the Mining Industry (DISER, 2016a) - Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry (DISER, 2016b) - Technical Guidance - A framework for developing mine-site completion criteria in Western Australia (Young, et al., 2019) - Guidance for the Assessment of Environmental Factors No. 6 – Rehabilitation of Terrestrial Ecosystems (EPA, 2006) - The International Principles and Standards for the Ecological Restoration and Recovery of Mine Sites (Young R. G., 2022)
Abandonment Bund Design	Guideline - Safety Bund Walls Around Abandoned Open Pit Mines (DoIR, 1997)

Management Aspect	Guidelines
Geotechnical Assessments	Ground Control Management in Western Australian Mining Operations – Guideline (DMIRS, 2019)
Materials Characterisation	- Preventing Acid and Metalliferous Drainage: Leading Practice Sustainable Development Program for the Mining Industry (DISER, 2016c) - Draft Guidance Materials Characterisation Baseline Data Requirements for MPs (DMP, 2016)
Waste Rock Landforms	Environmental Notes on Mining: Waste Rock Dumps (DMP, 2009)
Contaminated Sites	- Assessment and Management of Contaminated Sites – Contaminated Sites Guidelines (DWER, 2021) - Identification, Reporting and Classification of Contaminated Sites in Western Australia – Contaminated Sites Guidelines (DER, 2017)
Groundwater bores	Minimum Construction Requirements of Water Bores in Australia (NUDLC, 2020)



Refer to Appendix J for pdf version

Figure 11 Ministerial Statement Boundaries

4. STAKEHOLDER ENGAGEMENT

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a), the mine closure plan:

- *Lists those stakeholders affected by rehabilitation and mine closure and any consultation undertaken to date (Section 4.1.1); and*
- *Describes the strategy for ongoing stakeholder engagement (Section 4.1.3).*

MinRes' objective for stakeholder consultation in relation to closure planning is to identify stakeholders who may be affected by the implementation of this MCP and engage with them in a timely manner to allow their input to inform mine closure strategies, requirements for closure studies and definition of Post Mining Land Uses (PMLUs).

Effective stakeholder consultation is an integral component of MinRes' planning, assessment, and development processes for its ongoing operations through to, and including, mine closure.

4.1 External Stakeholders

4.1.1 Stakeholder Identification

In accordance with the Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia (ANZMEC/MCA) Strategic Framework for Mine Closure (ANZMEC & MCA, 2000), MinRes has identified key stakeholders for this MCP (Table 6). Section 4.1.3 provides a summary of the proposed future engagement strategy.

Table 6 External Stakeholders

Stakeholder group	Stakeholder
State Government	• Department of Mines, Energy, Industry Regulation and Safety (DEMIRS) * • Department of Biodiversity, Conservation and Attractions (DBCA) * • Department of Water and Environmental Regulation (DWER) * • Department of Planning, Lands and Heritage (DPLH) *³ • Pastoral Lands Board (PLB) • Environmental Protection Authority (EPA) • Conservation and Parks Commission of Western Australia* • Department of Primary Industries and Regional Development (DPIRD)
Local Government	• Shire of Yilgarn* • Shire of Coolgardie*
Native Title Party (Traditional Owners with native title rights)	• Marlinyu Ghoorlie*
Pastoral Lease Holder	• Red Dirt Pastoral Pty Ltd*
Community	• Community Consultation Group (CCG) members*

³ Based on DPLH feedback (13 August 2020), future consultation between MinRes and DPLH will specifically focus on matters related to Heritage and Native Title.

Stakeholder group	Stakeholder
Local and regional groups	• Conservation Council of Western Australia • Helena and Aurora Range Advocates Inc. • Nest Egg Foundation (formerly Malleefowl Preservation Group) & the National Malleefowl Recovery Group (WA Branch) • Wilderness Society Western Australia • Wildflower Society of Western Australia
Private organisations	• Tellus Holdings

Note: *key stakeholder

4.1.2 Stakeholder Consultation to Date

MinRes maintains a stakeholder engagement register that includes the outcomes of consultation related to closure. A summary of closure related engagement and where it is addressed in this MCP, is provided in Appendix B.

Significant engagements since submission of the last MCP include the following:

- Well-attended community forums in December 2021 and July 2022 where MinRes outlined:
 - The commitment to closure planning and implementation.
 - Technology being developed to support closure planning at a landform scale.
 - Proposed PMLU.
 - Progressive closure and rehabilitation progress, including Carina PAF cell investigation, rehabilitation of historic exploration disturbance at J4 and planned seed collection.
- Engagement with DEMIRS (then DMIRS) in June 2022 to discuss the approach to abandonment bund designs and WRL final designs, which is applicable to all sites within the Yilgarn hub.
- A meeting with DEMIRS in February 2023 to discuss the vision for closure and provide an overview of the three-year plan of forward works, studies & rehabilitation, including at the Carina, Aurora and J4 sites.
- A similar meeting with DBCA in March 2023 to discuss the closure vision and forward work plans with emphasis on closure matters with the potential to impact flora / fauna and the PMLU. This engagement also established the frequency for ongoing consultation.

The Marlinyu Ghoorlie People are recognised as a key stakeholder (Section 4.1). MinRes have been engaging with Marlinyu Ghoorlie and relevant knowledge holders since 2020. Engagement with Marlinyu Ghoorlie has focused on the drafting of a comprehensive claim-wide agreement (Indigenous Land Use Agreement). Agreement negotiations will be ongoing. Future engagement with Marlinyu Ghoorlie will include consultation and engagement regarding mine closure. It is intended for this MCP to be used as a starting point for those discussions with feedback included in the next update, to allow sufficient time for review and input by Marlinyu Ghoorlie (Section 4.1.3).

4.1.3 Future Consultation

The aims of closure-related stakeholder engagement include:

- Agreement of PMLU.
- Development of post-mining access plans.
- Identification of infrastructure to be retained and signing of agreements with third parties regarding post-closure legal responsibility.
- Agreement of completion criteria with lead regulatory agencies.

- Establishment of a formal closure sign-off and relinquishment mechanism with lead regulatory agencies that outlines the responsibilities and accountabilities and proposed methodologies to achieve sign-off.

The strategy for ongoing engagement with stakeholders to meet these aims is provided in Table 7.

Table 7 Stakeholder Consultation Program

Stakeholder	Timing	Planned communication
Traditional Owners	In accordance with MinRes' broader engagement strategy.	- Ongoing communication / consultation on project status. - Utilise this MCP to consult on closure strategy including: - Cultural values and implications for potential closure designs and outcomes. - Requirements for access to areas of cultural significance. - All engagement activities are undertaken through the MinRes Communities and Heritage Team.
Pastoral Lease Owner	As required.	- Focus on proposed closure activities occurring within the Station area (J4). - PMLU and associated rehabilitation and closure objectives. - Retention of roads and tracks and appropriate design to enable maintenance with pastoral equipment. - Post-relinquishment access considerations.
DEMIRS	Annual and as required.	- Annual compliance reporting and site inspections. - MCP strategy, design of WRLs and abandonment bunds, plans for transfer of access tracks / roads to third party post-closure, completion criteria.
DBCA Conservation and Parks Commission	6 monthly	MCP strategy, managing impacts of closure designs on flora and vegetation, completion criteria, post-mining land use, post-mining access, feral animal control.
DWER and EPA Services	As required	MCP strategy and MS obligations.
DPLH	As required	Based on DPLH feedback (13 August 2020), consultation between MinRes and DPLH will specifically focus on matters related to heritage and native title.
Shire of Yilgarn Shire of Coolgardie	Annual and as required.	- Ongoing communication / consultation on project status. - Review of the MCP strategy including plans for transfer of access tracks / roads to third party post-closure, completion criteria, PMLU, post-mining access.
CCG	Annual	- Ongoing communication / consultation on project status. - Review of the MCP strategy including plans for transfer of access tracks / roads to third party post-closure, completion criteria, post-mining land use, post-mining access.
Conservation Council of WA Helena and Aurora Range Advocates Inc. Nest Egg Foundation & National Malleefowl Recovery Group (WA Branch) The Wilderness Society Wildflower Society of WA	Annual (via invitation to the CCG annual meeting).	MCP strategy, managing impacts of closure designs on flora and vegetation, completion criteria, post-mining land use, post-mining access, feral animal control.
Stakeholders with access, tenure or infrastructure interests including: Tellus Holdings	As required.	MCP strategy with respect to infrastructure and areas of shared access or other third-party agreements.

4.2 Internal Stakeholders

Closure consultation with key internal stakeholders is undertaken and recorded as detailed in Table 8. Since submission of the previous MCP, the physical proximity and reporting structure of the closure and mine planning teams has been designed to facilitate important internal engagement between the two disciplines.

Table 8 Internal Stakeholder Consultation Plan

Stakeholder	Closure aspect	Nature and frequency of engagement	Record of outcomes
Closure team	Progressive closure and rehabilitation planning. Financial provisioning for closure.	- Line management responsibility for monitoring of conformance to MCP commitments through monthly meetings / periodic site visits. - Development of management strategies (as required). - Sign-off on budgets and plans (annual). - Integration of closure considerations into key project approvals / project changes. - Participation in risk assessment for MCP review and update.	Outcomes reflected in relevant sections of MCP (risk assessment, implementation, progressive rehabilitation and forward work plan).
Closure, Environment, Communities and Heritage and Land Access Teams and Technical specialists e.g., hydrogeologists, hydrologists, geotechnical engineers, geochemists, botanists.	Closure studies and monitoring. Stakeholder engagement.	- Delivery of closure studies and monitoring (ongoing). - Two-way communication regarding stakeholder engagement outcomes / commitments associated with environmental approvals / management and closure (ongoing). - Participation in risk assessment for MCP review and update.	Outcomes reflected in relevant sections of MCP (baseline and closure data, stakeholder engagement, risk register, PMLU, Completion Criteria).
Mine manager Mine Services Team	Progressive closure. Closure risk mitigation.	- Key closure management measures and risk mitigation, including minimising operational impacts, compliance to plans, topsoil and subsoil management, incidents and resourcing, and rehabilitation plans and schedule (periodic site meetings / monthly meetings). - Sign off on closure implementation procedures. - MCP update review.	- Outcomes reflected in relevant sections of MCP (implementation, risk register, monitoring and management). - Annual environment reports. - Operating procedure revisions.
Mine planners	Design to meet regulatory requirements.	- Provide data relating to mine pits, WRLs and incorporation of earthmoving requirements to achieve landform design in mine plan (regular fortnightly meetings). - Participate in risk assessment for MCP update.	Outcomes reflected in relevant sections of MCP (implementation and risk assessment).
Legal / accounts	Closure costs and responsibilities.	Closure responsibilities under agreements.	Incorporated in MCP obligations section.

5. BASELINE AND CLOSURE DATA AND ANALYSIS

STATEMENT OF COMPLIANCE WITH GUIDELINES

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes baseline data that:

- *Informs successful rehabilitation and closure*
- *Identifies the issues to be managed through the mine closure process and the environmental closure risks*
- *Informs the development of criteria or indicators for closure monitoring and performance*
- *Informs the establishment of achievable closure outcomes and goals in a local and regional context*
- *Establishes baseline conditions for closure monitoring programs.*

The mine closure plan also includes:

- *An analysis of the baseline data that describes how the wider receiving environment, receptors and exposure pathways have been considered*
- *An analysis of the baseline data that identifies the knowledge gaps and the risk of not having that information*
- *Details of the methodology of analysing the baseline data.*

All relevant technical reports are provided in Appendix C.

5.1 Climate

Key Points

- The climate of the Coolgardie region is semi-arid.
- Evaporation (2,200-2,800 millimetres (mm)) far exceeds average annual rainfall (~300 mm).
- Daily rainfall occurrences > 25 mm are rare. High rainfall events include 77 mm in 1999 at Southern Cross Airfield (BoM Site 012320) and 181 mm at Coolgardie (BoM Site 012018) in a 24-hour period.
- Lowest annual rainfall records include 83.7 mm (1999) and 151.4 mm (1969) at Southern Cross Airfield and Coolgardie respectively.
- There are no records of major flood events since 2014.
- Climate change is predicted to result in:
 - Increased temperatures (0.5 – 1.3 degrees Celsius (°C) by 2030 and 1.1 – 2.7°C by 2099).
 - Reduced rainfall (6% by 2030 and 12% by 2099), but an increase in the intensity of extreme events.
 - Increased evaporative demand in all seasons and an increase in the time spent in drought.
- Consideration of extreme rainfall events and climate change are factored into closure planning based on risk:
 - Rehabilitation considers timing of reliable rainfall and building resilience to climate change through species diversity.
 - Flood modelling considers 1:2,000 Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events (Section 5.6.1.4) and groundwater throughflow conditions resulting from a pit lake filling scenario (Section 5.6.2.3.2) have been based on the conservative assessment that the pit lake is filled to the crest (a 1:2,000 AEP event would result in a rise in pit lake levels of 3 - 9 m).
 - Groundwater modelling (Section 5.6.2.3.1) has used wet and dry climate change scenarios to define upper and lower bound conditions for pit lake levels and residual groundwater drawdown.
 - Landform design checks have been informed by berm capacity modelling conducted for the Yilgarn conditions generally and Carina site specifically (Section 5.9.1).

5.1.1 Climate Data

The Carina Operations are located within the Coolgardie Bioregion of WA, which experiences a semi-arid Mediterranean climate characterised by cool, wet winters and hot, dry summers. Representative Bureau of Meteorology (BoM) weather stations for the operations include the Southern Cross Airfield (Site 012320) located approximately 100 km south of the Carina Operations and Coolgardie (Site 012018) located approximately 100 km east of the Carina Southern Operations. Records have been collected from Southern Cross Airfield (Site 012320) since 1996 and from Coolgardie (Site 012018) since 1893, which is particularly valuable for trend determinations.

At both sites maximum temperature peaks ($> 30^{\circ}\text{C}$) occur between November and March (Table 9, Figure 12 and Figure 13). Rainfall occurs throughout the year with Southern Cross Airfield (Site 012320) receiving a mean 78 days and 302 mm of rainfall per year and Coolgardie (Site 012018) receiving a mean 49 days and 265.5 mm of rainfall per year. Wettest months (> 20 mm) occur between January and August. Driest months (< 20 mm) occur between October and December (Table 10, Figure 12 and Figure 13). However, monthly rainfall is not strongly seasonally distributed due to the influence of cyclonic weather patterns experienced from January to April.

Daily rainfall records for the Southern Cross Airfield (Site 012320) indicate there have only been 40 days (since 1996) where rainfall exceeded 25 mm in a 24-hour period and the single largest daily rainfall event was 77 mm. Only 168 daily rainfall records from Coolgardie (Site 012018) (over a 127-year period) exceeded 25 mm in a 24-hour period and the single largest daily event was 181 mm (January 1967). Annual rainfall records range from 151.4 mm (1969) to 552 mm (1999) at Southern Cross Airfield (Site 012320) and from 83.7 mm (1999) to 633 mm (1992) at Coolgardie (Site 012018). The most recent significant events at Southern Cross Airfield (Site 012320) occurred in April 2021 and April 2023, with 36.4 mm and 28 mm, respectively, of rainfall recorded in a 24-hour period (BoM, 2023a). At Coolgardie (Site 012018) recent significant events include 90.4 mm of rain received on 2nd October 2010 and 61.6 mm received on 19th March 2012 (BoM, 2024a). Also of note, at Coolgardie (Site 012018) the lowest monthly rainfall records (0 mm) for all months occurred in either 2018 or 2019. At Southern Cross Airfield (Site 012320) minimum monthly records for each month are more widely spread occurring between 2001 and 2022.

Rainfall records are also available from Dedari (Site 012204), 100 km south-east of the Carina mine area. For the period 1958 – 2015, the site reports mean annual rainfall of 295.3 mm, highest annual rainfall of 554.6 mm and lowest annual rainfall of 118.6 mm (BoM, 2024b). Credo (Station 012259), ~ 80 km east of the Carina mine area also provides some rainfall records for the period 2011 – 2024. Only highest daily rainfall statistics are provided with 121.6 mm of rain recorded in a 24-hour period on 23rd January 2014 (BoM, 2024c).

Evaporation data has been sourced from Luke et al. (1987) and the Queensland Government's Scientific Information for Land Owners (SILO) database (Table 10). Evaporation exceeds rainfall in all months of the year, with June having the minimum evaporation rate of approximately 70-80 mm and January the maximum of approximately 320-440 mm. The annual average pan evaporation for the region is between 2,200-2,800 mm, which exceeds annual rainfall by approximately a factor of 8.

Table 9 Temperatures at Southern Cross Airfield (BoM Station No. 012320) and Coolgardie (BoM Station No. 012018)

Statistic / Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean max. ($^{\circ}\text{C}$)													
012320 ¹	34.8	33.9	30.6	26.2	21.4	17.9	16.8	18.6	22	26.5	29.9	33.1	25.9
012018 ²	33.3	32.3	29.4	24.9	20.3	16.9	16.1	18.1	22	25.1	29.3	32.3	25

Statistic / Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean min. (°C)													
012320	17.9	17.8	15.5	11.8	7.3	4.6	3.7	4.0	5.7	9.5	13.1	15.7	10.5
012018	17	16.8	15.1	12	8.6	6.5	5.2	5.9	7.9	10.2	13.4	15.8	11.2

Source:

¹ Southern Cross Airfield from 1996 – October 2023 (BoM Station No. 012320) (BoM, 2023a)² Coolgardie from 1897 - 1953 (BoM Station No. 012018) (BoM, 2024a)**Table 10 Rainfall Data at Southern Cross Airfield (BoM Station No. 012320), Coolgardie (BoM Station No. 012018) and Mean Evaporation Data from DPIRD² and SILO database³**

Statistic / Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Monthly Rainfall (mm)													
012320	27.3	26.1	35.5	23.6	27.1	26.7	34.1	31.8	19.7	18.4	17.5	14.4	302.5
012018	23.4	27.5	25.3	21.7	28	28.8	23.8	23.6	13.6	16	16.4	17.1	265.5
Highest Monthly Rainfall (mm)													
012320	113	103.4	154.4	77.8	91.8	69	76.8	82.6	40.8	87.8	46.8	91.4	551.8
012018	194.4	237	219.4	105.5	115.4	165	75.3	93.8	92.6	90	77.8	101.2	633.2
Highest Daily Rainfall (mm)													
012320	60.0	56.8	66.0	77.0	39.0	23.0	39.4	53.2	14.2	42.0	26.0	36.6	-
012018	181.4	135.4	81.8	51.6	42.4	49	29.6	53	43.9	65.8	56.1	48.3	-
Lowest Monthly Rainfall (mm)													
012320	0	0	0	0	2.2	2	7.8	5.8	1.4	0.2	0.2	0	151.4
012018	0	0	0	0	0	0	0	0	0	0	0	0	83.7
Mean Pan Evaporation (mm)													
DPIRD ¹	436	350	314	194	120	80	91	109	151	244	306	409	2,804
SILO database ²	321.3	257.9	226.7	145.3	95.1	68.9	69.1	91.8	134.1	205.6	259.1	310.1	2,185

Sources:

¹ Southern Cross Airfield from 1996 – October 2023 (BoM Station No. 012320) (BoM, 2023a)² Coolgardie from 1893 - 2020 (BoM Station No. 012018) (BoM, 2024a)³ Pan Evaporation for Southern Cross (Luke, Burke, & O'Brien, 1987)⁴ Queensland Government Science Information for Landowners (SILO) Australian climate data (PSM Consult Pty Ltd, 2023 Draft)

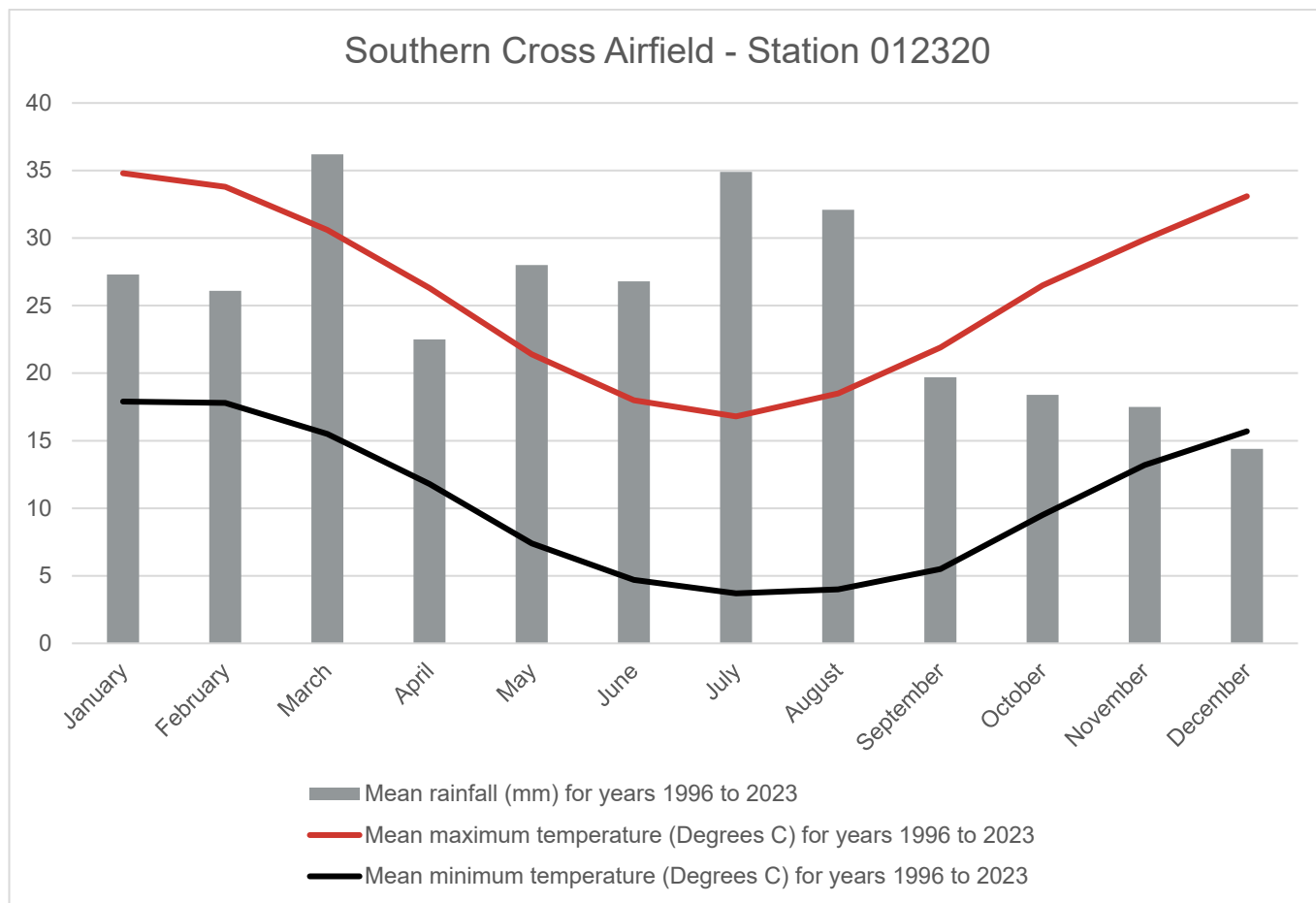


Figure 12 Southern Cross Airfield (Site 012320) Monthly Temperatures & Rainfall (BoM, 2023a)

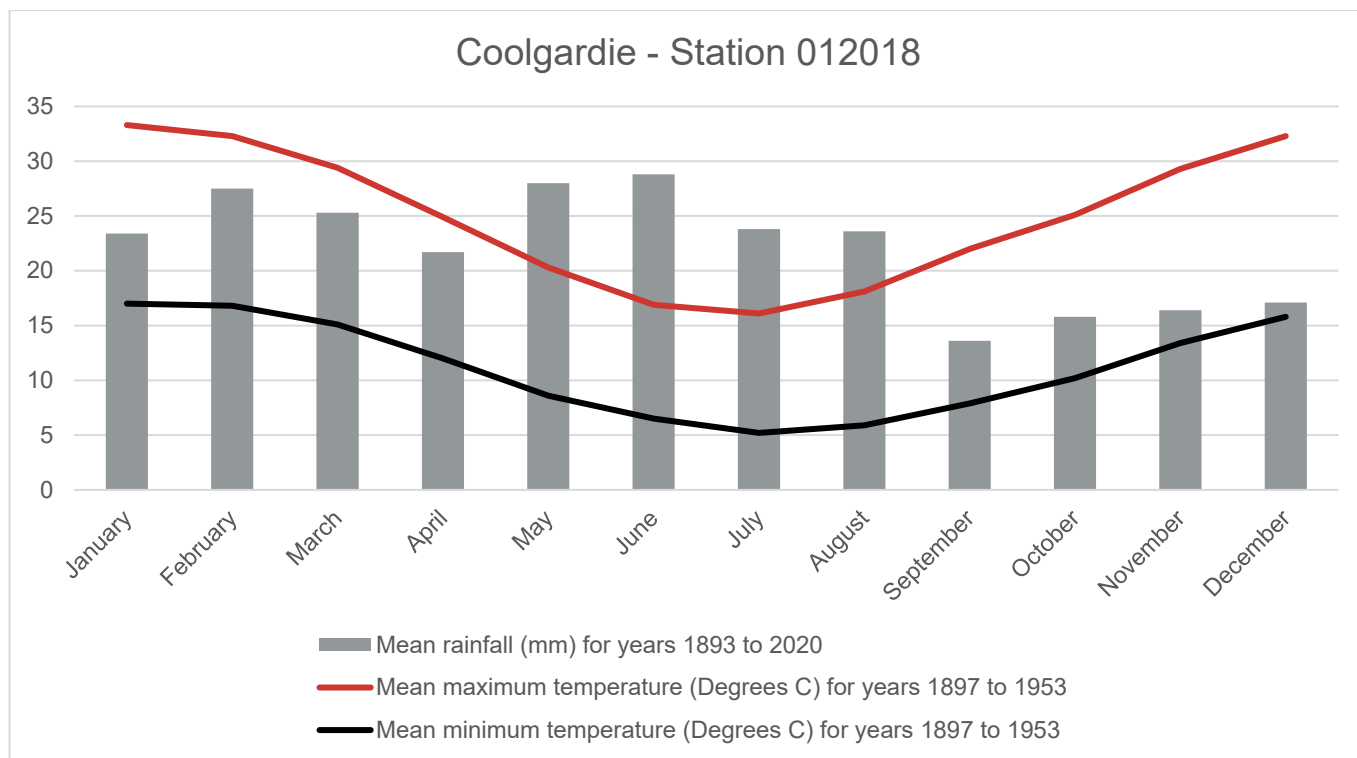


Figure 13 Coolgardie (Site 012018) Monthly Temperatures & Rainfall (BoM, 2024a)

The rainfall intensity frequency duration curve for Carina is provided as Figure 14 and the 1 in 2,000 AEP rainfall depths in Table 11.

Table 11 Carina Operations 1 in 2,000 AEP Rainfall Depths over 72-hour duration

Duration	1 in 2,000 AEP Rainfall Depth (mm)
5 min	30.3
10 min	45.7
15 min	55.5
20 min	62.6
25 min	68.1
30 min	72.6
45 min	82.6
1 hour	89.9
1.5 hour	101
2-hour	109
3-hour	123
4-hour	139
6-hour	152
9-hour	175
12-hour	194
18-hour	226
24-hour	250
30-hour	272
36-hour	290
48-hour	318
72-hour	352

Source: PSM (2024)

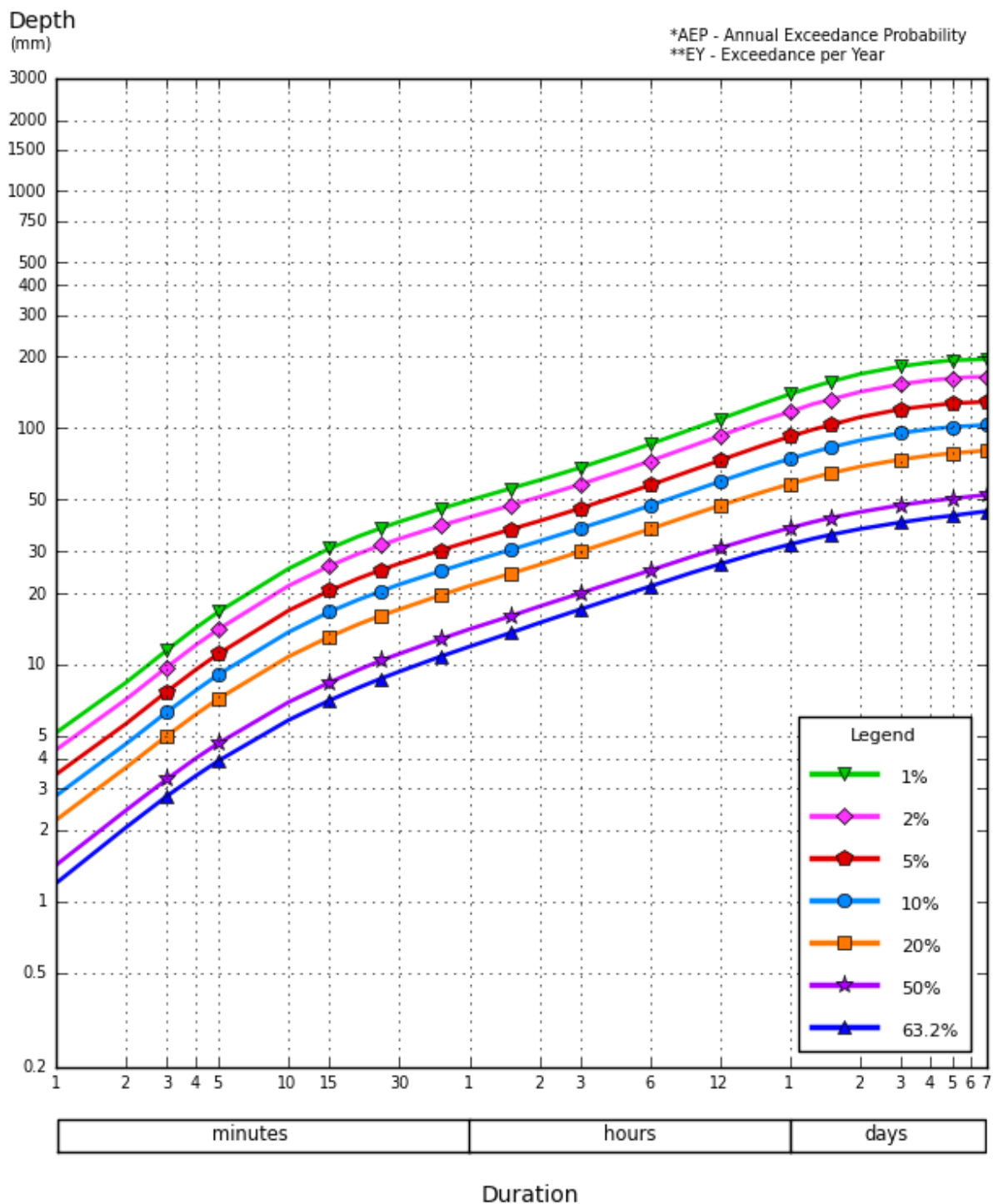


Figure 14 Rainfall Intensity Frequency & Duration for the Carina Local Catchment (Latitude -30.45° / Longitude 120.03°) (BoM, 2016)

Figure 15 shows wind speed and direction data for Southern Cross Airfield at 9 am and 3 pm (BoM, 2023a). North-easterly winds dominate in the mornings, with westerly winds in the afternoon. Winds between January and April are generally from north-east, east or south-east directions during both mornings and afternoons. During July to October, wind direction is predominantly north-west, west or south-west during the mornings and variable in the afternoons. Periods of calm (no wind and wind < 10 km/hr) occur during the mornings between May to July. Average wind speeds throughout the year vary from 12.8 - 22.2 km/h in the morning to 18.1 - 22.6 km/h in the afternoon. The strongest winds occur in the afternoons from July to November. Wind speed data is not available for Coolgardie (Site 012018).

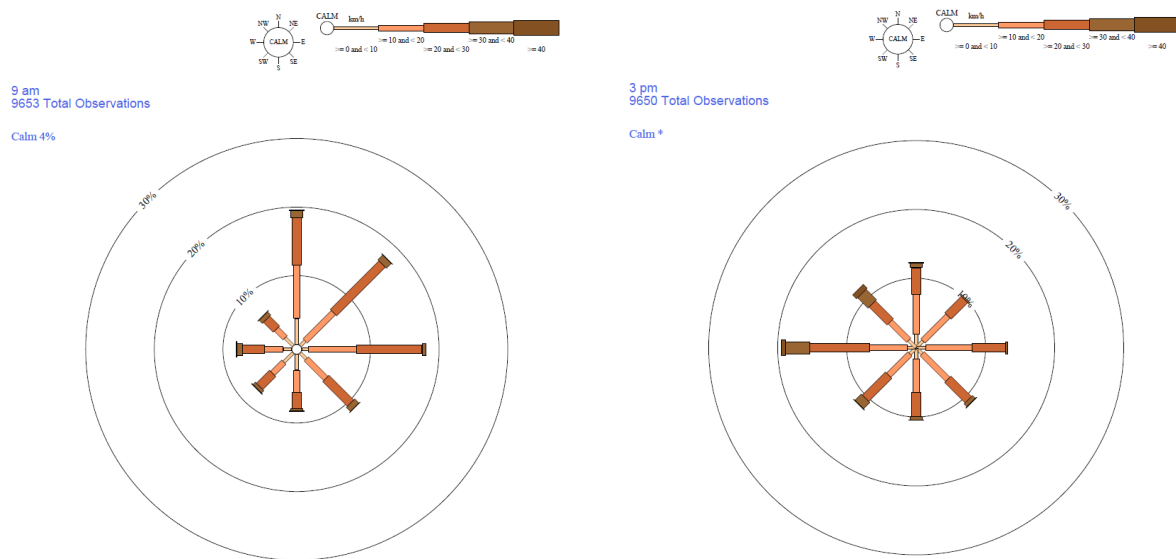


Figure 15 Southern Cross Airfield (Site 012320) – Wind Speed & Direction (BoM, 2023a)

5.1.2 Climate Change

Climate projections show the average annual temperature increasing by 0.5-1.3°C by 2030 and 1.1-2.7°C by the end of the century under intermediate and high emission scenarios, respectively (Sudmeyer, Edward, Fazakerley, Simpkin, & Foster, 2016). The intensity and duration of hot spells is expected to increase across WA (CSIRO and BoM, 2022).

An increase in the intensity of extreme rainfall events is predicted with high confidence, although the magnitude of the increases cannot be confidently projected. Time spent in drought is projected, with medium confidence, to increase over the course of the century. Evaporative demand is predicted with high confidence to increase in all seasons (CSIRO and BoM, 2022).

Winter rainfall is projected to decline over the century under both intermediate and high emission scenarios. Department of Water (DoW, 2015) describes the following climate scenarios based on climate change models:

- The dry scenario indicates, for the region as a whole, a 14% decline in rainfall, a 0.7°C temperature rise and a 3% increase in potential evapotranspiration by 2030. The drying trend continues in the latter half of the century, with rainfall projected to be 25% less by 2050, and 47% less by 2100.
- The median scenario indicates a less pronounced drying trend, with a 5% reduction in rainfall by 2030 and 17% by 2100. Temperature is projected to rise by 2.4 °C by 2100.
- The wet scenario results in only a 7% reduction in rainfall by 2100, and a 2.0 °C temperature rise. The wet scenario compared to the median scenario is associated with a larger reduction in relative humidity which results in a slightly larger rise in potential evapotranspiration. In the west of the region, drying trends are more pronounced relative to the regional averages.

5.1.3 Considerations For Closure

- Regional climate conditions inform flood modelling, groundwater modelling, pit lake water balances, and the surface water run-off and erosion rate assumptions used in landform designs.

- Design rainfall events for different landforms are based on risk and, may need to consider extreme events and long-term climate projections to enable closure designs to manage risk through the range of expected regional conditions.
- Landform design checks have been informed by berm capacity modelling of a 1:2,000 AEP event for Yilgarn conditions generally and largest daily run-off events for the Carina site (Section 5.9.1).
- Flood modelling has considered 1:2,000 AEP and PMF events (Section 5.6.1.4) while groundwater throughflow conditions resulting from a pit lake filling scenario have been based on the conservative assessment that the pit lake is flooded to the crest. That is, a 1:2,000 AEP event would result in a rise in pit lake levels of 3 – 9 m, well below the crest level (Section 5.6.2.3.2). Groundwater modelling used the DoW (2015) climate change scenarios to define upper and lower bound conditions for pit lake levels and residual groundwater drawdown (Section 5.6.2.3.1).
- Evaporation rates exceed rainfall during all months of the year thereby significantly influencing surface water and the soil cover water balance. This informs the construction and treatment of the rehabilitation surface profile, likely maintenance requirements, and may influence the success and timing of vegetation establishment in restoration or rehabilitation. Projected climate change is anticipated to impact native ecosystems, although the specific mechanisms and manner of this impact remain poorly understood, and restoration or rehabilitation activities should aim to establish resilient, durable ecosystems on mined landscapes through appropriate species selection, use of appropriate seed of local provenance, and ensuring vegetation is biodiverse and representative of the selected reference ecosystem (Gann, 2019) (Section 9.1.4).

5.2 Landscape

Key Points

- The Carina Operations are located in a region of relatively flat topography, interspersed with narrow ironstone ranges which rise to 150 m above the surrounding plains.
- The landscape shows little defined drainage.
- The ironstone ranges of the Southern Cross sub-region are recognised as centres of high biodiversity and refugial areas for endemic flora. The sandplains support assemblages dominated by numerous *Acacia* and *Myrtaceae*, and deeper soils support woodlands dominated predominantly by *Eucalyptus*.
- The ironstone ridges form natural high points in the region, which have informed the design heights of WRLs, and should be considered if any significant departures from design are proposed.
- Topography informs the design and location of surface water management and abandonment bund infrastructure for closure.

5.2.1 Regional Landscape

The Carina Operations are located within the Yilgarn Craton, which has been subjected to subsurface weathering resulting in a low plateau of little relief where there has been extensive development of ironstone duricrust associated with deep weathering (Bettenay, 1983). The region is characterised by low lying broad alluvial valleys and undulating areas of sand plain in the range of 400 – 600 metres above Australian Height Datum (m AHD), and narrow ranges.

These ranges are banded ironstone formations which rise to 150 m above the surrounding plains, having stony slopes and bedrock exposures on steep slopes and crests. The ironstone ridges of the Yilgarn region include the Windarling, Mt Jackson, Koolyanobbing, Parker, Helena and Aurora, Die Hardy and Mt Manning Ranges, Mt Elvire, and Bungalbin Hill.

The landscape shows little defined drainage and is dissected by broad palaeodrainage channels containing chains of salt lakes (Ecologia, 2002).

5.2.2 Local Topography

The Carina mine site and haul road to Carina Southern Operations lie to the east of the Finnerty Range. The topography is relatively flat, but the mine pits are located on a low relief ridge (PSM Consult Pty Ltd, 2024) north of the Yendilberin Hills (Mattiske Consulting, 2012c). The Yendilberin Hills form a narrow, approximately northwest- to southeast-trending rocky ridge with a maximum elevation of 523 m AHD at Mt Walton. At Carina, the highest point of the ridge is 495 m AHD, which is about 30 m above the surrounding plain (Rockwater Pty Ltd, 2015). Existing ground level at the southern end of the Carina open pit is 458 m AHD and at the lowest section of infrastructure area is 455 m AHD (Polaris Metals, 2011).

The J4 mining area lies within the Jackson Range. The deposit occurs about midway along an intermittently developed ridge of chert and Banded Iron Formation (BIF), which can be traced from the MinRes J1 deposit in the west, to the Bungalbin Deposit in the east (Rockwater Pty Ltd, 2015). A local high point of about 700 m AHD occurs in the Helena and Aurora Range, nearby to Bungalbin. The maximum elevation of the ridge at J4 is 475 m AHD, which is about 50 m higher than the surrounding plain (Rockwater Pty Ltd, 2015) and 25 m higher than the nearest streamline to the north of the project area (PSM Consult Pty Ltd, 2024).

The Aurora deposit is located 4 km south of Bungalbin Hill (part of the Helena and Aurora Range banded ironstone formation which rises 200 m above the surrounding plain) in a Broad Valley Landform system (Willmine Pty Ltd, 1994). The approximate elevation of the site is 480 m AHD (Greencap, 2022). The site is visible from nearby Helena Aurora (Bungalbin) ranges.

The approximate elevation of the Mt Walton Siding area is 470 m AHD (Greencap, 2022).

5.2.3 IBRA Bioregion and Sub-region

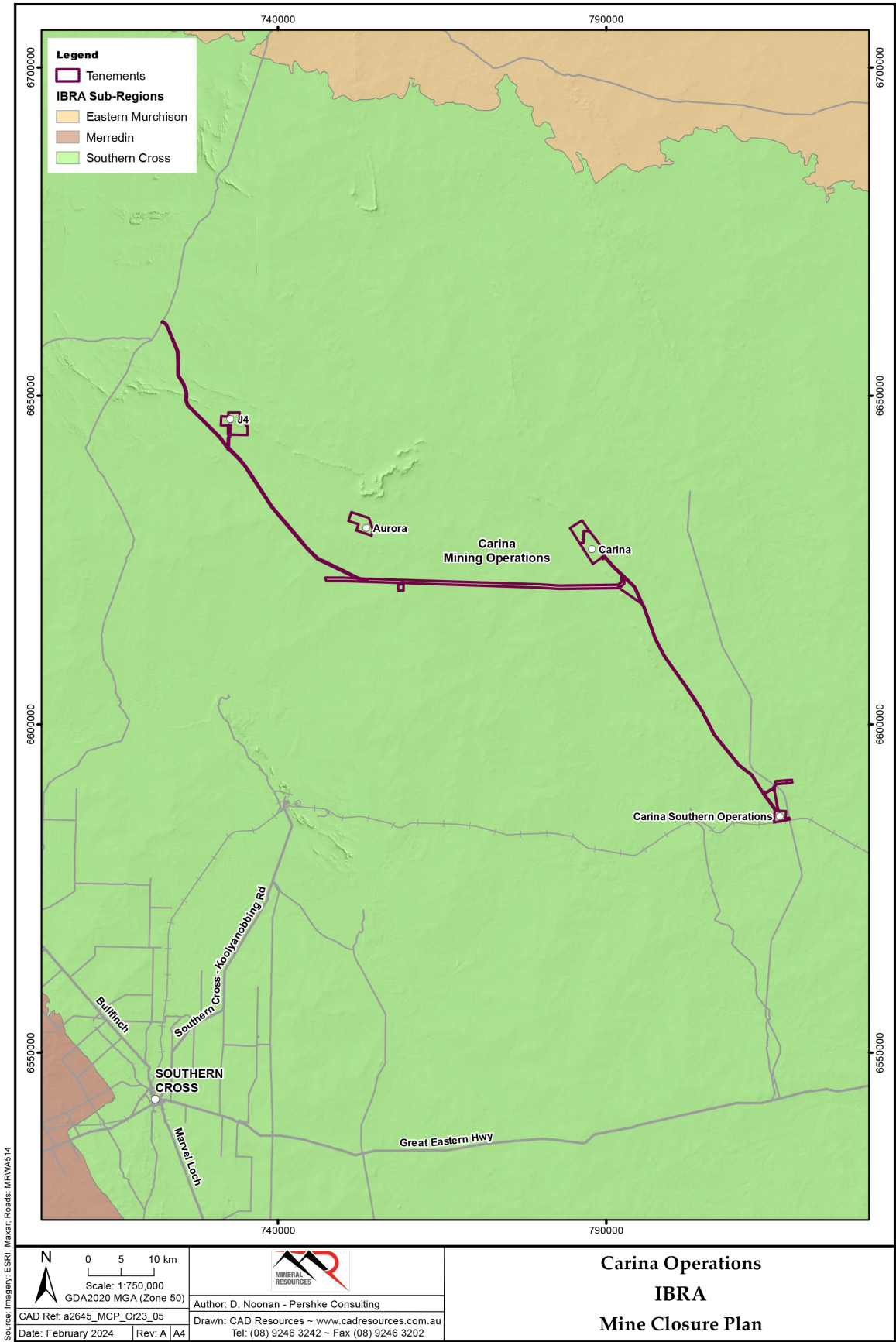
The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia's landscapes into 89 large, geographically distinct bioregions based on common climate, geology, landform, native vegetation and species information.

The Carina Operations are within the Southern Cross sub-region (C002) of the Coolgardie bioregion (DAWE, 2012) (Figure 16).

The Southern Cross sub-region is described as follows (Cowan, 2001):

- Characterised by subdued relief, comprising gently undulating uplands dissected by broad valleys with bands of low greenstone and ironstone hills over the underlying granite of the Yilgarn Craton. Drainage is occluded.
- Beds of banded ironstone occur sporadically within the greenstone belts and form high abrupt ridges rising conspicuously from surrounding plains.
- Valleys include chains of saline playa-lakes.
- This sub-region is characterised by high diversity at both species and ecosystem level. Saline playa-lakes support samphire shrublands. Diverse woodlands dominated by *Eucalyptus* occur on the low ironstone ridges and greenstone hills, valley alluvial areas, and broad plains of calcareous earths around the saline playa-lakes, harbouring numerous range-restricted species. Mallee and scrub assemblages dominate on sandplains associated with lateritised uplands, playas, and granite outcrops.

The ironstone ranges of the Southern Cross sub-region are recognised as centres of high biodiversity and refugial areas for endemic and range-restricted, ecologically specialised flora. Numerous short-range endemic invertebrates are known to occur in association with ironstone ranges and greenstone hills. Vegetation assemblages of this sub-region is described further in Section 5.5.1.



Refer to Appendix J for pdf version

Figure 16 IBRA Regions

5.2.4 Regional Soil Landscapes

DPIRD has established a nested hierarchy of soil-landscape mapping units across Western Australia to collate information resulting from varying levels and scales of mapping (Tille, 2006; Schoknecht, 2004). The hierarchy includes:

- regions and provinces, based on the descriptions and frameworks introduced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Soils for the whole of Australia in 1983.
- zones, defined on the basis of geomorphologic or geological criteria, suitable for regional perspectives.
- systems, which are areas with recurring patterns of landforms, soils and vegetation, suitable for regional mapping at scales of 1:250,000.

The Carina / Carina Extended, J4 and Aurora sites lie within the Mount Jackson Plains and Hills zone (263) of the Kalgoorlie Soil – Landscape Province which is located in the Goldfields between Lake Barlee and Mt Jackson and described by Tille (2006):

- Undulating plains (with some hills and stony plains) on greenstone and granitic rocks of the Yilgarn Craton.
- Red loamy earths with Red-brown hardpan shallow loams and some Red sandy earths, Red shallow loams, and Loamy gravels.
- Supports York gum-salmon gum-gimlet woodland with *Acacia* thickets and mulga scrub.

The Carina Haul Road and Carina Southern Operations extend south into the Norseman zone (266) of the Kalgoorlie Soil – Landscape Province, described by Tille (2006):

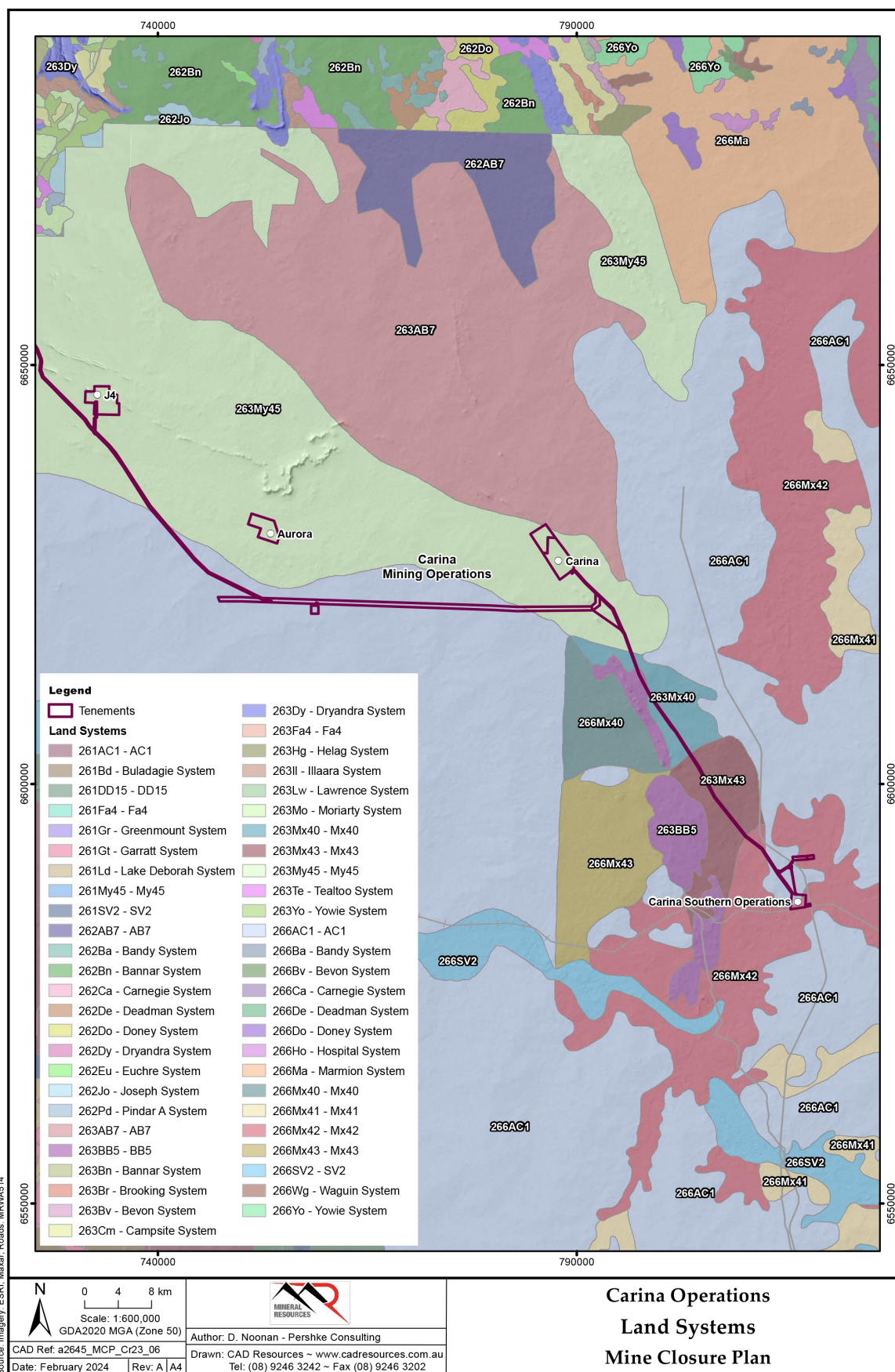
- Undulating plains and uplands (with some sandplains and salt lakes) on granitic rocks of the Yilgarn Craton.
- Calcareous loamy earths, Yellow sandy and loamy earths, Red loamy earths, Red deep sands and Salt lake soils.
- Supports Salmon gum-redwood-merrit-red mallee-gimlet woodland with *Acacia* - *Casuarina* thickets and some mulga shrublands and spinifex grasslands.

The Carina Operations intersect seven soil landscape mapping units within these two zones, described in Table 12 and shown in Figure 17.

Table 12 Soil Landscape Mapping Units of the Carina Operations Area

Soil mapping unit	Description
263My45	Undulating terrain with small gently sloping plains and some ranges on basic schists, gneisses, and allied rocks.
263Mx40	Flat to undulating valley plains and pediments; some rock outcrop.
263Mx43	Gently undulating valley plains and pediments; some outcrop of basic rock.
263AB7	Sandy outwash plains from granites, gneisses, and allied rocks with numerous small waterways and with pediments and breakaways of unit BE3 on ridges and slopes above the plains in a recurring pattern.
263BB5	Rocky ranges and hills of greenstones-basic igneous rocks.
266AC1	Gently sloping to gently undulating plateau areas, or uplands, on granites, gneisses, and allied rocks, with long gentle slopes and, in places, abrupt erosional scarps.
266Mx42	Broad flat to undulating valleys with isolated granitic rock outcrops and some low escarpments; some seasonal lakes and clay pans.

Source: DPIRD (2023)



Refer to Appendix J for pdf version

Figure 17 Regional soil mapping units Considerations for Closure

Landscape and topography inform potential impacts of closure designs on visual amenity. The remoteness of the Carina Operations, location of the mine sites on low ridges, minimal public access, and surrounding vegetation type (*Eucalyptus* woodland) restricts visibility of the sites. Aurora is an exception, being visible from the Helena and Aurora Ranges (Bungalbin) and accessible from public tracks. The risk assessment (Section 7) has identified potential impacts to visual amenity resulting from unsatisfactory restoration or rehabilitation outcomes.

The ironstone ridges form natural high points in the region which have informed the design heights of WRLs and should be considered if any significant departures from design are proposed.

Topography informs the design and location of surface water management and abandonment bund infrastructure for closure.

5.3 Materials Characterisation

5.3.1 Regional and Local Geology

The Carina Operations are located in the Yilgarn Craton, which consists of greenstone belts and granites of Archaean age (2,400-3,000 million years old) (Figure 18). The landscape of the region is varied, including granite rocky outcrops, low greenstone hills, laterite uplands and broad plains.

The geology of the three mine sites within the Carina Operations is described in the following sections.

5.3.1.1 Carina and Carina Extended

The Carina and Carina Extended deposits are situated in the southeast of the Marda-Diemals greenstone belt, within the Archaean Yilgarn Block (Figure 19). A craton scale sinistral fault zone, the Mt Dimer Shear Zone, separates the Marda-Diemals and Hunt Range greenstone belts. The Marda-Diemals belt can be divided into two greenstone successions. The lower 3.0 gigayear (Ga) greenstone succession includes a lower sequence of basalt and ultramafic rocks overlain by a relatively thick BIF / chert unit, which is then overlain by dominantly mafic volcanics. The upper 2.73 Ga greenstone succession unconformably overlays the lower succession and consists of felsic to intermediate volcanic rocks and clastic sedimentary rocks (Polaris Metals, 2011).

The deposit outcrops as a low ridge of hematite / goethite. The mineralisation forms a steeply west dipping isoclinally folded syncline 1.7 km in strike length to a maximum depth of 240 m below surface and a width averaging approximately 40-50 m (Polaris Metals, 2011).

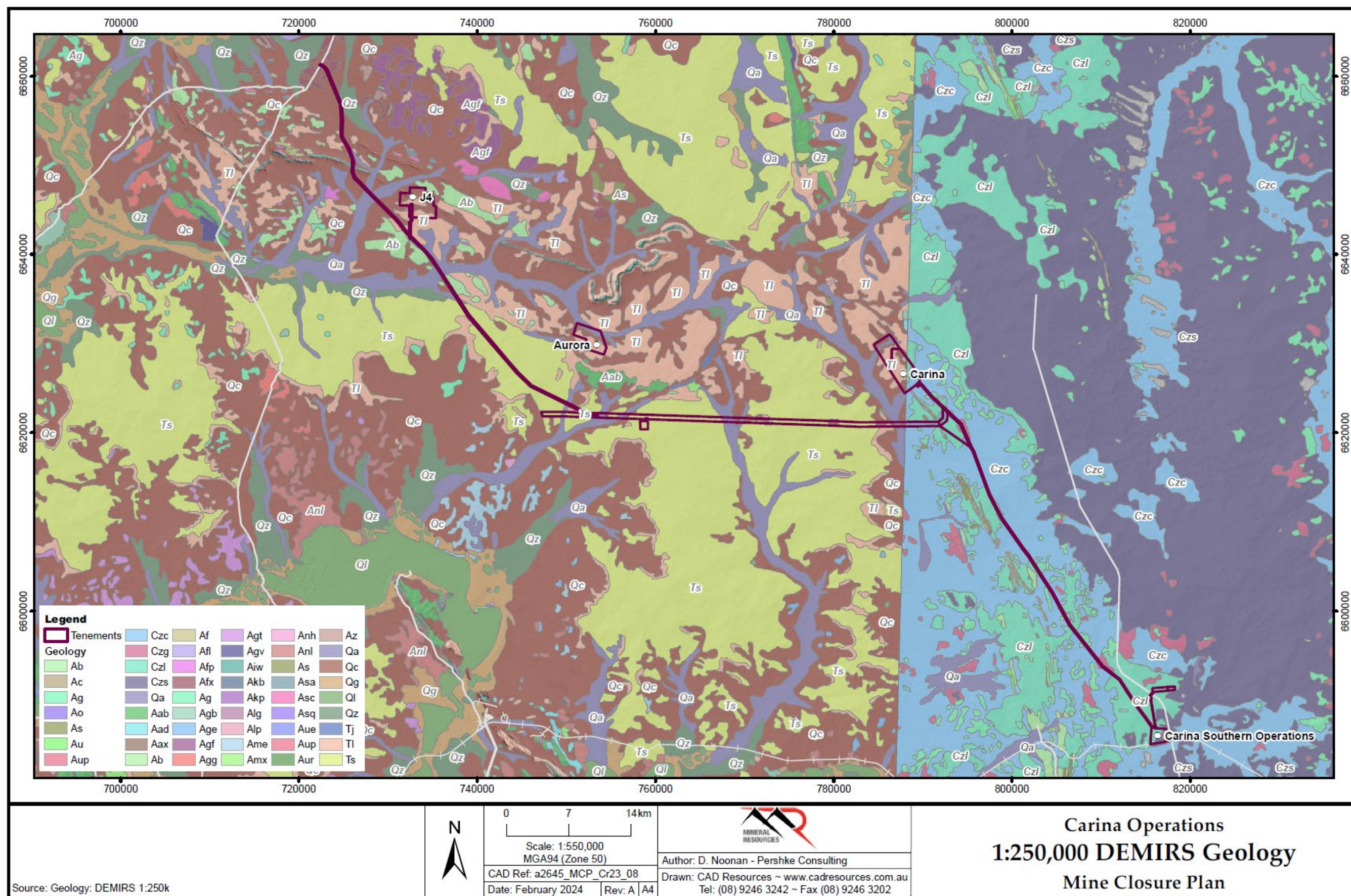
5.3.1.2 J4

The J4 project is situated in the Jackson Range within the Archaean Marda-Diemals Greenstone Belt, part of the Southern Cross Terrane (Figure 20). The BIF is part of the Mt Jackson-Bungalbin belt and occurs as two stratigraphic levels separated by basalt. These two units, and an additional thin banded iron formation within the basalt, contain dark grey to black iron-rich bands alternating with red jaspilite bands. The economic deposit occurs as a low east - west oriented ridge over approximately 2 km strike length and consists of two main ore bodies (Polaris Metals, 2015; MinRes, 2023a).

The local geology is a west-northwest trending mafic-ultramafic / chert / black shale sequence containing a stratabound massive pyrite unit, sometimes with associated siderite. It is the weathered goethite cap of this pyrite unit that comprises the J4 mineralisation. It is thought that the pyrite unit resulted from deposition under a volcanogenic massive sulfide environment from "black smokers". A second, smaller cherty ridge to the north parallels the main ridge in part (Polaris Metals, 2015; MinRes, 2023a).

5.3.1.3 Aurora

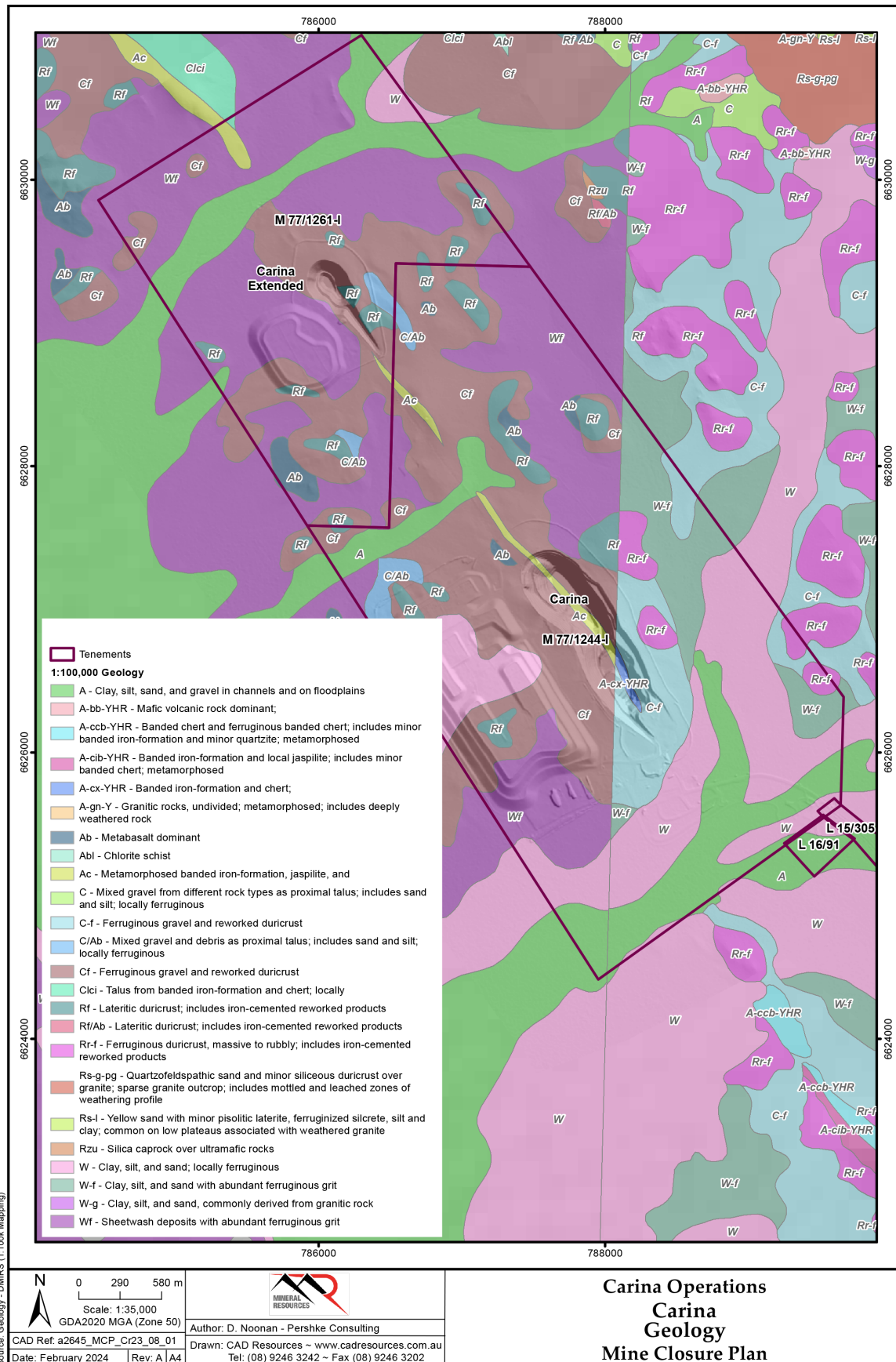
The Aurora tenement forms part of an easterly trending sequence of mafic volcanics (Figure 21). The gold mineralisation was hosted by northerly dipping quartz veins in those mafic volcanics. The gold was supergene enriched in ferruginous clays and had also spread into the laterite capping (Willmine Pty Ltd, 1994).



Refer to Appendix J for pdf version

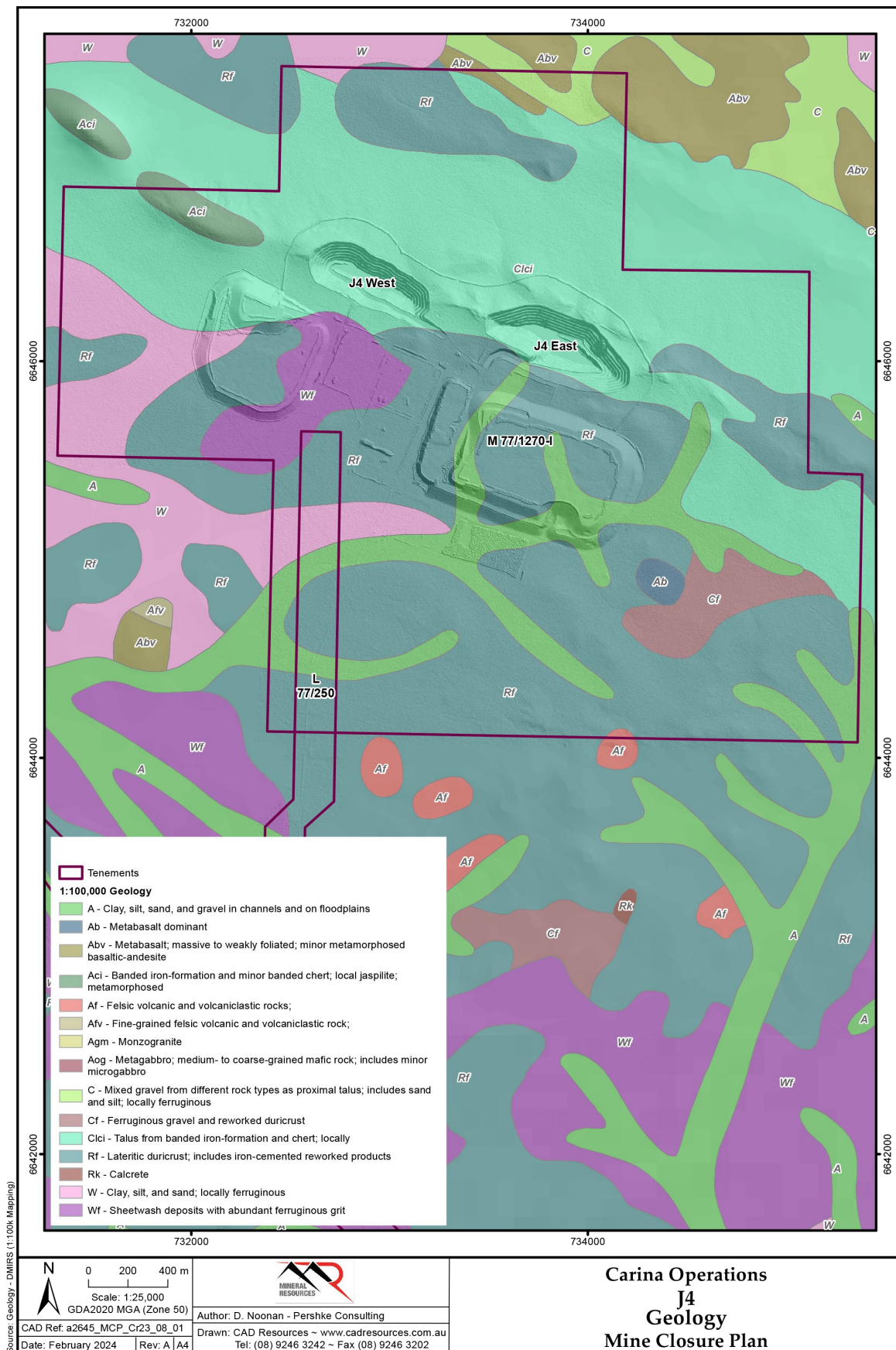
Figure 18 Carina Operations Geology

ENV-TS-RP-0617



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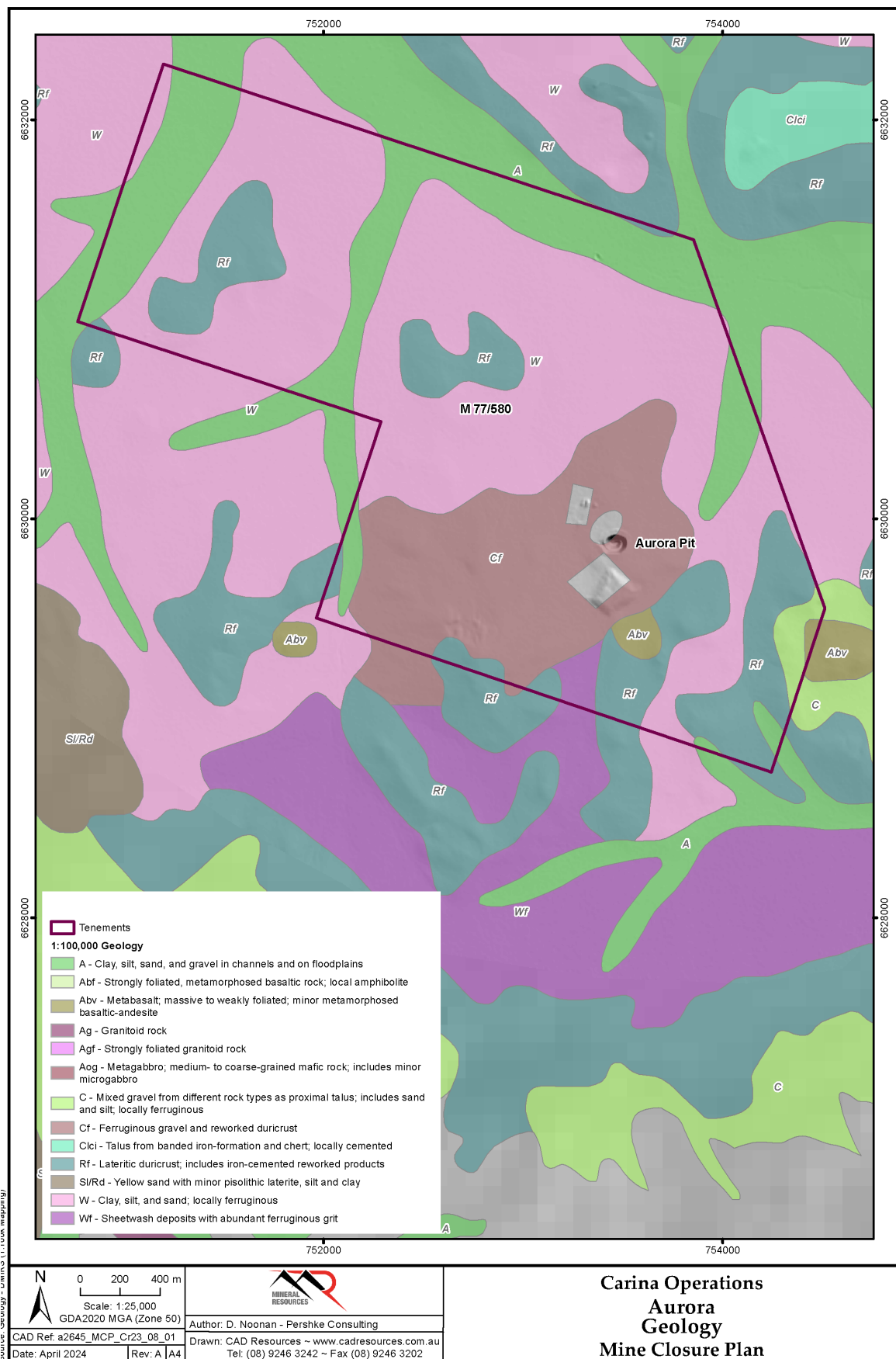
Figure 19 Carina Geology



Refer to Appendix J for pdf version

Figure 20 J4 Geology

ENV-TS-RP-0617



Refer to Appendix J for pdf version

Figure 21 Aurora Geology

ENV-TS-RP-0617

5.3.2 Waste Rock Lithologies

Characterisation of mine lithology prior to mining indicated that the general composition of mine waste would be as outlined in Table 13.

Table 13 Waste Rock Lithology

Lithology	Lithology Code	% by volume		% logged ⁽¹⁾
		Carina	Carina Extended	J4
Mafic schist	MAS	60	-	2.2
Basalt	BLT	-	50	29.6
Banded iron formation / chert / ultramafics	BIF / CHT / UM	38	26	5.1 / 1.2 / 14.4
Fault contact / transition zone	TZ	2	-	-
Regolith		-	5	-
Goethite	IG	-	-	29.4
Iron goethite silica	IGS	-	-	4.0
Low grade goethite	IG	-	18	-
Pyrite	PY	-	1	-
Black shale		-	-	1.9
Clay	CLY	-	-	6.5
TOTAL		100	100	94.3⁽²⁾

Source: (Polaris Metals, 2011; 2013a; 2015; SWC, 2014a)

Tables Notes:

(1) Percentage for J4 is based on frequency of lithologies being encountered out of a total of 13,470 samples and not based on volume.

(2) SWC (2014a) categorised 94.3% of samples only.

5.3.3 Geochemical Characterisation

Key Points

- Baseline analysis and characterisation classified the majority of waste rock material as Non-Acid Forming (NAF) or Potentially Acid Forming Low Capacity (PAF-LC) due to generally very low to low total sulfur. Higher sulfur material present in an oxidised form was termed Oxidised Acidic Waste (OAW) and does not generate significant loadings of acidity in the long-term. PAF material High Capacity (HC) was present in some deposits, per the below summary:
 - 98% by volume of mine waste from the Carina Deposit was classified as NAF or PAF-LC and 2%, associated with the fault zone, was classified as PAF-HC.
 - 80% of mine waste from Carina Extended contained < 0.1% Total Sulfur. Three of 39 samples tested in the Polaris (2013a) baseline study, from deeper in the profile contained elevated Total Sulfur associated with pyrite present in various lithology types.
 - 13% of waste from J4 was classified as PAF and 22.5% as OAW.
- Assessment of WRL cover and near-surface materials found:
 - Twenty-one samples of near-surface materials at the Carina and Carina Extended WRLs were NAF (3 samples from Carina WRL were Uncertain (UC)).
 - Near-surface materials at the J4 WRL were also predominantly NAF or UC. Two near-surface samples at J4 East WRL could be classified as PAF but both the NAG_{pH} and the Net Acid Producing Potential (NAPP) are close to the respective thresholds.
 - The UC samples reflect conservative estimations of acid producing potential (i.e., assuming all sulfur present is present as sulfide).
- An encapsulation cell was constructed to contain PAF material within the Carina WRL. An as-built assessment has been completed and is discussed in Section 5.9.3.4.
- A gap analysis is proposed to inform the need for further testing / modelling in relation to the following materials characterisation findings, particularly in relation to long-term pit lake quality:
 - Multi-element composition analysis found significant enrichment of As and Sb and slight to moderate enrichment of other metals in the Carina Extended and J4 WRL near-surface materials. Limited static and kinetic leach testing has been completed to assess the solute release risks.
 - PAF materials will remain exposed on the Carina Pit wall above the modelled post-closure pit lake elevation. Initial estimates are that 60,000 m² of PAF rock units, containing Total S between 0.4 to 1% could remain exposed.
 - Solute release from the exposed J4 pit walls, based on limited sulfidic materials being intercepted by the pits, is anticipated to present a low risk. However, materials with elevated sulfur occur close to the J4 East Pit walls.
- Backfill of the J4 West Pit will be carried out as part of the J4 East redevelopment and will involve the encapsulation of PAF waste (estimated at 7.2% of the total waste generated).
- Backfill in the southeastern end of the Carina Pit potentially contains PAF material.
- With respect to salinity:
 - Areas on the southern end of the J4 East WRL were found to be highly saline (> 400 mS/m, the threshold likely to impact on even salt tolerant species).
 - Three sites on the western end of the J4 West upper lift also tested as highly saline.
 - These salinity values are conservative as they are tested using a 1:2 ratio of solid to liquid, rather than the typical 1:5 ratio used for salinity tests used for determining impacts to vegetation establishment.
- Characterisation of waste materials at Aurora is required to inform landform designs.

The geochemical assessments of mine waste material completed for the Carina Operations are listed in Table 14 and include:

- Pre-mining characterisation of the waste rock component of the various deposits (Section 5.3.3.1).
- Post-mining characterisation of the WRL near-surface materials (Section 5.3.3.2), the J4 low-grade stockpile (Section 5.3.3.3) and pit walls (Section 5.3.3.4).

The AMIRA (2002) methodology for acid base accounting (ABA) methodology was typically used to determine a geochemical classification for each sample. The criteria for Net Acid Producing Potential (NAPP) and NAGpH used in the various assessments are provided in Table 15, Table 16 and Table 17 and shown graphically in (Figure 22). In some assessments, the Price (2009) methodology was used to classify material based on the Acid Neutralising Capacity (ANC) to Maximum Potential Acidity (MPA) ratio (Figure 23).

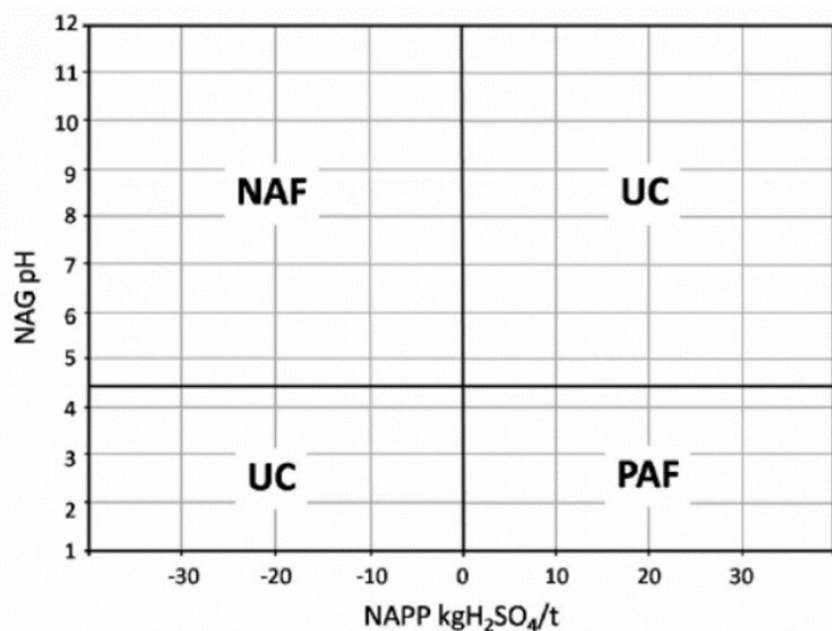


Figure 22 AMIRA (2002) Classification System Using NAPP & NAG_{pH} (Okane Consultants, 2023a)

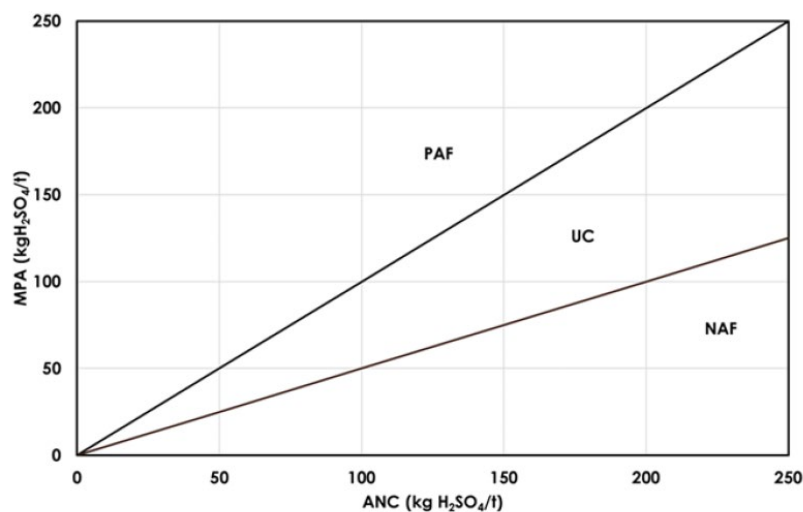


Figure 23 Price (2009) Classification System Using ANC & MPA (Okane Consultants, 2023a)

Table 14 Geochemical Assessments Completed for Carina Operations

Site	Geochemical assessment reference	Nature of assessment
Pre-mining assessments		
Carina Deposit	Polaris Metals (2011) Mining Proposal Carina Iron Ore Project (REG ID 28616) GHD (2013) Carina Iron Ore Project Geochemical Assessment	Baseline geochemical characterisation: screening of 1,583 and 7,521 assay records and static geochemical testing of 20 samples in 2011 and 2013 respectively.
Carina Extended Deposit	Polaris Metals (2013a) Carina Extended Mining Proposal (REG ID 41730)	Baseline geochemical characterisation: static geochemical testing (55 samples), leachate testing (16 samples) and kinetic testing (9 samples).
J4 Deposit	Polaris Metals (2013b) Methodology Used to Quantify NAPP of Waste Rock J4 Soil Water Consultants (SWC) (2014a) J4 Deposit Geochemical Characterisation Polaris Metals (2015) J4 Iron Ore Project Mining Proposal and Mine Closure Plan (REG ID 53360) Mineral Resources (2023a) J4 Redevelopment Mining Proposal (REG ID 117948)	Baseline geochemical characterisation: preliminary Acid and Metalliferous Drainage (AMD) investigation of 83 composite samples, screening of 465 assay records, static geochemical testing of 20 samples and multi-element composition and static leach testing of a sub-sample of 10 of these 20 samples.
Post-mining assessments		
Carina Extended WRL J4 WRLs J4 Low grade stockpile	Mine Earth (2022) Carina (J4 and Carina Extended) Soil and Waste Rock Characterisation – WRL Surface Characteristics	Geochemical assessment of J4 & Carina Extended as-built WRL surface materials based on near surface grab samples (10 samples Carina Extended, 9 samples J4 East and 8 samples J4 West) subjected to multi-element analysis (33 elements) and analysis of pH, Electrical Conductivity (EC), total carbon (C), total sulfur (S), ANC and Net Acid Generation (NAG). Methodology is described in more detail in Mine Earth (2022). Four of the samples collected from the J4 West WRL were sampled from an area on the upper bench of the WRL that contained suspected PAF material. Geochemical assessment of J4 low grade stockpile based on 272 composite assay records & one near surface grab sample.
Carina WRL	Okane (2023a) Carina PAF Cell Investigation Test Pit Sampling Program ¹ .	Geochemical assessment of as-built Carina WRL surface materials (topsoil and waste) to assess the extent of the PAF cell and compliance with design based on ten test pits dug to 0.5 m with an excavator, yielding 11 samples. These samples were analysed for paste pH, EC, Total S, NAG, ANC and Total C. Methodology is described in more detail in Okane (2023a).
Carina WRL	Okane (2023b) Carina PAF Cell Geotechnical and Geochemical Investigation Sonic Drilling Program ¹ .	A program to assess the extent of the PAF cell and compliance to design, discussed in Section 5.9.3.4.1.
J4 Deposit & J4 WRLs	SRK (2023) Mount Jackson J4 WRL Geochemical Review	Verification of baseline geochemical conclusions based on review of drill hole assay records (2001 – 2016). The review considered total in-pit cumulative drill hole lengths of 6,339 m (J4 East Pit and 6,259 m J4 West Pit). Five near surface grab samples (0 to 0.2 m depth) were sampled from the tip head on the south-west of J4 East WRL (identified as potential PAF) and field measurements of paste pH, paste EC and total dissolved solids (TDS) were completed as described by SRK (2023).
J4 WRLs	Mineral Resources (2024) J4 Test Pit Sampling. Results of Geochemical Testing.	Geochemical assessment of J4 East and J4 West as-built WRL materials at various depths to a maximum depth of 5 m based on excavated pit samples (from 11 locations on J4 West and 20 locations on J4 East). Samples were analysed for paste pH, paste EC, Total S, NAG and ANC.

Note:

1. Although the title of this report refers to PAF cell investigation, this report addresses WRL surface and near surface samples only. Drilling to assess the PAF encapsulation cell extent was completed in the separate report, Okane (2023b), which is discussed in Section 5.9.3.4.

Table 15 Geochemical Classification Criteria for Carina and Carina Extended Deposits Assessments

Material	Total S (%S)	ANC ⁴ /MPA ⁵	NAPP ⁶ (kg H ₂ SO ₄ /t)			NAG _{pH} ⁷
			Carina 2011	Carina 2013	Carina Extended	
PAF – High Capacity (PAF-HC)	> 1.0	0	> 40	> 10	> 40	< 4.5
Potentially Acid Forming (PAF)	0.5-1.0	< 1	> 20	-	10-40	< 4.5
PAF – Low Capacity (PAF-LC)	0.3-0.5	1-2	5-20	0-10	5-10	< 4.5
Non-Acid Forming (NAF)	< 0.3	> 2	≤ 5	< 0	- 5 to + 5	≥ 4.5
Acid Neutralising Capacity – Low Capacity (ANC-LC) [#]	< 0.3	- 5 to - 10	-	-	- 5 to - 10	≥ 4.5
ANC	< 0.3	- 10 to - 40	-	-	- 10 to - 40	≥ 4.5
Acid Consuming (AC)	< 0.3	> 40	< - 40	< -30	< - 40	≥ 4.5
Uncertain (UC)	-	-		> 0	-	≥ 4.5
				< 0	-	< 4.5

Source: Polaris Metals Pty Ltd (2011; 2013a), GHD (2013)

Table 16 Geochemical Classification Criteria for J4 Deposit, Carina WRL and J4 WRLs

Material	NAPP (kg H ₂ SO ₄ /t)	NAG _{pH}
Potentially Acid Forming (PAF)	> 0	< 4.5
Non-Acid Forming (NAF)	< 0	≥ 4.5
Uncertain (UC)	> 0	≥ 4.5
	< 0	< 4.5

Source: SWC (2014a), MinRes (2024)

Table 17 Geochemical Classification Criteria for Carina Extended and J4 WRLs

Material	NAPP (kg H ₂ SO ₄ /t)	NAG _{pH}
Potentially Acid Forming – Low Capacity (PAF -LC)	> 0 and ≤ 10	< 4.5
Potentially Acid Forming (PAF)	> 10	< 4.5
Non-Acid Forming (NAF)	< 0	≥ 4.5
Uncertain (UC)	> 0	≥ 4.5
	< 0	< 4.5

Source: Mine Earth (2022)

⁴ ANC - Acid neutralising capacity.⁵ MPA - Maximum potential acidity = total S (%) x 30.6 (reported as kg H₂SO₄/t).⁶ NAPP - Nett Acid Producing Potential = MPA - ANC (reported as kg H₂SO₄/t).⁷ NAG_{pH} - Net Acid Generation pH is the pH of the leachate after oxidation of the sample in dilute peroxide solution.

5.3.3.1 Baseline Geochemical Characterisation

5.3.3.1.1 Carina Deposit

Results of the pre-mining geochemical investigation of the Carina deposit are provided in Appendix D-1 and the key findings summarised below (GHD, 2013) applying the criteria outlined in Table 15:

- 26.2% of the material in the pit was classified conservatively (using the available Ca and S data in the assay database) as having a NAPP value of <0 kg $\text{H}_2\text{SO}_4/\text{t}$ (i.e., NAF).
- 65.4% of the samples had conservative NAPP values of 0-10 kg $\text{H}_2\text{SO}_4/\text{t}$, (i.e., PAF, but at low levels (PAF-LC)).
- 8.4% of the samples had a NAPP value of > 10 kg $\text{H}_2\text{SO}_4/\text{t}$ (i.e., potentially highly acid forming (PAF-HC)).
- The NAF and PAF-LC results are associated with the major waste types (mafic schist and BIF / chert / ultramafic bedrock) which combined comprise approximately 98% by volume of mine waste.
- The PAF-HC results are associated with material from the fault zone which represents approximately 2% by volume of mine waste. The total S values of the fault / transition zone material tested ranged from 5 - 22 %, up to two orders of magnitude higher than 0.3 % S, which was regarded as the minimum level required to produce significant acidity. They also had $\text{NAG}_{\text{pH}} < 4.5$ and NAPP values > 40 .

5.3.3.1.2 Carina Extended Deposit

Results of the pre-mining geochemical investigation of the Carina Extended deposit are provided in Appendix D-2 and the key findings summarised below (Polaris Metals, 2013a):

- As a geological extension of the Carina orebody, waste characteristics for Carina Extended were expected to be similar to those reported by Polaris Metals (2011) and summarised in Appendix D-1.
- Further analysis of 39 additional samples of major waste types and profiles indicated that 80% of samples contained $< 0.1\%$ total oxidisable S. Three samples, from deeper in the profile (120 – 130 m bgl) recorded 0.52 – 30% total oxidisable S.
- Four of the 39 samples were found to be PAF.
- There is a strong correlation of geochemical classification with waste lithology. Waste logged as basalt (BLT) and chert (CHT) is NAF. Ultramafic (UM) waste generally shows good ANC characteristics. PAF waste is associated with zones containing pyrite, logged as a combination of lithology types.
- Results of acid leachate tests (pH of the leachate is not known) indicated that the ultramafic waste produced higher levels of copper, chromium, nickel and zinc when compared with the other two main waste types. The background concentration of these metals in upper soil / rock samples (0-0.2m) exceed Ecological Investigation Levels as specified by DEC (2010), indicating that leachate concentrations above guidelines will likely not prevent successful rehabilitation of the waste landform.

5.3.3.1.3 J4 Deposit

The results of the pre-mining geochemical investigations of the J4 deposit, and a post-mining review of the drillhole database, are provided in Appendix D-3. The key findings of the baseline investigations and the post-mining review of the baseline data are summarised below (SRK, 2023; MinRes, 2023b; SWC, 2014a):

- In-pit waste grade materials typically had a low sulfur content.

- Median sulfur assays for the key waste lithologies were < 0.1% S in both pits, with the exception of Saprock (median 0.137 % S).
- 63% of logged waste in J4 East Pit and 85% of J4 West Pit waste had a sulfur content <0.1% S. If only the assay results from the actual mine depths and volumes of the J4 pits are considered, the data indicates that the waste rock mined had a median sulfur content of 0.05% S (J4 East Pit) and 0.02% S (J4 West Pit).
- 7% (J4 East Pit) and 1% (J4 West Pit) of the drilled and assayed waste⁸ had a sulfur content > 0.3% S. This material was predominantly above the water table (390 m RL) with only 0.2% (J4 East Pit) and < 0.05% (J4 West Pit) located below the water table.
- The majority of the higher sulfur (> 0.1% S) material was present in predominantly weathered materials of the upper 50 m of the pit and was described as OAW. This material may contain stored acidity in the form of hydroxy sulfate salts (such as alunite or jarosite); however, this has not been confirmed through mineralogical testing. Okane Consultants (2022c) note that management concerns are related to the potential for low pH and elevated salinity.
- A sulfur threshold of 0.3% S was used to classify PAF in the J4 mining block model (only applicable to materials below the water table). Based on the pre-mining block model, it was estimated that of the total waste grade material to be mined (29.9 Mm³), 13% was classified as PAF and 22.5% as OAW. Based on the actual (reduced) mine depths, the most recent mining block model indicates that the as-mined volume comprised 2.5% OAW and 0.8% PAF across the two pits. A higher proportion of OAW is likely to have been present in the volume mined from the J4 East Pit relative to the J4 West Pit.
- Of the major waste rock materials tested, all black shale samples were classified as PAF together with some samples of basalt, goethite and chert. Based on the Total S results, the generally low buffering capacity and the geochemical classification, all material which is contained below the zone of complete oxidation, which contains elevated total S contents, should be classified as PAF.
- Sampling (to extent of original pit shell designs) found some elements are present in the waste rock with enriched concentrations based on Geochemical Abundance Index (GAI) indices including As, B, Cd, Co, Cr, Cu, Mn, Ni and Sb.
- Limited static leach testing has been completed to assess the solute release risks. Trace metal concentrations were generally low and at close to detection limited in testing done using the Australian Standard Leaching Procedure (ASLP), however this method is completed at a high liquid to solid ratio (20:1) which generates dilute extraction solutions and so identification of key solutes of concern may have been limited by analytical detection limits.

Overall, the acid generation risk associated with the volumes mined to date, based on the available assay and geochemical datasets, are assessed to be low. Limited testing has been completed to assess the solute release or metal leaching risks associated with waste rock stored in the WRLs (SRK, 2023). The requirement to complete additional leachate testing will be considered through a gap analysis.

5.3.3.1.4 Aurora

No record of materials characterisation was included in the baseline documentation available for the Aurora deposit (Willmine Pty Ltd, 1994).

⁸ Note that of the in-pit waste logged length in the J4 East and West pits, 10% and 10.5% respectively, had no S assay data (SRK, 2023).

5.3.3.2 Geochemistry of WRL Near Surface Cover Materials

To further inform geochemical risk assessment and closure strategies for the Carina, Carina Extended and J4 WRLs, the AMD potential of the existing near surface materials of these WRLs has been assessed as detailed in Table 14.

The results of these studies are summarised in Table 18 and Appendix D-4 and described in more detail in Sections 5.3.3.2.1 to 5.3.3.2.3.

Table 18 Geochemical Assessment of WRL Near Surface Material Samples (J4 and Carina Extended)

WRL	No. of samples (depth)	% S	Geochemical assessment	
			ANC (kgH ₂ SO ₄ /t)	Acid forming potential (no. of samples)
Carina	11 (0.6 – 1.6 m)	< 0.15 (all samples)	0.5 – 99 (median 4.3)	PAF (3) / UC (1) / NAF (7) ¹ . PAF (0) / UC (3) / NAF (8) ² .
Carina Extended	10 (surface)	≤ 0.1 (9 samples) 0.3 (1 sample)	5 -18	NAF (10)
J4 East	9 (surface)	< 0.1 (7 samples) – 0.16	3 – 100 (median 19)	NAF (8) / UC (NAF) (1) ⁹
	50 (1 – 5 m)	< 0.1 – 0.38	< 0.5 – 56.7 (majority < 10)	PAF (2) / NAF (30) / UC (18)
J4 West	8 (surface)	< 0.01 – 0.13	4 – 25 (median 13)	NAF (8)
	22 (1 – 5 m)	< 0.1 – 0.12	< 0.5 – 12.4	18 NAF (18) / UC (4)

Notes: 1. Price (2009) methodology; 2. AMIRA (2002) methodology

Source: Mine Earth (2022), Okane (2023a); SRK (2023); MinRes (MinRes, 2024)

5.3.3.2.1 Carina WRL

A borehole drilling investigation on the Carina WRL was undertaken to confirm the location and as-built design of the PAF encapsulation cell (Okane Consultants, 2023b). The conclusions from this work are described in Section 5.9.3.4. The results of geochemical characterisation assessment completed on surface samples collected as part of this evaluation (Okane Consultants, 2023a) are summarised below and provided in Appendix D-5-1.

All samples, collected at depth to 0.6 – 1.6 m, returned a very low sulfur content (mean 0.05 wt%S), recorded paste pH values > 6 and mean total C content of 0.26 wt%C. EC was elevated in 6 samples (> 3,000 µS/cm) (Okane Consultants, 2023a).

The results of geochemical classification, using the two ABA methodologies described in Section 5.3.3 and the criteria outlined in Table 16, are summarised in Table 18. Three samples were classified as PAF using the Price (2009) methodology, but it was noted that non-sulfidic sulfur species were responsible for exaggerated MPA values. The same three samples were classified as UC using the AMIRA (2002) methodology. Okane (2023a) concluded that based on the latter classification, results of the test pit samples are not indicative of a risk for long-term acid production.

Based on the ABA results and very low sulfur contents across all samples, no further geochemical investigation was undertaken (Okane Consultants, 2023a).

⁹ Sample JR04 was classed as NAF by Mine Earth (2022) with a mis-calculated NAPP value of -1.3 kg kg/H₂SO₄/t. However, it is not considered that UC (NAF) classification makes a difference to the geochemical risk associated with the waste rock sample which had a sulfur content of 0.15% S, an ANC of 3 kg kg/H₂SO₄/t and NAG_{pH} 7.1 (SRK, 2023).

5.3.3.2.2 Carina Extended WRL

All samples (collected at surface) returned a very low sulfur content (with 9 of the 10 samples < 0.1% S and the tenth sample containing 0.3% S), recorded paste pH values ranged from 6.7 – 9 and low total C content up to maximum of 0.3%C. Salinity was low to moderate ($EC_{1:2}$ up to 1.83 mS/cm) (Mine Earth, 2022).

Total S results were reviewed as the first indicator for acid formation potential. Samples were classified as NAF when total S < 0.1%. For the one sample exceeding total S of 0.1%, ABA using the AMIRA (2002) methodology was used to determine geochemical classification based on the criteria outlined in Table 17.

All samples were assessed to be NAF (Table 18 and Appendix D-5-2) (Mine Earth, 2022).

Note that in calculating NAPP ($NAPP = MPA - ANC$), where the laboratory ANC was notably higher than the estimated CO_3 -C-ANC values, the lower of the two values (more conservative) was used as the reported ANC, which may overestimate the buffering capacity due to the dissolution of aluminosilicates not typically available for circum-neutral buffering (Mine Earth, 2022).

The multi-element contents were assessed using an adaptation of the GAI. Results between 10 and 100 times the Average Crustal Abundance (ACA) were considered slightly to moderately enriched, whilst those greater than 100 times ACA were considered sufficiently enriched to warrant further consideration. Results are provided in Appendix D-5-2. All samples were enriched for As with seven samples displaying significant enrichment (up to a maximum of 361 ppm). One sample displayed significant enrichment for Sb (38 ppm) and a number of samples recorded slight to moderate enrichment for Cr (four samples) and Ag (four samples) (Mine Earth, 2022). It was noted that the concentrations were below Health Investigation Levels (HIL) for industrial sites (DEC 2010). While the EILs would typically be considered to be a more appropriate guideline, comparisons to the HIL concentrations also infer a low risk for metalliferous drainage.

5.3.3.2.3 J4 WRLs

Surface sample results (2022)

All samples recorded low S content (ranging from 0.01% to 0.16% (median 0.03% S). The J4 East WRL surface exhibited circum-neutral to mildly alkaline pH ($pH_{1:2}$ values of 5.6 – 8.9) and low to moderate salinity ($EC_{1:2}$ values up to 1.52 mS/cm). The J4 West WRL surface exhibited circum-neutral pH ($pH_{1:2}$ values of 6.8 – 8.3) and low salinity ($EC_{1:2}$ values up to 0.69 mS/cm) (Mine Earth, 2022).

Samples with total S < 0.1% were classified as NAF. For all samples with total S > 0.1%, acid base accounting was used to determine geochemical classification based on the criteria outlined in Table 17.

All samples were classified as NAF with the exception of one sample which was classified as UC (NAF)¹⁰ with a low positive NAPP value of 1.6 kg/H₂SO₄/t (Table 18 and Appendix D-5-2) (Mine Earth, 2022; SRK, 2023).

The SRK review (2023) found good agreement between the AMIRA (2002) classifications of the in situ WRL samples and the in-pit samples. However, it also noted that the in situ WRL samples tend to the higher range of NAG_{pH} values (NAG_{pH} 7.1 to 10.1) of the in-pit waste rock samples assessed prior to mining (NAG_{pH} 3.7 to 9.4) and may not reflect some of the shallower materials mined earlier during the life of mine (including OAW).

¹⁰ Sample JR04 was classed as NAF in the Mine Earth (2022) report with a mis-calculated NAPP value of -1.3kg H₂SO₄/t. However, it is not considered that UC (NAF) classification makes a difference to the geochemical risk associated with the waste rock sample which had a sulfur content of 0.15% S, an ANC of 3 kg H₂SO₄/t and NAG_{pH} 7.1 (SRK, 2023).

Field-based testing of the five near surface samples from the J4 East southwest tip head were found to be circum-neutral with paste pH values ranging from 6.95 to 7.93 and moderate paste EC (0.46 – 3.85 mS/cm) and rinse test TDS values of 500 to 1,920 ppm. The geochemical characteristics of these samples were not assessed (SRK, 2023).

Multi-element composition analysis results for the J4 WRL surface samples are provided in Appendix D-5-2 and discussed below (Mine Earth, 2022)

- J4 East: All but one sample showed enrichment in As with one sample displaying significant enrichment (386 ppm). Most samples were enriched in Sb with three samples displaying significant enrichment (up to 44 ppm). A number of samples displayed slight to moderate enrichment for Ag (six samples), Cr (four samples), Co (one sample) and Cu (one sample).
- J4 West WRL: All samples displayed slight to moderate enrichment for As (up to 112 ppm). A number of samples displayed slight to moderate enrichment for Ag (three samples) and Mn (one sample).

SRK (2023) undertook a peer review and recommended that some additional verification sampling is completed to assess the characteristics of waste rock in the outer volume of the lower lifts of the J4 WRLs. Test-pit sampling was conducted in 2023 to address this recommendation with the results discussed below.

Test-pit sample results (2023)

Samples from the J4 East WRL indicated some elevated Total S results (> 0.2%) on the southern end and from one location on the northern face. Total S was low (< 0.1%) at all locations on the J4 West WRL. Sulfur speciation testing was not carried out, so the results do not differentiate between sulfide-sulfur and sulfate-sulfur content (the former used to characterise PAF / NAF and the latter used for an OAW designation) (MinRes, 2024).

Samples from all but one location were classified as NAF or uncertain using the AMIRA (2002) classification system (Table 16, Figure 24). Two samples could be classified PAF but both the NAG_{pH} and NAPP were close to the respective thresholds (Figure 24). Several samples were classified as Uncertain, but the MPA calculation assumed all sulfur present is present as sulfide. It is known that at J4 other forms of sulfur are present, particularly in the oxidised zone. Only a few samples had more than marginal ANC (range 25 – 58 kg $\text{H}_2\text{SO}_4/\text{t}$) and most samples had < 10 kg $\text{H}_2\text{SO}_4/\text{t}$ (MinRes, 2024). The geochemical classification results by test-pit location are illustrated in Figure 25 and Figure 26.

While the AMIRA (2002) procedure cannot be used to classify material as OAW, the NAG_{pH} values can be compared to the paste pH values to consider if oxidation of the material causes a reduction in the pH of leachate, i.e., through sulfide oxidation. In this context, the NAG_{pH} is sometimes assumed to be representative of the pH of leachate after oxidation, termed pH_{ox} . It was found that the pH_{ox} was generally higher than paste pH with some minor exceptions, indicating that these samples were likely all already oxidised. At one location the pH_{ox} was significantly lower than the paste pH, indicating that the sulfur in these samples was predominantly in the form of sulfide. On this basis one location would be classified OAW, as defined by SWC (2014a), and three other locations were just below the threshold, all from the southern face of the lower lift of the J4 WRL (MinRes, 2024). These results and a sample location figure are provided in Appendix D-5-3.

Overall, paste $\text{pH}_{1:2}$ results were consistent with the findings of Mine Earth (2022), i.e., all circum-neutral on the J4 West WRL and select samples with a moderately acidic paste $\text{pH}_{1:2}$ of 5 – 6 on the southern face of the lower lift of the J4 East WRL (MinRes, 2024).

Ten locations, also predominantly on the southern end of the J4 East WRL, were found to be highly saline, with three locations exceeding 400 mS/m, the threshold that will likely impact on even extremely salt tolerant species. One third of samples exceeded the salinity threshold of 200 mS/m cited by

Landloch (2023). The median EC for the J4 East WRL samples was 160 mS/m. Three sites on the J4 West WRL, on the western end of the upper lift, also tested as highly saline. The median EC for the J4 West WRL was 74 mS/m. These results differ from the Mine Earth (2022) results (noting that the latter were for surface samples only) (Section 5.3.5.1.3) which recorded only low to moderate salinity (MinRes, 2024). A preliminary desktop assessment of the potential implications of salinity for revegetation success has been completed with the results presented in Section 5.9.5.2.

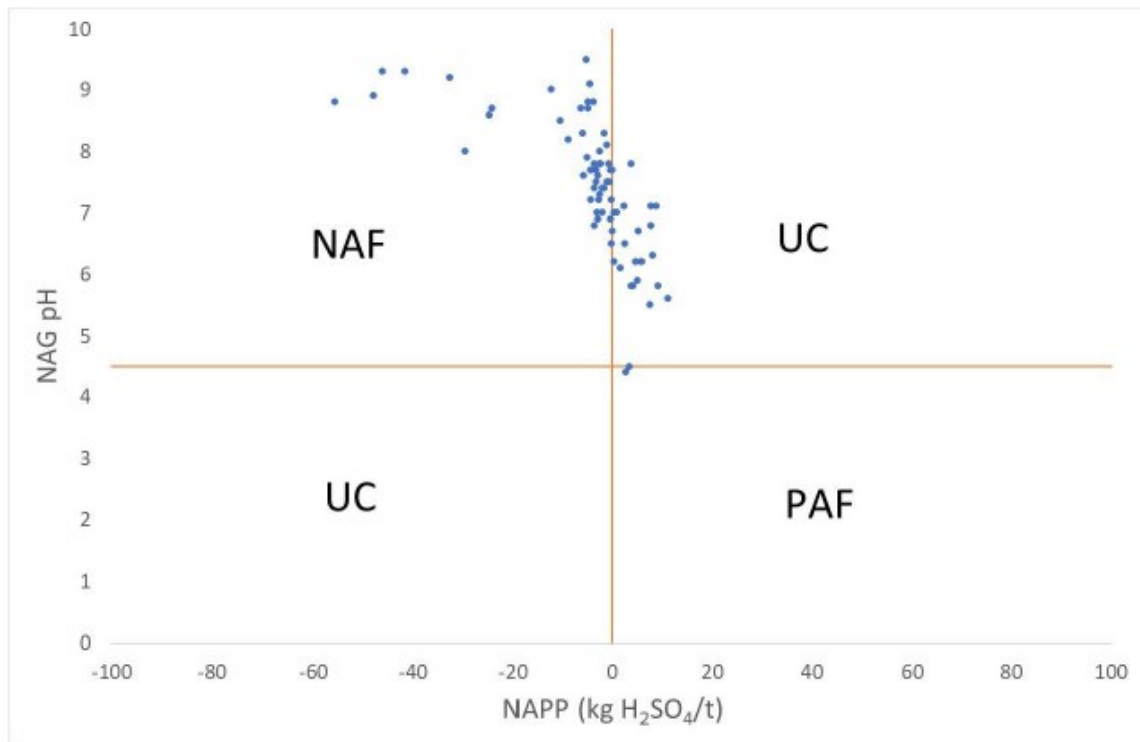


Figure 24 J4 East and J4 West PAF / NAF Classification according to AMIRA (2002) (MinRes, 2024)

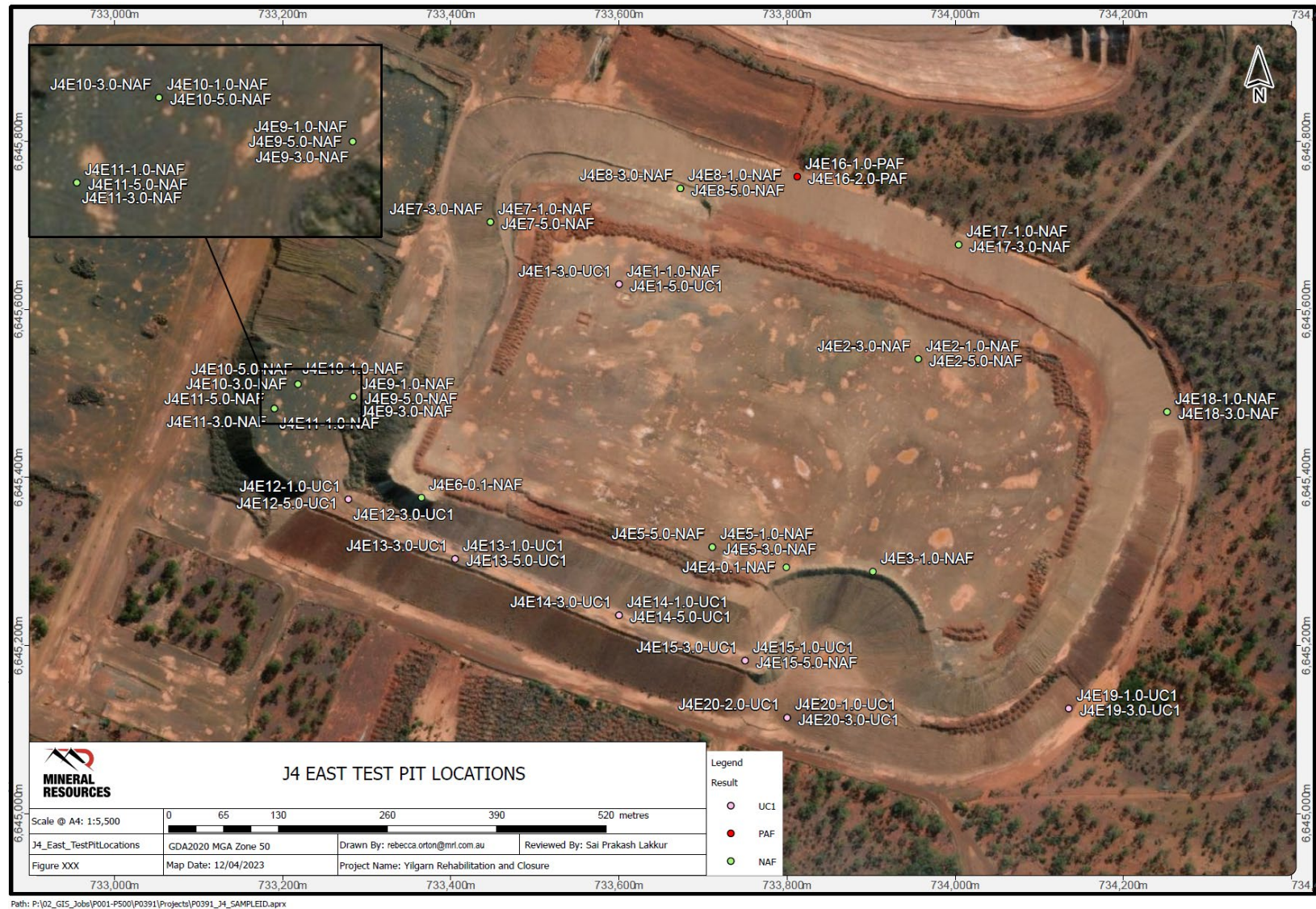


Figure 25 J4 East Pit Test Pit Locations and Results

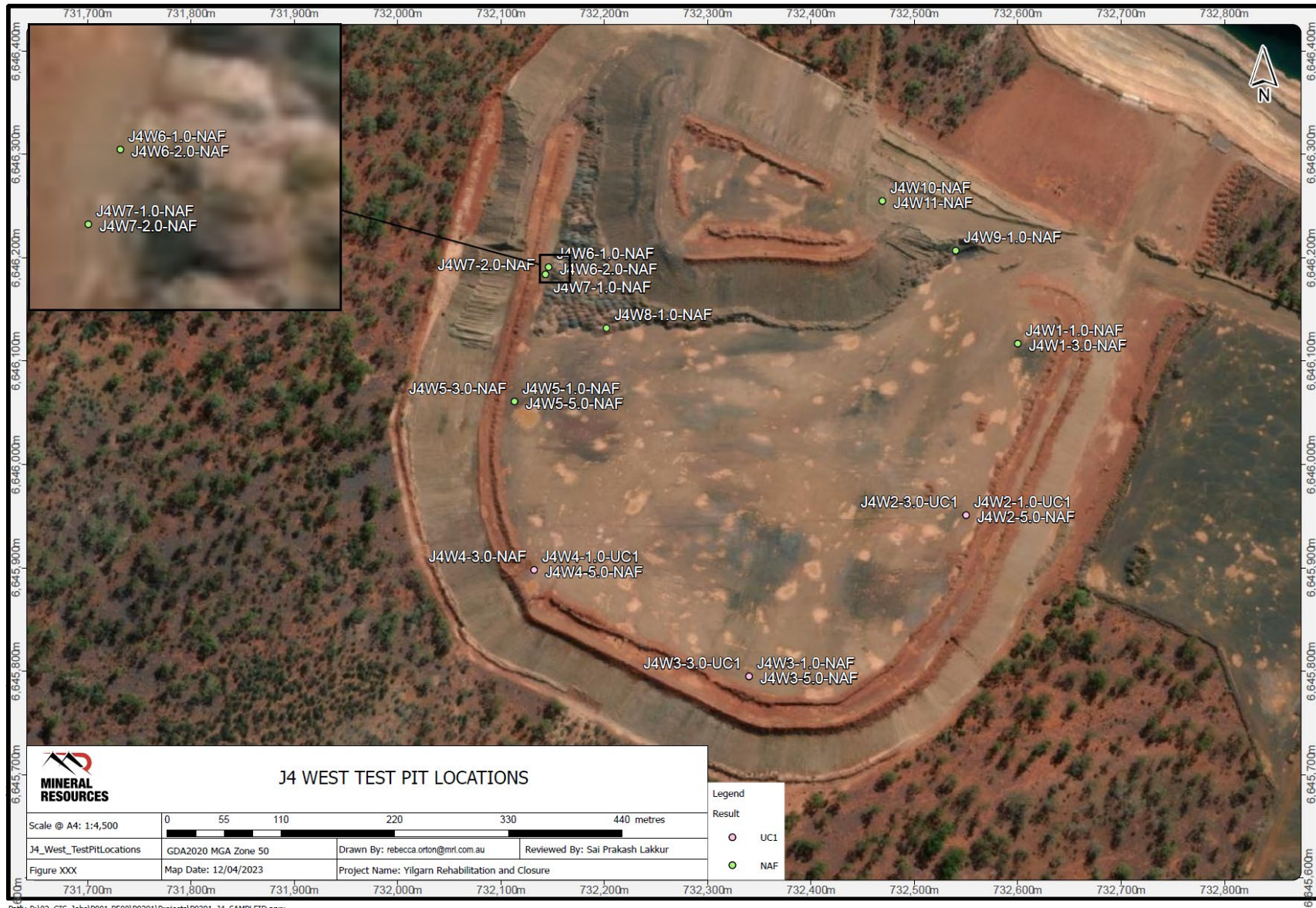


Figure 26 J4 West Pit Test Pit Locations and Results

5.3.3.3 Geochemistry of Low-Grade Ore Stockpile J4

Drilling of the mineralised stockpile, located to the west of the J4 East WRL was completed in 2019. Drill hole lengths ranged from depths of between 12 m to 18 m from the stockpile surface. In total, 272 composite samples were assessed (Mine Earth, 2022). In 2022, one near surface grab sample was assessed (SRK, 2023; Mine Earth, 2022). In 2023, nine samples were collected from test pits with depths ranging from 1 m to 5 m (MinRes, 2024).

Of the drill hole samples, 270 returned sulfur contents < 0.1% (0.006% S to 0.095% S) and two samples had sulfur contents of 0.12% S and 0.16% S (Mine Earth, 2022).

The grab sample had a low sulfur content (0.02%), moderate ANC (100kg H₂SO₄/t), alkaline NAG_{pH} (9.2) and was classified as NAF (SRK, 2023).

All nine test pit samples were classified as NAF (MinRes, 2024) based on a low sulfur content < 0.1% (0.013% S to 0.077% S) and NAG_{pH} ≥ 4.5.

Further geochemical assessment is required to inform the future use of this material, which has been identified as a potential source of rock armour due to high stability of low erosion risk, or rehabilitation of this stockpile (SRK, 2023) if it is not removed prior to closure.

5.3.3.4 Geochemistry of Pit Walls

5.3.3.4.1 Carina

Pit lake evolution modelling completed in 2015 (SWC, 2015b) utilised the Carina Pit design and block model to determine that approximately 150,000 m² of PAF¹¹ would be exposed at the end of mining at elevations between 300 to 480 m AHD, with Total S in these units ranging from 0.4 to 16 %. This study estimated that the pit lake would recover to an elevation of 376 mRL, after which time an estimated 60,000 m² of PAF rock units, containing Total S between 0.4 to 1%, would remain exposed and form a source of acidity for the pit lake.

The risk assessment (Section 7) has identified that these initial estimates of PAF exposure should be reviewed and a gap analysis will be undertaken to assess the need for further studies.

The modelled impacts of exposed PAF on pit lake chemistry is discussed in Section 5.6.2.3.2.

5.3.3.4.2 J4

Solute release from the exposed J4 pit walls, based on limited sulfidic materials being intercepted by the pits, are anticipated to present a low risk. However, per the SRK (2023) recommendations, sulfidic materials with elevated sulfur occur close to the J4 East Pit walls (potentially dewatered and subject to oxidation during mining) and solute release from these materials should be considered in pit lake chemistry (SRK, 2023). The planned gap analysis will address the need for additional testing.

Pit lake chemistry is further discussed in Section 5.6.2.3.2.

5.3.3.5 Geochemistry of Backfill Materials

5.3.3.5.1 Carina Pit

As part of a review conducted to investigate the placement of PAF within the Carina WRL (refer Section 5.9.3.4) Okane Consultants (2022c) reviewed block and survey models from operational mining.

¹¹ In the absence of geochemical characterisation studies at the time, all material containing ≥ 0.3% S was designated as PAF (SWC, 2015b).

Based on this review, the Carina Pit contains approximately 1.5 Mm³ of backfill material that could have been placed from September 2014 onwards. The backfill construction sequence is relatively unknown beyond a small indicated PAF survey of approximately a few thousand cubic metres. It is anticipated that PAF material not contained within the Carina WRL encapsulation cell, which contains less PAF than was planned, (refer Section 5.9.3.4) is contained within the Carina Pit backfill (Okane Consultants, 2022c).

Geochemistry of the Carina deposit is described in Section 5.3.3.1.1.



Figure 27 Carina Pit Backfill 2014 and 2015 (Okane Consultants, 2022c)

5.3.3.5.2 J4 West Pit Backfill

Additional waste material is currently being generated at J4 as described in the J4 Redevelopment Mining Proposal (MinRes, 2023a). Based on the earlier block modelling completed for the J4 deposit (SWC, 2014a), this waste material, sourced to depth of 302 m AHD, contains approximately 0.87 million Bank Cubic Metres (BCM) of PAF waste (7.2% of the total waste generated). The geochemistry of material from the J4 deposit is described in Section 5.3.3.1.3.

Encapsulation of this PAF material is planned as discussed in Section 9.2.1.4.

5.3.3.6 Asbestos and Radionuclides

No screening or analysis has been reviewed to confirm if fibrous materials are present in the waste rock or mineralised stockpile material. Key units of interest would be the mafic and ultramafic lithologies at J4 (SRK, 2023). The J4 East Redevelopment MP noted that previous investigations of the Mount Jackson Range have not identified the presence of fibrous materials or radioactive materials that would require management.

In considering this risk for the Yilgarn Operations, Landloch & EGi (2022) noted that, although the radioactivity of the mine rock types has not been specifically investigated, activity concentrations of ²²⁶Ra (²³⁸U) and ²³²Th for iron ore deposits are expected to be low, because iron ore rock types are generally not subject to significant enrichment in uranium and thorium. Multi-element analysis completed on drill hole samples collected from various depths within the Carina WRL reported neither uranium nor thorium as enrichment (GAI = 0) and concentrations in leachate were less than detection limits (Okane Consultants, 2023b).

5.3.3.7 Considerations for Closure

Most of the near-surface waste rock materials on the Carina, Carina Extended and J4 WRLs were found to be NAF with very low to low Total S content and considered to present a low risk of acid generation.

Analysis of test-pit samples to a depth of 5 m supports these findings. There was material near the threshold of a PAF classification identified at one location on the J4 East WRL, but there is no evidence

of widespread storage of PAF material on the edges of the WRLs at J4 that requires further management.

Samples of cover materials on the southern side of the J4 East WRL would fit the OAW classification, and there was variable salinity. The original cover recommendations for OAW materials (Polaris Metals, 2015) were similar to PAF material (i.e., 5 m of a non-reactive NAF cover) however this is considered conservative on the basis that OAW does not need to be protected from oxidation (MinRes, 2024). The thickness of a NAF cover could be reduced if the primary consideration of the cover is to isolate OAW from the plant root zone.

The implications of salinity for revegetation planning and success, where WRL construction and rehabilitation have progressed to a stage where creation of a capillary break is impracticable is discussed further in Section 5.9.5.2.

The need for further testing / modelling of pit wall exposures of PAF at Carina, estimates of PAF within backfill materials at Carina, and the potential for solute release from higher sulfur materials at shallow depths within the J4 East Pit walls, to impact on pit lake quality should be considered through a gap analysis.

PAF material being generated from the J4 East Pit redevelopment requires management and handling to meet design commitments for encapsulation of this material within the J4 West WRL and the J4 West Pit.

5.3.3.8 Knowledge Gaps & Forward Work Program

The following actions are planned to address knowledge gaps relating to geochemical characteristics of materials:

- Complete a gap analysis to determine the need for additional testing / modelling in relation to PAF exposure on the Carina Pit walls, PAF within backfill materials at Carina, and the potential for solute release from higher sulfur materials at shallow depths within the J4 East Pit walls.
- Investigate the optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable. Where cover is not practicable, use the characteristics of the substrate materials and closure objectives to inform species selection for revegetation or supplementary seeding.
- Refine reference ecosystem (s) and species mix for WRLs with consideration to the properties of the underlying waste rock material and the PMLU.
- Characterise waste materials at the Aurora site to inform landform designs.
- Review drill assays and undertake testing if required to confirm if fibrous or radioactive minerals are present in the waste rock or mineralised stockpile material. Key units of interest would include the mafic and ultramafic lithologies.
- Additional geochemical assessments will be needed for the J4 Low Grade Stockpile material if it is planned to be used as erosion resistant armouring material, or if this stockpile is not removed prior to closure.

5.3.4 Physical Characterisation of Waste Rock Material

Key Points

- The Carina WRL includes a PAF encapsulation cell. Assessment of the WRL cover materials focussed on their characteristics as encapsulation materials and concluded that materials in the area of the inferred PAF cell had the following properties that would reduce water ingress:
 - Emerson Class 8, stable when submerged in water (and predominantly Class 4 – 6 across the WRL).
 - Low plasticity, low hydraulic conductivity, and low permeability.
- The Carina Extended WRL comprises waste rock with variable erosional stability properties (Table 19) but is classified overall as having a Moderate stability rating across the surface of all slopes of the WRL.
- The J4 East WRL slopes typically comprise waste rock with Low or Moderate stability.
- The majority of the materials forming the southern and eastern slopes of the J4 West WRL are of Low stability, whilst the northern and western slopes are typically of Moderate and High stability material.
- The Aurora WRL has significant erosion, particularly on the batters, which is inferred to be a result of uncontrolled run-off from the WRL plateau. Materials characterisation data are required to inform rectification plans.
- Incorporation of sufficient surface water control features, such as berms and contour ripping, is required in all areas to mitigate the potential for concentrated surface water flow and erosion on WRLs.

Baseline physical characterisation of waste rock lithologies is not available for the Carina Operations mine sites, however, assessment of the WRL cover materials has been completed as follows:

- Carina WRL - SWC (2017) investigation of growth media included assessment of stability and Okane Consulting (2023a) assessed the geotechnical characteristics of encapsulation material at the surface of the Carina WRL.
- Carina Extended and J4 WRLs - Mine Earth (2022) mapped the surface distribution of high, moderate and low stability material on these WRLs. The waste rock sampling and observation methodology is described in Mine Earth (2022).
- Aurora WRL - Okane Consulting's (2022b) assessment included commentary on stability of the waste rock material.

The results for each site are discussed in the following sections.

5.3.4.1 Stability of Waste Rock Cover Materials - Carina

Initial assessment of the WRL surface materials at Carina focussed on their characteristics as a growth medium (see Section 5.3.5) but noted that the unrehabilitated surface with bare waste rock was less eroded than the areas with upper clay/saprolite material spread. Waste rock on its own is an unsuitable growth medium due to low water holding capacity; however, where contour ripping has brought a quantity of waste rock aggregate to the surface of topsoiled areas, it could promote surface stability (SWC, 2017).

Additional sampling was completed in 2022 to assess the geotechnical characteristics of encapsulation material at the surface of the Carina WRL. Eleven samples were collected from 10 test pits excavated to a depth of approximately 0.5 m (Okane Consultants, 2023a) and a further 65 samples collected from 12 boreholes drilled to either 15 m or 30 m depth (Okane Consultants, 2023b). The results are presented in Appendix E-1 and summarised below:

- The test-pit samples demonstrate a generally, higher percentage of coarse, cobble and gravel sized particles (> 4.75 mm) compared to smaller sand, clay and silt sized particles (Okane Consultants, 2023a). Drill hole samples showed a wide range of grain sizes, typical of waste rock landform

material and generally no correlation between particle size and depth. Moisture content remained relatively constant throughout the profile (Okane Consultants, 2023b).

- All surface samples and most of the borehole samples tested were assessed as Emerson Classification of 2 – 6, indicating that the material may not disperse initially but may do if remoulded (worked) when wet and may also exhibit slaking¹² behaviours (Okane Consultants, 2023a; 2023b).
- Testing of samples selected based on their proximity to the inferred PAF encapsulation cell concluded the following (Okane Consultants, 2023b):
- Surface material from two sites within the inferred PAF cell were Emerson Class 8 indicating this material is very stable when submerged in water. Material that potentially does disperse in water (Emerson Class 2) was located on the outer edges of the WRL (not on the batters), away from the encapsulated PAF cell.
- Atterberg testing of 10 drillhole samples from within the known extent of the PAF encapsulation cell found most samples displayed low plasticity clay and silt materials. These materials are generally more stable, less sensitive to moisture changes and present less capacity to retain water than high plasticity clays.
- Field hydraulic conductivity tests and falling head permeability results (14 samples) showed low hydraulic conductivity, suggesting that the materials have low permeability, indicative of fine sands and clays.
- Geotechnical properties of the waste rock material indicate suitability as a low permeability capping material that inhibits water infiltration.

Refer to Section 5.9.3.4 for a full assessment of PAF encapsulation at the Carina WRL.

5.3.4.2 Stability of Waste Rock Cover Materials - Carina Extended

The Carina Extended WRL comprises waste rock with variable erosional stability properties (Table 19) but is classified overall as having a Moderate stability rating across the surface of all slopes based on the extent of rehabilitation that has been implemented (Figure 28). Field observations indicate that the Low stability waste rock is dominated by oxide-transitional BIF, mafic schist, mineralisation, saprolite, saprock, chert and dolerite (Mine Earth, 2022).

Examples of Low, Moderate and High stability waste rock from the Carina Extended WRL are provided in Figure 29.

5.3.4.3 Stability of Waste Rock Cover Materials - J4

The J4 East WRL slopes typically comprise waste rock with Low or Moderate stability (Table 19 and Figure 28). Stockpiled low-grade ore material to the west of the WRL displays High stability and, if available, would be a suitable source of rock armour for areas of the WRL where Low stability waste rock is exposed at the surface. This is subject to further geochemical assessment as discussed in Section 5.3.3.1.3.

The majority of the southern and eastern slopes of the J4 West WRL comprise waste rock with Low stability, whilst the northern and western slopes are of Moderate and High stability material (Table 19 and Figure 28). The High stability material will be a suitable source of rock armour in areas where erosion is occurring, or where Low stability waste rock is exposed at the surface. The area of stockpiled waste rock on the upper surface of the first lift (shown in Figure 28) displayed variable erosional stability (Mine Earth, 2022).

¹² Slaking refers to the breakdown of soil aggregates when wet. Slaking reduces infiltration because the smaller aggregates or primary particles block soil pores.

Examples of Low, Moderate and High stability waste rock from the J4 WRLs are provided in Figure 29.

5.3.4.4 Stability of Waste Rock Cover Materials - Aurora

The Aurora WRL displays significant erosion particularly on the batters which is inferred to be a result of uncontrolled run-off from the WRL plateau. No materials characterisation data are available to inform rectification plans.

As discussed in Section 5.9.3.4 rectification works are proposed to manage surface water on the WRL plateau and prevent large scale erosion of the batter slopes. It is noted however that localised erosion will still occur as a result of water captured on the slopes themselves and further materials characterisation would be required to model and mitigate this issue (Okane Consultants, 2022b).

5.3.4.5 Considerations for Closure

Physical characteristics of waste rock materials will inform landform closure and rectification designs.

Based upon the waste rock characteristics observed at Carina Extended and the J4 WRLs (Mine Earth, 2022):

- High stability rock should be suitable for placement on final WRL slopes and may provide a useful source of durable rock armour.
- The suitability of moderate stability rock for use on final landform slopes will depend upon the as-dumped properties of the rock, the geometry of the landform slopes and associated drainage implications.
- Low stability rock should not be placed on final WRL slopes. Low stability rock will require the application of rock armour if exposed on WRL slopes. Where additional competent waste rock is applied to reshaped batter surfaces, it should be contour ripped into the underlying material to further armour the surface against erosion.

In all areas, incorporation of surface water control features (berms and contour ripping) is required, to mitigate the potential for concentrated surface water flow and erosion on WRLs.

In the area of the inferred Carina PAF encapsulation cell, waste material samples display geotechnical properties that reinforce the conclusion that the material has the potential to reduce water ingress. It has also been demonstrated that this material has been placed at sufficient depth over the PAF encapsulation cell (Section 5.9.3.4).

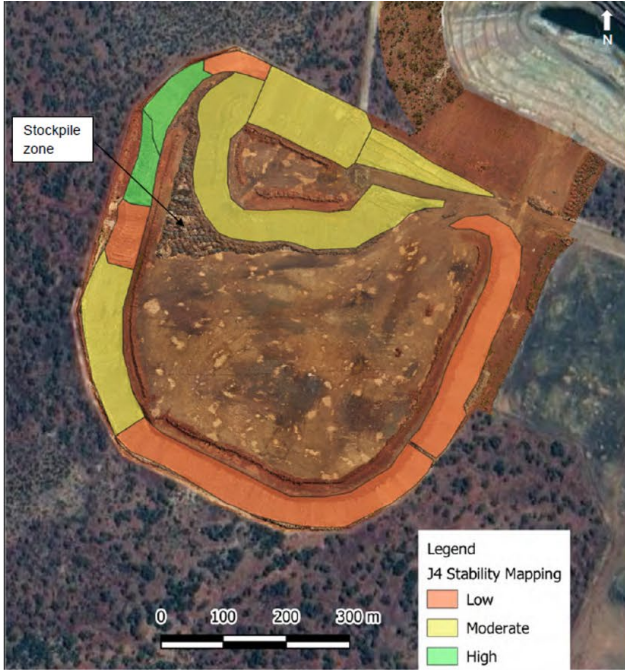
5.3.4.6 Knowledge Gaps & Forward Work Program

The following actions are planned to address knowledge gaps relating to physical characteristics of materials:

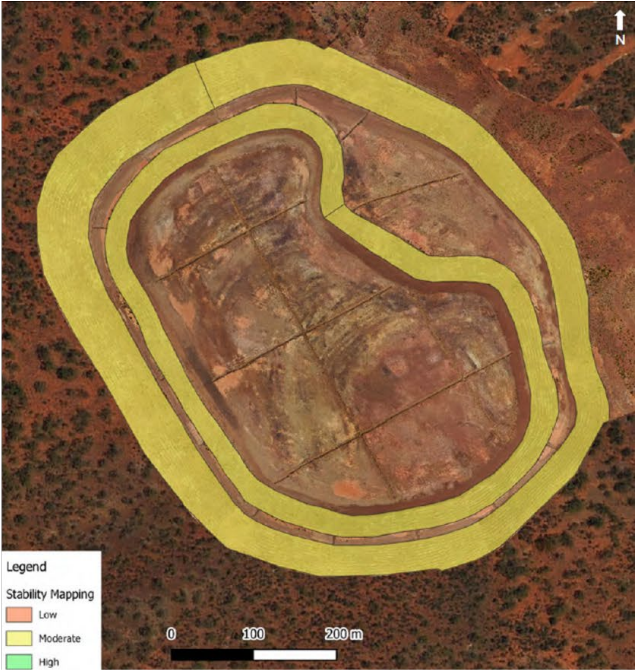
- Re-assess cover materials mapped as 'low stability' on the J4 WRLs to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, should be incorporated into the final landform design.
- WRL rectification plans will be developed and implemented where necessary to manage surface water run-off from the WRLs.
- Characterise waste materials at the Aurora site to inform landform designs.



J4 East WRL



J4 West WRL



Carina Extended WRL

Figure 28 Erosional stability maps for the J4 and Carina Extended WRLs (Mine Earth, 2022)

Table 19 Physical Characteristics of Waste Rock from J4 and Carina Extended WRLs

Stability	No. of Samples			Oxidation	Weathering	Hardness	Lithology	Particle Size < 2 mm (%)			Particle Size 2 mm – 2 cm (%)			Particle Size 2 cm – 10 cm (%)			Particle Size > 10 cm (%)		
	J4 E	J4 W	CE					J4E	J4W	CE	J4E	J4W	CE	J4E	J4W	CE	J4E	J4W	CE
Low	3	2	2	Oxide - transitional	Moderate – strong	Moderate – high	BIF, mineralisation, saprock, limonite, laterite, clay	60	60-70	40-50	20-40	10-30	30	14-19	10	19-27	0-1	0-10	1-3
Moderate	7	4	6	Oxide - transitional	Moderate – strong	Moderate – high	BIF, chert, mineralisation, saprock, dolerite, limonite, saprolite, clay, laterite	35-60	20-45	30-50	15-45	30-45	30-45	10-45	23-39	14-20	0-10	1-5	1-5
High	4	5	2	Oxide - fresh	Weak – strong	High	BIF, mineralisation, chert, dolerite, laterite, saprock, saprolite	15-35	15-30	0-35	25-45	30-60	40	25-35	12-30	20-30	10-30	3-20	0-5

Notes: J4 East WRL (J4E); J4 West WRL (J4W); Carina Extended WRL (CE)
Source: Mine Earth (2022)

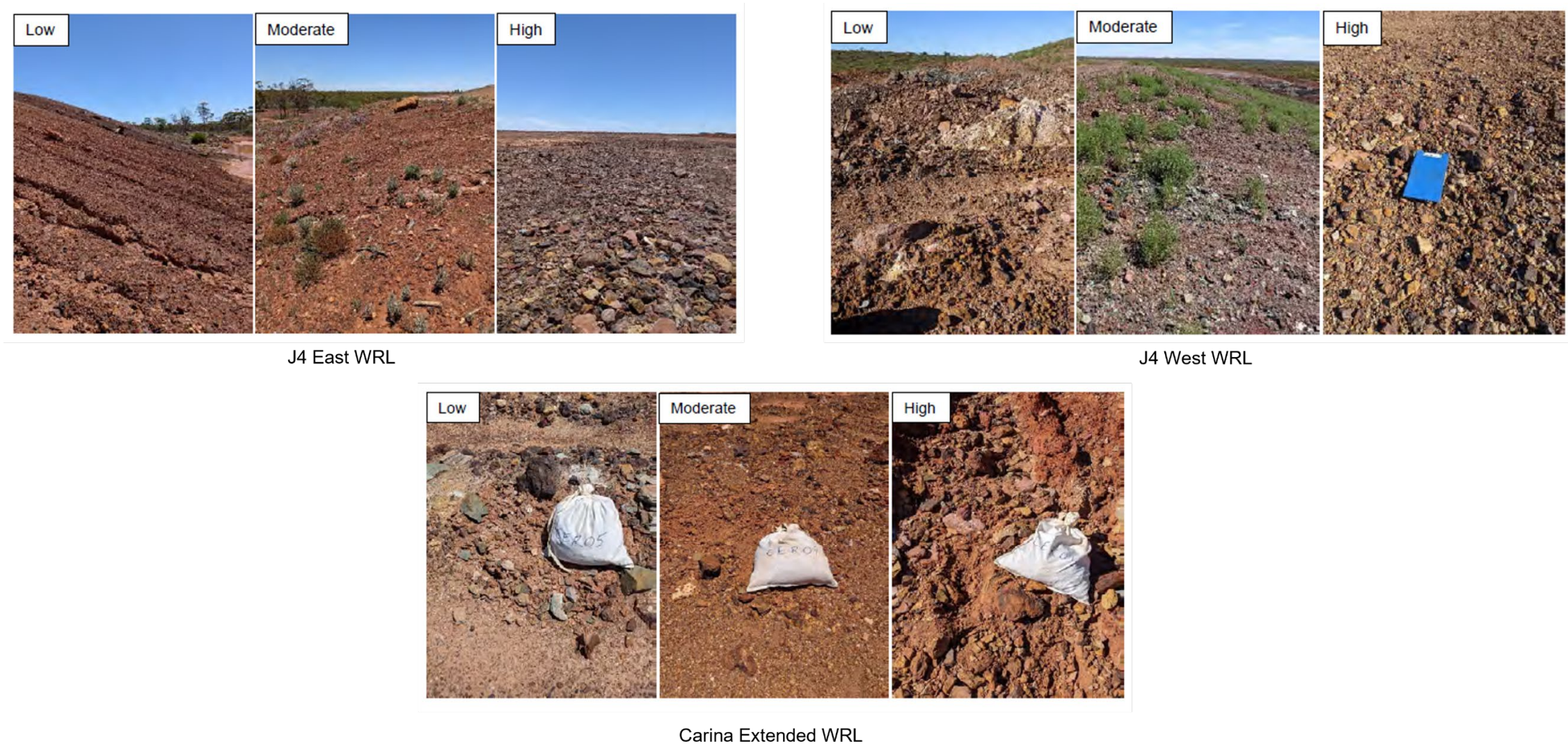


Figure 29 Examples of waste rock erosional stabilities on the J4 and Carina Extended WRLs

5.3.5 Soils and Growth Media

Key Points

- The regional soil landscape is described in Section 5.2.4
- The extent to which topsoil has been characterised varies across the Carina Operations. Data from baseline soil assessments is available for Carina Extended, J4 and, to a limited extent, Aurora. There is no baseline soil data for Carina and further characterisation is planned (see Table 62).
- Post-mining soil assessments have been completed for Carina, J4 and Carina Extended.
- There is no post-mining data for soil placed or stockpiled at Aurora and further characterisation is planned (Table 62).
- Assessment of soil placed on the WRL at Carina, or stockpiled at the base of the WRL, found it to be moderately saline, on average, with a pH that was neutral to slightly alkaline. Salinity in the placed soil was higher than in baseline soils from the nearby Carina Extended site. Studies have found that vegetation performed better on areas of the WRL where soil had been placed to a depth of 200 mm – 500 mm and ripped on the contour when compared to areas that had no topsoil applied or had topsoil applied but without contour ripping. The topsoil is prone to structural instability but was found to be more erosionally stable when contour ripping had brought up some waste rock aggregate to the surface.
- The underlying waste rock on the Carina WRL was also considered as a potential growth medium but was found to be unsuitable as samples were highly saline and alkaline on average.
- Soil that had been placed on the WRL surface at Carina Extended, or stockpiled at the base of the WRL, was found to be moderately to extremely saline (moderately saline average), with a pH that was slightly acidic to alkaline. Salinity in the placed soil was higher than in baseline soils while pH of the placed topsoil was comparable to baseline conditions. Stockpiled topsoil was generally found to have the same characteristics as the soil that had been placed. The ‘moderately saline’ to ‘extremely saline’ classification of some samples may be limiting the growth of some native vegetation species and may be contributing to the relatively sparse vegetation establishment observed on the WRL. The soil generally exhibited relatively low potential for erodibility because it has a high coarse fraction, low propensity for clay dispersion and moderately rapid drainage classification. However, it is susceptible to erosion where surface water control features are insufficient.
- Three SMUs were identified in the baseline studies at J4: SMU 1 shallow gravel, SMU 2 stony soil and SMU 3 brown non-cracking clay. SMU1 and SMU 2 are self-armouring and relatively stable from an erosion perspective. SMU 3 is structurally unstable, dispersive, highly erodible, and not suitable for use on the outer surface of WRLs.
- An assessment of soil that had been stockpiled or placed on the surface of the J4 East WRL, found that salinity ranged from non-saline to extremely saline. However, most samples were classified as non-saline to slightly saline in the stockpile and non-saline to moderately saline on the WRL surface. The pH of the topsoil was generally neutral. No major limitations for use as a rehabilitation material were identified for the J4 East stockpiled topsoil or placed topsoil.
- A topsoil stockpile is also located at the crest of the J4 West WRL. Salinity was more variable in this stockpile, ranging from non-saline to moderately saline with a slightly saline average. The pH was also variable, ranging from slightly acidic to strongly alkaline. The soil displayed low concentrations of plant available nutrients. However, no limitations for use as a rehabilitation material were identified for the stockpiled topsoil at J4 West WRL.
- The limited data from Aurora indicates that the topsoil is moderately saline with a pH that is alkaline. Observations of the erosion on the surface of the Aurora WRL suggest that soil cover is not erosion resistant; however, further soil characterisation is required.
- Surface treatment trials at the Carina WRL indicate that rehabilitation outcomes are improved when soil with an EC_{1:5} level of less than 200 mS/m is applied at a thickness of 100 – 300 mm, includes a 40 – 60% rock and 10 – 20% timber debris cover, and is ripped on the contour.
- There is an overall topsoil deficit across the Carina Operations. Further surveys will be undertaken to refine understanding of the topsoil balance.

An overview of the regional soil landscape is provided in Section 5.2.4 and the regional soil mapping units shown in Figure 17. Site specific studies undertaken to characterise soils and growth media characteristics across the Carina Operations are detailed in Table 20 and Table 21. These assessments and results are described in Sections 5.3.5.1 and relevant soil data is provided in Appendix F. Conclusions about the erosional stability of topsoil material are described in Section 5.3.5.2.

Table 20 Overview of Soil and Growth Media Knowledge Base Studies

Site	Carina	Carina Extended	J4	Aurora
Pre-mining / Baseline	X	✓	✓	✓
Post-mining (stockpiled and applied topsoil)	✓	✓	✓	X

Note: Studies undertaken = ✓ Studies not undertaken = X. See Table 21 for details.

Table 21 Soil Characterisation Studies Completed for Carina Operations

Site	Study	Sample No.	Nature of assessment
Pre-mining assessments (Baseline Soils)			
Carina Extended Deposit	(Polaris Metals, 2013a) Revised Mining Proposal Carina Extended	6 samples	Topsoil samples distributed over the proposed footprint of the waste landform and mine void were analysed for a range of physical and chemical properties including pH, conductivity, stability (Emerson test), texture (particle size distribution) and chemistry (Cation Exchange Capacity (CEC)).
J4 Deposit	SWC (2014b) J4 Soil Characterisation	24 sampling locations	Baseline soils characterisation: Samples from 24 soil trenches dug by hand to 1 m (or point of refusal), 8 microbe sampling sites and 7 opportunistic sampling sites were analysed for physical, hydraulic, chemical and microbial properties. Laboratory scale erosion tests were undertaken on three trench site samples.
Aurora	Marianna Partners (1993) Pre-mining environmental review of the existing environment at the Bungalbin Hill Prospect	Not reported.	This study described the existing environment at Bungalbin Hill Prospect (Aurora) prior to the commencement of mining by AMALG Resources. Exploration disturbance was evident at the site prior to sampling. Marianna Partners (1993) states that soil samples were collected from sites 'typical of the area' and samples were tested for pH and electrical conductivity.
Post-mining assessments (Stockpiled & Applied Soils)			
Carina WRL	SWC (2017) Carina WRL Growth Medium Investigation	94 samples from 33 sites across the WRL surface.	Characteristics of materials which have been placed on the outer surface of the Carina WRL were assessed to characterise the soil and regolith (growth medium). A total of 94 samples were collected from 33 soil trenches excavated to a maximum depth of 50 cm, and areas of particular interest, e.g., salt scalding for initial review. Samples representing soil units and similar soil profiles were selected for detailed analysis of chemical and physical properties.
	(Okane Consultants, 2023a)	Stockpiled topsoil – 10 samples	To geochemically and geotechnically assess stockpiled topsoil material, to determine suitability for use in rehabilitation works at the site, 13 topsoil

Site	Study	Sample No.	Nature of assessment
	Carina PAF Cell Investigation Test Pit Sampling Program	Spread topsoil – 3 samples	samples were taken, 10 from stockpiled material at the base of the landform and three from topsoil spread on the slopes of the landform.
	Landloch (2023) Carina and Carina Extended WRL: Rehabilitation Cover Design	8 grab samples	An investigation of the optimum growth cover design based on the outcomes of rehabilitation trials on the Carina WRL included assessment of the chemical and physical characteristics of the upper soil profile. Eight grab samples (5 kg) of soil were collected from the upper soil profile (~0.5 m depth).
Carina Extended, J4 East and J4 West WRLs	Mine Earth (2022) Carina Soil and Waste Rock Characterisation	34 samples	This investigation included assessment of topsoil, from topsoil stockpiles and areas of the WRLs under rehabilitation (where topsoil has been applied). A total of 34 samples were assessed.

5.3.5.1 Soils and Growth Media Assessment

The stripping of natural soils from disturbed areas, stockpiling of these materials during mining activities, and their respreading in support of restoration or rehabilitation activities during mine closure, is standard practice in mining. Numerous studies over many decades provide evidence that natural soils typically represent the most appropriate growth medium for native vegetation establishment on mined landscapes, and that different stripping and stockpiling approaches influence the quality of these soils at the point of use in restoration or rehabilitation (e.g., Tracey & Glossop (1980), Rokich, et al. (2000), Kumaresan, et al. (2017), Cross, et al. (2021b)). Baseline soil and growth media assessments provide important information on the chemical and physiological characteristics of natural soils, and patterns in these characteristics at different scales, and evaluate their potential as growth media to support desired post mining land uses. Holistic understanding of substrate and geomorphological characteristics (both abiotic and biotic), and of important ecological functions like plant-microbe interactions where possible, is important for establishing completion criteria and determining appropriate reference ecosystems (Young R. G., 2022).

Australian soil systems are relatively well-described and often mapped (e.g., for the Yilgarn: Anand and Paine (2002)). In the Yilgarn, soils are often characterised by multiple horizons and vegetation assemblages typically reflect patterns in soil characteristics (e.g., Anand and Paine (2002); Markey and Dillon (2008a; 2008b; 2010)). The 'A' horizon (hereafter referred to as 'topsoil'), typically the uppermost 100-200 mm, typically supports most soil microbiota, including functional groups responsible for key plant-microbe interactions such as arbuscular and ectomycorrhizal fungi, contains the soil-stored seed bank, is the horizon into which most annual plants and very shallow-rooted perennials root, and represents the most suitable medium for seed germination and seedling establishment of native vegetation (Graham, Florentine, Fox, & Luong, 2004; Schoknecht & Pathan, 2013; van Etten, Neasham, & Dalgleish, 2014; Moreira-Grez, et al., 2019; Naylor, McClure, & Jansson, 2022). Lower horizons below the 'A' horizon (hereafter referred to collectively as subsoil) typically represent the substrate(s) into which most perennial vegetation root and may also support important microbial communities (Schenk & Jackson, 2002; Naylor, McClure, & Jansson, 2022). Studies across the Carina Operations to date have not distinguished between the topsoil and subsoil.

Seven soil assessments have been completed across the Carina Operations since 1993. The extent of sampling and analysis varies across the different assessments, however, the information has been collated to the extent possible to establish a general understanding of soil characteristics. The soil analysis performed on the samples for each study is summarised in Table 22 and the results are described in Sections 5.3.5.1.1 to 5.3.5.1.4.

Table 22 Soil Analysis Performed on Samples

Parameter	(Marianna Partners, 1993) Pre-mining environmental review of the existing environment at the Bungalbin Hill Prospect (Aurora)	(Polaris Metals, 2013a) Revised Mining Proposal Carina Extended	SWC (2014b) J4 Soil Characterisation	Carina Growth Medium Investigation (SWC, 2017)	Mine Earth (2022) Carina (J4 and Carina Extended) Soil and Waste Rock Characterisation	Carina and Carina Extended WRL: Rehabilitation Cover Design (Landloch, 2023)	Carina PAF Cell Investigation Test Pit Sampling Program (Okane Consultants, 2023a)
Soil Physical Properties							
Particle size distribution	X	✓	✓ Pipette sedimentation	✓ Pipette sedimentation	✓	✓	✓
Gravel content	X	✓ Sieve analysis (> 2 mm soil fraction)	✓ Sieve analysis (> 2 mm soil fraction)	✓ Sieve analysis (> 2 mm soil fraction)	✓ Sieve analysis (> 2 mm soil fraction)	✓ Fine / coarse fraction	X
Bulk density	X	X	✓ Constant volume	✓ Constant volume	X	X	X
Structural stability	X	✓ Emerson dispersion	✓ Emerson dispersion	✓ Emerson dispersion	✓ Emerson Aggregate Test	✓ Emerson Aggregate Test	✓ Emerson Aggregate Test
Soil Hydraulic Properties							
Gravimetric moisture content	X	X	✓ Oven drying at 105 °C	X	X	X	X
Saturated hydraulic conductivity	X	X	✓ Constant head method	✓ Constant head method	✓	X	X
Water retention characteristics	X	X	✓ Pressure plate equipment	✓ Pressure plate equipment	X	X	✓ Water Holding Capacity (soil water retention curve)
Soil Chemical Properties							
pH	✓	✓	✓ 1:5 soil/water extraction	✓ 1:5 soil/water extraction	✓ (H ₂ O)	✓ 1:5 soil/water extraction	✓ 1:2 soil/water ratio
Electrical conductivity (EC; salinity)	✓	✓	✓ 1:5 soil/water extraction	✓ 1:5 soil/water extraction	✓	✓ 1:5 soil/water extraction	✓ 1:2 soil/water ratio
Macro-nutrients	X	✓ Na, K, Ca, Mg,	✓ Mineralised Nitrogen (N) KCl extractable Colwell Phosphorus (P) NaHCO ₃ extraction Colwell Potassium (K) NaHCO ₃ extraction Sulfur (S) KCl extractable	✓ Mineralised Nitrogen (N) KCl extractable Colwell Phosphorus (P) NaHCO ₃ extraction Colwell Potassium (K) NaHCO ₃ extraction Sulfur (S) KCl extractable	✓ N, P, K, S	✓ Mineralised total Nitrogen (N) Total phosphorus (P) and available (Colwell) Phosphorus (P) Available (Colwell) Potassium (K) Available (KCl) Sulfur (S)	✓ Total Nitrogen (N) Total Phosphorus (P) Nitrate Ammonia
Organic Carbon	X	X	✓ Walkley Black method	✓ Walkley Black method	✓	✓	✓
Soluble chloride (Cl)	X	X	X	X	X	✓	X
Total chloride (Cl)	X	X	X	X	X	X	✓
Exchangeable cations	X	X	✓ Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	✓ Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	✓ Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	✓ Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K)	X

Parameter	(Marianna Partners, 1993) Pre-mining environmental review of the existing environment at the Bungalbin Hill Prospect (Aurora)	(Polaris Metals, 2013a) Revised Mining Proposal Carina Extended	SWC (2014b) J4 Soil Characterisation	Carina Growth Medium Investigation (SWC, 2017)	Mine Earth (2022) Carina (J4 and Carina Extended) Soil and Waste Rock Characterisation	Carina and Carina Extended WRL: Rehabilitation Cover Design (Landloch, 2023)	Carina PAF Cell Investigation Test Pit Sampling Program (Okane Consultants, 2023a)
			NH ₄ Cl Extraction	NH ₄ Cl Extraction		Potassium (K), aluminium (Al)	
Cation Exchange Capacity (CEC)	X	✓	✓ Sum of exchangeable cations	✓	✓	✓	✓
Exchangeable Sodium Percentage (ESP; sodicity)	X	X	✓ EXP = (Ex. Na/CEC) x 100	✓	X	✓	✓
Heavy metals	X	X	X	X	✓ As, Cd, Cr, Co, Pb, Mo, Se	X	X
Extractable metals	X	X	X	X	X	X	✓ Fe, Cu, Zn, Mn,
Soil Microbial Properties							
Microbial Biomass Carbon (MBC)	X	X	✓ Chloroform fumigation	X	X	X	X
Soluble Organic Carbon (SOC)	X	X	✓ Carbon autoanalyser	X	X	X	X

5.3.5.1.1 Carina

BASELINE

A baseline soil investigation was not completed for the Carina site. An assessment of reference soil characteristics will be undertaken in 2024 to address this knowledge gap (see the forward work program described in Table 62). An assessment of the Carina Extended site, in the same vicinity, has been completed as described in Section 5.3.5.1.2 and has been used for comparison.

POST-MINING (STOCKPILED AND APPLIED TOPSOIL)

Sampling and analysis of stockpiled and applied topsoil at Carina was undertaken between 2017 and 2023. The analysis that was completed is provided in Table 22 and results are provided in Appendix F. Key findings are summarised below.

The three post-mining soil assessments that have been conducted at Carina are:

- Carina Growth Medium Investigation (SWC, 2017), which assessed soil from areas under different stages or rehabilitation and which had received different surface treatments. One of the intended outcomes of this study was to identify differences which exist across the different WRL rehabilitation areas and any potential limiting properties for rehabilitation success. This study also assessed underlying waste rock from within the WRL or exposed waste material to ascertain whether it would be suitable as a potential growth medium if topsoil was not applied. A semi-quantitative assessment of plant roots was also undertaken to assist in identifying potential adverse soil materials.
- Carina and Carina Extended WRL Rehabilitation Cover Design (Landloch, 2023), which further assessed the performance of surface treatment variables that had been used in the rehabilitation trials (see Section 5.9.2).
- Carina PAF Cell Investigation Test Pit Sampling Program (Okane Consultants, 2023a), which assessed representative samples from remaining topsoil stockpiles and from areas where topsoil had been applied for rehabilitation.

Results from the three studies consistently showed that the topsoil that had been either stockpiled or applied for rehabilitation displayed similar characteristics:

- Salinity ranged from non-saline to saline with a moderately saline average of between 100 and 135 mS/m reported in all three studies. Although baseline conditions for Carina have not been established, the salinity levels are generally higher than those reported in baseline results at the nearby Carina Extended site (see Section 5.3.5.1.2).
- The pH of the samples across all studies consistently ranged from circum-neutral (pH 7.1) to moderately alkaline (pH 9.3). This is consistent with baseline conditions reported at the nearby Carina Extended site.
- Soils across all studies were reported as predominantly Emerson Class 2 indicating that material either completely or partially disperses. Some samples collected by Okane (2023a), reported Emerson Class 3-6 which suggest the material would not disperse initially but may do so after rework from activities such as rehabilitation works.
- Landloch (2023), assessed trace elements (copper, iron, manganese, zinc and boron) and determined that they were not present at levels that would limit plant growth or present a toxicity issue in rehabilitation areas. Assessment of heavy metals by Okane (2023a) reported concentrations within the range of values typically encountered from surface soils within the region.

SWC (2017) assessed the underlying and exposed waste material in the Carina WRL to ascertain its suitability as a growth medium if topsoil was not applied. The waste rock was found, on average, to be extremely saline and had lower water holding capacity when compared to the topsoil. The studies

indicated that applying topsoil for rehabilitation provided a more favourable surface for plant growth compared with areas of bare water rock and provides some additional water holding capacity (SWC, 2017).

5.3.5.1.2 Carina Extended

BASELINE

One baseline soil assessment was undertaken prior to mining and sampled six samples from within the proposed footprint of the WRL and the mine void (Polaris Metals, 2013a). The analysis that was completed is provided in Table 22 and results are provided in Appendix F-1:

The results show that baseline topsoil was well-structured and generally stable (Emerson class 3), neutral-slightly alkaline (pH 5.7 – 8.4), non-saline (3.6 – 14 mS/m) and displayed low-moderate CEC (4.9 – 28 meq/100g).

POST-MINING (STOCKPILED AND APPLIED TOPSOIL)

One post-mining soil assessment has been undertaken at Carina Extended (Mine Earth, 2022). A total of nine samples were collected from the surface of the Carina Extended WRL, where rehabilitation has been implemented, and one sample was collected from a topsoil stockpile to the east of the WRL. The analysis that was completed is provided in Table 22 and results are provided in Appendix F. Key findings are summarised below.

- Salinity varied, ranging from slightly saline (23 mS/m) to extremely saline (630.6 mS/m). Most samples were reported as slightly to moderately saline, however, salinity was generally higher than that reported in the baseline samples.
- The pH of the soil was consistent with the baseline samples and ranged from neutral to moderately alkaline (pH 6.1 – 8.8). CEC (6.23 – 18.33 meq/100g) also reflected baseline conditions.
- Emerson class ranged from 3b (dry aggregate slakes but does not disperse; remoulded soil partly disperses), or 5 (aggregate slakes but does not disperse, no dispersion of remoulded soil, soil: water suspension remains dispersed), indicating potential for minor dispersion of the clay fraction, particularly following repeated disturbance. All samples were classified as non-sodic (ESP < 6%).
- Variable concentrations of heavy metals, within the range of values typically encountered from surface soils within the region.

Mine Earth (2022) reported that native growth on the WRL surface was generally sparse but was present near all sampling locations (Appendix H). Minor limitations to rehabilitation success were identified for the topsoil spread on the Carina Extended WRL. The 'moderately saline' to 'extremely saline' classification of some samples may limit the growth of some native vegetation species and may be contributing to the relatively sparse vegetation establishment observed on the WRL (Mine Earth, 2022).

5.3.5.1.3 J4

BASELINE

Topsoil Material

Baseline soil sampling and assessment across the J4 project area was undertaken as described in SWC (2014b). Soil samples were analysed for physical, hydraulic, chemical and microbial properties and laboratory scale erosion tests were undertaken on three samples. Key results tables are provided in Appendix F-2 and summarised below and in Table 23.

Three distinct Soil Mapping Units (SMU) were defined at J4:

- SMU 1 - Skeletal Gravels present as a thin layer (10 – 20 cm in depth) along the J4 ridgeline,
- SMU 2 – Shallow - Deep Gravels present on the slopes and gradually increasing to a depth of 1 m with increasing distance downslope. Depth on the northern slopes is appreciably thicker indicating that they are more protected and experience less erosion than the southern slopes; and

- SMU 3 – Deep Alluvial Clays effectively forming the plains surrounding the outcropping BIF ridges throughout the Yilgarn (i.e., regionally extensive).

Waste Material

Pre-mining assessment of the suitability of waste materials as a potential growth medium determined that (SWC, 2014b):

- The pH of most of the waste materials to be mined would typically be slightly acidic to moderately alkaline, with an average pH of 6.37. This is similar to the surficial soils and was not considered to impact on revegetation growth. However, pH < 4 was measured for waste materials below 100 m and was considered likely have a negative impact on revegetation growth and establishment if encountered in the root zone of the vegetation.
- The salinity of the waste materials shows a wide variability, ranging from non-saline (< 20 mS/m) to extremely saline (> 500 mS/m), however the average salinity of all waste materials tested (465 samples) was 83 mS/m, which is considered moderately saline. As with the pH data, the regolith profile to 100 m depth, contains waste materials with optimal salinities (i.e., < 50 mS/m), whilst the elevated, potentially problematic saline materials generally occur below 100 m depth.

Post-mining assessment of the J4 WRL cover materials is discussed in Section 5.3.3.2.3 and has identified isolated areas of extreme salinity.

Soil and Vegetation Associations

The J4 baseline soil assessment included observations about soil type and vegetation as follows (SWC, 2014b):

- The SMU 1 soil type is generally ≤ 10 cm but in deeply weathered sections or fractured systems may extend to a depth of 1 m (Figure 30). These deeper sections are likely to control the distribution of large shrub and tree species on ridges. The vegetation will be restricted to small groundcovers and shrubs where the soils are thin.
- The SMU 1 soil type is associated with the dominant *Neurachne annularis* groundcover, suggesting that this species and others on the skeletal profile are shallow rooted and drought tolerant and a suitable candidate for revegetation.
- The thicker SMU 2 soil type enables the roots of larger vegetation (*Eucalyptus* and *Acacia* species) to explore laterally and access fractures in the ironstone, where there is a greater volume of stored soil moisture. The lateritic hardcap prevents the underlying weathered clays from drying (SWC, 2014b).
- The deeper, clayey SMU 3 soils are generally present on the flat plains, support overstorey of *Eucalyptus* sp., *Allocasuarina* sp., and *Acacia* sp., with an understory of mostly *Atriplex nummularia* (Old man saltbush). *N. annularis* is generally absent from SMU 3. It is generally considered that ants play a major role in removing leaf litter and debris before it has time to decompose and accumulate into the surface soils to form topsoil. The SMU 3 soils therefore remain relatively bare from leaf litter and are generally unprotected by gravel armouring (SWC, 2014b)

Table 23 Soil Mapping Unit Characteristics Summary for J4 (SWC, 2014b)

Material	Major Soil Group of WA	Australian Soil Classification	Description
SMU 1 – Skeletal Gravels	Shallow gravel	Ferric-Petroferric Tenosol	The skeletal gravelly soils (SMU 1) were characterised as follows (SWC, 2014b): - Gravel content of 28 – 52% (average 44%), with the soil matrix described as having a loamy sand texture dominated by sand-size particles (80%) and a silt + clay content of 20% resulting in good water retention properties and PAW contents of around 10%. However, the high gravel content significantly reduces the overall water retention properties of these soils, such that based on a 40% gravel content, the skeletal gravels will only contain 6% PAW (or 6 mm/10 cm). - Low to moderate bulk density (around 1.65 g/cm³) and high permeability (> 2 m/day). - The finer soil matrix slakes rapidly when wet (i.e., very poor macro-structural stability), and has moderate micro-structural stability (Emerson Class 5). - Moderately acidic to neutral with an average pH of 6.0, and non-saline with an average EC of 5.2 mS/m. - Nutrient poor with very low levels of mineralised N (NH₄-N + NO₃-N < 5 mg/kg) and Colwell P (< 5 mg/kg), and moderate levels of Colwell K (average 135.2 mg/kg) and Extractable S (average 6.9 mg/kg). - Low organic C content (< 1.5%) reflecting the lack of organic matter accumulation observed in the field. - Non-sodic (ESP < 6%) with low CEC (average 5.6 meq/100g), indicating that kaolinite is the dominant clay mineral. - Very low levels of Microbial Biomass Carbon (MBC), between 21 and 43 mg/kg, regardless of leaf litter cover or exposure to direct solar radiation.
SMU 2 – Shallow-Deep Gravels	Stony soil	Lithosolic Clastic Rudosol – Leptic Rudosol	The shallow – deep gravels (SMU 2) were characterised as follows (SWC, 2014b): - Representative of a depositional sequence, rather than a pedogenic profile. The surface gravel generally gets finer and more rounded with increasing distance downslope, and exists in a friable brown loamy matrix, with negligible pedogenic horizonation. The contact between the surficial gravels and the underlying Tertiary surface is abrupt. There is no topsoil development within SMU 2. - Gravel content varies between 24 – 69%, (average 42%), which is similar to SMU 1. Also, similarly to SMU 1, the soil matrix in the deeper gravels is classified as a loamy sand, with an average of 81% sand and a silt + clay content of 19.1%. This similarity between SMU 1 and 2 reflects that the gravels within SMU 2 were derived from SMU 1 and were eroded and subsequently deposited downslope. - Moderate bulk density (~1.65 g/cm³) and free draining with saturated hydraulic conductivity values in the order of 0.6 – 2.6 m/day. - As with the gravels in SMU 1, the finer matrix is macro-structurally unstable (i.e., slaking rapidly when rewet), but is considered non-dispersive with an Emerson Class of 5. - The finer soil matrix has good water holding capacity (i.e., field capacity – 10 kPa moisture contents of 36%) and corresponding moderate to high PAW contents of between 8 – 19% (average 12.3%). - pH is widely variable from 4.65 to 9.06 (average 6.58). pH > 8 reflect the presence of calcrete (or gypsum/dolomite) in these soils, whilst acidic pH values are a result of iron ferrolysis. - Non-saline, with average EC of 13.6 mS/m. The one elevated salinity result was considered to be an artefact of the analysis technique and not indicative of field conditions. - N exists in the form of mobile NO₃-N and has leached from the topsoils so that they are deficient in N as well as deficient in Colwell P (< 5 mg/kg) but have moderate levels of Colwell K (average 135.2 mg/kg) and Extractable S (average 6.9 mg/kg). - Very low organic C content (typically < 1.0%) reflecting the lack of organic matter accumulation observed in the field. - Generally non-sodic (ESP < 6%), although there is an increase in ESP with depth (i.e., > 70 cm). Low CEC values (average 9.0 meq/100g) indicated that kaolinite is the dominant clay mineral. - No microbial properties were assessed for this soil type, although given its similarity to the skeletal SMU 1 soils and lack of both organic C and organic matter, it was considered that the gravelly soils of SMU 2 would also be biologically infertile.
SMU 3 – Deep Alluvial Clays	Brown, non-cracking clay	Brown Dermosol	The ‘alluvial – clayey soils’ (SMU 3) were characterised as follows (SWC, 2014b): - A homogeneous reddish brown sandy loam, with no pedogenic horizonation or organisation, well structured, with a crumb ped morphology. Like SMU 2 no topsoil development has occurred. - Contained less gravel (average 15%) than SMU 1 and SMU 2 soils. The gravel has a predominately pisolithic shape (i.e., small < 5 mm diameter and well rounded) reflecting its transported history. The fine fraction (i.e., < 2 mm) was classified as a sandy loam to clay loam, with an average of 66% sand and 34% silt + clay. - High water holding capacity (i.e., around 40% at field capacity; 10 kPa) and PAW content (i.e., 13.2%), which are considered to be optimal soil physical properties to support plant growth. Despite the fine texture the soils have a moderate permeability (average 0.32 m/day). - Macro-structurally unstable (i.e., slaking rapidly when rewet) and some materials have dispersive tendencies (i.e., Emerson Class 2), with the clays remaining in suspension for a prolonged period. - pH is widely variable (pH 5.03 – 9.07). Higher pH reflects the influence of calcrete (or gypsum/dolomite) formation and lower pH may reflect ferrolysis of iron minerals. - Non-saline with an average EC of 17.86 mS/m. Elevated EC values were considered to be due to dissolution of soluble salts during EC measurement, and not indicative of field conditions. - Low N and Colwell P (< 5 mg/kg) but contain moderate levels of Colwell K (average 135.2 mg/kg) and Extractable S (average 6.9 mg/kg). - Very low organic C content (typically < 1.0%) reflecting the lack of organic matter accumulation observed in the field. - Sodic (average ESP of 8.7) and relatively high CEC (average 18.5 meq/100g; with a maximum of 32.3 meq/100g), indicating that reactive smectite is present in the clay mineral fraction of these materials. - Low levels of MBC (12 to 38 mg/kg) reflecting the very poor topsoil development in these soils, and therefore lack of food source to support soil microbes.

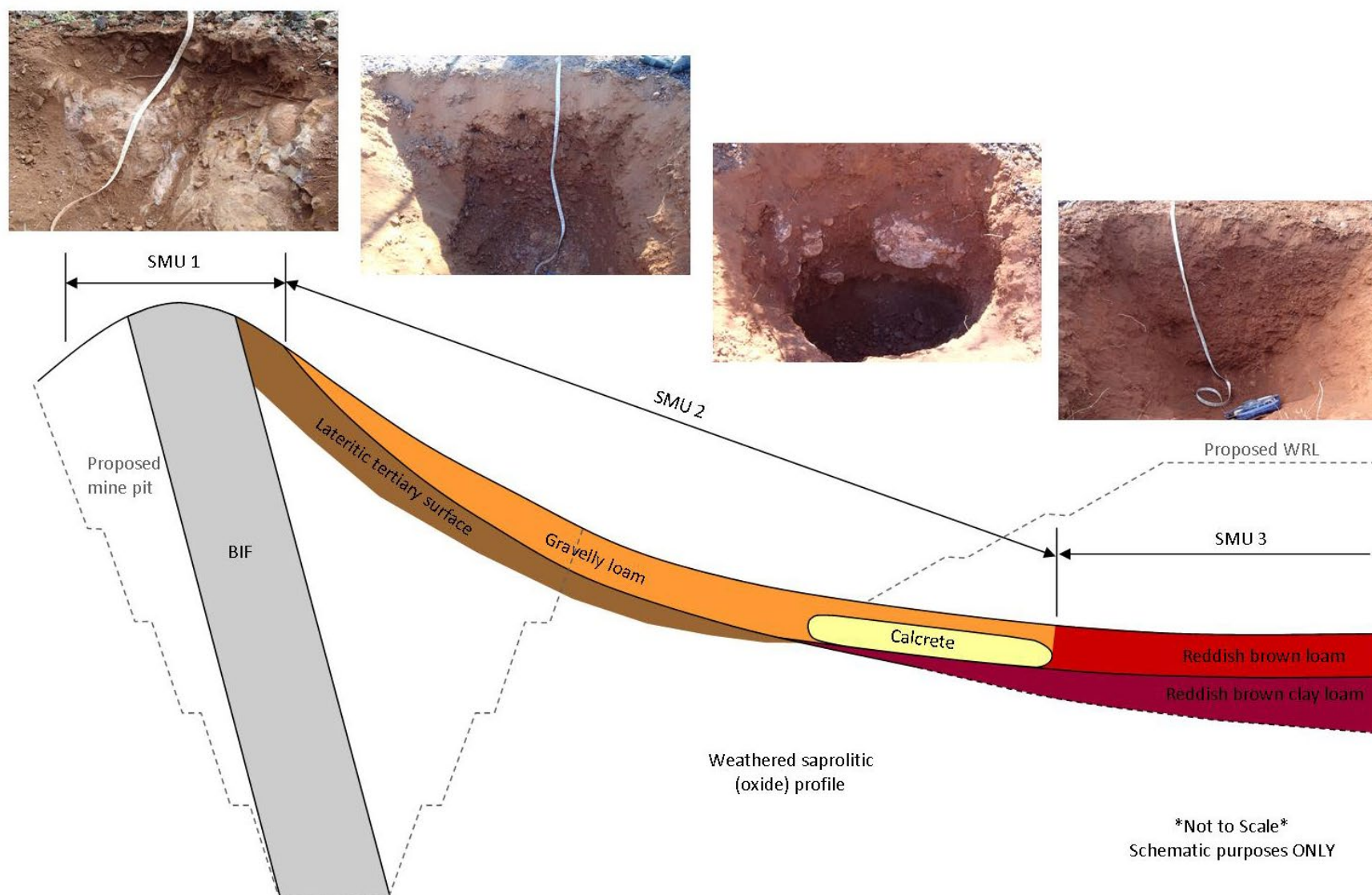


Figure 30 Schematic showing topographic sequence of soils at J4 (SWC, 2014b)

Post-Mining (STOCKPILED AND APPLIED TOPSOIL)

The soil units identified in the baseline studies were not formally segregated during stripping and storage of growth material at the J4 site (Astron, 2019b), and therefore the stockpiles will contain a blend of soil units. The stockpiles are still referred to as “topsoil” stockpiles per common practise.

Eighteen topsoil samples were collected from the J4 East area by Mine Earth (2022), including:

- seven from topsoil stockpiles present around the WRL crest.
- eight from stockpiles located to the south of the WRL.
- three from topsoil spread onto the batters of the lower lift on the southern and eastern faces of the WRL.

The analysis that was completed is provided in Table 22 and results are provided in Appendix F. Key findings are summarised below.

- Salinity in the stockpiled topsoil was variable ranging from non-saline (5 mS/m) to areas of extremely saline (447.3 mS/m). However, average salinity across the samples was moderately saline (46 mS/m) and was not considered by Mine Earth (2022) to be limiting to vegetation growth. Topsoil on the rehabilitated areas ranged from non to moderately saline (8 – 43.7 mS/m).
- The pH of the stockpiled topsoil ranged from neutral to moderately alkaline (pH 6.3 – 8.9) whilst the topsoil on the rehabilitated areas was consistently neutral (pH 6.5 – 6.8).
- Emerson class ranged from 3b (dry aggregate slakes but does not disperse; remoulded soil partly disperses), or 5 (aggregate slakes but does not disperse, no dispersion of remoulded soil, soil: water suspension remains dispersed), indicating potential for minor dispersion of the clay fraction, particularly following repeated disturbance. All samples were classified as non-sodic (ESP < 6%).
- Variable concentrations of heavy metals, within the range of values typically encountered from surface soils within the region.

No limitations were identified for use of the J4 East stockpiled topsoil or rehabilitated WRL surface soils as a surface rehabilitation material.

Sixteen samples were also collected from topsoil stockpiles located at the upper surfaces of the J4 West WRL. The topsoil at J4 West was generally less saline than the topsoil at J4 East and ranged from non-saline (10.3 mS/m) to moderately saline (71.7 mS/m) with an average that was slightly saline (23.1 mS/m). The soil ranged from neutral to strongly alkaline (pH 6.4 – 9.1) which is generally consistent, although slightly more alkaline, than the stockpiled soil at J4 East. No limitations were identified for use of the J4 West stockpiled topsoil as a surface rehabilitation material.

5.3.5.1.4 Aurora

BASELINE

The Aurora deposit is located in the Broad Valley landform unit (Dell, 1985) generally characterised by a calcareous B horizon with an intricate history of in situ weathering, colluvial, alluvial and aeolian action. The soils at the site were identified as a loose red sandy loam with some pisolites, which increased in concentration with depth (Marianna Partners, 1993).

Topsoil depth ranged from 300 mm to 400 mm in the four sites sampled Marianna Partners (1993). Soil pH was alkaline (8.87 – 9.49) and EC ranged from 26.9 – 1123 mS/m suggesting moderate to extreme salinity. EC was higher on the west side of the sampled area (average EC of 752 mS/m) than the east (average EC of 39.2 mS/m) Marianna Partners (1993).

5.3.5.2 Erosional Stability of Topsoil

5.3.5.2.1 Carina

Post-mining assessments of the Carina WRL surface materials identified that the topsoil is a relatively structurally stable reddish brown sandy loam, with minor to moderate gravel content (around 35%) and consistent clay contents (at around 15%). These surface soils are classified as stable due to the low ESP results and relatively high gravel content. The moderate salinity levels within the soil material cause aggregation and flocculation of the fine silt and clay particles, further enhancing stability. The topsoil cover is vulnerable to both surface sheet wash and rilling but is likely to be stable if sufficient surface stability features are in place (i.e., contour ripping) (SWC, 2017).

In contrast, Landloch (2023) assessed the growth covers at the rehabilitation trial as prone to structural instability based on the ESP-based criterion and ESI-based criterion (elevated ESP or low salinity), in addition to an appreciable clay fraction.

The results of erosion monitoring, carried out as part of the annual rehabilitation monitoring program are discussed in Section 5.9.3.2.

5.3.5.2.2 Carina Extended

Post-mining assessment of the applied and stockpiled topsoil materials at Carina Extended found (Mine Earth, 2022):

- Minor surface crusting and minor erosion of topsoil was evident at some sampling locations.
- Erosion of the surface soils at some sampling locations on the WRL, with rills and small gullies present where surface water flow has concentrated. The topsoil samples generally indicated a low potential for erodibility (high coarse fraction, low propensity for clay dispersion and 'moderately rapid' drainage classification), however the topsoil is susceptible to erosion where surface water control features are insufficient.

The results of erosion monitoring, carried out as part of the annual rehabilitation monitoring program are discussed in Section 5.9.3.2.

Erosional stability of waste rock material is discussed in Section 5.3.4.2.

5.3.5.2.3 J4

Water Erosion Prediction Project (WEPP) erosion modelling of the SMU 1 and SMU 2 topsoil types (see Table 23) at J4 was undertaken by SWC (2014b). The modelling reported sediment yields of < 1 mm soil loss per year for all material and slope configurations tested, indicating that all of the materials performed relatively well. The test work and results are described in more detail below.

Laboratory scale erosion tests were undertaken on three soil samples from J4: 'surficial gravel' (0 – 30 cm depth), surficial 'gravelly loam' (0 – 100 cm depth) and 'calcrete' (subsoil from 40 – 100 cm depth). The 'alluvial clayey' soils associated with SMU 3 were not directly tested because this soil type had been previously identified as structurally unstable, dispersive, and highly erodible and not suitable for use on the outer surface of the WRL (SWC, 2014b).

The soil parameters used in the WEPP model are provided in Table 24. Batter slopes were modelled assuming slope angles of 15° and 18°, and a lift height of 10 m to simulate conditions on the proposed post-mine landform. A lift height of 20 m was also modelled for the "Gravel" sample to demonstrate the effect of larger lift heights, which typically result in much higher erosion rates. The model assumed no vegetation or other surface cover (i.e., woody debris or plant litter).

Table 24 Key Soil Parameters used in the WEPP model at J4

Material ID	Sand (%)	Clay (%)	OM (%)	CEC (meq/100g)	K _{eff} (mm/hr)	K _i (kg s/m ⁴)	K _r (s/m)	TC (Pa)
'Gravel' (SMU 1)	78.4	12.4	1.07	5.3	20.7	1.9 x 10 ⁵	0.0011	4.9
'Gravelly loam' (SMU 2)	84.5	8.3	0.58	2.4	23.9	3.5 x 10 ⁵	0.0114	3.8
'Calcrete' (SMU 2)	78.5	6.9	0.28	25	8.0	2.8 x 10 ⁵	0.0004	4.9

Source: SWC (2014b)

Notes: K_{eff} = effective saturated hydraulic conductivity; K_i = interrill erodibility; K_r = rill erodibility; TC = critical shear stress

Results of the modelling (Table 25) indicated (SWC, 2014b):

- Average sediment yields of <15 t/ha/yr (< 1 mm soil loss per year) for the SMU 1 and SMU 2 material types and slope configurations tested, indicating that all of the materials performed relatively well.
- The "Gravel" material showed the highest resistance to erosion, producing only 5.6 t/ha/yr on slopes of up to 18°, where the lift height was 10 m.
- The gravelly loam and calcrete materials (SMU 2) also performed well, with predicted erosion rates of 9.9 and 5.9 t/ha/yr, respectively for an 18° slope and 10 m high lift.
- In contrast, the SMU 3 alluvial clay materials (based on testing for the nearby Yilgarn operations) at a slope of only 12° are expected to yield 27 t/ha/yr, with this increasing to 38 t/ha/yr at a slope angle of 18° for a 10 m lift (i.e., highly erodible).

Table 25 Summary of WEPP Erosion Modelling Results for J4

Material ID	Lift height (m)	Slope angle	Average annual run-off (mm/yr)	Average erosion rate (mm/yr)	Average erosion rate (t/ha/yr)
'Gravel' (SMU 1)	10	15°	8	0.3	5.6
		18°	8	0.3	5.6
	20	15°	8	0.5	8.2
		18°	8	0.5	8.2
'Gravelly loam' (SMU 2)	10	15°	6	0.5	8.4
		18°	6	0.6	9.9
'Calcrete' (SMU 2)	10	15°	19	0.4	5.9
		18°	19	0.4	5.9
'Alluvial clay' (SMU 3)	10	12°	40	1.7	27
		15°	42	2.1	33
		18°	60	2.4	38

Source: SWC (2014b)

SWC (2014b) note that, under baseline conditions, the stability of the surface soils is controlled and minimised by the following factors:

- Gravelly soils associated with SMU 1 and SMU 2 are self-armouring that results in a final land surface with a high surface roughness, limiting lateral movement of surface water and encouraging vertical infiltration into the profile.
- *Neurachne annularis* forms a patchwork groundcover on contour of the gravelly slopes of SMU 2 (and sometimes on the finer texture surface of SMU 3), which decreases the effective slope length and overall velocity of any surface flows.
- Cryptogam cover on the surface soils in SMU 3 (in the absence of both gravels and *Neurachne annularis* groundcover), which bind surface particles together and essentially form a continuous crust of the surface. This cover decreases infiltration and increases surface run-off, however, will also limit the detachment of surface soil particles and erosion and sediment loss. In the absence of, or when the cryptogam crust is damaged, the surface soils in SMU 3 are highly erodible and etch appreciably.

Post-mining assessment of the applied and stockpiled topsoil materials at J4 concluded (Mine Earth, 2022):

- Gully erosion was observed on the topsoiled lower batters of the southern and eastern J4 East WRL slopes (Section 5.9.3.2), however the lack of contour ripping likely resulted in concentrated water flow over the topsoil surface and increased erosion rates. The relatively high coarse fraction, minor potential for clay dispersion, low sodicity and moderate to rapid drainage classification indicates a relatively low erodibility, provided that concentrated surface water flow on the rehabilitated slopes is minimised.
- Minor surface crusting and erosion of stockpiled topsoil at J4 West was evident on some stockpiles. Similar to J4 East WRL, the materials are generally of low erodibility, provided the concentration of surface water flow on the rehabilitated surfaces is minimised.

Erosional stability of waste rock material is discussed in Section 5.3.4.3.

Rehabilitation monitoring, including assessment of erosion is yet to commence at J4.

5.3.5.2.4 Aurora

Post-mining assessment of the performance of the Aurora WRL found the degree of erosion observed, despite the low slope angle and height of the WRL, suggests that waste material and cover soil is not resistant to erosion, and vegetation is insufficient to provide additional erosion resistance on slopes (Okane Consultants, 2022a).

No materials characterisation data are available for a detailed analysis of erosion characteristics.

5.3.5.3 Topsoil Volume and Reconciliation

A reconciliation of stockpiled topsoil using a combination of GIS data, aerial imagery, survey and ground-truthing was completed in 2021 (Ecotec, 2022). The ground-truthing included an assessment of topsoil condition (Appendix F-3).

Topsoil requirements have been calculated from the 2023 MRF data and the latest landform designs.

The resultant topsoil balance for the Carina Operations is presented in Table 26 and indicates an overall topsoil deficit in the order of 0.6 Mm³ assuming topsoil is spread to depth of 200 mm on WRLs and 100 mm on flat areas. Subject to monitoring results, topsoil may be spread at depth of 50 – 100 mm on flat areas (Astron, 2019b) reducing this topsoil deficit. Consideration will also be given to Landloch (2023) recommendation that the minimum soil thickness (100 mm) of the ideal range (100 – 300 mm) should be targeted on WRLs to allow a greater surface area to be covered whilst achieving a similar species diversity to 300 mm thickness (Section 5.9.6.2). The topsoil balance will also be refined further to

account for significant amounts of topsoil currently stockpiled on WRLs that may not have been accounted for in the 2021 topsoil reconciliation, nor appear on MRF disturbance area maps as 'topsoil stockpiles' because the underlying domain is 'waste rock landform'. There is also topsoil stockpiled at the Carina Southern Operations that may not have been captured by MRF mapping data.

Table 26 Topsoil Balance

Domain		Topsoil Required¹ (m³)	Topsoil Available (m³)			Surplus / Deficit (m³) (excluding poor quality)
			Good to Excellent	Moderate-good to Moderate	Poor	
Carina & Haul Road	WRLs areas yet to be topsoiled³	82,488	114,774	20,445	1,070	
	Infrastructure⁴	424,260				
	Total	506,948	135,219		-	
J4 & Haul Road	WRLs areas yet to be topsoiled³	308,696	289,136	112,032	0	
	Backfilled J4 West Pit	17,300				
	New clearing for J4 East redevelopment	36,500				
	Infrastructure⁴	252,030				
	Total	614,526	401,168		0	- 213,358
Aurora	WRL area yet to be topsoiled³	2,256				
	Infrastructure⁴	601				
	Total	2,857	0		0	
TOTAL						- 0.6 million

Source: Ecotec (2022); MRF Data 2023, MinRes

Notes: ¹Topsoil is assumed to be placed at a depth of 200 mm on slopes and 100 mm on flat areas including J4 West Pit backfill (100 mm).²Poor condition classification based on age, compaction, weeds, salinity. Deficit assumes poor topsoil is not used. Further assessment (testing) required to ascertain whether the topsoil can be used during rehabilitation.³The area of WRL is based on the 2D footprint area.⁴The area disturbed by infrastructure excludes exploration disturbance and includes Low Grade stockpiles (assuming removed and footprint rehabilitated).

5.3.5.4 Considerations for Closure

Topsoil Balance

Reconciliation of available topsoil against current disturbance areas indicates a significant topsoil deficit.

J4 Soils

No major limitations for use as a surface rehabilitation material were identified for the J4 East or West stockpiled topsoil or spread topsoils, provided the concentration of surface water flow on the rehabilitated surfaces is minimised (Mine Earth, 2022). These conclusions were based on shallow grab samples. Subsequent test-pitting to a depth of 5 m has identified some areas of high salinity on the J4 WRLs as discussed in Section 5.3.3.2. Local salt tolerant species will be considered for rehabilitation of these areas as discussed in Section 5.9.5.2).

Baseline studies and materials characterisation (Section 5.3.3) indicate that, where topsoil stripping / placement and waste placement is yet to occur:

- The gravelly topsoils in SMU 1 and the topsoil and subsoil in SMU 2 exhibit optimal properties for use in rehabilitation (i.e., friable and structurally stable). The topsoils and subsoils in SMU 3 are sodic (i.e., structurally unstable and dispersive) and therefore unsuitable as an outer waste dump capping.
- Waste rock material with adverse chemical properties should not be placed within the potential root zone of the revegetation species.
- The water holding and plant available water capacity of the deeper waste rock materials (i.e., to 100 m depth) has not been determined (SWC, 2014b).
- Seeding will be required.

Carina Soils

Based on assessment of soil and waste materials already placed on the WRL:

- Contour ripping, which exposes gravel and rock material that provide armouring, and controlled amounts of vegetation debris would assist in creating a stable waste rock landform surface.
- Low infiltration of surface water caused by compaction and lack of contour ripping may be contributing to elevated salinity levels measured on plateau areas that are yet to be rehabilitated.
- Salinity levels of spread topsoil (3 locations sampled) are considered high and, subject to further assessment, may require selection of more saline-tolerant taxa within the seed mix.

Stockpiled topsoil materials were found to be slightly to extremely saline and should be tested prior to use.

Carina Extended Soils

The 'moderately saline' to 'extremely saline' topsoils identified on some areas of the Carina Extended WRL may be contributing to the relatively sparse vegetation establishment observed (Mine Earth, 2022).

The topsoils show relatively low potential for erodibility provided surface water controls are sufficient.

Aurora

No post-mining soils characterisation data is available for the Aurora site.

5.3.5.5 Knowledge Gaps & Forward Work Program

The following actions are proposed to address soils and growth media knowledge gaps:

- Undertake additional soil characterisation to further refine soil conditions in reference sites.

- Complete gap analysis to determine if materials characterisation of cover materials is sufficient to inform selection of the reference ecosystem.
- Develop and implement WRL rectification plans where necessary to manage surface water run-off from the WRLs.
- Topsoil will be salvaged prior to any WRL rectification works.
- Refine the topsoil balance to account for topsoil currently stockpiled on WRLs, material stockpiled at the Carina Southern Operations and J4 East Redevelopment works.
- Investigate alternative growth media where a topsoil deficit remains.

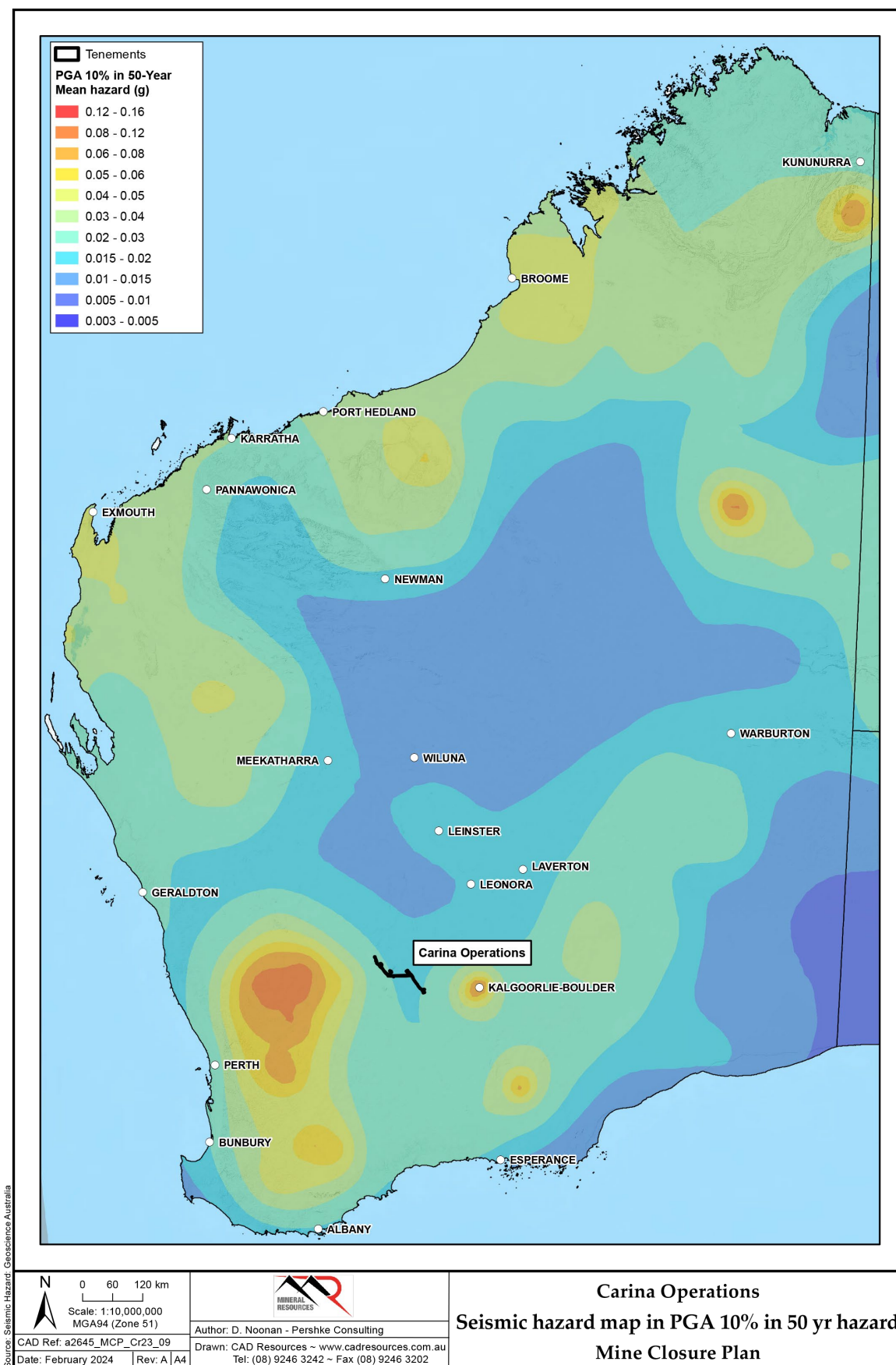
5.4 Seismicity and Stability

Key Points

- The potential Zone of Instability (ZOI) is used to identify long term risks associated with failure of pit walls, including interaction with adjacent landforms.
 - All WRLs are currently outside the ZOI.
 - Assessment of the J4 East WRL and abandonment bund interaction with the ZOI at the completion of mining will inform any requirement for remedial works prior to closure.
 - Some minor encroachment of the Carina abandonment bund into the ZOI of the Carina Pit (based on conservative methodology) has been identified and further assessment is required to determine if remedial works will be required at this location.
 - The Aurora abandonment bund is predominantly within the ZOI and will require relocation.
- Global stability assessments will be completed to support the 'safe and stable' closure objective.

5.4.1 Seismicity

The Carina Operations lie in a low-seismic hazard zone with a Peak Ground Acceleration (PGA) of approximately 0.015 to 0.03 g for a 10% probability of exceedance in a 50-year period (Figure 31). This equates to a 1:500 AEP.



Refer to Appendix J for pdf version

Figure 31 Carina Operations Seismic Hazard Map

ENV-TS-RP-0617

5.4.2 Landform Stability

5.4.2.1 Landform Encroachment on the ZOI

To determine the potential zone of instability (ZOI) around the pit shells, the methodology outlined in *Safety Bund Walls Around Abandoned Open Pit Mines Guideline*, Department of Industry and Resources, December 1997 (DOIR, 1997) has been utilised as follows:

- The area of potential instability of open pit walls is represented by a wedge of rock mass material termed the potentially unstable rock mass. The abandonment bund (or other landforms) must be constructed outside the area designated as the potentially unstable pit edge zone or zone of instability, plus a 10 m offset at the crest. This methodology is based on case history observations from WA gold mines that suggest that the maximum area of potentially unstable rock mass for failure through each class of rock can be defined by two separate design angles:
 - 25° for weathered rock; and
 - 45° for unweathered (fresh) rock.

This is a very conservative assessment. For the Carina Operations the pit shell rock condition has not been confirmed and a weathered rock state has been assumed to represent the worst-case scenario, adding further conservatism to the assessment.

The ZOIs for the Carina and Aurora pits based on this methodology (including the 10 m offset) are presented in Figure 32. In summary:

- The Carina and Carina Extended WRLs lie outside the weathered rock ZOI + 10 m offset boundary.
- A portion of the Carina abandonment bund lies within the weathered rock ZOI + 10 m offset boundary. An updated projection is required based on the actual base of weathering for the Carina Pit shell to determine if remediation is required (Okane Consultants, 2022a). The Carina abandonment bund is currently incomplete to allow machinery access for closure works (Astron, 2019b).
- The Aurora abandonment bund is inside the ZOI + 10 m offset boundary.

The Aurora WRL is located some distance from the Aurora Pit and well outside the ZOI + 10 m offset boundary (and not shown in Figure 32).

The J4 East Pit is currently being extended. If the final ZOI, as a result of the ongoing development of the J4 East Pit, has the potential to impact on the J4 East WRL, remedial earthworks will be required prior to closure. The abandonment bund location will comply with the DOIR (1997) requirements and remain within the approved disturbance boundary for the J4 site (MinRes, 2023b).

The J4 West Pit will be backfilled to surface and therefore there will be no ZOI issues impacting the J4 West WRL or the heritage site within the vicinity of the pit (refer Section 5.8.1). Backfill also removes the requirement for an abandonment bund.

5.4.2.2 Global Stability of Landforms

Global stability assessment of the Carina Operations WRLs is yet to be completed to demonstrate that WRLs meet a Factor of Safety (FOS) ≥ 1.5 .

5.4.3 Considerations for Closure

The potential ZOI is used to identify long term risks associated with failure of pit walls, including interaction with adjacent landforms or sensitive receptors.

- All WRLs are currently outside the ZOI. Assessment of the J4 East ZOI at the completion of mining will inform any requirement for remedial works on the J4 East WRL prior to closure and location of the abandonment bund.
- Some minor encroachment of the Carina abandonment bund into the ZOI of the Carina Pit (based on conservative assessment) has been identified and further assessment is required to determine if remedial works will be needed at this location.
- The Aurora abandonment bund is predominantly within the ZOI and will require relocation.
- Backfill of J4 West WRL negates requirement for further assessment of potential ZOI impacts on the J4 West WRL or the heritage site in the vicinity.

Global stability assessments will support the 'safe and stable' closure objective and ultimately any application for relinquishment of the tenements.

5.4.4 Knowledge Gaps & Forward Work Program

The following actions are planned to address knowledge gaps relating to landform stability:

- Complete global stability assessment for the Carina Operations WLRs to demonstrate that $FOS \geq 1.5$ is achieved.
- Complete an updated ZOI projection, based on the actual base of weathering, for the Carina Pit shell to determine if relocation of the NE portion of the abandonment bund is required.
- Design Aurora Pit abandonment bund to be located outside ZOI of Aurora Pit.
- Utilise post-mining ZOI assessment of J4 Pit to inform abandonment bund location and any requirement for remedial works on the J4 East WRL.
- Incorporate plans of abandonment bund locations in the next revision of the MCP.

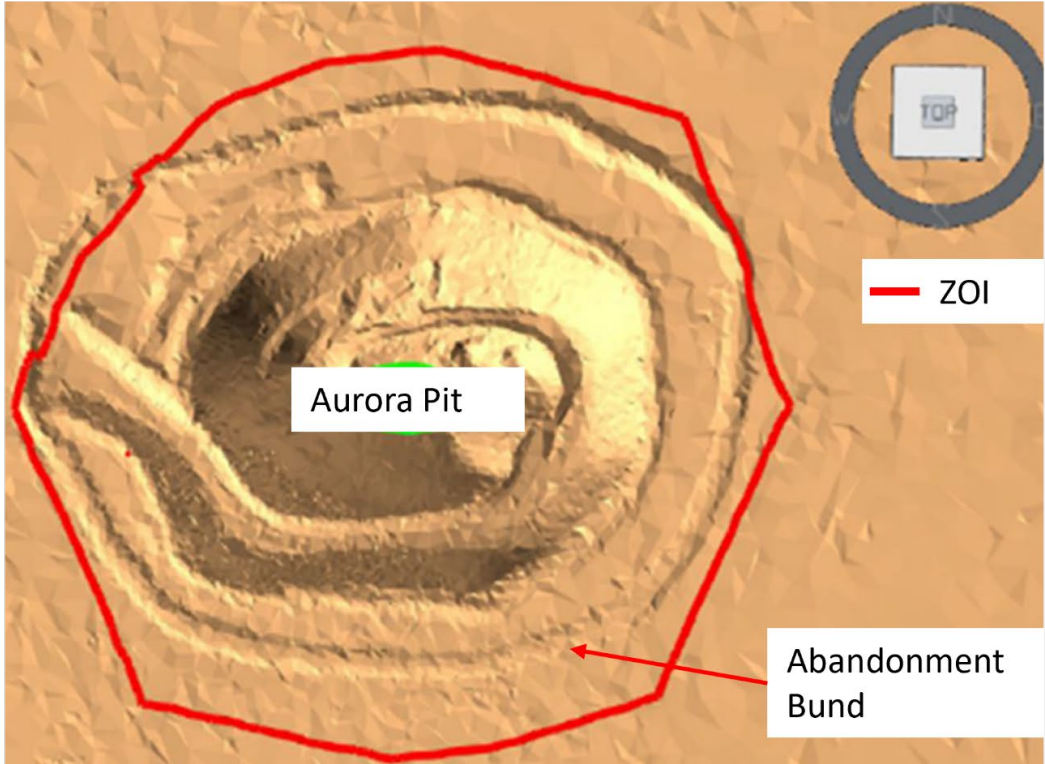
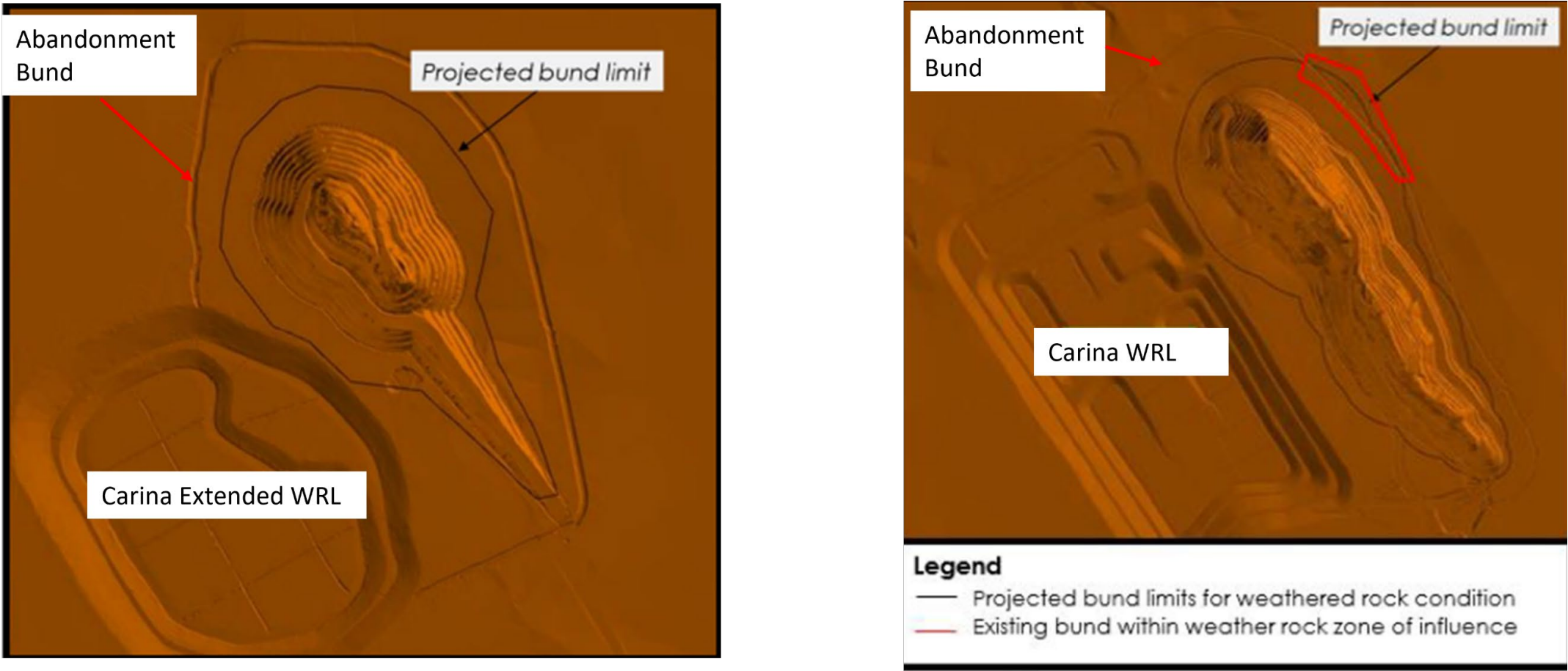


Figure 32 Zone of Instability and Abandonment Bund Locations – Carina and Aurora (Okane Consultants, 2022a; 2022b)

5.5 Biodiversity

Key Points

- The Carina Operations occur within a sub-region that is characterised by high species and ecosystem diversity, as it is a biogeographic interzone between the Coolgardie and Murchison biogeographic regions. This is reflected by the following findings of vegetation and flora surveys:
 - o Vegetation communities S2 and W22 at the Carina site are considered to have locally restricted distribution and clearing limits have been established as conditions of MS852 and MS 957.
 - o The dominant vegetation communities of the region are a mixture of diverse *Eucalyptus* woodlands and scrub communities.
 - o No Threatened flora under the BC Act or EPBC Act have been recorded at the Carina Operations, but twenty-nine species currently recognised by DBCA as Priority flora have been recorded.
 - o There are ten Priority Ecological Communities (PEC) within 50 km of the Carina Operations. The Carina site and eastern end of the J4 haul road intersect the Finnerty Range / Mt Dimer / Yendilberin Hills vegetation assemblages (BIF) PEC but mapped vegetation units do not match the PEC. The J4 site falls within the Mt Jackson Range vegetation assemblages (BIF) PEC and eight of the vegetation communities mapped were considered to represent occurrences of this PEC.
 - o Baseline flora and vegetation data for the Aurora site are limited, but the dominant vegetation community is equivalent to the well described W2 vegetation mapping unit at Carina / Carina Extended. Three Priority flora species were recorded during an assessment of the former camp site area.
- Baseline weed richness and abundance at the Carina Operations was generally very low, most weeds being associated with access tracks and former pastoral and exploration activities. MS 852 requires that no new weed species are introduced into the Carina project area and that the extent of weed cover shall not exceed that identified in the baseline survey (or on nearby comparable land), whichever is less. New weed species have been observed during operational and rehabilitation monitoring. Weed control has proven effective over some assessment periods but requires sustained effort.
- Carina and J4 operations are outside the known occurrence of plant pathogen *Phytophthora cinnamomi* (Dieback), and this species has not been detected during operational monitoring. Three species of *Phytophthora* have been identified across the site, but they are believed to be native plant pathogens and are not subject to the National Threat Abatement Plan for *P. cinnamomi* or either of the DBCA management documents (DBCA, 2015; 2020). Precautionary management procedures are proposed for the operations phase will be applied to closure as relevant.
- Carina Operations straddle a transition zone from the mainly *Acacia*-dominated shrublands of the arid interior to the *Eucalyptus* woodlands and forests of the wetter, more predictable rainfall areas of the South-west, resulting in a very diverse range of species. In addition to the high floristic diversity noted above, this is also reflected in high fauna diversity reported for Carina, Carina Extended, J4 and J4 Haul Road.
 - o Desktop surveys note some 241 fauna species may occur at Carina / Carina Extended, with 389 species occurring within a 35 km radius of the J4 area. Approximately half of the expected assemblage were recorded during field surveys.
 - o Four species were recorded or have a high chance of occurrence at Carina and although not currently listed as Threatened or Priority fauna, may be of local conservation significance due to their association with BIF outcropping.
 - o One State and Federally listed Threatened fauna species, Malleefowl (*Leipoa ocellata*), has been recorded (through observations of mounds / scats) that will require continued consideration into the closure phase as discussed in Section 9.1.6.
 - o The Carina Operations areas are not of significance for Short Range Endemic (SRE) fauna, nor subterranean fauna. It was considered likely that the high level of short-range endemism identified in the

J4 impact area (40 potential SRE) was to a large part due to the low taxonomic resolution achievable due to the lack of mature males in the sample

- Monitoring is required to demonstrate that water within pit lakes does not:
 - Result in an increase in introduced fauna to a level that may have a measurable impact on conservation significant flora and vegetation or conservation significant fauna species.
 - Directly impact native fauna that uses it as a water source.

There are no known GDEs within the Carina Operations area, but generic mapping (BOM, 2024) identifies some areas with high potential for aquatic GDEs that appear to be associated with playa lake systems. One of these occurs in the vicinity of the Carina site and its nature and status need to be confirmed.

The Carina PEMP is implemented to manage flora, vegetation and fauna factors throughout operations and relevant aspects will remain as closure management requirements during the post-closure monitoring and management phase.

5.5.1 Flora and Vegetation

The Carina Operations are located within the Coolgardie Botanical District as defined by Beard (1972) which corresponds with the Southern Cross sub-region of the Coolgardie bioregion. This sub-region is characterised by high species and ecosystem diversity, as it is a biogeographic interzone between the Coolgardie and Murchison biogeographic regions (Cowan, 2001). This sub-region is characterised by diverse eucalypt woodlands (*Eucalyptus salmonophloia*, *E. salubris*, *E. transcontinentalis*, *E. longicornis*), with scattered chains of salt lakes supporting samphire communities. Granite basement outcrops support swards of *Borya constricta* with stands of *Acacia* and *Eucalyptus* on deeper adjacent soils. Mallees and scrub heaths occur on the upland areas of sandplains, gravelly sandplains, and laterite breakaways, and other areas of sand lower in the landscape. Scrub heath vegetation harbours diverse communities dominated by *Acacia* and Myrtaceae (Cowan, 2001).

Beard (1972) originally described the major vegetation formations of the area, and characterises several vegetation units in the region including: *Acacia* thickets on sandplains, *Acacia* thickets on ironstone, *Acacia* scrub on granite, *Acacia* scrub with saltbush understorey, Mulga low woodland, Sclerophyll woodland and Shrub steppe. These units are covered within two main vegetation systems: the Bungalbin system (vegetation on the ironstone outcrops, including the Bungalbin hills) and the Jackson system, representing a greater part of the landscape mostly comprising dissected sandplains (Beard, 1972) (Mattiske Consulting, 2008a).

The region is botanically significant, supporting high floristic diversity including numerous endemic plant species, including many which exhibit restricted and highly localised distribution. Native flora exhibit adaptation to the arid environment and often unpredictable rainfall patterns, and rates of endemism likely reflect the anomalous geology of the region with isolated elevated ironstone outcrops representing centres of diversity and endemism among the discontinuous series of sandplains, alkaline clay-loams, and salt lakes that are typical of this part of the Archaean Yilgarn Craton and typically support less diverse vegetation assemblages (Payne A.L., 1998; Cross A. a., 2021a).

Flora and vegetation surveys completed across the Carina Operations include:

- Carina Northern and Carina Southern Operations
 - Mattiske Consulting (2008a) Flora and Vegetation of the Carina Exploration Lease Area.
 - Mattiske Consulting (2008b) Flora and Vegetation of the Proposed Carina Transport Route.
 - Mattiske Consulting (2009a) Flora and Vegetation Survey of the Proposed Carina Transport Route Carina Mine to Mount Walton Road Siding Preliminary Report.

- Mattiske Consulting (2009b) Declared Rare and Priority Flora Survey (M77/1244A).
- Read (2010) Carina Iron Ore Project: Mt Walton Siding Vegetation.
- Mattiske Consulting (2010) Flora and Vegetation Survey for the Proposed Carina Mine Rail Siding.
- Mattiske Consulting (2011b) Flora and Vegetation Survey for the Proposed East Jaurdi Aerodrome.
- Mattiske Consulting (2011a) Flora and Vegetation Survey (Infill) Carina and Chameleon Prospects Tenements E77/1275, E77/946 & E77/3946-1.
- Mattiske Consulting (2012a) Threatened and Priority Flora Survey Tenement M77/580 Proposed Exploration Camp Interim Report
- Mattiske Consulting (2012b) Threatened and Priority Flora Survey. Tenement M77/1261A: Carina Extended
- Mattiske Consulting (2012c) Review of Flora in Tenements E77/1115 & M77/1244 Carina Exploration and Mine Tenements Vegetation Communities W2, W4 and W15.
- Jackson 4
 - Ecologia (2013a) J4 Mine and Haul Road Flora and Vegetation Assessment.
- Aurora
 - Marianna Partners (1993) Pre-mining Environmental Review of the Existing Environment at the Bungalbin Hill Prospect.

The results of these surveys are summarised in the following sections. Given the age of many of these surveys, taxonomic or species range revisions will have occurred that have not been addressed in this MCP (other than to update the nomenclature and status of significant flora species). MinRes will employ subject matter experts to review baseline information when used to inform closure activities such as definition of reference ecosystems and development of associated seed mixes. Vegetation maps from the original studies are available from the referenced surveys included in Appendix C.

If additional disturbance is required to implement closure plans, baseline studies will be reviewed, and additional surveys undertaken as required (refer to Section 9.1.6).

MinRes also undertakes annual vegetation condition monitoring, rehabilitation monitoring and weed control programs to satisfy the Ministerial Statements 852, 957 and 988 (Section 3.3). Significant flora and weed species identified during these monitoring and management programs are included in Section 5.5.1.2 and Section 5.5.1.4.

5.5.1.1 Vegetation Associations

5.5.1.1.1 Carina Northern Operations (Carina and Carina Extended)

Eleven vegetation communities have been mapped across the Carina and Carina Extended project areas (Mattiske Consulting, 2008a; 2011a), with dominant vegetation assemblages including:

- The W2 Eucalypt Woodland of *Eucalyptus salmonophloia* with *Eucalyptus ravida* and mixed *Eucalyptus* over *Eremophila ionantha*, *Exocarpos aphyllus*, *Atriplex nummularia*, *Acacia colletioides*, and *Atriplex vesicaria* occurring on the deeper more fertile clay soils on the flats; and
- The W22 Open Low Woodland of *Eucalyptus corrugata* with mixed *Eucalyptus* over *Allocasuarina campestris* and *Acacia burkittii* over *Alyxia buxifolia*, *Philotheca brucei* subsp. *brucei* and *Isopogon gardneri*, *Scaevola spinescens*, and *Olearia muelleri* on red-brown clays soils on mid and lower slopes.

During EPA assessment of the Carina and Carina Extended Project it was determined that vegetation types S2 and W22 had locally restricted distribution and the following approval condition was applied (MS 852 & MS 957):

- Condition 5 -1 The proponent shall implement the proposal so that it does not adversely affect vegetation, in particular S2 and W22 vegetation communities, outside the proposal boundary as shown in Figure 2 and delineated by Map Grid of Australia (MGA) co-ordinates listed in Schedule 2. [Attachment 3 to MS 852 restricts vegetation clearing of “up to 89.5 ha of W22 vegetation community and up to 8.6 ha of the S2 vegetation community” and replaces Schedule 1, Schedule 2, Attachment 1 & 2 of MS 852.

Baseline vegetation condition was classified as excellent to pristine (Mattiske Consulting, 2011a).

5.5.1.1.2 Carina Haul Route

Twenty-one plant communities were mapped across the Carina Haul Route, divided into two broad groups (Mattiske Consulting, 2009a):

- Sclerophyllous *Eucalyptus* woodland dominated by *Eucalyptus salmonophloia* and *Eucalyptus salubris*, over an understorey dominated by species of *Acacia*, *Eremophila*, and *Atriplex*.
- Scrub communities with overstorey often comprising species of *Allocasuarina*, *Acacia*, and *Callitris preissii*, with diverse shrubs species including numerous Proteaceae and Myrtaceae (dominant throughout the southern section of the proposed transport route on sandy soils).

5.5.1.1.3 Carina Southern Operations (Mt Walton Siding, Carina Camp, and East Jaurdi Aerodrome)

Ten vegetation communities were mapped across the Mt Walton siding area and two across the Carina Camp area (Mattiske Consulting, 2009a; 2010) as follows:

- S9 Low scrub of *Melaleuca acuminata* and *Melaleuca eleuterostachya* over *Triodia desertorum* and mixed herbs on brown sandy clay soil on seasonally wet depressions.
- S10 Scrub of *Callitris preissii* and *Melaleuca nematophylla* with emergent *Eucalyptus leptopoda* subsp. *subluta* over *Leptospermum fastigiatum*, *Beaufortia interstans*, *Leucopogon hamulosus*, *Grevillea acacioides*, *Calytrix creswellii* (P3) and mixed shrubs over *Triodia ?desertorum* on yellow sandy soils on lower to mid-slopes.
- S11 Scrub of *Acacia resinimarginea*, *Callitris preissii*, *Eucalyptus pileata* and mixed *Allocasuarina* species over *Melaleuca hamata* and *Leptospermum fastigiatum* over *Baeckea* sp. Mt Clara (R.J. Cranfield 11693) and mixed shrubs on lateritic yellow sandy soils on mid to upper slopes.
- S12(b) Scrub (fire disturbed) of *Allocasuarina corniculata*, mixed *Banksia* and *Eucalyptus* species with emergent *Callitris preissii* over *Melaleuca cordata*, *Grevillea didymobotrya* subsp. *didymobotrya* and mixed shrubs over *Triodia desertorum* and occasional *Lepidobolus preissianus* subsp. *volubilis* and *Schoenus hexandrus* on yellow sandy soils on gently undulating plains.
- S30 Open low woodland to low woodland of *Eucalyptus horistes* and *Eucalyptus leptopoda* subsp. *subluta* over occasional *Callitris preissii* and *Allocasuarina spinosissima* over *Beyeria brevifolia*, *Beyeria sulcata*, *Leucopogon* sp. Coolgardie (M. Hislop & F. Hort MH 3197) and mixed shrubs over *Triodia scariosa* on yellow sandy soils on flats.
- S31 Mosaic of open scrub to scrub of *Acacia resinimarginea*, *Callitris preissii* and occasional *Allocasuarina spinosissima* with occasional emergent *Eucalyptus horistes* and *Eucalyptus leptopoda* subsp. *subluta* over *Leptospermum fastigiatum* and *Melaleuca hamata* over *Phebalium canaliculatum*, *Phebalium filifolium*, *Micromyrtus monotaxis* and mixed shrubs over *Triodia scariosa* on lateritic yellow sandy soils on lower to mid-slopes.

- S32 Scrub of *Acacia resinimarginea* with occasional *Callitris preissii* and occasional emergent *Eucalyptus leptopoda* subsp. *subluta* over *Leptospermum fastigiatum*, *Melaleuca hamata*, *Phebalium canaliculatum*, *Phebalium filifolium* and mixed shrubs on lateritic yellow sandy soils on flats and lower slopes.
- S33 Hummock grassland of *Triodia scariosa* with emergent *Prostanthera semiteres* subsp. *semiteres* on coarse yellow-white sandy soils in seasonally wet depressions.
- W29 Low woodland of *Eucalyptus ?comitae-vallis*, *Eucalyptus horistes* and *Callitris preissii* over *Melaleuca hamata* over mixed shrubs over *Triodia scariosa* and *Triodia ?desertorum* on yellow sandy soils on flats.
- W45 Low woodland of *Eucalyptus horistes* and *Eucalyptus oleosa* subsp. *oleosa* with occasional *Callitris preissii* over mixed shrubs over *Triodia scariosa* on yellow sandy soils on flats.
- W45(b) Low woodland (burnt) of *Eucalyptus horistes* and *Eucalyptus oleosa* subsp. *oleosa* with occasional *Callitris preissii* over mixed shrubs over *Triodia scariosa* on yellow sandy soils on flats.

Mattiske Consulting (2011b) surveyed the East Jaurdi Aerodrome tenements and identified 45 species within vegetation communities described as typical of the area as reported in previous assessments (Mattiske Consulting, 2009a; 2010). The vegetation communities were not listed or mapped.

5.5.1.1.4 J4

Thirty vegetation communities were mapped across the J4 and haul road baseline study area (Ecologia, 2013a), 28 of which were within the disturbance envelope (Polaris Metals, 2015). Twenty-nine of the 30 vegetation units were found to be associated with Priority Flora (Section 5.5.1.2). Eight of the vegetation communities were considered components of the Priority 1 Mount Jackson Range vegetation complexes (banded ironstone formation) PEC (Section 5.5.1.3).

The vegetation communities at J4 (Figure 33) can be grouped into four floristic groups described as follows (Ecologia, 2013a):

- Rocky midslopes / ridgetops (RMR) – vegetation associated with the hilltops, midslopes and footslopes of the BIF ranges in the study area, with a strong presence of *Neurachne annularis* in the ground stratum and *Eucalyptus* species and *Grevillea georgeana* also dominant. The exception to this pattern is RMR5A communities which are located on low rises scattered widely through the plains but are clustered with the BIF range quadrats due to the dominance of *Neurachne annularis*. Three of these RMR vegetation units support eight of the fourteen priority flora recorded during the survey.
- Sandy floodplains (SP) and Red sandy/gravelly plains (SGP) - primarily located on the flats, floodplains and creek lines in the study area, with open *Eucalyptus* woodland over chenopods such as *Atriplex vesicaria* and other low shrubs.
- Yellow sandplains (YS) - dense shrublands rich in myrtaceous species frequently growing with various *Allocasuarina* species and *Phebalium canaliculatum*. These vegetation units are typically located on the flat plains with deep orange-yellow sandy soils.

Species richness within the J4 vegetation units ranged from 29 to 6.3 species per 400 m² quadrat. The median species richness observed amongst all vegetation units was 13.8 species per 400 m² quadrat.

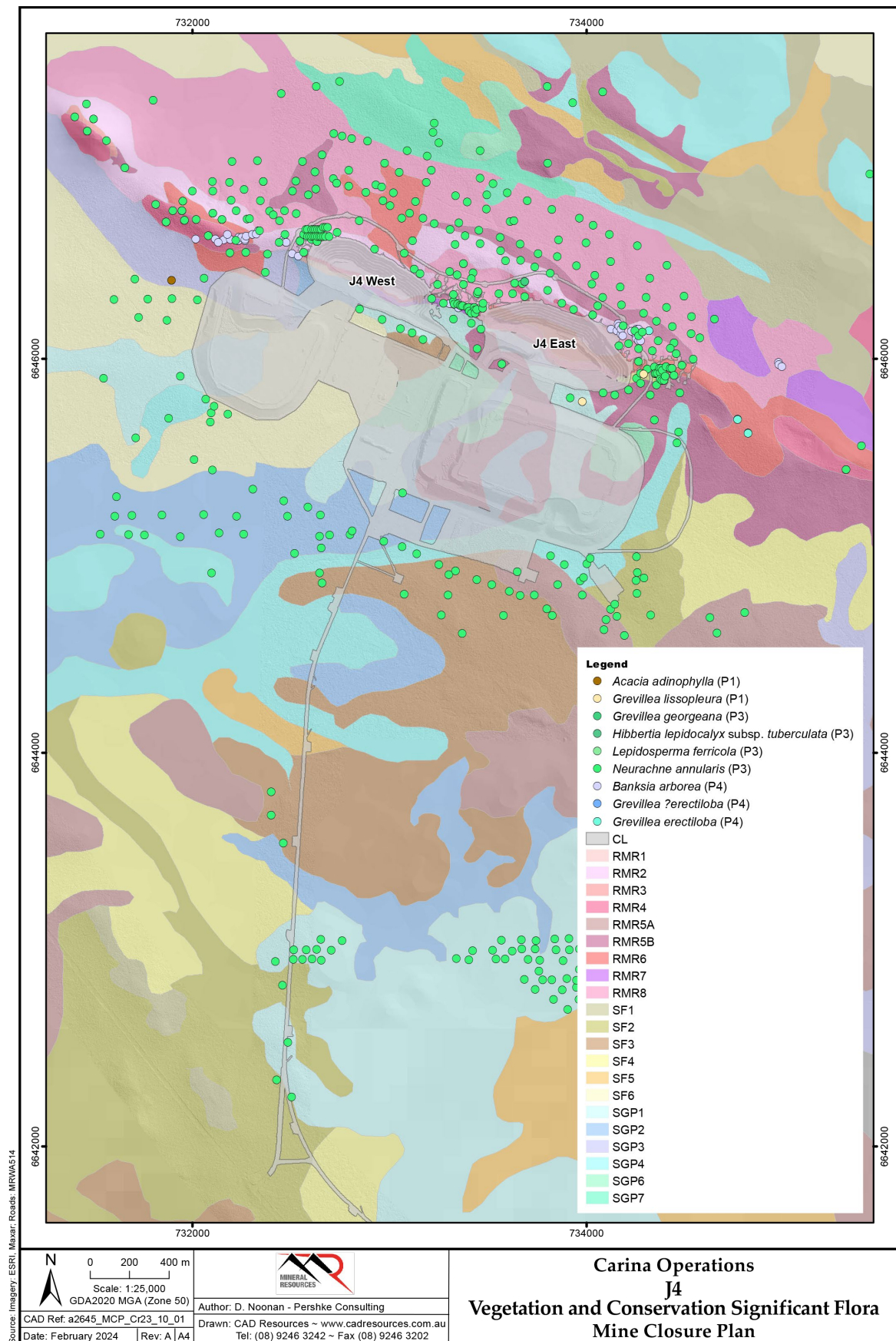
Baseline vegetation condition ranged predominantly from very good to excellent. Two quadrats were considered in poor conditions due to vegetation clearing for exploration. The most commonly observed disturbance was rabbit tracks and scats which were recorded in all areas assessed to be in very good condition. Other disturbances were associated with vehicle tracks and to a lesser extent, cattle tracks and other introduced species.

5.5.1.1.5 Aurora

The Aurora site is typical of Broad Valley landform units in the area described by Dell *et. al.* (1985) as *Eucalyptus* low woodland dominated by *E. salubris*, *E. longicornis* and *E. griffithsi* over saltbush scrub. The most recent survey of the Aurora camp and access road area (Mattiske Consulting, 2012a) identified that vegetation within the tenement M77/580 corresponds to the W2 vegetation mapping unit described for the Carina Northern operations (Mattiske Consulting, 2012c) as woodland of *Eucalyptus salmonophloia* with *Eucalyptus salubris* and mixed eucalypts over *Eremophila ionantha*, *Exocarpos aphyllus*, *Atriplex nummularia* and *Acacia colletioides* over *Atriplex vesicaria* on flat red clay soils. The vegetation was considered to be healthy and in excellent condition.

The original baseline survey of the Aurora site (Marianna Partners, 1993) comprised assessment of only two transects and included significant areas of disturbance but is provided below for completeness:

- Vegetation on the west side dominated by *Atriplex vesicaria* and *Sclerolaena* under *Eucalypt* woodland with pockets of *Acacia acuminata*, scattered *Grevillea acuaria* and *Senna nemophila*.
- Vegetation on the eastern side of the site donated by *Halgania andromedifolia* under *Eucalypt* woodland with tall shrubs of *Eremophila scoparia*, *Eremophila ionantha*, *Atriplex nummularia*, *Exocarpus aphylla* and *Santalum acuminatum*. The scrub layer was represented by *Olearia muelleri* and *Maireana triptera* with some occurrence of *Atriplex vesicaria* and *Maireana georgei* and scattered *Scaevola spinescens*, *Encyphaena tomentosa* and *Senna nemophila*.
- Plant species occurring across the whole site were dominated by *Portulaca oleracea*, *Grevillea acuaria*, *Olearia muelleri* and *Exocarpus aphylla*. Annual species were represented by various *Sclerolaena*, *Helipterum*, and *Stipa* species.
- An area in the centre of the prospect was highly disturbed by former exploration activity and supported populations of juvenile *Eremophila ionantha*, *Eremophila* species, *Stipa* and *Sclerolaena*.
- Plant species richness ranged from 11 – 12 species per 200 m² transect and average plant density of 0.26 – 0.82 plants / m². Approximately 50% of plants counted in the latter transect were juvenile, i.e., less than 12 months old.



Refer to Appendix J for pdf version

Figure 33 Vegetation and Priority Flora – J4

Veg Code	Description
RMR1	<i>Brachychiton gregorii</i> low isolated trees, over <i>Eremophila georgei</i> and <i>Philotheca brucei</i> subsp. <i>brucei</i> mid, sparse shrubland, over <i>Austrostipa elegantissima</i> sparse tussock grassland
RMR2	<i>Acacia incurvaneura</i> tall, sparse shrubland, over <i>Eremophila latrobei</i> subsp. <i>latrobei</i> mid, sparse shrubland, over <i>Neurachne annularis</i> sparse tussock grassland
RMR3	<i>Acacia quadrimarginea</i> tall, sparse shrubland, over <i>Calycoptephus paucifolius</i> and <i>Melaleuca nematophylla</i> mid, sparse shrubland, over <i>Neurachne annularis</i> sparse tussock grassland
RMR4	<i>Acacia quadrimarginea</i> tall, sparse shrubland, over <i>Philotheca brucei</i> subsp. <i>brucei</i> , mid, sparse shrubland, over <i>Neurachne annularis</i> tussock grassland
RMR5	<i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall, sparse shrubland, over <i>Ptilotus obovatus</i> and <i>Olearia muelleri</i> , low sparse shrubland, over <i>Neurachne annularis</i> tussock grassland
RMR6	<i>Grevillea zygaloba</i> tall/mid, sparse shrubland, over <i>Dianella revoluta</i> var. <i>divaricata</i> sparse herbland, over <i>Neurachne annularis</i> tussock grassland
RMR7	<i>Eucalyptus longicornis</i> tall, open woodland, over <i>Grevillea zygaloba</i> mid, sparse shrubland, over <i>Neurachne annularis</i> open tussock grassland
RMR8	<i>Eucalyptus corrugata</i> , tall, open woodland, over <i>Acacia tetragonophylla</i> and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid, sparse shrubland, over <i>Neurachne annularis</i> tussock grassland
SF1	<i>Eremophila scoparia</i> mid, sparse shrubland, over <i>Atriplex vesicaria</i> , <i>Maireana trichoptera</i> and <i>Sclerolaena diacantha</i> low sparse shrubland <i>Sclerolaena drummondii</i>
SF2	<i>Eucalyptus ravidia</i> mid, woodland, over <i>Atriplex nummularia</i> and <i>Atriplex vesicaria</i> low, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SF3	<i>Eucalyptus corrugata</i> mid, open woodland, over <i>Eremophila alternifolia</i> and <i>Senna artemisioides</i> subsp. <i>filifolia</i> , mid, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SF4	<i>Eucalyptus salubris</i> , tall woodland, over <i>Eremophila scoparia</i> mid, sparse shrubland, over <i>Atriplex vesicaria</i> low, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland.
SF5	<i>Eucalyptus salmonophloia</i> mid, open woodland, over <i>Eremophila scoparia</i> and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SF6	<i>Eucalyptus corrugata</i> mid, open woodland, over <i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) and <i>Exocarpos aphyllus</i> mid, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SF7	<i>Eucalyptus longicornis</i> mid, open woodland, over <i>Eremophila scoparia</i> and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid, sparse shrubland, over <i>Olearia muelleri</i> low sparse shrubland, over <i>Austrostipa elegantissima</i> and/or <i>A. trichophylla</i> open tussock grassland
SGP1	<i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall, sparse shrubland, over <i>Atriplex nummularia</i> and <i>Olearia muelleri</i> mid sparse shrubland, over <i>Sclerolaena fusiformis</i> low, sparse shrubland
SGP2	<i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall, sparse shrubland, over <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid, sparse shrubland, over <i>Maireana georgei</i> low sparse shrubland, over <i>Neurachne annularis</i> open hummock grassland
SGP3	<i>Eucalyptus loxophleba</i> subsp. <i>lissophloia</i> mid, open mallee woodland, over <i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall sparse shrubland, over <i>Eremophila decipiens</i> subsp. <i>decipiens</i> mid, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SGP4	<i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall, shrubland, over <i>Ptilotus obovatus</i> low, sparse shrubland, over <i>Aristida contorta</i> and <i>Austrostipa elegantissima</i> open tussock grassland
SGP5	<i>Olearia exiguiifolia</i> and <i>Westringia cephalantha</i> mid, sparse shrubland, over <i>Triodia scariosa</i> open hummock grassland and/or <i>Austrostipa elegantissima</i> open tussock grassland
SGP6	<i>Eucalyptus sheathiana</i> mid, open woodland, over <i>Acacia erinacea</i> mid, sparse shrubland, over <i>Scaevola spinescens</i> and <i>Olearia muelleri</i> low, sparse shrubland, over <i>Austrostipa elegantissima</i> open tussock grassland
SGP7	<i>Acacia ramulosa</i> var. <i>ramulosa</i> tall, shrubland, over <i>Ptilotus obovatus</i> and <i>Maireana georgei</i> low, sparse shrubland, over <i>Austrostipa elegantissima</i> and <i>A. trichophylla</i> open tussock grassland
YS1	<i>Allocasuarina corniculata</i> low, open woodland and <i>Acacia sibina</i> tall, sparse shrubland, over <i>Baeckea elderiana</i> low, sparse shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS2	<i>Acacia effusifolia</i> tall, sparse shrubland, over <i>Baeckea</i> sp. Bungabin Hill (B.J. Lepschi, L.A. Craven 4586) low, sparse shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS3	<i>Acacia resinimarginea</i> tall, sparse shrubland, over <i>Phebalium canaliculatum</i> and <i>Thryptomene urceolaris</i> mid, shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS4	<i>Acacia resinimarginea</i> tall, sparse shrubland, over <i>Phebalium canaliculatum</i> and <i>Thryptomene urceolaris</i> mid, sparse shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS5	<i>Acacia effusifolia</i> mid, sparse shrubland, over <i>Phebalium canaliculatum</i> and <i>Thryptomene urceolaris</i> , low, sparse shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS6	<i>Acacia coolgardiensis</i> mid shrubland, over <i>Phebalium canaliculatum</i> low, sparse shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> open tussock grassland
YS7	<i>Allocasuarina acutivalvis</i> subsp. <i>acutivalvis</i> low, open woodland, over <i>Acacia resinimarginea</i> tall shrubland, over <i>Thryptomene urceolaris</i> and <i>Phebalium canaliculatum</i> mid, open shrubland

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Figure 34 Legend J4 Vegetation Communities shown in Figure 33

5.5.1.2 Significant Flora and Vegetation

No plant species gazetted as Threatened Flora under the *Biodiversity Conservation Act* 2016 (BC Act) or listed under the federal *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) have been recorded at the Carina operations.

Twenty nine priority species currently listed by DBCA have been recorded across the Carina Operations (Table 27 and Figure 33 to Figure 37).

Table 27 Priority Flora Carina Operations

Species	Priority (P)Status	Carina Northern	Carina Southern	J4	Aurora
<i>Acacia adinophylla</i>	P1			✓	
<i>Grevillea lissopleura</i>	P1			✓	
<i>Lepidosperma lyonsii</i>	P1		✓		
<i>Melichrus</i> sp. Coolgardie (K.R. Newbey 8698)	P1		✓ ¹³		
<i>Phebalium appressum</i> ¹⁴	P1		✓ ¹³		
<i>Hakea rigida</i>	P2		✓		
<i>Hibbertia lepidocalyx</i> subsp. <i>tuberculata</i>	P3	✓			
<i>Leucopogon</i> sp. Yellowdine (M.Hislop and F. Hort MH 3194)	P2		✓		
<i>Acacia crenulata</i>	P3	✓			
<i>Acacia formidabilis</i>	P3		✓		
<i>Banksia lullfitzii</i>	P3		✓		
<i>Calytrix creswellii</i>	P3		✓	✓ ¹³	
<i>Cryptandra crispula</i>	P3		✓		
<i>Cyathostemon verrucosus</i>	P3		✓		
<i>Eutaxia ?nanophylla</i>	P3		✓		
<i>Grevillea georgeana</i>	P3	✓		✓	
<i>Homalocalyx grandiflorus</i>	P3		✓		
<i>Hysterobaeckea cornuta</i>	P3			✓ ¹³	
<i>Lepidosperma ferricola</i>	P3			✓	
<i>Melichrus</i> sp. Bungalbin Hill (F.H. and M.P. Mollemans 3069)	P3			✓ ¹³	
<i>Mirbelia ferricola</i> R Butcher	P3		✓		
<i>Neurachne annularis</i>	P3			✓	✓
<i>Stenanthemum newbeyi</i>	P3	✓			✓
<i>Stylidium choreanthum</i>	P3		✓	✓	
<i>Styphelia saxicola</i>	P3				
<i>Banksia arborea</i>	P4	✓		✓	

¹³ Identified during Vegetation Condition or Rehabilitation Monitoring and not yet mapped (Astron, 2020c; 2020a).

¹⁴ Misidentified in 2019 as *Micromyrtus erichsenii* (Astron, 2020c)

Species	Priority (P)Status	Carina Northern	Carina Southern	J4	Aurora
<i>Grevillea erectiloba</i>	P4			✓	✓
<i>Sowerbaea multicaulis</i>	P4		✓		

Source: DBCA (2024a), Mattiske Consulting (2008a; 2008b) (2009a; 2009b) (2010; 2011a; 2011b), (2012a; 2012b; 2012c) Astron (2020c)

The following is noted with respect to priority flora species identified during earlier surveys Mattiske Consulting (2008a; 2008c; 2009a; 2009b; 2010; 2011a; 2011b; 2012a; 2012b; 2012c):

- *Mirbelia* sp. *Helena & Aurora* (B.J. Lepschi 2003) is more recently known as *Mirbelia ferricola* R. Butcher (P3) (DBCA, 2024b).
- *Spartothamnella* sp. *Helena & Aurora Range* (P.G. Armstrong 155-109) found at the Carina Northern and Carina Southern operations was revised to *Spartothamnella canescens* K.R. Thiele & K.A. Sheph which is more recently known as *Teucrium disjunctum* K.R. Thiele & K.A. Sheph. (DBCA, 2024b) which is not listed as a priority flora species (DBCA, 2024a).
- *Daviesia purpurascens* recorded at the Carina Southern operations is no longer listed as priority flora (DBCA, 2024a) .
- The priority classification of *Lepidosperma lyonsii* has changed from P4 to P1 (DBCA, 2024b).

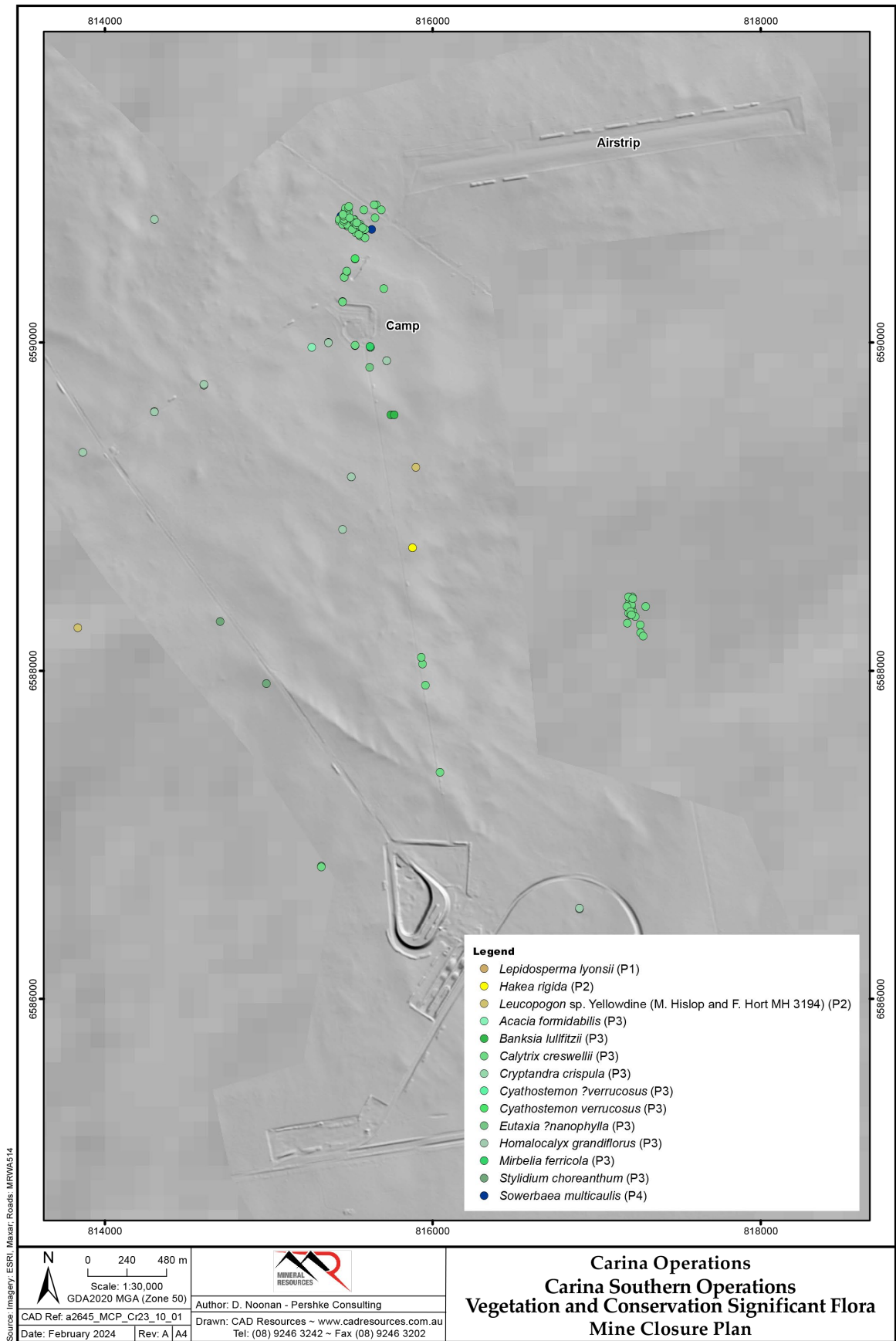
Two priority flora species have been recorded within rehabilitation monitoring sites (Astron, 2023a):

- *Grevillea georgeana* (P3) was recorded within the SR03 borrow pit rehabilitation monitoring site for the first time in 2016 and has been recorded each year since.
- *Lepidosperma lyonsii* (P1) was first recorded within the SR02 borrow pit rehabilitation monitoring site in 2017, and while it was misidentified in 2018 and 2019 surveys and consequently not recorded in those years it was present in 2022 monitoring indicating continued presence.

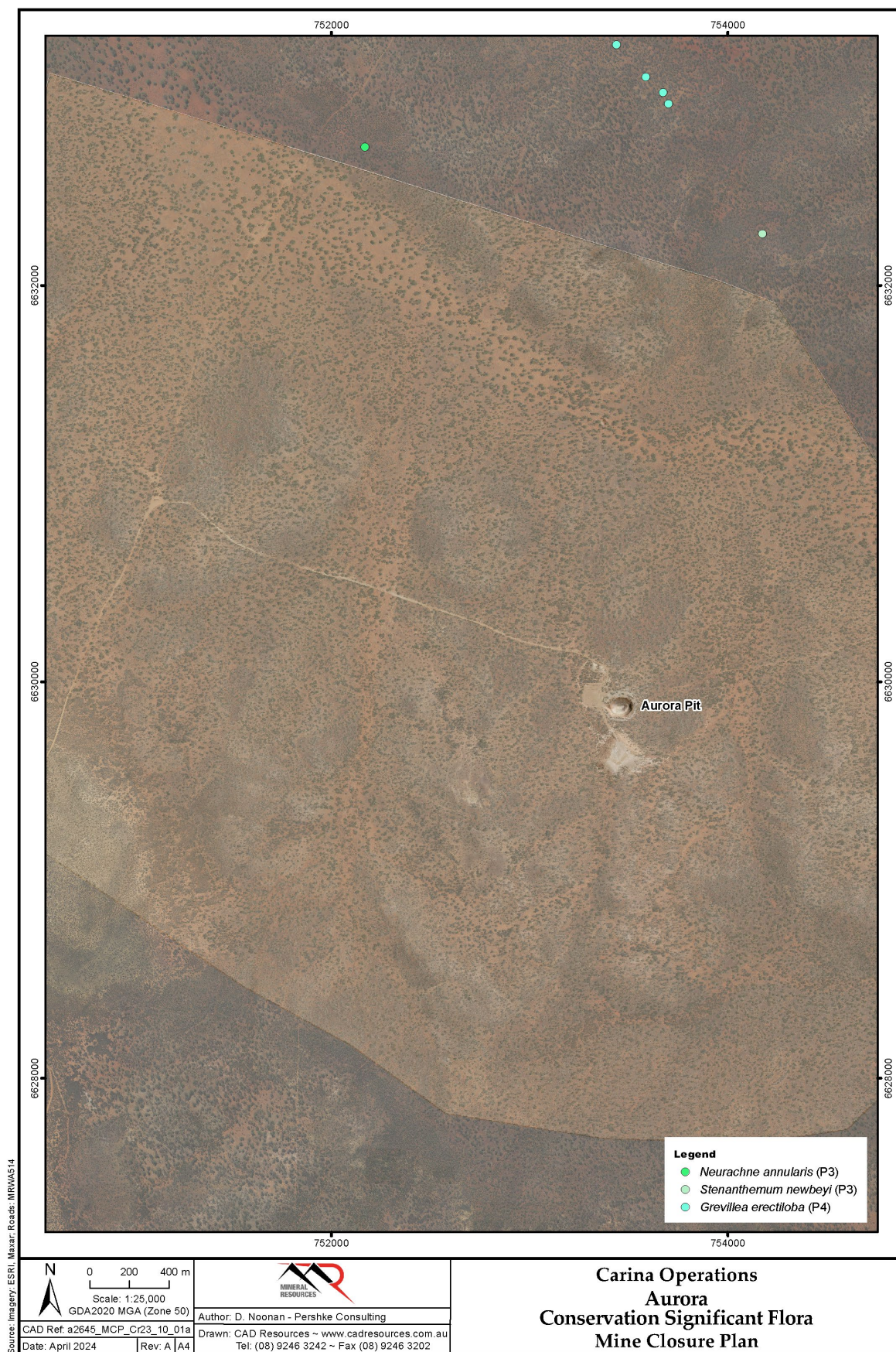


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Figure 35 Priority Flora Carina



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Figure 36 Priority Flora – Carina Southern



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Figure 37 Priority Flora - Aurora

5.5.1.3 Threatened and Priority Ecological Communities

No listed Threatened Ecological Communities (TEC) have been recorded in the Carina Operations area (Figure 38) (DBCA, 2023d).

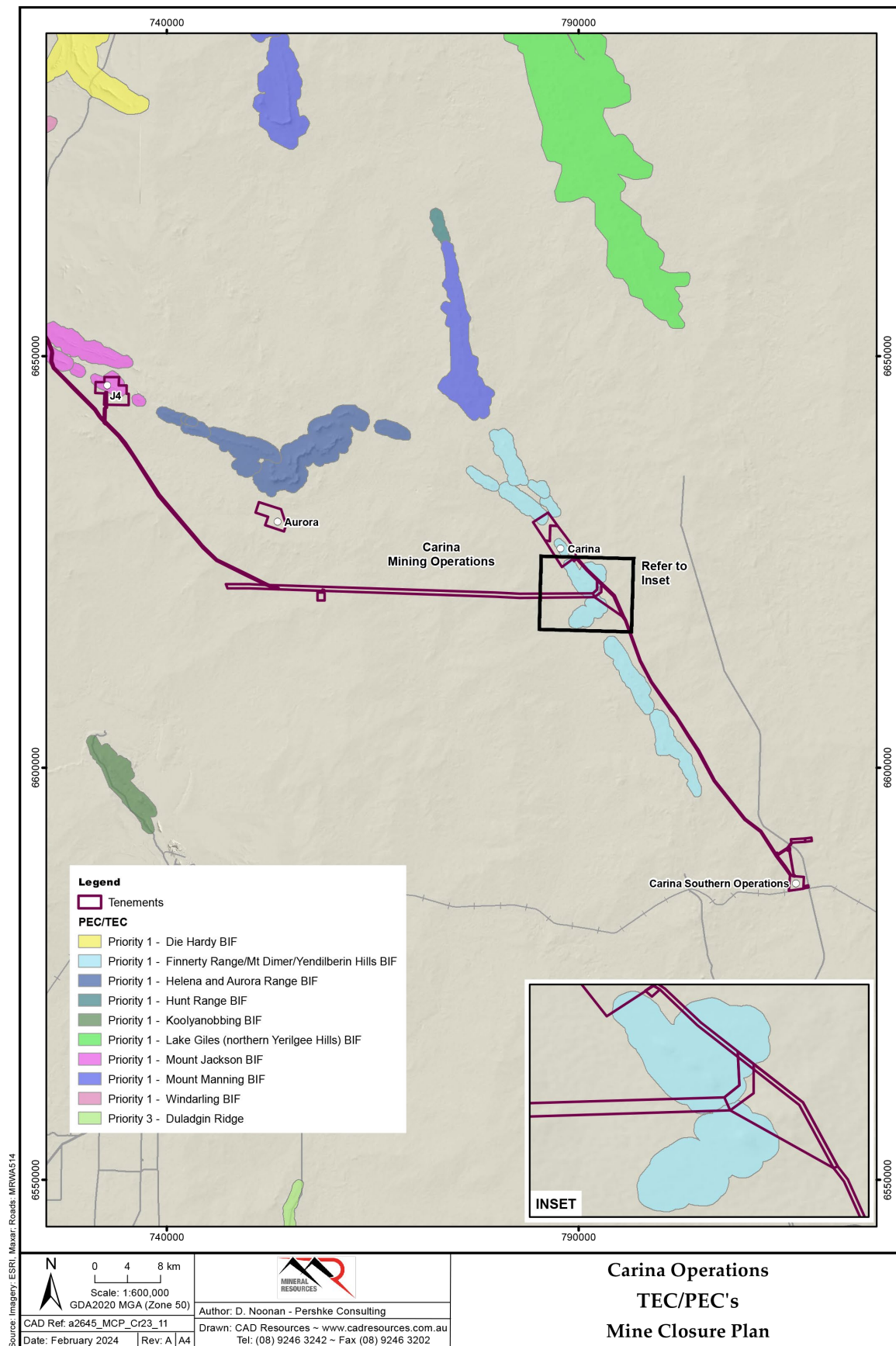
There are ten PECs within 50 km north of the Carina Operations areas, all but one of which are associated with the surrounding BIF ranges (Figure 38) (DBCA, 2023e). These include:

- Die Hardy Range / Diemels vegetation assemblages (BIF) (P1).
- Finnerty Range / Mt Dimer / Yendilberin Hills vegetation assemblages (BIF) (P1).
- Hunt Range vegetation assemblages (BIF) (P1).
- Koolyanobbing vegetation assemblages (BIF) (P1).
- Lake Giles (northern Yerilgee Hills) vegetation assemblages (BIF) (P1).
- Mount Jackson Range vegetation assemblages (BIF) (Priority (P) 1).
- Windarling Ranges vegetation assemblages (BIF) (P1).
- Helena and Aurora Range vegetation assemblages (BIF) (P1).
- Mount Manning Range vegetation assemblages (BIF) (P1).
- Duladgin Ridge vegetation assemblages (P3).

The Carina and Carina Extended mine tenements fall within the boundaries of the Finnerty Range / Mt Dimer / Yendilberin Hills vegetation assemblages (BIF) PEC (Figure 38). While the boundary for this PEC encompasses the Carina Extended mine tenement and extends from Mt Dimer in the north to the Finnerty Ranges in the south, statistical analysis of data for vegetation units S2 and S6 yielded a low level of similarity (Mattiske Consulting, 2011a). On this basis, it was concluded that these vegetation units did not form part of the PEC (Mattiske Consulting, 2012b).

The J4 operations fall within the Mt Jackson Range vegetation assemblages (BIF) PEC (Figure 38). Eight of the vegetation communities mapped by Ecologia (2013a) were considered to represent occurrences of this PEC, including two units representing less than 0.1% of vegetation communities mapped within the study area that were restricted to the BIF range.

The eastern end of the J4 Haul Road overlaps the Finnerty Range / Mt Dimer / Yendilberin Hills vegetation assemblages (BIF) PEC (Figure 38). However, baseline vegetation survey suggested none of the mapped vegetation units described matched the PEC vegetation description (Ecologia, 2013a).



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Figure 38 Priority Ecological Communities – Carina Operations

5.5.1.4 Weeds and Declared Plants

No Weeds of National Significance (WONS) or species of Declared Pests have been recorded in any of the baseline surveys completed for the Carina Operations sites, nor in subsequent monitoring.

Baseline

Weeds recorded during baseline monitoring are presented in Table 28 and summarised below:

- Baseline weed presence and abundance were low across the Carina Operations.
- No weeds were recorded in baseline assessments of the Carina Haul Road, Mt Walton Rail Siding (Mattiske Consulting, 2009a; 2010), Carina Village (Mattiske Consulting, 2010; Read, 2010), East Jaurdi Aerodrome (Mattiske Consulting, 2011b) or the Aurora site (Marianna Partners, 1993).
- Two weed species (**Erodium cicutarium* and **Erodium botrys*) were recorded within Carina and Carina Extended exploration tenement area but not the mining area (Mattiske Consulting, 2008a; 2011a).
- During a spring survey in 2011 large numbers of **Centaurea melitensis* were observed growing along the edges of the Jaurdi track. **Sonchus oleraceus* and **Erodium botrys* were also observed along the Jaurdi track in the vicinity of the Carina mine (Mattiske Consulting, 2012c).
- Seven species of weeds were recorded within the J4 mining area and haul road baseline survey area, all at low abundance (two or less individuals) with the exception of **Sonchus oleraceus* (42 individuals recorded).

Current Situation

Weed monitoring and management conducted during the operations phase to satisfy the requirements of Ministerial Statements 852, 957 and 988 (Section 3.3), and as part of rehabilitation monitoring (Section 5.9.3.1), has recorded weeds within the Carina Operations areas as listed in Table 28 and shown in Figure 39 to Figure 43.

Maltese Cockspur (**Centaurea melitensis*) was the most frequently recorded species at both the Carina and J4 project areas, accounting for approximately 70-80% of individual plants mapped and controlled during 2021 and 2022 respectively. Rough Sowthistle (**Sonchus asper*) was also prominent across both project areas (Astron, 2021c; 2023d). Both species were also present at the Aurora Camp in 2022 (Astron, 2023c).

Rough Sowthistle (**Sonchus asper*) was recorded at four Carina WRL sites in 2018 and all five Carina Extended WRL rehabilitation sites in 2019¹⁵ prior to that) and has continued to be recorded through to 2022 with abundance increasing since 2018 (Astron, 2023a).

Ruby Dock (**Rumex vesicarius*) was recorded for the first time at two sites on the Carina WRL in 2022 (153 individuals and 8 individuals respectively) (Astron, 2023a) and manually removed (Astron, 2023d).

Weed control has effectively controlled three species of weeds identified in previous monitoring but not present in 2022 (Astron, 2023a; 2023d): **Tribulus terrestris* (Carina Camp) (Astron, 2021c), **Cucumis myriocarpus* and *Citrullus colocynthis* (former Aurora Camp) (Astron, 2021c) and **Erodium botrys* (Carina Extended WRL) (Astron, 2020a).

Monitoring of vegetation health occurs within a buffer zone bordering the J4 haul road. Monitoring between 2018 and 2022 has recorded no weed species (Astron, 2021b; 2023c). Monitoring of vegetation health and condition also occurs within a buffer zone of the Carina mining area. In 2018 **Sonchus*

¹⁵ **Sonchus asper* is often mistaken for **Sonchus oleraceus*, which is the more commonly recorded of the two species. It is likely that **Sonchus asper* has been present at the Carina WRL in previous years, but was misidentified as **Sonchus oleraceus* (Astron, 2019a)

oleraceus was recorded at monitoring transects between 2016 to 2018 but has not been recorded since¹⁵ (Astron, 2020c; 2023b).

Additional weed monitoring methods, such as aerial survey techniques, are also being investigated to maximise effectiveness of weed control efforts (Section 10.2.2.2). As these methodologies are tested and refined, the results will be utilised to refine the understanding of the current weed situation and will be incorporated in the next revision of the MCP.

Weed monitoring and management applicable to the closure phase is discussed in Section 10.2.2.

Table 28 Weeds – Carina Operations

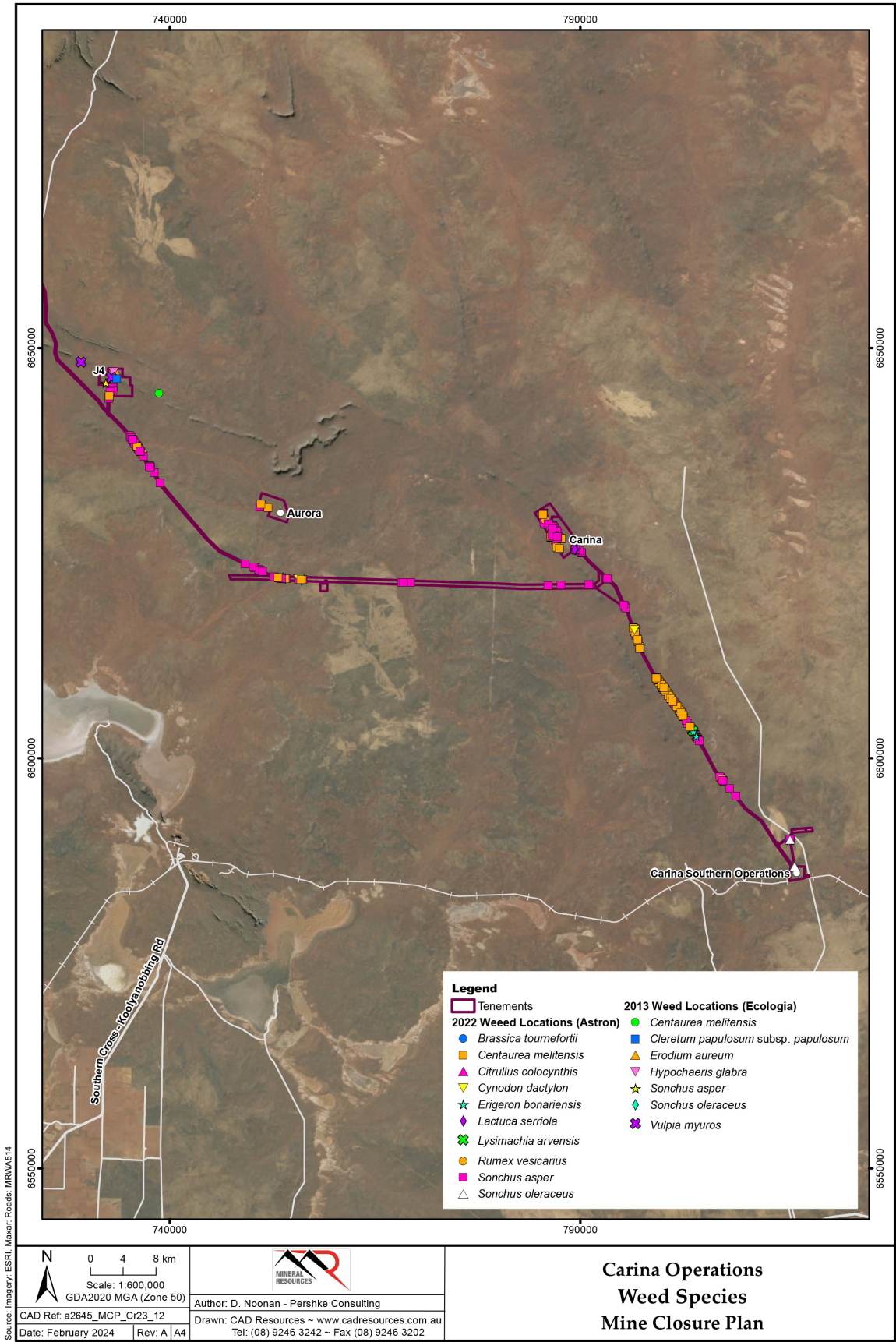
Species	Common Name	Ecological Impact	Invasiveness	Carina Northern (Baseline)	Carina Northern (Current)	Carina South & Haul Rd (Current)	J4 Baseline	J4 & Haul Rd (Current)	Aurora (Current)	Comment
* <i>Brassica tournefortii</i>	Mediterranean Turnip	Unknown	Rapid	-	-	✓	-	-	-	Annual herb, 0.1- 0.6 m high, yellow-cream-white flowers. Sandy soils. Aggressive weed of disturbed ground, roadsides. Widespread throughout WA and extending to South Australia.
* <i>Centaurea melitensis</i>	Maltese Cockspur	Moderate	Rapid	✓	✓	-	✓	✓	✓	Annual daisy to 1 m height is a widespread weed of roadsides and other disturbed areas from Carnarvon to Eucla. Considered to be potentially serious weed for the locality. Maltese cockspur produces abundant seed which is dispersed a short distance by wind and by water, soil and animal movement. Seeds can persist in the soil for up to four years.
* <i>Citrullus colocynthis</i>	Colocynth	Moderate	Rapid	-	-	✓	-	-	-	Trailing perennial, herb or climber. Yellow flower, Jan to Oct. Sandy, rocky, stony loam, clay soils, wet soils. In disturbed areas, floodplains.
* <i>Cleretum papulosum subsp. papulosum</i>	-	Not listed	Not listed	-	-	-	✓	-	-	A prostrate succulent herb occurs in a variety of substrates in rocky, sloping or flat habitats. Found mainly in the South-West province.
* <i>Cynodon dactylon</i>	Couch	High	Rapid	-	✓	✓	-	✓	-	Rhizomatous (or stoloniferous), prostrate perennial, grass-like or herb, 0.05 - 0.3 m high. Green-purple flower, Jun to Nov or Feb. Sand, loam, clay. Widespread WA and into Northern Territory. Survives most fire. Seedbank persistence 3 – 4 years.
* <i>Erigeron bonariensis</i> ¹⁶	Flaxleaf Fleabane	Unknown	Rapid	✓	✓	✓	-	-	-	Erect annual, herb, 0.15-1.5 m high. White flower, Jan to Dec. Variety of soils. Weed of cultivation, waste places & roadsides. Widespread south west of WA, Pilbara, Coastal areas of northern WA and into central Australia.
* <i>Erodium aureum</i>	-	Low	Moderate	-	-	-	✓	-	-	A spreading short-lived perennial herb to 0.2 m high. Found across entire lower half of WA and especially common on loamy soils in the arid zone.
* <i>Erodium botrys</i>	Long storksbill	Unknown	Unknown	✓	✓ ¹⁷	-	-	-	-	Ascending or decumbent annual, herb, 0.01-0.2 m high. Blue-purple flower, Aug to Nov. Southwest WA and Nullarbor,
* <i>Erodium cicutarium</i>	Common Storksbill	Low	Moderate	✓	✓	-	-	-	-	A small herb to 0.2 m high widely distributed across the southwest of the State. A weed of wasteland, crops and pastures.
* <i>Hypochaeris glabra</i>	Smooth Catsear	Unknown	Rapid	-	-	-	✓	-	-	Rosetted annual or perennial herb to 0.5 m high. Widely distributed across WA. Common weed of roadsides and bushland.
* <i>Lactuca serriola</i>	Prickly Lettuce	Low	Rapid	-	✓	-	-	-	-	Erect annual or biennial, herb, 0.4-2 m high. Yellow flower, Oct to Dec or Jan to Feb. Roadsides, disturbed sites. Widespread south west of WA and north to Pilbara and Carnarvon.
* <i>Lysimachia arvensis</i>	Pimpernel	Unknown	Rapid	-	✓	-	-	-	-	A hairless spreading annual. A widespread weed of gardens, paddocks, granite rocks and disturbed areas throughout the southwest.
* <i>Rumex vesicaria</i>	Ruby Dock	High	Rapid	-	✓	-	-	-	-	An erect annual herb to 1 m high. Found along roadsides and disturbed areas on sandy alluvial soils and gravelly ironstone soils throughout WA.
* <i>Sonchus asper</i>	Rough (Spiny) Sowthistle	-	-	-	✓	✓	✓	✓	✓	Erect, robust, spiny annual of biennial herb, yellow flowers. Seasonally wet areas, disturbed sites. South and south west WA.
* <i>Sonchus oleraceus</i>	Common Sowthistle	Unknown	Rapid	✓ ¹⁸	✓	✓	✓	-	-	An erect annual herb to 1.5 m high is a very widespread weed of disturbed areas and occurs in a variety of soils throughout WA. Ranking reflects high level of invasiveness and wide current and potential distribution.
* <i>Vulpia myuros forma myuros</i>	Rats Tail Fescue	Unknown	Rapid	-	-	-	✓	-	-	A tufted annual grass to 0.7 m high. A widespread weed of crops, pastures and revegetation areas throughout south western Australia. Ranking reflects high level of invasiveness and wide current and potential distribution.

Source: DBCA (2023a; 2023b; 2024b). Baseline: Carina Northern (Mattiske Consulting, 2008a; Mattiske Consulting, 2011a; Mattiske Consulting, 2012c). J4 (Ecologia, 2013a). Current: All (Astron, 2016; 2017; 2019a; 2020a) (Astron, 2021a; 2023a; 2023b; 2023c) (Astron, 2021c; 2023d)

¹⁶ Unconfirmed due to the poor quality of the specimen available (Mattiske Consulting, 2012c). Formerly *Conzya bonariensis*.

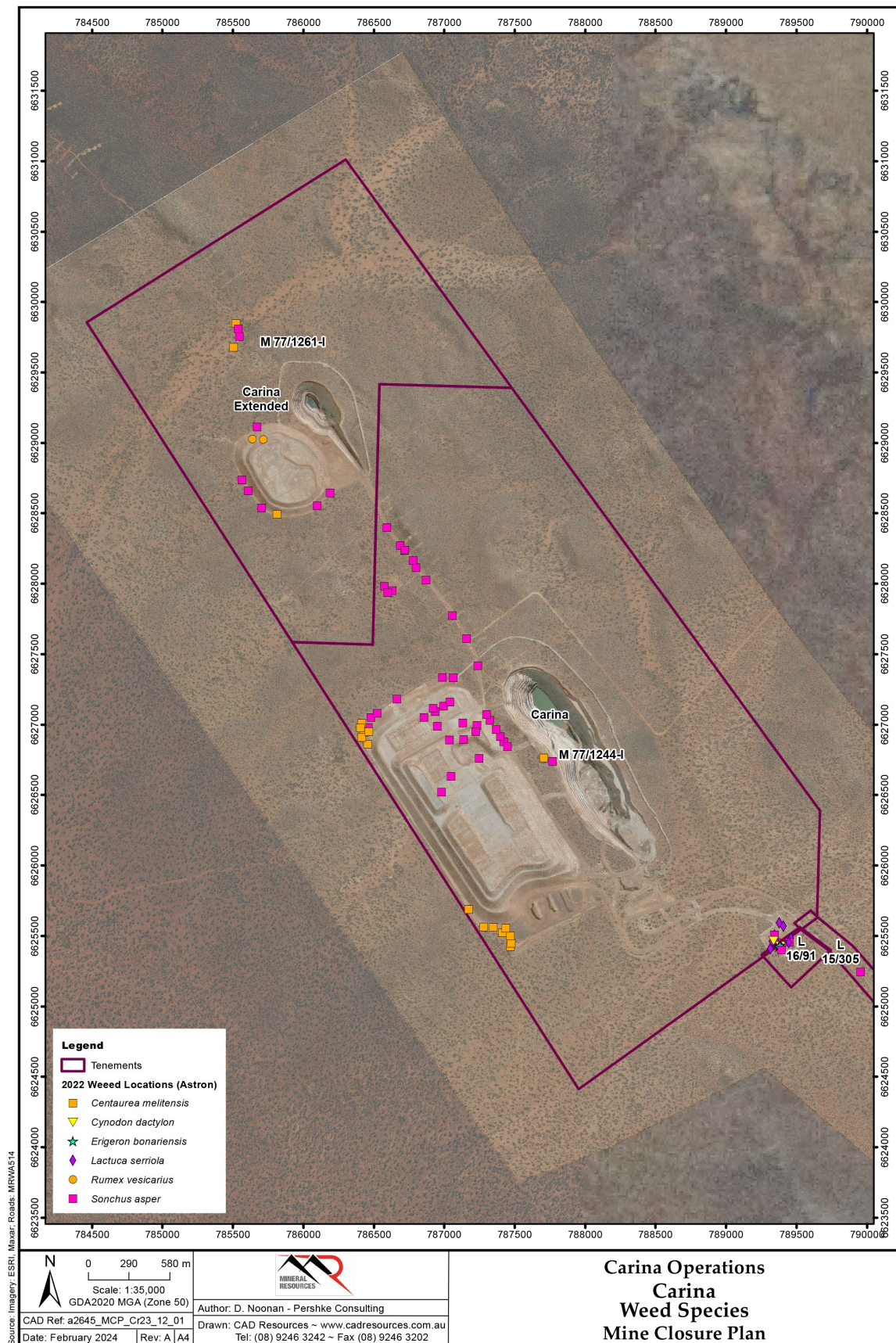
¹⁷ Recorded in monitoring 2018 / 2019 but controlled and not recorded since.

¹⁸ Recorded on Jaurdi Access Track in vicinity of Carina mine area.



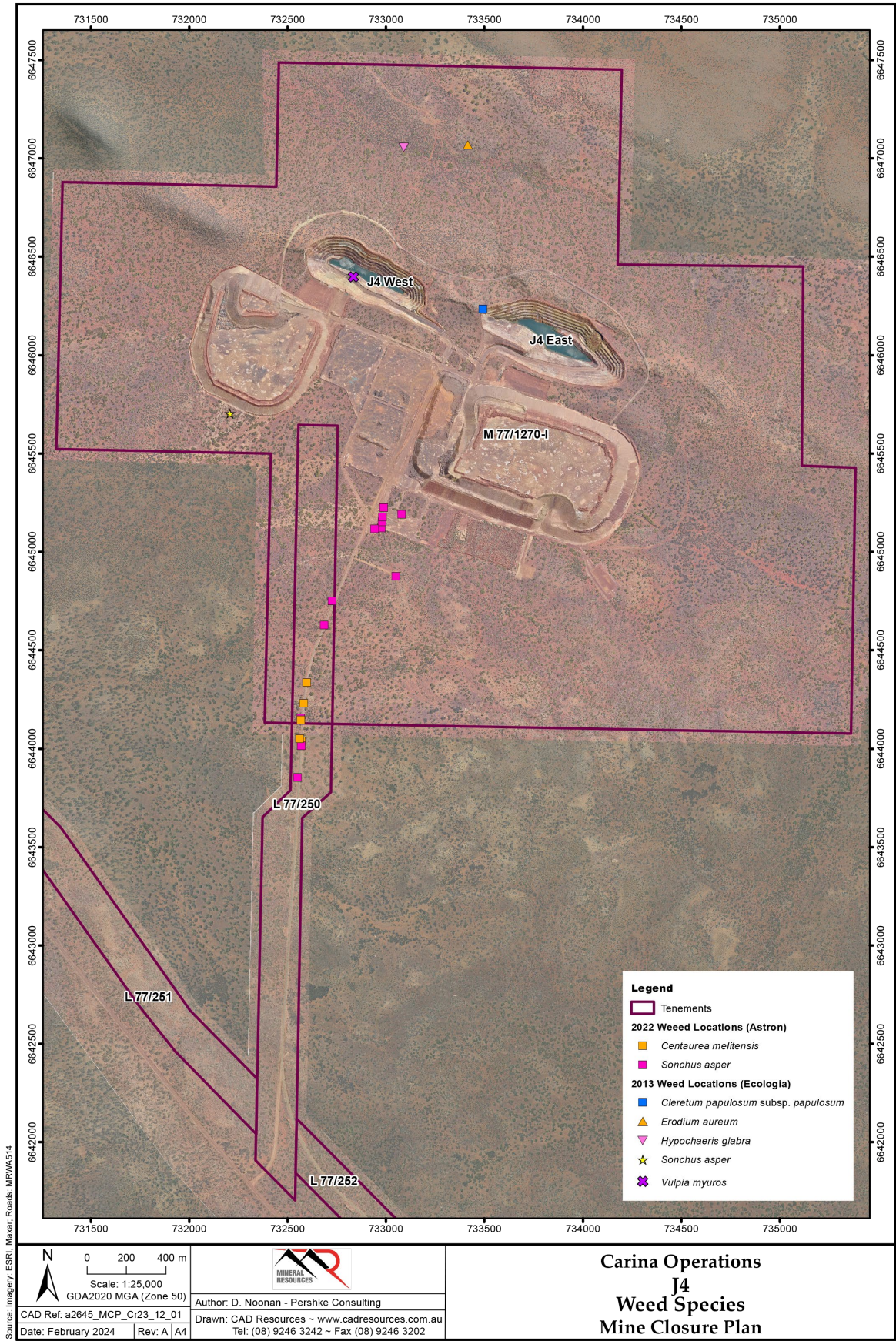
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Figure 39 Weeds – Carina Operations



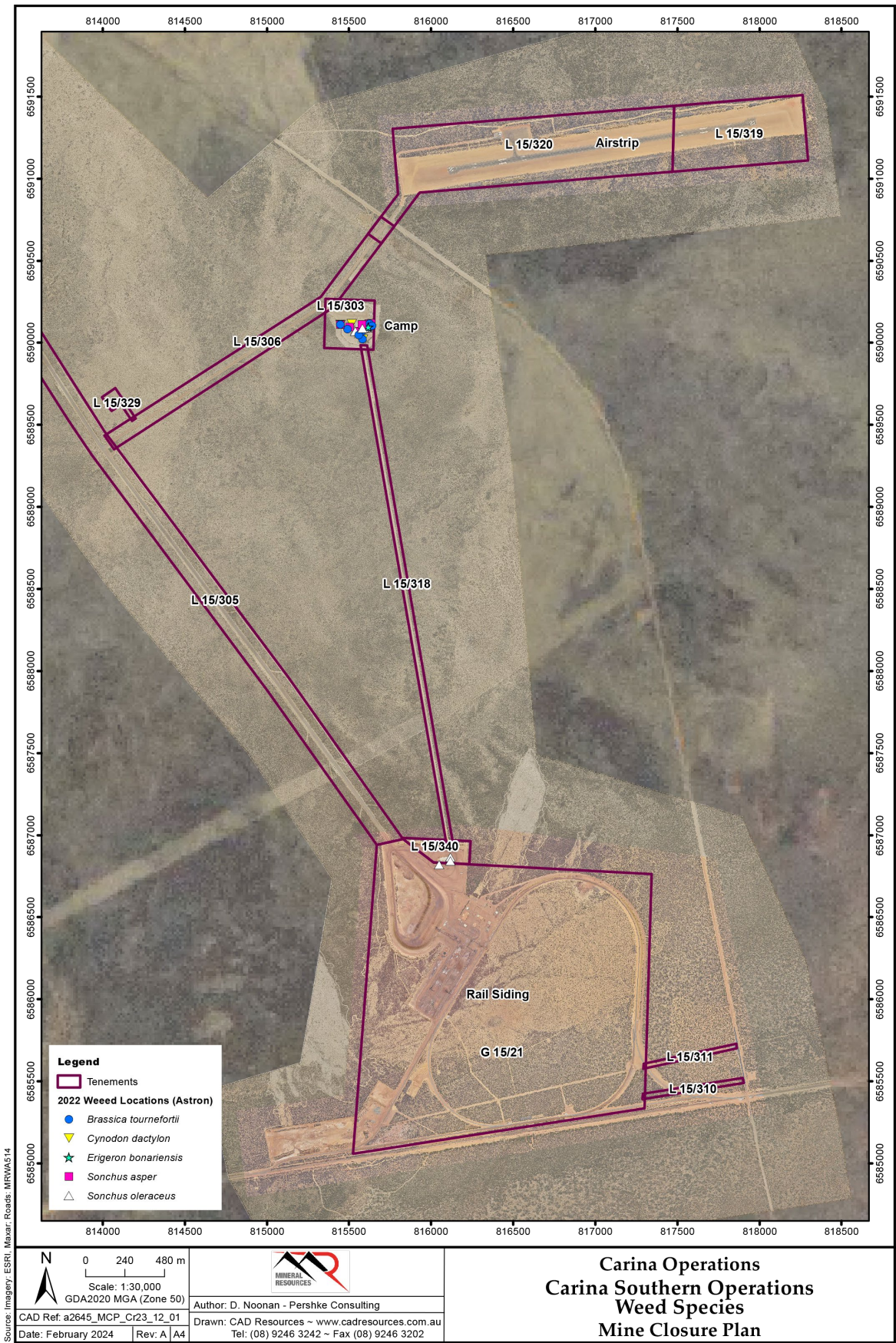
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Figure 40 Weeds – Carina and Carina Extended



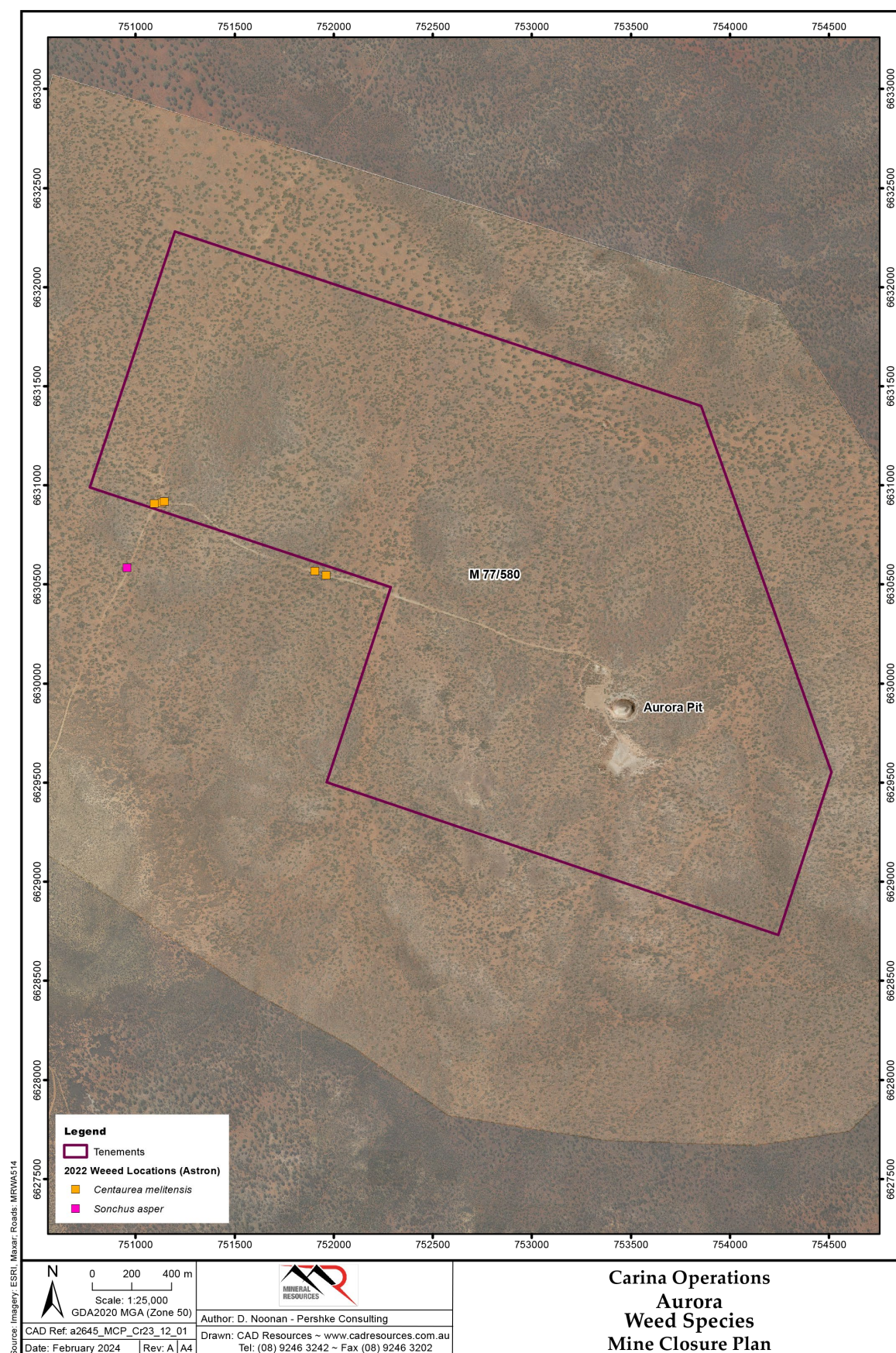
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Figure 41 Weeds – J4



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Figure 42 Weeds – Carina Southern Operations



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Figure 43 Weeds - Aurora

5.5.1.5 Plant Pathogens (*Phytophthora* Dieback)

Phytophthora Dieback monitoring is being conducted during the operations phase to satisfy the requirements of Ministerial Statement 852 (Section 3.3). Phytophthora Dieback is the common name for the disease in native ecosystems caused by plant pathogens from the genus *Phytophthora*, most notably *P. cinnamomi*. Over 40 species of *Phytophthora* are currently described, including many species native to ecosystems in Australia, but *P. cinnamomi* is considered one of the greatest threats to plant biodiversity in Western Australia (Great Southern Bio Logic, 2023).

The Carina and J4 operations are outside the known occurrence for *P. cinnamomi*, which is the species generally referred to in Western Australian Government management guidelines and practices. The Vulnerable Zone for Phytophthora Dieback includes all areas of the southwest occurring west and south of the 400 mm rainfall isohyet (Great Southern Bio Logic, 2023).

Findings and recommendations of the latest survey and subsequent phylogenetic analysis are summarised below (Great Southern Bio Logic, 2023; Great Southern Bio Logic, 2024):

- *P. cinnamomi* was not detected in the cumulative total of 65 soil and tissue samples collected from the three *Phytophthora* surveys completed to date. However, there were ten recoveries of three *Phytophthora* spp, including two undescribed species, from the 65 samples.
- Phylogenetic analysis confirmed that each of the three species identified across Carina and J4 are distinct species with similar morphologies. As all three are only known from dry environments, originate from very similar ecologies, that are very different to a typical environment where other *Phytophthora* species are found, they are considered to be unique from the species known to be introduced to WA. Of the three species found across the MinRes survey area, none have been identified outside of WA which in consideration of the previous points means *P. arenaria*, *P. sp. Aus 4E* and *P. sp. Aus 4B* are most likely to have evolved in the dry environments of WA and are most likely to be native and endemic to the area.
- Observations from within the areas classified as infested by these species commonly identify single plant deaths in areas of otherwise healthy vegetation, however, there are three larger areas where there is significant, localised vegetation decline. These areas have now been extensively sampled resulting in a very low rate of recovery of additional positive samples. This may suggest that other factors are causing the vegetation decline, and potentially increasing the impact of the pathogen upon susceptible species present.
- From the distribution of the species, it does appear that, they are being spread along haul roads by MinRes activities. Management strategies for the operations phase are being developed and will be applied to mitigate the risk of further spread of *Phytophthora* spp.

While three species of *Phytophthora* have been identified across the site, they are, as identified above believed to be native plant pathogens and are not subject to the National Threat Abatement Plan for *P. cinnamomi* or either of the DBCA management documents (DBCA, 2015; 2020).

5.5.2 Terrestrial Fauna and Habitat

The Carina Operations straddle the boundary between the Eremaean and the South-West Botanical Provinces: described as the 'mulga - eucalypt line' (Burbidge, 1995) which marks the transition from the mainly *Acacia* shrublands of the arid interior to the *Eucalyptus* woodlands and forests of the wetter, more predictable rainfall areas of the South-west. As a consequence, the fauna assemblage includes a range of species that are respectively at their south-western and north-eastern limits of their distribution, resulting in a very diverse range of species (Ninox Wildlife Consulting, 2009). The biological values of the BIF landforms of the Midwest and Eastern Goldfields have been documented (DEC, 2007) including their potential to support vertebrate fauna of high conservation significance and short-range endemic fauna (Ninox Wildlife Consulting, 2009).

Terrestrial fauna surveys completed for the Carina Operations include:

- Ninox Wildlife Consulting (2009) Fauna Survey of the Carina Prospect.
- Bennelongia (2011) Yilgarn Iron Ore Project: Troglofauna Surveys.
- Dalcon Environmental (2012) Terrestrial Invertebrate Short-range Endemic Assessment (Carina Extended).
- Bamford Consulting Ecologists (2012) Fauna Assessment for Carina Extended, Carina North and Chamaeleon Project Areas.
- Ecologia (2013b) J4 Mine and Haul Road Terrestrial and Subterranean Fauna Assessment.

An additional eight short-range endemic and land snail identification reports have not been listed here but are appended to Ninox Wildlife Consulting (2009) and Bamford Consulting Ecologists (2012) which are provided in Appendix C. The results of these surveys are summarised in Section 5.5.2.4.

Baseline fauna surveys were not completed for the Carina Southern Operations and Aurora sites.

5.5.2.1 Fauna Habitat

5.5.2.1.1 Carina

Ninox Wildlife Consulting (2009) surveyed habitat associated with the major plant and soil associations identified by Mattiske Consulting (2008a) W2, W4, W12, W24 (Eucalypt Woodland) and S2 (Scrub) (refer to (Polaris Metals, 2013a) for vegetation unit locations and description) and made the following observations:

- The W24 vegetation / habitat type had a diverse plant community and complex structure which has been shown in many studies to be of importance to birds.
- The S2 vegetation / habitat type (in the BIF outcropping and adjacent woodland) was composed of a mixture of eucalypts and sheoaks, with the latter generally supporting large numbers of invertebrates with the resulting increased presence of insectivorous birds. This habitat is also important for an undescribed and probably short range endemic millipede and also harbours the locally conservation significant skink, *Cyclodomorphus melanops elongatus*.
- Bird species diversity and index of abundance were highest at sampling sites within W24 and S2.
- Native mammals were also only trapped at sites within W24 and S2 vegetation units. Spinifex in W24 supported the Southern Ningau (Ningau *yvonneae*) and BIF outcropping at S2 supported the Little Long-tailed Dunnart (*Sminthopsis dolichura*) and the Western Pygmy-possum (*Cercartetus concinnus*). Eight species of bats were recorded at Carina using two Anabats.

5.5.2.1.2 Carina Extended

Bamford Consulting Ecologists (2012) reported that habitat at Carina Extended was similar to that documented by Ninox Consulting (2009) for Carina as would be expected given similar landforms and vegetation types. They identified two major vegetation and substrate associations (Bamford Consulting Ecologists, 2012):

- Low Rocky Hills: a complex of exposed solid rock, exposed fragmented rock and shallow gravelly to loamy soils over rock, supporting vegetation that can be broadly described as scrub and scrub-heath, incorporating vegetation types S2 and S6 (Mattiske Consulting, 2011a).
- Woodland on Plains: loam and clayey-loam plains supporting eucalypt woodland over mixed and very patchy shrubs; mostly *Acacia* and *Eremophila* but also *Maireana* in some areas. Compared with the rocky hills this habitat type is regionally widespread.

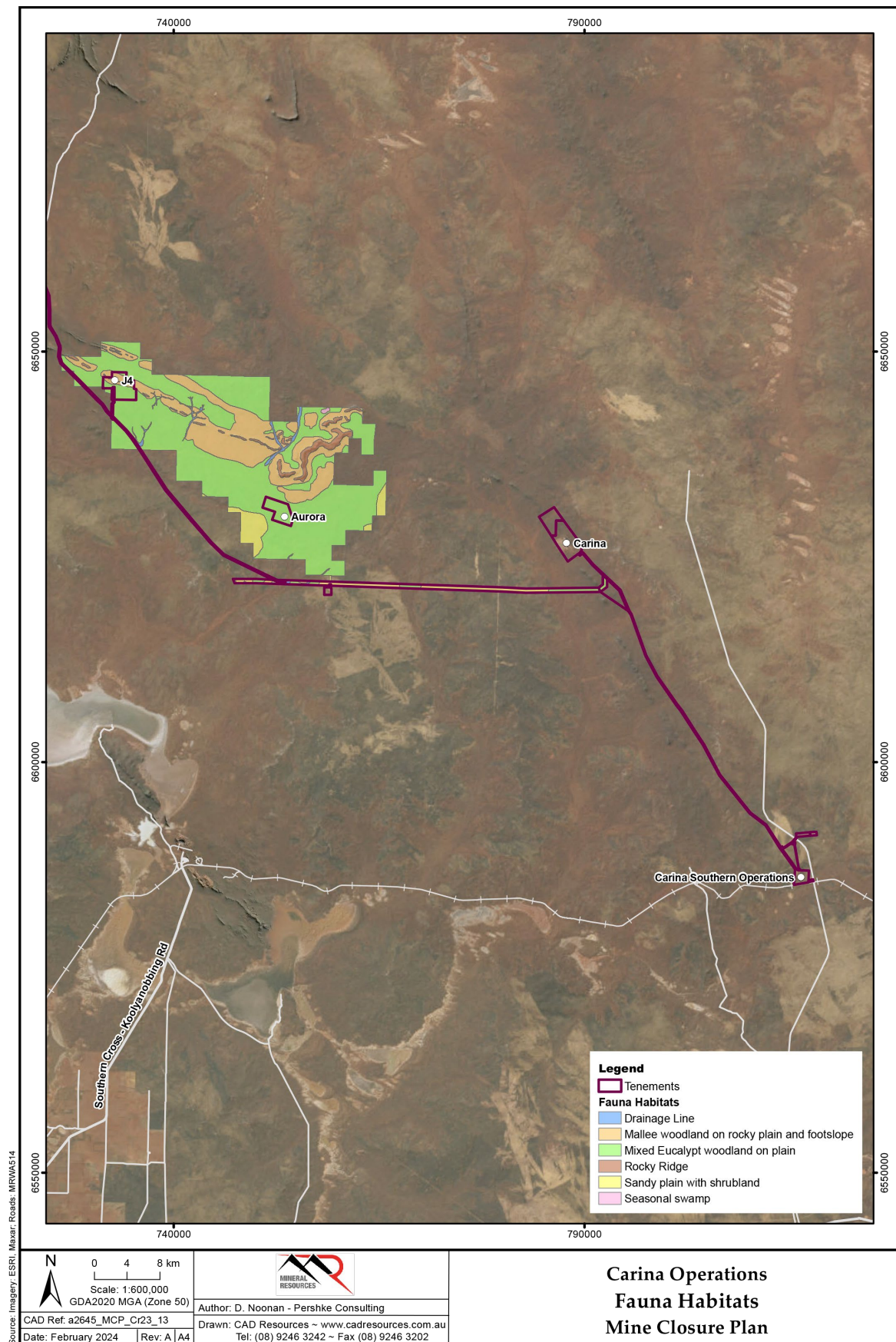
Bamford Consulting Ecologists (2012) found that the Low Rocky Hills had higher levels of abundance of reptiles, higher bird species richness and harboured more birds of conservation significance (based on classification at the time of the survey) (Section 5.5.2.3.2) than the Woodland on Plains.

5.5.2.1.3 J4 and Haul Rd

Ecologia (2013b) recorded five habitat types from within the J4 mining area and Haul Road (Figure 44 and Figure 45) and described them as follows:

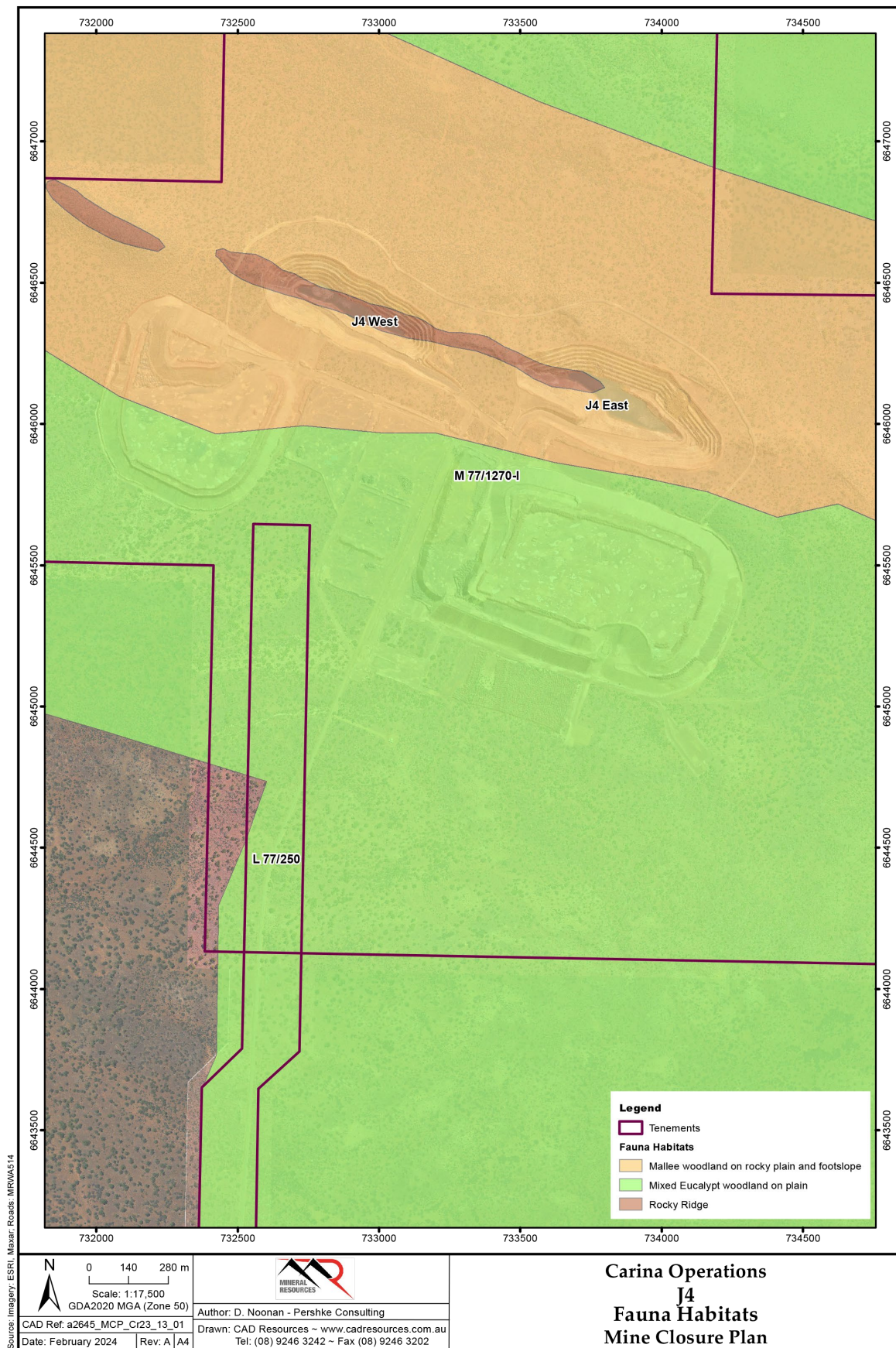
- Rocky ridge – provides potential shelter for mammals; nesting and breeding habitat for Peregrine Falcon; and habitat for herpetofauna that hunt and shelter between rockpiles. Avifauna is usually sparse due to the open vegetation and lack of flowering shrubs and trees SRE invertebrate fauna can be sparse due to hard, rocky surface and lack of cover but some scorpions may utilise patches of deeper soil and pseudoscorpions may be found under rocks. The Tree-stem trapdoor spider (*Aganippe castellum*, Priority 4) has been found to utilise this habitat type, at the base of larger trees which provide suitable leaf litter and moist conditions.
- Mallee woodland on rocky plain and footslopes – typically harbours vertebrate fauna that can occur in a variety of habitat types including mammals; generalist avifauna that inhabit patches of denser vegetation; birds of prey that utilise the open vegetation; and reptiles that do not rely on soft surfaces to construct burrows. Includes south-facing hillslopes that can support a large range of SRE habitats due to the presence of moist microhabitats, including the Tree-stem trapdoor spider. Lacks amphibians due to absence of surface water and soft substrates.
- Mixed eucalypt woodland - most dominant habitat, covering 66% of the survey area and expected to support high species diversity due to the greater structural complexity of the vegetation and the presence of tall trees that provide hollows, logs (wood debris) and habitat for arboreal species. May support mammals and bats; the avifauna can be particularly rich; herpetofauna is similarly diverse as the habitat provides shelter under logs, leaf litter and bark; and SRE invertebrate fauna, particularly Mygalomorph spiders, can also be rich due to the presence of moist microhabitats created by shade and deep leaf litter beds.
- Sandy plain with shrubland – potential habitat for mammal and reptile species that require soft substrate for the construction of burrows. Avifauna presence likely moderate but potential habitat for Malleefowl and specialised amphibians (that can aestivate in sand during summer). An abundance of leaf litter suitable habitat for burrowing Mygalomorph spiders.
- Drainage line – may attract high diversity of species when surface water is available. However, is more likely to provide moist microhabitats which could support amphibians and SRE invertebrates, enhanced by location of this drainage line on south-facing slopes of ridges in the survey area.

A sixth habitat type (Seasonal swamp) was mapped but not described due to its small area and location outside planned area of disturbance at J4.



Refer to Appendix J for pdf version

Figure 44 Fauna Habitat – J4 and Haul Road



Refer to Appendix J for pdf version

Figure 45 Fauna Habitat – J4 Mining Area

5.5.2.2 Terrestrial Fauna

5.5.2.2.1 Carina

Field survey at Carina recorded 84 native terrestrial fauna species including 22 reptiles, 59 birds and 11 native mammals (of which 8 species were bats). Bird species richness was considered relatively high particularly in the W24 and S2 vegetation areas which recorded 34 and 31 bird species respectively. The fact that no species of frogs were recorded likely reflected the lack of claypans, large granite exposures and stream habitats within the survey area (Ninox Wildlife Consulting, 2009).

Evidence of five species of feral or introduced mammal were reported based on observations of the European Rabbit (*Oryctolagus cuniculus*) and European Red Fox (*Vulpes vulpes*) and evidence of Feral Dog (*Canis f. familiaris*) and One-humped Camel (*Camelus dromedarius*). The European Rabbit (*Oryctolagus cuniculus*) was extremely common with many individuals observed, scats and diggings recorded in every site and an apparent significant grazing impact (Ninox Wildlife Consulting, 2009).

5.5.2.2.2 Carina Extended

Field survey at Carina Extended recorded 32 native terrestrial fauna species (1 frog, 5 reptiles, 25 birds and 1 native mammal). For the survey area overall (that also captured additional tenement areas in the vicinity) approximately half (110 species) of the expected assemblage (241 species) was recorded from field survey (Bamford Consulting Ecologists, 2012). Ninox Wildlife Consulting (2009) note that experience throughout Western Australia has shown that sampling in several seasons and over several years, is necessary to compile a complete inventory of small mammals, amphibians and reptiles.

One introduced species, the House Mouse (*Mus musculus*), was recorded at Carina Extended (Bamford Consulting Ecologists, 2012).

5.5.2.2.3 J4

Field survey at the J4 planned disturbance area recorded 84 native terrestrial fauna species including 28 reptiles, 46 birds and 9 native mammals (8 of which were bats). No frogs were recorded. In the broader J4 survey area, a total of 176 native species were recorded including 2 amphibians, 48 reptiles, 90 birds and 17 native mammals (9 of which were bats). This is just under half the expected native fauna assemblage (389 species) based on desktop survey for an area extending 35 km from J4 (Ecologia, 2013b).

Three introduced species were recorded at J4 including the House Mouse (*Mus musculus*), European Rabbit (*Oryctolagus cuniculus*) and Cat (*Felis catus*) (Ecologia, 2013b).

5.5.2.3 Significant Fauna Species

Conservation significant species recorded or considered to have high likelihood of occurrence across the Carina Operations are summarised in Table 29 on the basis of survey findings summarised in Sections 5.5.2.3.1 to 5.5.2.3.3 that follow.

5.5.2.3.1 Carina

No species currently listed as threatened under the EPBC Act and the BC Act or protected under the BC Act have been recorded at Carina. Three recorded bird species originally reported as conservation significant (Ninox Wildlife Consulting, 2009) are no longer listed as threatened or priority fauna (DBCA, 2023c).

Ninox Wildlife Consulting (2009) noted that the following species recorded at Carina may be habitat-specific to the BIF outcropping (DEC, 2007): the skink *Cyclodomorphus melanops elongatus*; the Little Woodswallow (*Artamus minor*); and Gilbert's Whistler (*Pachycephala inornate*). They also described

species that were not recorded but have high potential to occur within the Carina area: Fork-tailed swift (*Apus pacificus*) (Migratory [MI]); Peregrine Falcon (*Falco peregrinus*) (Other specially protected fauna [OS]); Long-tailed dunnart (*Sminthopsis longicaudata*) (Priority 4); and Woolleys' Antechinus (*Pseudantechinus woolleyae*) (not listed, but may be habitat specific to BIF outcropping, (DEC, 2007).

An inactive Malleefowl (*Leipoa ocellata*) nest was located approximately 0.5 km east of the tenement (Ninox Wildlife Consulting, 2009) and the area is within the likely distribution of the species on Species Profile and Threats (SPRAT) Database (DCCEEW, 2024) indicating likelihood of occurrence in the area.

The remains of nests constructed by the Lesser Stick-nest Rat (*Leporillus apicalis*), a species considered extinct, were noted in small caves in the BIF outcrops (Ninox Wildlife Consulting, 2009).

5.5.2.3.2 Carina Extended

One species currently listed as threatened under the EPBC Act and the BC Act, the Malleefowl (*Leipoa ocellata*) was recorded at Carina Extended through secondary evidence (old mounds). Three recorded bird species originally reported as conservation significant (Bamford Consulting Ecologists, 2012) are no longer listed as threatened or priority fauna (DBCA, 2023c).

Similarly to Carina, a number of bird species were recorded that, although not listed as threatened or priority species, may be of local conservation significance due to their association with BIF outcropping. In addition, the Rufous treecreeper (*Climacteris rufus*) was noted as a Eucalypt Woodland specialist (Bamford Consulting Ecologists, 2012).

5.5.2.3.3 J4

One species currently listed as threatened (Vulnerable) under the EPBC Act and the BC Act, the Malleefowl (*Leipoa ocellata*) has been recorded at J4 through secondary evidence (fresh tracks & old mounds). Four recorded bird species originally reported as conservation significant (Ecologia, 2013b) are no longer listed as threatened or priority fauna (DBCA, 2023c).

The Fork-tailed swift (*Apus pacificus*) (MI) and Peregrine Falcon (*Falco peregrinus*) (OS) were not recorded within the planned disturbance area but were recorded within the broader J4 survey area and are considered to have a high likelihood of occurrence at J4 (Ecologia, 2013b).

One invertebrate species, the Tree-stem trapdoor spider (*Idiosoma castellum*, formerly *Aganippe castellum*) is considered to have high likelihood of occurrence based on numerous records from within the broader survey area and one previous record within the J4 disturbance area (Ecologia, 2013b).

Table 29 Significant Fauna – Carina Operations

Common name	Species	EPBC Act	BC Act	Carina Extended	J4 Disturbance Area	J4 Survey Area
Malleefowl	<i>Leipoa ocellata</i>	VU	VU	✓	✓	-
Peregrine Falcon	<i>Falco peregrinus</i>	-	OS	-	-	✓
Fork-tailed Swift	<i>Apus pacifica</i>	MI	MI	-	-	✓
Tree-stem trapdoor spider	<i>Idiosoma castellum</i> (formerly <i>Aganippe castellum</i>)	-	P4	-	-	✓

Source: Bamford Consulting Ecologists (2012), Ecologia (2013b)

Notes:

- EPBC and BC Act Classifications: VU – Vulnerable species; MI Specially protected species - Migratory species; OS – Other specially protected fauna.
- DBCA classification: P4 – Priority 4 (rare, near threatened and other species in need of monitoring).

5.5.2.4 Short Range Endemic Fauna

5.5.2.4.1 Carina

Specimens of spiders, scorpions, pseudoscorpions and millipedes were collected from the Carina site during surveys completed in 2008 and their status reported as follows (Ninox Wildlife Consulting, 2009):

- None of the scorpions were considered to be SREs.
- All but one species of the millepede genus *Antichiropus* were confirmed as SRE. Males and females of *Antichiropus* sp. nov. ('Mt Gibson 1') were taken at two sites at Carina and the specimens were found to be conspecific with a species so far known only from Mt Gibson. As this species is only known from two localities, although widely spaced, it was considered an SRE. Specimens were collected from both Carina and another Polaris tenement (Chameleon), confirming the population extended over at least a 12 km range locally.
- The taxonomic status and difficulties in identifying female and juvenile spiders (the *Missulena* 'occatoria' group and the spider *Aganippe*) did not allow for a definitive statement on their status as SRE.
- Specimens of land snails collected at Carina belong to the families Bulimulidae, Punctidae, Pupillidae and Camaenidae. None were considered to be SREs.

5.5.2.4.2 Carina Extended

A total of 19 taxa representing four orders (Araneae, Diplopoda, Gastropoda, Isopoda) and 10 families were collected from the Carina Extended survey area and analogue locations in 2011 (Dalcon Environmental, 2012).

No confirmed SRE were collected from Carina Extended at the time of the survey. One confirmed SRE, Diplopoda *Antichiropus* 'Mt Jackson 1' is now known from both Carina Extended, another Polaris tenement (10 – 12 km from Carina Extended) and other sites approximately 70 km to the north west (Polaris Metals, 2013a).

Nine potential SRE taxa (5 Mygalomorphs, 3 Pseudoscorpions and 1 Isopoda) representing 4 families were collected from Carina Extended. All but one (Teyl 'MYG021') were collected from other locations surveyed in 2011. Teyl 'MYG021' was collected from another Polaris tenement 10 – 12 km from Carina Extended surveyed in 2008 (Ninox Wildlife Consulting, 2009) confirming that none of the potential SRE taxa collected are unique to the Carina Extended project area (Polaris Metals, 2013a).

5.5.2.4.3 J4 and Haul Road

A total of 40 potential SREs, four likely SREs and five confirmed SRE species were collected from the J4 survey area and planned project disturbance area including (Ecologia, 2013b):

- 23 morphospecies of spider, including 2 likely SRE and 12 potential SRE species.
- 11 morphospecies of scorpion, including 4 potential SRE species.
- 17 morphospecies of pseudoscorpion, including 11 potential SRE species.
- 14 morphospecies of isopod, including 1 confirmed SRE, 7 potential SRE and 2 likely SRE species.
- 10 morphospecies of snail, including 3 potential SRE species.
- 5 morphospecies of millipedes, including 4 confirmed SREs.
- 1 species of centipede, a potential SRE.
- 3 morphospecies of geophilomorph, including two potential SREs.

Of these, one likely SRE (*Idiosoma* sp. indet) and three potential SREs (*Aname* 'MYG279', *Kwonkan* sp. indet. and 'PSEAAD PSE076'), were recorded from within the J4 impact area only. 'PSEAAD PSE076' represented a new genus and species of pseudoscorpion (Ecologia, 2013b).

It was considered likely that the high level of short range endemism identified in the impact area was to a large part due to the low taxonomic resolution achievable due to the lack of mature males in the sample (Ecologia, 2013b).

5.5.2.4.4 Aurora

Short-range endemic fauna survey was not completed prior to development of the Aurora site in 1993. The guidance for assessment of SRE invertebrate fauna for formally assessed development proposals was not released until 2009.

5.5.2.5 Stygofauna and Troglifauna

5.5.2.5.1 Stygofauna

Sampling at Carina (Bennelongia, 2009), Carina Extended (Bennelongia, 2011) and J4 (Ecologia, 2013b) resulted in no stygofauna records, despite measured groundwater physico-chemistry parameters at J4 being within habitable ranges for stygofauna.

Subterranean fauna surveys conducted in the wider region also suggest a lower abundance and diversity of both troglifauna and stygofauna in the Yilgarn region than in the Pilbara. The calcrete aquifers of the northern Yilgarn are associated with stygofauna, whilst the southern Yilgarn (south of Menzies), is considered less suitable for stygofauna due to the absence of groundwater calcretes and less favourable groundwater (Biota, 2019) as cited in (MinRes, 2023d).

A subterranean fauna assessment was not completed for Aurora, but as the mine void is above the water table, this is not considered a knowledge gap for closure.

5.5.2.5.2 Troglifauna

Carina

A total of six troglifauna species were found at Carina (from 72 samples), four species within the proposed pit and two outside. Three of the four species within the proposed pit were known to occur elsewhere, including another *Polaris* tenement 12 km away. The fourth species, a dipluran, *Parajapygidae* sp B6 was represented by a single individual. Although it was known only from the proposed pit that was considered likely to be an artefact of a single specimen being collected. *Parajapygidae* sp. B6 was found in mafic schist, which is a widespread habitat in the area, and so the species is likely to be more widespread (Bennelongia, 2009).

Carina Extended

Survey of the Carina Extended area in 2010 (66 samples collected) supported the findings at Carina, i.e., the occurrence of a low diversity troglifauna community occurring at low abundance in the Carina / Carina Extended project area (Bennelongia, 2011).

The troglifauna community at Carina Extended comprised approximately 15 species belonging to eight Orders / Classes. The majority of species occurred in very low abundance, with less than 5 specimens recorded. Isopods and diplurans dominated the community, each providing 27% of the species. The structure of the Carina / Carina Extended troglifaunal community was similar to that of the nearby Mount Jackson and Koolyanobbing Ranges at the Order / Class level; with the notable exception that arachnid Orders present at the latter sites were absent from the Carina / Carina Extended community (Bennelongia, 2011).

The troglofauna species recorded during the Carina / Carina Extended troglofauna surveys appeared to have ranges that were mostly restricted on a sub-regional scale, i.e., to the Hunt Range. It was concluded that troglofauna species were not restricted within the Hunt Range because specimens of the same troglofauna species occur in multiple deposits within the Hunt Range; and troglofauna occur in both mineralised and non-mineralised lithologies within the Hunt Range (Bennelongia, 2011).

J4

Five troglobitic morphospecies from two Orders (Isopods and Bristle Millipedes) were collected from the J4 planned disturbance area. Samples were collected from a two-phase trapping survey of ten drill holes (two traps were installed in the second phase resulting in 30 samples in total) (Ecologia, 2013b).

Of these, three morphospecies were considered likely SRE and were to be subject to morphological comparison with specimens collected previously in the region (Ecologia, 2013b). The poor condition of reference specimens collected during previous surveys in the region however, prevented a morphological comparison (MinRes, 2023a).

5.5.2.6 Groundwater Dependent Ecosystems

There are no known GDEs within the Carina Operations area but generic mapping (BoM, 2024d) identifies some areas with high potential for aquatic GDEs that appear to be associated with playa lake systems. One of these occurs in the vicinity of the Carina site and its nature and status need to be confirmed (Figure 46).

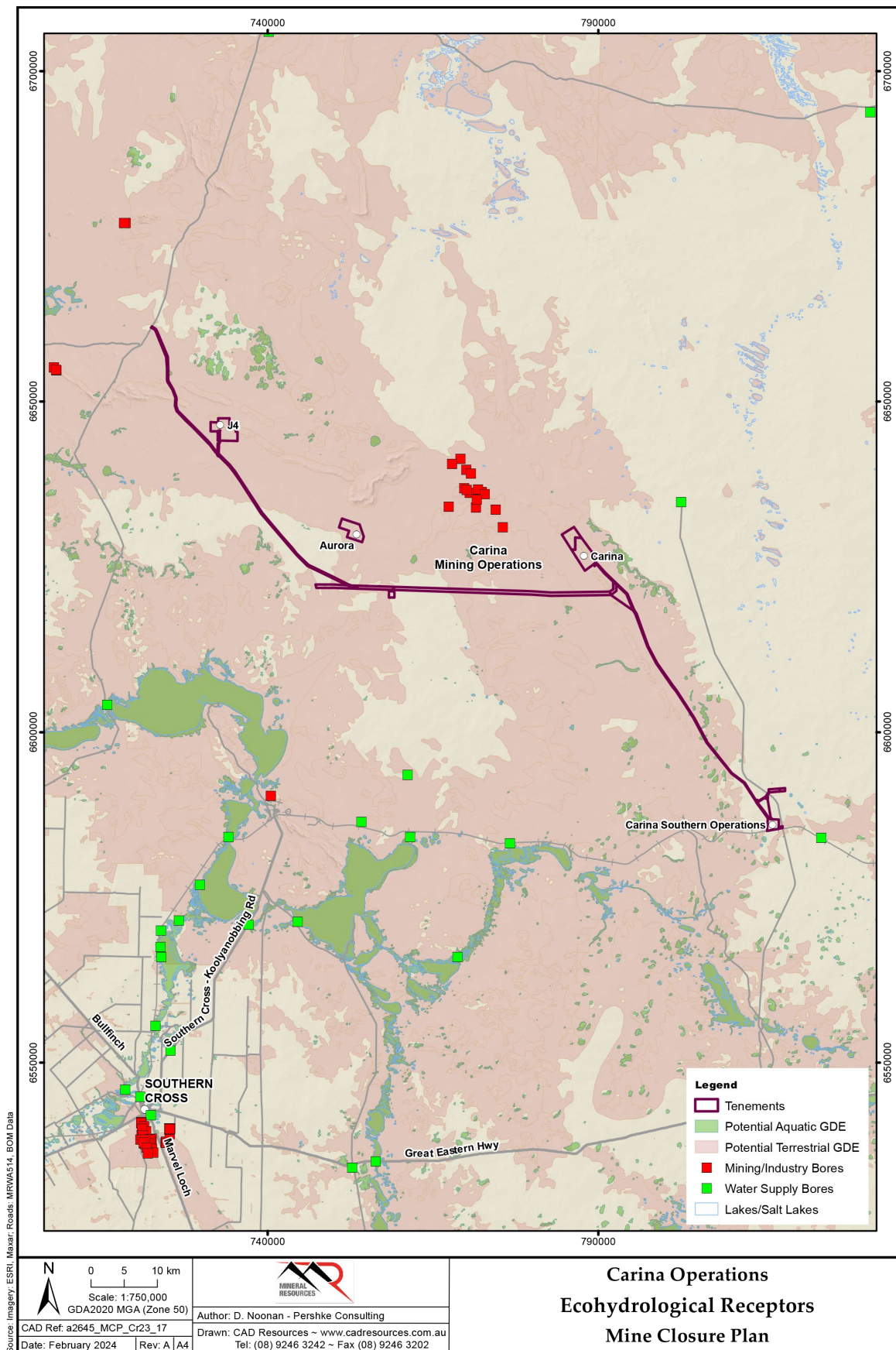
The Australian GDE toolbox (S Richardson (SKM), 2011) identifies three classes of GDE:

- Aquifer and cave ecosystems (Type 1) provide unique habitats for living organisms (e.g., stygofauna and troglofauna).
- Ecosystems dependent on the surface expression of groundwater (Type 2) include wetlands, lakes, seeps, springs, river baseflow, coastal areas and estuaries that constitute brackish water and marine ecosystems. In these cases, the groundwater extends above the earth surface, as a visible expression and provides water to support aquatic biodiversity by providing access to habitat (especially when surface run-off is low) and regulation of water chemistry and temperature.
- Ecosystems dependent on subsurface presence of groundwater (Type 3) which includes terrestrial vegetation that depends on groundwater fully, or on a seasonal or episodic basis, in order to prevent water stress and generally avoid adverse impacts to their condition. In these cases, and unlike the situation with Type 2 systems, groundwater is not visible from the earth surface. These types of ecosystems can exist wherever the water table is within the root zone of the plants, either permanently or episodically.

Although the GDE Atlas indicates some low to moderate potential for terrestrial GDEs in the Carina Operations Area (Figure 46), none of the vegetation baseline investigations for the Carina Operations identified groundwater dependent ecosystems, likely reflecting the depth and quality of groundwater.

The GDE Atlas includes no data on subterranean ecosystems for Western Australia (BoM, 2024d).

As discussed in 5.5.2.7, no listed TEC are present in the area (DBCA, 2023d), nor PECs associated with subterranean fauna (DBCA, 2023e).



Refer to Appendix J for pdf version

Figure 46 Ecohydrological Receptors

ENV-TS-RP-0617

5.5.2.7 Threatened and Priority Ecological Communities

No listed TEC have been recorded in the Carina Operations area (Figure 38) (DBCA, 2023d).

5.5.3 Considerations for Closure

Vegetation and Flora

Baseline vegetation and flora survey data, together with soil – vegetation associations (Section 5.3.5.1.3), inform:

- reference ecosystems for reconstructed landforms and other disturbed areas suitable for to the post-mining land use (Section 9.1.4);
- which in turn inform species lists for native seed collection (Section 9.1.4); and
- vegetation completion criteria (refer to Section 8.2).

MinRes also has legal obligations to restrict direct disturbance of the W22 and S2 vegetation communities to the area specified in Ministerial Statements 852 and 957 and to monitor the health and condition of the vegetation located within 1 km of the project boundary (Appendix A-4). This requires consideration for closure planning aspects such as abandonment bund construction that may require additional disturbance and for closure execution (e.g., dust control).

MinRes also has closure obligations for weed and Phytophthora Dieback management at the Carina Operations arising from tenement and Ministerial Statement conditions (0). Weed control and dieback hygiene are implemented throughout operations and it is expected they will remain a closure management requirement during the post-closure monitoring and management phase (Section 10) to enable achievement of completion criteria (Section 8.2).

Baseline weed data will be an important input for setting and assessing completion criteria for weeds. MS 852 requires that no new weed species are introduced into the Carina project area and that the extent of weed cover shall not exceed that identified in the baseline survey (or on nearby comparable land), whichever is less.

Fauna

While no known GDEs have been mapped within the Carina Operations, one potential aquatic GDE is mapped less than 5 km to the north east of the Carina mine area. It is possible that this is associated with a small playa lake system but this needs to be confirmed.

The Threatened fauna species, Malleefowl (*Leiopa ocellata*) will require continued consideration into the closure phase to avoid injury and disturbance to mounds (unless unavoidable and approved) during closure execution.

Objectives for re-creation of fauna habitat will provide an input to the revegetation species mix

MS 852 required (prior to the commencement of operations) the submission of ‘strategies to avoid fauna deaths in areas of mining, the haul road, the rail siding and other areas’. These strategies are address in the Carina and J4 PEMP (Polaris Metals, 2023).

The Carina PEMP will be implemented as relevant to the post-closure monitoring and management phase (Section 10) to enable achievement of completion criteria (Section 8.2). In particular, monitoring is required to demonstrate that water within pit lakes does not:

- Result in an increase in introduced fauna to a level that may have a measurable impact on conservation significant flora and vegetation or conservation significant fauna species.
- Directly impact native fauna that uses it as a water source.

There are no further considerations for closure of the Carina Operations associated with SRE or subterranean fauna species.

5.5.4 Knowledge Gaps & Forward Work Program

The following actions are proposed to address biodiversity related knowledge gaps:

- Refine reference ecosystem(s) and species mix for all domains to be rehabilitated, with consideration to cover materials properties (as a growth substrate) and the PMLU.
- As closure designs progress into execution plans at Carina, consider the potential impacts to the W22 and S2 vegetation communities arising from design changes and clearing required for construction access.
- Investigate additional weed monitoring methods, such as aerial survey techniques, to maximise effectiveness of weed control efforts.
- Conduct a pit lake risk assessment to assess the likelihood of significant numbers of feral fauna being attracted to the lake and the potential impacts of pit lakes on native fauna.
- Confirm the nature and status of the potential aquatic GDE, that appears on the GDE Atlas (BoM, 2024d), 5 km north east of the Carina Operations.

5.6 Hydrology

5.6.1 Surface Water

Key Points

- Carina Operations Overall
 - o The Carina Operations intersect several surface water sub catchments of Western Australia, in the Avon River Basin.
 - o Surface water run-off occurs in response to large storm events or following rare periods of prolonged rainfall. During these events, surface water flow may be channelised where there is sufficient convergence of flow, but in smaller drainage systems, and occurs predominantly as sheet flow.
 - o The Carina Operations do not intersect any Surface Water Proclamation Area, Irrigation District, Water Management Zone or Waterway Management Area under *the Rights in Water and Irrigation (RIWI) Act 1914*.
 - o Due to the ephemeral nature of surface water run-off and water bodies in the region there is no baseline surface water quality or flow data for the Carina Operations.
- Carina
 - o The Carina project is situated in the Lake Eva sub catchment which drains in a southerly direction, ultimately entering a system of lakes through the northern limit of Lake Eva which is approximately 45 km south of the Carina mine area.
 - o The Carina Pit / WRL area has a local upstream catchment of approximately 38 km².
 - o Flood modelling of 1 in 2,000 AEP events showed that the floodplain reaches the southeastern end of the abandonment bund, with depths in the order of 0.1 to 0.3 m and velocities between 0.6 and 0.8 m/s. The PMF event was also modelled, and the area of interaction between the floodplain and the abandonment bund was the same but at higher depth and velocity.
 - o Incorporation of a flood protection bund into the abandonment bund has been recommended. Geotechnical and construction specifications for the flood bund are yet to be developed.
 - o The 1 in 2000 AEP and PMF floodplains also interact with a road proposed to be retained post-closure with the potential to affect the integrity of the road in a major storm event.
- Carina Extended
 - o A small (6 ha) catchment upstream of the Carina Extended abandonment bund has the potential to cause erosion but the risk is not considered significant from a surface water perspective. It is noted however as a consideration for abandonment bund design from a safety perspective (Section 9.2.1.2).
- J4
 - o The J4 operations are situated in the Muka surface water sub catchment, approximately 40 km east of the Lake Hamersley playa lake system.
 - o The J4 pits are located on ridge lines that define the boundaries between northern and southern drainage systems, with the WRLs located nearby to the pits.
 - o The effect of regional flooding on both the pits and WRLs would, therefore, be negligible post-closure.
- Aurora
 - o The Aurora site is situated in the far eastern extent of the Muka sub catchment which drains in a westerly direction toward the Hamersley Lakes, which are approximately 60 km west of the site.
 - o The site is located on a local topographic high and is nearby to a regional watershed directing water away from the site to the north and south.
 - o Flood modelling indicates that the proposed abandonment bund will prevent floodwaters from a 1 in 2,000 event and a PMF event entering the Aurora Pit. Flood depths and velocities indicate that the risk of scouring and erosion are low and that no armouring is required.

- o Flood plain impacts at the toe of the WRL indicate minor potential for sediment release in a PMF event. It is noted however that rectification works are required to control the surface water run-off from the WRL itself that is currently causing erosion and sediment release from the batter slopes.

5.6.1.1 Regional Hydrology

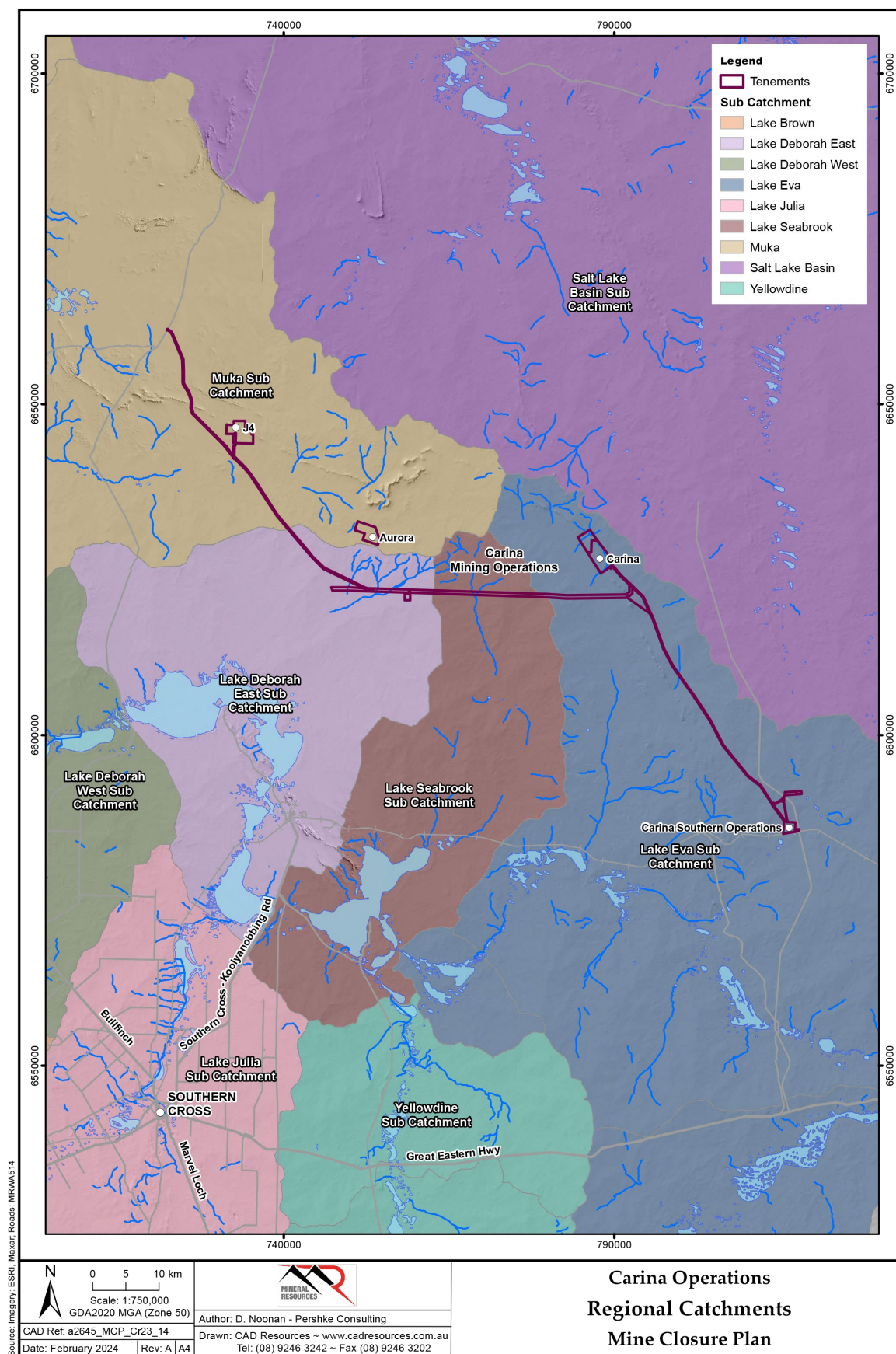
The Carina Operations lie at the eastern margin of the southwest drainage division of WA in the Avon River Basin. Topography is generally subdued, with elevations in the range of 400 to 600 m AHD, and narrow ranges which rise to 150 m above the surrounding country. Local surface water drainage comprises poorly defined, ephemeral creek channels which drain from the ranges towards a network of playa lakes located in broad, shallow valleys. The playa lakes are generally internally draining and act as sinks for run-off from the upgradient areas. The largest playa lakes in the region are Lake Seabrook, Lake Deborah East and the Hamersley Lakes (PSM Consult Pty Ltd, 2023 Draft) (Figure 47). These lakes are large, intermittent salt lakes that are generally dry through most years and only fill following periods of significant rainfall (i.e., every ten years or more).

Surface water run-off occurs in response to large storm events or following rare periods of prolonged rainfall. During these events surface water flow may be channelised where there is sufficient convergence of flow but in smaller drainage systems occurs predominantly as sheet flow (PSM Consult Pty Ltd, 2023 Draft).

No nationally significant wetlands are known in the Coolgardie Bioregion (DAWE, 2005). Lake Deborah East and West were listed as wetlands of sub-regional significance for the maintenance of ecological processes at a sub-regional scale (Cowan, 2001).

The Carina Operations do not involve the taking and / or use of surface water. In addition, the operations do not intersect any Surface Water Proclamation Area, Irrigation District, Water Management Zone or Waterway Management Area under the RIWI Act 1914.

Minimal stream flow or gauging data are available for inland Australia. The nearest stream flow gauge is Lake Ace Creek Hatters Hill, approximately 250 km to the south of the Carina Operations. This gauge is in a much less arid region and is likely to have significantly differing governing loss / infiltration values and therefore of limited value in assessing the catchments of the Carina Operations (PSM Consult Pty Ltd, 2024).



Refer to Appendix J for pdf version

Figure 47 Carina Operations Regional Catchments

5.6.1.2 Local Hydrology

5.6.1.2.1 Carina, Carina Extended and Carina Southern Operations

The Carina project is situated in the Lake Eva sub catchment which drains in a southerly direction, ultimately entering a system of lakes through the northern limit of Lake Eva which is approximately 45 km south of the Carina mine area (Golder Associates, 2013a) (Figure 48).

The Carina and Carina Extended Pits are situated near minor ridge lines.

The Carina mine area has a local upstream catchment of approximately 38 km² which includes stream reaches flowing adjacent to the pit. The Carina Pit abandonment bund is approximately 2.7 m higher than the thalweg¹⁹ of the stream at the southeastern side of the pit (PSM Consult Pty Ltd, 2024) (Figure 49).

The Carina Extended mine area lies to the south-east of a catchment of 17 km². This catchment is drained by a stream which has a thalweg approximately 5.9 m lower than the elevation of the Carina Extended Pit abandonment bund (PSM Consult Pty Ltd, 2024) (Figure 49). There is a small 6 ha catchment located on the north eastern side of the abandonment bund (Figure 50).

The Carina Mine Infrastructure Area (CMIA) (at the Carina mine area) is located adjacent to an ephemeral stream draining a small sub-catchment to the north-east. A small flood bund has been installed around this area.

Surface soils in the Carina mine area are typified by a gravelly, silty, sand.

Catchment characteristics for the Carina mine area are presented in Table 30.

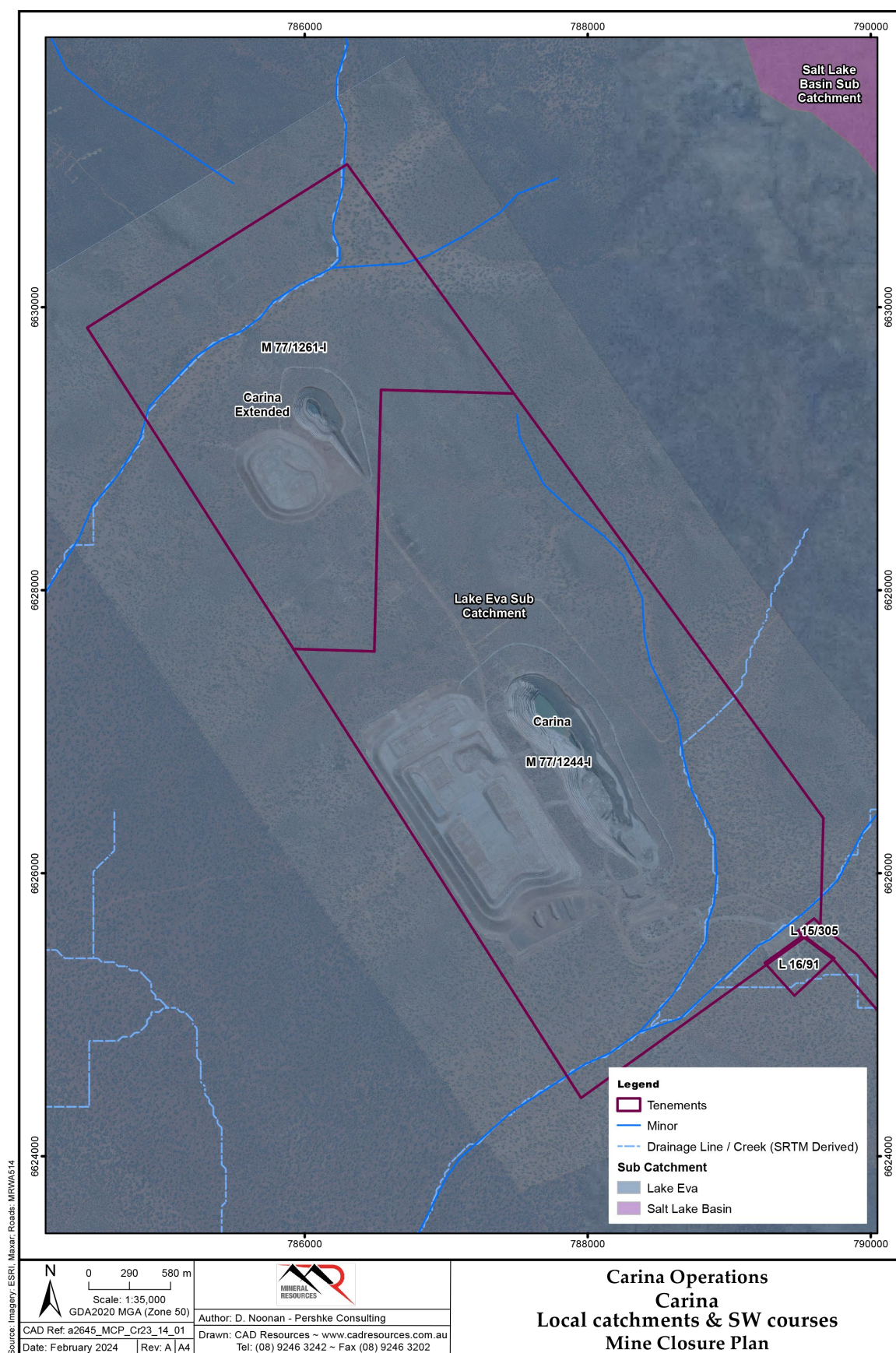
Table 30 Catchment Characteristics Carina

Attribute	Carina
Centroid longitude	120.03°
Centroid latitude	-30.45°
Modelled outlet longitude	120.00°
Modelled outlet latitude	-30.47°
Area (km ²)	38
Mainstream length (km)	6.9
Equal area slope (m / km)	6.1
Maximum catchment elevation (mRL)	513
Average flow distance (km)	4.8
Typical drainage direction	South – west

Source: PSM Consult Pty Ltd (2024)

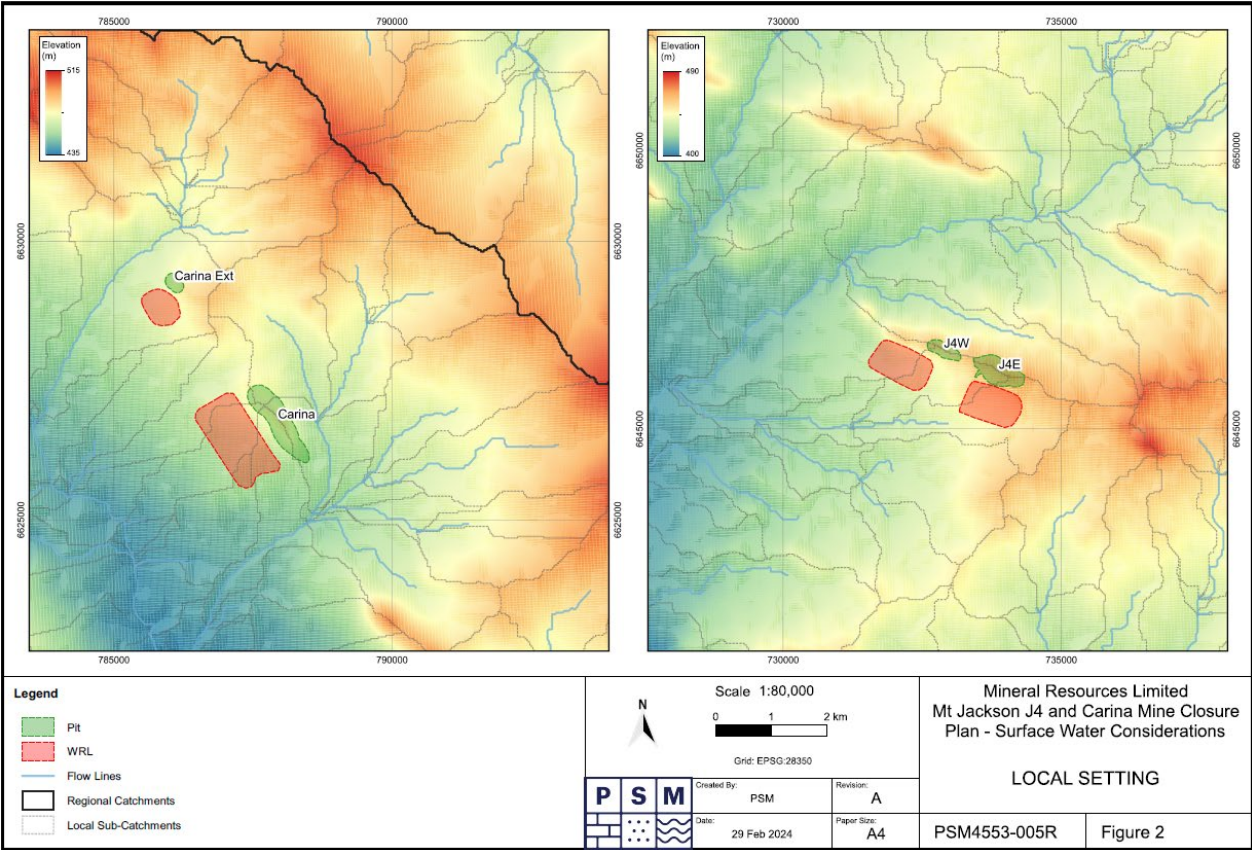
Local hydrology for the Carina Southern Operations is depicted in Figure 51. Hydraulic modelling to inform final landform design for this Infrastructure / General Disturbance domain is yet to be completed.

¹⁹ Thalweg - a line connecting the lowest points of successive cross-sections along the course of a valley or river.



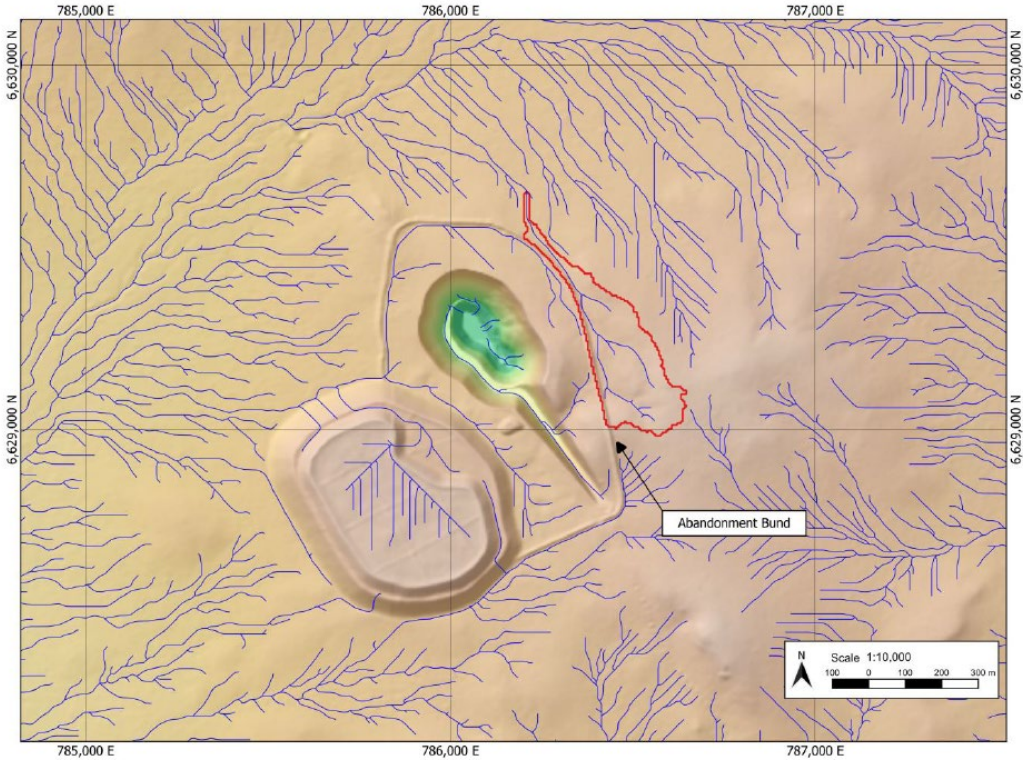
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Figure 48 Local Catchments – Carina and Carina Extended



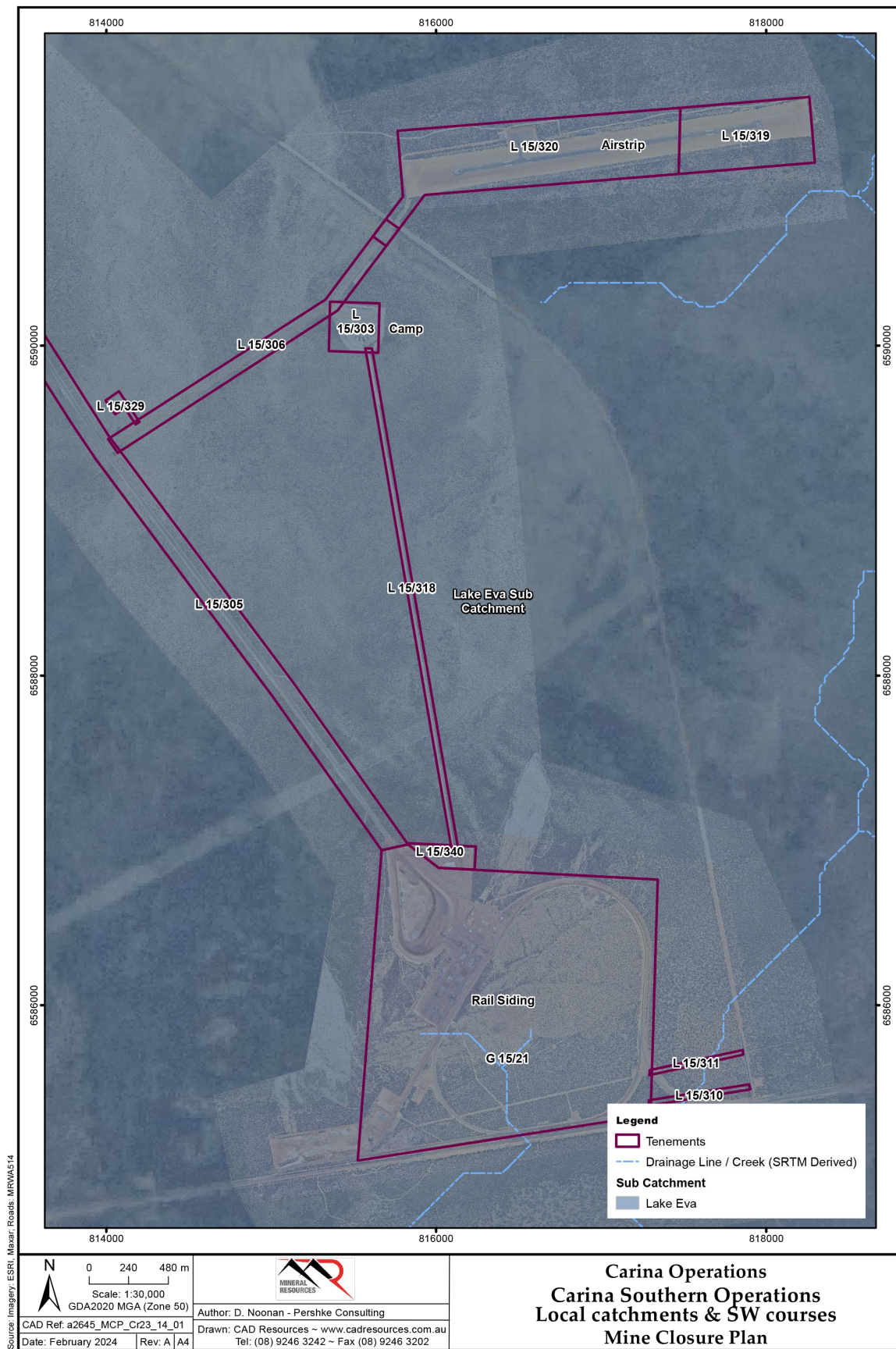
Source: PSM Consult Pty Ltd (2024)

Figure 49 Carina and J4 Local Hydrology



Source: PSM Consult Pty Ltd (2024)

Figure 50 Carina Extended Local Catchment



Refer to Appendix J for pdf version

Figure 51 Local Catchments – Carina Southern Operations

5.6.1.2.2 J4

The J4 Deposit is situated toward the eastern extent of the Muka sub catchment which drains in a westerly direction toward the Hamersley Lakes, approximately 50 km west of J4 (Golder Associates, 2013a).

The J4 Deposit is located on a ridge of chert and BIF which forms a catchment divide between northern and southern surface water drainage systems (Golder Associates, 2013a) (Figure 49 and Figure 52).

The maximum elevation of the ridge at J4 is 475 m AHD, which is about 50 m higher than the surrounding plain (Rockwater Pty Ltd, 2015). The J4 pits are more than 25 m higher than the main local streamline to the northwest (Figure 49). The WRLs are near the boundary of local sub catchments draining to the southwest (PSM Consult Pty Ltd, 2024).

The haul road alignment from the J4 site to the main haul road corridor does not cross any clearly defined surface water drainage systems. The main haul road corridor running east west towards Carina intersects up to 15 surface water drainage systems (Golder Associates, 2013b) (Figure 54).

Table 31 Catchment Characteristics for Identified J4 Haul Road Upslope Catchments

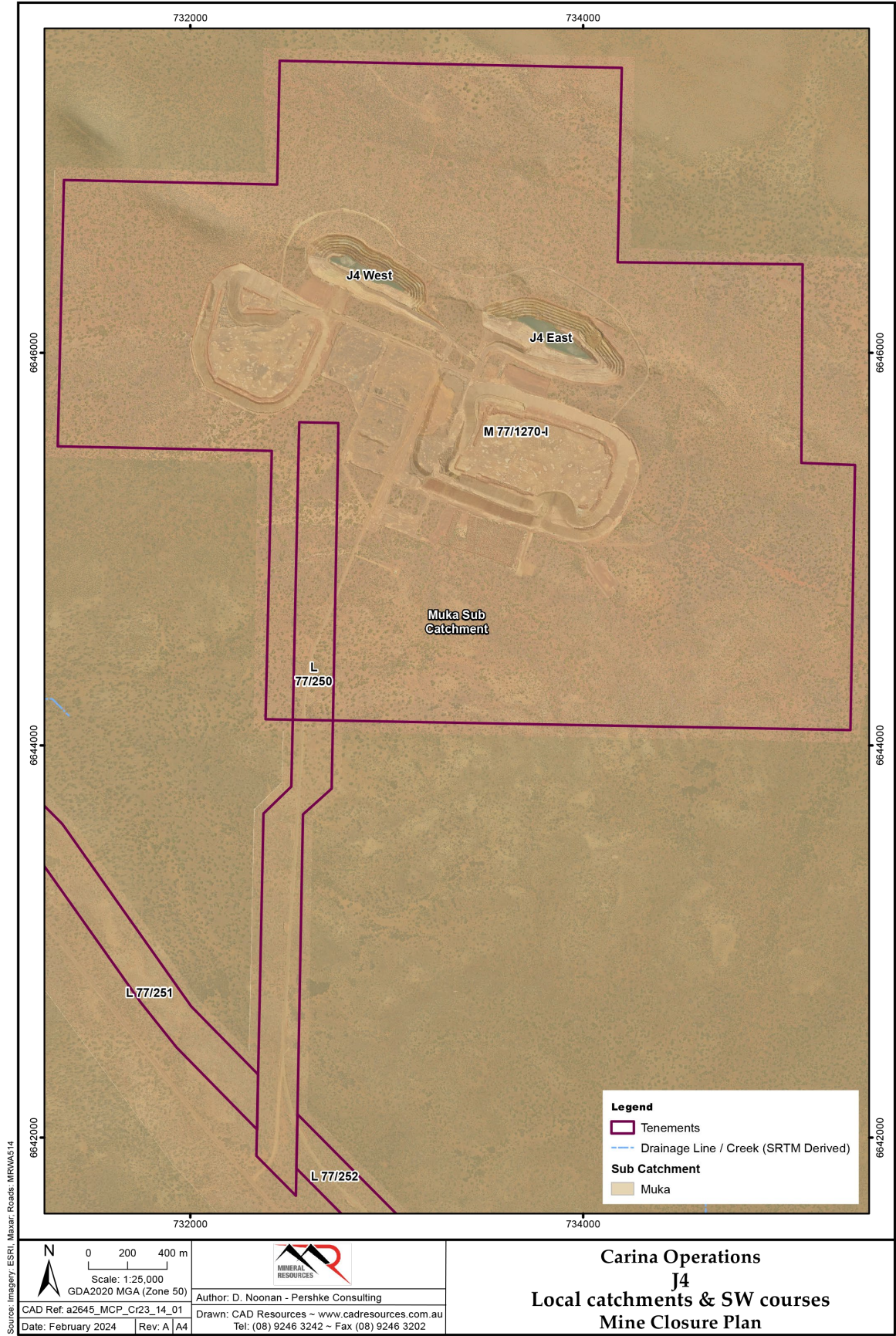
Catchment	Area (km ²)	Main Stream Length (km)	Slope (m / km)
1	588.0	42.2	1.9
2	196.9	25.4	2.6
3	168.8	19.0	3.4
4	14.7	5.0	5.0
5	10.8	3.2	9.4
6	7.2	2.1	9.5
7	11.0	2.9	8.6
8	23.5	5.0	8.0
9	21.8	6.9	7.2
10	37.2	6.6	5.3
11	26.5	6.5	4.6
12	32.7	7.9	3.8
13	52.1	8.3	4.8
14	281.9	23.5	2.1
15	17.0	4.6	5.4

Source: Golder Associates (2013b)

5.6.1.2.3 Aurora

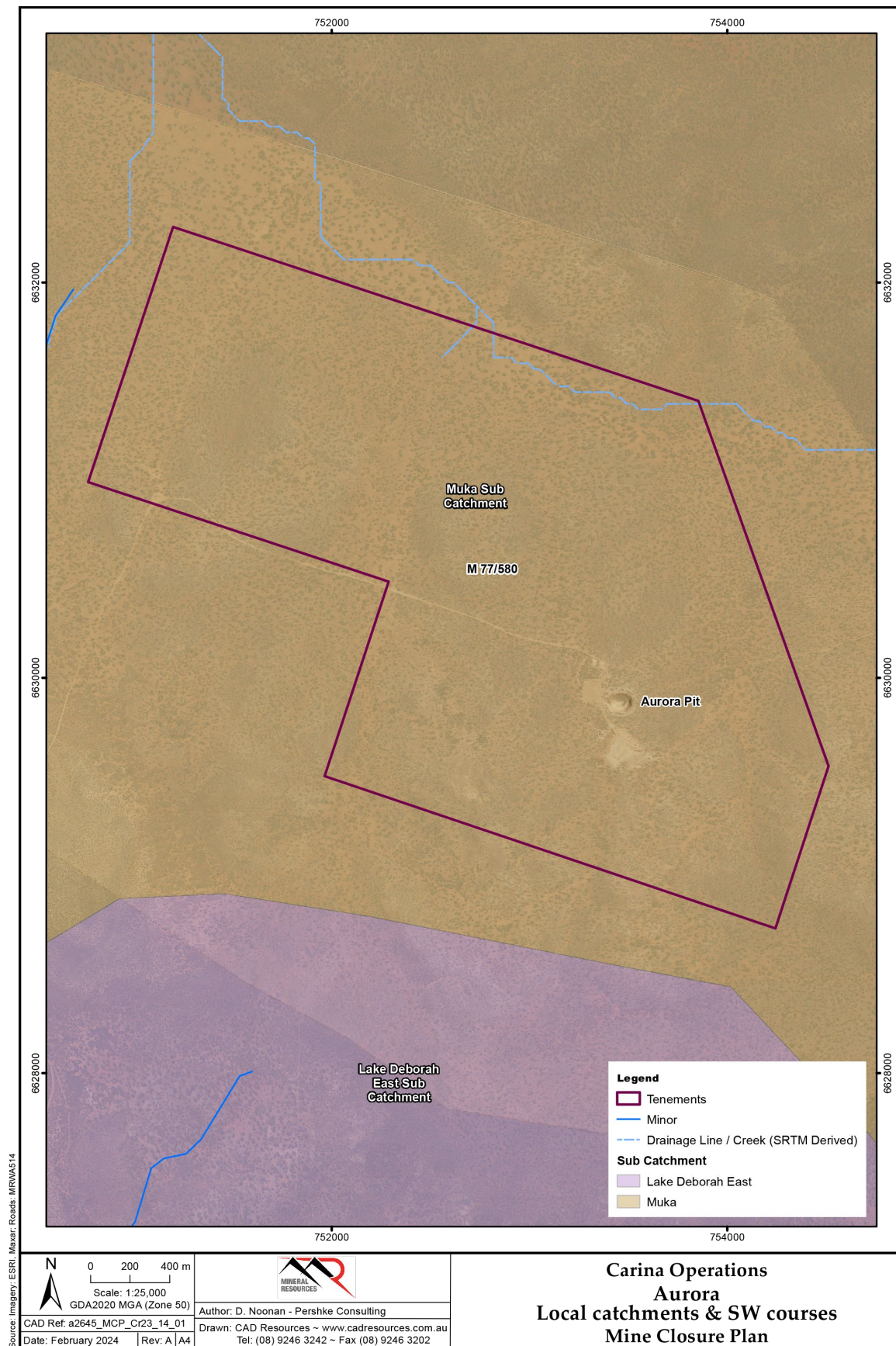
The Aurora site is situated in the eastern portion of the Muka sub catchment which drains in a westerly direction toward the Hamersley Lakes, which are approximately 60 km west of the site (Figure 47).

The site is located on a local topographic high and is nearby to a regional watershed directing water away from the site to the north and south. The general surface is flat with a slight gradient and there are no rock outcrops in the site area. There are no permanent water bodies or wetlands in the vicinity of the site (WMS, 2024) (Figure 53).



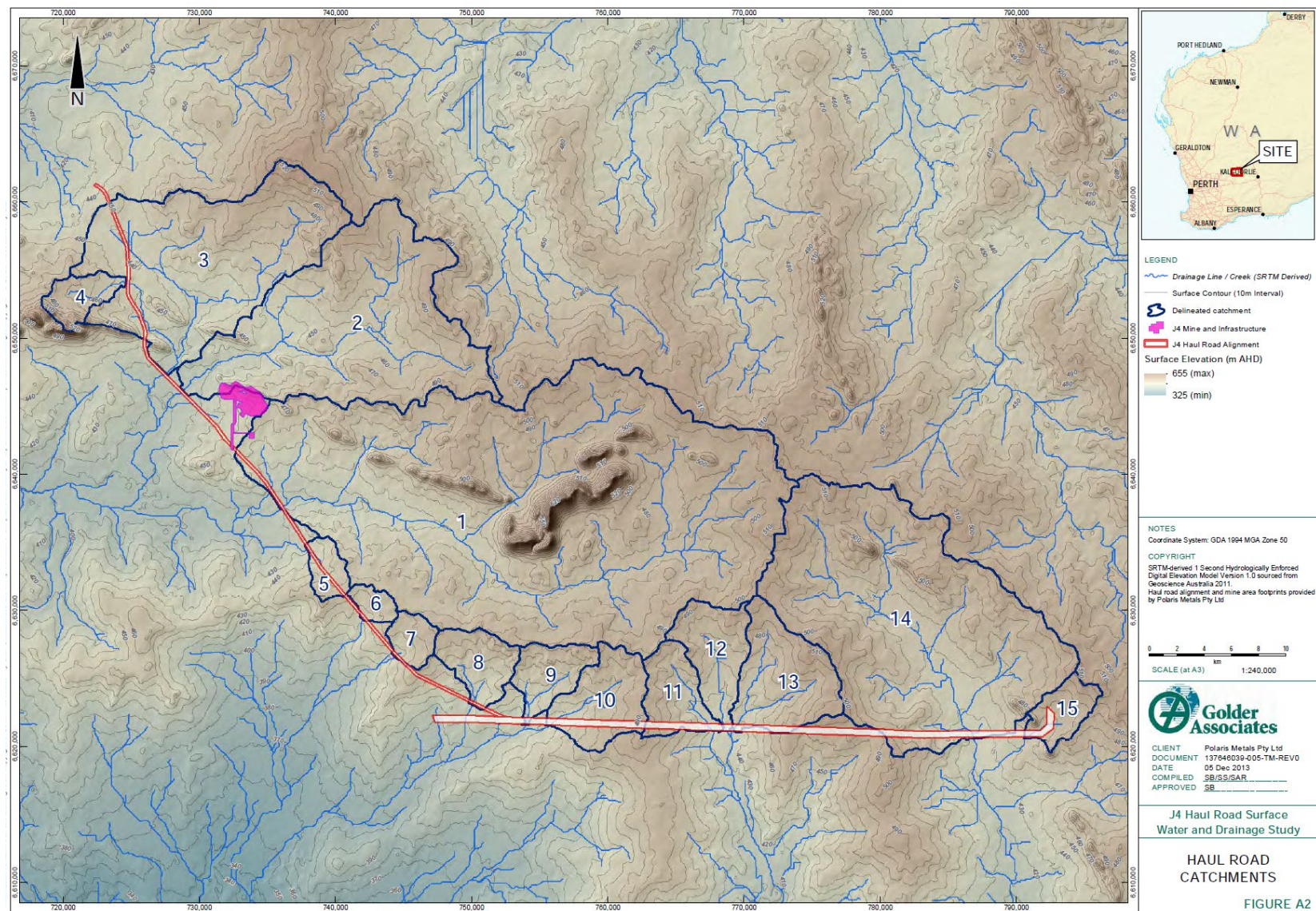
Refer to Appendix J for pdf version

Figure 52 Local Catchments – J4



Refer to Appendix J for pdf version

Figure 53 Local Catchments – Aurora



Source: Goldier Associates (2013b)

Figure 54 J4 Haul Road Local Hydrology
ENV-TS-RP-0617

5.6.1.3 Surface Water Quality

Due to the ephemeral nature of surface water run-off and water bodies in the region there is no baseline surface water quality data for the Carina Operations.

5.6.1.4 Flood Potential

5.6.1.4.1 Carina / Carina Extended

The Carina and Carina Extended Pits are situated near minor ridge lines as discussed in Section 5.6.1.2.1.

Detailed investigation of the floodplain around the Carina Pit and Carina WRL was considered necessary to understand the potential flood impacts. The assessment and results for 1:2,000 AEP and PMF surface water events are described below.

The Carina Extended site is approximately 5.9 m higher than the nearest main creek line and has a smaller catchment than the Carina site. As modelled flood depths for the Carina site were generally less than 2 m for the PMF event, it was considered that this creek line does not pose any significant risk to Carina Extension WRL, and no detailed flood modelling was warranted. As discussed in Section 5.6.1.2.1 (Figure 50), there is a small 6 ha catchment located on the northeastern side of the Carina Extension abandonment bund which will drain adjacent to the abandonment bund toe before flowing to the main creek line further to the northwest. However, this is unlikely to cause an excessive risk due to the small catchment, relative to the significantly larger catchment modelled for the Carina mine site. Given the small size of the catchment, there would also not be a significant impact on the pit or downstream environment if this bund were to breach. Based on insignificant risk from a surface water perspective, the flow generated by this catchment was not modelled in detail (PSM Consult Pty Ltd, 2024). This finding is however noted as a consideration for abandonment bund design from a safety perspective (Section 5.6.1.5 and Section 9.2.1.6).

PEAK FLOW ESTIMATES

Peak surface flow estimates inform the flooding characteristics of the local floodplain and have been determined for the Carina mine area based on catchment characteristics (Table 30) and rainfall estimates for up to a 1 in 2,000 AEP event. Catchment run-off parameters include estimates of areal reduction factors, storm temporal patterns and regional loss parameters assessed from the Australian Rainfall and Runoff data hub (<https://data.arr-software.org/>) and Book 5 of AR&R (Ball, 2019) (PSM Consult Pty Ltd, 2024) and are provided in Appendix C. Temporal patterns for short duration, extreme storm events were sourced from Jordan *et al.* (2005) as cited in (PSM Consult Pty Ltd, 2024). Estimates of peak flow run-off flows for the Goldfields region were sourced from Flavell (Flavell, 2012) as cited in (PSM Consult Pty Ltd, 2024).

Probable Maximum Precipitation (PMP) rainfall depths (provided in Appendix G) were estimated using the Generalised Short Duration Method (GSDM) using the following parameters (PSM Consult Pty Ltd, 2024):

- Catchment area of 38 km²
- Duration limit of 4.5 hours
- 80% smooth and 20% rough terrain category
- Catchment Elevation Factor of 1
- Moisture Adjustment Factor of 0.76.

Characteristics of the PMP event were used to extrapolate loss parameters for the 1 in 2,000 AEP event. As all upstream catchments are less than 100 km², the PMP has an estimated AEP of 1 in 10,000,000

(PSM Consult Pty Ltd, 2024). Given the catchments are located in the arid region an Initial Loss (IL) = 0 mm and Continuing Loss (CL) < 3 mm/hr is recommended (PSM Consult Pty Ltd, 2024).

A combination of regional methods and hydrologic modelling (using the RORB²⁰ software) was used to develop estimates of peak flood estimates and hydrographs. The use of multiple methods allowed an understanding of the uncertainty in estimates of peak flow run-offs. Interpolation between the 1 in 100 AEP and PMP allows estimation of the IL and CL parameters for the 1 in 2,000 AEP event (Table 32).

Table 32 Extrapolated IL and CL for 1 in 2,000 AEP Event in the Carina Mine Area

Catchment	Initial Loss (IL) (mm)	Continuing Loss (CL) (mm / hr)
Carina	6.8	2

Source: PSM Consult Pty Ltd (2024)

RORB modelling of the 1 in 2,000 AEP event using the loss parameters in Table 32 produced the design peak flows presented in Table 33. A k_c of 2.81 and an m value of 0.8 were adopted as described in (PSM Consult Pty Ltd, 2024).

Table 33 Design Peak Flows for 1 in 2000 AEP – Carina Catchment

	IL/CL Method		PL/Method	
	Peak Flow (m ³ /s)	Critical Duration	Peak Flow (m ³ /s)	Critical Duration
Flatlands West temporal patterns applied	409	1.5 hr	327	1.5 hr
Jordan et al. (2005) temporal patterns applied	410	1.5 hr	331	1.5 hr

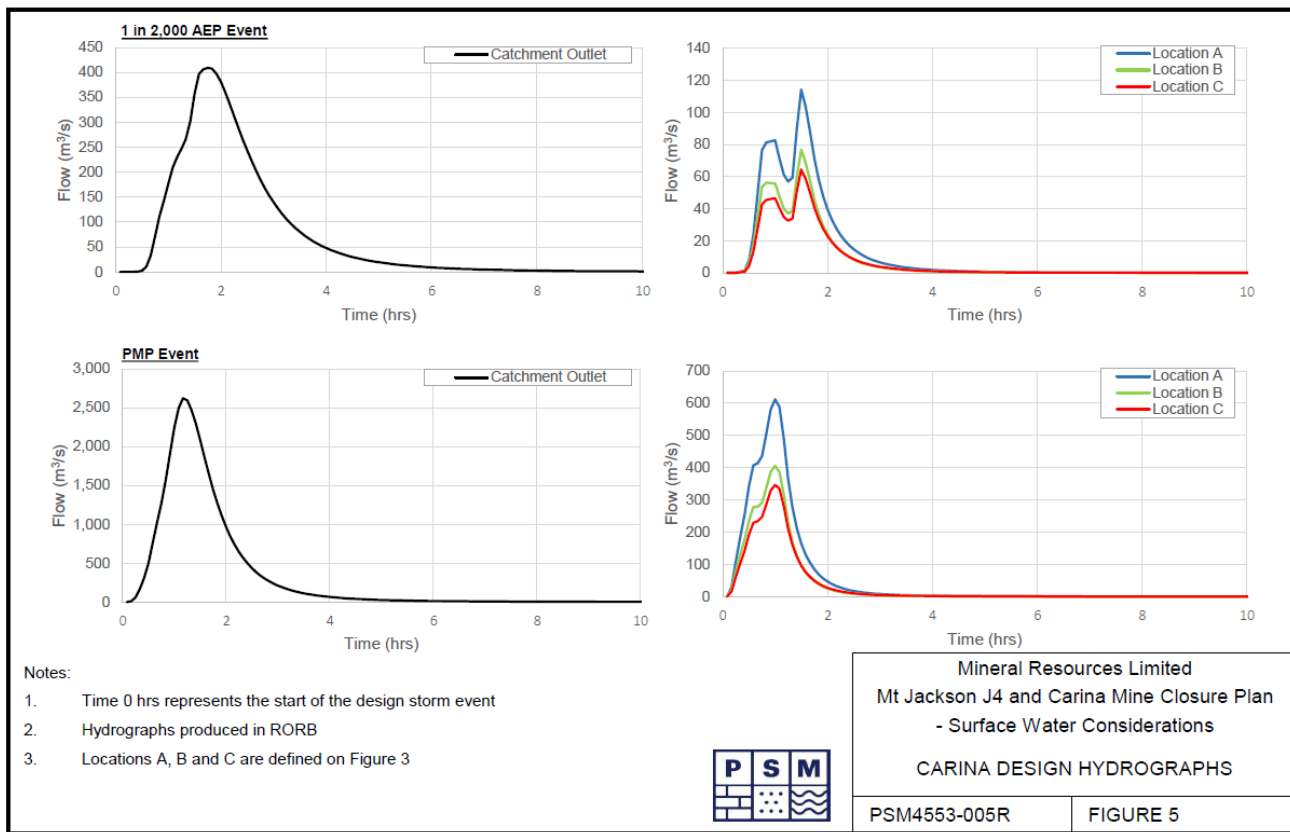
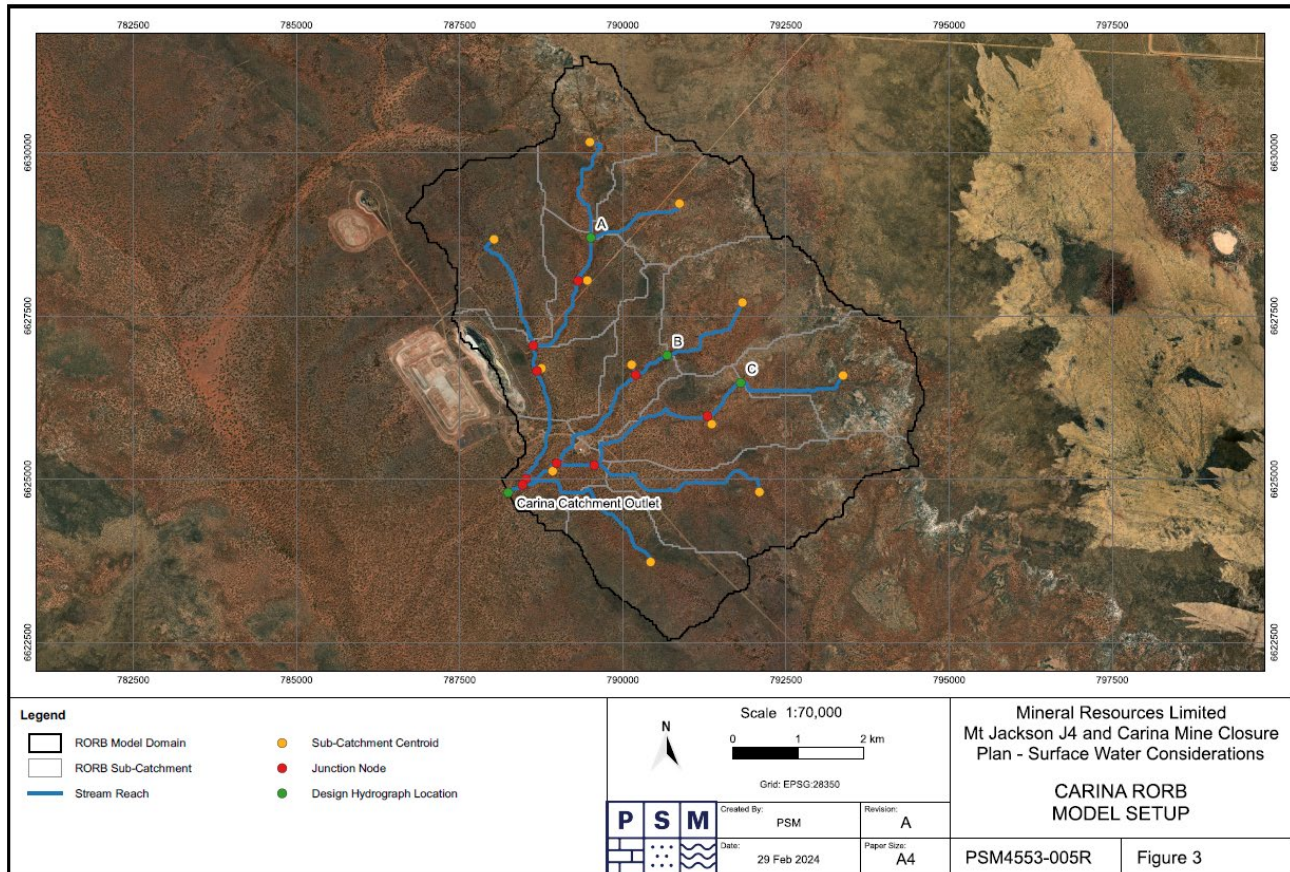
Source: PSM Consult Pty Ltd (2024)

Sensitivity modelling using the extreme event temporal patterns from Jordan *et al.* (2005) produced similar peak flows to those predicted by the AR&R Data Hub temporal patterns (Table 33) (PSM Consult Pty Ltd, 2024).

Base case peak flows from the IL / CL method provide estimates towards the upper bound of the available methods and were adopted for the hydraulic modelling described in the sub-section below. Results from the Proportional Loss (PL) method were used for sensitivity analysis (PSM Consult Pty Ltd, 2024).

The 1 in 2,000 AEP design hydrograph for each catchment outlet was produced with the Australian Rainfall and Runoff Data Hub temporal pattern matching the peak flow from Table 33, as shown in Figure 55. To allow detailed hydraulic modelling of the adjacent floodplains, the associated hydrographs for points further upstream in the catchment were also extracted (Figure 55) and used as inputs to the hydraulic model.

²⁰ RORB is an event-based rainfall-run-off model where a catchment is divided into sub-areas linked by reaches where each sub-area is represented by a conceptual storage that simulates the combined overland flow and channel storage.



Source: PSM Consult Pty Ltd (2024)

Figure 55 CARINA 1:2,000 AEP Hydrographs & RORB Model Set Up

FLOOD MODELLING

Flood modelling was undertaken by PSM Consult (PSM Consult Pty Ltd, 2024) using TUFLOW HPC hydraulic software to simulate flood depths, extents and velocities. Modelling was completed for the following event cases:

- A 1 in 2,000 AEP using the IL / CL model for the 1.5-hour critical duration
- A PMF design event using the IL / CL model for the 1.0-hour critical duration

A rain-on-grid approach was used to represent the rainfall run-off process across the TUFLOW model domains. A cell wetting / drying depth of 0.2 mm was used. Rainfall that would be captured within pits was omitted from the model as it would not affect the floodplain. For each catchment, the local rainfall temporal pattern modelled was consistent, which resulted in the design peak flows and hydrographs discussed in the sub section above. The point rainfall values from the Intensity-Frequency-Duration (IFD) data (Section 5.1.1) were used and adjusted using the applicable Australian Rainfall and Runoff areal reduction factors. The loss values applied for each model domain were consistent with those summarised in Table 32.

Figure 56 and Figure 57 show the 1 in 2,000 AEP event maximum flood depths and maximum flood velocities, respectively for the Carina site area. The results show:

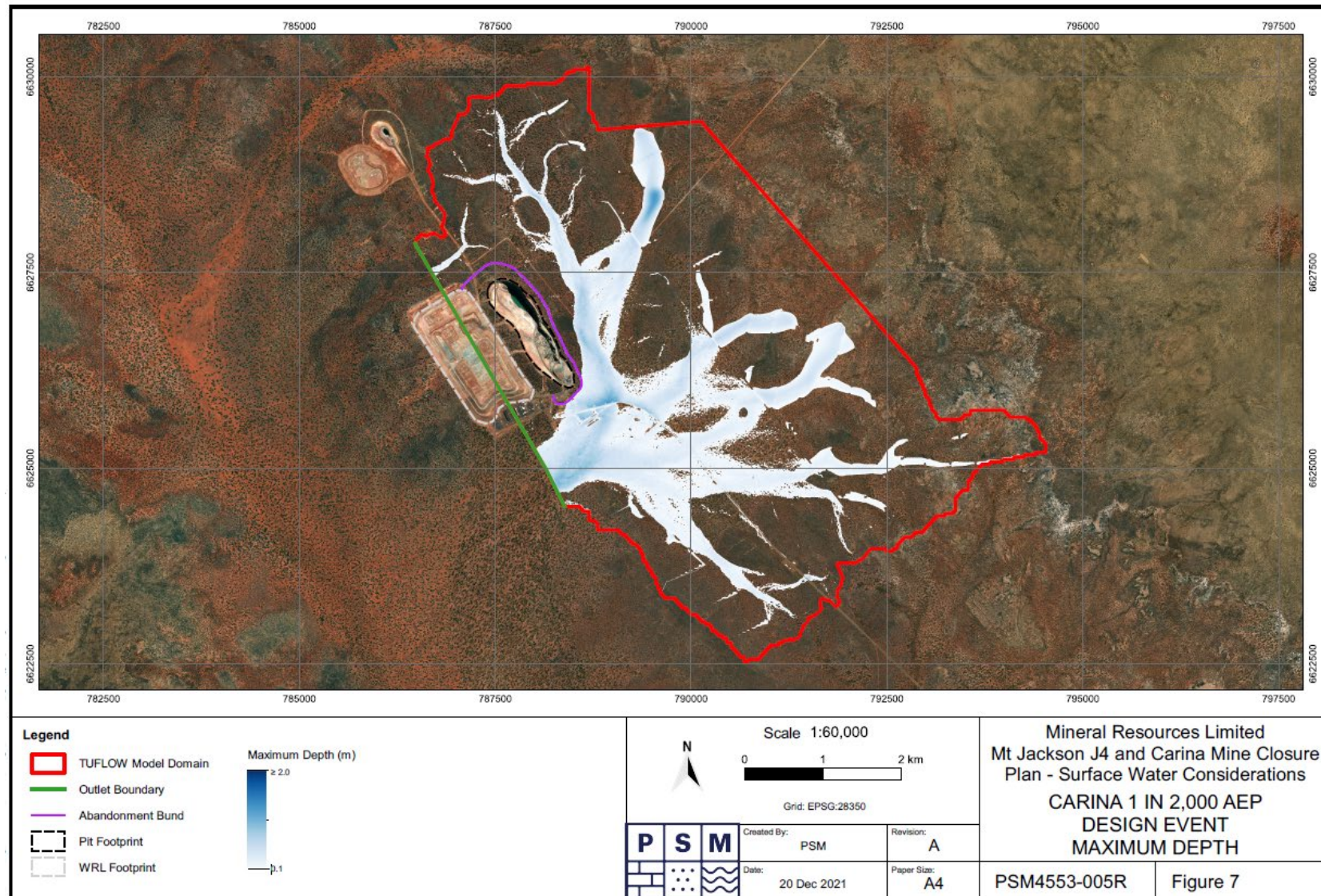
- The 1 in 2,000 AEP floodplain is only near the southeastern end of the abandonment bund, with depths in the order of 0.1 to 0.3 m.
- Velocities at the southeastern end of the abandonment bund range between 0.6 and 0.8 m/s.
- There is a localised sub catchment at the northern end of the Carina Pit for which the 1 in 2,000 AEP floodplain does not reach the position of the abandonment bund.
- A roadway, which is understood to remain for mine closure, runs southeast to northwest on an alignment adjacent to the southern end of the Carina Pit does appear to impact the main floodplain, with the flow overtopping and flowing across the road. Erosion of this road during a flood event is likely and could require some maintenance following an extreme storm if access to the pit is required.
- No significant flow or velocity associated with the floodplain reaches the WRL (PSM Consult Pty Ltd, 2024).

Figure 58 and Figure 59 show the PMF design event maximum flood depth and maximum flood velocities, respectively for the Carina site area. The results show:

- The PMF flood plain is only near the southeastern end of the abandonment bund, with depths in the order of 0.3 to 1.3 m.
- Slightly increased extent of flooding along the southeastern end of the abandonment bund.
- Increase in velocity along the southeastern end of the abandonment bund up to 1.9 m/s.
- Extents of the PMF do not reach the abandonment bund along the northern end of the Carina Pit.
- Erosion of the roadway described above is expected during a PMF event and could require some maintenance following an extreme storm as noted above.
- No significant flow or velocity, associated with the main floodplain, reaches the WRL (PSM Consult Pty Ltd, 2024).

PSM (2024) note that there is potential that the downstream roadway geometry was different to that modelled which could limit the validity of the flood predictions in this setting. However, including the roadway produced the maximum flood depths adjacent to the abandonment bund which is critical to establishing flood protection bund heights.

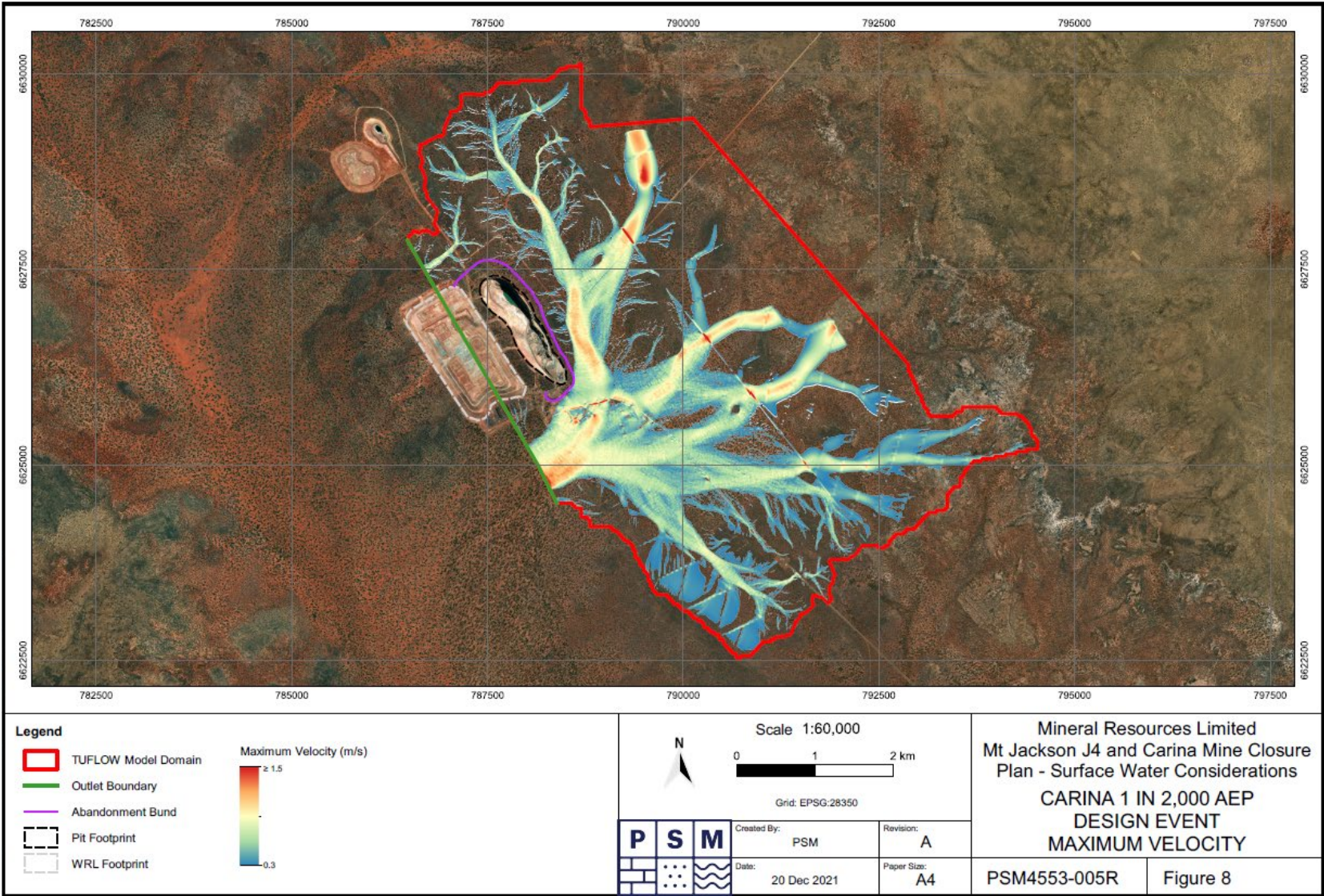
Sensitivity analysis (focussing on shorter duration events more critical to the smaller catchments) confirmed that the smaller catchments, such as those along the northern edge of the abandonment bund do not produce conditions that require additional closure measures (PSM Consult Pty Ltd, 2024).



Source: PSM Consult Pty Ltd (2024)

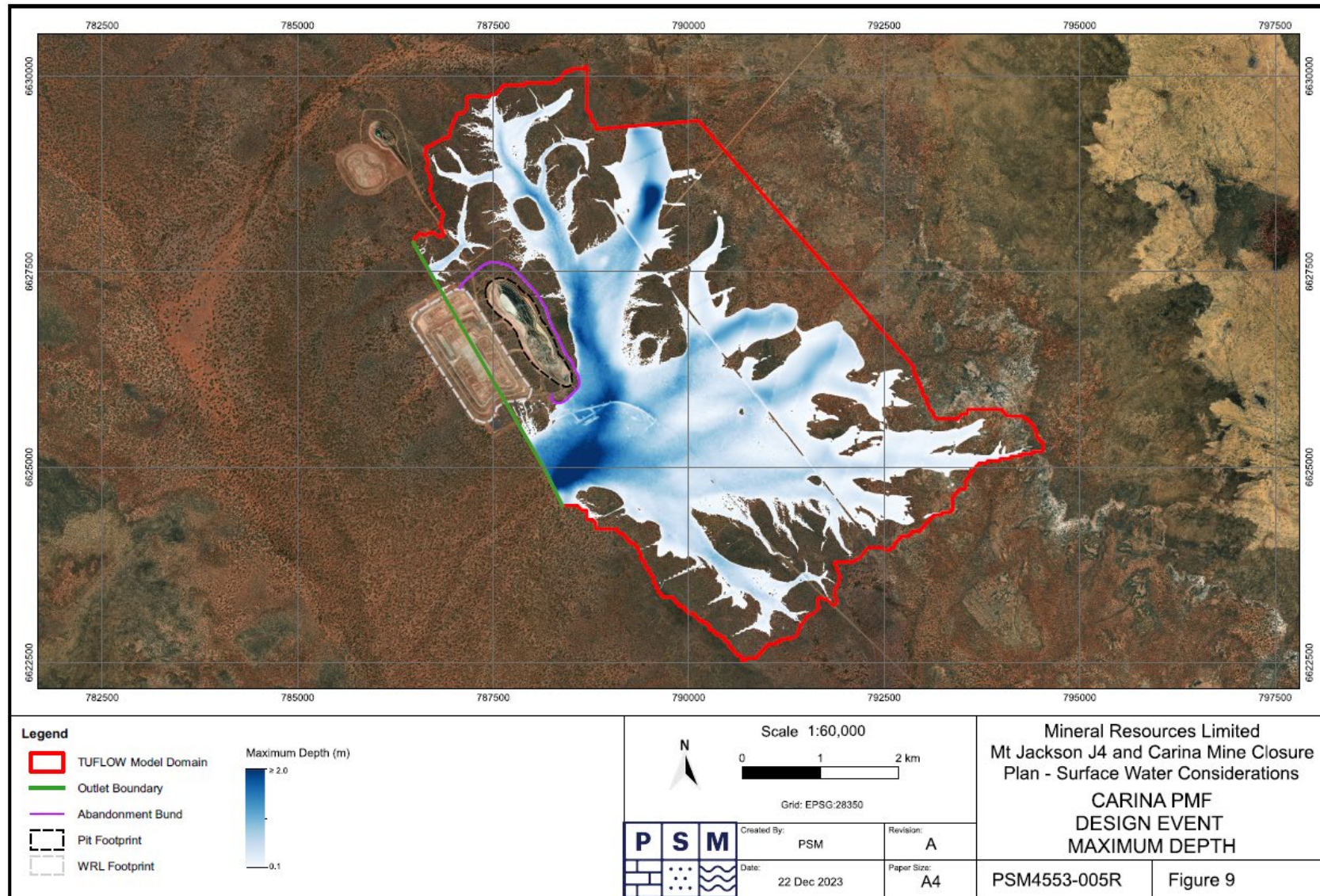
Figure 56 Carina 1:2, 000 AEP Flood Modelling (Depth)

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Source: PSM Consult Pty Ltd (2024)

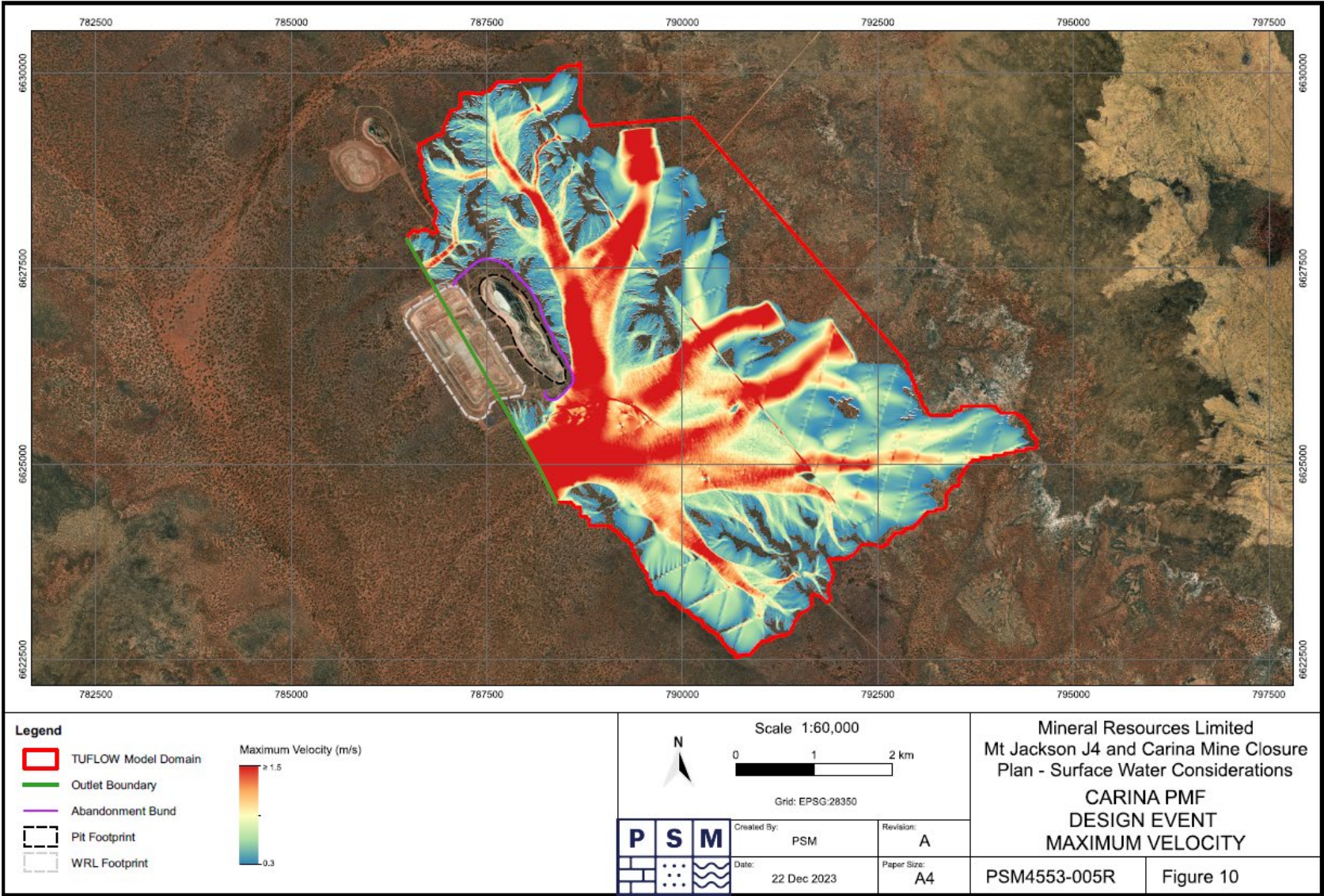
Figure 57 Carina 1:2, 000 AEP Flood Modelling (Velocity)



Source: PSM Consult Pty Ltd (2024)

Figure 58 Carina PMP Flood Modelling (Depth)

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Source: PSM Consult Pty Ltd (2024)

Figure 59 Carina PMP Flood Modelling (Velocity)
ENV-TS-RP-0617

Modelled peak flow results for the Carina catchment are shown in Table 34. These results show that the TUFLOW rain-on-grid approach is providing peak flows consistent with the RORB hydrologic predictions (Table 33), and the IL / CL loss model is providing larger peak flows than the PL loss model and the design event results in the governing peak flow (PSM Consult Pty Ltd, 2024).

Table 34 Modelled Peak Flow Estimates – Carina

Event	Design / Sensitivity	Event Duration (hours)	Loss Model	Peak Flow (m ³ /s)
1 in 2,000 AEP	Design	1.5	IL/CL	393
	Sensitivity	1.5	PL	313
	Sensitivity	0.5	PL	262
PMF	Design	1	IL/CL	2,686
PMP	Sensitivity	0.75	IL/CL	2,427

Source: PSM Consult Pty Ltd (2024)

5.6.1.4.2 J4

The J4 site is situated along a ridgeline (more than 25 m higher than the main local streamline to the northwest) such that flooding of regional streamline catchments is not expected to affect the pit abandonment bund or WRL. Extension of the J4 East Pit does not affect this conclusion (PSM Consult Pty Ltd, 2024).

A simple site hydraulic model and flood risk assessment found that the J4 site is located more than 1 km from the 100 year flood extent and approximately 10 – 12 m above the associated modelled peak flood level (Golder Associates, 2013c).

5.6.1.4.3 Aurora

The Aurora site is located on a local topographic high and is nearby to a regional watershed directing water away from the site to the north and south.

A 1:2,000 AEP and PMF event surface water assessment was undertaken to assess the potential risks to the pit and proposed realigned abandonment bund (refer Section 9.2.1.5). Risks assessed include risk of floodwaters overtopping the bund and entering the pit, and the risk of scour and erosion of the bund.

PEAK FLOW ESTIMATES

Design rainfall was derived based on the Australian Rainfall and Runoff (ARR) guidelines. Areal reduction factors (ARF) were not required to be applied due to the small size of the catchments.

Design rainfall inputs for the 1 in 2,000 AEP event were extracted from the ARR Data Hub website.

PMF rainfall was estimated using the GSDM method. As the site is located within the ‘intermediate zone’ of GSDM zones, the maximum duration that is applicable using this method was linearly interpreted to be 4.5 hours. A Moisture Adjustment Factor (MAF) of 0.76 was selected for the site. Temporal patterns for short duration, extreme storm events were sourced from Jordan *et al.* (2005) as cited in WMS (2024).

Due to the location of the site in an area lacking gauged catchments, rainfall losses were unavailable through the ARR Data Hub website. Losses for the Eastern Goldfields were initially adopted, and the IL adjusted until the resulting peak flow matched the design flow rate estimated using the Regional Flood Frequency Procedure (RFFP). Based on this approach an IL of 16 mm was adopted for the 1% AEP event. As CL has comparatively low variability and distribution across any specific region the Eastern Goldfields value of 3 mm/hr was adopted. The IL and CL for the 15 AEP was adopted for the 1 in 2, 000 AEP event (WMS, 2024).

For the PMF event, IL and CL values were set to 0.0 mm and 1.0 mm/hr respectively, in accordance with ARR2019 Guidelines (WMS, 2024).

Outlets were implemented around the boundary of the model domain to allow all flows to exit the model without pooling against the domain boundary. A boundary condition utilising Water Level (Head) vs. Flow with a constant grade of 0.0165 was adopted, in line with the topographical grading of the northern downward slope. Sensitivity testing using a constant grade of 0.05 found minimal difference in the peak water levels and velocities at the site, and therefore the original slope was deemed adequate (WMS, 2024).

A Manning's value of 0.04 was adopted for the entire model domain due to limited roughness variability across the catchment which comprises neutral red earths with a variable content of ironstone gravel (WMS, 2024).

FLOOD MODELLING

Flood modelling was undertaken by WMS (2024) using TUFLOW version 2023-03-AC hydraulic software to simulate flood depths, extents and velocities. The model extent was delineated to fully capture the upstream catchment interacting with the pit and WRL. The terrain data was modified to replace the existing abandonment bund with the proposed new abandonment bund design and location. Modelling was completed for the following event cases:

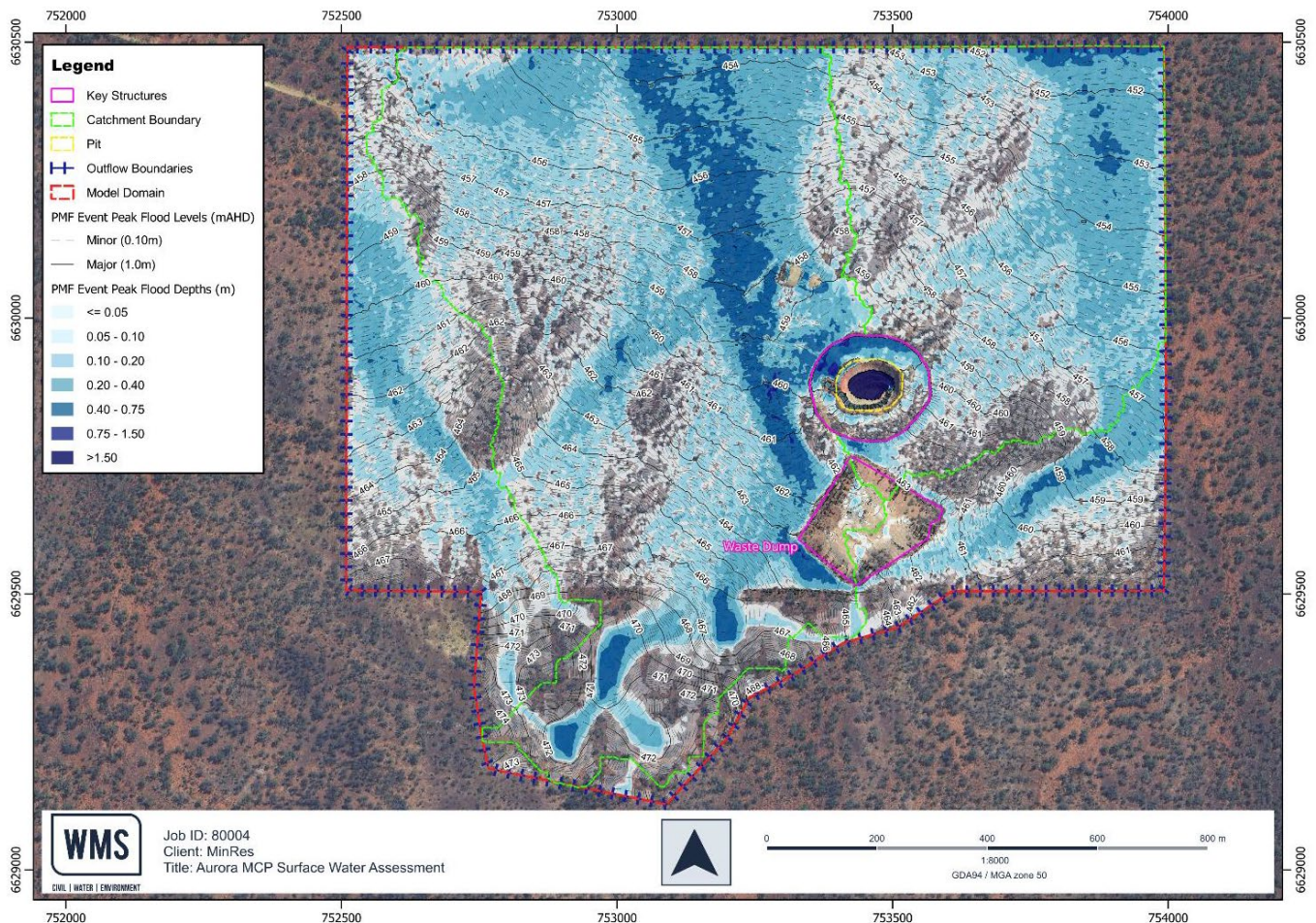
- A 1 in 2,000 AEP for the 0.5 hour and 1.5 hour critical durations.
- A PMF design event for the 0.75 hour (45 minute) critical duration.

The results of the hydraulic modelling are summarised below (WMS, 2024):

- North-Western section of Proposed Abandonment Bund:
 - In the PMF event the peak flood depth occurs on the inside of the bund at 0.84 m with 1.16 m freeboard. The peak flood velocity occurs at the bund exterior at 1.65 m/s.
 - In the 1 in 2,000 AEP event the peak flood depth occurs on the inside of the bund at 0.60 m with 1.4 m freeboard. The peak flood velocity occurs at the bund exterior at 0.90 m/s.
 - The risk of overtopping and scouring is therefore low. The scouring risk assessment is based on the threshold of 2.0 m/s for erosion protection of dumped graded rock.
- Southern Section of Bund:
 - In the PMF event, the peak flood depth is 0.50 m with 1.35 m freeboard remaining. Peak flood velocities occur further downstream of this section as floodwaters gravitate north against the bund wall. The peak flood velocity is 1.3 m/s.
 - During a 1 in 2,000 AEP event, the peak flood depth at this section of the bund reaches 0.38 m with a remaining freeboard of 1.47 m. The peak velocity is 0.71 m/s.
 - The risk of overtopping and scouring is also low.
- Rainfall within Pit:
 - The peak modelled volume of rainfall within the pit was 28.7 megalitre (ML) for the PMF event and 6.7 ML for the 1 in 2,000 AEP event.

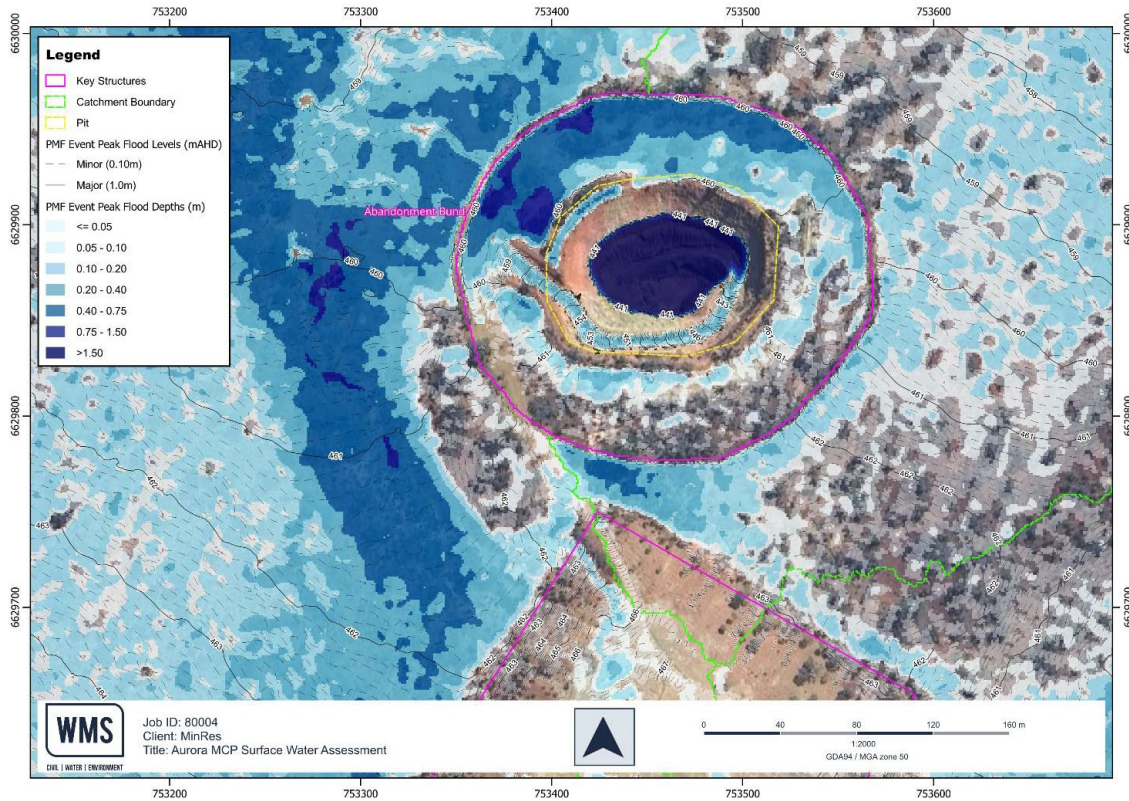
- **Aurora WRL:**

- During a PMF event, the peak flood depth is 0.79 m at the south-western boundary of the waste dump. The peak velocity reaches 2.2 m/s at the northern section of the waste dump due to the steeper slope of run-off from the waste dump. This exceeds the 2 m/s threshold and there is some potential for minor sedimentation to occur downstream.
- In a 1 in 2,000 AEP event, the peak flood depth is 0.45 m at the southern-western boundary, and the peak flood velocity is 1.48 m/s at the northern section of the waste dump.



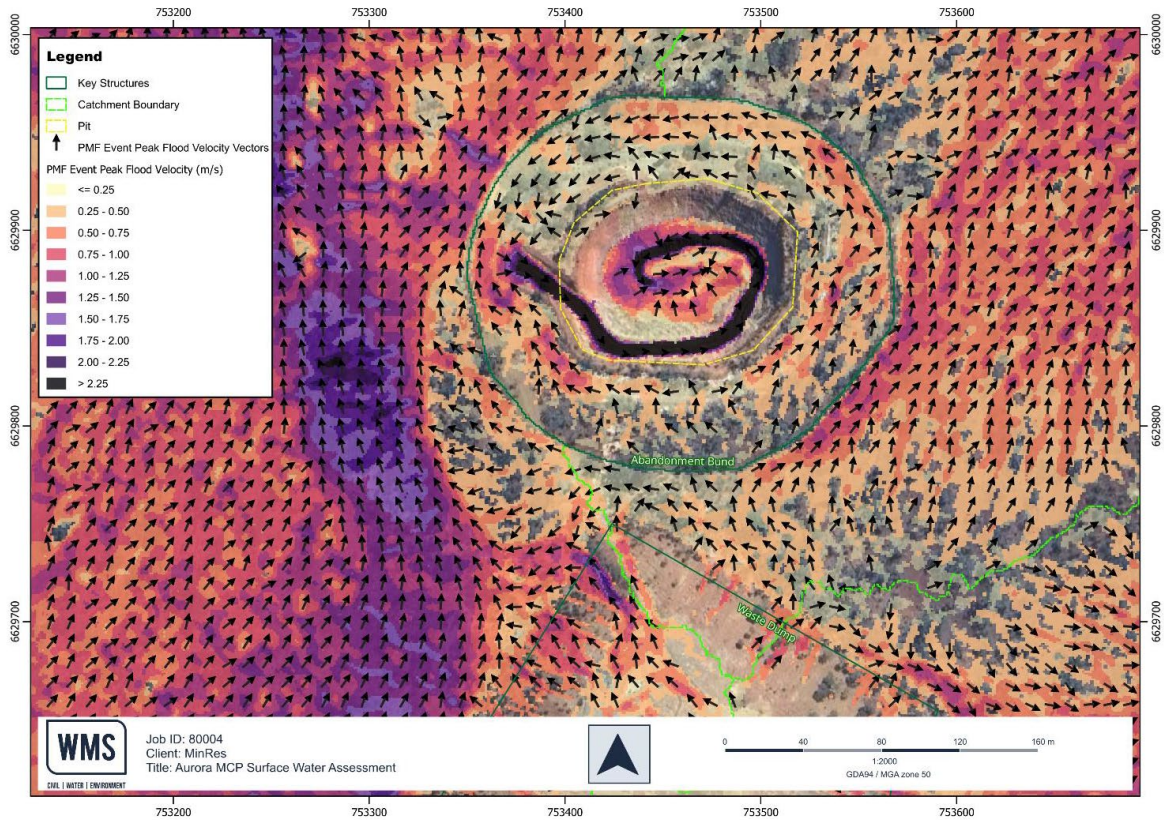
Source: WMS (2024) (This report, including A3 maps is provided in Appendix C)

Figure 60 PMF Storm Event – Peak Flood Depth (Model Domain)



Source: WMS (2024)

Figure 61 PMF Storm Event – Peak Flood Depth (Pit and WRL Area)



Source: WMS (2024)

Figure 62 PMF Storm Event – Peak Flood Velocity (Pit and WRL Area)

WSM (2024) concluded:

- The proposed abandonment bund is sufficiently sized to prevent both 1 in 2,000 AEP and PMF events floodwaters from overtopping into the pit void.
- The potential for scouring and erosion to impact the abandonment bund are negligible. Geotechnical risks to the bund are low given the low flood depths and low velocity of flows approaching the bund and ponding inside the bund for both modelled AEPs. Some minor cracking may occur from the long-term wetting and drying of the bund and can be managed with routine inspection and maintenance to ensure stability.
- Given the velocities at the base of the waste dump in a PMF event, there is potential for some minor sedimentation to occur downstream. However, due to the low volume of flows from the small catchment of the waste dump and the frequency and likelihood of the PMF occurrence, major erosion and sedimentation risks are low.
- Some gully formation and minor erosion may still occur on the waste dump batter slopes resulting from long-term water run-off. To reduce ongoing surface water run-off, it is recommended to include rectification controls in the waste dump closure design.

5.6.1.5 Considerations for closure

Given the proximity of the 1 in 2,000 AEP and PMF floodplain to the southern area of the Carina Pit abandonment bund, an engineered flood protection bund in the southern portion of the closure bund has been recommended to manage closure flood impacts. Outside of this area there are no requirements for the abandonment bund with respect to closure surface water performance (PSM Consult Pty Ltd, 2024).

Although the modelled velocities adjacent to the abandonment / proposed flood protection bund are less than the 2 m/s threshold for armouring, there is a concentration of velocities adjacent to the eastern corner of the bund and it is recommended armouring is placed in this area.

The 1 in 2000 AEP and PMF floodplains also interact with a road proposed to be retained post-closure with the potential to affect the integrity of the road in a major storm event.

A small 6 ha catchment could result in flow adjacent to the Carina Extension abandonment bund and cause erosion in a PMF event. A breach of this bund would not be expected to impact downstream surface water receptors. The potential for failure of this bund (and associated safety risks) however would inform any requirement for armouring.

Hydraulic modelling will be required to inform closure of the Haul Road. Prior to closure, MS 988 requires that the design, construction and operation of the Haul Road does not impact the surrounding environment and existing infrastructure from the effects of surface water flow impedance, dust, use of saline water, weed encroachment and fire.

The flood bund around the Carina Mine Infrastructure Area will require removal at closure and the area re-contoured to manage post-closure surface water run-off.

The proposed abandonment bund design and location for Aurora is sufficient to prevent pit flooding and the potential for scouring and erosion of the structure are negligible. There is potential for minor sediment release from the toe of the Aurora WRL in a PMF event and the risk of major erosion and sedimentation is considered low. Planned rectification works for the Aurora WRL will however be necessary to control the erosion resulting from uncontrolled surface water run-off from the WRL itself.

5.6.1.6 Knowledge Gaps & Forward Work Program

The following actions are proposed to address knowledge gaps:

- Develop geotechnical and construction specifications for the recommended flood bund for the Carina Pit.
- Complete flood modelling, hydraulic modelling and materials characterisation necessary to inform final landform design for the Infrastructure / General Disturbance domain.
- Use the flood modelling results to inform closure strategy / designs for the roadway proposed to be retained at Carina.
- Review the potential for erosion to impact on the integrity of the Carina Extension abandonment bund, to determine any armouring requirement, to mitigate safety risk.
- Complete hydraulic modelling to inform closure of the Haul Road and the Carina Mine Infrastructure Area.
- Develop and implement Aurora WRL rectification plan to control surface water run-off.

5.6.2 Groundwater

Key Points

- The Carina Operations are in the transition zone between the Wheatbelt, and the Goldfields located within the proclaimed Goldfield Groundwater Management Area (Deborah sub-area).
- Groundwater in the region occurs in fractured rock aquifers and in porous media aquifers associated with ephemeral creeks and paleochannels. Groundwater storage in the fractured rock aquifers is generally low except in localised areas of BIF. Recharge is via rainfall and discharge occurs via evaporation from the playa lakes and bore fields.
- Groundwater is predominantly hypersaline with usage limited to mining operations.
- Groundwater flow:
 - At Carina is interpreted to flow from north to south within the greenstone unit and BIF.
 - At J4 groundwater flow is assumed to be from the catchment divide in the north towards the palaeochannel in the south. Faulting and erosion may provide preferential flow paths towards the palaeochannels. The main receptors are the playa lakes which are some distance (~ 50 km) from the mine sites.
- Pre-mining groundwater levels and depths to groundwater were reported as follows:
 - Carina – 412 m AHD (~ 38 – 67 m bgl)
 - Carina Extended – 400 m AHD (70 m bgl)
 - J4 – inferred ~ 405 m AHD (based on production bore data that may not have captured pre-mining levels)
- Below water table mining has occurred at the Carina and J4 operations. Pit lakes have formed and will remain at Carina, Carina Extended and the J4 East Pits. J4 West Pit is currently a pit lake but is planned to be backfilled for closure.
 - The pit lakes are predicted to stabilise at lower elevations than the pre-mining groundwater level (i.e., remain groundwater sinks). Carina Extended may become a through-flow system with flow towards the Carina Pit Lake.
 - The pit lake elevations will result in residual drawdowns that will extend radially several kilometres.
 - Solutes in the pit lakes are likely to increase over time as the rate of evaporation exceeds the rate of precipitation and groundwater inflow. However, since the pits are predicted to act as sinks, the elevated solutes are unlikely to impact groundwater quality since groundwater flow is predicted to be towards the pit. Pit lake quality at Carina and J4 East will also be influenced by PAF exposure in pit walls and potential PAF in backfill (Carina).
 - An initial assessment of the potential for density driven flow indicated that this is unlikely but will be further reviewed as groundwater and pit lake models are refined.
- Further monitoring is required to calibrate pit lake and groundwater models.
- A gap analysis is proposed to identify the further work necessary to refine estimates of long-term pit lake chemistry.
- There are no known GDEs within the Carina Operations area, but generic mapping (BOM, 2024) identifies some areas with high potential for aquatic GDEs that appear to be associated with playa lake systems. One of these occurs in the vicinity of the Carina site and its nature and status need to be confirmed.

5.6.2.1 Regional Hydrogeology

AQUIFERS

The Carina Operations are in the Southern Cross Province of the Yilgarn Craton which comprises Archaean-age granite and greenstone bedrock. Groundwater occurs in fractured rock aquifers and in porous media aquifers associated with ephemeral creeks and paleochannels. Groundwater storage in the fractured rock aquifers is generally low except in localised areas of BIF. The higher porosity and associated water storage capacity of the BIF is a result of brittle faults and hydrothermal alteration, the same processes which have led to the enrichment of the iron ore. These small aquifer pockets are occasionally interconnected by faults. Fault structures may transmit significant amounts of water when connected to a permeable orebody or a paleochannel. The surrounding metasediments and greenstones are highly weathered and more permeable than the fresh rock but the transmissivity of both is low, thus the country rock is generally not considered an aquifer (PSM Consult Pty Ltd, 2023 Draft).

The Yilgarn Palaeodrainage system hosts the largest groundwater storage volumes and act as discharge locations for the fractured rock aquifers. In the paleochannels, groundwater is mainly present in a basal sand unit. This porous aquifer is confined or semi-confined by fine grained lacustrine deposits and hosts hypersaline groundwater on the trunk palaeodrainage and in playa lake settings. The groundwater salinity decreases away from the playas, both on tributaries to the trunk palaeodrainage and in country rocks as the catchment elevations increase on crests and ridges (PSM Consult Pty Ltd, 2023 Draft).

GROUNDWATER FLOWS

Groundwater heads in the weathered and fractured bedrocks occur at comparatively high elevations in the catchment compared to the palaeochannels of the Yilgarn Palaeodrainage, thereby demonstrating that groundwater flow is from the bedrock to the palaeochannels (Commander, 1992). It is, therefore, likely that the palaeochannel aquifer is recharged via leakage from adjacent bedrock aquifers and shallow alluvial profiles (PSM Consult Pty Ltd, 2023 Draft).

RECHARGE AND DISCHARGE

Recharge

Recharge to the fractured rock aquifer occurs through rainfall. Johnson (2000) suggested that the dominant recharge mechanism is downward leakage and groundwater movement through the bedrock weathering profile. It is expected that recharge may be higher in the BIF ranges where infiltration is facilitated through fractures and weathered rocks (PSM Consult Pty Ltd, 2023 Draft).

Recharge to palaeochannels occurs through:

- Direct recharge through rainfall where the lacustrine sediments are absent (mainly in the upper reaches of the paleochannel network).
- Up gradient aquifers in the tributary.
- Throughflow from the surrounding alluvial, colluvial, and fractured rock aquifers where heads are higher than in the paleochannel (PSM Consult Pty Ltd, 2023 Draft).

Groundwater recharge rates to the paleochannel aquifer system are difficult to quantify. Net groundwater recharge was interpreted to constitute a small proportion of rainfall (Turner, 1993). Recharge estimates range up to 1% of annual rainfall or less (PSM Consult Pty Ltd, 2023 Draft). Conceptually, the recharge is episodic, with links to high-rainfall events, and possibly follows a theme whereby net recharge only occurs once a rainfall threshold has been exceeded (Johnson S. C., 1999). These aspects allude to recharge being widely variable depending on transient climatic and event circumstances, and that recharge as a percentage of average annual rainfall is potentially a poor proxy for actual recharge rates (PSM Consult Pty Ltd, 2023 Draft).

Discharge

Groundwater discharge in the area occurs from bore fields (most often developed in the fractured rock aquifers) and naturally via evaporation from the playa lakes (PSM Consult Pty Ltd, 2023 Draft).

ENVIRONMENTAL VALUES AND BENEFICIAL USES

The Carina Operations are in the transition zone between the Wheatbelt, and the Goldfields located within the proclaimed Goldfield Groundwater Management Area (Deborah sub-area).

Groundwater in this area is predominantly hypersaline with beneficial usage mostly associated with mining operations but there are also potential groundwater dependent ecosystems as discussed in Section 5.5.2.6 and shown on Figure 46.

5.6.2.2 Local Hydrogeology

5.6.2.2.1 Carina

GROUNDWATER LEVELS

The pre-mining groundwater level at Carina was reported to be 412 m AHD. This elevation corresponds to a depth of about 38 m bgl at the southern end of the deposit, and 67 m bgl in the most elevated, central part of the deposit (PSM Consult Pty Ltd, 2023 Draft; Rockwater Pty Ltd, 2009).

The pre-mining groundwater level for the Carina Extended deposit was reported as approximately 400 m AHD, some 70 m bgl (Polaris Metals, 2013a).

Both the Carina and Carina Extended Pits were mined below the water table. An assessment of groundwater level monitoring data associated with dewatering operations at Carina suggests up to 70 m of drawdown has occurred due to pit dewatering (PSM Consult Pty Ltd, 2023 Draft).

GROUNDWATER FLOW

The Carina Operations are located high in the catchment in what is expected to be a recharge zone. Groundwater is interpreted to flow from north to south within the greenstone unit and BIF (PSM Consult Pty Ltd, 2023 Draft).

Under baseline conditions a local groundwater divide potentially occurred between Carina and Carina Extended. Groundwater flow from Carina Extended potentially flowed north initially before transitioning to the south (PSM Consult Pty Ltd, 2023 Draft).

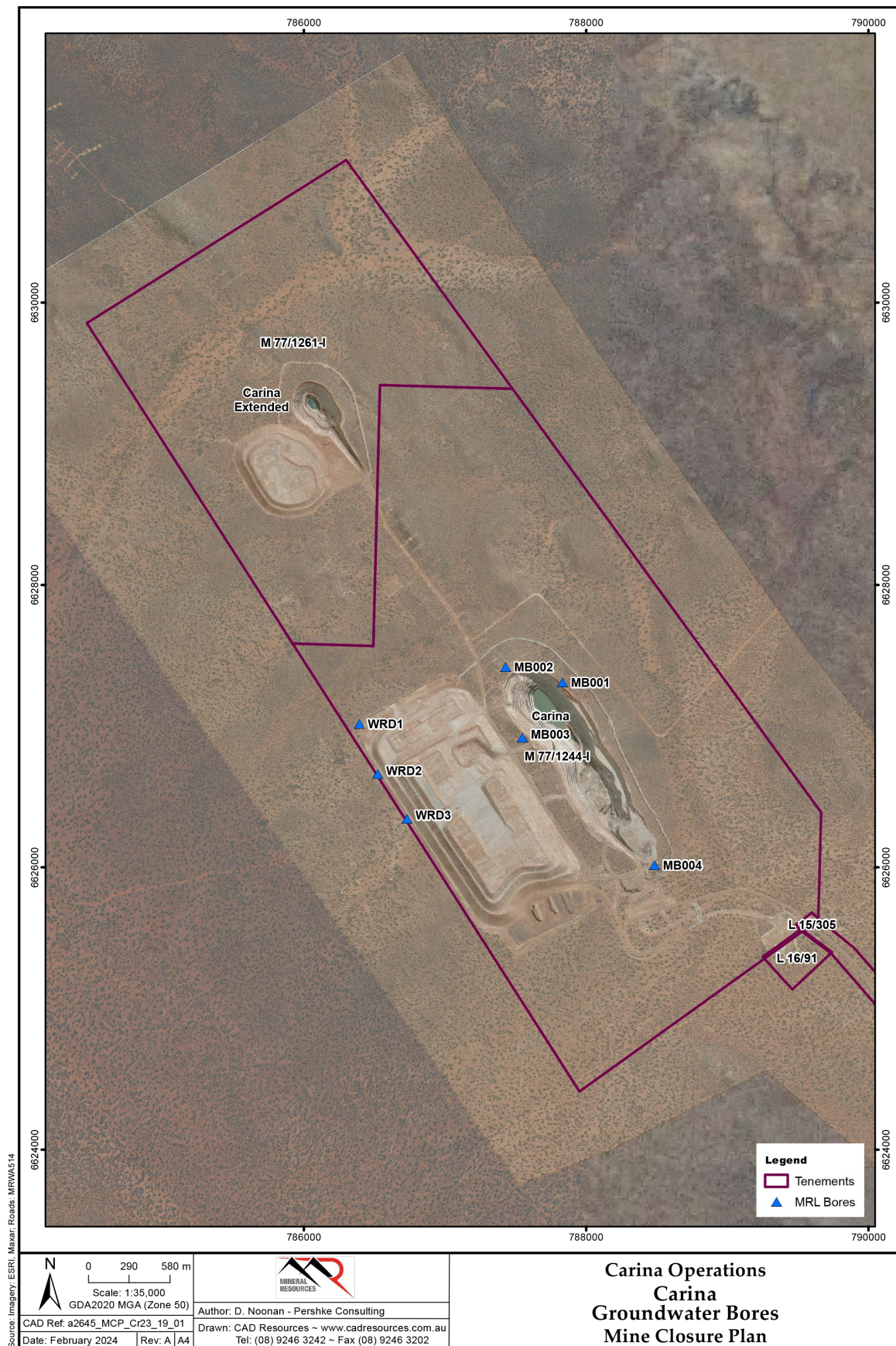
In post-closure, both pits are likely to create local groundwater sinks and a cumulative sink which reverses the baseline groundwater flow paths (PSM Consult Pty Ltd, 2023 Draft).

GROUNDWATER QUALITY

The groundwater quality beneath the Carina WRL has been monitored since 2013 and groundwater quality samples were also taken during dewatering operations from 2013 to 2016 (Figure 63). No groundwater monitoring data for Carina Extended has been identified.

The groundwater quality data for the WRL and Carina Pit are presented in Appendix G-1 and are of similar quality, summarised as follows:

- Total Dissolved Solids (TDS) 27,000 to 37,000 mg/L;
- pH 7 to 8.1; and
- Groundwater was of a Mg-Ca-Na-Cl-SO₄ type which exceeded the Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (2018) values for TDS, Hardness, manganese, chloride, arsenic, nickel, iron, and sulfate (PSM Consult Pty Ltd, 2023 Draft).



Refer to Appendix J for pdf version

Figure 63 Groundwater Bores – Carina

PIT LAKE LEVELS

Pit lakes have formed at both the Carina and Carina Extended Pits. Water is currently being pumped out of the Carina Pit to supply water for the Carina Southern crushing operations. The most recent pit lake data and representative water balance fluxes are provided in Table 35.

PIT LAKE QUALITY

Carina Pit Lake water quality was monitored at monthly to half yearly intervals between 2017 and 2021 and Carina Extended Pit was also monitored regularly between 2019 and 2020. The quality data are provided in Appendix G-2. In summary, monitoring to 2021 indicated (PSM Consult Pty Ltd, 2023 Draft):

- Both pit lakes are saline to highly saline and of a Mg-Ca-Na-Cl-SO₄ type.
- Carina Pit Lake ranges from pH 6.1 to 7.9 and Carina Extended Pit Lake ranges from pH 7.8 to 7.9.
- The concentration of TDS, Hardness, boron, chloride, manganese, nickel, sodium, and sulfate typically exceeded the ANZG (2018) values.
- In 2017, the Carina Pit Lake also reported occasional exceedance of the ANZG (2018) values for mercury and iron.

CONCEPTUAL SITE MODEL

Reflecting the regional hydrogeology described above, the hydrogeological units at Carina include:

- Greenstone bedrocks;
- Mineralised and unmineralised BIF; and
- Fault structures Figure 64) (PSM Consult Pty Ltd, 2023 Draft).

The Carina deposits occur in the Yendilberin Hills which are composed of metamorphosed BIF, chert, and quartzite. The BIF has been extensively altered to goethite and hematite which forms the orebody. Both sides of the ore body are bounded by basalt. The outer contacts of the ore body with the basalt are strongly sheared and composed of clay and pyrite. At its southern end, the Carina orebody is bounded by basalt, suggesting that the BIF ridge has been truncated and offset by a fault. At its northern end, the orebody appears to grade into unaltered BIF and chert (PSM Consult Pty Ltd, 2023 Draft; Rockwater Pty Ltd, 2009).

Geotechnical logs and photos of diamond core show that the goethite-hematite orebody is vuggy and locally cavernous, which indicates that the permeability of the orebody is likely to be high. This contrasts with the adjoining basalt, which appears to be relatively unfractured and of low permeability (Rockwater Pty Ltd, 2009).

Aquifer hydraulic conductivity and specific yield were derived for all of the major geologic units of the Carina Deposit and calibrated in a groundwater model using historical pit extraction and groundwater monitoring data (Rockwater Pty Ltd, 2009) and are presented in Table 36.

Table 35 Pit Lake Characteristics Carina (December 2020 & November 2021)

Pit	Crest Area (m ²)	Pit Floor Elevation (m AHD)	Lake Elevation (m AHD)	Depth (m)	Volume (m ³)	Average Evaporation (L/s)	Average Rainfall (L/s)	Average Groundwater Inflow (L/s)
Carina ¹	444,300	290	343.8	53.8	1,236,652	1.9 to 2.3	0.2 to 1.5	4.3 to 6.2
Carina Extended ¹	96,900	365	378.6	13.6	40,760	0.2 to 0.3	0 to 0.2	0.1 to 0.5

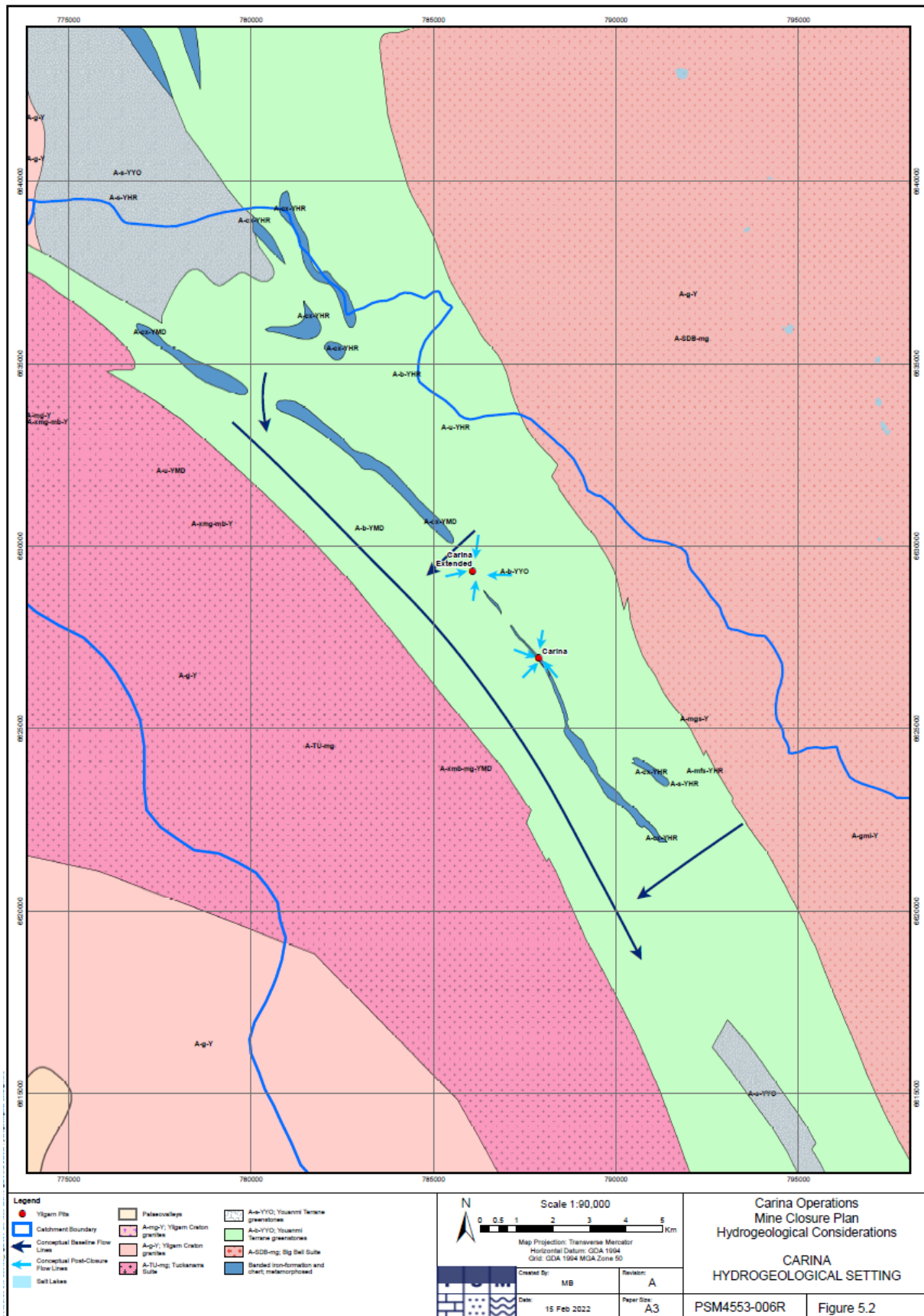
Source: PSM Consult (2023 Draft)

Note: 1. Water balance estimated for the period between May 2019 and July 2020

Table 36 Summary of Hydraulic Properties – Carina

Geologic unit	Hydraulic Conductivity (m/day)	Specific Yield (dimensionless)
Fractured along-strike ore-host unit (Layer 1)	10	0.05
Fractured along-strike ore-host unit (Layer 2)	1	0.005
Orebody	80	0.05
Country rock (northeast)	0.00003	0.01
Country rock (southwest)	0.01	0.0001

Source: PSM Consult (2023 Draft); (SWC, 2015b)



Source: PSM Consult (2023 Draft)

Figure 64 Carina Hydrogeological Setting

5.6.2.2.2 J4

GROUNDWATER LEVELS

The pre-mining water level at J4 was reported to be 388 m AHD (Rockwater Pty Ltd, 2015).

Recent modelling inferred a pre-mining groundwater level of approximately 405 m AHD but noted that this was based on production bore data that may not have captured pre-mining groundwater levels (PSM Consult Pty Ltd, 2023 Draft).

Both the J4 East and J4 West Pits were mined below the water table. All groundwater level observations (2017 – 2021) are influenced by pumping (PSM Consult Pty Ltd, 2023 Draft).

GROUNDWATER FLOW

The regional groundwater flow direction is assumed to be from the catchment divide in the north towards the palaeochannel in the south. Within the regional flow pattern, the Mount Jackson Range likely acts as a local groundwater divide.

Higher recharge rates are expected to occur through the fractured BIF than the adjoining mafic bedrocks.

Faulting and erosion of the BIF ridge may provide preferential flow paths from north to south. West of J4, groundwater may flow preferentially along strike towards the palaeochannel and then follow the sandy sediments to the southwest.

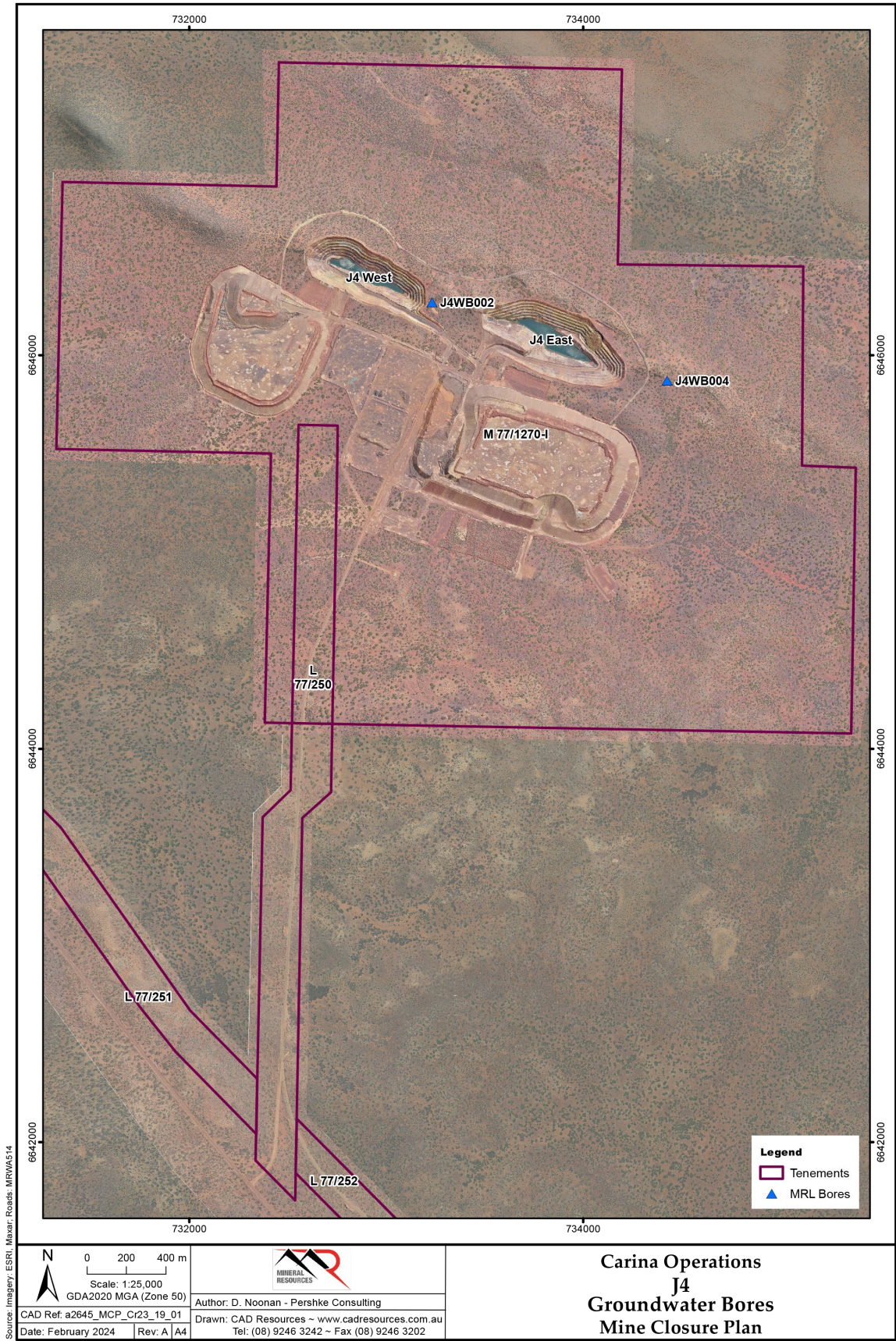
Mining below the water table will have locally reversed the groundwater gradients and drawdown (during mining) may have extended to the paleochannel. In post-closure, both pits are likely to create local groundwater sinks and a cumulative sink which will reverse the baseline groundwater flow paths (PSM Consult Pty Ltd, 2023 Draft).

GROUNDWATER QUALITY

Groundwater quality data available from three production bores monitored from 2017 to 2021 (Figure 65) are provided in Appendix G-1 and summarised below:

- pH of groundwater from both pits ranged from 7 to 7.9.
- TDS of groundwater from J4 West Pit bores ranged from 4,000 to 6,500 mg/L with an exceedance of the ANZG (2018) values for TDS, hardness, chloride, manganese, sodium, and sulfate.
- TDS of groundwater from J4 East Pit bores ranged from 10,000 to 25,000 mg/L, with manganese below the ANZG (2018) value.
- Total alkalinity (CaCO_3) of the J4 East Pit bores ranged from 760 – 800 mg/L.

The upper layer of relatively fresh water (TDS at the base of the orebody was found to be approximately 25,000 mg/L) is readily depleted by high pumping rates (Rockwater Pty Ltd, 2015).



Refer to Appendix J for pdf version

Figure 65 Groundwater Bores – J4

PIT LAKE LEVELS

Pit lakes have formed in the J4 East and J4 West Pits. The most recent pit lake data and representative water balance fluxes are provided in Table 37. There is likely to be seasonal variability which is not captured by the data as evidenced by an evaporation line at J4 West showing that the pit lake elevation had recently receded by approximately 0.5 m. The higher lake elevations at J4 West may be attributed to proximity to a palaeochannel aquifer recharge source and discharge to the deeper pit at J4 East. This concept implies a throughflow system at J4 West, from the palaeochannel to J4 East (PSM Consult Pty Ltd, 2023 Draft).

PIT LAKE QUALITY

Pit lake quality data collected for both J4 East and J4 West Pits since 2019 (Appendix G-2) demonstrates:

- TDS 8,100 to 16,000 mg/L;
- pH 8.1 to 8.4; and
- The pit lake water quality exceeded the ANZG (2018) values for TDS, hardness, chloride, boron manganese, sodium, and sulfate (PSM Consult Pty Ltd, 2023 Draft).

CONCEPTUAL SITE MODEL

Reflecting the regional hydrogeology described above, the hydrogeological units at J4 include:

- Greenstone bedrocks.
- Mineralised and unmineralised BIF.
- Fault structures.
- Palaeochannels (Figure 66) (PSM Consult Pty Ltd, 2023 Draft).

The bedrock units around the J4 pits consist of a northwest trending mafic to ultramafic greenstone sequence. The BIF is part of the Mt Jackson-Bungalbin belt and occurs as two stratigraphic units separated by basalt. The BIF units contain dark grey to black iron-rich bands alternating with red jaspilite bands.

The J4 Deposits occur as a low east-west trending ridge approximately 2 km in strike length and hosting two ore bodies separated by a zone of patchy mineralisation of limited depth. The Mount Jackson range is heavily faulted around the J4 pits resulting in the weakening and erosion of the BIF and a lowering of the range topography. The faults were interpreted to have contributed to unusually deep weathering (measured at 240 m vertical depth in one section). Palaeochannel sediments of the Yilgarn Palaeodrainage are expected south and west of the J4 Deposits. It is however unknown how deep the palaeochannel is incised in the bedrock this far up in the catchment (PSM Consult Pty Ltd, 2023 Draft).

Photos of diamond core show that the goethite ore is broken, vuggy and locally cavernous, which indicates that the permeability and porosity of the orebody is likely to be high. The core photos also show that the chert layers within the hanging-wall rocks are vuggy but owing to the interbedded layers of basalt (weathered to clay) the bulk permeability of these rocks will be considerably lower than the orebody. Basaltic rocks intersected at depth within the footwall are locally fractured along the contact with the orebody, but otherwise fairly fresh (Rockwater Pty Ltd, 2015).

Aquifer hydraulic properties have been assumed based on the values reported for the J1, J2 and J3 pit areas of MinRes' Yilgarn Operations and are presented in Table 38 .

Table 37 Pit Lake Characteristics J4 (November 2021)

Pit	Crest Area (m ²)	Pit Floor Elevation (m AHD)	Lake Elevation (m AHD)	Depth (m)	Volume (m ³)	Average Evaporation (L/s)	Average Rainfall (L/s)	Average Groundwater Inflow (L/s)
J4 West ¹ .	134,800	354	372.4	18.4	145,643	0.9 to 1.0	0.1 to 0.5	1.1 to 1.6
J4 East ² .	191,300	343	368.9	25.9	348,383	1.5 to 1.8	0.2 to 0.9	2.2 to 3.1

Source: PSM Consult (2023 Draft)

Notes:

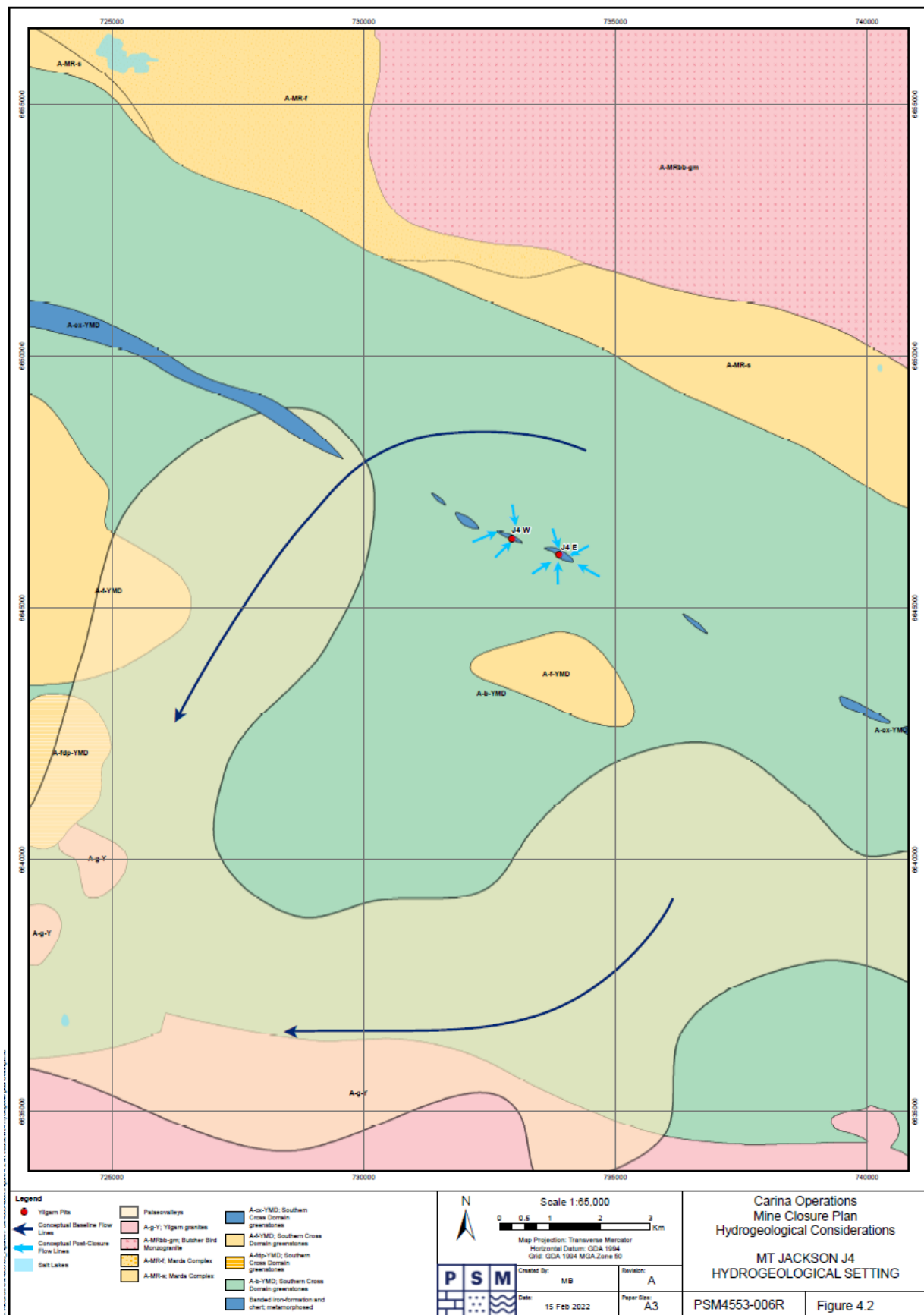
1. Water balances estimated for the period between April 2019 to November 2021

2. Water balances estimated for the period between April 2019 to June 2021

Table 38 Summary of Hydraulic Properties – J4

Hydrogeological unit	Hydraulic Conductivity (m/day)	Specific Yield (dimensionless)	Specific Storage (m ⁻¹)
Bedrock	0.001 to 0.01	0.001 to 0.01	10 ⁻⁶
Mineralised BIF	10 to 50	0.001 to 0.10	10 ⁻⁶
Unmineralised BIF	0.5 to 2	0.001 to 0.01	10 ⁻⁶
Fault Structures	0.5 to 2	N/A	10 ⁻⁴
Paleochannel	5	0.04 to 0.20	10 ⁻⁵

Source: PSM Consult (2023 Draft)



Source: PSM Consult (2023 Draft)

Figure 66 J4 Hydrogeological Setting

5.6.2.2.3 Carina Southern Operations

Drilling at the East Jaurdi Aerodrome (23 vertical holes to a depth of 27 m to 63 m) indicates there is limited groundwater in the locality. Recorded water table depth varied from 21 to 49 m bgl. Water in flows were generally minimal with only two holes recording flows of any significance, 35 litres per minute and 40 litres per minute (Crushing Services International, 2011).

5.6.2.2.4 Aurora

Mining of the Aurora pit remained above the groundwater table and there is no baseline information available for this site.

It was reported that no groundwater was encountered in exploration (Willmine Pty Ltd, 1994).

5.6.2.3 Post-Closure Groundwater Assessments

5.6.2.3.1 Groundwater Modelling Approaches

Pit lake water balances and numerical groundwater modelling have been completed for the Carina and J4 Pits as described in the sub-sections below. The first phase of assessment was completed prior to the proposal to backfill the J4 West Pit. Results for both scenarios (backfill and no backfill of J4 West Pit) have been presented to inform risk assessment of an unplanned closure scenario.

Pit Lake Water Balance

Predictive water balances were developed to classify how the pit lakes would function post-closure (i.e., sink, source or through-flow system), and to determine risks to surrounding land uses. The following inputs were used:

- Upper and lower bound groundwater inflows were prescribed based on the historical water balance and assumed to decrease linearly between the current pit lake elevation and the pre-mining water table.
- Average, wet, and dry climate scenarios were developed based on guidance by the Department of Water (DOW) (DoW, 2015).
- A factor of between 0.7 and 0.9 was applied to the evaporation rates to account for the effects of sheltering and salinity on evaporation from the pit lakes.
- Long-term TDS concentrations of the pit lakes were estimated by coupling solute concentrations to the water balance equations (PSM Consult Pty Ltd, 2023 Draft).

Pit lake filling scenarios were also simulated to estimate recovery timeframes and assess whether contaminants could escape the pit lake capture zones.

Numerical Groundwater Model

The numerical groundwater model used a transmissivity-based analytical groundwater model. An analytical method was used to estimate residual drawdown based on application of radial flow in an unconfined aquifer for a (long-term) period of dewatering. The simulations assumed horizontal flow in a homogenous Equivalent Porous Media. The pits were simulated as production bores by matching the groundwater level within the well to the predicted post-closure pit lake level (PSM Consult Pty Ltd, 2023 Draft).

The radial flow equations produce circular residual drawdown patterns whereas residual drawdown is expected to have some subtle elongation beneath the BIF ridgelines. Therefore, the resultant contours are presented as indicative of the potential drawdown extents (PSM Consult Pty Ltd, 2023 Draft).

Pit inflow rates were adjusted in the model until the target predicted water level of the J4 East and J4 West Pit lakes were achieved.

5.6.2.3.2 Pit Lake and Groundwater Modelling Results

The modelling indicated that the J4 and Carina Pit lakes are expected to act as groundwater sinks under all circumstances considered. Carina Extended may become a throughflow system with groundwater flowing towards the Carina Pit Lake (PSM Consult Pty Ltd, 2023 Draft).

Groundwater Levels

Residual drawdowns associated with all of the Carina Operations groundwater sinks extend radially for several kilometres (Figure 67 and Figure 68), dictated by assumptions of recharge rates from rainfall (PSM Consult Pty Ltd, 2023 Draft). The modelled residual drawdown (lower bound – dry climate) at J4 approaches but does not intersect the palaeovalleys (modelled prior to the J4 West backfill proposal) (Figure 68). The extent of drawdown would be reduced in the scenario where J4 West Pit is backfilled.

Pit Lake Water Balance

The expected range of pit lake elevations and salinities for the lower and upper bound groundwater inflow scenarios are summarised in Table 39. There was little difference between the dry, wet, and median climate scenarios, therefore, only the median climate is presented (PSM Consult Pty Ltd, 2023 Draft).

The pit lakes are predicted to stabilise at lower elevations than the groundwater level (405 m AHD at J4 and 410 m AHD at Carina) and will function as cumulative groundwater sinks post-closure. In the Carina Extended Pit, the model predicts that pit lake elevation will become lower over time.

The TDS concentrations of the pit lakes will increase with time due to evapo-concentration effects and after 80 years is estimated to reach between (PSM Consult Pty Ltd, 2023 Draft):

- 77,000 – 135,000 mg/L in the J4 East Pit Lake
- 55,000 – 100,000 mg/L in the J4 West Pit Lake (if not backfilled); 135,000 – 180,000 in the Carina Pit.
- Will exceed typical solubility limits predicted with a simple mass balance in the Carina Extended Pit.

The predicted trends at J4 reflect the historical groundwater quality which shows a higher TDS in J4 East Pit than J4 West Pit (PSM Consult Pty Ltd, 2022).

The findings for the Carina Pit are broadly consistent with those reported in the previous MCP based on predictions of post-closure pit lake elevation of 376 m AHD at 23 years post-closure and TDS of 70 – 100, 000 mg/L (hypersaline) at 50 – 100 years after equilibrium conditions have been reached (SWC, 2015b).

Given the hypersaline setting, PSM Consult Pty Ltd (2022) assessed the potential for density contrasts between the pit lake and groundwater to drive throughflow against the estimated point water heads. The assessment (Appendix G-3) indicated that density driven flow from the J4, and Carina Pits is unlikely.

As discussed in 5.3.3.4.1, an earlier assessment of pit lake evolution for the Carina Pit estimated 60,000 m² of exposed PAF rock units, with 0.4 to 1 % Total S, above the estimated equilibrium pit lake elevation (376 m AHD) (SWC, 2015b). This exposure could be in the order of another 10 – 20,000 m² (SWC,

2015b)²¹ based on the lower estimated final pit lake elevations (357 m AHD) modelled by PSM Consultants (2023 Draft) (Table 39).

SWC (2015b) modelled pit lake pH in response to groundwater level recovery and oxidation of exposed PAF materials and predicted that the pit lake will remain circum-neutral (pH > 6) before the pit lake level reaches equilibrium and would become acidic in the long term, except for the inherent buffering expected from the groundwater (pH 7), which would see the pit lake buffer to around pH 6 – 7. This prediction assumed a groundwater alkalinity of 200 mg/L of CaCO₃ equivalent (SWC, 2015b). Geochemical mixing (PHREEQC) modelling during the groundwater recovery stage and after equilibrium water levels have been reached, predicted pH declining slowly over time to pH 6.8 at 100 years after equilibrium (SWC, 2015b). It was noted that with time, the inputs of acidity from reacting PAF exposed on the pit walls will effectively cease due to both armouring of the sulfide minerals during weathering and the formation of a clayey saprolite which will limit the permeability of the pit walls (SWC, 2015b).

Recent monitoring data demonstrated that the groundwater throughflow source is weakly alkaline, hence does have some buffering capacity which may mitigate some of the PAF effects (PSM Consult Pty Ltd, 2023 Draft).

As noted in Section 5.3.3.4.2 solute release from the exposed J4 pit walls, based on limited sulfidic materials being intercepted by the pits, are anticipated to present a low risk. However, sulfidic materials occur close to the J4 East Pit walls and solute release from these materials should be considered in pit lake chemistry (SRK, 2023).

Pit Lake Filling Assessment

A hypothetical worst-case pit filling scenario (pit filled to crest) was modelled and indicated that pit lake recession times for the lower and upper bound scenarios were (PSM Consult Pty Ltd, 2023 Draft):

- 15 and 18 years, respectively for J4 West Pit (if not backfilled).
- 18 and 22 years, respectively for J4 East Pit.
- 20 and 25 years, respectively for Carina Pit.
- 27 and 34 years, respectively for Carina Extended Pit.

This is representative of the time when the pit lake could act as a groundwater source rather than a groundwater sink. Once the pit lake recedes below the groundwater level, the groundwater flow direction would begin to reverse and recapture any contaminants released from the pit during this period (PSM Consult Pty Ltd, 2022).

This is a very conservative case as the simulated filling event far exceeds water levels resulting from direct rainfall in a 1:2,000-year event. For reference, the 1:2,000-year 72-hour rainfall event was reported to be 352 mm. Direct rainfall from this event would produce a pit lake elevation increase, depending on the antecedent lake levels, of less than (PSM Consult Pty Ltd, 2023 Draft):

- 3 m and 5 m for the J4 West (if not backfilled) and J4 East Pits respectively; and
- 5 m and 9 m for the Carina and Carina Extended Pits respectively.

For reference, the maximum predicted pit lake level for the J4 Pits is ~370 m AHD and the pit crest levels are ~ 443 – 465 m AHD. The maximum predicted pit lake level for the Carina Pits is ~370 – 390 m AHD (PSM Consult Pty Ltd, 2023 Draft) and the pit crest levels ~ 460 – 480 m AHD (Rockwater Pty Ltd, 2009) (SWC, 2015b).

²¹ Table 5 of SWC (2015b) indicates that the 370 – 380 mRL bench has exposed PAF of 20,038 m² with average sulfur of 1.02% and the 360 – 370 mRL bench has a surface area of 21,950 m² with average sulfur content of 1.922%.

Table 39 Modelled Post-Closure Pit Lake Elevations & Quality

Pit Lake	Post-closure pit lake (m AHD)	Time to steady state (years)	Post-closure TDS (mg/L) ¹ .
J4 West (if not backfilled)	373 – 380	4 – 13	55,000 – 100,000
J4 East	371 – 381	8 – 26	77,000 – 135,000
Carina	357 – 370	29 -37	135,000 – 180,000
Carina Extended	365 – 388	16 – 30	SL (after 12 – 79 years)

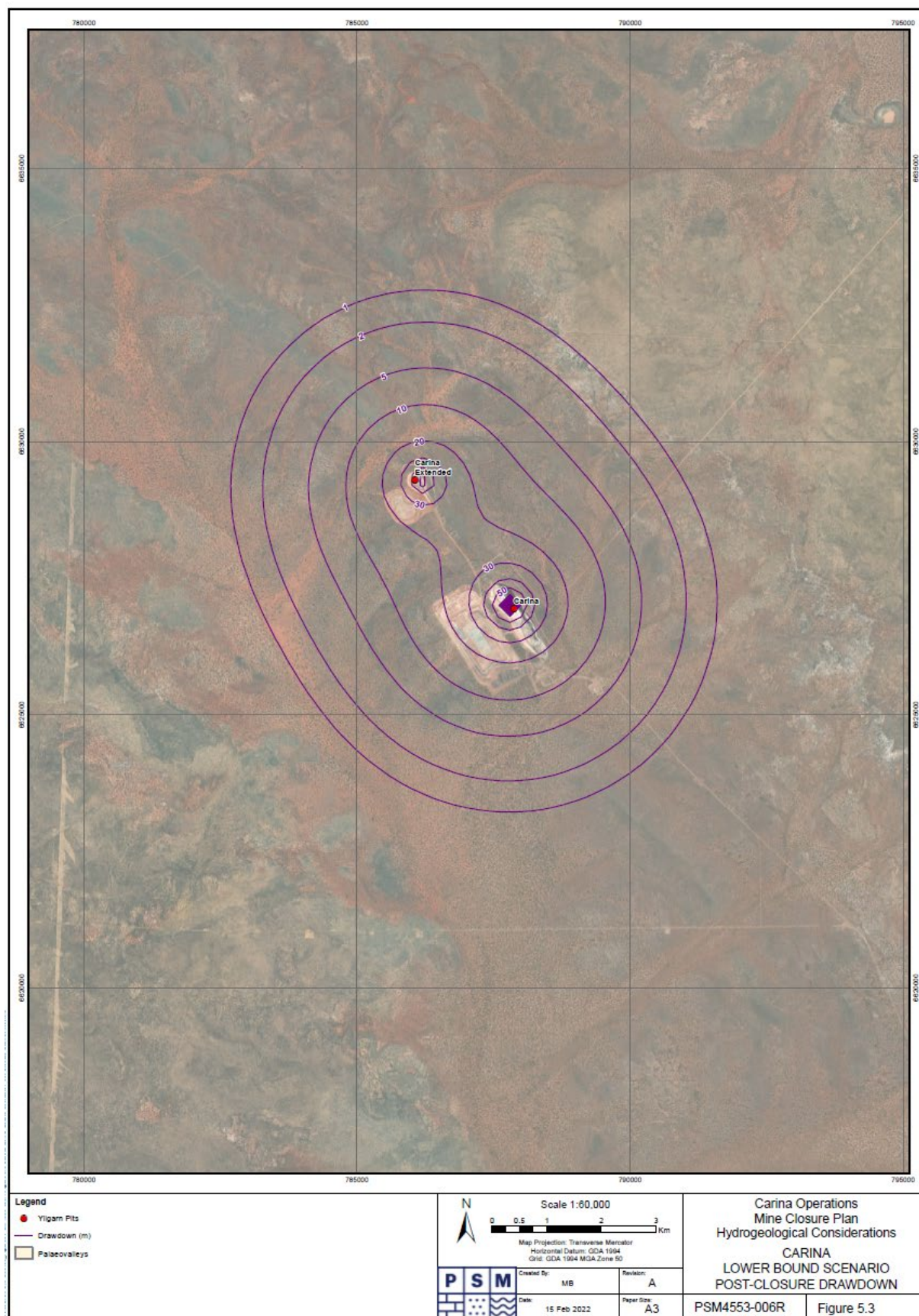
Source: Adapted from PSM Consult (2023 Draft)

Notes:

- After 80 years
- Lake elevations approach steady-state asymptotically.
- SL indicates that the salinities predicted with a simple mass balance exceed typical solubility limits.
- () indicates the years to reach salinity limit.



ENV-TS-RP-0617



Source: PSM Consult (2023 Draft)

Figure 68 Modelled Residual Drawdown Carina / Carina Extended Lower Bound Scenario

5.6.3 Considerations for Closure

Modelling indicates that the closure scenarios of residual pit lakes at the Carina, Carina Extended and J4 East Pits would be unlikely to result in significant post-closure impacts to receptors from changes to groundwater levels and quality, although further monitoring to validate the groundwater model and further assessment of potential receptors are required to confirm this.

In all circumstances considered, it is expected that pit lakes will become groundwater sinks, with the flow of groundwater being toward the pits. This will result in residual drawdown of surrounding groundwater levels extending radially several kilometres from the pits. Modelled drawdown from J4 East Pit approaches but does not intersect the inferred palaeochannel location.

Water in the pit lakes will become more saline over time as the rate of evaporation exceeds the rate of precipitation and groundwater inflow. However, as the pit lakes are predicted to be sinks, the elevated salinity in the pits is unlikely to impact groundwater qualities. In a conservative worst-case scenario where pit lakes fill to the crest, there is potentially movement of pit lake water out of the pits but once the pit lakes recede below the groundwater level, the groundwater flow direction would begin to reverse and recapture any contaminants released. If contaminants did temporarily enter the groundwater system, they would migrate slowly (as groundwater flow is characterised by low velocities of particulates) and mix with groundwater in storage and rainfall recharge which would promote dilution. The likelihood of pits filling to overflow is considered low on the basis that in a 1:2,000 rainfall event, pit lake levels would rise by only 3 – 5 m at J4 and 5 – 9 m at Carina, significantly below (20+ m) the pit crest levels.

Initial review found that density driven flows from the pit lakes would be unlikely.

In addition to the effects of evaporation, pit lake chemistry at Carina and J4 East will be influenced by PAF that will remain exposed on pit walls above the final pit lake level, the behaviour of higher sulfur materials at shallow depth within the pit walls (J4 East), the potential PAF content of backfill (Carina) and the quality and quantity of groundwater inflow.

5.6.4 Knowledge Gaps & Forward Work Program

The following actions are proposed to address knowledge gaps:

- Develop groundwater and pit lake monitoring program and implement for the period necessary to validate the groundwater and pit lake models to provide confidence that the systems are functioning as expected.
- Conduct a gap analysis to identify the need for further testing / modelling.
- Review the requirement for further assessment of the potential for density driven flow as groundwater and pit lake models are refined.
- Confirm the nature and status of the potential aquatic GDE that appears on the GDE Atlas (BoM, 2024d), north east of the Carina Operations.

5.7 Contamination

5.7.1 Preliminary Site Investigation

A Preliminary Site Investigation (PSI) was completed for the Carina Operations in 2022 (Greencap, 2022). The objectives of the PSI were to identify potential source(s) of contamination associated with current and historical site activities, and to determine potential risks to human health, the environment and any environmental values.

The scope of work comprised a desktop review of available information, site inspection, development of a preliminary conceptual site model (CSM) to determine potential source-pathway-receptor (SPR) linkages for the Project in its current use and for its PMLU, and identification of data gaps requiring further assessment.

The PSI identified areas of concern across the project requiring further assessment, including potential contamination associated with fuel infrastructure. SPR linkages were determined to be potentially complete and data gaps were identified, including, the nature and extent of soil and groundwater impacts. The PSI report is provided in Appendix C.

MinRes will liaise directly with DWER Contaminated Sites Branch on an as-needed basis in relation to potential reporting requirements under the CS Act. Any relevant updates will be provided in subsequent MCPs.

5.7.2 Considerations for Closure

Provisions will need to be made in decommissioning and rehabilitation plans for investigating / remediating potentially contaminated sites that have not been investigated and remediated prior to closure.

5.7.3 Knowledge Gaps & Forward Work Program

To address knowledge gaps, a Sampling and Analysis Quality Plan (SAQP) will be prepared to guide a Detailed Site Investigation (DSI). The overarching objective of the DSI (to be documented in the SAQP) will be to seek to address the identified data gaps in the preliminary CSM; this is required to assess compatibility with the proposed PMLU for the site. Specific objectives comprise the following:

- Identify the nature and extent of contamination within each area of concern, to the extent practicable.
- Assess potential risks to relevant receptors and enable refinement of the CSM.
- Determine requirements for management action and / or remediation with consideration to the PMLU.

MinRes will also liaise (as required) with relevant stakeholders to determine applicable assessment and validation criteria that appropriately assesses compatibility with the PMLU.

5.8 Social and Heritage Values

5.8.1 Aboriginal Heritage

Multiple heritage surveys have been conducted across the Carina North, Carina Southern and J4 project areas, including haul roads. The results of the surveys completed to date and a search of the Aboriginal Heritage Inquiry System (AHIS) have identified:

- One location at Carina that occurred within the mine footprint. This site was disturbed as part of the mining operations with Section 18 approval granted by the Minister for Energy; Training and Workforce Development; Indigenous Affairs on 17 May 2011.
- Two lodged heritage places at J4 listed on the Aboriginal Heritage Place Register (AHIS) (Figure 69):
 Site Identification Number (ID) 20145 covers the north eastern corner of the Site and has a range of types of cultural significance including artefacts / scatter, mythological significance, and a water source.
 Site ID 29778 is located south of the J4 West Pit and north of the ROM area. MinRes corresponded with the then Department of Aboriginal Affairs (DAA) in September 2014 regarding rock-hole and artefact scatter. DAA advised that it is “unlikely that it will be assessed as a site under section 5 of the AH Act”. MinRes received Letters from Traditional Owners agreeing that the rock-hole portion of Site 29778 shall “be left undisturbed” and that the artefacts can be salvaged enabling a portion of the site to be disturbed. Correspondence and the salvage report were provided as part of the J4 Redevelopment Mining Proposal (MinRes, 2023a). This proposal included excision of the rock-hole portion of Site 29778 from the J4 development envelope.
- One site of heritage significance, a heritage tree, is located within tenement L15/305 in native vegetation adjoining the haul road. This is outside of any disturbed areas.
- No sites or places registered on the Aurora tenement area. It is noted however that correspondence from the then Department of Aboriginal Sites of the Western Australian Museum stated that there appears to have been virtually no previous research into Aboriginal sites within the tenement or the vicinity (Willmine Pty Ltd, 1994).

MinRes will continue to work closely and collectively with Marlinyu Ghoorlie to ensure Heritage Places and Sites are avoided and protected. MinRes also continues to work closely with DPLH to ensure compliance with the Aboriginal Heritage Act and seeks advice when required (MinRes, 2023a).

Management of cultural heritage during closure is discussed in Section 9.1.5.

5.8.2 European and Other Heritage

Under the EPBC Act, a list of National and Commonwealth Heritage is maintained by the Department of Climate Change, Energy, the Environment and Water (DCCEW). No records on the National or Commonwealth Heritage Lists are located within the vicinity of the Carina Operations (DCCEW, 2023).

The Heritage Council of Western Australia (HCWA) maintains the State Register of Heritage Places and other heritage listings under the *Heritage Act* 2018 (Heritage Act) (Heritage Council of WA, 2023). There are no State Registered Places (the highest level of recognition afforded at the State level) or other listings in the vicinity of the Carina Operations.

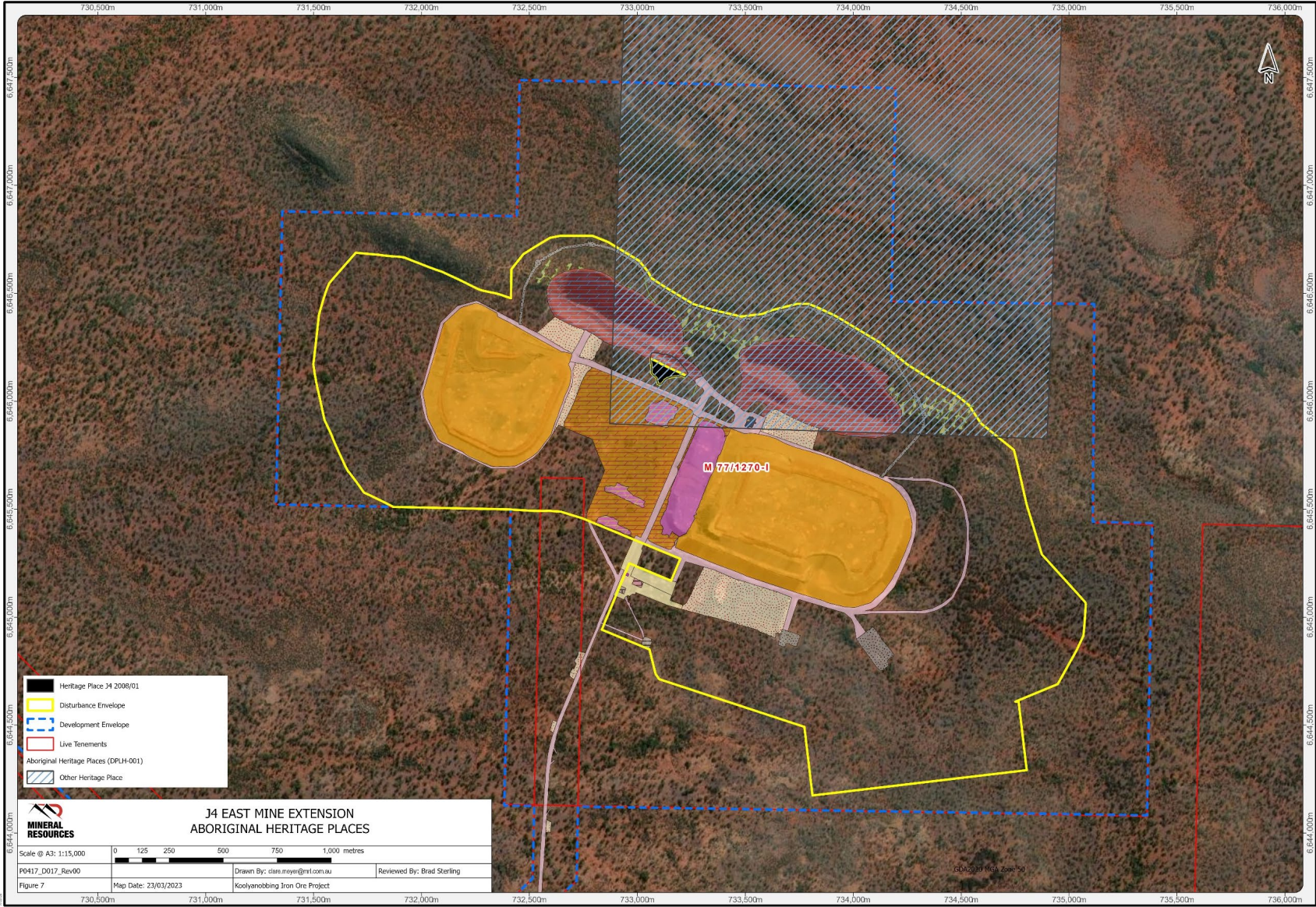


Figure 69 Heritage Sites J4

5.8.3 Local Land Use

The Carina Operations are located in a remote part of Western Australia within the Shire of Yilgarn and the Shire of Coolgardie local government areas and in the boundary of the Marlinyu Ghoorlie Registered Native Title Claim.

The Shire of Yilgarn covers 30,720 km² and supported a population of 1,173 people during the 2021 census (ABS, 2021a). Southern Cross (370 km east of Perth) is the Shire's major town. Other town sites include Bodallin, Bullfinch, Koolyanobbing and Marvel Loch. The Carina Operations are located approximately 100 km north-north east of Southern Cross and 50 km north-east of Koolyanobbing. The Shire of Coolgardie covers 30,400 km² and supported a population of 3,478 people at the 2021 census (ABS, 2021b). Coolgardie and Kambalda are the two major town centres. The Carina Operations are located approximately 125 km north-west of Coolgardie.

On a regional setting, the primary land use is low intensity grazing and conservation with mining being a dominant industry. Underlying land tenure includes pastoral, conservation and UCL as described in Section 2.3.2. The J4 haul road traverses the Mount Manning Conservation Park which also surrounds the Aurora site located on UCL (refer Figure 2, Section 2.3.2). It is proposed to convert this Conservation Park to a Class A national park subject to the development of an Indigenous Land Use Agreement with the Marlinyu Ghoorlie (DBCA, 2021a). The Carina Northern Operations are located within the former Jaurdi pastoral station, which was proposed for inclusion in the Yilgarn conservation reserve system based on landscape and biodiversity values (EPA, 2007). The area is not yet vested under any Act that is administered by DBCA.

No third-party mining operations border the Carina Operations. The Carina site is approximately 15 km from the (25 km² reserve boundary) Mt Walton Intractable Waste Storage Facility and a similar distance from the Tellus Holdings Sandy Ridge Facility (for storage of low-level radiological waste). As discussed in Section 2.1, agreements are in place for use of a portion of the Mt Walton Intractable Waste Storage Facility access road to access the Carina Southern Operations.

There are various public access tracks in the area that provide access to the Mount Manning Conservation Park. Those affected by the Carina Operations are the access from Mt Jackson to the west, the access from Koolyanobbing to the south via the Koolyanobbing Track and the access between Mt Dimer and Mt Finnerty on the ex-Jaurdi pastoral lease. The existing public access track between the Bullfinch-Evanston Road at Marda (north of Mt Jackson) and the Mount Manning Conservation Park traverses the western pit at the J4 mine. To maintain public access, the track has been diverted to the north of the mine site along an existing exploration track on the northern side of the range. There are also access related obligations arising from tenement conditions (Appendix B-1) and potentially obligations from third parties with access agreements or ownership of infrastructure within the Carina Operations vicinity.

5.8.4 Considerations for Closure

Early heritage surveys may not have involved the Marlinyu Ghoorlie. Heritage values inform closure plans, particularly where additional disturbance (e.g., abandonment bund construction) is required and where sites are within the vicinity of potentially unstable areas. Heritage sites also require protection during closure implementation.

Impacts of closure landform design and road decommissioning / retention on post-closure land access need to be considered.

Local land use and underlying tenure inform PMLU.

5.8.5 Knowledge Gaps & Forward Work Program

The following actions are proposed to address knowledge gaps:

- Consult with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys to inform closure planning.
- As closure designs progress into execution plans, consider the potential impacts to heritage sites arising from design changes and clearing required for construction access.
- Develop a Land Access Plan (or similar) in consultation with all relevant stakeholders and to meet the conditions of tenements and third-party agreements.

5.9 Other Closure Related Data

This section summarises:

- The outcomes of berm capacity modelling and rectification recommendations used to inform assessment of the Carina and J4 WRLs closure design (Section 5.9.1).
- The results of rehabilitation trials on the Carina WRL (Section 5.9.2).
- Progressive closure performance of the Carina Operations WRLs, including rehabilitation and erosion monitoring and assessment of as-constructed landforms against approved designs for geotechnical and geochemical stability (Section 5.9.3).
- Rehabilitation performance of areas other than WRLs (Section 5.9.4).
- Benchmarking, research, and trials with relevance to the Carina Operations (Section 5.9.5).

5.9.1 WRL Berm Capacity Assessment

Key Points:

- Assessment of the minimum berm width required to adequately control surface water on WRLs within the Yilgarn area has been assessed to inform the closure design of these landforms (Okane Consultants, 2021a; 2022a; Landloch, 2023).
- The original modelling (Okane Consultants, 2021a) was completed for MinRes' Windarling site but given similarities in location, rainfall and soil erosion characteristics, it was deemed appropriate for the first phase of assessment to use most of these metrics across all MinRes sites in the Yilgarn, including Carina (Okane Consultants, 2022a). Okane's (2022a) conceptual model included specific rainfall and run-off conditions, the physical properties of local 'gravelly topsoils' reserved for rehabilitation activities and the following conceptualised embankment / berm geometry:
 - o 10 m high 15° lifts.
 - o Crest bund around the perimeter of the upper plateau area.
 - o No vegetation cover.
 - o 5° berm back slope.
- Based on this conceptual model, the Okane assessment determined that a 10 m lift height requires a minimum 10 m berm width, and a 15 m lift height requires a minimum 13 m berm width to provide the minimum capacity to accommodate 300 years of accumulated sediments plus run-off predicted from a 1 in 2000-year Average Recurrence Interval (ARI), critical duration storm event. The minimum freeboard estimated in these circumstances was 0.01 m. The assessment indicated an approximately linear relationship between lift height and required berm width.
- The second phase of assessment (Landloch, 2023) utilised measurements of run-off and sediment concentrations from materials collected from the upper profile of the Carina WRL and the Carina Extended WRL. The model considered the existing batter geometry and largest daily run-off and erosion estimates derived from testing of Carina materials and assumed a freeboard depth of 0.3 m and a backslope of 5°.
- Based on these model parameters, Landloch (2023) concluded that a berm width of 10 m is suitable for the Carina Extended WRL lift height of 7.5 m but that minimum widths for the middle berm and upper berms on the Carina WRL should be 22 m and 14 m respectively.

The minimum width required for berms on WRLs has been assessed to inform the closure design of these landforms (Okane Consultants, 2021a; 2022a; Landloch, 2023). The original modelling (Okane Consultants, 2021a) was completed for WRLs at MinRes' Windarling site but given similarity of location, rainfall and soil erosion characteristics, it was deemed appropriate to use most of these metrics for the first phase of assessment for the Carina Operations (Okane Consultants, 2022a) (Section 5.9.1.1). Subsequently, measurements of run-off and sediment concentrations from materials collected from the

upper profile of Carina WRL and the Carina Extended WRL have been used by Landloch (2023) to refine berm capacity requirements (Section 5.9.1.2).

The Okane assessment concluded that a 10 m lift height requires a minimum 10 m berm width and a 15 m lift height requires a minimum 13 m berm width to provide the minimum capacity to accommodate 300 years of accumulated sediments plus run-off predicted from a 1 in 2000-year ARI, critical duration storm event for the geometry modelled (Okane Consultants, 2021a; 2022a).

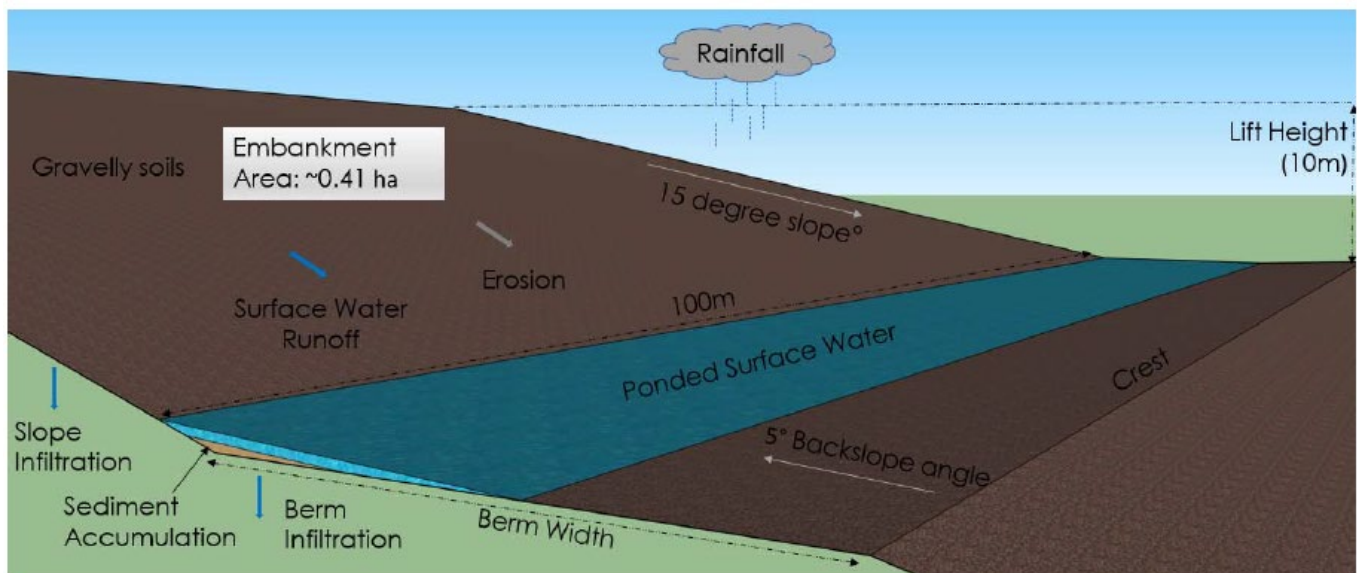
The Landloch assessment concluded that minimum berm widths of 14 and 22 m (Lifts 1 and 2 respectively) were required for the existing geometry of the Carina WRL and a minimum berm width of 10 m is required for the Carina Extended WRL (Landloch, 2023).

The determination of these berm width requirements is described in detail below. The results of the berm capacity assessment inform WRL design and rectification plans as discussed in Section 5.9.6.1 and Section 9.2.2.

5.9.1.1 Berm Capacity Assessment – 2022

Berm capacity modelling was initially completed to determine suitable berm widths for a range of different slope lengths at a fixed angle. This modelling involved an integrated consideration of hydrological and erosion processes for different lift heights and slope lengths, and a balance of both the sediment and water volumes to determine a minimum recommended size for the storage berms (Okane Consultants, 2022a).

The conceptual model of the system included specific rainfall and run-off conditions, the physical properties of local 'gravelly topsoils' reserved for rehabilitation activities and the embankment / berm geometry as conceptualised in Figure 70. The model assumed that there was no vegetation cover, and that crest bunds were constructed around the perimeter of the upper plateau area (Okane Consultants, 2021a).

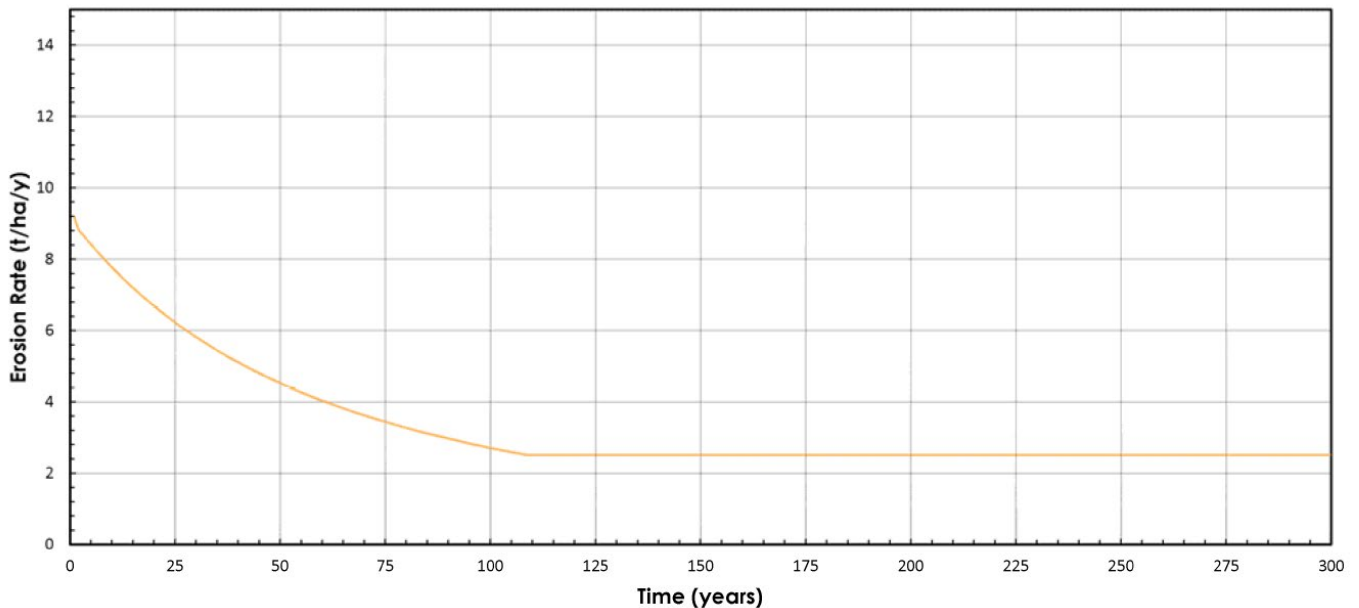


Source: Okane Consultants (2021a)

Figure 70 Conceptualisation of the Berm Capacity Assessment

The assessment considered the ability of berms to accommodate sediment deposited in the berms from upstream slopes as well as anticipated surface water run-off volumes. The erosion metrics used to account for sediment accumulation were based on the erosion modelling conducted by SWC (2012) at Windarling. SWC concluded that the self-armouring properties of the gravelly materials would reduce

erosion and promote stability over time. Okane Consultants (2021a), therefore, incorporated a soil armouring function into erosion modelling to represent the gradual reduction in the rate of soil erosion over time as armouring occurs (Figure 71).



Source: Okane Consultants (2021a)

Figure 71 Soil Armouring Function

The commercial surface water model 'DRAINS' was used to assess surface water run-off and ponding within WRL berms for a 1 in 2,000-year ARI critical duration storm. The DRAINS model results determined the critical storm duration to be 45 minutes resulting in approximately 0.6 m ponded water. The balance of accumulated sediment, water and remaining freeboard for a 10 m wide berm with a 5° back slope is summarised in Table 40. The predicted minimum freeboard depth is measured from the crest of the berm to the top water level (Figure 72). This is after accounting for both accumulated sediment and maximum ponded water (Okane Consultants, 2021a).

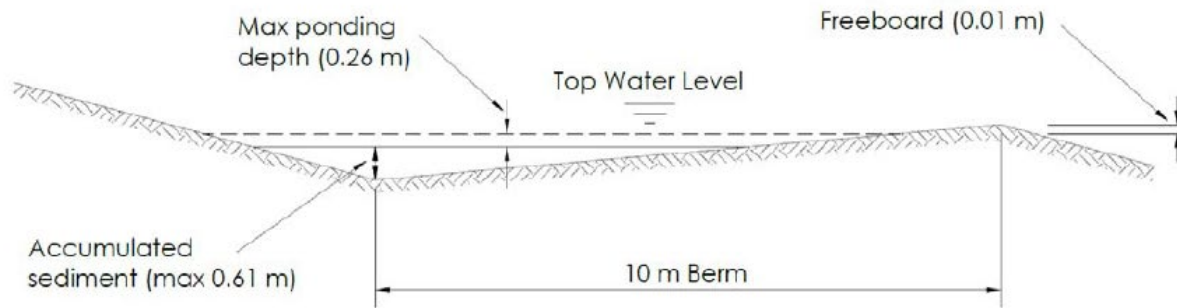
Table 40 Summary of Accumulated Sediment, Water and Freeboard

Berm width (m)	Berm storage capacity (m ³ /100 m)	300-year accumulated sediment volume (m ³)	Maximum ponded volume (m ³)	Minimum freeboard height ¹ (m)	Remaining berm capacity ² (m ³)
10	576.5	279.0	290	0.01	7.0

Source: Okane Consultants (2021a)

Notes:

- 1. Minimum freeboard estimated following 300 years sediment deposition and maximum ponded volume from the maximum ponded surface water volumes (from 1 in 2000-year ARI, critical storm).
- 2. Remaining berm capacity after accounting for sediment deposition (300 years) and maximum ponded surface water volumes (from 1 in 2000-year ARI, critical storm).



Source: Okane Consultants (2021a)

Figure 72 1 in 2000 Year ARI Run-off and Sediment Depths After 300 Years

The Windarling assessment determined that for a 10 m lift height, a 10 m berm width provides the minimum capacity to accommodate 300 years of accumulated sediments plus run-off predicted from a 1 in 2000-year ARI, critical duration storm event for the geometry depicted in Figure 70 (Okane Consultants, 2021a).

The assessment indicated an approximate linear relationship between lift height and required berm width. The lift heights that were assessed, and the subsequent minimum berm capacity required for each lift, are detailed in Table 41 together with the relevant metrics of each berm, such as the storage capacity, erosion sediment volume, free board and surplus capacity (Okane Consultants, 2022a).

Table 41 Minimum Berm Width per Lift Height and Associated Values

Lift Height (m)	Minimum Berm Width 300 yr. erosion (m)	Berm Storage Capacity (m ³)	300 yr. Eroded sediment volume (m ³)	Maximum ponded volume (m ³)	Freeboard height (m)	Surplus capacity (m ³)
5	7	281	157	108	0.02	15
7.5	9	466	194	228	0.04	45
10	10	577	279	291	0.01	7
12.5	12	832	406	362	0.04	64
15	13	977	526	424	0.02	27
17.5	15	1301	659	495	0.08	148
20	16	1481	795	558	0.06	129
22.5	17	1673	933	621	0.06	119
25	18	1876	1076	684	0.05	116
27.5	19	2091	1227	746	0.05	117
30	20	2317	1378	810	0.05	129
5	7	281	157	108	0.02	15

Source: Okane Consultants (2022a)

5.9.1.2 Berm Capacity Assessment – 2023

Required berm widths for the Carina and Carina Extended WRLs were derived for the existing geometry using the cumulative mean average annual long-term erosion rate over 300 years for Carina materials and the largest daily run-off value. Samples of material collected from above and below the existing berms at Carina and Carina Extended WRLs were subjected to rainfall simulations to determine the erosion rates used in this assessment. A backslope of 5° and freeboard depth of 0.3 m were assumed. Time series data of daily run-off and erosion were generated using the WEPP run-off / erosion model for the actual batter geometry, including a storm event with an annual exceedance probability of 0.05% (Landloch, 2023).

The results are presented in Table 42.

Table 42 Berm capacity requirements expressed as the cross-sectional area of the bench for the 300-year design life

Landform	Berm Position	Existing Minimum Berm Width with 5° backslope (m)	Existing Berm Capacity (m³/m width of slope)	Maximum Long-term Erosion Rate ¹ .	Largest Daily Run-off Value (mm)	Required Sediment Volume (m³/m width of slope)	Volume Run-off Volume (m³/m width of slope)	Required Berm Capacity (m³/m width of slope)	Remaining Berm Capacity (Total – with freeboard minus the Sediment Volume)	Minimum Berm Width Assuming 5° Backslope (m) ² .
Carina WRL	Upper	10	5.6	3.6	91	2.6	3.1	10.3	7.7	14
	Middle	8	3.6	10.7	91	13.3	5.3	26.3	13.0	22
Carina Extended WRL	-	10	6.3	0.6	106	0.3	2.5	6.3	5.9	10

Source: Landloch (2023)

Notes

- 1: The maximum long-term average erosion rate for a 300-year period was derived from measurements of run-off and sediment concentrations from materials collected from the upper cover profile of Carina WRL and Carina Extended WRL.
- 2: The minimum permissible berm width was calculated using the following procedure (Landloch, 2023):
- Assume a triangular cross-section.
 - Generate time series data of daily run-off and erosion using the WEPP run-off / erosion model using the batter geometry in question, including a storm event with an AEP of 0.05%.
 - Calculate the maximum average erosion rate for the batter geometry in question. Convert this rate to a cumulative erosion volume for a 300-year period.
 - Determine the maximum daily run-off depth generated from the batter geometry in question by interrogating the WEPP time series run-off data. Convert this daily run-off depth to a daily volume.
 - Add the 300-year cumulative erosion volume and the maximum daily run-off volume to determine the berm capacity required to store 300 years of eroded sediment while still maintaining the ability to store the maximum run-off event modelled.
 - Hold the backslope gradient as a constant of 5° (95) and adjust the berm width until the berm capacity matches the required berm capacity.

5.9.2 Rehabilitation Trials

Key Points:

- Trial areas were established on the western and eastern slopes of the Carina WRL in 2015 and 2016 respectively to assess a range of rehabilitation surface treatments. The key variables of the trial were ripping across or down the slope, and application of timber debris and / or fertiliser as part of the surface treatment. All treatments included the application of topsoil and seed.
- The trial areas have been assessed for erosion and vegetation performance with conclusions as follows:
 - All treatments improved the surface stability of the WRL. The application of timber debris combined with ripping on the contour had the potential to reduce rilling. However, in some areas, the timber debris concentrated surface flows leading to increased rilling. Ripping downslope accelerated this trend (SWC, 2017; Landloch, 2023).
 - There is a strong positive correlation between ripping on contour and erosion and vegetation performance.
 - Although salinity was not a trial variable, it was measured during performance assessment of the trial sites and found to have a negative impact on vegetation at EC_{1:5} levels > 200 mS/m (Landloch, 2023).
 - Species diversity was most strongly influenced by salinity, wood debris cover and soil thickness. Vegetation cover was influenced by salinity, rock cover and wood debris cover.
- Based on rehabilitation trial results, vegetation cover and species diversity can be maximised at the Carina site when growth covers have the following characteristics (Landloch, 2023):
 - Addition of 10-20% timber debris;
 - EC_{1:5} levels < 200 mS/m;
 - Soil thickness between 100 – 300 mm; and
 - 40 – 60% rock cover.
- Plant mortality was highest in the treatment with no timber debris. Further investigation would help determine if the application of timber debris had an impact on survival of species with greater water requirements (e.g., *Eucalyptus* sp.) in the long term (Landloch, 2023).
- Fertiliser was predominantly found to have no impact on vegetation performance when assessed in 2017 (SWC, 2017). This variable was not reassessed in the 2023 study (Landloch, 2023).

Rehabilitation trial areas were established on the western and eastern slopes of the Carina WRL in 2015 and 2016 respectively to assess four different surface treatments (Treatments 1 – 4) as summarised in Table 43. The key variables were:

- ripping across or down the slope; and
- application of timber debris as part of the surface treatment.

All treatments included the application of topsoil and seed, however as noted in the results discussed below, applied topsoil depth was found to be variable.

The trial areas were monitored from 2015 to 2017 as part of the Carina Operations rehabilitation monitoring program described in Section 10.2.1 and Section 5.9.3.1 (SWC, 2015a; Astron, 2016; 2017; 2019a). On-ground monitoring of the sites ceased in 2018 but the trial areas continue to be included in relevant remote sensing monitoring calculations (Astron, 2019a).

In 2023, the trial sites were re-assessed to inform the optimum growth cover design for WRL areas yet to be rehabilitated or requiring remediation at Carina (Landloch, 2023).

Where the monitoring and assessment found significant differences in erosion and vegetation performance between the treatments, these have been noted in Table 43.

In summary, the monitoring and assessment found:

- All of the treatments improved surface stability of the WRL.
- Timber debris had the potential to contribute both positively and negatively to erosion performance as follows:
 - The addition of larger vegetation litter concentrated surface flows in some areas, leading to increased rilling and erosion. Ripping downslope (Treatment 3) accelerated this trend (SWC, 2017).
 - Where wood debris was applied to the surface, this resulted in a reduction in formation of erosion features in Treatment 2 (ripped on contour) but not Treatment 3 (ripped downslope) (Landloch, 2023).
- Timber debris also had the potential to contribute both positively and negatively to vegetation performance (Landloch, 2023):
 - Higher species richness was generally recorded in treatments involving incorporation of timber / vegetation mulch.
 - Treatment 2 (debris applied, ripped on contour) had significantly higher vegetation cover (18%), plant density and increased establishment of overstorey species than other treatments and the lowest plant mortality. Live vegetation cover in Treatment 3 (debris applied, ripped downslope) was only slightly lower than Treatment 2. It was suggested that the debris improves water storage capacity or availability.
 - Lowest vegetation cover and plant density were recorded for Treatment 1²² and Treatment 4 (no timber debris). High plant mortality was also recorded in Treatment 4 and further investigation would help determine if the application of timber debris had an impact on survival of species with greater water requirements (e.g., *Eucalyptus* sp.) in the long term.
 - At cover levels > 25%, the application of wood debris was shown to have a negative impact on vegetation establishment.
 - Optimum vegetation establishment was shown to be achieved at cover levels of 10 – 20%.
- Although not intended to be a trial variable, soil thickness was found to have a strong positive relationship with species diversity, but no strong relationship with vegetation cover. This influence was attributed to the increased soil seed bank. Species diversity was lowest in Treatment 1 which had the lowest soil thickness. Maximum species diversity was achieved where soil thickness ranged from 100 to 300 mm. Soil thickness (and low salinity) may explain the greater establishment of overstorey species in Treatment 4 compared to Treatment 1 (Landloch, 2023).
- There is a positive correlation between ripping on contour and vegetation and erosion performance. The trial rehabilitation areas which have been spread with topsoil material provide a more favourable surface than waste rock, with sufficient soil depth to provide some water holding capacity whilst contour ripping has brought up a quantity of waste rock aggregate to promote surface stability and reduce the effects of erosion prior to vegetation establishment (SWC, 2017).
Deviation of ripping off contour may have contributed to the most significant erosion gully observed in Treatment 2 (Astron, 2017).
Based on timber debris application and soil thickness alone, Treatment 3 should have performed similarly to Treatment 2 with respect to vegetation diversity. However, it is likely that the down-slope ripping reduced the potential for infiltration of rainfall on the batter and increased the potential for seed and nutrient to be washed away (Landloch, 2023) .

²² Field observations found very minimal wood debris to be present on Treatment 1. Where it was present it was not in mulched form, and it was unclear if the wood debris had been mechanically placed on slopes or was already present in stockpiled topsoil that had been re-spread. The assessment of wood debris was excluded from this treatment (Landloch, 2023).

- Fertiliser application predominantly had no significant impact on vegetation performance (Astron, 2017).
- Rock cover was found to have a positive impact on vegetation cover at percentages up to 40% but a negative impact at > 60% (Landloch, 2023).
- Salinity, although not a trial variable was found to have a strong influence on vegetation performance. Salinity had a stronger influence on species diversity than the presence or absence of wood debris and soil thickness. Salinity had a negative impact on vegetation at EC_{1:5} levels > 200 mS/m.
- Structural stability, fertility and pH of the trial treatments were consistent across the treatments (Landloch, 2023), noting that Landloch did not sample the upper batters that received fertiliser.

Table 43 Carina WRL Rehabilitation Trial

Treatment ¹	Timber debris variable (SWC, 2017)	Ripping variable (Astron, 2016)	Fertiliser variable (50 kg/ ha)	Monitoring Sites (West / East) (Astron, 2017)	Erosion performance	Vegetation performance (refer to Figure 73 for monitoring locations)
1	Timber debris mulched and incorporated	Shallow ² Across-slope / contour	Fertiliser applied	SR08 / SR13	• Minor / scattered erosion (Astron, 2017)	Positive - In 2016 all sites except SR20 recorded mean native cover > analogue sites⁴. - SR12 achieved species richness of 50% of analogue sites. Tree species were recorded in 2017. Negative - Treatment 1 recorded lowest mean total vegetation cover overall (4%) and significantly lowest mean vegetation density (Astron, 2017). Landloch (2023) reported average alive cover of 15% compared to 18% in Treatment 3. <i>Sonchus oleraceus</i> (weed) was recorded in SR08 & SR12 (Astron, 2017). - High average rock cover (63%) is potentially having a negative impact on vegetation establishment and cover. Average soil thickness in Treatment 1 was also significantly lower with corresponding lower species diversity. (Landloch, 2023).
			No fertiliser	SR12 / SR20		
2	Timber debris applied intact (un-mulched)	Shallow / Deep ³ Across-slope / contour	Fertiliser applied	SR07 / SR14	- The addition of larger vegetation litter has concentrated surface flows in some areas, leading to increased rilling and erosion (SWC, 2017). - SR11 reported highest erosion and also highest mean deviation of ripping from the contour (5°) (Astron, 2017). - Landloch reported that limited data was available for analysis of the relationship between wood debris and rill formation but analysis of average rill counts across each of the treatments did show however, that where wood debris was applied to the surface, this resulted in a reduction in formation of erosion features in Treatment 2 but not Treatment 3 (Landloch, 2023).	Positive - Mean total cover of Treatment 2 (9%) and vegetation density was significantly higher than other treatments (Astron, 2017). In 2023, Treatment 2 continued to display highest alive vegetation cover (18.3%) and lowest mortality rate (Landloch, 2023). - Sites SR14 and SR17 recorded native species richness ≥ analogue sites (Astron, 2017). - Site SR17 recorded tree species in 2017 (Astron, 2017). - A negative relationship was found between salinity greater than approximately 260 mS/m EC_{1:5}, species diversity and vegetation cover. However, this was not reflected in results for Treatment 2 and 3 which recorded two high EC readings of EC_{1:5} 480 mS/m and 260 mS/m. Additional factors may be influencing vegetation establishment in these treatment areas, or the two samples tested were not representative of the treatment area overall (Landloch, 2023). - In 2017, erosion had not affected vegetation performance significantly (SWC, 2017). Landloch could not analyse the impact of gullyng on vegetation cover and species diversity due to the low number of gullies recorded (Landloch, 2023). Negative <i>Sonchus oleraceus</i> was most abundant in SR07. - Debris cover levels > 25% appear to negatively affect species diversity.
			No fertiliser	SR11 / SR17		
3	Timber debris applied intact (un-mulched)	Deep Down-slope	Fertiliser applied	SR06 / SR15	- The addition of larger vegetation litter has concentrated surface flows in some areas, leading to increased rilling and erosion, and the downslope contouring in Treatment 3 has accelerated this trend (SWC, 2017). SR11 reported highest erosion and also highest mean deviation of ripping from the contour (5°) (Astron, 2017). - Application of wood debris to the surface did not result in a reduction in formation of erosion features in Treatment 3 (Landloch, 2023).	Positive - Similar to Treatment 2 above except as noted below. - Cover in Treatment 3 West ranged from 2% to 10 %. SR06 and SR10 were the only sites across all treatments that appeared to show impact of fertiliser application on mean cover (Astron, 2017). - Sites SR14, SR17 and SR18 recorded native species richness ≥ analogue sites (Astron, 2017). - Sites SR17 and SR18 recorded tree species in 2017 (Astron, 2017). Negative - SR10 was the only site that did not record any overstorey species (Astron, 2017). - Although soil thickness in Treatment 3 was comparable to Treatment 2, species diversity was lower in Treatment 3 indicating downslope ripping may have reduced recruitment (Landloch, 2023).
			No fertiliser	SR10 / SR18		
4	No timber debris applied	Deep Across-slope / contour	Fertiliser applied	SR05 / SR16	• Minor / scattered erosion (Astron, 2017).	Positive - Similar vegetation establishment to other treatments. Supported greater establishment of <i>Eucalyptus</i> species (than Treatment 1 which had lowest soil thickness), but also showed high plant mortality. Negative - Cover was low, ranging from 3 – 8 % (Astron, 2017; Landloch, 2023) and attributed to lower soil thickness than Treatments 2 and 3 (Landloch, 2023). - High average rock cover (70%) potentially having a negative impact on cover (Landloch, 2023). - High plant mortality possibly due to lack of timber debris and reduced water holding capacity (Landloch, 2023). <i>Sonchus oleraceus</i> was recorded in SR19 (Astron, 2017).
			No fertiliser	SR09 / SR19		

Source: Adapted from SWC (2015a; 2017); Astron (2017); Landloch (2023)

Notes:

1. Soil and growth medium was spread on all treatments, and seed was applied to all treatments: 2. Single tines with large, winged tine. 3. Three tines with standard ripping boots to 1 – 1.5 m depth. SR07 and SR11 should have been shallow ripped on the contour but monitoring indicates they were deep ripped similar to areas SR08 and SR12 (Astron, 2016). 4. All conclusions in relation to analogue sites are considered preliminary pending a review of the representativeness of current analogue sites.

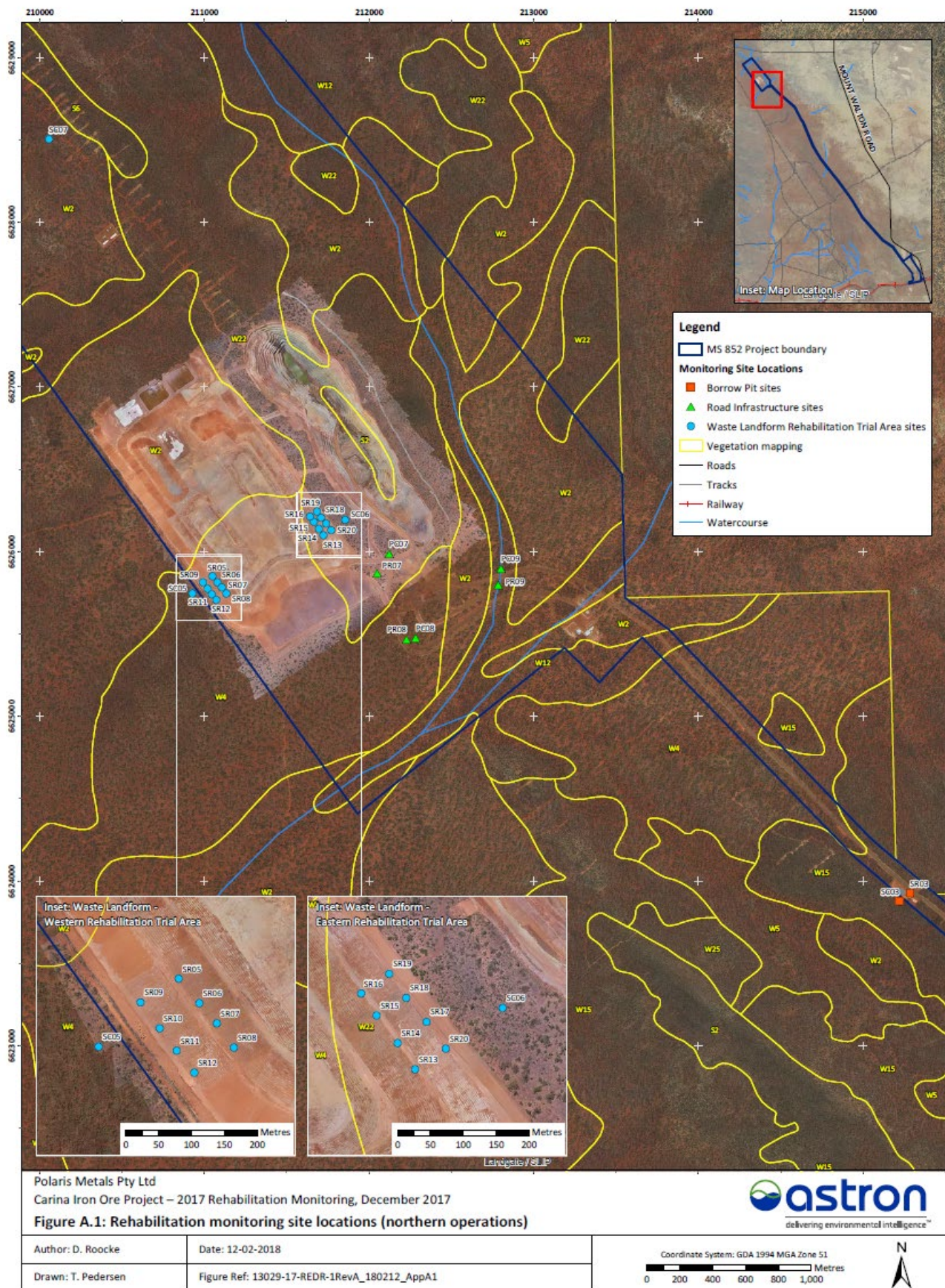


Figure 73 Carina WRL Rehabilitation Trials – Monitoring Locations (Astron, 2017)

5.9.3 WRL Closure Performance

As discussed in Section 8, MinRes has developed and continues to refine completion criteria to assess the progress of WRLs towards the overall closure objectives of ‘*creating safe and stable landforms that minimise erosion and support vegetation*’ and ‘*establishing post-mining landforms that are compatible with the natural surroundings*’.

To meet these objectives, several specific closure outcomes have been defined for the WRLs including final height, and surface, geotechnical stability and geochemical stability, which are measured in-part by the criterion ‘*construction in accordance with the approved design*’.

To facilitate assessment of performance against the closure objectives, this section summarises the results of:

- Progressive rehabilitation monitoring (Section 5.9.3.1).
- Erosion performance assessment (Section 5.9.3.2).
- Assessment of the ‘as built’ landform geometry against approved designs for ensuring visual amenity and geotechnical stability (Section 5.9.3.3).
- Assessment of conformance of the ‘as-built’ landform with approved designs for ensuring geochemical stability (Section 5.9.3.4).

This information has been considered, together with information from other sections of this MCP, to define the proposed closure approach for each landform (Section 5.9.6.1), and the additional studies / monitoring required to confirm that each landform meets completion criteria, or enable an alternate design to be developed for approval (Section 5.9.7).

5.9.3.1 Rehabilitation Monitoring – Vegetation Performance

Key Points

- Rehabilitation monitored to date on the Carina and Carina Extended WRLs is yet to display consistent trends across all attributes to determine if vegetation is progressing towards a similar structure to the analogue sites. The rehabilitation monitoring results do show some positive trends in species dominance, cover and presence of overstorey species (at Carina Extended WRL). However, the variability in performance against these parameters, structural differences, and the complete absence of overstorey species in some areas need to be addressed as per the conclusions of Astron (2023a).
- Carina WRL
 - o Native species richness has progressively increased and in 2022 was similar to the analogue sites.
 - o Species dominance results are variable. A decline in species dominance (a positive trend) was recorded at two of the rehabilitation sites in 2022. But in two sites species dominance increased due to either *A. burkitti* or *Sclerolaena fusiformis*. There was continued dominance of *Maireana triptera* at one site. At seven years post rehabilitation, it would be expected that some improvement in species dominance would be recorded at all sites.
 - o Cover at the rehabilitation sites significantly exceeds the analogue sites due to an increasing presence of species such as *A. burkittii*, *Atriplex stipitata* and *Maireana tomentosa* subsp. *tomentosa*. Two rehabilitation sites showed declining trend in native cover due to a large proportion of herbaceous species with low cover.
 - o Vegetation structure at the rehabilitation sites is dominated by herbaceous species and lacks the mid to tall shrub species, the key stratum of the analogue sites. Similarly, mean overstorey cover is lower than analogue sites, which is expected while overstorey species are immature, however two sites recorded no overstorey species.

- o Succession and recruitment of overstorey species was recorded at two sites. This indicates that the sites are stable and can support mature vegetation. However, dead trees were recorded at one site and so further monitoring is required to make conclusions about long-term self-sustaining vegetation. Mature trees were recorded for the first time at a third site, which had previously recorded no seedlings and sparse juveniles.
- Carina Extended WRL
 - o Native species richness has increased significantly over time and in 2022 was similar to analogue sites, which showed a decline in species richness.
 - o Species dominance was similar between rehabilitation and analogue sites.
 - o Cover was higher at the rehabilitation sites compared to the analogue sites but not significantly. This is expected with two-year-old rehabilitation.
 - o Vegetation structure at the rehabilitation sites remains different to that of the analogue sites in 2022, however, the proportion of Tussock grasses, low shrubs and mid shrubs have increased at the rehabilitation sites since 2018. This provides an early indication that the vegetation is progressing towards a structure similar to the analogue sites.
 - o Overstorey species have been recorded at the rehabilitation sites, including one species (*E. transcontinentalis*) shared with the analogue sites, two unconfirmed species (identification pending maturation to the point where reproductive material is available for assessment) and one species that is not present in the analogue sites (*Codonocarpus continifolius*), but is present in the area.
 - o Recruitment was observed at all rehabilitation sites, with succession recorded at one site.
 - o No dead overstorey species have been recorded since monitoring commenced in 2018. Cover of overstorey species remains low reflecting the high proportion of juveniles given the age of the rehabilitation.
- Since 2020, weed abundance has increased at Carina WRL and weed cover and abundance have increased at Carina Extended WRL. One weed species (**R. vesicarius*), not previously recorded at Carina Extended, was recorded for the first time in 2022 and can establish rapidly. The results reinforce the need for continued weed management to meet completion criteria and ensure revegetation success (Astron, 2023a).
- Rehabilitation of the J4 WRLs is not sufficiently progressed to warrant monitoring.
- Formal monitoring is also yet to occur at the Aurora WRL as it requires a level of remediation that is likely to disturb existing regrowth.

The WRLs at the Carina Operations are in various stages of construction, closure and rehabilitation (Table 44).

Rehabilitation monitoring of the Carina WRL and Carina Extended WRL commenced in 2015 and 2018 respectively, as described in Section 10.2.1. Rehabilitation monitoring and analogue sites are summarised in Table 44 and shown in Figure 74. More detail about the monitoring and analogue sites is provided in Appendix H. Supporting figures and data are provided in Astron (2023a) included in Appendix C. Monitoring results for the revegetation parameters being assessed to measure performance against the rehabilitation conditions of MS 852, which inform vegetation completion criteria, are summarised in Table 45.

A review of the rehabilitation monitoring methodology, selection of analogue sites and use of remote landscape scale monitoring to ensure representative data collection (this includes ensuring that monitoring data are not inadvertently over-estimating progress) is underway as discussed in Section 10.2.1.

Rehabilitation of the J4 WRLs is not sufficiently progressed to warrant monitoring. Formal monitoring is also yet to occur at the Aurora WRL as it requires a level of remediation that is likely to disturb existing regrowth (Section 5.9.3.3).

Table 44 Closure and Rehabilitation Status of WRLs & Monitoring Locations

WRL	Status	Rehabilitation status	Monitoring Sites ²³ (year commenced)	Analogue sites (year established)
Aurora	Inactive	Partially under rehabilitation	-	-
Carina	Inactive	Partially under rehabilitation (approx. 90 ha of 130 ha)	SR21 (2018) SR22, SR23, SR24, SR25 (2015)	SC05 (2015), SC06 (2017), SC10 (2018)
Carina Extended	Inactive	Fully under rehabilitation (approx. 32 ha)	SR26, SR27, SR28, SR29, SR30 (2018)	SC07 (2017), SC11 (2018), SC12 (2018)
J4 East	Inactive	(Re-profiling completed and topsoil applied 2017 / 18)	-	SC08 (2017)
J4 West	Operational.	Batters re-profiled, topsoil spread, no ripping)	-	SC09 (2017)

Source: Astron (2023a)

²³ Each site comprises a single transect 50 m in length with ten 2 m by 2 m quadrats set up at 5 m intervals. Where the site was too small for a 50 m transect, two 25 m transects run parallel to each other and are 50 m apart. Transects were used to monitor understorey vegetation and surface characteristics, while one 50 m by 50 m quadrat was installed to monitor overstorey vegetation and weed species. The overstorey quadrat spans 25 m either side of the transect. Where the site contains two 25 m transects, the overstorey quadrat was 100 m by 25 m (Astron, 2023a).

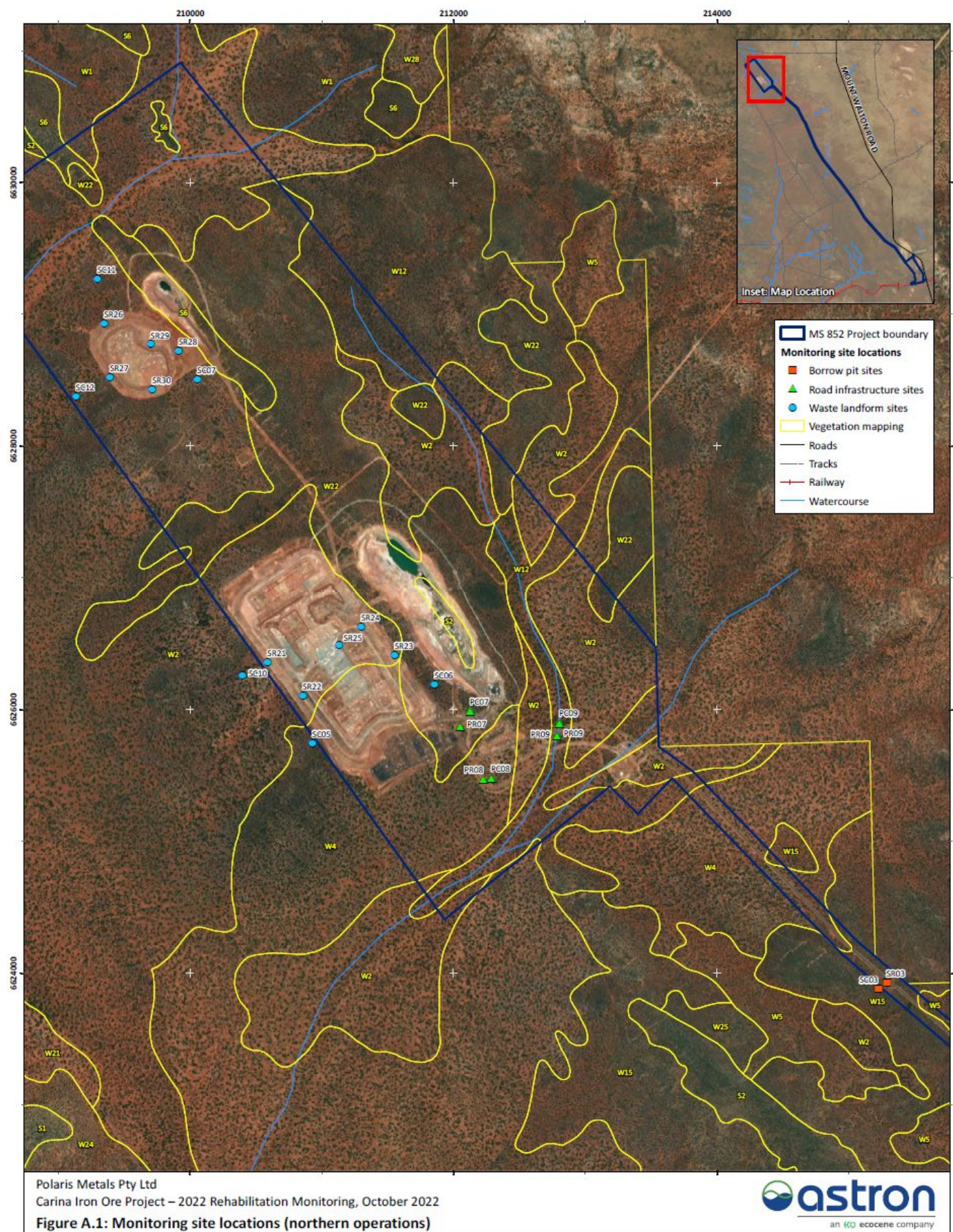


Figure 74 Rehabilitation Monitoring Sites – Carina & Carina Extended

Table 45 Rehabilitation Monitoring – Summary of Vegetation Performance on WRLs

Basis for completion criteria (Section 8)	Performance parameter (Astron, 2023a)	Progress (Astron, 2023a) (Appendix C)
To satisfy MS852: Condition 11-1 (1) The waste material landforms shall be constructed so that their ability to support local native vegetation are similar to undisturbed natural analogue landforms. Condition 11-1 (6) The percentage cover of living self-sustaining native vegetation in all rehabilitation areas shall be comparable to that of undisturbed natural analogue sites.	Species inventory and richness.	Carina WRL - An increasing trend in native species richness has been observed in all rehabilitation sites between 2018 and 2022. - Overall, in 2022, mean native species richness in rehabilitation sites (10) was similar to analogue sites (12). Species richness in Site SR23 remains the lowest at 5.
		Carina Extended WRL - Species richness at the rehabilitation sites have increased significantly over time. In comparison, species richness has declined at the analogue sites since 2019. - In 2022, rehabilitation sites were similar to the analogue sites.
	Berger Parker index of species evenness.	Carina WRL The results for species dominance vary across the WRL. - Sites SR22 and SR25 displayed a positive trend (i.e., a decline in species dominance reflecting an increase in the diversity of species contributing to vegetation cover). - In contrast, species dominance increased at SR21 due to <i>A. burkittii</i> and SR24 due to <i>Sclerolaena fusiformis</i>. - Site SR23 continues to be dominated by <i>M. triptera</i>.
		Carina Extended WRL In 2022, species dominance was similar between rehabilitation sites and analogue sites. - Species dominance at the rehabilitation sites has been decreasing (a positive trend) as vegetation progresses, whilst increasing slightly at the analogue sites. - Only one rehabilitation site (SR26) increased slightly in species dominance due to an increase of <i>A. burkittii</i> and <i>S. diacantha</i>. - One analogue site, SC11 had the highest species dominance of all the Carina Extended WRL sites and was dominated by <i>Exocarpos aphyllus</i>.
	Mean native cover (using linear model analysis or similar).	Carina WRL Mean native cover at the rehabilitation sites significantly exceeded the analogue sites in 2022 (and has been higher since 2019) & increased at three sites between 2020 and 2022 due to an increasing presence of species such as <i>A. burkittii</i>, <i>Atriplex stipitata</i> and <i>Maireana tomentosa</i> subsp. <i>tomentosa</i>. There was a declining trend in native cover at SR22 & SR23 due to large proportion of herbaceous species with low cover, such as <i>S. diacantha</i>, <i>M. trichoptera</i> and <i>M. triptera</i>.
		Carina Extended WRL - In 2022, native cover was higher at the rehabilitation sites compared to the analogue sites, but not significantly. - Mean native cover at the rehabilitation sites significantly increased between 2020 and 2022, whilst the analogue sites increased slightly between 2020 and 2022 and have declined in cover since 2018.
	Mean native cover contribution by each vegetation stratum.	Carina WRL - Vegetation structure at the rehabilitation sites remains different to the analogue sites, with the rehabilitation sites dominated by herbaceous species, while the analogue sites consist of mid to tall shrub species. - Sites SR24 and SR25 are trending towards the analogue sites with a continued reduction in the cover of herbs. However, all the rehabilitation sites, except SR21, lack mid shrub species which is a key stratum in the analogue sites.
		Carina Extended WRL The vegetation structure at the rehabilitation sites remains different to that of the analogue sites in 2022. However, the proportion of Tussock grasses, low shrubs and mid shrubs have increased at the rehabilitation sites since 2018. This is an early indication that the vegetation is progressing towards a structure similar to the analogue sites.
	Plant health and dust loading	Carina WRL - There was a general decline in plant health between 2020 and 2022 at all sites (including analogue sites) except SR23, with a lower proportion of plants in excellent health in 2022. However, there were fewer dead plants recorded in 2022 compared to 2020 at both the rehabilitation and analogue sites. - Dust loading overall was negligible at all rehabilitation and analogue sites in 2022. This was an improvement compared to 2020 in which low dust loads were recorded at three sites and moderate loads were recorded at two sites.
		Carina Extended WRL - There was a general decline in plant health at the rehabilitation sites between 2020 and 2022. One analogue site (SC07) had improved plant health overall, but the remaining two analogue sites had reduced plant health similar to the rehabilitation sites. Dead plants were recorded at all analogue sites and one rehabilitation site, but there were fewer dead plants compared to 2020. - Dust loading was low to negligible at rehabilitation and analogue sites in 2022. Low dust loading was recorded at two rehabilitation sites in 2022. However, the overall proportion of plants with low dust loading had reduced since 2020. Whilst negligible dust loading was recorded at all analogue sites.
	Overstorey species	Carina WRL - Mean overstorey cover at the rehabilitation sites increased slightly between 2020 and 2022 but remains lower than the analogue sites, which is expected from juvenile trees. No overstorey species were recorded at SR21 and SR25. - Sites SR22 and SR23 are displaying recruitment and succession of overstorey species, with seedlings, juveniles and mature trees recorded since 2018. - Site SR24 recorded no seedlings and sparse juveniles. However, mature trees were recorded for the first time since 2018, demonstrating the site is now establishing overstorey species.

Basis for completion criteria (Section 8)	Performance parameter (Astron, 2023a)	Progress (Astron, 2023a) (Appendix C)
To satisfy MS852 (<i>continued</i>): Condition 11-1 (1) The waste material landforms shall be constructed so that their ability to support local native vegetation are similar to undisturbed natural analogue landforms. Condition 11-1 (6) The percentage cover of living self-sustaining native vegetation in all rehabilitation areas shall be comparable to that of undisturbed natural analogue sites.	Overstorey species (<i>continued</i>)	Carina Extended WRL - One of the six confirmed overstorey species present at the analogue sites, has been recorded in the rehabilitation sites: <i>E. transcontinentalis</i>. Two unconfirmed overstorey species were also recorded in the rehabilitation sites and could not be identified to species level due to the immature life stage and lack of reproductive material. One additional overstorey species was recorded at the rehabilitation sites, which was not present at the analogue sites: <i>Codonocarpus cotinifolius</i>. - Juvenile plants were recorded at all rehabilitation sites, whilst two sites (SR27 and SR28) recorded mature overstorey species for the first time. Site SR27 has demonstrated good establishment of overstorey species, with seedlings, juveniles and mature trees recorded since 2020. - Continued recruitment was recorded at only two sites: SR27 and SR30. - No dead overstorey species were recorded at the rehabilitation sites in 2022, nor have they been since 2018, indicating a stable landform capable of supporting overstorey vegetation. - Overstorey cover increased at three of the five rehabilitation sites but did not exceed 0.3% in 2022 due to a high proportion of juveniles and remains very low compared to analogue sites. Cover of overstorey species at the rehabilitation sites is expected to be lower than the analogue sites, while the majority of overstorey species cover is from juvenile trees compared to mature trees at the analogue sites.
To satisfy MS852: Condition 11-1 (7) No new species of weeds (including both declared weeds and environmental weeds) are introduced into the rehabilitated areas as a result of the implementation of the proposal.	Comparison of weed species inventory between rehabilitation and analogue sites, and to previous flora, vegetation and weed surveys.	Carina WRL One weed species (<i>*Sonchus asper</i>) was recorded at four Carina WRL rehabilitation sites in 2022, and no weeds were recorded at the analogue sites.
		Carina Extended WRL One weed species (<i>*S. asper</i>) was recorded across all five rehabilitation sites in 2022. <i>*Rumex vesicarius</i> was recorded for the first time at SR26 and SR29 in 2022 (153 individuals and 8 individuals respectively). <i>*R. vesicarius</i> has not previously been detected at Carina
To satisfy MS852: Condition 11-1 (8) The cover of weeds (including both declared weeds and environmental weeds) in rehabilitated areas shall not exceed that identified in the baseline survey condition 10-1(2) or exceed that existing on comparable, nearby land, determined by condition 10-1(3) which has not been disturbed during implementation of the proposal, whichever is less.	Linear model or 95% Confidence Interval comparison of mean weed cover between rehabilitation and corresponding analogue sites, and to baseline (2015) data. NB: where cover values are low (< 0.01%), abundance can be used as a surrogate.	Carina WRL - No change was recorded in mean weed cover across the rehabilitation sites. - However, mean weed abundance has increased since 2020 primarily due to an increase in abundance at sites SR22 and SR24. - Continued weed control activities are required to minimise the impact of weed populations on successful native vegetation establishment.
		Carina Extended WRL - Mean weed cover has increased over time from 0.10% in 2020 to 0.22% in 2022. - Weed cover at site SR27 increased compared to 2020, and the abundance of <i>*S. asper</i> increased from 56 individuals in 2020 to 568 individuals in 2022. - Weed cover and abundance also increased at the rehabilitation sites compared to the baseline data (2018), although this was not significant based on the 95% Confidence Interval. - No weeds have been recorded at the analogue sites to date. <i>*Rumex vesicarius</i> has fruits which contain numerous, viable seeds and can establish rapidly.

Notes:

1. Measured by comparison between rehabilitation site and corresponding analogue site.

5.9.3.2 Erosion Performance Assessment

Key Points

- The Carina WRL displayed rilling and erosion gullies when first assessed in 2018. This was attributed to higher than average rainfall received after rehabilitation in 2016. By 2020, erosion ranged from low to extensive. In 2022, active erosion was observed at three of the five Carina WRL rehabilitation sites, compared to all five sites in 2020 indicating that parts of the Carina WRL rehabilitation may be stabilising. However, where erosion was present, the severity had increased since 2020 with some rills developing into gullies (Astron, 2023a).
- Carina Extended WRL initially displayed limited erosion, attributed to low rainfall after rehabilitation in 2018, but by 2020, erosion was reported as low to extensive with increased severity reported at some, but not all sites in 2022. All sites were recorded as actively eroding in 2022 (Astron, 2023a). Erosion at Carina Extended was attributed in some instances to surface water concentration on berms and in relatively shallow rip-lines on the batters (Mine Earth, 2022).
- Gully erosion has been observed on the J4 WRLs and has been exacerbated because contour ripping has not been completed (Mine Earth, 2022). Low erosional stability material mapped on areas of the J4 WRLs will be re-assessed to inform the final landform design for these features (Section 5.3.4.6).
- The Aurora WRL contains multiple erosion channels, some of significant length and depth, attributed primarily to uncontrolled surface water run-off from the WRL plateau (Okane Consultants, 2022a).

Erosion performance assessment of the Carina Operations WRLs to date includes:

- Assessment of the Carina and Carina Extended WRLs conducted as part of the annual rehabilitation monitoring program (Section 5.9.3.2.1).
- Field observations made during materials characterisation investigations at the J4 WRLs (Mine Earth, 2022) (Section 5.9.3.2.2) and performance assessment of the Aurora WRL (Okane Consultants, 2022b) (Section 5.9.3.2.3).

An assessment of the erosion performance of the different surface treatments applied to the Carina rehabilitation trial areas has also been completed with the results discussed in Section 5.9.2.

Erosional stability characteristics of waste rock and topsoil materials is described in Sections 5.3.4 and 5.3.5.2 respectively.

Erosion performance assessment and materials characteristics inform the WRL design and rectification plans described in Section 5.9.6.1 and Section 9.2.2.

5.9.3.2.1 Carina and Carina Extended

The annual rehabilitation monitoring program initially included ground-based LiDAR survey to assess erosion performance and establish a baseline as described in SWC (2015a). In 2018, remote sensing surveys commenced to produce data on gully depth and width and ripping deviation from the contour for assessment of landform stability. On-ground assessment of erosion is also completed as part of assessment of the rehabilitation monitoring transects (Astron, 2018). Data supporting the summary of results below is provided in Appendix H.

Carina WRL

When assessed in 2018, erosion gullies had established across the Carina WRL, with an average depth of 0.14 m and a maximum depth of 0.69 m. Above average rainfall following rehabilitation in 2016 is considered to have contributed to the initial gully formation which is not inconsistent with similar rehabilitated materials across the region. The on-ground monitoring recorded low erosion at the rehabilitation sites and no erosion at any of the analogue sites (Astron, 2019a).

By 2019, rills at one monitoring site had developed into gullies (i.e., maximum depth > 0.5 m). Active erosion rills were also recorded at the remaining four rehabilitation sites; however, none were classified as gullies (Astron, 2020a). By 2020, erosion at Carina WRL continued to range from low to extensive but appeared to have stabilised. However, it was noted that dry seasonal conditions had limited the ability to accurately assess erosion performance (Astron, 2021a).

In 2022, active erosion was observed at three of the five Carina WRL rehabilitation sites, compared to all five sites in 2020 indicating that parts of the Carina WRL rehabilitation may be stabilising. However, where erosion was present, the severity had increased since 2020 with some rills developing into gullies. The analogue sites continued to display no erosion (Astron, 2023a) (Appendix H).

Carina Extended WRL

When first assessed in 2019, the Carina Extended WRL remained stable with no significant erosion features, reflecting low rainfall received after completion of rehabilitation in 2018 (Astron, 2020a). By 2020, erosion at the rehabilitation sites increased, ranging from low to extensive. The average number of rills increased at four of the five monitoring sites, and average maximum rill width also increased at four sites, indicating active erosion despite below average annual rainfall over the previous two years (Astron, 2021a). In 2022, the average number of rills, width and depth had again increased compared to 2020, although this increase was not observed at all sites. All rehabilitation sites were recorded as actively eroding and did not have a stable surface in 2022. The analogue sites continued to display no erosion (Astron, 2023a) (Appendix H).

A materials characterisation assessment completed by Mine Earth (2022) also reports field observation of numerous erosion gullies on the rehabilitated batter surfaces. They attribute this to surface water concentration in berms and in relatively shallow rip-lines on the batters. This is discussed further in Section 5.9.3.3.

5.9.3.2.2 J4

Gully erosion was observed on the southern and eastern faces of the J4 East WRL. The gully erosion appears to have been exacerbated by the lack of contour ripping (Mine Earth, 2022).

Similarly, a lack of contour ripping has contributed to erosion of the topsoil which has been spread to date on the upper section of the lower lift on some of the J4 West WRL batter slopes. No limitations were identified for the use of J4 stockpiled topsoil material as a surface rehabilitation material, provided the concentration of surface water flow on the rehabilitated surfaces is minimised (Mine Earth, 2022).

As discussed in Section 5.3.4.3, waste rock mapped as low stability on multiple batters of the J4 WRLs (Mine Earth, 2022) will be re-assessed to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, should be incorporated into the final landform design for these features (Section 5.3.4.6).

5.9.3.2.3 Aurora

There are multiple erosion channels evident in the surface topography of the Aurora WRL. The most significant erosion channel presents as a 30 m long gully up to 0.7 m in depth. The location of the erosion channels and absence of plateau cells, baffles and crest bunding suggests the primary contributor to the observed erosion is pooled water from the WRL plateau. The inconsistent plateau surface, with no fixed Reduced Level (RL), is likely contributing to concentration of surface flows on particular slope faces (Okane Consultants, 2022a).

5.9.3.3 WRL Landform Design Assessments

Key points

- All WRLs are currently located outside the ZOI of adjacent pits.
- The interaction of the J4 East WRL with the final J4 East Pit shell will require re-assessment when mining is complete at J4 East Pit. The ZOI criterion will not apply to the J4 West WRL when backfill to surface is complete.
- Berms are missing, or of insufficient width, on portions of the Carina, J4 East and J4 West WRLs.
- Berms are less than design width on the Carina Extended WRL, but design width assumed higher lift height. Further assessment of as-built berm width versus berm capacity assessment for as-built lift height is required.
- Berm back sloping is inconsistent across the WRLs.
- There are a number of exceedances of design lift height:
 - Carina WRL lift 2 (by 5 m)
 - Carina Extended WRL lift 1 (by 3 m in some areas)
 - J4 East lift 2 (by > 5 m)
 - J4 West WRL lift 1 / 2 (variable)
- The J4 East and J4 West WRLs exceed their maximum design height.
- The height of the Aurora WRL is lower than design, resulting in only one lift and an expanded footprint.

This section summarises the findings of the following assessments completed to compare WRL design geometry submitted in the latest approved MCP (Astron, 2019b) or relevant MPs against the as-built geometry (Table 46):

- Okane Consultants (2022a) Yilgarn Health Check – Carina WRL Designs, Revision 2.
- Okane Consultants (2021b) Yilgarn Health Checks – J4 WRLs revised.
- Okane Consulting (2022b) Yilgarn Health Check – Aurora WRL Designs.
- Landloch (2023) Carina and Carina Extended WRL: Rehabilitation Cover Design.

The berm capacity modelling discussed in Section 5.9.1 has been used as a reference for berm widths. The landform design assessments inform the WRL design and rectification plans described in Section 5.9.6.1 and Section 9.2.2.

5.9.3.3.1 Carina WRL

The Carina WRL is inactive, and the landform is partially under rehabilitation. The landform falls outside the ZOI of the pit (Section 5.4.2).

The key gaps between the design and as built geometry are (Table 46 and Figure 75) (Okane Consultants, 2022a):

- The height of the second lift exceeds the design height by 5 m.
- Berm widths are less than 10 m in most areas and, furthermore, berm capacity assessment modelling (Section 5.9.1) has increased the minimum recommended berm width beyond that of the original design.
- Berm back sloping is inconsistent in many areas.

Re-profiling and rehabilitation of the top surface is yet to be completed and needs to maintain the PAF encapsulation cell cover depth (Section 5.9.3.4).

5.9.3.3.2 Carina Extended WRL

The Carina WRL is inactive, and the entire landform is under rehabilitation. The landform falls outside the ZOI of the pit (Section 5.4.2).

The key gaps between the design and as built geometry are (Table 46 and Figure 76) (Okane Consultants, 2022a):

- The height of the first lift ranges from 8 m to 18 m due to the undulating ground surface. The maximum height exceeds the design height by 3 m. As the exceedance is on the first lift it does not have implications for downslope berm width.
- Berm widths are less than 10 m in multiple areas. However, it is noted that the design berm width (10 m) was for a planned lift height of 10 m. For the as-built lift height of approximately 7 m, berm capacity modelling studies (Section 5.9.1) recommend a berm width ranging from < 9 m (Okane Consultants, 2022a) to 10 m (Landloch, 2023).
- Berm back sloping is inconsistent in many areas.

The top surface includes a back slope with overall angle of 3 – 4° (Landloch, 2023).

5.9.3.3.3 J4 East WRL

The J4 East WRL is inactive, re-profiling and topsoil spreading has been completed for some batters. The interaction of the landform with the ZOI of the pit needs to be reassessed when the J4 East Pit redevelopment is complete (Section 5.4.2).

The key gaps between the design and as built geometry are (Table 46 and Figure 77) (Okane Consultants, 2021b):

- Total height exceeds (by a few metres) the maximum design height of 30 m.
- The height of the second lift (> 20 m) exceeds the design height (15 m).
- One area exceeds the maximum overall slope angle (> 16°).
- Berms are missing or berm widths are less than 20 m in multiple areas. Note that berm capacity assessment modelling (Section 5.9.1) indicates that the design berm width (20 m) was conservative for the design 15 m lift height.
- Berm back sloping is absent, and no berm cross-bunds are evident.

5.9.3.3.4 J4 West WRL

Material placement on the J4 West WRL recommenced in 2023 to receive waste from the J4 East Pit redevelopment. Some re-profiling and topsoil application has occurred on the constructed portion of the WRL.

The interaction of the landform with the ZOI of the pit is no longer applicable as the J4 East Pit redevelopment plans to backfill the J4 West Pit to surface (Section 5.4.2).

The key gaps between the design and as built geometry relate to (Table 46 and Figure 77) (Okane Consultants, 2021b):

- Total height exceeds (by a few metres) the maximum design height of 30 m.
- The lift height of the northern portion of the WRL (constructed as a single lift) is > 20 m and exceeds the design height (15 m). The southern portion of the WRL comprises two lifts. The second lift exceeds the design height (15 m).
- The north and west faces exceed the design maximum overall slope angle (> 16°).

- Berms are missing from the north face of the WRL, and berm widths are less than 20 m in multiple areas. Berm capacity assessment modelling (Section 5.9.1) indicates that the design berm width (20 m) was conservative for the design 15 m lift height.
- Berm back sloping is absent, and no berm cross-bunds are evident.

5.9.3.3.5 Aurora WRL

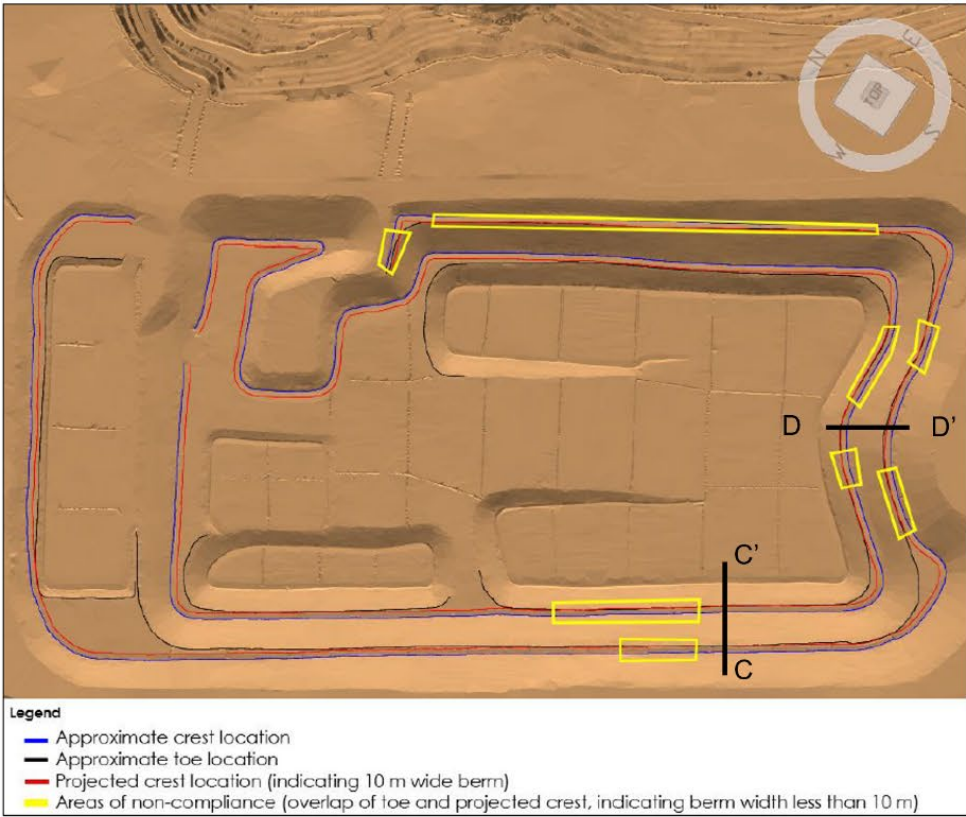
The Aurora WRL is inactive, and some historic rehabilitation has occurred on the batter slopes. The landform falls outside the ZOI of the pit (Section 5.4.2).

The key gaps between the design and as built geometry relate to (Table 46 and Figure 78) (Okane Consultants, 2022b):

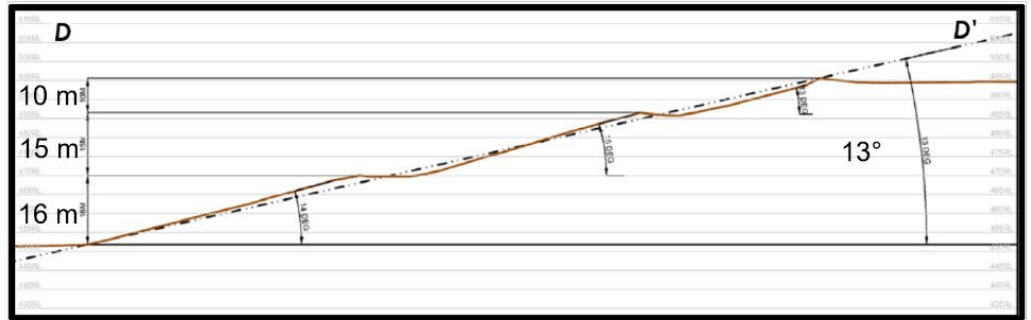
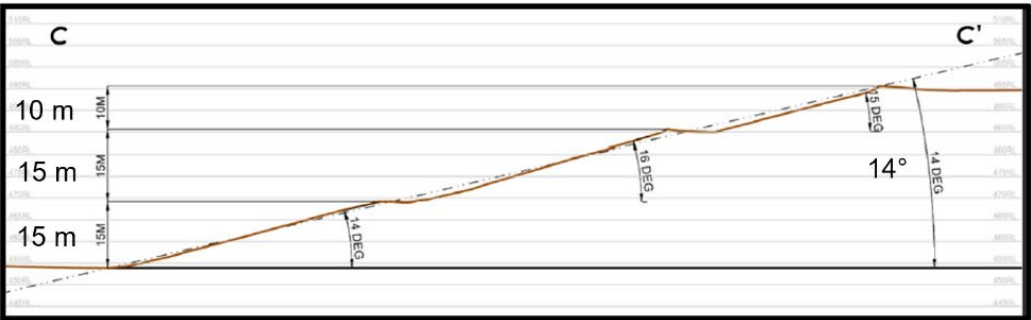
- The height is significantly less than design resulting in an increased footprint area (4 ha compared to planned footprint of 2.2 ha).
- Due to being constructed in a single lift there was no requirement to install the designed berm.



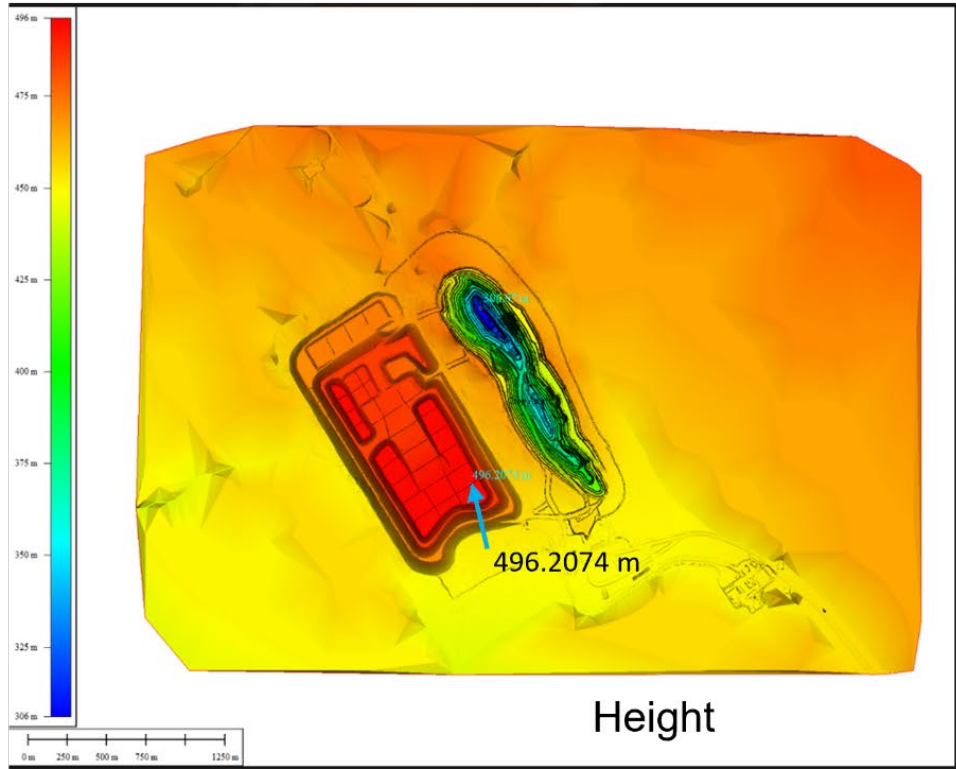
Batter Gradient Assessment



Batter Width Assessment



Cross Sections



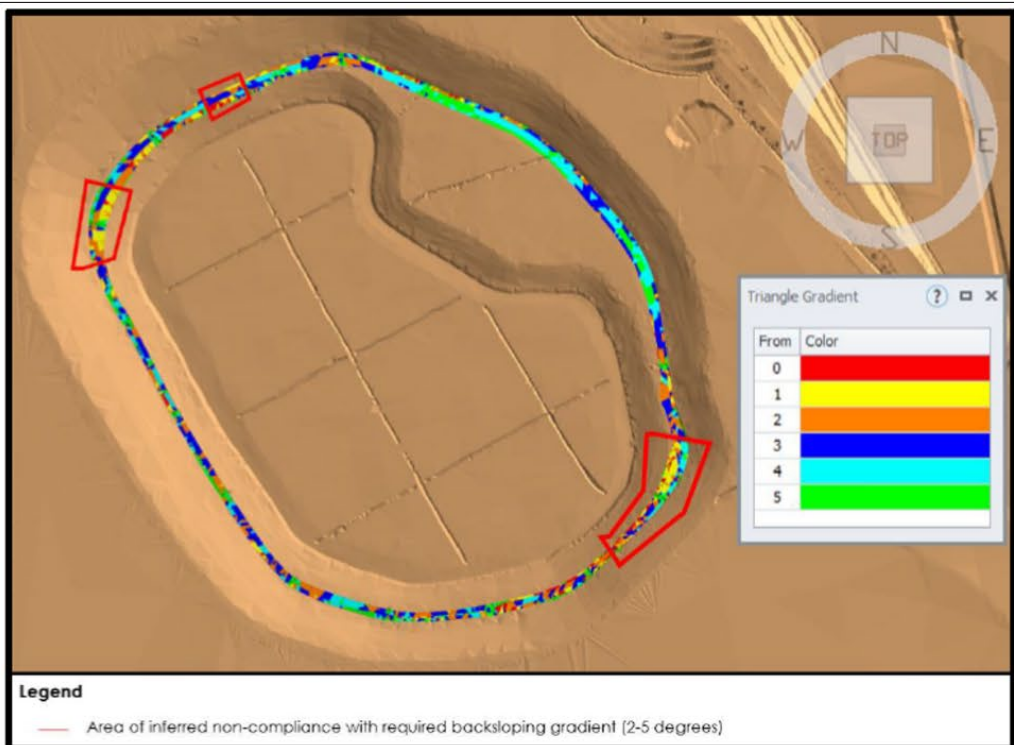
Batter Backslope Assessment

Source: Okane Consultants (2022a)

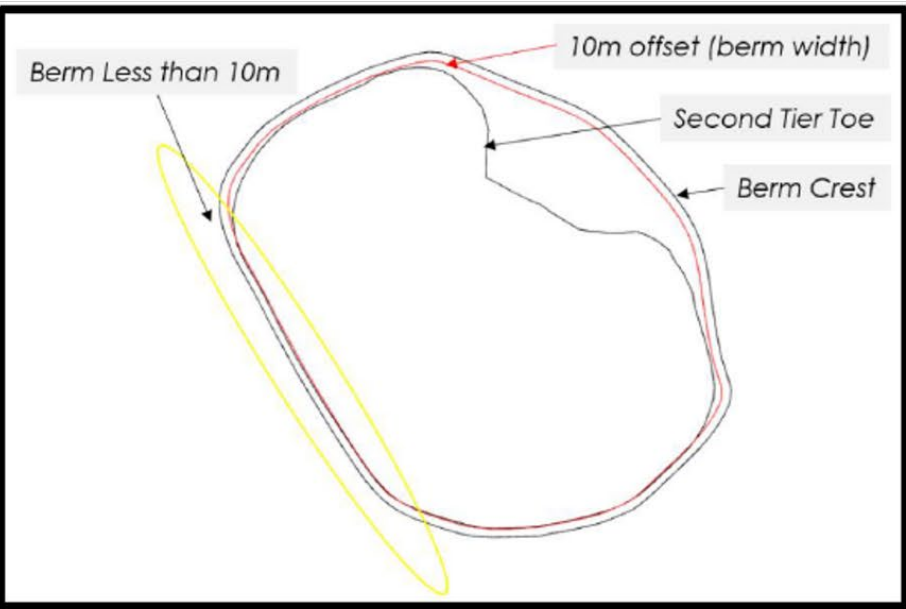
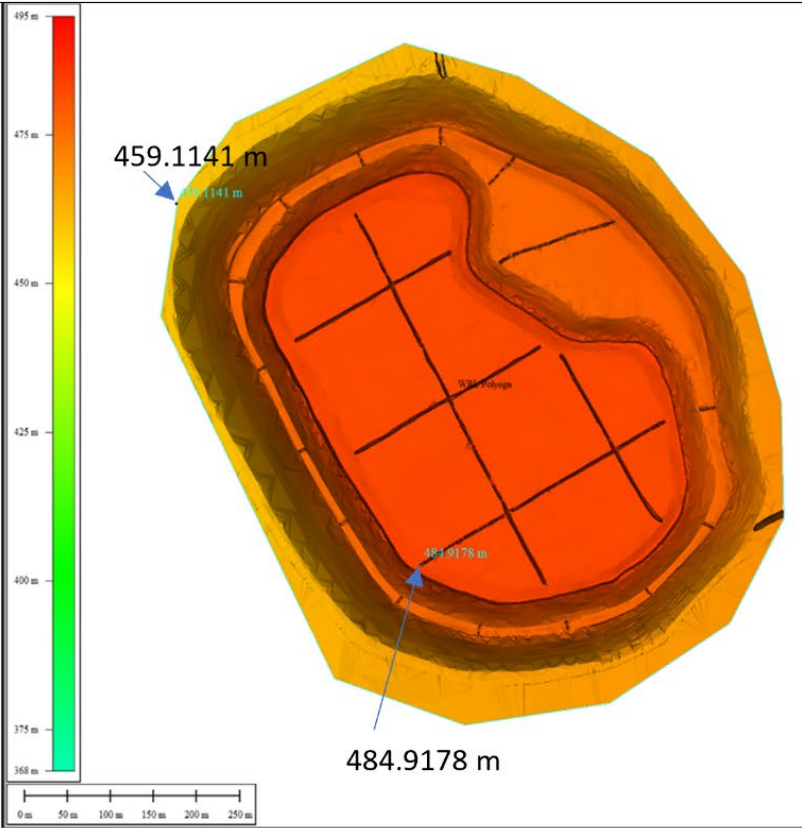
Figure 75 Carina WRL – As-Built Design Assessment



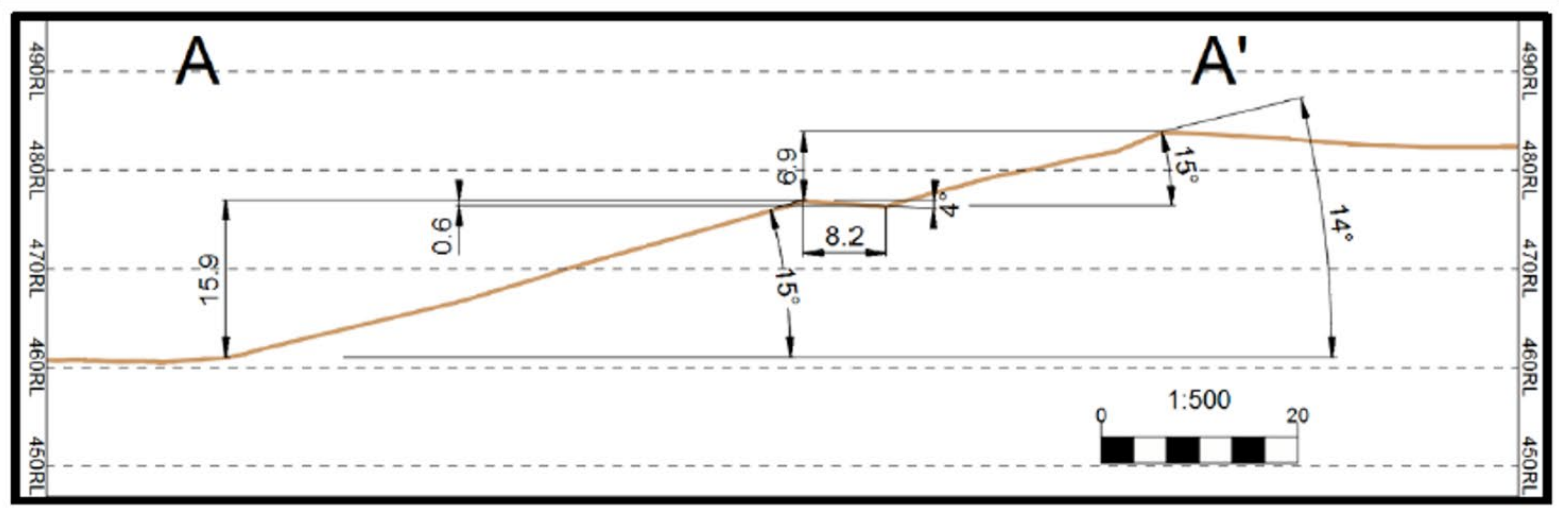
Batter Gradient Assessment



Berm Backslope Assessment



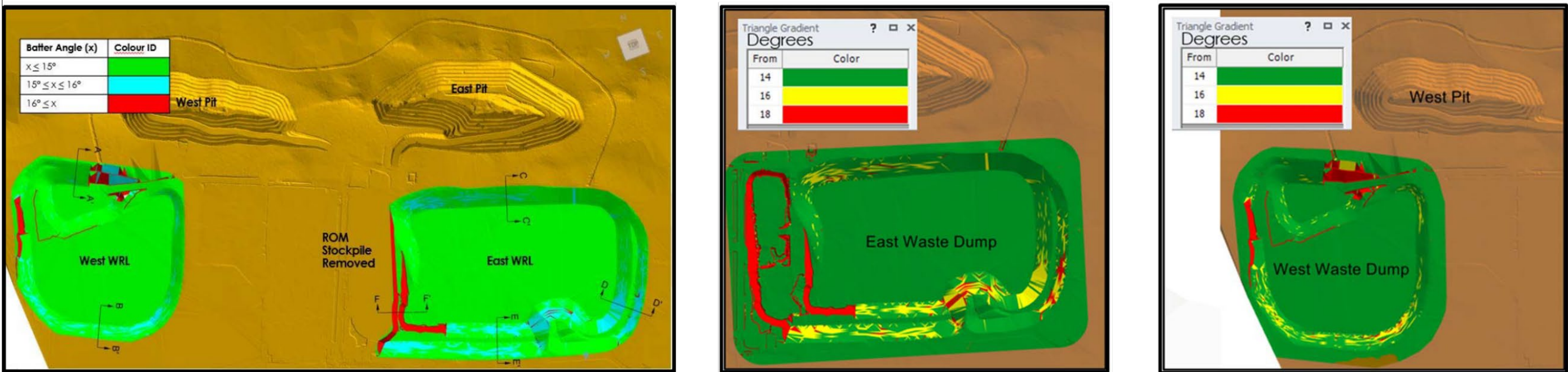
Berm Width Assessment



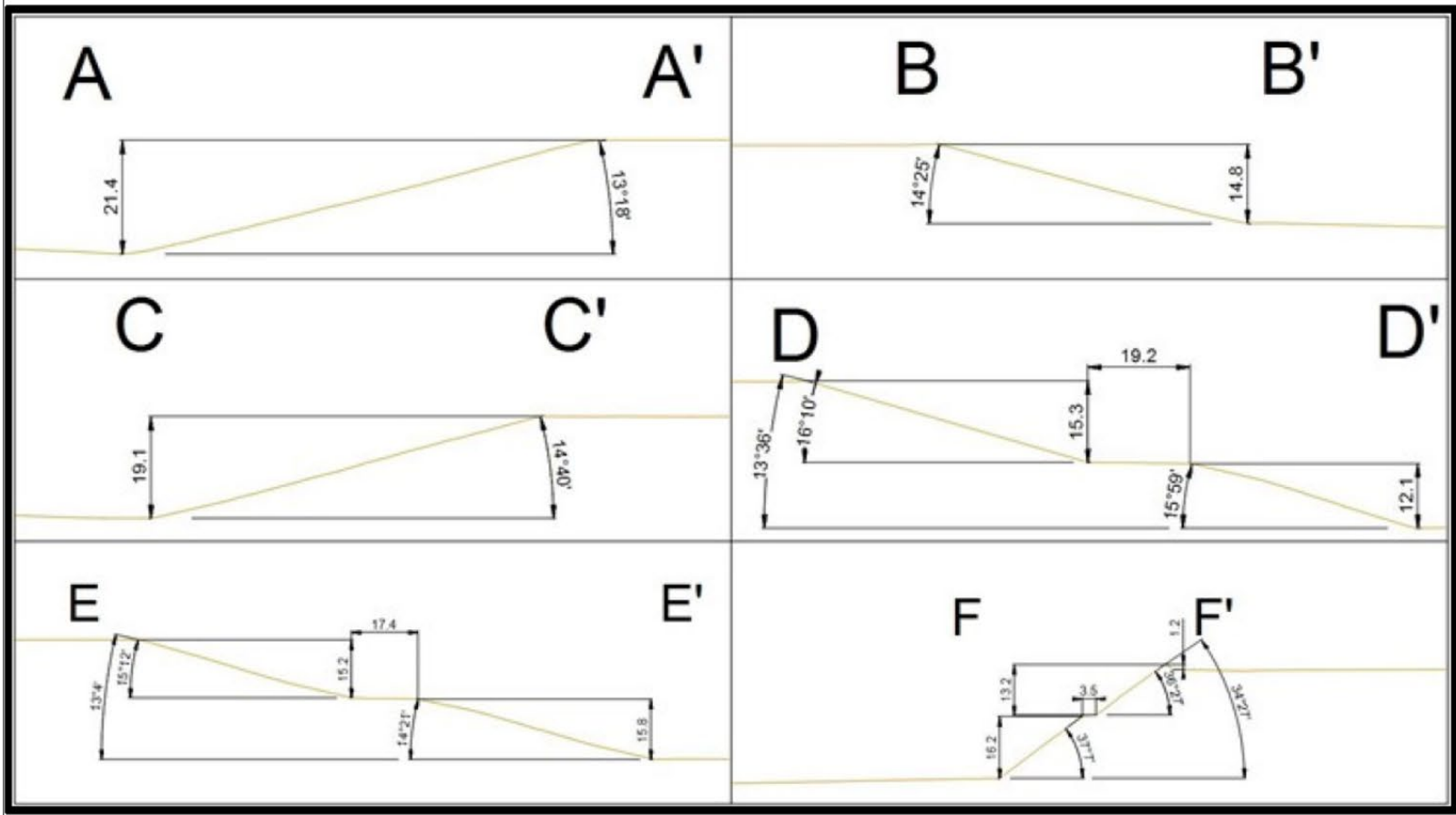
Cross Section

Source: Okane Consultants (2022a)

Figure 76 Carina Extended – As-Built Design Assessment



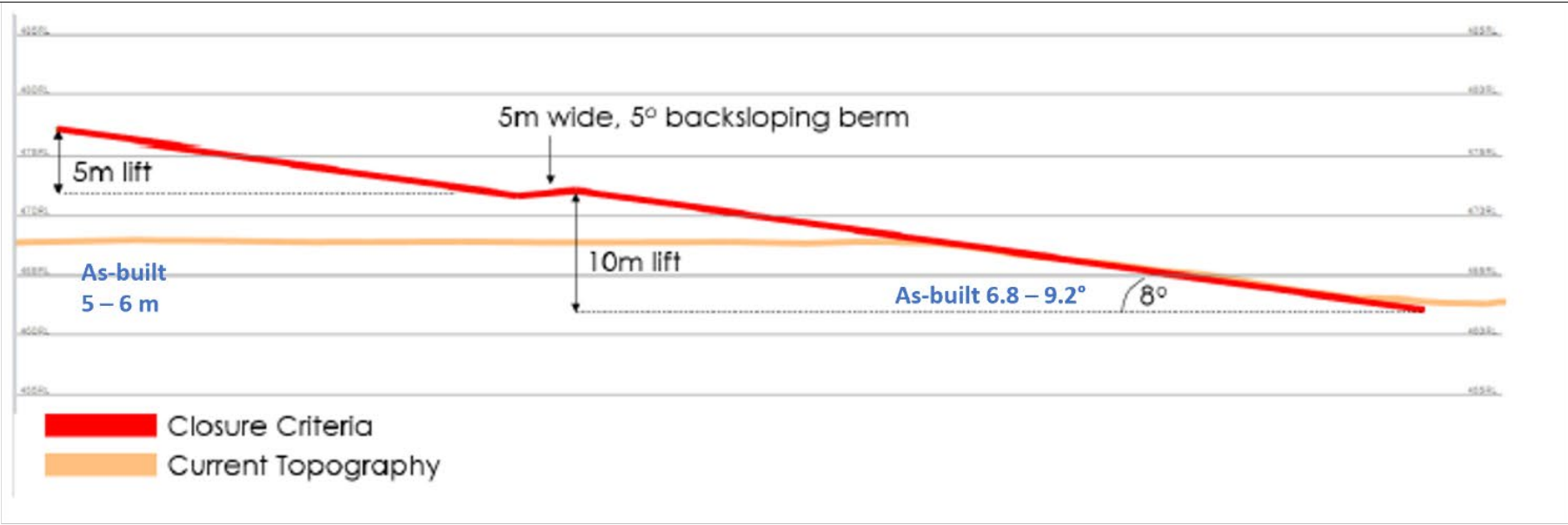
Batter Gradient Assessment



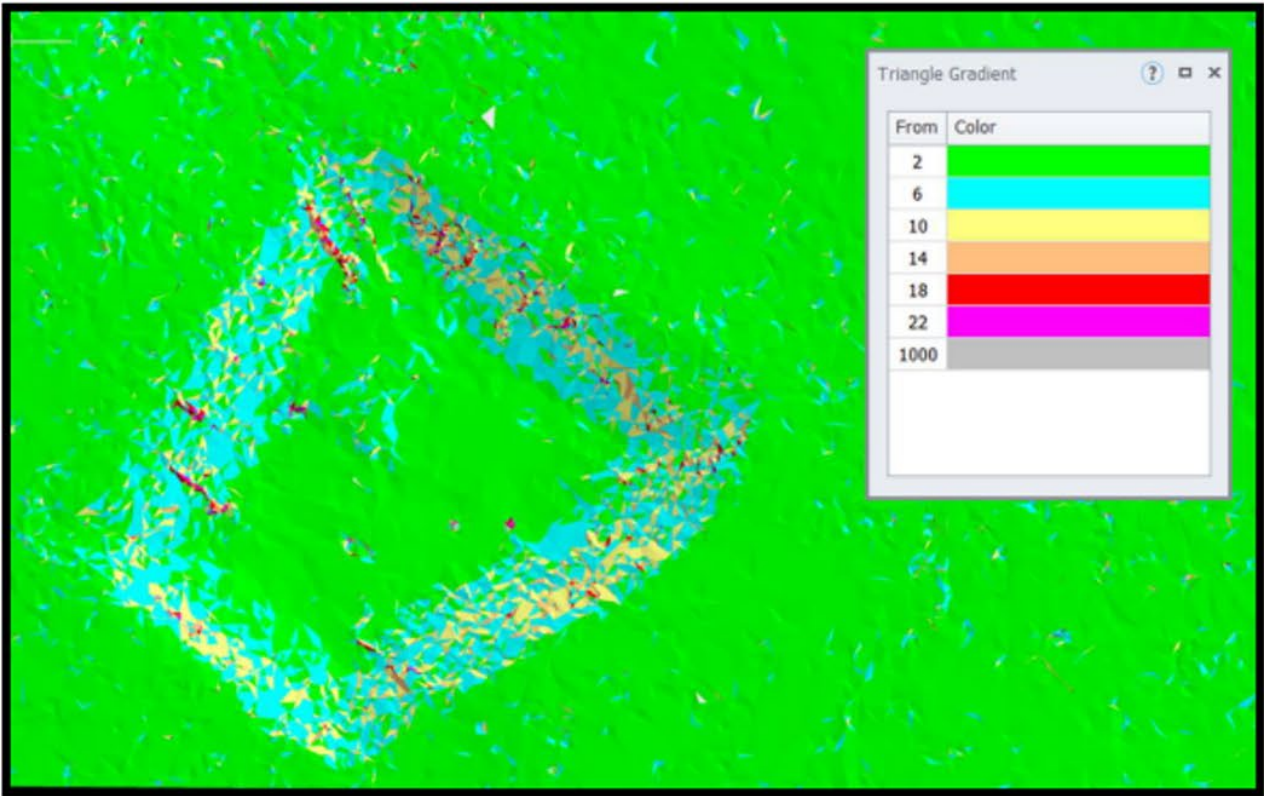
Cross Sections
Lift height, batter angle and berm width assessment

Source: Okane Consultants (2021b)

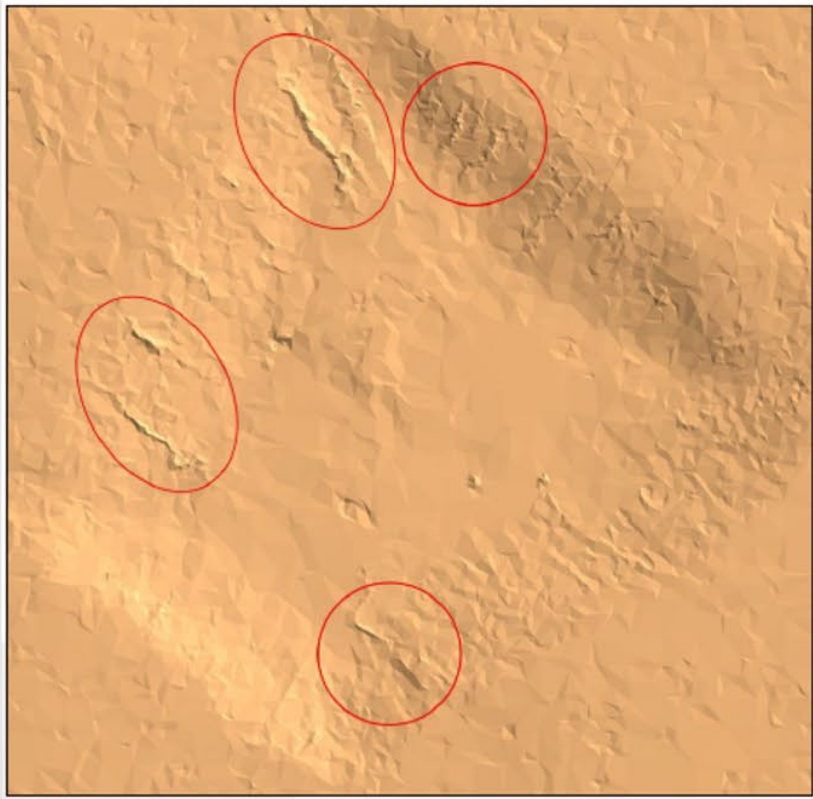
Figure 77 J4 WRLs – As Built Design Assessment



Cross – Section: As-built vs Interpreted Design Criteria (adapted from Okane, 2022b)



Batter Gradient Assessment



Erosion

Source: Okane Consultants (Okane Consultants, 2022b)

Figure 78 Aurora WRL – As-Built Design Assessment

Table 46 WRL As-Built Design Assessment – Carina Operations

WRL	Status	Design geometry	As built geometry
Carina	Inactive Partially under rehabilitation	- Maximum height: 500 m AHD - Maximum lift height: - Lift 1 – 22 m - Lift 2 – 10 m - Lift 3 – 10 m - Maximum batter angle: 18° - Maximum overall slope angle 16° - Berm width²⁴: 10 m - Berm backslope 2 – 5° - Berm cross-bunds (baffles) at intervals of 50 to 100 m Source: Astron (2019b) which is consistent with the following MPs: REG ID 28616 (2011), REG ID 41955 (2013), REG ID 50795 (2014), REG ID 52261 (2014), with the exception of berm backslope. The MPs state 2 – 5°, which was incorrectly reported as 5° by Astron (2019b).	- Maximum height 496 m AHD i.e., < 500 m AHD. - Maximum lift height: - Lift 1 (16 m) meets design, i.e., < 22 m - Lift 2 (15 m) exceeds design 10 m. - Lift 3 (10 m) meets design 10 m - Maximum batter angle: < 18°²⁵ - Maximum overall slope angle ≤16° (average 13°). - Berm width: most faces non-compliant for berm width. - Berm backslope: back sloping inconsistent in many areas. - Baffles evident on most berms (but anticipated to require reinstatement following rectification). Source: Okane (2022a) and Landloch (2023)
Carina Extended	Inactive Fully under rehabilitation	- Maximum height: 487 mRL (from REG ID 41730) - Lift height: - Lift 1 – 15 m - Lift 2 – 10 m - Maximum batter angle: 18° - Maximum overall slope angle 16° - Berm width²⁴: 10 m - Berm backslope 2 – 5° - Berm cross-bunds at intervals of 50 to 100 m Source: Astron (2019b) which is consistent with REG ID 41730 (2013), with the exception of berm backslope. The MP states 2 – 5°, which was incorrectly reported as 5° by Astron (2019b) (but was reported correctly in the MCP 2017).	- Maximum height 485 mRL i.e., < 487 mRL - Lift height: - Maximum Height of Lift 1 is 18.0 m which exceeds design of 15 m. Note that pre-mining surface is undulating with the lift height ranging from 8 m to 18 m. - Lift 2 is 6.9 m, lower than design allowance of 10 m. - Maximum batter angle < 18°²⁵ - Maximum overall slope angle ≤16° (average 14°). - Berm width: multiple areas non-compliant for design berm width. - Back sloping inconsistent in many areas. - Baffles evident on most berms (but would require reinstatement if rectification works were undertaken). Source: Okane (2022a) and Landloch (2023)
J4 East	Inactive Re-profiling completed and topsoil applied to some batters 2017 / 18	- Maximum height: 30 m - Lift height: - Lift 1 – 15 m - Lift 2 – 15 m (with inter-berm batter) - Maximum batter angle: 16° - Maximum overall slope angle (not specified – but for two lifts is 13.3°) - Berm width: 20 m - Berm backslope minimum 5° - Berm cross-bunds at intervals of 50 to 100 m Source: Astron (2019b) which is consistent with the following MPs: REG ID 53360 (Feb 2015), 56760 (Oct 2015), 117948 (2023). REG ID 53360 proposed 3 x 10 m lifts but this was revised to 2 x 15 m lifts in REG ID 56760.	- Maximum height > 30 m in many areas. - Lift height: - Lift 1 < 15 m - Lift 2 > 20 m - Maximum batter angle: Majority of WRL faces have batter angle < 16°. One area > 16°. - Maximum overall slope angle > 13.3° - Berm width: berms are missing from the north face of the East WRL and width in multiple areas is < 20 m. - No back sloping of berms. - No berm cross-bunds evident. Source: Okane Consultants (2021b)
J4 West	Active Batters re-profiled, topsoil spread on some batters, no ripping.	- Maximum height ~ 475 m AHD - Lift height: - Lift 1 – 15 m - Lift 2 – 15 m - Maximum batter angle: 16° - Berm width: minimum 20 m - Berm to have a minimum 5-degree backslope (sufficient to store a 1:100-year 72-hour storm event with 50% storage capacity). - Baffles located every 50 – 100 m along the berms to prevent lateral movement and convergence of surface water flow. Source: Astron (2019b) which is consistent with the following MPs: REG ID 53360 (Feb 2015), 56760 (Oct 2015), 117948 (2023). REG ID 53360 proposed 3 x 10 m lifts but this was revised to 2 x 15 m lifts in REG ID 56760.	NB: Assessment below is for WRL status in 2021. Waste rock placement re-commenced in late 2023. - Maximum height > 30 m in many areas. - Lift height (the south portion of the WRL comprises two lifts and the north face comprised a single lift): - Lift 1 (north face) > 20 m and (south portion) > 15 m. - Lift 2 (south portion) > 15 m - Batter angle: majority of WRL faces have batter angle < 16°. Two areas on north and west faces > 16°. - Berms are missing from the north face of the West WRL and width in multiple areas is < 20 m. - No back sloping of berms. - No berm cross-bunds evident. Source: Okane Consultants (2021b)

²⁴ Note incorrectly reported as 20 m in Table 21, but correctly reported as 10 m in Table 4 of the MCP (Astron, 2019b). 10 m is consistent with MP design.

²⁵ Where the 3D depiction suggested areas of localised elevated batter angle cross-sections were assessed in more detail and the batter angles found to be compliant. Displayed non-compliance is localised or may be attributable to tessellation of survey data. The remaining minor non-compliance with batter angle is associated with crest bunds (rectification only recommended where this would result in no disturbance to established vegetation) (Okane Consultants, 2022a).

WRL	Status	Design geometry	As built geometry
Aurora	Inactive Partially under rehabilitation	- Maximum height: 15 m - Lift height: - Lift 1 – 10 m - Lift 2 – 5 m - Batter angle: < 20° (NB: not specified in earlier MPs or MCPs) - Berm width: 5 m (installed at 10 m level) - Backslope: inward sloping Source: Willmine Pty Ltd (1994).	- Maximum height: ~ 6 m - Lift height: single lift of ~ 6 m - Batter angle: < 20° (overall 8° with approximately 90% of individual faces < 6°) - No berm applied as first lift height was not reached. - No baffles present on WRL plateau. - Works proposed to address surface instability (refer Section 5.9.3.2). Source: (Okane Consultants, 2022b)

5.9.3.4 WRL PAF Encapsulation Assessment

Key Points

- One PAF encapsulation cell has been constructed for the Carina Operations within the Carina WRL.
- An initial review completed by Okane (2022c):
 - Concluded that the as-built PAF cell comprised an area substantially smaller than the originally planned PAF footprint.
 - Concluded that the PAF cell is compliant with the original design specifications of distance from the base of the waste landform and from the batters of the landform.
 - Recommended that further drilling be undertaken to confirm the extent of PAF within the WRL and assess the cover thickness and properties of cover and encapsulation materials.
- Further to this recommendation, 140 samples, from twelve drill holes, were collected and analysed with conclusions as follows:
 - The overall sulfur contents within the measured samples are generally low at <0.1%, with approximately 5% of samples > 0.3% sulfur.
 - Hydraulic conductivity is low indicating that the fine fraction dominates the hydraulic conductivity characteristics of the material and is sufficient as a low permeability capping material that inhibits water infiltration.
 - PAF was intersected north east of the inferred extent of the PAF cell but at sufficient depth (11 – 14.2 m) from the surface to make it low risk.
 - In two locations the depth of the PAF encapsulation cell cover material is at the minimum recommended i.e., 2 m.
- Okane recommends further encapsulation with NAF waste material on the surface of the Carina WRL, specifically over the area of the inferred PAF cell and extending towards the north-east, to reduce the risk of PAF exposure at the surface of the WRL.

The intent to construct PAF encapsulation cells in the Carina WRL, Carina Extended and the J4 East WRL was described in their respective MPs (Polaris Metals, 2011; 2013a; 2015).

A PAF encapsulation cell was constructed in the Carina WRL. An assessment of compliance to design has been completed and the results are summarised in Section 5.9.3.4.1.

PAF encapsulation cells were not constructed in the Carina Extended or J4 WRLs:

- At Carina Extended, baseline assessment of the deposit found that PAF material was located at depth (120 – 130 m bgl) (Section 5.3.3.1.2) and would only be accessed at the final stage of pit development if the full depth of the deposit was mined. Actual depth of mining was approximately 100 m bgl (365 m AHD) (PSM Consult Pty Ltd, 2023 Draft).
- At J4, post-mining assessment of the assay results from drill hole intervals within the as-mined volume of the J4 East and West Pits (mined to less depth than planned) found that the majority of high sulfur samples were outside the mined pit volumes, primarily within fresh material below the J4 pit shells (SRK, 2023) (refer Section 5.3.3.1.3 and Appendix D-3). However, an area was identified on J4 West, where potentially PAF material (from close to the base of mining) could have been placed (Okane Consultants, 2022c). Subsequent testing of this material (refer to Section 5.3.3.2) determined the material to be NAF (Mine Earth, 2022; MinRes, 2024).

The handling of OAW at J4 is a separate issue discussed in Section 5.3.3.2.3 and Section 5.3.3.7.

5.9.3.4.1 Carina WRL

Mining of the Carina deposit intersected PAF material (refer to Section 5.3.3.1.1) which was required to be encapsulated within the WRL as represented in Figure 79.

An initial review completed by Okane (2022c):

- Assessed the mining block model, satellite imagery and survey data. They concluded that the WRL construction commenced in 2012, with PAF placement starting in 2014 and ending before March 2015, which is consistent with the estimates of PAF material present or absent during this time in the block model pit shell.
- Found that the quantity of PAF material reported in end of month survey of the PAF cell in November 2014 was significantly higher than the amount of PAF predicted by the block model alone, indicating that active identification and segregation of PAF material was occurring during the mining process.
- Concluded from survey pick-up data that the as-built PAF cell comprised an area substantially smaller than the originally planned PAF footprint.
- Concluded from comparison of the base and top of PAF surveys, and the final mining surface, that the PAF cell is compliant with the original design specifications of distance from the base of the waste landform and from the batters of the landform.
- Recommended that further drilling be undertaken to confirm the extent of PAF within the WRL and assess the cover thickness and properties of cover and encapsulation materials.

The recommended drilling program was carried out in 2022 (Okane Consultants, 2023b) with the following conclusions:

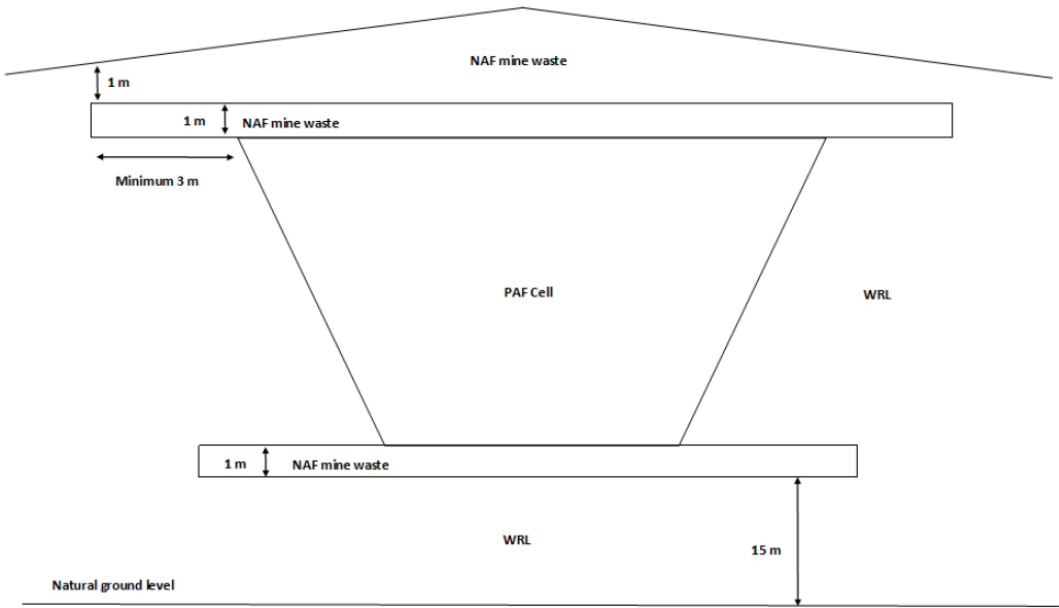
- PAF has been encapsulated within the Carina WRL, but that lateral extent of the PAF material differs from the inferred PAF cell (Figure 81).
- The volume encapsulated was less than originally planned.
- In the area intersected by drillholes BH04 and BH05, the PAF encapsulation cover just meets the 2 m minimum capping design criteria.
- The extent of the PAF cell to the north east is undefined but the material intersected at BH08 is considered low risk due to the 11 m of NAF cover present (Okane Consultants, 2023b).

The drilling program and the results of Phase 1 and Phase 2 geochemical and geotechnical analysis that support these conclusions are summarised below.

Twelve boreholes were drilled in and around the designed cell area (Figure 80) and 140 samples collected for initial geochemical and geotechnical assessment (Okane Consultants, 2023b). A sub-sample of eighty-eight samples (samples with a Total S > 0.1%) were subjected to further testing as summarised in Table 47.

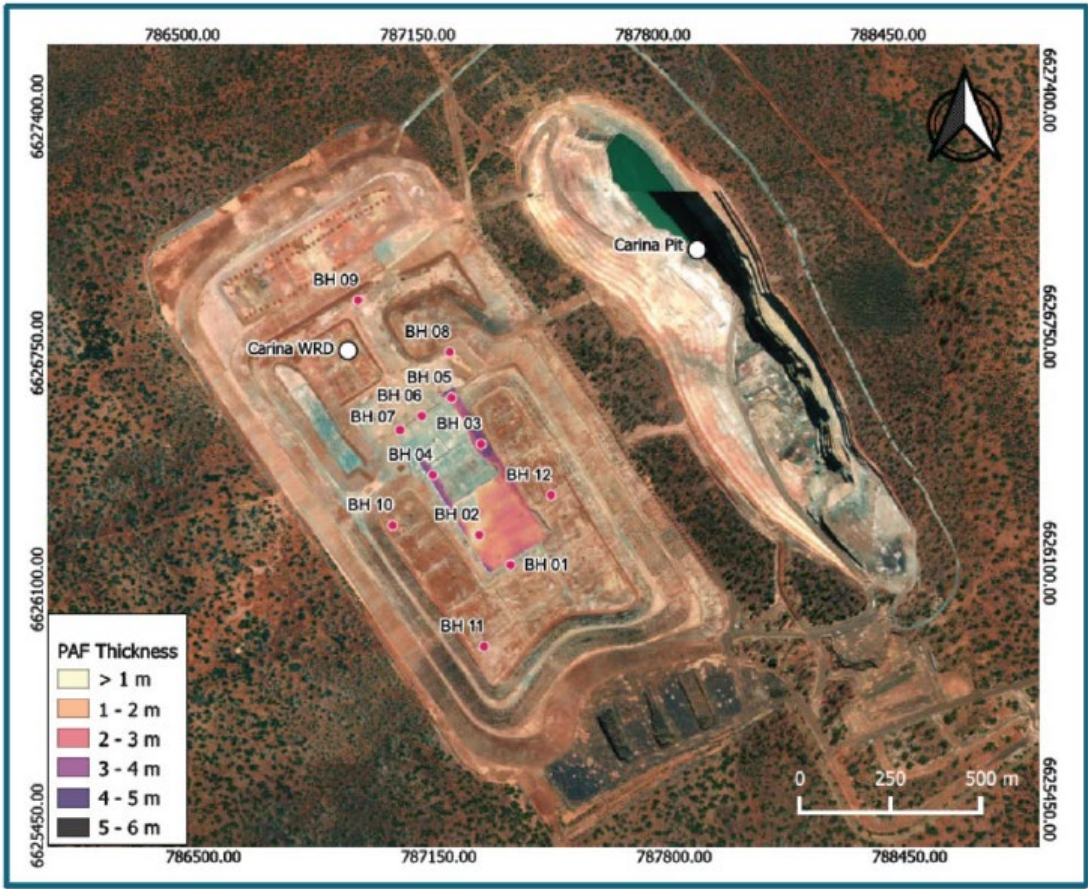
Table 47 Carina WRL PAF Encapsulation Cell Sampling and Testing Program

No. of Samples	Analysis
140	Phase 1 Paste pH and EC (1:2), Total S and Total Carbon (C), NAG _{pH} , NAG acidity (pH4.5 and 7), ANC.
88	Phase 2 - Sulfur speciation (on Phase 1 samples with > 0.1% Total S) (12 samples) - Total Inorganic Carbon (16 samples) - Australian Standard Leaching Procedure (Leach Test) – Deion water, Al, Fe (by ICP-AES), Sb, As, Cd, Cr, Co, Cu, Pb, MN, Ni, Se, Th, U, Zn (by ICP-MS) (11 samples) - Elements – 48 metals (11 samples) - X-ray Diffraction (XRD) (26 samples) - Acid buffering characterisation curve (ABCC) (on Phase 1 samples with ANC > 55 kg H₂SO₄/t (12 samples)



Source: Polaris Metals Pty Ltd (2011) and Okane Consultants (2023a)

Figure 79 PAF encapsulation cell conceptual design



Source: Okane Consulting (2023b)

Figure 80 Carina WRL PAF Cell Investigation Boreholes



Source: Okane Consulting (2023b)

Figure 81 PAF Cell Extent Based on Drilling Results

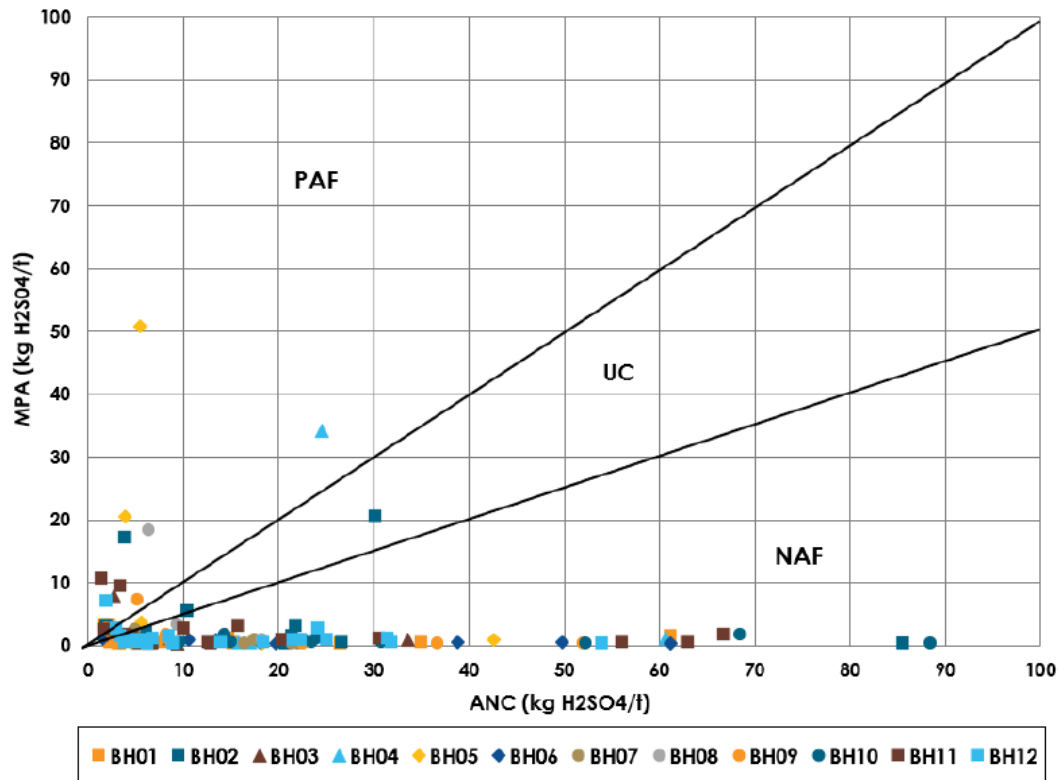
Results of Phase 1 Geochemical Analysis

Overall, sulfur content of the drillhole samples was low (mean 0.08%). Approximately 5% of samples had > 0.3% Total S. Highest total S results were seen in samples from within the inferred PAF cell (maximum 1.66% sampled at 2.4 – 3.8 m depth within the WRL).

Samples from Phase 1 were classified using the Price (2009) and AMIRA (2002) methodologies described in Section 5.3.3. The results are presented respectively in Figure 82 and Figure 83. In summary:

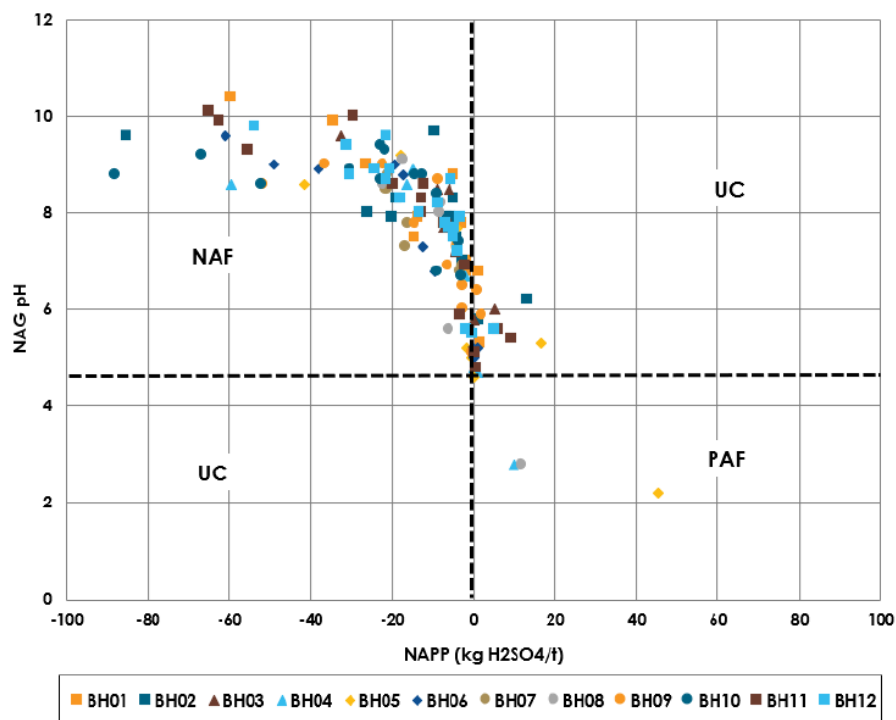
- All but one of the samples classified as PAF or Uncertain in Figure 82 and Figure 83 were within the inferred PAF cell. One sample (BH08) was from outside the inferred PAF cell suggesting that the PAF cell may extend further to the north east (Figure 80).
- The samples classified as PAF were located between 475 mRL and 485 mRL. PAF material in BH04 and BH05 was within 2 – 2.4 m of the WRL surface (i.e., at the limit of the minimum 2 m

cover). The material classified as PAF in BH08 was between 11 – 14.2 m from the surface (Figure 84 and Figure 85).



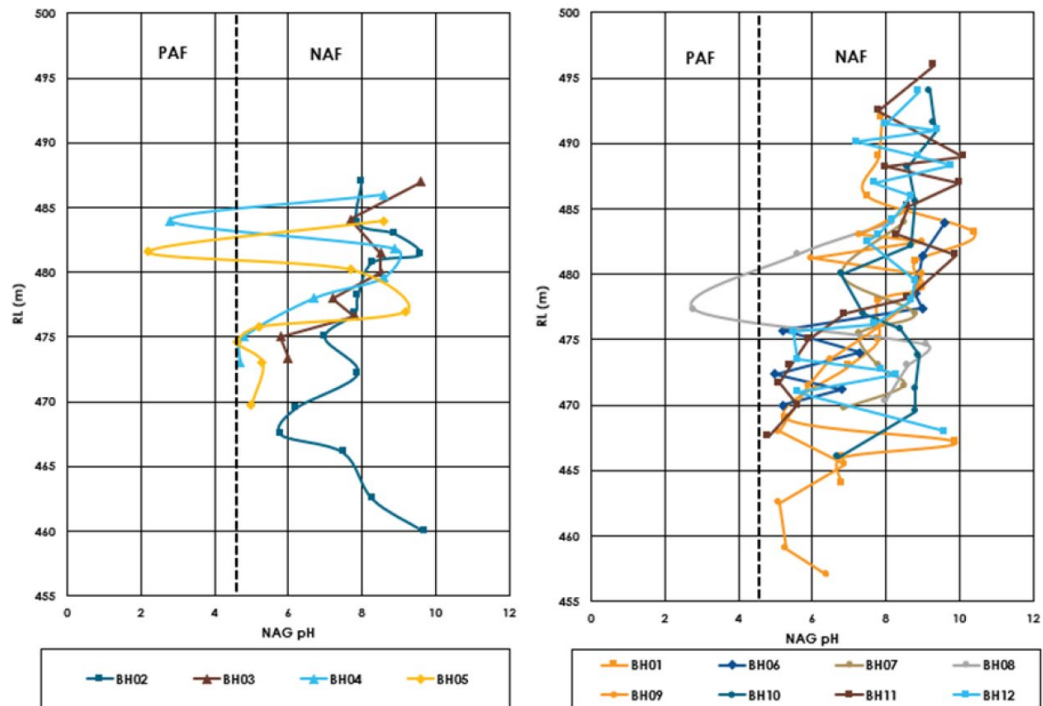
Source: Okane Consultants (2023b)

Figure 82 ABA classification using ANC and MPA (Price, 2009)



Source: Okane Consultants (2023b)

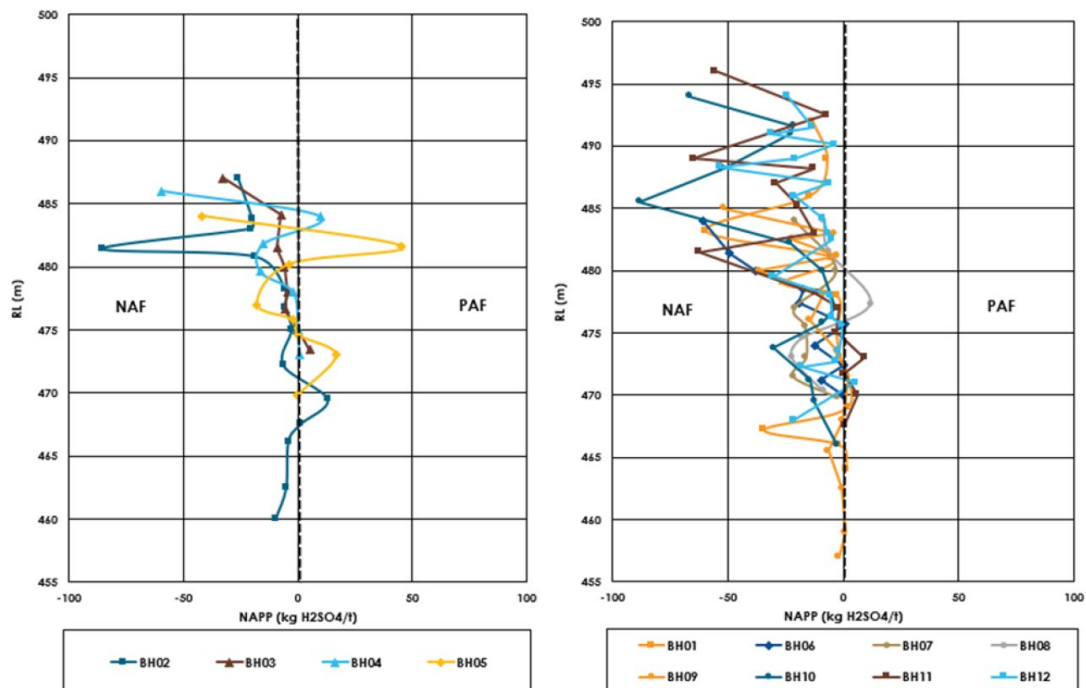
Figure 83 ABA classification using NAPP and NAG pH (AMIRA, 2002)



Source: Okane Consultants (2023b)

Left – results from samples located within the known PAF cell (BH02 to BH05). Right – results from samples located outside the known PAF cell (BH01, and BH06 to BH12).

Figure 84 NAG_{pH} against RL



Source: Okane Consultants (2023b)

Left – results from samples located within the known PAF cell (BH02 to BH05). Right – results from samples located outside the known PAF cell (BH01, and BH06 to BH12).

Figure 85 NAPP vs RL

Results of Phase 2 Geochemical Analysis

Sulfur speciation, GAI assessment and ASLP results are summarised below:

- BH01, BH02, BH03, BH06 and BH07 showed exaggerated MPA values, where sulfur is present in the form of non-acid forming sulfur species, such as gypsum. Low sulfide-S values and low Titratable Actual Acidity (TAA) indicate low oxidation rates and therefore, low acid generation potential. BH02 samples showed low sulfide-S values but some KCl-S present, indicating oxidation but likely minimal oxidation potential and acid generation remaining. Samples also showed some enrichment in As and Se but very little element mobility.
- BH04, BH05 and BH08 samples showed increased sulfide-S values and KCl-S compared to other samples, indicating oxidation is occurring but also sulfide is present to further oxidise and produce more acidity. BH02 showed some enrichment in As, Se, S and Sb, but no element mobility. All samples showed some element enrichment and element mobility in Al, Fe, Co, Mn and Ni. It was noted that element enrichment does not always result in element mobilisation (see Okane Consultants (2023b) and Appendix D.

Results of Geotechnical Analysis

Geotechnical properties of the waste rock material indicate suitability as a low permeability capping material that inhibits water infiltration (Okane Consultants, 2023b). The analysis found that:

- Waste material sampled comprises fine grained clay / sand sized particles (< 0.075 mm).
- Atterberg Limits indicate the waste material is predominately low plasticity clay and silt materials with a low Liquid Limit and low Plasticity Index (PI) (difference between Liquid Limit and Plastic Limit).
- Hydraulic conductivity is low.

Sampled waste material is typically Emerson Class 4-6 where material does not disperse initially but may do so upon remoulding and may exhibit some flocculation or slaking behaviour.

5.9.4 Rehabilitation Performance for Areas Other Than WRLs

Key Points

- Rehabilitation of 11 ha of borrow pits and 10 ha of road infrastructure within the Carina Operations has been monitored since 2015 with results to date as follows (Astron, 2023a):
 - o Overall, the rehabilitated borrow pits and road infrastructure sites have a stable surface, are resistant to erosion and have the ability to support native vegetation.
 - o At the borrow pit sites, vegetation monitoring results are yet to display consistent trends across all attributes to determine if the sites are progressing towards a similar structure to the analogue sites. The monitoring results do show some positive trends in species richness, cover and structure. However, there are site specific issues such as high species dominance and relatively low cover.
 - o Similarly, the road infrastructure sites show some positive trends with respect to cover and species dominance. However, there is site variability for these monitored variables, a difference in vegetation structure (higher proportion of shrubs and herbs and a lower proportion of tree species and hummock grasses) and continued poor performance at three sites.
 - o Several weed species were recorded in 2022, contrasting with 2020 when no weed species were recorded, indicating a need to increase weed control activities.

In addition to the rehabilitation of WRLs discussed in Section 5.9.3.1, progressive rehabilitation at the Carina Operations includes:

- 11 ha of borrow pits along the Carina haul road.

- 10 ha of road infrastructure at Carina (Figure 86).

Monitoring at these locations commenced in 2015 as indicated in Table 48. The results of vegetation monitoring are summarised in Table 49. Maps showing the location of monitoring quadrats and analogue sites are included in Astron (2023a), which is provided in Appendix C.

No erosion or evidence of fire was recorded at the rehabilitation or analogue sites in 2022. Evidence of disturbance (track clearing) was recorded at one of the analogue sites. Invertebrate and fauna activity were recorded at all rehabilitation and analogue sites. The physical attributes of the borrow pit rehabilitation sites differed from the analogue sites in the following respects:

- Evidence of water pooling and a surface crust.
- Very low cryptogram cover.
- Dominated by rock cover.
- More bare ground and lower leaf litter.

The physical attributes of the road infrastructure rehabilitation sites differed from the analogue sites in the following respects (Astron, 2023a):

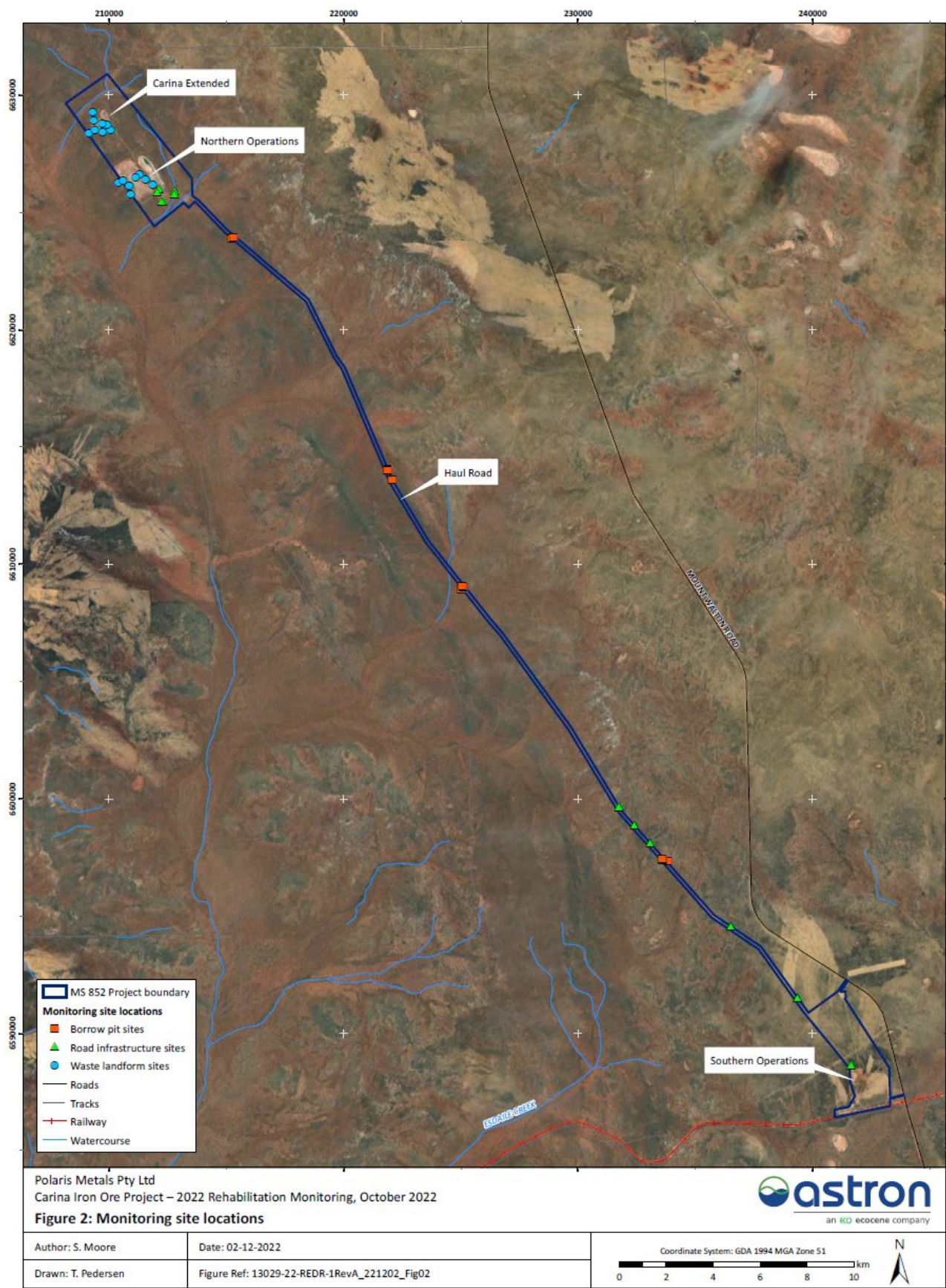
- An observed reduction in surface crust.
- Very low cryptogram cover.
- Lower litter cover.

Table 48 Closure and Rehabilitation Status of Borrow Pits and Haul Road Infrastructure and Monitoring Locations

WRL	Rehabilitation status	Monitoring quadrats ²⁶ (year commenced)	Analogue site (year established)
Carina Haul Road Borrow Pits	Rehabilitation implemented (2012 – 2015)	SR01, SR02, SR03, SR04 (2015)	SC01, SC02, SC03, SC04 (2015)
Carina Road Infrastructure	Rehabilitation implemented (2015)	PR01, PR02, PR03, PR04, PR05, PR06 (2015) PR07, PR08, PR09 (2016)	PC01, PC02, PC03, PC04, PC05, PC06 (2015) PC07, PC08, PC09 (2017)

Source: Astron (2023a)

²⁶ A single 5 m by 5 m quadrat was established where the rehabilitation area was too small for a transect.



Source: Astron (2023a)

Figure 86 Rehabilitation Monitoring Locations – Borrow Pits and Haul Road Infrastructure

Table 49 Rehabilitation Monitoring Results – Borrow Pits and Haul Road Infrastructure

Basis for completion criteria (Section 8)	Performance parameter (Astron, 2023a)	Progress (Astron, 2023a)
To satisfy MS852: Condition 11-1 (1) The waste material landforms shall be constructed so that their ability to support local native vegetation are similar to undisturbed natural analogue landforms. Condition 11-1 (6) The percentage cover of living self-sustaining native vegetation in all rehabilitation areas shall be comparable to that of undisturbed natural analogue sites.	Species inventory and richness.	Borrow Pits - Native species richness has been higher at all rehabilitation sites compared to analogue sites since 2016. - A minor declining trend is evident, reflecting progress towards a more stable state. - Two species of conservation significance have been recorded <i>Grevillea georgeana</i> (P3) (at SC03 in all years since 2016) and <i>Lepidosperma lyonsii</i> (P1) recorded at SC04 each year.
		Road Infrastructure - Overall, mean native species richness was slightly lower than at the analogue sites. - Five rehabilitation sites had lower species richness and three rehabilitation sites had higher species richness than the analogue sites. Species richness increased at most sites between 2020 and 2022 but had declined at the three sites that exceeded the analogue sites. - Species richness at the analogue sites declined slightly between 2020 and 2022.
	Berger Parker index of species evenness.	Borrow Pits - Species dominance overall was similar between rehabilitation sites and analogue sites. - One exception was site SR03 dominated by <i>A. burkittii</i>. The dominance of this species has continued to increase since 2016 and may be slowing the establishment of other native species.
		Road Infrastructure - Species dominance overall was similar between rehabilitation sites and analogue sites in 2022. - Species dominance increased at four rehabilitation sites and decreased at four rehabilitation sites between 2020 and 2022. - The former recorded an increase in cover of Acacia and Eucalyptus species, such as <i>A. burkittii</i>, <i>Acacia heteroneura</i> var. <i>heteroneura</i>, <i>E. loxophleba</i> subsp. <i>loxophleba</i> and <i>E. transcontinentalis</i>.
	Mean native cover (using linear model analysis or similar).	Borrow Pits In 2022 cover was similar at rehabilitation and analogue sites. Cover has been decreasing at analogue sites since 2015 and increasing at the rehabilitation sites since 2020. SR04 had the highest mean native cover (26%).
		Road Infrastructure Mean native cover at all rehabilitation sites increased between 2020 and 2022. Cover at four sites now exceeds analogue sites. Cover at three sites remains significantly lower than their analogues sites despite being 7 years post-rehabilitation.
	Mean native cover contribution by each vegetation stratum.	Borrow Pits - Vegetation structure at the rehabilitation sites remains different to the analogue sites, with the rehabilitation sites having a higher proportion of herbaceous species and lower proportion of hummock grasses. Dominance of herbaceous species is most pronounced at SR01. The other rehabilitation sites had a higher proportion of mid shrubs, such as <i>Grevillea zygomorpha</i>, and tall shrubs such as <i>Acacia burkittii</i>, <i>Acacia sibina</i>, <i>Melaleuca hamata</i> and <i>Melaleuca nematophylla</i>. The proportion of herbs at the rehabilitation sites have slowly declined since 2015, which is considered a process of natural succession as rehabilitation progresses. - Although hummock grass cover (<i>Triodia tomentosa</i>) at Site SR02 has increased since 2015 to 13.2%, this is still lower than the respective analogue site with cover of 54%. Without seed dormancy treatment, these grasses may take a long time to establish in rehabilitation sites. Site SR04 is lacking sedges and low shrubs.
		Road Infrastructure - The vegetation structure at the rehabilitation sites remains different to that of the analogue sites in 2022. - The main differences at the rehabilitation sites were the higher proportion of low shrubs, such as <i>Maireana trichoptera</i> and <i>Maireana triptera</i>, the lower proportion of tree species such as <i>E. leptopoda</i>, <i>E. oleosa</i> subsp. <i>oleosa</i> and <i>E. loxophleba</i> subsp. <i>supraevis</i>, and the small proportion of hummock grasses such as <i>T. tomentosa</i>.
	Plant health and dust loading	Borrow Pits - Understorey plant health at all sites was generally in good condition, but there was a general decline in plant health between 2020 and 2022 at all sites (including analogue sites) attributed to low rainfall in 2022. - Dust loading overall was negligible at all rehabilitation and analogue sites in 2022 consistent with 2020. The extreme dust loads recorded in 2017 have not re-occurred.
		Road Infrastructure - Plant health declined at seven of the nine rehabilitation sites and five of the nine analogue sites between 2020 and 2022. The proportion of plants in excellent health reduced but most sites had a large proportion of plants in good health. Dead plants were recorded at two analogue sites and three rehabilitation sites. These results were attributed to low rainfall in 2022. - Dust loading overall was negligible across all rehabilitation sites in 2022. Two analogue sites recorded low dust scores in 2022.
	Overstorey species	Borrow Pits - Overall, the rehabilitation sites continued to have much lower overstorey cover than analogue sites, reflecting the age of the rehabilitation. - In 2022, seven confirmed overstorey species were recorded across the borrow pit sites, including three confirmed <i>Eucalyptus</i> species: <i>E. corrugata</i>, <i>E. horistes</i> and <i>E. vittata</i>, with the latter absent in the analogue sites. Four additional overstorey species occur at the analogue sites; <i>Callitris preissii</i>, <i>E. cometae-vallis</i>, <i>E. oleosa</i> subsp. <i>oleosa</i> and <i>Santalum acuminatum</i>. - Two rehabilitation sites include both juvenile and mature overstorey species. Site SR01 displayed good establishment and succession of overstorey species. In contrast SR02 rehabilitation was completed at the same time as SR01, but no seedlings, juveniles or mature overstorey plants have been recorded since 2017.

Basis for completion criteria (Section 8)	Performance parameter (Astron, 2023a)	Progress (Astron, 2023a)
		- Sparse juveniles have been continually recorded at SR04, but none have reached maturity after seven years of monitoring and nine years after rehabilitation was completed. SR04 also lacks continued recruitment as seedlings have been absent from the site for the last two years. - Site SR03 had sparse juveniles, but also contained a sparse number of dead plants, suggesting the juveniles may be dying off before they reach maturity. SR03 also had no recruitment for the first year since 2015, as no seedlings were present in 2022.
		Road Infrastructure - Astron (2023a) did not report explicitly on overstorey species. - The species dominance results indicate the presence of overstorey species in some rehabilitation sites.
To satisfy MS852: Condition 11-1 (7) No new species of weeds (including both declared weeds and environmental weeds) are introduced into the rehabilitated areas as a result of the implementation of the proposal.	Comparison of weed species inventory between rehabilitation and analogue sites, and to previous flora, vegetation and weed surveys.	Borrow Pits - Four weed species were recorded in 2022 (compared to none in 2020) indicating weed control was not as effective as previous years. - The majority of weeds counted were <i>*Centaurea melitensis</i>, a weed species not recorded in 2015 baseline survey, but was recorded from 2017 to 2019. <i>*Erodium cicutarium</i> was recorded for the first time at SR01 in 2022 with 30 individuals. This weed species was previously recorded at a Carina exploration tenement by Mattiske Consulting (Mattiske Consulting, 2008a). The other weed species recorded were <i>*Lysimachia arvensis</i> and <i>*Sonchus oleraceus</i>. - No weeds were recorded at the analogue sites.
		Road Infrastructure - One weed species (<i>*Sonchus. asper</i>) was recorded across two rehabilitation sites (PR08 and PR09) for the first time in 2022 (3 individuals in total). <i>*Sonchus oleraceus</i> recorded at rehabilitation site PR08 in 2018 was not recorded in 2020 nor 2022. - No weeds have been recorded at the analogue sites since 2018.
To satisfy MS852: Condition 11-1 (8) The cover of weeds (including both declared weeds and environmental weeds) in rehabilitated areas shall not exceed that identified in the baseline survey condition 10-1(2) or exceed that existing on comparable, nearby land, determined by condition 10- 1(3) which has not been disturbed during implementation of the proposal, whichever is less.	- Linear model or 95% Confidence Interval comparison of mean weed cover between rehabilitation and corresponding analogue sites, and to baseline (2015) data. - NB: where cover values are low (< 0.01%), abundance can be used as a surrogate.	Borrow Pits - Mean weed abundance was similar to the 2015 baseline survey results. - Continued weed control activities are required to minimise the impact of weed populations on successful native vegetation establishment.
		Road Infrastructure - Three individual of <i>*S. asper</i> were recorded in 2022. Maintaining weed control activities will be required to ensure the population does not increase. - No weeds have been recorded at the analogue sites to date.

5.9.5 Benchmarking, Research & Trials

5.9.5.1 Benchmarking

Polaris is a wholly owned subsidiary of MinRes. MinRes operates mines throughout the Yilgarn and Pilbara regions of WA and has experienced environmental professionals who exchange information and learnings. Polaris and its parent company MinRes are active participants in regional management and working groups and are collaborating with organisations and tertiary institutions involved in mine site restoration research. The Polaris stakeholder engagement program also provides opportunities for information exchange with community members, Traditional Owners and organisations such as the Wildflower Society and Nest Egg Foundation (formerly Malleefowl Preservation Group).

The Carina Operations comprise three sites at different stages of closure which can provide learnings to inform the closure strategy.

MinRes also uses a range of consultants that have experience across a wide range of sites in WA to advise on landform design and rehabilitation matters.

5.9.5.2 Research & Trials

Research

MinRes, in conjunction with the Australian Research Council (ARC) Centre for Mine Site Restoration (CMSR) and Curtin University, has commenced genetic pollination studies of key endemic species to the region. The work is anticipated to assist in the determination of rehabilitation success and the trend towards reaching a self-sustaining ecosystem by providing better quality baseline biodiversity data. MinRes has funded a new ground-breaking study on plant pollinator interactions using eDNA. The study took place in Bungalbin East within the Helena and Aurora Ranges near Koolyanobbing and was recently published in Environmental DNA. The study is the first of its kind to use eDNA to simultaneously detect mammal, insect, and bird pollinators from multiple flower plant species. Results found new evidence of a western pygmy possum visiting a flower and was the first eDNA metabarcoding based identification of an interaction of a mammal with flowers. Research conclusions will inform the refinement of the Project's closure outcomes and associated completion criteria as discussed in Section 8. This work is part of a four-year Research and Development Strategy. Building upon the above study, MinRes is also currently funding a PhD program at Curtin University evaluating the efficacy of eDNA as a more general and wholistic environmental monitoring approach, including for rehabilitation and restoration.

MinRes are also funding the National Malleefowl Recovery Group to undertake a variety of research programs into the ecological requirements of Malleefowl in rehabilitated and restored landscapes.

Trials

Rehabilitation trials have been conducted on the Carina WRL as described in Section 5.9.2.

Drone seeding trials have been carried out on a newly rehabilitated landform at another MinRes site within the Yilgarn region. Bentonite pellets containing local provenance seeds were spread at controlled rates (ranging from 0 – 8 kg, pelleted and non-pelleted) and within controlled areas. The learnings from this trial will be incorporated into future rehabilitation practices at the Carina Operations.

Desktop Review of Salinity

Assessment of WRL surface cover materials (Section 5.3.3.2), spread topsoil and topsoil stockpiles (Section 5.3.5.1) has identified isolated areas of high to extreme salinity.

A background review (Landloch, 2024) was carried out to establish a reference salinity measurement for potential impacts to common revegetation species in the Goldfields region and considered the findings of the following studies (MinRes, 2024):

- Jennings et al. (1993) trialled salinity impacts on common Goldfields species, including *Atriplex bunburyana*, *Atriplex vesicaria*, *Maireana pyramidata*, *Acacia linophylla*, *Acacia acuminata*, *Eucalyptus torquata* and *Eucalyptus striatocalyx*. The most robust establishment of the species assessed occurred where $EC_{1:5} < 45$ mS/m, and best plant vigour occurred where $EC_{1:5} < 110$ mS/m.
- Brearley et al. (2000) reported field trials investigating salinity impacts on germination and growth of a number of salt tolerant species (mainly *Atriplex* and *Maireana* species). In general, where $EC_{1:5}$ of growth media was > 300 – 400 mS/m, plant cover tended to be lower (less than 20%) than for growth media with $EC_{1:5} < 300$ mS/m.
- Barrett (2000) trialled the germination of several halophytes used in rehabilitation of gold and nickel mines in the eastern Goldfields. Perennial tree and shrub species assessed included *Atriplex nummularia*, *Atriplex vesicaria*, *Casuarina obesa*, and *Maireana georgei*. Germination was reduced by 50% at $EC_{1:5}$ values of ~ 150 mS/m compared with low salinity germination.
- Lison and Howard (2021) present a salinity threshold of 200 mS/m for material that may impact revegetation efforts for sensitive to moderately salt tolerant species in the Goldfields.

The salinity values noted in the studies described by Landloch (2024) are based on analysis of a sample comprising a solid to liquid ratio of 1:5. Analysis of WRL cover materials for salinity used a sample comprising a 1:2 ratio of solid to liquid so the salinity results (Section 5.3.3.2.3) are more conservative (MinRes, 2024).

5.9.6 Considerations for Closure

The studies outlined in this section have implications for WRL closure designs (or rectification plans) as discussed in Section 5.9.6.1 and surface treatments to create optimal conditions for revegetation as discussed in Section 5.9.6.2.

5.9.6.1 WRL Closure Design Considerations

Closure design (or rectification plans) for WRLs at the Carina Operations are informed by design geometry commitments, the geochemical, geotechnical and growth medium related properties of the surface cover materials, surface water control requirements and flood modelling outcomes. The Carina WRL design must also maintain security of encapsulated PAF material. Where a WRL is under rehabilitation the results of rehabilitation monitoring also inform the closure strategy.

Table 50 summarises the baseline data and closure study results from the preceding sections of this MCP relevant to WRL closure design or rectification plans and describes the conceptual closure strategy for each WRL based on this data.

Where the strategy has progressed to more detailed design, this is presented in Section 9.2.2.

Rectification plans are currently proposed for all but the Carina Extended WRL. The current situation for the Carina Extended WRL is as follows:

- The WRL has been fully rehabilitated.
- There is a non-compliance with Lift 1 height (18 m vs planned 15 m). This exceedance is not considered significant and to avoid rehabilitation disturbance, approval for this design variation is sought via this MCP (Section 9.2.2.3).
- Based on the as-built lift height and desktop assessment of berm widths, Okane Consultants (2022a) made only one rectification recommendation and that was to correct the back slope angle of berms to 2 – 5° . It was concluded that berm widths were sufficient, based on the minimum berm width requirement (~ 9 m) defined by Okane Consultants (2022a) for the as-built lift height of 7 m. Landloch (2023) identified a greater minimum berm width requirement than Okane (2022a). This

difference is partly driven by the different freeboard parameters applied to the modelling (Section 5.9.1).

- Any rectification works at Carina Extended WRL would necessitate disturbance of rehabilitation which is displaying some positive trends (Section 5.9.3.1). It is acknowledged however that active erosion is still evident at all rehabilitation sites (Section 5.9.3.2.1).

Before proceeding with a plan to disturb establishing rehabilitation at Carina Extended, MinRes propose to:

- Review the two berm capacity modelling studies (Section 5.9.1) and parameters used to refine the recommended minimum berm width, which currently ranges from ~ 9 m to 10 m, based on Carina materials properties, and stipulated freeboard of 0.01 m and 0.3 m respectively.
- Complete a more detailed assessment of the as-built berm widths on the Carina Extended WRL. The initial assessment identified the areas where berm width was less than 10 m, but actual berm width was only measured at one cross-section (Figure 76).
- Consider the results of two further years of erosion monitoring data.

Although the Aurora WRL departs from the design criteria in that it occupies a greater footprint, the resultant lower height is a more desirable outcome for surface stability, and rectification of the landform to align with the original design geometry is not recommended (Okane Consultants, 2022b).

Rectification work is however proposed to address poor erosion performance (Table 50 and Section 9.2.2.6).

5.9.6.2 WRL Surface Treatment Considerations

The assessment of rehabilitation trial results has generated the following considerations for closure:

- Based on the Carina assessment, vegetation cover and species diversity can be maximised at the Carina WRLs when growth covers have the following (Landloch, 2023):
 - Addition of 10-20% timber debris.
 - EC_{1:5} levels < 200 mS/m.
 - Soil thickness between 100 – 300 mm.
 - 40 – 60% rock cover.

- Although Landloch (2023) note that these findings are specific to the Carina site, they support the following general considerations with respect to rehabilitation surface treatment (Landloch, 2023):

Of the four physical factors that affect plant growth, including mechanical impedance, water, aeration and temperature, water availability is often the most important. Increasing rock cover and wood debris cover, up to a certain threshold, may have a positive impact through trapping surface water, and potentially seed, reducing soil water evaporation and increasing the depth of wetting. Too much rock or wood debris cover however may have a negative impact by affecting optimum plant germination requirements (i.e., sunlight, temperature).

Salinity is known to have a potentially negative impact on germination and seedling establishment by inhibiting water uptake or because of ion toxicity or imbalance. Salinity testing of topsoil stockpiles should be carried out to delineate the occurrence of problematic soils which should be excluded from use in rehabilitation where possible.

- Where underlying waste rock is found to be saline, this can be managed through the use of a capillary break. But where this may not be practicable on partially or fully rehabilitated WRLs, the inclusion of a greater number of salt tolerant species (refer to Section 5.9.5.2) within the seed species mix and / or amendment of the completion criteria to reflect lower levels of expected diversity and / or vegetation cover, may be a more effective strategy (Landloch, 2023).
- Based on topsoil availability (refer to Section 5.3.5.3) the minimum soil thickness (100 mm) of the ideal range (100 – 300 mm) should be targeted to allow a greater surface area to be covered whilst

achieving a similar species diversity to 300 mm thickness. Additional soil resources should be identified, or additional seeding undertaken if the desired soil thickness cannot be achieved (Landloch, 2023).

- Creation of a growth cover with 40-60% surface rock can be achieved via introduction of rock fragments into the upper cover layer via deep ripping, where the underlying waste material is rocky, or mixing of non-rocky soils with rocky soils prior to spreading (Landloch, 2023).
- Timber debris if applied, must achieve, but not exceed, the target cover rate of 10-20%. Landloch (2023) suggest progressively rehabilitating smaller sections and placing a pre-determined lineage of stockpiled wood debris to be placed at the bottom of each section which can be applied to the batter of each section using an excavator fitted with a grabber attachment.
- SWC (2014b) also considered the utilisation of vegetation debris at the J4 site and made the following recommendations:
 - Methodology that involves tracking over ripped surfaces should be avoided as it has the potential to fill the rip lines and negate their effectiveness. The use of an excavator is put forward as an alternative, provided it has sufficient reach to allow for an even distribution across the surface.
 - Application of vegetation debris to batter surfaces should only occur if there is sufficient volume of material to form a continuous cover across the surface. Otherwise, its presence on the surface may exacerbate erosion and surface water run-off by removing water convergence in rip lines and directing water downslope in places.
 - Mulching of vegetation debris prior to re-application is beneficial as it facilitates the composition process, but practicability would need to be assessed.

As discussed in Section 5.3.3.2.3, OAW and localised areas of high to extreme salinity have been identified on the J4 WRLs. The initial recommendation to treat this material like PAF, and encapsulate with 5 m of NAF, is considered overly conservative, given that there is no requirement to prevent oxidation of this material. Cover depth should be informed by the requirement to provide an acceptable growth medium on the surface of the WRL (MinRes, 2024). It has been recommended in Section 5.3.3.8 that further assessment be undertaken to determine the cover requirement necessary to ensure that OAW material does not adversely impact the plant root zone, where cover is practicable. Where cover is not practicable, Landloch (2023) recommend the inclusion of a greater number of salt tolerant species within the seed species mix and / or amendment of the completion criteria to reflect lower levels of expected diversity and / or vegetation cover.

Table 50 Summary of Baseline and Closure Data Applicable to WRL Closure Strategy

Departures from design geometry (Section 5.9.3.3)	Geotechnical & surface stability (Sections 5.3.4, 5.6.1.4, 5.9.1 & 5.9.3.2)	Geochemical stability & surface salinity (Sections 5.3.3.2 and 5.9.3.4)	Revegetation progress (Sections 5.9.2 and 5.9.3.1)	Proposed closure strategy
Carina WRL				
- Lift 2 height of 15 m is > design 10 m. - Berm width: most faces non-compliant for berm width. - Berm backslope: back sloping inconsistent in many areas. - Baffles evident on most berms (but anticipated to require reinstatement following rectification works).	- FOS still to be assessed. - Outside ZOI. - Existing PAF encapsulation cell cover materials are sufficient to limit infiltration. - The final surface cover over the PAF encapsulation cell area should be convex (water-shedding). - By 2020, erosion ranged from low to extensive. Parts of the Carina WRL rehabilitation may be stabilising. However, where erosion was present, the severity had increased since 2020 with some rills developing into gullies. - No significant flow or velocity, associated with the main PMF floodplain, reaches the WRL. - Berm capacity modelling recommends minimum berm width ranging from 10 m – 14 m for a 10 m lift height (depending on modelled parameters, including freeboard).	- Cover materials samples on the Carina WRL were NAF (3 samples were Uncertain (UC)). - It has been demonstrated that PAF has been suitably encapsulated in a purpose built encapsulation cell. It has been recommended that the cover thickness over sections of the PAF cell should be increased to minimise risk of disturbance during rehabilitation surface preparation e.g., ripping. - There was a commitment to ensure that residual salt in former evaporation ponds on the surface of the Carina WRL were buried at sufficient depth. - Some spread topsoil has high salinity. - Stockpiled topsoil materials were found to be slightly to extremely saline and should be tested prior to use. - Landloch found that EC_{1:5} levels < 200 mS/m are optimal. Desktop review found that salt-tolerant species in the region could be suitable for higher salinity but that 400 mS/cm is limit of tolerance for even salt tolerant species.	- The overall positive trend in species richness, species dominance and native cover is an encouraging result. - But the differing vegetation structure and other site-specific issues (species dominance / lack of overstorey) highlight that the rehabilitation is not displaying consistent trends across all attributes. - The rehabilitation trials indicate that addition of 10-20% timber debris and 40 – 60% rock cover can create optimal growth cover properties (but levels higher than this can have a negative effect on revegetation success. Practicable methods for implementation require further assessment. - The rehabilitation trials and identified topsoil deficit suggest that minimum topsoil thickness (100 mm) of the ideal range (100 – 300 mm) should be targeted.	- Develop a final landform design that: - Rectifies departures from design geometry (using a selected method to achieve berm capacity). - Meets PAF encapsulation cell cover depth and extent recommendations using materials that will limit infiltration. - Creates a convex cover over the PAF encapsulation cell and concave cover elsewhere. - Incorporates armouring requirements (if found necessary from flood modelling results). - Where possible separates highly saline materials from the root zone. - Topsoil application, surface treatments, selection / development of reference ecosystems and seed mixes and seeding will be conducted generally in accordance with the procedures outlined in Section 9.1.4. - Refine completion criteria to reflect reference ecosystem characteristics. Knowledge gaps - Review berm capacity modelling results to determine minimum berm capacity / width. - Evaluate risks / benefits of the three construction methods proposed to achieve minimum berm capacity. - Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable. - Where cover is not practicable, use the characteristics of substrate materials (and closure objectives) to inform the reference ecosystem / species selection for revegetation or supplementary seeding. - Determine if there is a practicable method of applying timber debris to rehabilitation surfaces that will achieve, but not exceed, the target cover level (10 – 20%) and not enhance erosion.
Carina Extended WRL				
- Lift height 1 of 18 m is > design 15 m. - Back sloping inconsistent in many areas. - Multiple areas non-compliant for design berm width (noting that design width of 10 m based on planned 10 m lift height. Actual lift height 7.5 m). - Baffles evident on most berms (but anticipated to require reinstatement following rectification works).	- FOS still to be assessed - Outside ZOI - The WRL is not within a flood plain. - WRL surface classified overall as having Moderate stability based on rehabilitation cover. - However, all monitoring sites were recorded as actively eroding in 2022. - The WRL may require rectification works in relation to berm widths and backslopes. - Berm capacity modelling recommends minimum berm width ranging from 10 m – 14 m for a 10 m lift height (depending on modelled parameters, including freeboard). For the as-built height of 7.5 m recommended minimum berm width capacity ranges from ~ 9 m to 10 m (depending on parameters modelled, including freeboard).	- Cover materials were NAF. - No PAF encapsulation cell required. - The 'moderately saline' to 'extremely saline' classification of some samples of topsoil spread on the WRL may be contributing to the relatively sparse vegetation establishment observed on the WRL.	- Positive trends in native vegetation attributes including species richness, native cover, species dominance and overstorey species. - Vegetation structure at the rehabilitation sites remains different to that of the analogue sites, however there is some early indication that the vegetation is progressing towards a structure similar to the analogue sites. - Overstorey species, recruitment and succession (at one site) have been recorded. - The results of rehabilitation trials at Carina potentially applicable to similar material types on Carina Extended.	- Seek approval via this MCP for Lift 1 height of 18 m (Section 9.2.2.3). - Address knowledge gaps to determine if rectification works are required. - Define reference ecosystem / species selection for supplementary seeding of saline areas (where the closure status of the WRL makes cover impracticable or detrimental). - Refine completion criteria to reflect reference ecosystem characteristics. Knowledge gaps - Complete more detailed assessment of as-built berm widths (to expand on current assessment which simply concludes berms are < 10 m design width). - Review berm capacity modelling results to refine minimum berm capacity / width. - Establish surface stability trajectory after two more monitoring periods. Revisit this strategy if significant increase in severity of erosion after first year of additional monitoring.

Departures from design geometry (Section 5.9.3.3)	Geotechnical & surface stability (Sections 5.3.4, 5.6.1.4, 5.9.1 & 5.9.3.2)	Geochemical stability & surface salinity (Sections 5.3.3.2 and 5.9.3.4)	Revegetation progress (Sections 5.9.2 and 5.9.3.1)	Proposed closure strategy
J4 East WRL				
- Maximum height > 30 m in many areas. - Lift height 2 > 20 m design height. - Maximum overall slope angle > 13.3° - Berms are missing from the north face of the East WRL and width in multiple areas is < 20 m. - No back sloping of berms. - No berm cross-bunds evident.	- FOS still to be assessed - ZOI to be re-assessed to account for J4 redevelopment. - Low stability rating of waste rock present at multiple slopes likely to require additional rock armouring to mitigate erosion. - The WRL is not within a flood plain. - Gully erosion has been observed on the J4 WRLs and has been exacerbated because contour ripping has not been completed. - Berm capacity modelling (for Windarling and Carina materials) indicates minimum berm width ranging from 13 m to 22 m for a 15 m lift height (depending on parameters modelled, including freeboard).	- Cover materials at the J4 WRLS were also predominantly NAF or Uncertain (UC) the latter reflecting conservative estimations of acid producing potential. - Areas on the southern end of the J4 East WRL were found to be highly saline (> 400 mS/m, the threshold likely to impact on even salt tolerant species).	- Rehabilitation monitoring yet to commence. - The results of rehabilitation trials at Carina are considered site specific. Consider possible application to J4 based on growth cover materials properties.	- Address knowledge gaps to finalise the preliminary landform rectification plan provided to DEMIRS (MinRes, 2023c) including: - Backfilling of the section on the southeastern side of the WRL. - Construction of surface water control including back sloping of berms and construction of cell bunds / baffles. - Where practicable separate OAW / saline materials from the root zone based on cover depth investigations. - Topsoil application, surface treatments, selection / development of reference ecosystems and seed mixes and seeding will be conducted generally in accordance with the procedures outlined in Section 9.1.4. - Refine completion criteria to reflect reference ecosystem characteristics. Knowledge gaps - Assess interaction of the WRL with the ZOI of the final J4 East pit shell to inform final closure design. - Re-assess cover materials mapped as 'low stability' to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, should be incorporated into the final landform. - Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable. Where cover is not practicable, use the characteristics of substrate materials (and closure objectives) to inform the reference ecosystem / species selection for revegetation or supplementary seeding.
J4 West WRL				
- Maximum height > 30 m in many areas. - Lift height (note the south portion of the WRL comprises two lifts and the north face comprised a single lift): - Lift 1 (north face) > 20 m and (south portion) > 15 m. - Lift 2 (south portion) > 15 m - Batter angle: two areas on north and west faces > 16°. - Berms are missing from the north face of the West WRL and width in multiple areas is < 20 m. - No back sloping of berms. - No berm cross-bunds evident.	- FOS still to be assessed. - ZOI not applicable as J4 West Pit planned to be backfilled to surface. - Low stability rating of waste rock present at multiple slopes likely to require additional rock armouring to mitigate erosion. - The WRL is not within a flood plain. - Gully erosion has been observed on the J4 WRLs and has been exacerbated because contour ripping has not been completed. - Berm capacity modelling (for Windarling and Carina materials) indicates minimum berm width ranging from 13 m to 22 m for a 15 m lift height (depending on parameters modelled, including freeboard).	- Cover materials at the J4 WRLS were also predominantly NAF or Uncertain (UC) the latter reflecting conservative estimations of acid producing potential. - Three sites on the western end of the J4 West upper lift tested as highly saline.	- Rehabilitation monitoring yet to commence. - The results of rehabilitation trials at Carina are considered site specific. Consider possible application to J4 based on growth cover materials properties.	- The J4 West WRL will be expanded as part of the J4 East Redevelopment (Section 9.2.2.5). - Rectification of design non-compliances will occur as part of this expansion to achieve the design parameters outlined in the J4 East Redevelopment MP (MinRes, 2023a) (which are consistent with the MCP 2019 and the original J4 MP REG ID 56760 (Polaris Metals, 2015)). - PAF materials from J4 East Pit will be backfilled into J4 West Pit in the first instance and will only be encapsulated in the J4 West WRL as a contingency if backfill capacity in the J4 West Pit has been reached. Dispersive materials are not expected to be encountered but if identified would be handled in the same manner as PAF materials. - Topsoil application, surface treatments, selection / development of reference ecosystems and seed mixes, and seeding will be conducted generally in accordance with the procedures outlined in Section 9.1.4. - Refine completion criteria to reflect reference ecosystem characteristics.
Aurora WRL				
- Maximum height: ~ 6 m - Lift height: single lift of ~ 6 m - Batter angle: < 20° (overall 8° with approximately 90% of individual faces < 6°)	- FOS still to be assessed. - Outside ZOI - Multiple and significant erosion gullies. Observed sediment deposition beyond toe of WRL. - No materials characterisation data available.	No materials characterisation data available.	Partially (historically) rehabilitated but not part of formal rehabilitation monitoring program on basis that significant rectification works required to address field observations of significant erosion.	Although the Aurora WRL departs from the design criteria in that it occupies a greater footprint, the resultant lower height is a more desirable outcome for surface stability. Rectification of the landform to align with the original design geometry is not recommended.

Departures from design geometry (Section 5.9.3.3)	Geotechnical & surface stability (Sections 5.3.4, 5.6.1.4, 5.9.1 & 5.9.3.2)	Geochemical stability & surface salinity (Sections 5.3.3.2 and 5.9.3.4)	Revegetation progress (Sections 5.9.2 and 5.9.3.1)	Proposed closure strategy
- No berm applied as first lift height was not reached. - No baffles present on WRL plateau. - The WRL occupies an area of 40 ha compared to planned footprint of 22 ha which likely accounts for reduced height overall. This compliance assessment addresses geometry / stability only. - No rectification works proposed from geometry perspective.	PMF flood assessment indicates minor potential for sediment release from toe but makes no recommendation for armouring based on low risk.			- Rectification is proposed to address erosion caused by uncontrolled surface water run-off. - Complete landform design to: - Control surface water run-off from the plateau by installing a crest bund. - Re-profile batter slopes based on materials characterisation results. - Salvage available topsoil from the existing WRL batters prior to rectification works. - Topsoil application, surface treatments, selection / development of reference ecosystems and seed mixes and seeding will be conducted generally in accordance with the procedures outlined in Section 9.1.4. - Refine completion criteria to reflect reference ecosystem characteristics. Knowledge gaps - Materials characterisation to inform landform design.

5.9.7 Knowledge Gaps & Forward Work Program

Carina WRL

- Finalise the landform design for the Carina WRL informed by surface water run-off control and PAF encapsulation requirements, review of berm capacity modelling results, geochemical and geotechnical characteristics of the surface cover materials, flood modelling results and design commitments.
- Identify a suitable source of NAF / non-dispersive material to facilitate the recommendation to increase surface cover depth over the PAF encapsulation cell in the Carina WRL.

Carina Extended WRL

- Complete more detailed assessment of as-built berm widths (to expand on current assessment which simply concludes berms are < 10 m design width).
- Review berm capacity modelling results to refine minimum berm capacity / width.
- Review surface stability trajectory after two more monitoring periods. Revisit this strategy if significant increase in severity of erosion after first year of additional monitoring.

J4 East WRL

- Address knowledge gaps to finalise the preliminary landform rectification plan provided to DEMIRS:
- Assess interaction of the WRL with the ZOI of the final J4 East Pit pit-shell to inform final closure design.
- Re-assess cover materials mapped as 'low stability' to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, should be incorporated into the final landform design.

J4 West WRL

- Rectify design non-compliances at the J4 West WRL as part of the expansion of the J4 East Pit to achieve the design parameters provided in the J4 East Redevelopment MP.
- Re-assess cover materials mapped as 'low stability' to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, should be incorporated into the final landform design
- Source as constructed / compliance to plan report at completion of J4 West WRL expansion and J4 West backfill operations.

Aurora WRL

- Develop Aurora WRL rectification plan to control surface water run-off.
- Material characterisation to inform landform design.

All WRLs

- Review the potential application of the Carina rehabilitation trial findings to surface treatment of all WRLs.
- Determine if there is a practicable method of applying timber debris to rehabilitation surfaces that will achieve, but not exceed, the target cover level (10 – 20%) and not enhance erosion.
- The learnings from a Drone Seeding trial, undertaken at another MinRes operation within the Yilgarn, will be incorporated into future rehabilitation practices at the Carina Operations.
- Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable.

- Where cover is not practicable, use the characteristics of substrate materials, and closure objectives, to inform species selection for revegetation or supplementary seeding.
- Refine completion criteria to reflect reference ecosystem characteristics.

6. POST MINING LAND USE

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes the post-mining land use(s) that has been proposed or agreed with key stakeholders, including regulators. The mine closure plan describes how the post-mining land use(s) is:

- *Relevant to the environment in which the mine will operate or is operating (Section 6.2)*
- *Achievable in the context of post-mining land capability (Section 6.2)*
- *Acceptable to the key stakeholders (Section 6.1)*
- *Ecologically sustainable in the context of the local and regional environment (Section 6.2).*

6.1 Background

There is no one set of commonly accepted guidelines for identification of Post-Mining Land Uses (PMLUs) and selection of the preferred use. However, the 2019 framework for developing mine-site completion criteria in WA produced by DEMIRS and the Western Australian Biodiversity Science Institute (WABSI) (Young, et al., 2019) confirms that the PMLU must be:

- Relevant to the tenure and the environment in which the mine is located.
- Considerate of historical commitments at the site and at a regional scale.
- Achievable in the context of land capability and safeguarded against physical, chemical and biological hazards.
- Acceptable to key stakeholders.
- Ecologically sustainable and, where appropriate, economically productive.
- Within any other legislative constraints.

These guidelines are reflected in the DEMIRS Guidelines for Mine Closure Plans (DMIRS, 2020a).

The Carina Operations are located on several different land tenure types, including UCL, Crown Land, pastoral lease and existing or proposed conservation reserves as detailed in Section 2.3.2 and within the boundaries of a native title claim as detailed in Section 3.5.

Stakeholder engagement has commenced regarding PMLU as recorded in Appendix B and summarised below:

- At a meeting in March 2023, DBCA raised their preference for 'natural environment' PMLU on DBCA managed land. Note that in earlier consultation with the Office of the Environmental Protection Authority (OEPA) they advised that closure aspects of Ministerial Statement 852 can be assessed on OEPA's behalf by DBCA (then Department of Parks and Wildlife).
- A closure presentation to DEMIRS (then DMIRS) in February 2023 raised no issue with the proposed PMLUs.
- A closure and rehabilitation update presented to a Shire of Yilgarn Community Forum in July 2022 for contracting, tourism and mining company representatives, raised no objections to the PMLUs proposed.
- DPLH were approached in August 2020 in relation to closure objectives and PMLUs for other sites within MinRes' Yilgarn Hub but advised that they would only provide input on matters related to Heritage and Native Title.

- Engagement with Traditional Owners since 2020 has focused on drafting a comprehensive claim-wide agreement and will extend to PMLUs when these negotiations are complete.

MinRes will continue stakeholder engagement as described in Section 4.1.3., to finalise the PMLUs.

Based on current land use, underlying tenure and the consultation undertaken to date, this MCP assumes the PMLUs proposed in Section 6.2.

6.2 Proposed Post Mining Land Uses

In advance of stakeholder agreement being reached on the final PMLUs for the Carina Operations, Polaris has used the Australian Land Use and Management (ALUM) classification (ABARES, 2016) and underlying tenure to assign potential PMLUs for areas of the Carina Operations that are yet to be rehabilitated Table 51.

Table 51 Approach to Assigning Post-Mining Land Uses

Land Use (ALUM Classification)	Tenure Type	Domains
• Natural Environments	• UCL • Proposed 5(1)(h) Conservation and Mining Reserve • Mount Manning – Helena-Aurora Range Conservation Park	• WRLs • ROM pads and stockpiles • Infrastructure and general disturbance • Exploration • Mine pits backfilled to surface
• Production from Relatively Natural Environments	• Pastoral Lease	
• Extractive Industry Not in Use	• All	• Mine pits left as residual dry voids or pit lakes.

The ALUM 'Natural Environments' classification has been assigned to areas where the underlying tenure is UCL or existing or proposed conservation reserve on the understanding that:

- Once established, the proposed 5(1)(h) reserve can be utilised for both nature conservation and exploration and mining activities.
- While rehabilitation areas may not achieve a standard that is of equivalent value to undisturbed areas being conserved, rehabilitation outcomes will provide vegetation and fauna habitat that could support, or at least not adversely affect any potential conservation values in adjacent areas.

Similarly, the classification 'Production from Relatively Natural Environments' has been used for areas where the underlying tenure is pastoral on the understanding that the areas will be compatible with pastoral use, but there may be some areas (e.g., WRLs) where grazing of livestock is discouraged to avoid impacts to the vegetation cover and maintain erosional stability of landforms.

The application of the PMLUs outlined in Table 51 to specific areas of the Carina Operations is detailed in Table 52 and Figure 87 to Figure 90. Figures covering the extent of the Haul Route are provided in Appendix J.

Table 52 Provisional Post Mining Land Use by Domain

Domain	Provisional PMLU ¹ .	Features	Underlying Cadastre
Mine Pits	Extractive Industry Not in Use.	Carina Pit, Carina Extended Pit	UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
		Aurora Pit	UCL (surrounded by Conservation Park)
		J4 East Pit, J4 West Pit	Pastoral Lease
	Production from Relatively Natural Environments	J4 West Pit (backfilled to surface)	Pastoral Lease
WRLs	Natural Environments	Carina WRL, Carina Extended WRL	UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
		Aurora WRL	UCL (surrounded by Conservation Park)
		J4 East WRL, J4 West WRL	Pastoral Lease
ROM Pads & Stockpiles	Natural Environments	Carina ROM Pads (2) & Low Grade Stockpiles (3)	UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
		Carina Southern ROM Pad	Crown Land (G15/21, L15/340, L15/311, L15/310)
		Aurora Low Grade Stockpiles	UCL (surrounded by Conservation Park)
	Production from Relatively Natural Environments	J4 ROM Pad & Low Grade Stockpiles	Pastoral Lease
Infrastructure & General Disturbance, Exploration, Dams & Drains (excluding infrastructure within the Haul Road corridor)	Natural Environments	Carina Southern Operations – Carina Camp, East Jaurdi Aerodrome	UCL
		Carina Southern Operations – Mt Walton Rail Siding, MRT Haulage workshop, offices, buildings, water treatment and washdown, crushing and processing, fuel storage, power generation, process water dams, laydown, hardstand, borrow pits, unsealed access (G15/21 and L15/340)	Crown Land
		Carina Northern Operations – buildings, heavy vehicle workshop, washdown and water treatment, flood bund (Carina Mine Infrastructure), saline process water dams, bores, topsoil stockpiles, laydown, hardstand, borrow pits, unsealed access roads.	UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
	Production from Relatively Natural Environments	J4 – buildings, offices, workshops, fuel storage facility, laydown, hardstand, saline process water dams, bores, topsoil stockpiles, laydown, hardstand, resource definition drilling disturbance	Pastoral Lease
Transport & Service Corridors (including laydown, borrow pits, topsoil stockpiles, communications towers, pipelines and dams within the Haul Road corridor)	Natural Environments	Haul Road Carina to Carina Southern	UCL / UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
		Haul Road Carina to J4 (East – West portion)	UCL / UCL (DBCA Land of Interest – former pastoral lease proposed for conservation)
		Haul Road Carina to J4 (south of Aurora, northwest towards J4 portion)	UCL / Conservation Park
		Access road to Carina Camp and East Jaurdi Aerodrome	UCL
		Southeastern access to Mt Walton Rail Siding (L15/310 and L15/311)	Crown Land
		Access road to Aurora	UCL (surrounded by Conservation Park)
	Production from Relatively Natural Environments	Haul Road Carina to J4 (northwest extent to J4 portion)	Pastoral lease

1. PMLUs

Extractive Industry Not in Use – Mine voids and pit lakes will not likely support a specific post-closure land use due to access being restricted by abandonment bunds. Mine voids and pit lakes will not impact on the surrounding land use

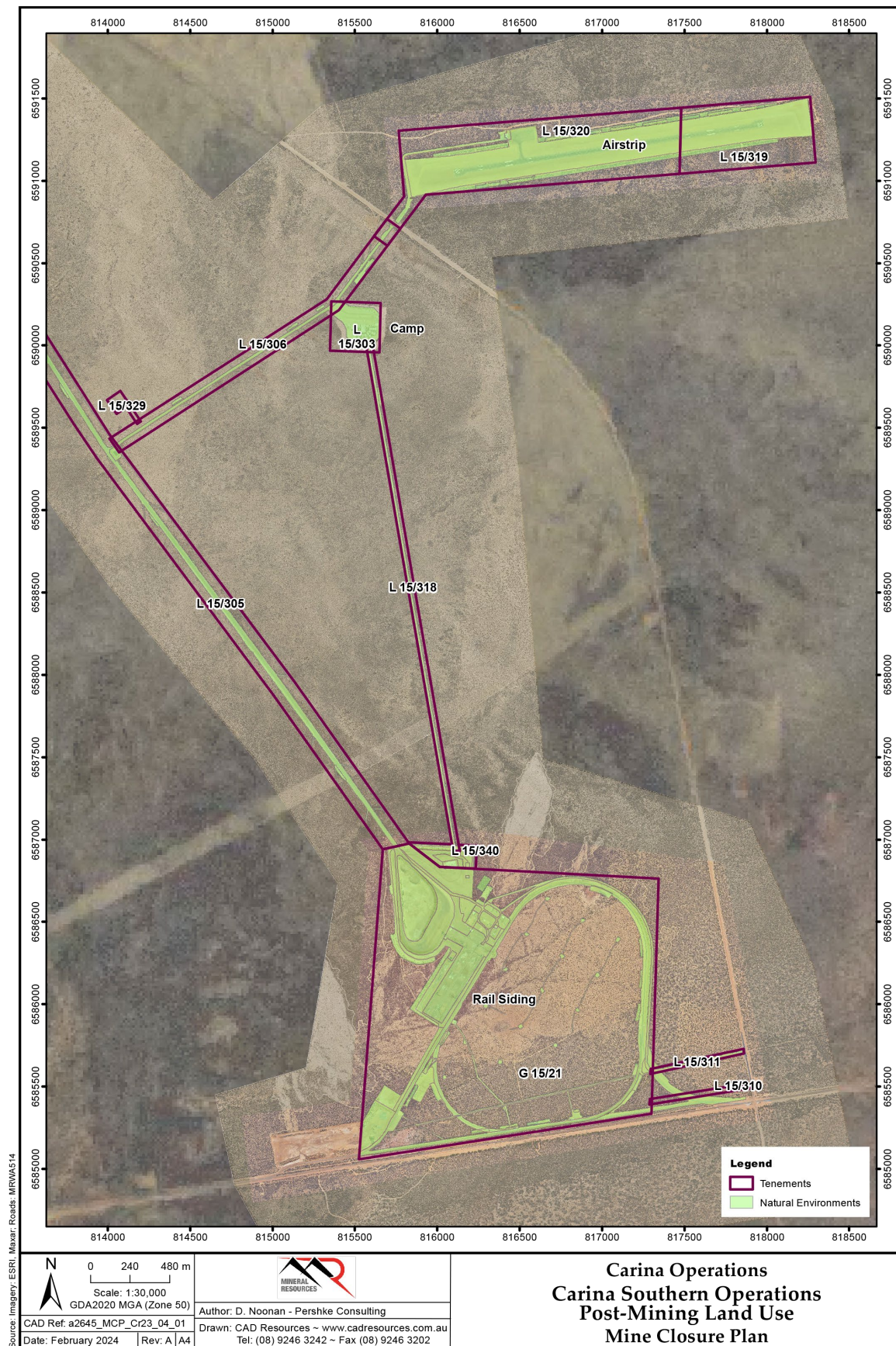
Natural Environments – Rehabilitation is expected to result in native vegetation types that are representative of the region

Production from Relatively Natural Environments Surrounding land use is pastoral. Rehabilitation is expected to support Low intensity grazing/native pastoral ecosystem, with the site expected to revert to pastoral purposes (subject to further discussions with Red Dirt Pastoral).



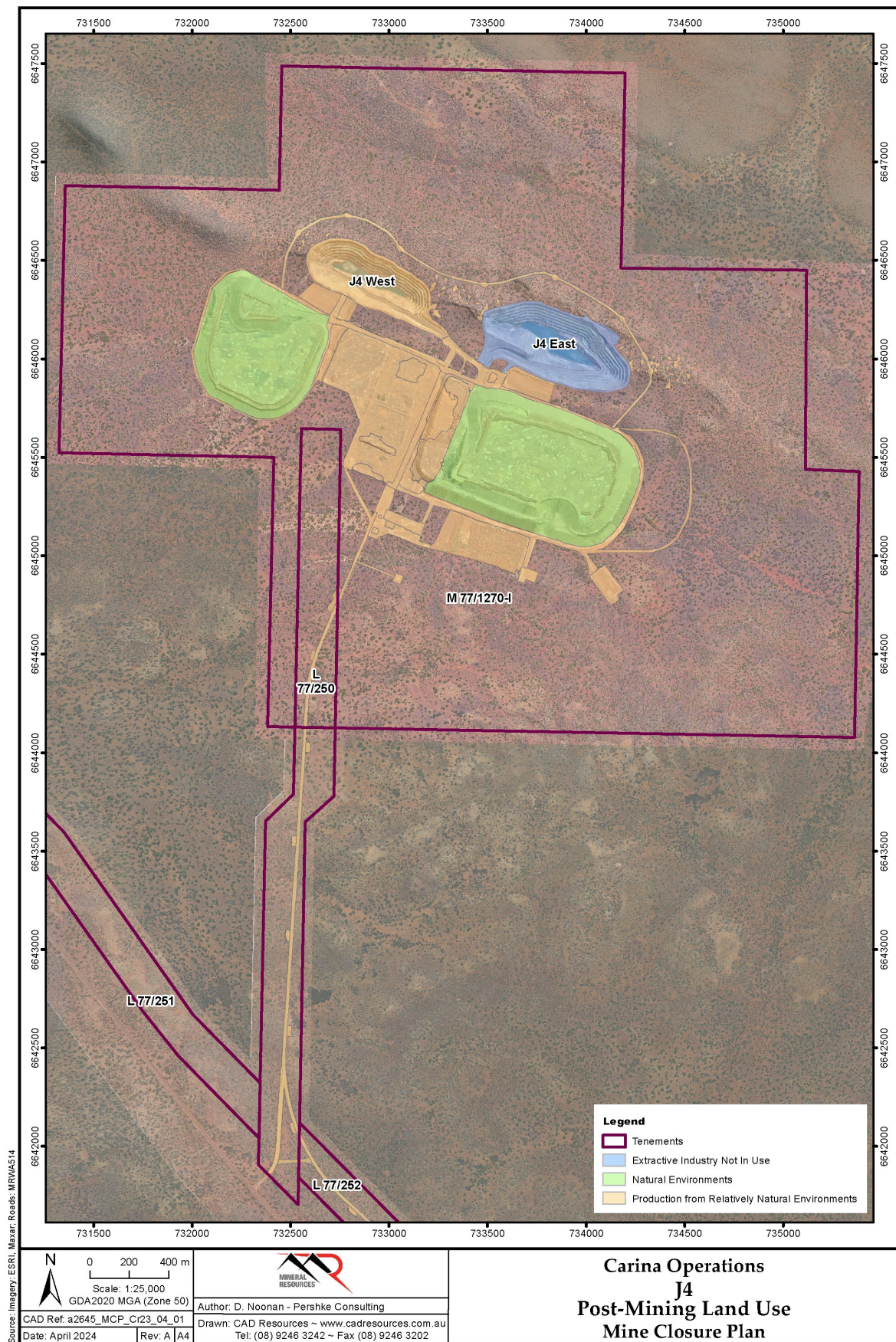
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Figure 87 Post Mining Land Use – Carina



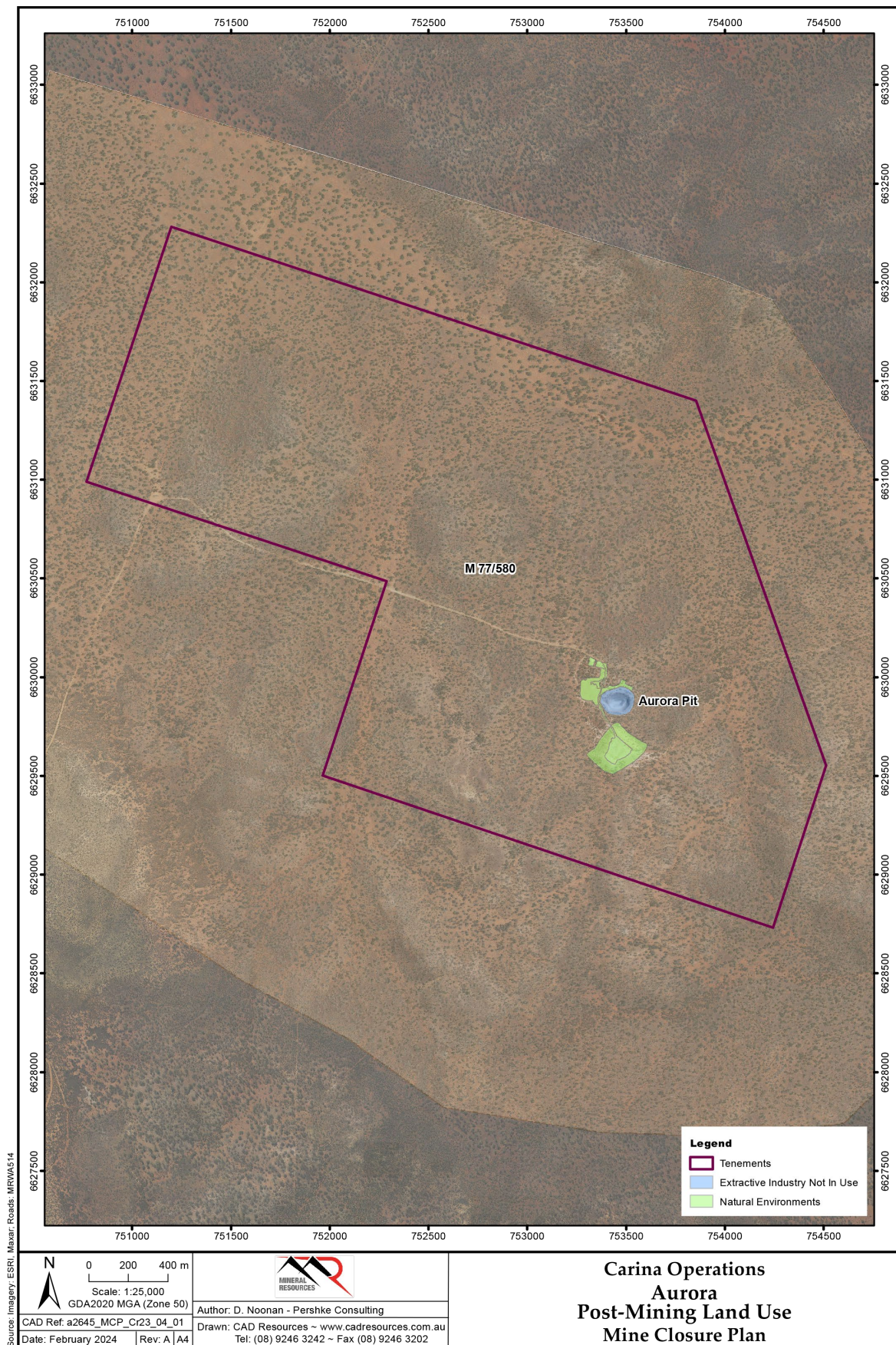
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Figure 88 Post Closure Land Use – Carina Southern Operations



Refer to Appendix J for pdf version

Figure 89 Post Mining Land Use – J4



Refer to Appendix J for pdf version

Figure 90 Post Mining Land Use – Aurora

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7. CLOSURE RISK ASSESSMENT

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes an environmental closure risk assessment (Table 53) that:

- *Identifies all the environmental closure risk pathways*
- *Evaluates these risks to derive an inherent risk rating, prior to the application of treatments*
- *Identifies appropriate risk treatments, using the hierarchy of control*
- *Re-evaluates the risk pathways to derive a residual risk rating*
- *Demonstrates that all residual risks are as low as reasonably practicable (ALARP).*
- *The mine closure plan provides information on the processes and methodologies undertaken to identify the closure risks and their potential environmental impacts post-mining, including a description of the risk assessment criteria and risk evaluation techniques (Section 7.1 and Appendix I).*

7.1 Risk Assessment Approach

A closure risk assessment was conducted for the closure of the Carina Operations in January 2023. The approach taken to the assessment is consistent with the Australian and New Zealand Standard (AS/NZS) for Risk Management (AS/NZS ISO 31000:2018) (Standards Australia, 2018) and summarised below.

In accordance with DEMIRS guidance (DMIRS, 2020b), the risk assessment only considered environmental risks. Risks to the safety of third parties and cultural values were included within this definition. The impacts of there being an insufficient financial provision for closure works has also been included since this would have environmental outcomes.

The risk assessment has been based on information from technical reports reviewed during the preparation of this MCP, and subject matter expert input during a workshop. The closure risk workshop included subject matter experts from mine planning, geotechnical stability, geochemistry, hydrogeology, surface water, heritage, landform design, closure planning, rehabilitation, land access and environmental approvals.

The following key points should be noted in relation to the approach taken to the risk assessment and the definitions of terms used:

- Definition of inherent risk:
 - Given that many areas of the Carina Operations have already been constructed, the inherent risk assessment for these features assumed that the as built landform represents the inherent risk as there is little value in assuming that there are no controls when several controls have already been implemented. Where there is uncertainty regarding the effectiveness of historical controls (e.g., PAF placement practices), the inherent risk rating reflects this.
 - For those areas of the Carina Operations that have not yet been constructed or are not already under rehabilitation, the inherent risk assessment assumed that no controls were in place.
 - In the case where a commitment has been made to backfill a void, but backfill has not yet been implemented, the backfilled void case has still been assessed. The rationale for this approach is that backfilled voids can have environmental consequences and evaluation of this activity allows risks to be identified and controls planned, if required. The inherent risk assumes that no controls are implemented during backfilling.
- Definition of residual risk:

- The residual risk assessment considers the level of risk remaining once all controls outlined in this MCP have been implemented.
- Where landforms have already been constructed / under rehabilitation and there are still uncertainties associated with the effectiveness of controls, or further work is required to formulate effective controls, the residual risk remains the same as the inherent risk until effective controls have been identified.
- **Likelihood:**
 - The risk evaluation assesses the likelihood of a given level of consequences occurring, rather than the likelihood of an initiating event occurring (i.e., the initiating event and the consequences need to occur).
- **Unplanned closure:**
 - Given the maturity of the Carina Operations, unplanned closure has been factored into the causes of key risks that would be affected by this event.
- **Uncertainty:**
 - Where there are uncertainties that require further study to refine closure designs and gain a better understanding of risk, these were identified for inclusion in the forward work program.

The risk matrices used for the closure risk assessment are provided in Appendix I.

7.2 Identification of Key Issues

The closure and rehabilitation risks identified in the environmental risk assessment for the Carina Operations are detailed in Table 53 (which also specifies the forward work program designed to address uncertainties). The risks in Table 53 have been colour coded as follows, based on the risk matrix in Appendix I:

Extreme	High	Medium	Low
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Table 53 provides the following information:

- Column 1 identifies the domain to which the risk is relevant.
- Column 2 identifies the aspect relevant to the risk. In line with the WABSI guidance on completion criteria (Young, et al., 2019), these aspects align with those used in defining completion criteria. The risk assessment helps identify the importance of each criterion.
- Column 3 provides an identification number for each risk which is used in the correlation of risks to completion criteria.
- Column 4 describes the risk.
- Column 5 identifies the potential causes of each risk (i.e., the initiating events) and where relevant the pathway by which a receptor may be impacted. In some cases, some background context is provided to facilitate the identification of possible impacts to receptors (which follows in Column 7).
- Column 6 identifies the site to which each risk applies.
- Column 7 identifies the possible impacts to receptors.
- Columns 8 to 10 provide the inherent risk ranking (see notes in Section 7.1) for definitions used for inherent risk).
- Column 11 summarises the controls and management measures designed to reduce the risk to as low as reasonably practicable.

- Columns 12 to 14 provide the residual risk ranking (i.e., once the controls and management measures outlined in Column 10 have been implemented – also see notes in Section 7.1 for definitions used for residual risk).
- Column 15 outlines the forward work programs identified to reduce uncertainties and refine closure designs.

Various references have been provided within Table 53 to locations within this MCP where further relevant information has been presented.

Table 53 Risk Assessment

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
WRL	Geochemistry	R1	PAF materials within WRLs result in generation of AMD (including Neutral Mine Drainage (NMD)) or saline drainage (SD) that impact receptors. <i>Note this risk only considers the potential for AMD / NMD from oxidation of PAF materials, due to inadequate handling and encapsulation. Post-closure exposure of encapsulated PAF due to erosion and / or landform instability is considered separately in Risks R8 and R28.</i>	Inadequate segregation and handling or encapsulation of PAF materials leads to release of AMD, NMD or saline drainage that impacts the WRL surface and surface water run-off, or results in toe seepage or impacts to groundwater receptors. [Context The vast majority of waste rock at Carina has been assessed as NAF, with only small proportion of PAF material located below water table, Carina (~2%) and Carina Extended (Sections 5.3.3.1.1 and 5.3.3.1.2). Testing has shown that cover materials are low S (mean of Carina WRL surface samples 0.05 %S) or NAF (Carina Extended) and the AMD potential of these materials is limited (Section 5.3.3.2.1 and 5.3.3.2.2). The Carina WRL PAF encapsulation cell is present and meets design. Surface cover of NAF is at minimum 2 m so potential to compromise cover during surface rehabilitation works treatment. (Section 5.9.3.4). Carina Extended WRL cover materials show enrichment of As and Sb (Section 5.3.3.2.2). No direct groundwater pathway to Paleochannels (Section 5.6.2.2.1)]	Carina and Carina Extended	Impacts to regional groundwater quality are expected to be low due to 1) the natural salinity of groundwater; and 2) residual drawdown from below water table voids that remain as pit lakes (Section 5.6.2.2 and Section 5.6.2.3). The most likely impacts would be: - Localised impacts to revegetation from capillary rise of salts / metals associated with oxidation of PAF materials and associated impacts to visual amenity. - Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation.	Medium	Possible	Medium	- Materials characterisation (Section 5.3.3.1.1 and 5.3.3.1.2). - Confirmed encapsulation of PAF waste material in designated PAF cell at Carina (Section 5.9.3.4). - Cover materials of both WRLs have been tested and have been shown to be NAF (Section 5.3.3.2). - Increase cover thickness of Carina PAF encapsulation cell to reduce risk of exposure during final surface rehabilitation / shaping works (Section 9.2.2). - WRL inspection program (Section 10.2.5).	Minor	Unlikely	Low	Develop final design for the Carina WRL informed by surface water run-off control and PAF encapsulation requirements, review of berm capacity modelling results, geochemical and geotechnical characteristics of the surface cover materials and design commitments. (Section 9.2.2).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
WRL	Geochemistry	R2	PAF materials within J4 East WRL result in generation of AMD (including NMD) or saline drainage (SD) that impact receptors. <i>Note this risk only considers the potential for AMD / NMD from oxidation of PAF materials, not from Oxidised Acidic Waste (OAW) (this risk is considered separately below – Risk R5)</i>	Inadequate segregation and handling or encapsulation of PAF materials leads to release of AMD, NMD or saline drainage that impacts the WRL surface and surface water run-off, or results in toe seepage or impacts to groundwater receptors. [Context This risk applies to J4 East WRL only Material movement is largely complete at J4 East WRL. Waste rock at J4 was predominantly NAF with some PAF materials below water table (0.8% of original as-mined volume – both pits) (Section 5.3.3.1.3) Mining was not as deep and originally planned and during operations, no designated PAF cells were deemed to be required (Section 5.3.3.1.3). Testing of WRL cover materials confirms predominantly NAF (Section 5.3.3.2.3). WRL cover samples show some enrichment of As and Sb (Section 5.3.3.2.3). West of J4, groundwater may flow preferentially along strike towards the palaeochannel and then follow the sandy sediments to the southwest. (Section 5.6.2.2.2)].	J4	- Impacts to regional groundwater are expected to be low due to 1) the natural salinity of groundwater, and 2) residual drawdown from the J4 East pit lake post-closure (Section 5.6.2.2 and Section 5.6.2.3). - The most likely impacts would be: - Localised impacts to revegetation from capillary rise of salts associated with oxidation of PAF materials and associated impacts to visual amenity. - Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation. The potential extent of the impact is limited by the as-built status of the WRL with respect to PAF.	Medium	Possible	Medium	- Materials characterisation (Section 5.3.3.1.3). - Cover materials of J4 East WRL have been tested and have been shown to be NAF. - WRL inspection program (Section 10.2.5).	Minor	Possible	Medium	

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
WRL	Geochemistry	R3	PAF materials within J4 West WRL result in generation of AMD (including NMD) or saline drainage (SD) that impact receptors. <i>Note this risk only considers the potential for AMD / NMD from oxidation of PAF materials, not from Oxidised Acidic Waste (OAW) (this risk is considered separately below – Risk R5. Also the risk of PAF material encapsulated in J4 West backfill is considered separately below (Risk R22).</i>	Inadequate segregation and handling or encapsulation of PAF materials leads to release of AMD, NMD or saline drainage that impacts the WRL surface and surface water run-off, or results in toe seepage or impacts to groundwater receptors. [Context This risk applies to J4 West WRL only The J4 West WRL is actively receiving waste from J4 East Pit. Waste rock at J4 was predominantly NAF with some PAF materials below water table (0.8% of original as-mined volume – both pits) (Section 5.3.3.1.3). Mining prior to 2023 was not as deep and originally planned and during operations, no designated PAF cells were deemed to be required (Section 5.3.3.1.3). Testing of WRL cover materials placed prior to 2023 confirms NAF. Some cover samples show enrichment of As and Sb (Section 5.3.3.2.3). J4 redevelopment estimates 7.2% of waste generated will be PAF but is planned to be encapsulated in J4 West Pit backfill) ((Section 5.3.3.1.3). West of J4, groundwater may flow preferentially along strike towards the palaeochannel and then follow the sandy sediments to the southwest. (Section 5.6.2.2.2)]	J4	- Impacts to regional groundwater are expected to be low due to 1) the natural salinity of groundwater, and 2) residual drawdown from the J4 East pit lake post-closure (Section 5.6.2.2.2 and Section 5.6.2.3). - The most likely impacts would be: - Localised impacts to revegetation from capillary rise of salts associated with oxidation of PAF materials and associated impacts to visual amenity. - Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation. - The potential extent of the impact will depend on material placement which is still in progress.	Major	Possible	High	- Materials characterisation (Section 5.3.3.1.3). - Cover materials of existing J4 West WRL have been tested and have been shown to be NAF (Section 5.3.3.2.3). - PAF material from current mining will be encapsulated with NAF in J4 West Pit backfill and J4 West WRL (Section 9.2.2) and managed as outlined in (Section 9.1.3): - Progressive waste characterisation during operations to confirm baseline materials characterisation in accordance with leading practice (DISR & DFAT, 2016) (Section 9.1.3). - Waste placement audits will occur on a quarterly basis and determine if performance criteria have been met. Annual audit of the PAF and dispersive materials (if identified), management procedures, including sampling, placement, bunding, and groundwater monitoring processes. - Materials balance reconciliation to ensure adequate NAF waste rock is identified and segregated. - Groundwater sampling at monitoring bore network around the Project as per Groundwater Operating Strategy (GWOS) and DWER Part V License L8945/2016/2. - WRL inspection program (Section 10.2.5).	Minor	Unlikely	Low	Compliance to approved plan. Confirmation at end of construction (Section 5.9.7).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
WRL	Geochemistry	R4	PAF materials within WRL result in generation of AMD (including NMD) or saline drainage (SD) that impact receptors.	Inadequate segregation and handling or encapsulation of PAF materials leads to release of AMD, NMD or saline drainage that impacts the WRL surface and surface water run-off, or results in toe seepage or impacts to groundwater receptors. [Context Legacy pit was mined above water table and waste rock was therefore expected (but not confirmed) to be NAF (Section 5.3.3.1.4). Materials are dispersive (Section 5.9.3.2.3)]	Aurora	The most likely impacts would be: - Localised impacts to revegetation from capillary rise of salts associated with oxidation of PAF materials and associated impacts to visual amenity. - Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation.	Medium	Unlikely	Medium	Materials characterisation to be completed (Section 5.9.7).	Medium	Rare	Low	Characterisation of waste materials at the Aurora site (Section 5.9.7).
WRL	Geochemistry	R5	Oxidised Acidic Waste (OAW) materials placed on outer layer of WRL result in acidic seepage, salinity on surfaces of the WRL or saline seepage at the toe of the WRL.	- High sulfur materials present in the upper profile of the J4 pits (in the oxidised zone) may contain stored acidity in the form of hydroxy sulfate salts (such as alunite or jarosite), however this has not been confirmed through mineralogical testing. - Released salts may impact the WRL surface or result in saline toe seepage. [Context Recent test pitting complete to 5 m depth detected some OAW with resultant salinity potentially growth limiting (Section 5.3.3.2.3)]	J4	- Impacts to revegetation from salinity which in-turn can impact visual amenity and increase the potential for erosion. - There is also potential for poor quality surface water run-off or toe seepage to impact surrounding vegetation.	Medium	Likely	High	- Materials characterisation (Section 5.3.3.1.3). - All materials with > 0.3% flagged as 'PAF' resulting in encapsulation of OAW > 0.3%S (Section 9.1.3). - Test pitting of as-built WRL completed to confirm location of placed OAW (Section 5.3.3.1.3). - Preliminary desktop review of salinity tolerance of regional species completed to inform species selection (Section 5.9.5.2.). - WRL inspection program (Section 10.2.5).	Minor	Unlikely	Low	- Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable. (Section 5.3.3.8). - Where cover is not practicable, use the characteristics of the substrate materials (and closure objectives) to inform reference ecosystem / species selection for revegetation or supplementary seeding (Section 9.1.4).
WRL	Geochemistry	R6	Fibrous or radioactive waste materials placed on outer layer of WRL restrict post-mining land use.	Failure to identify, segregate and encapsulate waste rock containing fibrous or radioactive materials.	Carina / Carina Extended / J4	- Fibrous or radioactive materials present a risk to human health and access to areas has to be restricted so that PMLU cannot be achieved. - Temporary and / or permanent constraint on traditional cultural activities.	Major	Possible	High	If fibrous materials encountered during operations they are managed in accordance with Dust and Fibrous Materials Management Plan (MinRes, 2023a) (Section 9.1.1).	Major	Unlikely	Medium	- Review of drill assays and testing as required to confirm if fibrous or radioactive minerals are present in the waste rock or mineralised stockpile material. Key units of interest would include the mafic and ultramafic lithologies (Section 5.3.3.8). - Develop sampling plan based on risk assessment outcomes (Section 5.3.3.8).

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WRL	Erosion	R7	Erosion of WRL limits revegetation success and releases sediment to adjacent land.	- Inadequate materials characterisation and placement of erodible / dispersive materials at the surface of the WRL. - Inadequate surface water management controls included in design. - WRL not constructed to design. [Context Carina Extended WRL rated as moderate stability due to revegetation (Section 5.3.4.2). Topsoils have some / generally low propensity for erosion (particularly where surface water control features are insufficient) (Section 5.3.5.2.2). Carina Extended WRL some departures from design but required further assessment (Sections 5.9.3.3.2 and 5.9.6.	Carina Extended	- Erosion impacts on revegetation success and sediment impacts vegetation adjacent to WRL. - Temporary and / or permanent constraint on PMLU and / or traditional cultural activities.	Major	Likely	High	- Materials characterisation to inform landform design / rectification works (Section 5.3.4.2). - Rehabilitation monitoring results inform requirement for erosion / surface rectification works on constructed WRLs (Section 5.9.3.2.1). - Assessment of berm capacity on WRLs completed to inform design & rectification works. Carina specific materials data utilised (Section 5.9.1). - Compliance to design checks on WRLs and Carina WRLs Rehabilitation Cover Design assessment completed 2023 (Section 5.9.3.3.2). - Continued landform-wide erosion monitoring to confirm that erosion is stabilising (Section 10.2.3).	Major	Unlikely	Medium	- Complete more detailed assessment of as-built berm widths. - Review berm capacity modelling results to refine minimum berm capacity / width. - Review surface stability trajectory after two more monitoring periods to inform closure strategy. Revisit this strategy if significant increase in severity of erosion after first year of additional monitoring (Section 5.9.7).

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WRL (PAF encapsulated)	Erosion	R8	Erosion of WRL limits revegetation success, releases sediment or AMD to adjacent land.	- Inadequate materials characterisation and placement of erodible / dispersive materials at the surface of the WRL. - Inadequate surface water management controls included in design. - WRL not constructed to design. - Erosion leads to exposure of PAF encapsulation cell. [Context Carina WRL incorporates PAF encapsulation cell (Section 5.9.3.4) Characterisation shows that Carina waste rock materials have some resistance to erosion (Section 5.3.4.1). Topsoils have some / generally low propensity for erosion (particularly where surface water control features are insufficient) (Section 5.3.5.2.1). Departures from design (Section 5.9.3.3.1). Surface rehabilitation and shaping for surface water control still to be completed on Carina WRL (Section 5.9.3.3.1) No significant flow or velocity, associated with the main PMF floodplain, reaches the WRL (Section 5.6.1.4.1).	Carina	- Erosion impacts on revegetation success and sediment impacts vegetation adjacent to WRL. Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation. - Temporary and / or permanent constraint on PMLU and / or traditional cultural activities.	Major	Likely	High	- Materials characterisation to inform landform design / rectification works (Section 5.3.4.1 and 5.3.5.2.1). - Rehabilitation monitoring results inform requirement for erosion / surface rectification works on constructed WRLs (Section 5.9.3.2.1). - Assessment of berm capacity on WRLs completed to inform design & rectification works. Carina specific materials data utilised (Section 5.9.1). - Compliance to design checks on WRLs completed 2023 (Section 5.9.3.3). - PAF encapsulation cell confirmed > 3 m from outside batter faces (Section 5.9.3.4). - Flood modelling informs erosion protection requirements (Section 5.6.1.4.1). - Implementation of rectification works (Section 5.9.6 and Section 9.2.2). - Development of work packs and construction supervision for reshaping and rehabilitation activities (Section 9.1.1). - Landform-wide erosion monitoring to confirm that erosion is stabilising (Section 10.2.3).	Major	Unlikely	Medium	Develop final design for the Carina WRL informed by surface water run-off control and PAF encapsulation requirements, review of berm capacity modelling results, geochemical and geotechnical characteristics of the surface cover materials, flood modelling and design commitments (Section 5.9.7).

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WRL	Erosion	R9	Erosion of WRL limits revegetation success and releases sediment to adjacent land.	- Inadequate materials characterisation and placement of erodible / dispersive materials at the surface of the WRL. - Inadequate surface water management controls included in design of WRLs. - WRL is not constructed to design. [Context Multiple batters (yet to be rehabilitated) currently identified as low stability (Section 5.3.4.3). Assessment of existing stockpiled topsoil materials identified no limitations, provided surface water controlled (Section 5.3.5.2.3). Active erosion observed on WRL slopes where topsoil has been applied is attributed to lack of contour ripping and concentrated surface water flows (Section 5.9.3.2.2). Flood risks at J4 WRLs negligible due to position on ridge (>25 m higher than nearest streamline) (Section 5.6.1.4.2). J4 East WRL not constructed to design. J4 West WRL under active construction. Plateau rehabilitation / surface water control still to be completed on J4 East WRL (Section 5.9.3.3.3 and Section 5.9.3.3.4).	J4	- Erosion impacts on revegetation success and vegetation adjacent to WRLs. - Temporary and / or permanent constraint on PMLU and / or traditional cultural activities.	Major	Likely	High	- Materials characterisation to inform landform design (Section 5.3.4.3). - Rehabilitation monitoring results inform requirement for erosion / surface rectification works on constructed WRLs (Section 5.9.3.2). - Assessment of berm capacity on WRLs completed to inform design & rectification works (Section 5.9.1). - Compliance to design checks on WRL completed (Section 5.9.3.3). - J4 West WRL rectification works to meet design criteria submitted in J4 East redevelopment Mining Proposal (Section 9.2.2.4 and Section 9.2.1.4). - Development of work packs and construction supervision for reshaping and rehabilitation activities (Section 9.1.1). - Landform-wide erosion monitoring to confirm that erosion is stabilising (Section 10.2.3).	Major	Unlikely	Medium	- Address knowledge gaps to finalise the preliminary landform rectification plan for the J4 East WRL: - Assess interaction of the WRL with the ZOI of the final J4 East pit shell to inform final closure design. - Re-assess cover materials mapped as 'low stability' to determine whether one or a combination of treatments: ripping, surface water controls or armouring, should be incorporated into the final landform design (Sections 5.9.7 and 9.2.2.4). - Rectify design non-compliances at the J4 West WRL as part of the expansion of the J4 East Pit to achieve the design parameters provided in the J4 East Redevelopment MP (Sections 5.9.7 and 9.2.2.5).

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WRL	Erosion	R10	Erosion of WRL limits revegetation success and releases sediment to adjacent land.	- Inadequate materials characterisation and placement of erodible / dispersive materials at the surface of the WRL. - Inadequate surface water management controls included in design of WRL. - WRL is not constructed to design. [Context Significant erosion has developed due to pooling and uncontrolled run-off from the surface of the WRL (Section 5.9.3.2.3). Aurora tenement surrounded by Conservation Park proposed as future National Park (Section 2.3.2.3). PMF flood assessment indicates no erosion protection required for WRL. But recommends that surface water run-off controls are implemented in the WRL closure design (Section 5.6.1.4.3)]	Aurora	- Erosion impacts on revegetation success and vegetation adjacent to WRL. - Potential for increased sediment load to surface waters.	Major	Almost certain	Extreme	- Materials characterisation to inform landform design (Section 5.9.7). - Flood modelling completed to inform erosion protection requirements (Section 5.6.1.4.3). - WRL rectification plan to incorporate surface water run-off controls (Section 9.2.2.6 and Section 9.2.2). - Development of work packs and construction supervision for reshaping and rehabilitation activities (Section 9.1.1).	Major	Unlikely	Medium	- Material characterisation to inform this design. (Sections 5.3.4.6 and 5.9.7). - Develop and implement Aurora WRL rectification plan to control surface water run-off (Section 5.9.7 and 9.2.2.6). - Implement design subject to the necessary approvals (Section 5.6.1.6 and 9.2.2).
All except WRLs & Mine Voids	Erosion	R11	Final landforms (excluding WRLs & associated access ramps covered in <i>Risks R7 to R10</i>) erode or have poor drainage post-closure.	- Drainage requirements have not been factored into the final land profile. - Competent material or other erosion protection measure not placed in areas prone to erosion. - Flooding modelling has not adequately considered infrastructure agreed to be retained at closure, e.g., roads.	All	- Erosion impacts on revegetation success and adjacent vegetation. - Potential for increased sediment load to surface waters.	Major	Possible	High	- Land surface is re-profiled to accommodate drainage and erosion protection is provided as required (Section 9.1.2). - Flood modelling informs landform design and erosion protection requirements (Section 9.1.2).	Major	Unlikely	Medium	Complete flood modelling, hydraulic modelling and materials characterisation necessary to inform final landform design for the Infrastructure / General Disturbance domain (Section 5.6.1.6 and Section 9.1.2).
All areas to be rehabilitated	Growth medium	R12	Insufficient or unsuitable growth media results in poor vegetation outcomes	- Inadequate topsoil salvage and / or poor handling and storage results in growth media of insufficient quantity or quality. - Variable topsoil handling practices over time (including potential impacts from saline water used for dust suppression) and length of topsoil storage in historic areas reduces usability of stockpiled topsoil. - No topsoil reconciliation. - Alternate growth media are not identified in the event of a topsoil deficit.	All	- Potential impacts to re-vegetation outcomes and associated impacts to visual amenity. - Increased potential for erosion. Inability to meet post-mining land use.	Major	Almost certain	Extreme	- Stockpiled topsoil reconciliation and quality assessment (Section 5.3.5.3). - Investigation of alternate growth media (Section 5.3.5.5). - In yet to be disturbed areas: Baseline soil studies pre-determine depth of topsoil and subsoil available for stripping (Section 5.3.5). - Topsoil handling and storage incorporated in mine planning (Section 9.1.4).	Major	Likely	High	- Salvage topsoil prior to WRL rectification works (Section 5.3.5.5). - Refine topsoil balance to account for topsoil stockpiled on WRLs, stockpiles at Carina Southern Operations and J4 East topsoil salvage (Section 5.3.5.5). - Investigate alternative growth media where a topsoil deficit remains (Section 5.3.5.5). - Undertake additional soil characterisation to further refine soil conditions in reference sites (Section 5.3.5.5).

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WRL	Vegetation	R13	Rehabilitation practices do not meet ecological completion criteria <i>Note this risk excludes risks associated with AMD / erosion that impact the establishment of vegetation (see Risks R1 – R5 and Risks R7 – R11)</i> <i>This risk is specific to revegetation of WRLs. All other areas to be rehabilitated have been assessed separately (see Risk R14).</i>	- Ineffective surface treatment fails to create suitable substrate for plant establishment and growth (e.g., water holding capacity, salinity, underlying waste rock is detrimental to plant establishment and persistence). - Seed of insufficient quantity or quality is collected and / or applied. Inadequate understanding of seed treatment and plant establishment requirements. - Reference ecosystems not appropriate for WRL landform characteristics. - Reference ecosystems (and associated fauna habitat) fail to re-establish due to inappropriate seed mix, poor or variable seed germination, weed competition or failure of seedlings to persist. - Vegetation not resilient to stressors such as fire, drought, feral animals, anthropogenic disturbances or climate change.	All	- Rehabilitated areas do not support self-sustaining ecological communities. - Impacts to ecological value of rehabilitated areas. - Rehabilitation does not support post-closure land use. - Reduced visual amenity. - Spread of invasive weeds. - Delayed return by fauna due to lack of habitat. - Wind or water erosion of bare areas impacts on downstream surface water and / or vegetation quality.	Major	Almost certain	Extreme	- Implement Land Rehabilitation Procedure (MRL-EN-PRO-0009_00). - Implement Weed Hygiene and Control Procedure (MRL-EN-PRO-0007_00). - Progressive rehabilitation and monitoring. - Reference ecosystems developed from baseline flora and vegetation work, with consideration to post-closure landscapes, hydrology, soil conditions, fauna habitat values and PMLU. - Seed mixes developed from the reference ecosystem. - Use of local provenance species and seed. - Program timing of seed collection to maximise seed viability. - Program timing of seed dispersion to coincide with favourable climate conditions. - Seed bank with commercial provider. - Database of species and volume of seed in storage. - Conduct research, if required, into seed management practices for difficult to establish species. - Rehabilitation trials (Carina) inform surface treatments / ameliorants (Section 5.9.2). - Landform scale rehabilitation monitoring and implementation of corrective actions, where required, until completion criteria achieved (Section 10.2.1). - Feral animal management where required (Section 9.1.6 and 10.2.6). - If stressors occur prior to the vegetation developing and demonstrating resilience factors (e.g., soil seedbank and / or plant recruitment has been demonstrated) remedial seeding or planting will be undertaken (Section 317).	Major	Possible	High	- Use landscape-scale rehabilitation monitoring data to develop completion criteria appropriate to the various post-mining landforms and PMLU (Section 8.2.1). - Consult with stakeholders regarding the PMLU (Section 4.1.3). - Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable (Section 5.9.7). - Refine reference ecosystem (s) and species mix for WRLs with consideration to the properties of the growth substrate achieved and the PMLU. (Sections 5.5.4 and 5.9.5.2.). - Review potential application of Carina rehabilitation trial findings to other WRLs (Sections 5.9.7 and 9.1.4). - Determine if there is a practicable method of applying timber debris to rehabilitation surfaces that will achieve, but not exceed, the target cover level (10 – 20%) and not enhance erosion (Sections 5.9.7 and 9.1.4)..

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All areas to be rehabilitated	Vegetation	R14	Rehabilitation practices do not meet ecological completion criteria <i>Note this risk excludes risks associated with salinity and erosion that impact the establishment of vegetation (see Risks R1 – R5 and Risks R7 – R11). Also this risk does not apply to WRLs that are considered separately (Risk R13).</i>	- Ineffective surface treatment fails to create suitable substrate for plant establishment and growth (e.g., compaction, water holding capacity, salinity). - Seed of insufficient quantity or quality is collected and / or applied. - Inadequate understanding of seed treatment and plant establishment requirements. - Reference ecosystem (and associated fauna habitat) fail to re-establish due to inappropriate seed mix, poor or variable seed germination, weed competition or failure of seedlings to persist. - Vegetation not resilient to stressors such as fire, drought, feral animals, anthropogenic disturbances.	All	- Rehabilitated areas do not support self-sustaining ecological communities. - Impacts to ecological value of rehabilitated areas. - Rehabilitation does not support post-closure land use. - Reduced visual amenity. - Spread of invasive weeds. - Delayed return by fauna due to lack of habitat. - Wind or water erosion of bare areas impacts on downstream surface water and / or vegetation quality.	Major	Almost certain	Extreme	- Implement MRL Land Rehabilitation Procedure (MRL-EN-PRO- 0009_00). - Implement MRL Weed Hygiene and Control Procedure (MRL-EN-PRO-0007_00). - Progressive rehabilitation and monitoring (Section 10.2). - Reference ecosystem developed from baseline flora and vegetation work, with consideration to post-closure landscapes, hydrology, soil conditions, fauna habitat values and PMLU. - Seed mixes developed from the reference ecosystem. - Use of local provenance species and seed. - Program timing of seed collection to maximise seed viability. - Program timing of seed dispersion to coincide with favourable climate conditions. - Seed bank with commercial provider. - Database of species and volume of seed in storage. - Conduct research, if required, into seed management practices for difficult to establish species. - Landform scale rehabilitation monitoring and implementation of corrective actions, where required, until completion criteria achieved (Section 10.2.1). - Feral animal management as required (Section 9.1.6 and 10.2.6). - If stressors occur prior to the vegetation developing and demonstrating resilience factors (e.g., soil seedbank and / or plant recruitment has been demonstrated) remedial seeding or planting will be undertaken (Section 10.2.1.3).	Major	Possible	High	- Use landscape-scale rehabilitation monitoring data to develop completion criteria appropriate to the various post-mining landforms and PMLU (Section 8.2.1). - Consult with stakeholders regarding PMLU (Section 4.1.3).

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All	Vegetation	R15	Introduce detrimental <i>Phytophthora</i> species through rehabilitation and closure activities.	- Movement of topsoil and other growth media between sites. - Trafficking across infected areas for closure implementation, monitoring and maintenance.	All	- Potential impacts to re-vegetation outcomes and associated impacts to visual amenity. - Impacts on biodiversity.	Severe	Possible	High	- Mapping and identification of <i>Phytophthora</i> species to inform development of management strategies for the Carina Operations areas (Section 5.5.1.5). - Application of developed <i>Phytophthora</i> management strategies to closure activities.	Severe	Unlikely	High	Apply <i>Phytophthora</i> management plans developed for the Carina Operations areas to closure activities as relevant (Sections 5.5.4 and 9.1.6).
All except residual voids	Vegetation	R16	Weed density levels in revegetation do not meet Completion Criteria or, new weed species present and persist.	Failure of weed hygiene practices or failure to implement weed hygiene procedures. [Context: Very low weed presence prior to mining].	All	- Impacts on biodiversity. - Impacts to post-mining land use.	Major	Likely	High	- Measures to maximise revegetation success (<i>see Risks R12, R13 and R14</i>) to minimise weed establishment. - Implement MRL Weed Hygiene and Control Procedure (MRL-EN-PRO-0007_00) (Section 9.1.6 and 10.2.2). - Monitoring including aerial survey (Section 10.2.2)	Major	Unlikely	Medium	Investigate additional weed monitoring methods, such as aerial survey techniques, to maximise effectiveness of weed control efforts. (Section 10.2.2).
All	Operational contamination	R17	Contamination caused during operations has not been identified and remediated during operations or closure implementation phases	Contamination (e.g., from leaks and spills of chemicals and hydrocarbons, WWTP, landfill) is not identified for remediation during operations or closure implementation phase.	All	Potential impacts to soils, surface water, ecological receptors and post-mining land use.	Medium	Almost certain	High	- Compliance with (Section 9.1.7: Management and closure of the landfill as per the Site Operating Licence (Part V). - Implement Hydrocarbon and Chemical Procedure (MRL-EN-PRO-0002_01). - INX Software system in place to capture potentially contaminating incidents. - Decommissioning plans include requirement to make underground infrastructure safe / non-polluting (Section 9.2.4.3). - Preliminary site investigations (including review of history, photographs, government records, meetings with people with historical knowledge of the site) (Section 5.7). - Detailed site investigations (Section 5.7). - Remediation action plans, if required (Section 9.1.7). - Validation sampling (Section 9.1.7).	Minor	Unlikely	Low	- A Sampling and Analysis Quality Plan (SAQP) will be prepared to guide a Detailed Site Investigation (DSI) (Section 5.7.3). - Development of remediation action plans as required as part of closure execution planning (Section 9.1.7). - Communication with relevant stakeholders to determine applicable validation criteria (Section 5.7.3).

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Mine Voids (mined BWT)	Groundwater	R18	Planned pit lakes (sinks) result in drawdown of groundwater levels that impacts receptor (s).	Pit lakes act as sinks resulting in residual drawdown of groundwater that impacts receptors. [Context: Modelled residual drawdown extends radially several kilometres but significant distance from palaeochannels (Section 5.6.2.3). Low transmissivity bedrocks likely limit the amount of connectivity between the Carina Pits with the palaeochannel and salt lakes / palaeochannels (Section 5.6.2.2.1)]	Carina and Carina Extended	- The main potential receptors to groundwater at Carina are the salt lake systems. The nearest salt lake (BoM, 2024d) is > 25 km from Carina / Carina Extended. - Predicted drawdown does not intersect the known salt lakes (Section 5.6.2.3).	Medium	Unlikely	Medium	- Groundwater modelling completed to predict extent of residual drawdown (Section 5.6.2.3). - Modelling considered lower bound (low recharge / dry climate scenario) and upper bound (higher recharge/ wet climate scenario) scenarios (Section 5.6.2.3). - Monitoring for the period necessary to enable calibration and validation of groundwater and pit lake models (Section 10.2.4).	Minor	Unlikely	Low	- Develop groundwater and pit lake monitoring program and implement for the period necessary to validate groundwater and pit lake models, to provide confidence that the systems are functioning as expected (Sections 5.6.4 and 10.2.4). - Confirm the nature and status of the potential aquatic GDE that appears on the GDE Atlas (BoM, 2024d), north east of the Carina Operations (Section 5.5.4).
Mine Voids (mined BWT)	Groundwater	R19	Planned or unplanned pit lakes (sinks) result in drawdown of groundwater levels that impacts receptor (s).	- J4 Pit lake act as sinks resulting in residual drawdown that impacts receptors. - Unplanned pit lake at J4 West (e.g., due to premature closure) would result in cumulative sink increasing the residual drawdown impact. [Context Modelled residual drawdown extends radially several kilometres but does not intersect the palaeochannel (Section 5.6.2.3). Modelling completed prior to planned backfill of J4 West Pit represents unplanned closure situation. Modelled residual drawdown extended further than backfill scenario but did not intersect palaeochannel (Section 5.6.2.3)].	J4	- The main potential receptors to groundwater at J4 are the salt lake systems. The nearest salt lake is > 25 km from J4. - Predicted drawdown (including unplanned pit lake at J4 West) does not intersect the salt lakes or palaeochannels (Section 5.6.2.3).	Minor	Possible	Medium	- Groundwater modelling completed to predict extent of residual drawdown (Section 5.6.2.3). - Modelling considered lower bound (low recharge / dry climate scenario) and upper bound (higher recharge/ wet climate scenario) scenarios (Section 5.6.2.3). - Monitoring for the period necessary to enable calibration and validation of groundwater and pit lake models (Section 10.2.4).	Minor	Unlikely	Low	Develop groundwater and pit lake monitoring program and implement for the period necessary to validate groundwater and pit lake models. to provide confidence that the systems are functioning as expected (Sections 5.6.4 and 10.2.4).

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Mine Voids (mined BWT)	Groundwater	R20	Planned pit lakes become temporary throughflow systems with potential to impact on water quality at receptors	- Temporary throughflow releases water with elevated solutes (from evapo-concentration of solutes contained in groundwater, and potentially from pit wall exposures at Carina Pit and / or backfill materials present in portion of Carina Pit) down gradient. - Groundwater model / pit lake modelling inaccurate and pit lakes do not behave as sinks. - Extreme rainfall event or surface water flooding event raises pit lake level above surrounding groundwater table level. [Context A 1 in 2000 AEP and PMF at Carina is predicted to reach the SE end of the abandonment bund at a flood depth of 0.1 – 0.3 m. A PMF impacts similar area of abandonment bund (Section 5.6.1.4.1). Some PAF will remain exposed in Carina pit walls after pit lake level equilibrates (Section 5.3.3.4.1). A portion of the Carina Pit contains backfill (Section 5.3.3.5.1). Carina Extended Pit is not in 1:2000 AEP or PMF floodplain (Section 5.6.1.4.1). Carina Extended may become a through-flow system with flow towards the Carina pit lake (Section 5.6.2.3.2). Initial review concludes no density driven flow expected from Carina Pit(Section 5.6.2.3.2).]	Carina and Carina Extended	- Receptors for contaminants would be the downgradient playa lakes of the Yilgarn, which act as local and sub-catchment scale groundwater sinks associated with the Yilgarn Palaeodrainage. The nearest salt lake is > 25 km from Carina / Carina Extended. - Throughflow from the Carina Extended Pit would be captured in the Carina Pit. - If heavy rainfall or flooding turned the pit lakes into a recharge source, the effect would be temporary and contaminant migration would eventually be recaptured by the pit lakes. NB 1:2, 000 year 72-hour rainfall event would increase pit lake elevation by 5 – 9 m) - If contaminants did temporarily enter the groundwater environment they would migrate slowly (as groundwater flow is characterised by low velocities of particulates), mixing with groundwater in storage and rainfall recharge, which would promote dilution.	Medium	Unlikely	Medium	- Hydrological and hydrochemical modelling to predict behaviour of pit lakes. - Numerical modelling considered lower bound (low recharge / dry climate scenario) and upper bound (higher recharge/ wet climate scenario) scenarios. - Monitoring for the period necessary to enable calibration and validation of groundwater and pit lake models (Section 5.6.2.3.2). - Flood modelling to inform requirement for surface water controls necessary to prevent floodwaters resulting from an extreme rainfall event post-closure entering Carina Pit (Section 5.6.1.4.1).	Minor	Unlikely	Low	- Develop groundwater and pit lake monitoring program and implement for the period necessary to validate groundwater and pit lake models, to provide confidence that the systems are functioning as expected (Sections 5.6.4 and 10.2.4). - Undertake a gap analysis to determine the need for further testing / modelling (Section 5.6.4). - Develop geotechnical and construction specifications for the recommended flood bund for the Carina Pit (Sections 5.6.1.4.1 & 9.2.1.2.1).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
Mine Voids (mined BWT)	Groundwater	R21	Planned or unplanned pit lakes become temporary throughflow systems with potential to impact on water quality at receptors	- Temporary throughflow releases water with elevated solutes (from pit lake evapo-concentration of solutes contained in groundwater or inputs from pit wall exposures or from J4 West backfill) down gradient. - Groundwater model / pit lake modelling inaccurate and pit lakes do not behave as sinks. - Extreme rainfall event or surface water flooding event raises pit lake level above surrounding groundwater table level. [Context: No potential for flooding to enter pits at J4 (Section 5.6.1.4.2). Initial review concludes no density driven flow expected from J4 East pit (Section 5.6.2.3.2). Contaminants released from the J4 West pit backfill would be captured in the J4 East Pit Lake (Section 5.6.2.3.2)]	J4	- Receptors for contaminants would be the downgradient playa lakes of the Yilgarn, which act as local and sub-catchment scale groundwater sinks associated with the Yilgarn Palaeodrainage. The nearest salt lake is > 25 km from J4. - If heavy rainfall turned the pit lakes into a recharge source, the effect would be temporary and contaminant migration would eventually be recaptured by the pit lakes. NB 1:2, 000 year 72-hour rainfall event would increase pit lake elevation by 5 – 6 m) - If contaminants from J4 East pit lake did temporarily enter the groundwater environment they would migrate slowly (as groundwater flow is characterised by low velocities of particulates), mixing with groundwater in storage and rainfall recharge, which would promote dilution.	Medium	Rare	Low	- Hydrological and hydrochemical modelling to predict behaviour of pit lakes. - Numerical modelling considered lower bound (low recharge / dry climate scenario) and upper bound (higher recharge/ wet climate scenario) scenarios (Section 5.6.2.3.2). - Monitoring for the period necessary to enable calibration and validation of groundwater and pit lake models (Section 5.6.2.3.2).	Minor	Rare	Low	- Develop groundwater and pit lake monitoring program and implement for the period necessary to validate groundwater and pit lake models, to provide confidence that the systems are functioning as expected (Sections 5.6.4 and 10.2.4). - Undertake a gap analysis to determine the need for further testing / modelling (Section 5.6.4).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
Mine Voids (mined BWT)	Groundwater	R22	Backfilled pit impacts water quality at receptors.	PAF within backfill material oxidises and releases AMD when groundwater levels recover and throughflow system re-establishes, or NMD is released from saturated backfill. [Context J4 West Pit is being backfilled with waste from J4 East Pit. Waste rock at J4 was predominantly NAF with some PAF materials below water table (0.8% of original as-mined volume – both pits). J4 redevelopment estimates 7.2% of waste generated will be PAF (Section 5.3.3.1.3). PAF is being encapsulated above the water table. Infiltration is limited due to highly evaporative environment (Section 5.3.3.5.2). Prior to mining, groundwater from J4 West area may flow preferentially along strike towards the palaeochannel and then follow the sandy sediments to the southwest. Expected that post-closure drainage from J4 West would be predominantly towards the J4 East pit lake sink (Section 5.6.2.2.2).]	J4	- The majority of materials mined from the J4 East and J4 West pits have low S content and present a low risk of acid generation. - Impacts to regional groundwater are expected to be low due to 1) the natural salinity of groundwater, and 2) residual drawdown from the J4 East pit lake post-closure. - Any solutes that are released from J4 West Pit would be expected to be captured within the drawdown footprint of J4 East pit.	Insignificant	Likely	Medium	- Waste characterisation (Section 5.3.3). - Groundwater modelling (Section 5.6.2.3). - PAF encapsulation within J4 West pit above water table (Section 5.3.3.5.2) and: - Progressive waste characterisation during operations to confirm baseline materials characterisation in accordance with leading practice (DISR & DFAT, 2016). - Waste placement audits will occur on a quarterly basis and determine if performance criteria have been met. - Annual audit of the PAF and dispersive materials (if identified) management procedures, including sampling, placement, bunding, and groundwater monitoring processes. - Materials balance reconciliation to ensure adequate NAF waste rock is identified and segregated. - Groundwater sampling at monitoring bore network around the Project as per GWOS and DWER Part V License L8945/2016/2 (Section 10.2.4). - In the event of unplanned closure, encapsulation of any exposed PAF in backfill would be undertaken (Section 9.4).	Insignificant	Unlikely	Low	Compliance to approved plan. Confirmation at end of construction (Section 5.9.7).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
All	Surface water	R23	Final landforms interrupt surface water flows. <i>Risk excludes haul route which is discussed in Risk R27.</i> <i>Not applicable to Carina Extended and J4 WRLs which have been assessed to have negligible flood risk.</i>	- Flooding during extreme rainfall events post-closure is captured by Carina Pit. - Carina WRL extends into flood plain. - Infrastructure (including abandonment bunds, retained roads (excluding the haul road) impact run-off. [Context Modelling shows that the 1 in 2,000 AEP and PMF flood plain is within proximity of the Carina Pit and the flood depth against the abandonment bund would be 0.1 – 0.3 m in a 1 in 2000 AEP event and higher in PMF (Section 5.6.1.4.1).]	Carina	Reduced surface water flow impacts downstream vegetation, or impounded water impacts vegetation upstream.	Minor	Possible	Medium	- Hydraulic modelling and flood analysis to inform surface water controls including requirement for flood protection bund (Sections 5.6.1.4.1). - Modelling considers 1:2000 AEP and PMF events (Section 5.6.1.4.1).	Insignificant	Possible	Low	Develop geotechnical and construction specifications for the recommended flood bund for the Carina Pit (Sections 5.6.1.4.1 & 9.2.1.2.1).
All	Surface water	R24	Final landforms interrupt surface water flows. <i>Risk excludes haul route which is discussed in Risk R27.</i> <i>Not applicable to Carina Extended and J4 WRLs which have been assessed to have negligible flood risk.</i>	Infrastructure (including abandonment bunds, retained roads) impacts run-off. [Context The proposed abandonment bund is sufficiently sized to prevent both 1 in 2,000 AEP and PMF events floodwaters from overtopping into the pit void. (Section 5.6.1.4.3).]	Aurora	Reduced surface water flow impacts downstream vegetation.	Minor	Possible	Medium	Hydraulic modelling and flood analysis informs landform design (Sections 5.6.1.4.3).	Insignificant	Possible	Low	Finalise design for Aurora Pit abandonment bund, informed by hydraulic modelling results (Section 9.2.1.1).
Mine Voids (mined BWT)	Surface water	R25	Flooding causes pit lakes to overflow.	Pit located in surface water catchment intercepts surface water run-off and floods during high rainfall events to the point of overflow. [Context Modelling shows that the 1 in 2,000 AEP & PMF flood plains are within proximity of the Carina Pit (Section 5.6.1.4.1) and the flood depth against the abandonment bund would be 0.1 – 0.3 m in a 1 in 2,000 AEP event (Section 5.6.1.4.1)]	Carina	Pit lakes overtop and release diluted but potentially poorer quality water to downstream lands, vegetation and ultimately playa lake systems.	Minor	Possible	Medium	- Hydraulic modelling and flood analysis (Sections 5.6.1.4.1). - Surface water management controls will be implemented at Carina Pit (including flood protection bund incorporated into portion of abandonment bund (Section 5.6.1.6).	Minor	Rare	Low	Develop geotechnical and construction specifications for the recommended flood bund for the Carina Pit (Sections 5.6.1.4.1 & 9.2.1.2.1).
Mine Voids (mined AWT)	Surface water	R26	Flooding causes pit to fill and overflow.	Pit located in surface water catchment intercepts surface water run-off and floods during high rainfall events to the point of overflow. [Context Initial modelling shows that the Aurora pit is within the 1: 2000 and PMF flood plains (Section 5.6.1.4.3).]	Aurora	Pit lakes overtop and release potentially poor quality water to downstream lands, vegetation and ultimately playa lake systems.	Minor	Unlikely	Low	- Hydraulic modelling and flood analysis (Section 5.6.1.4.3). - Abandonment bund will reduce inflow to the pit (Section 5.6.1.4.3).	Minor	Unlikely	Low	- Characterisation of waste materials at the Aurora site to inform landform designs. (Section 5.3.4.6). - Finalise design for Aurora Pit abandonment bund, informed by hydraulic modelling results (Section 9.2.1.1).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
Haul route	Surface water	R27	Post-closure landform (haul roads and access roads) disrupt surface water flows post-closure.	- Haul road and access road closure designs include inadequate surface water controls. Haul road closure not in accordance with design. - Inadequate maintenance of operational surface water controls by third party if ownership is transferred post-closure. Infrastructure (including creek crossings etc.) are in poor condition when ownership of road is transferred post-closure.	Haul Road	- Reduced surface flows to downstream receptors (vegetation). - Erosion, caused by altered surface water flows, impacts land and vegetation.	Minor	Likely	Medium	- Hydraulic modelling and flood analysis (Section 5.6.1.6). - If not transferred to third party, remove the haul road and access roads and rehabilitate to allow appropriate drainage (Section 9.2.4). - Post-closure maintenance requirements will be formally transferred to a third party as part of the transfer agreement (Section 9.2.4).	Minor	Unlikely	Low	- Consult with third parties regarding the requirement for the haul road post-closure (Section 9.2.4). - Develop decommissioning / closure plans based on whether roads will be removed or retained / modified / transferred to a third party (Section 9.2.4). - Where required, based on topography, hydraulic modelling informs landform design where roads are removed (Section 9.1.2).
WRL	Geotechnical stability	R28	Slope failure of WRL impacts on revegetation success (PMLU) and / or surrounding land. <i>This risk does not consider safety impacts see Risk R37.</i>	- WRL not constructed in accordance with design for geotechnical stability and surface water controls. - Flooding destabilises the toe of landforms. Slope failure exposes encapsulated PAF. [Context: Carina and Carina Extended WRLs are currently outside the predicted ZOI of pit wall (Section 5.4.2.1). No significant flow or velocity, associated with the main PMF floodplain, reaches the WRL (Section 5.6.1.4.1). Carina WRL includes PAF encapsulation cell (Section 5.9.3.4)]	Carina and Carina Extended	- Impacts to revegetation on failed area leading to associated impact to visual amenity. - Failure of external WRL faces could impact on adjacent vegetation. - Potential for poor quality surface water run-off and / or toe seepage which impacts on surrounding vegetation.	Medium	Unlikely	Medium	- Hydraulic modelling and flood analysis (Section 5.6.1.4.1). - Geotechnical assessments to assess landform stability (Section 5.4.2).	Insignificant	Rare	Low	Global geotechnical stability assessment to verify that WRLs meet FOS requirements (Section 5.4.4).
WRL	Geotechnical stability	R29	Slope failure of WRL impacts on revegetation success (PMLU) and / or surrounding land. <i>This risk does not consider safety impacts see Risk R37.</i>	WRL not constructed in accordance with design for geotechnical stability and surface water controls. [Context: Flood risk negligible for J4 (Section 5.6.1.4). ZOI not applicable to J4 West WRL provided J4 West backfill completed as planned (5.4.2.1).]	J4	- Impacts to revegetation on failed area leading to associated impact to visual amenity. - Failure of external WRL faces could impact on adjacent vegetation.	Severe	Likely	Extreme	- Geotechnical assessments to inform landform stability (Section 5.4.2). - The preliminary ZOI will continue to be assessed as mining progresses. The Pit and WRL designs will be modified as required to ensure that permanent infrastructure (including WRLs, abandonment bunds, etc.) is located outside of the final ZOI (REG ID 117948) (Section 5.4.4).	Insignificant	Rare	Low	- Global geotechnical stability assessment to determine if WRLs meet FOS requirements (Section 5.4.4). - Utilise post-mining ZOI assessment of J4 Pit to inform abandonment bund location and any requirement for remedial works on the J4 East WRL (Section 5.4.4).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
Mine Voids	Geotechnical stability	R30	Pit wall failure impacts on heritage site. <i>This risk does not consider safety impacts see Risk R37.</i>	- Heritage site located within the ZOI of J4 West Pit. - Unplanned closure interrupts backfill of J4 West Pit.	J4	Pit wall failure impacts on adjacent heritage site.	Severe	Likely	Extreme	- Geotechnical assessments to refine understanding of pit wall stability and potential impact on heritage site (Section 5.4.3). - If geotechnical assessment demonstrates long-term instability, in the event of unplanned closure sufficient backfill will be undertaken to buttress the J4 West pit wall.	Severe	Rare	Medium	Geotechnical assessment of J4 West pit stability in vicinity of known heritage site (Section 5.8.1 and 9.4.3).
WRL	Visual amenity	R31	Landform designs negatively impact visual amenity. <i>Note other visual amenity concerns are addressed in:</i> <i>Risks R1 – R5 – Failure to manage PAF materials</i> <i>Risks R12 to R15 – Revegetation failure</i> <i>Risks R28 and R29 – WRL slope failure</i> <i>Risk R36 – Cultural Values</i> <i>Risk R42 – PMLU</i>	- Height of final landforms exceeds design levels and causes visual amenity impact. [Context: Design levels for WRLs lower than natural high points in the area. Assessments of as built landforms against design levels have identified that (Section 5.9.3.3): - Carina WRL within design height. - Carina Extended WRL within design height. - J4 East WRL exceeds 30 m design height. - J4 West WRL exceeds 30 m design height. - Aurora WRL significantly < design height. - Aurora is only site visible from public view point (Section 5.2.2).	All	- Visual impacts to local stakeholders. - Impact on cultural values.	Minor	Possible	Medium	- Heights of landforms have been designed to blend with surrounding ridges (Sections 5.2.2 and Section 5.9.3.3). - Compliance to design checks of constructed WRLs completed (Section 5.9.3.3). - Minor (< 5 m) departures from design height not expected to cause visual impacts. - Aurora is the only site visible from public viewpoints.	Insignificant	Possible	Low	

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
All	Vegetation	R32	Change to disturbance footprint to accommodate closure designs exceeds allowable vegetation disturbance impacts.	- Vegetation disturbance conditions (MS 852) not considered in closure designs. - Failure to adequately protect conservation significant vegetation community W22 during closure execution results in exceedance of approved disturbance. [Context: As-built WRL slope angles compliant with design (i.e., requiring no rectification that would require further clearing) (Section 5.9.3.3). Potential minimal clearing requirement associated with Carina abandonment bund rectification – if further assessment confirms within ZOI (Section 5.4.2.1).]	Carina and Carina Extended	- Impacts to biodiversity values. - Loss of habitat.	Medium	Possible	Medium	- Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001) (Section 9.1.6). - Vegetation community with disturbance limits have been identified and mapped (Section 5.5.1.1). - Obligations register developed to capture commitments for exclusion / protection (Section 3). - Exclusion / protection areas mapped within MinRes GIS database and available to planners / designers (Section 9.1.6). - Exclusion requirements are factored into closure designs. - Compliance with landform designs. - Implementation of Carina Project Environmental Management Plan (PEMP) throughout closure execution phase as relevant (Section 9.1.6).	Medium	Rare	Low	As closure designs progress into execution plans at Carina, consider the potential impacts to W22 vegetation community arising from design changes and clearing required for construction access (Section 5.5.4).
All	Heritage	R33	Change to disturbance footprint to accommodate closure designs impacts on heritage site. <i>Note – this risk is specifically related to disturbance to heritage sites. Other impacts to cultural values are considered in Risk R36.</i>	The footprint required to accommodate closure designs (e.g., WRL slope rectification, abandonment bunds, surface water management infrastructure) encroaches on heritage sites.	Carina Northern and Carina Southern	Impacts to cultural heritage.	Severe	Possible	High	- Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001) (Section 9.1.5). - Heritage surveys are conducted as part of pre-clearing approvals (Section 9.1.5). - Consultation with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).	Severe	Rare	Medium	- As closure designs progress into execution plans, consider the potential impacts to heritage sites arising from design changes and clearing required for construction access (Section 5.8.5). - Consult with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).
All	Heritage	R34	Change to disturbance footprint to accommodate closure designs impacts on heritage site. <i>Note – this risk is specifically related to disturbance to heritage sites. Other impacts to cultural values are considered in Risk R36.</i>	The footprint required to accommodate closure designs (e.g. WRL slope rectification, abandonment bunds, surface water management infrastructure) encroaches on heritage sites.	J4	Impacts to cultural heritage.	Severe	Likely	Extreme	- Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001) (Section 9.1.5). - Heritage surveys are conducted as part of pre-clearing approvals (Section 9.1.5). - Known sites fenced off / signed as required during closure execution (Section 9.1.5). - Consultation with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).	Severe	Rare	Medium	- As closure designs progress into execution plans, consider the potential impacts to heritage sites arising from design changes and clearing required for construction access (Section 5.8.5 & 9.1.2). - Consult with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
All	Heritage	R35	Change to disturbance footprint to accommodate closure designs impacts on heritage site. <i>Note – this risk is specifically related to disturbance to heritage sites. Other impacts to cultural values are considered in Risk R36.</i>	The footprint required to accommodate closure designs (e.g., WRL slope rectification, abandonment bunds, surface water management infrastructure) encroaches on heritage sites.	Aurora	Impacts to cultural heritage.	Severe	Likely	Extreme	- Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001) (Section 9.1.5). - Heritage surveys are conducted as part of pre-clearing approvals (Section 9.1.5). - Consultation with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).	Severe	Rare	Medium	- As closure designs progress into execution plans, consider the potential impacts to heritage sites arising from design changes and clearing required for construction access (Sections 5.8.5 and 9.1.2). - Consultation with the Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).
All	Cultural	R36	Cultural values have not been factored into closure designs.	- Inadequate consultation with Traditional Owners to identify cultural values relevant to closure designs. - Safe access to sites of cultural significance not considered.	All	Impacts to cultural values.	Major	Likely	High	- Consultation with Traditional Owners to identify cultural values and how these might impact closure designs (Section 4.1.3). - Safe access requirements are factored into closure designs (Section 9.1.8). - Consultation with Marlinyu Ghoorlie, of previous discussions in relation to artefacts that have been removed / stored / relocate and any requirements for repatriation (Section 9.1.5).	Medium	Unlikely	Medium	- Consultation with Traditional Owners to discuss potential closure designs and outcomes (Section 4.1.3). - Incorporate requirements for safe access and cultural values (where possible) in closure designs (Section 9.1.8). - Consult with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys (Sections 5.8.5 and 9.1.5).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
All except infrastructure	Community safety	R37	Inadvertent access to unsafe or unstable areas by the community.	Failure of abandonment bunds due to incorrect location (e.g., too close to unstable pit wall); inadequate construction (e.g., poor materials selection or inadequate flood protection). [Context: Portion of Carina abandonment bund within ZOI (based on initial conservative assessment) 1:2,000 AEP and PMF floodplain in proximity to southern area of Carina Pit abandonment bund. Potentially requires an engineered flood protection bund (with armouring). J4 is situated on a ridge and flooding of regional streamline not expected to affect the pit abandonment bund or WRL closure requirements. Abandonment bunds at Carina incomplete. Aurora abandonment bund needs to be relocated / reconstructed. 1:2000 AEP / PMF interaction with Aurora abandonment bund but low velocity (DRAFT results only) J4 East abandonment bund requires review following J4 East redevelopment.	All	Potential for fatality of community member.	Severe	Likely	Extreme	- Abandonment bunds constructed in accordance with designs agreed with DEMIRS (Section 9.2.1.1). - Pit shell geotechnical assessment informs abandonment bund location (Sections 5.4.2.1). - Signage erected around open pits warning of hazard (Section 9.1.8). - Consultation with post-mining land owner / manager to identify post-closure access requirements and closure of tracks where not transferred to 3rd party (Section 4.1.3).	Severe	Rare	Medium	- Consultation with post-mining land owner / manager re post-closure access (Section 4.1.3). - J4 East Pit abandonment bund design informed by final extent of J4 East Pit (Section 5.4.4). - Complete an updated ZOI projection, based on the actual base of weathering, for the Carina Pit shell to determine if relocation of the north east portion of the abandonment bund is required (Section 5.4.4). - Finalise design for Aurora abandonment bund (Sections 5.3.4.6, 5.4.4 & 9.2.2.6). - Review the potential for erosion to impact on the integrity of the Carina Extension abandonment bund to determine any armouring requirement (Section 5.6.1.4.1 & 9.2.1.2) - Complete tasks required to progress abandonment bund designs to an execution plan (Section 9.2.1.1).
Infrastructure	Community safety	R38	Unused infrastructure is accessible to the public leading to injury or fatality.	- Security measures not in place. Infrastructure has not been removed or transferred to a third party. - Clear responsibilities for maintenance and security are not documented in asset transfer agreements.	All	Potential for injury or fatality of community member.	Severe	Likely	Extreme	- Decommissioning and demolition of all infrastructure that is not required by a third-party post-mining (Section 9.2.4). - Responsibility for securing and maintaining infrastructure has been formally transferred to a third party where ownership of the infrastructure has been transferred (Section 9.2.4).	Insignificant	Rare	Low	- Consultation with third parties regarding the requirement for infrastructure post-closure (Section 4.1.3). - Development of decommissioning and demolition plans prior to closure (Section 9.2.4.3).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
Mine Voids (mined BWT)	Fauna	R39	Pit lakes attract and increase feral fauna numbers resulting in a measurable negative impact on conservation significant flora and vegetation or conservation significant fauna species.	Planned / unplanned pit lakes provide source of water (or fringing vegetation) that increases feral animal populations which prey on native fauna or consume or damage native vegetation. [Context The salinity of pit lakes (Section 5.6.2.3) is likely to deter feral animals from utilising the lakes as a water source. In addition, there is a low likelihood that fringing vegetation will develop around the pit lake which provides food or habitat source and acts as an attractant. Existing surrounding land use at Carina is conservation (former Jaurdi Pastoral station has been destocked since 1989) so low baseline presence of feral animals (Section 5.8.3).]	All	Increased populations of feral animals may impact conservation significant flora and vegetation or conservation significant fauna species.	Major	Unlikely	Medium	- Monitoring carried out to meet Carina PEMP commitments during operations will inform closure requirements (Section 10.2.6). - Post-closure observation of feral animal populations as pit lakes establish. Implement feral animal controls as necessary based on outcomes of observations (Section 10.2.6).	Minor	Unlikely	Low	Conduct a pit lake risk assessment to assess the likelihood of significant numbers of feral fauna being attracted to the lake (Section 5.5.4).
Mine Voids (mined BWT)	Fauna	R40	Pit lakes act as a source of contaminated water or food for native fauna populations.	- Levels of bioavailable metals in pit lake increase due to AMD or NMD and evapo-concentration. - Pit lakes used by native fauna populations as food or water source with resultant bioaccumulation of contaminants of potential concern. [Context The salinity of pit lakes is likely to deter native animal populations from utilising the lakes as a water source. In addition, there is a low likelihood that fringing vegetation will develop around the pit lake which provides food or habitat source and acts as an attractant]	All	Impacts to biodiversity (native fauna).	Medium	Possible	Medium	Implement pit lake monitoring program for the period necessary to validate pit lake model and determine requirement for any additional monitoring (Section 10.2.4).	Medium	Possible	Medium	Conduct a pit lake risk assessment to assess the potential impacts to fauna and inform closure planning (Section 5.5.4).
All	Governance	R41	Access requirements for post-closure land uses or ongoing agreements have not been factored into closure designs.	- Inadequate consultation with Stakeholders to identify access requirements. - Access requirements to meet third party obligations are not identified and factored into closure designs.	All	Post mining land use cannot be achieved without rectification works.	Medium	Likely	High	- Stakeholder consultation (Section 4.1.3). - Commitments regarding third party access will be maintained by MinRes Land Access group (Section 3).	Minor	Unlikely	Low	- Liaise with Land Access Group in relation to third party agreements that may include post-closure access requirements (Section 4.2). - Develop a Land Access Plan (or similar) in consultation with all relevant stakeholders and to meet the conditions of tenements and third-party agreements. (Section 5.8.5).

Domain	Aspect	Risk ID	Risk Description	Cause / Pathway	Site	Impact description	Inherent Risk			Controls and / or Management Measures	Residual Risk			Forward work plan
							Consequences	Likelihood	Risk		Consequences	Likelihood	Risk	
All	Governance	R42	Land condition does not meet post-closure land use requirements <i>Note, this risk focuses on risks arising from inadequate consultation with post-closure land owners / managers rather than risks arising from final land condition, stability, revegetation success etc. which are dealt with separately in this table.</i>	- Post-closure land use objectives and completion criteria have not been developed and reviewed in consultation with key landowners / managers. - Changes in legislation or community expectations.	All	Closure outcomes are not aligned with post-mining landowner / managers expectations.	Severe	Likely	Extreme	- Stakeholder consultation program. - Closure commitments maintained in consultation and obligations registers (Section 3 and 0).	Medium	Possible	Medium	- Consultation with stakeholders to confirm post-mining land use and associated performance objectives and completion criteria (Section 4.1.3). - Consultation with Traditional Owners to be prioritised prior to next MCP update. Use this MCP as a starting point for those discussions with feedback included in the next MCP update, to allow sufficient time for review and input by Marlinyu Ghoorlie (Section 4.1.3).
Governance	Governance	R43	Financial provisioning insufficient to undertake the rehabilitation and closure activities in accordance with the MCP.	- Poor understanding of closure requirements / stakeholder expectations. - Closure cost is not regularly reviewed as new information becomes available and / or new areas of the mine are disturbed. - Materials handling & waste disposal requirements not adequately considered (e.g., removal and disposal of bitumen, road base)	All	Poor closure outcomes. <i>(Refer to impact descriptions for all Closure Risks)</i>	Severe	Possible	High	- Detailed Closure Cost Estimate revised annually (Section 11.2). - Compliance with MRF guidelines and annual reporting (Section 10.4). - Internal stakeholder engagement (Section 4.2). - Closure study program informed by risk assessment (Section 7).	Minor	Unlikely	Low	-

8. CLOSURE OUTCOMES & COMPLETION CRITERIA

Statement Of Compliance With Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes:

- *Site-specific closure outcomes consistent with the post-mining land use(s) that are realistic and achievable based on the closure risk assessment (Table 54).*
- *Completion criteria that are specific, measurable, achievable, relevant and time-bound, and will demonstrate the achievement of the closure outcomes and monitoring (Table 54).*

8.1 Closure Outcomes

The overall goal for closure of the Carina Operations is that:

Rehabilitated areas within the Carina Operations Area will be safe, stable, non-polluting, integrated with the surrounding landscape and have self-sustaining native vegetation capable of supporting utilisation by local native fauna, so that the Carina Operations tenements can be relinquished without any unacceptable future liability for MinRes, the Government or the community.

The aspects and closure outcomes that require management to achieve this goal (see Table 54) and, therefore, the proposed PMLU (Section 5.9.7) have been informed by the closure obligations (Section 3), stakeholder input to date (Section 4), an understanding of the closure environment (Section 5) and closure risk assessment (Section 7).

It is acknowledged that Traditional Owner consultation remains a key knowledge gap to ensure that the completion criteria reflect expectations around the PMLU and how it is achieved. This is proposed to be addressed as a priority as discussed in Section 4.1.2.

8.2 Completion Criteria

Completion criteria are the measures against which achievement of the closure outcomes can be evaluated and reported. Demonstrated achievement of the completion criteria will indicate that the agreed PMLU can be met and ultimately support application for tenure relinquishment.

As per the DEMIRS guidance, completion criteria are intended to be evidence based, follow the Specific, Measurable, Achievable, Relevant, Time-bound (S.M.A.R.T.) principle (ANZMEC & MCA, 2000), support the PMLU, and be achievable given permanent changes to landforms, soils and hydrology.

8.2.1 Review and Refinement of Completion Criteria

The development of completion criteria is an iterative process, and the completion criteria presented in Table 54 have been refined from those presented in earlier versions of this MCP with consideration to feedback from DEMIRS (2023a), other stakeholder input (0), knowledge base updates (Section 5), risk assessment (Section 7) and a review of closure obligations and commitments (0).

Preliminary quantitative metrics are provided in Table 54. Reference ecosystems (Section 5.5.3) as well as monitoring techniques are currently being reviewed (Section 10). Development of appropriate quantitative metrics requires collection of data over several seasons. Therefore, the outcomes of this review and ongoing refinement of all completion criteria will be reported in future revisions of the MCP.

As discussed in Section 4.1.2, consultation with DBCA was initiated in March 2023 and a commitment to ongoing consultation was made. Feedback from that meeting and earlier discussions with DPAW (now

DBCA) in 2017 about the Carina mine site that has been considered in refining the completion criteria include:

- DBCA preference is for MinRes to tie abandonment bunds into existing ridge lines / waste rock landforms where possible thereby reducing the need to disturb more land to construct the bunds. DBCA's key interest would be to avoid disturbance to priority / threatened flora in the region.
- DBCA suggested preference is for 'natural environment' PMLU, where underlying tenure is UCL or potential reserve.
- DBCA (at the time DPAW) was of the view that the objective of rehabilitation in areas of native vegetation should, wherever possible, be the re-establishment of self-sustaining native vegetation communities that, as closely as possible, have similar floristic diversity and composition to the pre-mining environment or equivalent analogue / reference sites. Mining pit voids, waste facilities and landforms approved as part of mining developments represent a significant rehabilitation challenge but continuous improvement in design and management of these domains toward meeting acceptable criteria for the applicable land use should be the objective (Polaris Metals, 2017). In a subsequent discussion with DBCA, it was noted that floristic diversity and abundance are largely driven by the substrate into which plant roots develop. Where this substrate in an artificial landscape such as a mine WRL is very different to undisturbed substrate, the capability to support specific floristic communities is constrained. DBCA indicated that those parts of the disturbance footprint that had resulted in less disturbance to substrates should perhaps have a higher level of revegetation outcomes than the areas of WRL where revegetation may be constrained due to highly altered substrates (Polaris Metals, 2017).

8.2.2 Current Completion Criteria

Table 54 outlines the currently defined completion criteria for the Carina Operations and includes information about the risk drivers for each completion criterion and how the criterion will be measured and reported as follows:

- Closure outcome: The particular closure objective or outcome that the completion criterion is intended to evaluate.
- Aspect: The element of closure (environment, safety or governance) that needs to be addressed in order to meet closure outcomes.
- Risk ID: The identified risk pathway (Table 53) that the closure outcome and completion criteria have been developed to address. Where more than one risk relates to a particular set of criteria, this has been shown in the Risk ID column, and the specific domains / sites / features to which each risk relates are outlined in the adjacent domain / site column. The colour coding relates to the colour coding used in Table 53 for the inherent risk rating, i.e.,

Extreme	High	Medium	Low
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- Domain / Site: Specifies the domains or sites that the criteria relate to. Additional information relating to closure implementation for each closure domain is provided in Section 9.2.
- Completion Criteria: The measurable indicators against which final achievement of the particular closure outcome can be evaluated and which will collectively demonstrate successful closure of the site.
- Performance Indicator: A level of performance measured through planning and implementation phases that provides assurance that completion criteria will be met.
- Measurement Tools and Timing: How and when Polaris will demonstrate that the performance indicators or completion criteria have been met.

- Reporting: How Polaris will submit that a particular completion criterion or overall closure outcome has been achieved with consideration to DEMIRS Mine Closure Completion Guidance (DMIRS, 2020b).

The WABSI Guidance (Young, et al., 2019) identifies three types of criteria attributes (i.e., how achievement can be measured) as follows:

- P – installed / built as planned;
- C – categorical – the feature is present or absent or the activity has been achieved or not; and
- Q – quantitative, the attribute can be measured and compared against a numerical target.

The attributes of each of the criteria outlined in Table 54 have been provided in brackets.

Table 54 Completion Criteria

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
1 Post-mining land use & management								
1.1	Post-mining land use (PMLU) <i>The post-closure land condition is compatible with the PMLU.</i>	Governance	R42	All	- Monitoring, inspection and audit demonstrate that the closure outcomes have been substantially met, as demonstrated by achievement of the criteria for (C): - Safety (1.2); - Land management (1.3); - Access (1.4); - Visual amenity (1.5); - Landform stability (3); - Surface water, groundwater and contamination (4, 5 and 6); - Rehabilitation (7); - Heritage (8); and - Flora and fauna (9) - Post-closure landowner / manager agrees that completion criteria have been met and accepts land management responsibilities (C).	- Stakeholder engagement has been completed to define the PMLU for each domain (C). - Completion criteria have been developed which reflect the performance requirements for the PMLU (post-closure land condition) as identified through consultation with key stakeholders (C).	- Audit of progressive completion: - The PMLU for each domain is documented in the MCP (C). - Stakeholder engagement register documents outcomes of consultation on PMLU and performance requirements (C). - Audit at completion: - Demonstrated achievement of safety (1.2), land management (1.3), access (1.4), visual amenity (1.5), landform stability (3), surface water, groundwater and contamination (4, 5 and 6), rehabilitation (7), heritage (8), and flora and fauna (9) criteria (C). - Documented acceptance of the post-closure land condition and land management requirements by the post-closure landowner / manager (C).	MCP updates. Completion Report submitted for domain or site when all completion criteria achieved.
1.2	Safety <i>Public health and safety hazards have been mitigated.</i>	Infrastructure	R38	Infrastructure	- Surface infrastructure, other than that subject to asset transfer agreements has been removed from site (C). - Transferred infrastructure meets the specifications in asset transfer agreements (P). - Buried infrastructure has been removed to a depth of 0.5 m and concrete footings to a depth of 1.5 m below ground level unless otherwise agreed with the post-relinquishment landowners / managers (C). - Bores not required post-relinquishment have been decommissioned as per the Minimum Construction Requirements of Water Bores in Australia (2011) (C). - No waste material or rubbish remains other than in agreed landfill locations (C). - Site has been assessed as safe by the District Mines Inspector (C).	- Asset transfer agreements (including responsibility for ongoing management and safety) are in place and specify condition of infrastructure at transfer (C). - Condition assessments of infrastructure have been conducted and rectification plans developed to meet the specifications in asset transfer agreements (C). - Buried infrastructure to remain post-closure has been agreed with regulators and post-relinquishment landowners / managers (C). - Decommissioning and demolition plans have been developed for all infrastructure where there is no agreement for it to remain and include processes to ensure that facilities are de-energised and appropriate security measures are in place following closure and prior to demolition (C). - Decommissioning waste disposal plans have been developed and reflect disposal methods and locations agreed with key stakeholders (C). - Performance indicators for safe access (1.4) met (C).	- Audit of progressive completion: - Decommissioning and supporting consultation documented in MCP (C). - Agreements on rectification requirements and completion of rectification plans reported in MCP (C). - Audit post-decommissioning / demolition / rectification: - Signed asset transfer agreements (C). - Decommissioning / demolition contractor's report of works completed against plans (P). - Waste management records (P). - Bore decommissioning close-out report (P). - Survey and inspection post-demolition: - Site inspection and review of high-definition aerial imagery to assess infrastructure removed as planned (P) - Inspection by District Mine Inspector (C). - Audit at completion: - Surveys, inspection and demolition contractor reports (C). - Achievement of criterion for post-relinquishment access (1.4) (C). - Documented acceptance of the post-closure land condition and management by the post-closure landowner / manager (C).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved and demonstrates that: - All infrastructure has been removed / decommissioned as agreed. - No waste or rubbish remains on site other than in agreed locations. - Asset transfer agreements have been signed for remaining infrastructure. - Post-decommissioning inspection completed by District Mines Inspector.

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
1.2	Safety <i>Public health and safety hazards have been mitigated cont'd</i>	Inadvertent access	R37	All	- Abandonment bunding constructed in accordance with DoIR (1997) and / or in agreement with DEMIRS (C). - Site has been assessed as safe by the District Mines Inspector (C).	- Pit wall stability assessments completed to inform abandonment bund location (C). - Materials characterisation and flood modelling completed and informed materials selection for abandonment bund construction (C) - Locations of abandonment bunds have been approved by DEMIRS (and DWER if any requirement for disturbance outside approved development envelope) and informed by heritage survey (C). - Areas of the closed site that are potentially hazardous have been identified and plans have been developed to eliminate or mitigate identified hazards (C).	- Audit of progressive completion: - Abandonment bund design approved via MCP and supported by materials characterisation, ZOI assessment, flood modelling results, records of agreements with DEMIRS, regulatory land disturbance approvals and heritage survey (C). - Hazardous areas of the closed site have been identified and documented in MCPs (C). - Survey and inspection: - Survey within 12 months post-closure confirms abandonment bunds constructed in accordance with design (P). - Inspection by District Mine Inspector within 12 months post-closure (P). - Annual inspection of abandonment bund integrity post-closure until completion (P). - Audit at completion: - Reports of inspections post-construction and post-closure (C). - Achievement of criterion for post-relinquishment access (1.4) (C).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved and includes: - Audits of abandonment bund construction. - Post-decommissioning inspection report from District Mines Inspector.
1.3	Land management <i>Land management requirements are commensurate with the PMLU, or formal arrangements have been made to provide for management of residual risks.</i>	Governance	R42	All	- At completion, land management requirements are typical of the PMLU (Q), or where additional management is required: - These activities have been documented in a post-relinquishment land management plan (C). - Provisions have been made for the additional activities and the post-relinquishment landowner / manager accepts responsibility for implementation of the land management plan (C).	- Post-closure monitoring and maintenance records enable post-relinquishment management requirements to be determined (Q). - Comparison of post-relinquishment land management requirements with land management requirements typical of the PMLU (Q). - Residual risk assessment and consultation with the post-relinquishment landowner / manager has been conducted to inform post-relinquishment land management requirements (C) - A post-relinquishment land management plan has been prepared where activities additional to those typical of the PMLU are required (C).	- Audit at completion: - Assessment of post-relinquishment land management requirements compared to land management requirements typical of the PMLU (C). - Post-completion residual risk assessment has been completed (C). - Post-relinquishment land management plan, if required, to confirm that ongoing land management requirements and residual risks additional to those typical of the PMLU have been addressed (C). - Documented acceptance of the post-relinquishment land management plan by the post-relinquishment landowner / manager (C).	- Completion Report submitted for domain or site when all completion criteria achieved and includes: - Post-relinquishment land management plan. - Acceptance of the post-relinquishment land management plan by the landowner / manager.
1.4	Post-relinquishment access <i>The post-closure landform includes provision for safe access, where required.</i>	Cultural	R36	All	- The post-closure landform provides access to meet tenement conditions and stakeholder agreements (P). - The Safety criterion (1.2) is achieved.	- Provisions for post-closure access are informed by tenement conditions, consultation with key stakeholders and third-party agreements (C). - Provisions for post-closure access are incorporated into final landform design and decommissioning plans (P).	- Audit at completion: - Closure obligations register and stakeholder engagement to determine whether access has been provided in accordance with conditions and agreements (P). - Documented acceptance of the post-closure land condition and access arrangements by the post-closure landowner / manager and third parties with whom there are access agreements (C). - Achievement of Safety criterion (1.2) (C).	Completion Report submitted for domain or site when all completion criteria achieved and includes documented acceptance of the post-closure land condition and access arrangements by the post-closure landowner / manager and third parties with whom there are access agreements
		Governance	R41					
1.5	Visual amenity <i>The heights of final landforms are compatible with</i>	Visual amenity	R31	WRLs	WRLs are constructed substantially to approved design height (P). Where there are significant (> 5 m) departures from the approved design height, these have been agreed with key stakeholders (C).	Design height of WRLs has considered height of surrounding topography (C). Assessment of landform height against design height (the height approved via Mining Proposals) and rectification if	- Audit of progressive completion: - Approved heights (from Mining Proposals or MP / MCP Amendments) and elevations of surrounding topography are captured in MCP (C). - Audit at completion:	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including audit of final

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
	surrounding landforms.				Note other aspects of visual amenity are addressed by achievement of criteria 1.2, 3 and 7.	required prior to reshaping and rehabilitation (P). Where rehabilitation has been implemented and variations from design height are not substantial (< 5 m) a height variation has been sought via the MCP (C). Where variation is substantial (> 5 m), impacts to visual amenity are considered in consultation with key stakeholders and, if not acceptable, rectification plans have been developed to meet the design height, or if acceptable, approval for height variation is sought via amendment to the relevant MP or MCP (C).	Final landform height against approved heights or approved variations (P).	landform height against approved heights.
3. Landform Stability								
3.1	Surface stability <i>Rehabilitated surfaces are stable and are not subject to unacceptable rates of erosion.</i>	Erosion / stability	R7 R8 R9 R10 R11	WRLs (Carina / Carina Extended / J4) WRLs (Aurora) All except WRLs	- WRLs and drainage management features have been built substantially in accordance with the approved designs (P). - Erosion features in rehabilitation areas meet targets: - If erosion is evident, the rate of change of erosion has stabilised over three consecutive assessment periods within a minimum monitoring period of five years (Q). - Erosion or sedimentation from landform has not substantially impacted on adjacent vegetation (Q). - Erosion does not expose encapsulated deleterious materials (Q).	WRLS - Landform designs have been informed by materials characterisation, erosion modelling, surface water run-off studies (of a 1 in 2,000 AEP event) and flood modelling of a PMF (C). - A competent materials inventory has been developed and compared to landform design requirements (C). - There are sufficient sources of competent material to implement landform designs (or rectification plans) (Q). All - Performance indicators for geotechnical stability (3.2) and vegetation establishment (7.2) have been met (C).	- Audit of progressive completion: - Landform design, basis for design (or variation to design) and supporting studies have been documented in the MCP (C). - The approved design, used as the basis for compliance assessment, is consistent with the designs submitted in Mining Proposals except where variations have been approved via MP or the MCP (C). - Survey / inspection (post-construction and prior to rehabilitation where possible) of as built geometry against design (P). - Erosion monitoring and monitoring of adjacent vegetation until it is demonstrated that erosion has stabilised (Q). - Audit at completion: - Post-construction survey and inspection reports (C). - Post-closure monitoring and inspection demonstrates achievement of the completion criteria for three consecutive seasons (Q). - Demonstrated achievement of criteria for geotechnical stability (3.2) and vegetation establishment (7.2) (C).	- Erosion monitoring results reported in AERs and / or MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including conformance of as built geometry with design.
3.2	Geotechnical stability <i>Landforms are safe and geotechnically stable.</i>	Stability	R28 R29	WRLs (Carina and Carina Extended) WRLs (J4)	- WRLs have been built substantially in accordance with the approved design geometry as outlined in Section 9 (P). - WRLs are located substantially outside the ZOI of adjacent mine voids such that a slope failure would not impact the PMLU, safe access, the structural integrity of the WRL or expose encapsulated deleterious materials (P). - WRLs / backfill landforms have a FOS $\geq$ 1.5 (Q). - J4 West Pit backfilled sufficiently so that a pit wall failure would not impact adjacent heritage site (P)	- Design geometry has been informed by waste characteristics affecting stability (C). - The zone of instability of adjacent mine voids; and - PMF modelling. Performance indicators related to safety (1.2) and surface stability (3.1) have been met (C).	- Audit of progressive completion: - Landform design, basis for design, variation to design (or rectification plans) and supporting studies are documented in MCP (C). - The approved design (used as basis for compliance assessment) is consistent with the designs submitted in Mining Proposals except where variations have been approved via MP or the MCP (C). - Survey / inspection of as built landform against design (P). - Audit at completion: - Post construction survey report (C).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including post construction survey and geotechnical reports.

Re f	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
			R30	J4 West Pit	Safety (1.2) and surface stability (3.1) criteria are met (C).		- Geotechnical reports demonstrating landforms meet criteria (C). - Demonstrated achievement of criteria for safety (1.2) and surface stability (3.1) (C).	
3.3	Geochemical stability <i>Landforms are non-polluting.</i>	PAF materials	R1	WRLs (Carina WRL and Carina Extended WRL)	- No visual evidence of AMD run-off or seepage from WRLs and no impacts to health of adjacent vegetation attributable to saline seepage or AMD (Q). - No exposed PAF, radioactive or fibrous material on WRLs (C). - No evidence of mineral scalds in rehabilitation areas (C). - Contamination (5.1), groundwater quality (6.2) and vegetation establishment (7.2) criteria are met (C).	- Materials characterisation has been completed to inform materials handling strategies (C). - PAF materials have been encapsulated or blended with NAF materials, in accordance with design (Section 9) and advice provided by specialist consultants (P / Q). - If present, radioactive or fibrous materials have been encapsulated in accordance with design and advice provided by specialist consultants (P/Q). - Where records for placement of deleterious materials are not available, cover assessment for exposed materials completed, and rectification plans developed, as required (C). - In constructed WRLs where PAF-LC / salinity is impacting on vegetation performance, rectification plans have been developed or reference ecosystem / seed mixes have been modified to suit the substrate conditions (C). - Source-pathway-receptor (SPR) assessments inform AMD monitoring programs and site inspections (C). - Performance indicators for contamination (5), groundwater (6) and vegetation establishment (7.2) have been met.	- Audit of progressive completion: - Materials characterisation studies are documented in the MCP (C). - Materials handling strategies and / or rectification plans and supporting studies are documented in the MCP (C). - As-built reports or post-construction assessments demonstrating materials handling or rectification plans completed to plan (P). - Inspection / monitoring post-closure: - Surface condition of WRL slopes, WRL toe and health of adjacent vegetation (Q). - AMD monitoring program (as required by SPR assessment) (Q). - Audit at completion (10 years post-closure): - Inspection / monitoring results (C). - Evidence (in the form of validation samples) submitted for achievement of criteria for contamination (5.1), groundwater quality (6.2) and vegetation establishment (7.2) (C).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including post-closure inspections and results of any AMD monitoring.
			R2	WRLs (J4 East WRL)				
			R3	WRLs (J4 West WRL)				
			R4	WRLs (Aurora)				
		Oxidised Acidic Waste materials	R5	WRLs (J4 East and J4 West)				
		Fibrous or Radioactive materials	R6	WRLs				
4. Surface Water								
4.1	Surface water flow <i>The post-closure landform maintains the flow of surface water to key receptors.</i>	Surface water	R23 R24	All (Carina and Aurora)	- Surface water management controls are established in the post-closure landform to maintain surface water flows around landforms that may significantly impound or capture surface water flow (C). - The criterion for surface stability (3.1) is met (C).	- Surface water management designs are informed by (C): - Hydraulic modelling (including consideration of extreme rainfall events) and consideration of impacts to identified ecohydrological and cultural receptors. - Materials characterisation (stability) assessment. - The applicable performance indicators for surface stability (3.1) are met (C).	- Audit of progressive completion: - Surface management designs and supporting studies have been documented in the MCP (C). - Survey and inspection post-closure implementation: - Final landform survey (P). - Inspection / survey of as-built surface water management infrastructure against designs (P). - Inspection post-closure for minimum ten years: - Triennial visual performance assessment of drainage control features (Q). - At completion: - Survey and inspection results (C) - Verification submitted for achievement of surface stability criterion (3.1)	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including survey and inspection results.
			R27	Haul Road	- The rehabilitated haul road does not obstruct regional drainage patterns (C). - The criterion for surface stability (3.1) is met (C).	- The rehabilitated haul road has been designed to reflect the drainage patterns of surrounding topography (C). - The applicable performance indicators for surface stability (3.1) are met (C).		
4.2	Surface water quality	Surface water	R25	Mine Voids – Mined BWT (Carina)	Surface water management infrastructure has been provided, where required, to prevent overflow of pit lakes due to	- Surface water management designs are informed by (C): - Hydraulic modelling (including consideration of extreme rainfall		

Re f	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
	Overflow from pit lakes does not adversely impact surface water receptors.		R26	Mine Voids – Mined AWT (Aurora)	capture of surface water during flood events (C). Note other potential impacts to surface water quality are addressed by: - Criterion 3.1 (surface stability) - Criterion 3.2 (geochemical stability). - Criterion 5.1 (operational contamination)	events) and consideration of impacts to identified ecohydrological and cultural receptors. Materials characterisation (stability) assessment.		
5. Contamination								
5.1	Contamination Contaminated sites have been identified and addressed.	Operational contamination	R17 R18	All	- Contaminated sites, as defined by Contaminated Sites Act 2003, have been remediated in accordance with the PMLU classification (C). - Validation sampling confirms remediation satisfies objectives of the remedial action plan (Q).	- Contamination present at closure has been identified and, where required, remedial action plans developed (C). - Remedial Action Plans have been implemented (P).	- Audit of progressive completion: - Remediation action plans documented in MCP with supporting soil and / or groundwater investigations (C). - Remediation validation reports (C).	- MCP updates. - Site Remediation Validation report submitted for domain or site when all completion criteria achieved.
6. Ground Water								
6.1	Ground water levels Groundwater levels are acceptable at key receptors.	Groundwater	R18	Mine voids (Mined BWT) (Carina / Carina Extended)	Post-mining groundwater and pit lake levels are within predicted ranges which have been assessed as not causing unacceptable impacts to receptors (Q).	- Hydrogeological modelling and assessment of impacts of residual groundwater drawdown to potential ecohydrological receptors from post-closure mine void closure strategy has been conducted (C). - Where unacceptable post-closure drawdown impacts are predicted at key receptors, closure designs (e.g., backfill strategies) have been developed to mitigate these impacts (C). - Groundwater and pit lake monitoring program developed to allow model validation (C).	- Audit of progressive completion: - Predicted post-closure groundwater drawdown impacts on ecohydrological receptors with supporting hydrogeological modelling are documented in MCP (C). - Groundwater level and / or pit lake monitoring until model is validated (Q) - Audit at completion: - Model validation reports (C).	- Groundwater monitoring results reported in Annual Aquifer Reviews and / or MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including groundwater and pit lake monitoring data and model validation reports.
			R19	Mine voids (Mined BWT) (J4)				
6.2	Ground water quality Groundwater quality is acceptable at key receptors.	Groundwater throughflow (pit lakes)	R20	Mine voids (Mined BWT) (Carina / Carina Extended)	- Modelling (validated by monitoring) and source-pathway-receptor assessment shows that pit lakes: - Will not become throughflow systems, or if temporary throughflow conditions occur, contaminants will not impact key ecohydrological receptors (Q). - Will not release density driven flow, or if density driven flow is likely to occur, hydrogeological assessment concludes that contaminants will not impact key ecohydrological receptors (Q).	- Materials characterisation completed for backfill (C). - Modelling studies (including surface water, groundwater, pit lake) and source-pathway-receptor assessments have been used, as appropriate, to assess the potential for impacts to ecohydrological receptors (C). - Where unacceptable impacts are predicted at key receptors, closure designs (e.g., backfill) have been developed to mitigate these impacts, where required (C). - Groundwater and / or pit lake monitoring program used to validate models (C). - Performance indicators for geochemical stability (3.3) are met (P).	- Audit of progressive completion: - Materials characterisation, monitoring and supporting modelling studies (where required) are documented in the MCP (C). - Groundwater and / or pit lake monitoring until model is validated (Q). - Audit at completion: - Model validation reports (C). - Achievement of geochemical stability criterion (3.3).	- Groundwater monitoring results reported in AERs and / or MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including groundwater and pit lake model validation reports.
			R21	Mine voids (Mined BWT) (J4)				
		Geochemistry of backfill	R22	Mine voids (Mined BWT) (J4)	- Groundwater and / or pit lake monitoring shows that quality is within reference ranges, or where reference ranges are exceeded, source-pathway-receptor models or solute transport modelling show no significant impact to key receptors (Q). - The contamination completion criterion (5.1) has been met (C).	The performance indicators for contamination (5.1) have been met (C).	- Audit at completion: - Demonstrated achievement of contamination criterion (5.1).	
		Operational contamination	R17 R18	All	The contamination completion criterion (5.1) has been met (C).			

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
7. Rehabilitation								
7.1	Topsoil / growth media <i>Suitable growth media is available to support achievement of vegetation outcomes.</i>	Topsoil / growth media	R12	All areas to be rehabilitated	Growth medium profile is implemented as designed (C).	- Sufficient and suitable growth media has been identified to support plant establishment and growth (C). - Alternative growth media have been identified where there is a topsoil deficit (C). - Stockpiled topsoil of poor quality has been remediated where possible or buried > 1 m below ground surface (C). - Growth media has been placed in accordance with rehabilitation plans (C).	- Audit of progressive completion: - Topsoil reconciliation reported in progressive MCP updates (C). - Alternative growth media investigations reported in progressive MCP updates (C). - Audit at completion: - Demonstrated achievement of vegetation establishment criterion (7.2).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved.
7.2	Vegetation establishment and resilience <i>Vegetation in rehabilitated areas is locally native, resilient, reflective of the reference ecosystem and supports native fauna assemblages. Reference ecosystem to be determined through a desktop study, on-ground verification and stakeholder feedback.</i>	Vegetation	R13 R14	All areas to be rehabilitated	- Locally native species present in the reference ecosystem or adjacent ecosystems are seeded on areas to be restored or rehabilitated. - Native vegetation in restored or rehabilitated areas comprises only locally native species that occur in the reference ecosystem or adjacent ecosystems. - Species diversity and composition of native vegetation in restored or rehabilitated areas is within or above the range of variation present in the reference ecosystem at quadrat scale (Q). - Vegetation cover of native perennial species, and the cover of bare ground, in restored or rehabilitated areas is within or above the range of variation present in the reference ecosystem at quadrat scale (Q). - Cumulative native species richness within each closure domain provides at least 50% representation of the native species diversity present in a comparable spatial area of the reference ecosystem. - Evidence from restored or rehabilitated areas or adjacent rehabilitated areas of flowering and seed production from >50% of perennial species at quadrat scale to date (Q). - Species considered keystone to the reference ecosystem are well-represented throughout the rehabilitated area - Restored or rehabilitated areas support assemblages of native fauna.	- Completion criteria have been developed which reflect the performance requirements for the PMLU (post-closure land condition) as identified through consultation with key stakeholders (C). - Rehabilitation seed mixes have been informed by baseline vegetation mapping, characteristics of the final landforms / substrates, PMLU and fauna habitat value (C). - Seed requirements have been identified and the necessary quantities collected to meet the seed mix requirements in accordance with the rehabilitation schedule (C). - All seeds used in rehabilitation are from locally native species that occur in the reference ecosystem or adjacent ecosystems (C). - At least one keystone species present in all of monitoring quadrats (C). - Rehabilitation monitoring program in place to measure performance against completion criteria (C).	- Audit of progressive completion: - Quality control records of local provenance seed collection and procurement processes (C). - Progressive rehabilitation summarised in MCP (C). - Post-closure monitoring until completion criteria are met: - Monitoring of rehabilitated areas commencing 12 months after seeding (Q). - Species richness – Progressively achieving >25% of quadrats harbour species richness within or above the range of variation present in quadrats established in the reference ecosystem by year 3, >50% of quadrats harbour species richness within or above the range of variation present in quadrats established in the reference ecosystem by year 5, 100% of quadrats harbour species richness within or above the range of variation present in quadrats established in the reference ecosystem by year 7. Cumulative species richness in monitoring quadrats totals >20% of total species richness in the reference ecosystem by year 3, >30% by year 5, and >50% by year 7. - Native vegetation cover – all rehabilitation monitoring quadrats possess >10% of native vegetation cover by year 3. >50% of rehabilitation monitoring quadrats possess native vegetation cover within the range of variation present in quadrats established in the reference ecosystem, >75% by year 7 and 100% by year 10. - Vegetation structure – more than 75% of rehabilitation monitoring quadrats contain at least one living individual of at least one species considered to be each of middle and lower storey vegetation and >25% of rehabilitation monitoring quadrats contain at least one living individual of at least one species considered upper storey vegetation (subject to presence in the reference ecosystem) by year 3, >75% of	- Rehabilitation monitoring reported in AERs and / or MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved.

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
							rehabilitation monitoring quadrats contain multiple living individuals of multiple species considered to be each of middle and lower storey vegetation and >25% of rehabilitation monitoring quadrats contain at least one living individual of at least one species considered upper storey vegetation (subject to presence in the reference ecosystem) by year 5, >75% of rehabilitation monitoring quadrats contain established mature individuals of species considered to be each of middle and lower storey vegetation and >25% of rehabilitation monitoring quadrats contain at least one living individual of at least one species considered upper storey vegetation (subject to presence in the reference ecosystem) by year 7, >100% of rehabilitation monitoring quadrats contain established mature individuals of species considered to be each of middle and lower storey vegetation and >25% of rehabilitation monitoring quadrats contain one or more established, mature, living individuals of one or more species considered upper storey vegetation (subject to presence in the reference ecosystem) by year 10. - Keystone species representation – Progressively achieving >50% of quadrats containing the performance indicator by year 3, >75% of quadrats containing the performance indicator by year 5, 100% of quadrats containing the performance indicator by year 7. - Audit at completion: - Monitoring demonstrates achievement of the completion criteria (C).	
7.3	Weeds & Dieback <i>Weeds or Dieback do not compromise revegetation success or surrounding vegetation.</i>	Weeds / Pathogens	R15 R16	All	All - Priority weed species have been controlled in accordance with weed management plans (P). - Weeds do not compromise the development of native vegetation on restored or rehabilitated areas and do not represent a significant long-term weed risk to surrounding vegetation (C). - Restored or rehabilitated areas harbour only weeds that occur in the reference ecosystem, if weeds are present (Q). - Average weed cover is not greater in restoration or rehabilitation monitoring quadrats than in quadrats established in the reference ecosystem (Q).	- Weed and dieback risks have been identified and management plans developed (C). - Baseline weed surveys have been completed (C). - Baseline dieback surveys have been completed where risk identified (C) - Weed monitoring (including assessment of impacts on adjacent vegetation) is conducted (C) and control program has been implemented in accordance with plans (P). - Where dieback risk has been identified, dieback monitoring (including assessment of impacts on adjacent vegetation) is conducted (C) and hygiene program has been implemented in accordance with plans (P).	- Audit of progressive completion: - Baseline weed and dieback situation and the outcomes of operational monitoring are documented in the MCP (C). - Weed / dieback completion criteria have been documented in the MCP (C). - Annual post-closure monitoring until completion criteria are met (Q). - Audit at completion: - Weeds have been controlled in accordance with management plans (P). - Weed and dieback monitoring demonstrates achievement of the completion criteria (C). - Vegetation establishment criterion (7.2) is met.	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including weed monitoring records.

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
8. Heritage								
8.1	Cultural values <i>Protection of heritage sites.</i>	Heritage	R33	All (Carina Northern and Carina Southern)	- Requirements for repatriating artefacts have been met (C). - Protection of heritage sites and post-closure access is facilitated by achievement of the access (1.4), surface (3.1) and geotechnical (3.2) stability criteria (C).	- Heritage sites and requirements for repatriation of artefacts (approved for disturbance during operations) have been identified in consultation with Traditional Owners and captured in the GIS database for planning (C). - Disturbance footprint of final landform design has been mapped in relation to heritage sites (C). - Procedures are in place to manage land disturbance during closure implementation (C). - Performance indicators associated with land access criteria (1.4) surface (3.1) and geotechnical (3.2) stability criteria are met.	- Audit of progressive completion: - Closure disturbance footprint relative to identified heritage sites documented in MCP (C). - Any agreement for repatriation of artefacts documented in MCP (D). - Audit at completion: - Confirmation from Traditional Owners that artefacts have been repatriated (C). - Evidence that landform stability (3) criteria have been met (C).	- MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including confirmation from Traditional Owners that requirements for repatriation of artefacts have been met.
			R34 R35	All (J4 and Aurora)	<i>Note cultural values will also be considered in refining Closure Outcome 1.1 Post-Mining Land Use and Closure Outcome 7.2. 'Vegetation in rehabilitated areas is locally native, resilient, reflective of the reference ecosystem and supports native fauna assemblages'.</i>			
9. Flora and Fauna								
9.1	Flora, vegetation and fauna habitat <i>Direct and indirect impacts to conservation significant flora, vegetation and fauna habitat are minimised.</i>	Flora and fauna	R32	All	- Protection of flora, vegetation and fauna habitat from indirect impacts is supported by achievement of the weed (7.3) surface stability (3.1), geotechnical stability (3.2) and geochemical stability criteria (3.3) (C). - Closure activities have been completed within approved disturbance envelopes (C). - Rehabilitated areas support and are utilised by native invertebrate and vertebrate fauna after ten years (C). - Rehabilitated areas contain leaf litter, coarse woody debris, and/or rocky material to support foraging and refuge of invertebrate and vertebrate fauna after ten years (C). - At completion, feral animal control requirements are typical of the PMLU, or where additional management is required: - These activities have been documented in a post-relinquishment land management plan (C). - Provisions have been made for the additional activities and the post-relinquishment landowner / manager accepts responsibility for implementation of the land management plan (C).	- Environmental management plans approved for the operations phase are applied as relevant to the closure implementation phase (P). - Significant flora, vegetation and fauna habitat (as identified by site regulatory approvals and including Malleefowl mounds) have been identified and captured in the GIS database for closure planning (C). - Evidence of utilisation by simple invertebrate through to common vertebrate groups (C). - Evidence of coarse woody debris or rocky material and evidence of leaf litter or other organic detritus in rehabilitated areas (C). - Closure designs minimise impacts to significant flora, vegetation and fauna habitat (C). - Feral animal observations and required control measures have been recorded to facilitate residual pit lake risk assessment and inform post-relinquishment land management plan (C). - Performance indicators associated with landform stability criteria (3) are met (C) - If Safety criterion (2.1) (installation of abandonment bunds) cannot be met without disturbing conservation significant flora, vegetation or fauna habitat, engagement with regulators has been undertaken to agree the location and obtain the necessary approvals (C).	- Audit post-closure implementation phase: - The implementation of the approved PEMP has been completed to the satisfaction of DWER (C). - The closure disturbance footprint and approvals are documented in the MCP (C). - Survey of surfaces following earthworks to confirm completion to plan (P). - Evidence from rehabilitation monitoring quadrats or adjacent rehabilitated areas of simple invertebrate assemblages via observations of invertebrate pollinators (e.g., visiting flowers) and ants by year 3 (C). - Evidence from rehabilitation monitoring quadrats or adjacent rehabilitated areas of complex invertebrate assemblages via observations of invertebrate pollinators (e.g., visiting flowers), ants and other invertebrate groups by year 5 (C). - Evidence from rehabilitation monitoring quadrats or adjacent rehabilitated areas of occasional vertebrate utilisation via infrequent bird sightings (e.g., visiting flowers, hunting, roosting) or indicators of other vertebrates (e.g., tracks, scats, burrows) by year 7 (C). - Evidence from rehabilitation monitoring quadrats or adjacent rehabilitated areas of common vertebrate utilisation via numerous bird sightings (e.g., visiting flowers, hunting, roosting) or indicators of other vertebrates (e.g., tracks, scats, burrows) by year 10 (C). - Evidence of leaf litter or other organic detritus are present in >25% of rehabilitation monitoring quadrats by year 5, >50% by year 7 and 100% by year 10 (C). - Audit at completion - Residual risk of feral animal impacts has been assessed and there is documented	- AERs and required management plans (submitted during operations phase) - MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved and includes: - Feral animal risk assessments. - Survey reports. - Landowner acceptance of management requirements exceeding those typical of the PMLU
			R39	Mine Voids (BWT)				

Ref	Closure Outcome	Aspect	Risk ID	Domain (Site if not all sites)	Completion Criteria	Performance Indicators	Measurement tools and timing	Reporting
							acceptance of any ongoing management requirements exceeding those typical of the PMLU by the post-relinquishment landowner / manager (C). - Survey reports showing completion to plan (P). - Landform stability (surface, geotechnical and geochemical) (3), vegetation establishment (7.2) and weed (7.3) criteria are met (C). - Monitoring demonstrates achievement of the completion criteria (C).	
9.2	Influence of pit lakes on native fauna <i>Pit lakes do not adversely impact native terrestrial fauna.</i>	Flora and fauna	R40	Mine voids – mined BWT	There is no significant pathway at closure for pit lakes to act as a source of contaminants for native terrestrial fauna (C).	- A pit lake risk assessment has been conducted (C). - Appropriate management measures have been developed, in consultation with the relevant stakeholders, if a potential for unacceptable impacts to native fauna populations have been identified (C).	- Audit of progressive completion: - Pit lake risk assessment (based on conceptual source-pathway-receptor model) is documented in MCP (C). - Management measures, if required, informed by pit lake risk assessment and consultation with DBCA and approved via MCP (C). - Approved management measures have been completed as planned (P). - Annual monitoring of pit lake quality until trends are established that support assumptions of the source-pathway-receptor model (Q). - Audit at completion: - Pit lake quality monitoring results support assumptions of the source-pathway-receptor model (P).	- Pit lake monitoring results reported in AERs and / or MCP updates. - Completion Report submitted for domain or site when all completion criteria achieved including data supporting assumptions of the source-pathway-receptor model.

9. CLOSURE IMPLEMENTATION

Statement Of Compliance With Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes:

- *A closure work program for achieving the closure outcomes, with implementation strategies and timeframes for each domain and / or feature of the mining operations (Section 9.2 and 9.3)*
- *Contingencies for premature or early closure or suspension of operations (Section 9.4).*

To satisfy the agreed closure outcomes (Section 8.1), the Carina Operations will be closed and rehabilitated by implementing the work programs described in this section. The approach to closure implementation is as follows:

- Standard work practices and management approaches are described in Section 9.1 and will be applied to closure and decommissioning works, as appropriate.
- Work programs specific to each closure domain and feature are outlined in Section 9.2 and will be progressively refined and implemented as each domain / feature approaches closure. The approach to achieving closure outcomes for different features within a domain type may vary depending on the site history. Work programs will be refined as studies, investigations and design work are completed and will incorporate feedback from monitoring. These refinements will be detailed in future revisions of the MCP.
- Progressive closure and rehabilitation will be undertaken, where possible, to demonstrate commitment to achieving the closure outcomes and maximise the opportunities for continuous improvement and adaptive management. Section 9.3 outlines the progressive closure works completed since the last MCP revision and the works planned to be completed between 2024 and 2026.

Although closure planning is generally applicable to an operation's planned life and, therefore, reflects the type of landforms, infrastructure and other features present on site at the end of mine life, contingencies for early closure are also considered as discussed in Section 9.4.

Section 9.5 collates the forward work programs identified in Sections 5, 7 and 9.2. These programs will be used to refine closure work programs and completion criteria.

9.1 Closure and Rehabilitation Standard Work Practices

This section outlines the standard closure and rehabilitation procedures and practices adopted for the Carina Operations (Sections 9.1.1 to 9.1.8). Where these work practices address a specific closure risk, they are also referenced in Table 53. In addition to closure procedures and practices, MinRes has developed an environmental management plan (Section 3.6) and procedures governing operational activities to meet regulatory commitments and obligations. These will be applied to the closure phase, as appropriate.

All MinRes plans and procedures referenced in this MCP may be refined from time to time to incorporate current best practice, monitoring feedback or stakeholder input. Where there is a difference between the information in this MCP and the plan or procedure held within the MinRes Document Control Management System (DCMS), the document within DCMS shall take precedence.

To maintain quality control over rehabilitation works, MinRes has instigated the development of work packs which describe reshaping and rehabilitation works to be conducted. A construction supervisor

checks that works are performed in accordance with the work packs, and the work packs are signed off once completed.

9.1.1 Closure and Rehabilitation Responsibilities

The Yilgarn Operations Land Rehabilitation Procedure (MRL-EN-PRO-0009) requires that:

- Mine rehabilitation forms part of the mine planning process.
- Mine rehabilitation is progressively implemented.
- Works are conducted to a standard that aligns with rehabilitation objectives and criteria.

The procedure does not provide technical guidance which will vary from site to site but does outline responsibilities for:

- Material characterisation to identify future risks or opportunities for positive rehabilitation outcomes.
- Encapsulating or otherwise containing materials representing a risk to the environment or human health.
- Material scheduling, including topsoil, subsoil, competent waste rock, saline, sulfidic or asbestiform materials and opportunities for backfilling.
- Landform design, including location on the site, provision for drainage, erosion control, encapsulation of PAF or saline materials, cover systems, final slope angle, lift height and berm width on landforms and type and depth of surface material (e.g., topsoil, rock armouring).
- Managing topsoil and subsoil resources (where present) so that they are utilised efficiently, and to promote vegetation growth and reduce contamination, destruction, resource loss or weed presence.
- Surface treatments, including deep ripping of compacted areas, contour ripping of slopes and scarification.
- Species selection for seeding (assuming topsoil is either not used or cannot provide sufficient seed to achieve the desired outcome).
- Making provision for any special requirements such as use of woody debris, or special measures to encourage fauna colonisation etc.
- Research / trial requirements if established industry standards are not suitable for site conditions.
- Monitoring rehabilitation and associated analogue sites and assessing against closure criteria.
- Reporting progress of rehabilitation work in Annual Environmental Reports (AER), MRF submissions and any other statutory reports required.

9.1.2 Landform Design

The closure landform will be achieved through integrated planning for the closure of the domains described in Section 2.4 including:

- Mine pits and associated abandonment bunds.
- WRLs.
- Footprints of ROM pads, stockpiles and decommissioned infrastructure.
- Retained infrastructure and access features.

Landform design is governed by closure obligations and commitments, PMLU and closure objectives, and is informed by the following inputs:

- The surrounding topography, landscape features and visual amenity.
- Hydrological data and modelling.

- Hydrogeological data and modelling.
- Physical and chemical characterisation of waste rock material.
- Stability and erosion assessments.
- Proximity of conservation significant flora, conservation significant fauna habitat, heritage sites and surface water features.
- Closure risk assessment.
- Stakeholder input, including requirements for safe access post-closure.
- Mine planning considerations.
- Performance assessment of closed areas and avoiding disturbance, where possible, of rehabilitated areas that are on a trajectory to meeting completion criteria.

Landform designs for mine pits and WRLs have been progressed as outlined in Section 9.2. Work will continue to refine closure designs for inclusion in future revisions of the MCP.

9.1.3 Management of PAF / Materials with Elevated Sulfur

9.1.3.1 Identification

Waste materials are characterised prior to, and during mining operations to inform handling requirements.

Prior to mining, samples are collected from resource definition drill programs, geochemically analysed and reported by subject matter experts for review and incorporation into the MCP. As this data is often limited due to drill holes targeting mineralisation, or occurred historically without further geochemical analysis, additional sampling and testing is undertaken during mining using either blasthole or pit floor samples.

During mining operations, on-site mining geologists undertake blasthole sampling of all waste rock types where the mining model flags material with Total Sulfur > 0.3% and select locations for lower risk material. The sampling and testing program is conducted in accordance with the most recent approved version of the MinRes waste rock management procedure which has been developed to align with the Preventing Acid and Metalliferous Drainage - Leading Practice Sustainable Development Program for the Mining Industry (DISER, 2016c). A minimum of one sample per 40,000 US tons will be collected for each lithology and weathering. Where more than one waste lithology / alteration type exists, sample numbers are skewed to reflect the percentage of waste per lithology type. Samples are tested for static geochemistry parameters.

All transitional and fresh waste material recording Total Sulfur > 0.3% is conservatively classified as PAF material until testing indicates otherwise.

9.1.3.2 Management

Based on the specific geochemical characteristics and volumes of the waste materials at any deposit (including NAF / PAF material ratios, MPA and ANC), PAF material will be managed through either backfill / left in-pit below water table, or encapsulation in an ex-pit WRL. Specialist advice is sought to determine the appropriate management methodology prior to the development of a mine pit and / or progressively during the mining operation, as required.

During mining of the J4 East Pit (MinRes, 2023a), waste placement audits are planned that will inform the as-constructed status of the J4 West backfill and J4 West WRL for closure.

Management of PAF / oxidised materials associated with already constructed landforms has been investigated as part of MinRes' closure study program (as discussed in Section 5). Recommendations

arising from these investigations have been incorporated into the designs outlined in Section 9.2 and 9.3. PAF / oxidised materials management measures will be refined, if required, as new information becomes available.

Records of PAF material placement will be maintained as described in Section 12.

9.1.4 Rehabilitation Earthworks and Revegetation

Following the landform shaping and drainage works for each domain (Section 9.2), surface preparation for areas to be rehabilitated will involve:

- Ripping on contour and deep ripping if ground is compacted (e.g., former hardstand areas, transport corridors).
- Applying the outcomes of rehabilitation trials and other investigations relevant to surface treatment methods (e.g., topsoil spreading depths and timber debris application) as knowledge gaps are addressed (Section 9.5).
- Spreading available topsoil or appropriate growth media.
- Where available tree debris and large rocks may be used during rehabilitation works to provide fauna habitat.

To facilitate revegetation of these areas:

- Topsoil, and subsoil where required, will be recovered to maintain soil quality and maximise potential for germination of the seed resource. Stockpiled topsoil and subsoil will be signposted to prevent accidental use or degradation.
- Saline water will not be used for dust suppression on stockpiled topsoil.
- Stockpiled topsoil at all sites will be tested prior to use and excluded if found to have growth limitations (e.g., excessive salinity).
- All seed used in rehabilitation of the Carina Operations will be local provenance native seed sourced from the Coolgardie IBRA region. Seed collection training was undertaken in 2022, with the Marlinyu Ghoorlie people.
- Reference ecosystems and associated rehabilitation seed mixes are being refined for the various domains with consideration to:
 - The agreed PMLU.
 - The attributes of the domain that are relevant to establishing and sustaining vegetation. WRLs and mine pits backfilled to surface for example have modified geomorphology, hydrological characteristics and, in some cases, saline substrate conditions that need to be considered.
 - Creation of fauna habitat.
 - Incorporating priority flora where appropriate and possible given the landform and substrate to be rehabilitated and the current knowledge of seed germination.
 - Stakeholder consultation.
 - Progressive rehabilitation monitoring and trial results.
- Seed mixes are also designed to assist in building resilience to stressors, including drought and fire, through species selection and diversity.
- A catalogue detailing the species and volume of seed available in storage is maintained. Rare and Priority flora seed is stored with a commercial provider.
- Seed will generally be spread in May / June i.e., just prior to expected winter rainfall. Aerial seeding (using drones) was trialled to spread seed at the Yilgarn Operations in 2022 and 2023. Records of

the seed mix deployed against flight path have been mapped and provided to MinRes. MinRes will review the results and consider using this technique at the Carina Operations.

The Carina and J4 PEMP (Polaris Metals, 2023) will be applied as relevant to rehabilitation earthworks, topsoil handling and revegetation activities, including:

- Management of saline water used for dust suppression.
- Implementing weed / dieback hygiene procedures for equipment and vehicles involved in rehabilitation works.
- Limiting movement of vehicles to designated access routes and areas, especially during wet conditions and imposing speed limit.
- Managing personnel and vehicle traffic to avoid identified areas of weed / dieback infestation and dry, dust prone areas that are not active work areas.

9.1.5 Protection of Cultural Heritage

There is the potential for closure designs and works to impact on sites of cultural heritage directly or indirectly (e.g., via landform instability or erosion). All work will be conducted in compliance with the *Aboriginal Cultural Heritage Act 1972*.

Avoidance of identified heritage sites in closure designs will be the primary management tool for their protection from direct disturbance. Where avoidance of identified heritage places is not practicable, Polaris will seek to consult with the relevant Native Title Group to conduct appropriate heritage studies and apply for heritage approvals to disturb in accordance with the amended *Aboriginal Heritage Act (1972)*.

Procedures established during the operations phase are implemented, where applicable to closure, to minimise inadvertent impacts to heritage places during closure implementation. This will include the Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001), which stipulates conditions to be adhered to prior to any land clearing. Conditions such as demarcation of heritage places to be avoided or protected, or confirmation that the relevant Native Title Group has approved disturbance according under appropriate regulatory processes. MinRes maintains a GIS database that is utilised to locate identified heritage sites during planning (Section 12).

Indirect impacts to heritage sites post-closure are managed via the achievement of the closure objectives and completion criteria discussed in Section 8.

Post-closure aspects of relevance to Traditional Owners, including cultural values, repatriation of artefacts and access, will be discussed with the relevant Native Title Group through the stakeholder engagement process. All work will be conducted in compliance with the amended *Aboriginal Heritage Act (1972)*.

9.1.6 Protection of Flora, Vegetation and Fauna

There is the potential for closure designs and works to impact on flora, vegetation, fauna and fauna habitat directly or indirectly.

Protection of Flora and Fauna at the Carina operations is a specific requirement of MS 852 as follows:

- Condition 5-1 The proponent shall implement the proposal so that it does not adversely affect vegetation, in particular S2 and W22 vegetation communities.
- Condition 6-1 Prior to ground disturbing activities the proponent shall prepare and submit strategies to avoid fauna deaths in areas of mining, the haul road, the rail siding and other areas associated with the proposal.

Minimising disturbance to flora, vegetation and fauna habitat, and avoidance of conservation significant species, in closure designs will be the primary management tool for their protection from direct impacts. Where clearing outside approved disturbance envelopes or direct impacts to conservation significant species cannot practically be avoided to achieve safe closure, Polaris will consult with the relevant stakeholders, complete pre-clearing surveys, as required, and seek the necessary approvals for disturbance under the EPBC Act or BC Act. Inadvertent direct impacts to flora and fauna habitat (including Malleefowl mounds) will be minimised by implementing the Land Activity Permit (LAP) & Clearing Procedure (MRL-PD-PRO-0001) which requires a number of checks to be undertaken prior to any land clearing, including that regulatory approvals are in place, environmental constraints are considered, and sites to be avoided or protected are stipulated. MinRes maintains a GIS database that is utilised to locate flora and fauna areas of significance during planning (Section 12).

Direct impacts to native fauna during the closure implementation phase (e.g., vehicle strike, entrapment) will be managed by implementing the PEMP (Section 3.6) as applicable to closure, including requirements for workforce education, access management, speed limits, signage and feral animal control. As decommissioning plans are refined, they will consider the potential for entrapment of fauna in infrastructure during dismantling, backfilling and earthworks processes, and stipulate management requirements.

Indirect impacts to flora, fauna and fauna habitat during the closure implementation phase (e.g., via dust, saline water spray, sediment, weeds, dieback, fire or feral fauna) will be minimised by implementing the PEMP and relevant MinRes procedures as applicable to closure (Section 3.6)

Indirect impacts to flora, fauna and fauna habitat post-closure are managed by the achievement of closure objectives and completion criteria discussed in Section 8.

Requirements for post-closure access to areas of significant flora and fauna habitat will be discussed with DBCA in the stakeholder engagement process.

9.1.7 Contamination Assessment and Management

Where possible, sites with the potential for soil and groundwater contamination will be managed during the operations or progressive closure phases. However, there are a number of facilities required for the life of the operations that will require contamination assessment and management during the final closure phase. Where this is the case, infrastructure rehabilitation plans will incorporate investigation, remediation and validation sampling of these sites in accordance with the requirements of *the Contaminated Sites Act, 2003*.

The potential for contamination during the closure implementation phase will be minimised by implementation of the Hydrocarbon and Chemical Management Procedure (MRL-EN-PRO-0002), as relevant.

9.1.8 Site Safety, Security and Access

Abandonment bunds will be installed to prevent inadvertent access to remaining mine voids as detailed in Section 9.2.1.1.

Site infrastructure that is not transferred to a third party will be decommissioned and removed as detailed in Section 9.2.4. The current base case for closure is that all infrastructure will be removed, other than the roads required for post-relinquishment access as discussed below.

Stakeholder consultation is ongoing to inform the final landform design and retention of roads and tracks necessary for the post-mining land use and to enable Traditional Owners to access places of importance. Designs will also address access requirements arising from tenement conditions (Appendix A-1) and any obligations to third parties with existing access agreements or ownership of infrastructure

within the Carina Operations vicinity. Progressive commitments to post-relinquishment access, including a review of existing third-party agreements, will be incorporated in future revisions of the MCP.

Prior to site relinquishment, signage, fencing, locked gates or other security measures will be installed as required.

Tenement conditions also include a number of access notification requirements prior to works on DBCA or pastoral lands or in the vicinity of public infrastructure areas (0) that will be incorporated into closure works programs, as they are developed for these areas.

9.2 Domain Specific Closure Tasks

9.2.1 Mine Pits

The current status and closure strategy for each of the mine pits is summarised in Table 55. Further details are provided by site in Sections 9.2.1.2 to 9.2.1.5. Details of closure activities / designs applicable to all pits are provided in Section 9.2.1.1. Where additional works are required to finalise designs, these have been summarised in the relevant sections and / or included in the forward work program outlined in Section 9.5.

Table 55 Mine Pit Status and Closure Summary

Pit	Status	Pit lake	Residual Void	Backfill
Carina				
Carina	Mining complete BWT Partially backfilled	✓		✓
Carina Extended	Mining complete BWT	✓		
J4				
J4 East	Active mining BWT	✓		
J4 West	Mining complete BWT Active backfill			✓
Aurora				
Aurora	Mining complete AWT Included underground workings reported as sealed, but to be confirmed, refer Section 9.2.1.5)		✓	

9.2.1.1 Closure Activities/ Designs Applicable to All Pits

Abandonment bunds will be constructed around all pits to prevent inadvertent access post-closure. The final location of the abandonment bunds will consider:

- The ZOI of the pits, as discussed in Section 5.4.2.
- Minimising disturbance to vegetation and habitat (Section 9.1.6) and operating within approved disturbance envelopes (Section 5.5.1.1.1).
- The topography surrounding the pit. Where WRLs are inaccessible by vehicle, it has been proposed that they can be used as part of the abandonment bund strategy to minimise disturbance requirements (DBCA preference, refer Section 8.2.1). MinRes notes however DEMIRS' comments that the department is generally not supportive of WRLs forming part of the abandonment bund

strategy but will consider individual proposals outside guidance, based on risk (consultation in June 2022; 0). MinRes proposes to continue to discuss this matter with DEMIRS where applicable (Section 4.1.3).

Abandonment bunds will be constructed in accordance with the DoIR (1997) Safety Bund Walls Around Abandoned Open Pit Mines Guideline and will be 2 m high with a base width of 5 m. Where construction of the abandonment bunds will require clearing of undisturbed areas, pre-clearing surveys will be conducted for significant flora, fauna and heritage sites as discussed in Sections 9.1.5 and 9.1.6.

Signage will be installed at all entry points to alert the public of a closed mine in the area and advising that there is no access. Access roads to the pits will be closed and rehabilitated.

9.2.1.2 Carina and Carina Extended

The Carina Pit and Carina Extended Pit will remain as pit lakes. The Carina Pit is partially backfilled. Closure studies indicate that:

- The pits will remain as sinks with the potential for throughflow from Carina Extended Pit to the Carina Pit.
- Pit lake levels will equilibrate to levels in the order of 90 m below the pit crest levels. A 1:2,000 year 72-hour rainfall event, depending on the antecedent lake levels, would raise pit lake elevation by less than 5 m and 9 m for the Carina and Carina Extended Pits, respectively.
- Water in the pit lake will become more saline over time due to evapo-concentration (135,000 – 180,000 mg/L at Carina after 80 years and will exceed solubility limits at Carina Extended). Exposures of PAF on the Carina Pit wall post-closure and potentially in backfill will also influence pit lake chemistry.
- The Carina Pit is located within the 1 in 2,000 and PMF event flood plains. A flood protection bund is recommended for the southeastern portion of the abandonment bund as discussed in Section 9.2.1.2.1.
- The north east section of the Carina Pit abandonment bund is within the conservative ZOI projection.
- A small 6 ha catchment could result in flow adjacent to the Carina Extension abandonment bund and cause erosion in a PMF event. While this risk is not significant from a surface water perspective (Section 5.6.1.4.1), it should be considered when finalising the abandonment bund design and armouring applied if necessary).

A number of forward work requirements have been identified (Section 9.5) to inform closure planning for the Carina and Carina Extended Pits.

9.2.1.2.1 Carina Flood Protection Bund

A flood protection bund has been recommended for the southern portion of the Carina abandonment bund (Section 5.6.1.6) with minimum crest elevations to provide a 0.5 m freeboard for the PMF flood event and, using the Austroads (2013) AGRD05 manual as a guide, facing rip rap between set out points CL1 and CL2 (Figure 91 and Table 56). Geotechnical and construction specifications for the flood protection bund need to be developed.

Table 56 Flood Protection Bund Setout Points

Setout Point ID	Easting (m)	Northing (m)	Minimum Bund Crest Elevation (m RL)
CL1	788,550	6,626,235	453.7
CL2	788,560	6,625,985	452.1
CL3	788,315	6,625,820	451.0

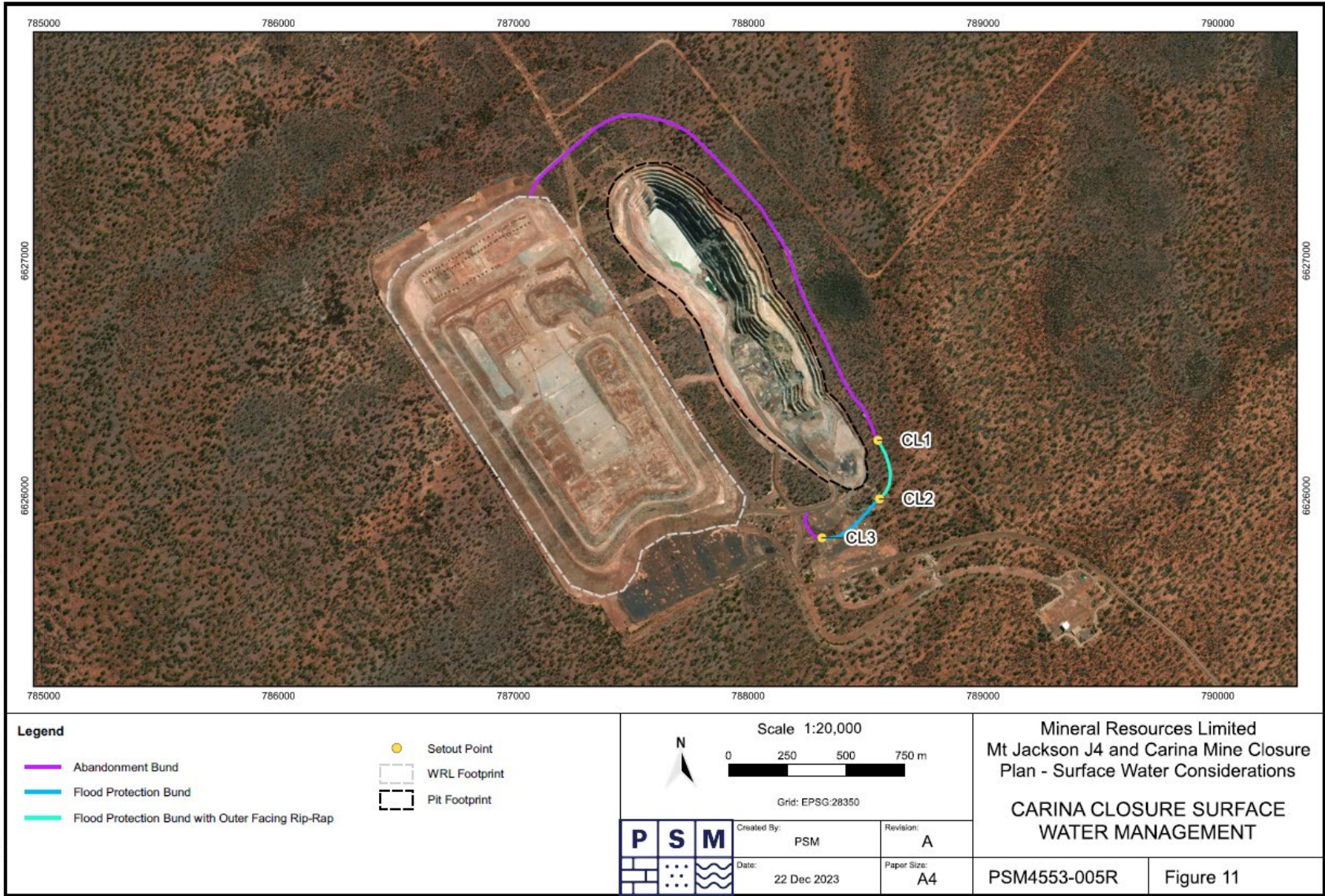
Source: PSM Consult (2024)

Table 57 Austroads Rock Slope Protection Rip Rap Design

Flow velocity (m/s)	Rock protection class	Rip rap layer thickness (m)	D ₁₀ (mm) ¹	D ₅₀ (mm) ¹	D ₁₀₀ (mm) ¹
< 2.0	None	-	150	300	400
2.0 – 2.6	Facing	0.50	200	400	550
2.6 – 2.9	Light	0.75	300	550	750
2.9 – 3.9	¼ tonne	1.00	400	700	900
3.9 – 4.5	½ tonne	1.25	550	900	1,150
4.5 – 5.1	1 tonne	1.60	750	1,150	1,450
5.1 – 5.7	2 tonnes	2.00	900	1,450	1,800
5.7 – 6.4	4 tonnes	2.50	150	300	400

Source: PSM Consult (2024)

¹Notes: D_x denotes a rip rap diameter (D) where x% is finer by weight.



Source: PSM Consult (2024)

Figure 91 Closure Surface Water Management - Carina
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9.2.1.3 J4 East Pit

The J4 East Pit will remain a pit lake. Closure studies indicate that:

- The J4 East Pit will remain as a groundwater sink.
- Pit lake levels will equilibrate to levels of ~85 m below the pit crest levels. A 1:2,000 year 72-hour rainfall event depending on the antecedent lake level, would raise pit lake elevation by less than 5 m.
- There is negligible flood risk at the J4 site.
- Water in the pit lake will become more saline over time due to evapo-concentration (estimated to reach 77,000 – 135,000 mg/L after 80 years). Higher sulfur materials within the pit walls have the potential to influence pit lake chemistry.
- Assessment of the J4 East ZOI at the completion of mining will inform any requirement for remedial works on the J4 East WRL prior to closure and location of the abandonment bund.

A number of forward work requirements have been identified (Section 9.5) to inform closure planning for the J4 East Pit.

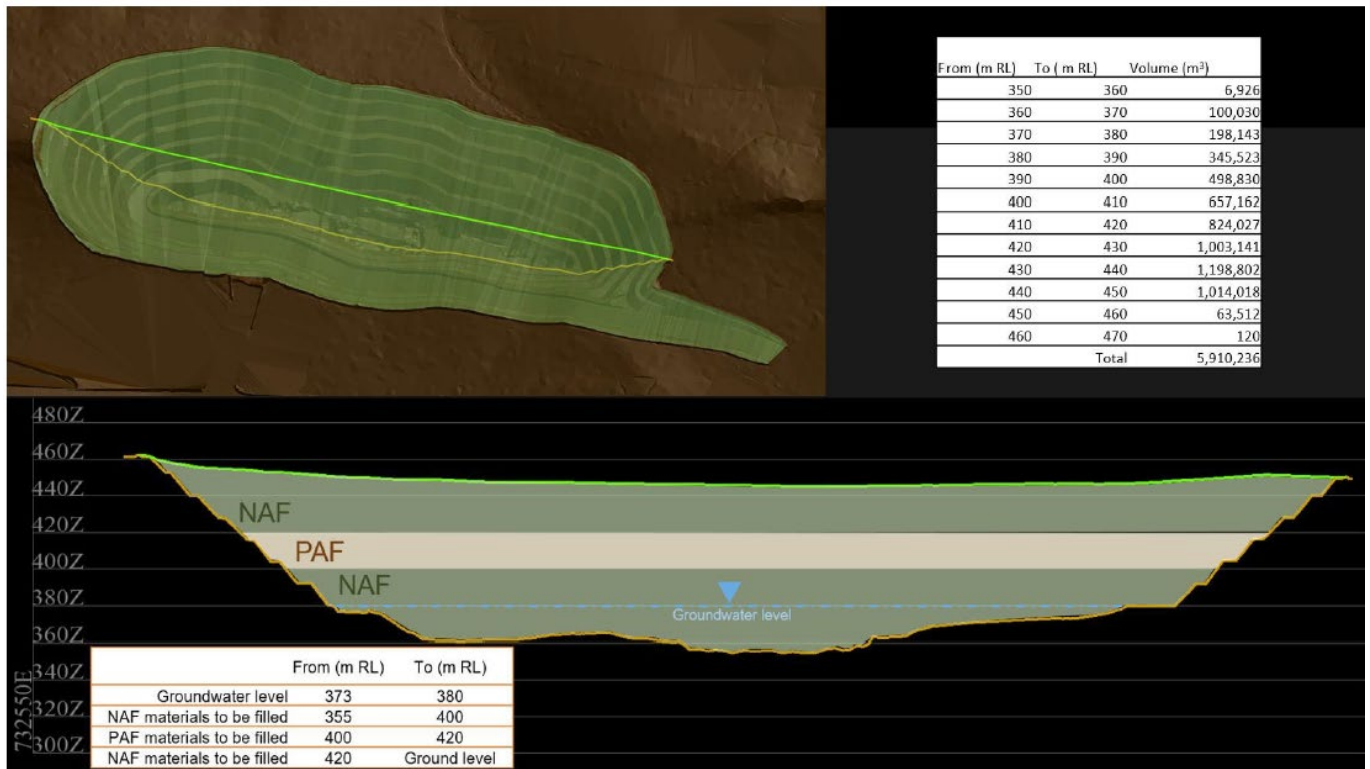
9.2.1.4 J4 West Pit

The J4 West Pit will be backfilled with waste material from the J4 East Pit.

The backfill will include a PAF encapsulation cell as detailed in the J4 East Redevelopment MP (MinRes, 2023a) with the following design features (Figure 92):

- The pit will be backfilled with non-dispersive and NAF material to approximately 20 m above known groundwater level (~ 380 m AHD), i.e., to 400 m AHD.
- PAF material will be deposited between 400 m AHD and ~ 420 m AHD.
- PAF material will be covered with a 20 m layer of non-dispersive and NAF waste material to surface level ~ 460 m AHD. The cover will be designed to minimise oxygen ingress and infiltration and be resistant to surface erosion.

Waste will be deposited into the pit by haul truck and compacted. Limited settlement is expected; however, the area will be subject to inspections for 12 months following the completion of the backfill, prior to final contouring and placement of topsoil. Due to the relatively small surface area of the backfilled pit, and the outcome of backfilling the pit to natural surface levels and directing flows away from the surface of the backfilled area, surface water ponding is not anticipated to be significant (MinRes, 2023a).



Source: MinRes (2023a)

Figure 92 J4 West Backfill – PAF Management

9.2.1.5 Aurora Pit

The Aurora Pit will remain as a dry void. Closure studies have identified that:

- The current abandonment bund is within the ZOI of the pit and does not meet design geometry requirements.
- A conceptual new abandonment bund location and design has been reviewed to demonstrate that it would prevent pit capture of flood waters during a PMF event.
- Flood modelling indicates negligible scour and erosion potential for the conceptual abandonment bund location (i.e., no armouring required) (Section 5.6.1.4.3).

Historic underground workings are reported to have been sealed but this requires confirmation. An air vent is still visible in the pit wall.

Materials characterisation has also been identified as a knowledge gap to be addressed to inform final closure designs for the Aurora site, including the final abandonment bund design.

9.2.1.6 Knowledge Gaps & Forward Work Program

Knowledge gaps and forward work actions identified throughout Section 5 of this MCP to inform closure plans for mine pits and abandonment bunds are summarised in Section 9.5.

The following additional tasks are required to progress abandonment bund designs to an execution plan:

- Consultation with DEMIRS and DBCA to confirm the location of abandonment bunds.
- Confirmation of waste rock sources with appropriate characteristics for construction of abandonment bunds.
- Assessment of additional clearing required for the construction of abandonment bunds (including clearing required for earthmoving machinery access during construction).

- Pre-clearing surveys (where required) for conservation significant flora and fauna, and heritage sites.
- Submission of regulatory approval request for abandonment bund works that require additional clearing.
- Progress the abandonment bund designs to an execution plan.

9.2.2 WRLs

Most of the WRLs at the Carina Operations have already been constructed and their as-built status has been assessed with respect to as-built design geometries, cover material properties and erosion. The Carina and Carina Extended WRLs are partially and fully rehabilitated respectively, and rehabilitation monitoring is ongoing. The J4 West WRL is receiving waste from the J4 East Pit. The closure pathway for each WRL is, therefore, different depending on its current status.

A summary of the proposed closure strategy for each WRL is provided in Table 50, with further details provided by site in Sections 9.2.2.2 to Section 9.2.2.6. Section 9.2.2.1 outlines general design principles and aspects of the closure strategy that will be applicable to all areas of WRLs that have not yet been rehabilitated.

9.2.2.1 Closure Design Principles and Strategy Applicable to all WRLs not yet Rehabilitated

For those areas of the Carina Operations WRLs that have yet to be rehabilitated, the following closure design principles will be implemented:

- WRL lift heights and batter angles will be as stipulated in the most recently approved MP or MP Amendment relevant to the site (or in accordance with minor variations approved via the MCP).
- Berms will be back sloped and have baffles installed along their length at nominally 50 to 100 m intervals.
- Berm width and geometry will be governed by the results of berm capacity modelling as relevant to each site.
- Top surface will be levelled so that they are relatively flat and internally draining.
- Ramps will be re-profiled as required.
- A crest bund with a minimum height of 0.5 m will be installed on the top surface of the WRL to prevent run-off down the batter slopes.
- Topsoil application, surface treatments, selection / development of reference ecosystems and seed mixes and seeding will be conducted generally in accordance with the procedures outlined in Section 9.1.4.
- Completion criteria will be refined to reflect reference ecosystem characteristics.
- Landform wide monitoring will be conducted generally in accordance with the procedures outlined in Section 10 until achievement of completion criteria can be demonstrated. A completion report will then be compiled and submitted as outlined in Section 10.5.

9.2.2.2 Carina WRL

As outlined in Table 50, closure studies completed since 2019 support a final landform design that:

- Rectifies departures from design geometry (including using one of the methods discussed in Section 9.2.2.2.1 to achieve berm capacity).
- Enhances the PAF encapsulation cell cover that has been confirmed to be adequate but could potentially be intersected by rehabilitation surface preparation activities (Section 9.2.2.2.2).

- Creates a convex cover over the PAF encapsulation cell and a concave cover elsewhere.
- Where rehabilitation has not yet been completed, minimises interaction between saline materials and the plant root zone.

9.2.2.2.1 Methods proposed to achieve berm capacity

Berm capacity modelling studies completed since submission of the previous MCP have proposed several options for achieving the minimum berm capacity at Carina.

Okane (2022a) proposed that to address the lift 2 height exceedance and meet berm capacity requirements across the Carina WRL:

- An additional berm (adding a fourth) could be added to the face between the first and second berm to effectively reduce the lift height to 10 m; or approval could be sought to retain the current height of the 2nd Lift subject to widening the associated berm to a width of 13 m. (Note however that the berm capacity modelling completed by Landloch (2023) and described below indicates that a berm width of 22 m is required for the current lift height of 15 m).
- Widen berms in most areas.
- Install sufficient back sloping on all berms (to 2-5°).

Landloch (2023) propose the following alternative to widening berms:

- Berm capacity requirements could be met by increasing the backslope gradient of the berm. For the Carina WRL example assessed, backslopes of 10° and 20° would be required to achieve the required berm capacity of the upper and middle slopes respectively. An increased backslope gradient can be achieved by either of the following methods:
 - Cutting material from the toe of the upper batter, which maintains a triangular section but can be difficult to execute and if underlying material is dispersive, the increased water head, caused by the increase backslope gradient, will promote tunnelling. Placement of dispersive material at the crest of the batter may also promote tunnelling at the edge of the berm.
 - Cutting material from the crest of the berm is more likely to achieve the required backslope gradient, minimise exposure of underlying material and more evenly distribute the depth of ponding across the berm reducing the risk of over-topping. Cut material may be placed on top of the crest bund or against the slope of the batter. But this method will result in a trapezoidal cross-section which MinRes considers has a greater risk of overtopping and failure.
- Regardless of which approach is used, it will be important to ensure:
 - Cut material is compacted on placement to prevent water from passing through.
 - Berms are not ripped.
 - The required berm capacity i.e., the volume with freeboard is maintained.

9.2.2.2.2 Materials Encapsulation Requirements

It has been demonstrated that the PAF encapsulation cell within Carina WRL has been built to design (Section 5.9.3.4) but to ensure that it is not compromised by surface treatment activities for rehabilitation:

- Okane (2023b) recommend the depth of cover of NAF waste material over the area of the inferred PAF cell and extending towards the north-east is increased, to reduce the risk of PAF exposure at the surface of the WRL during ripping and rehabilitation activities.
- Polaris (2011) committed to shape a convex surface over the top of the PAF encapsulation cell to shed water away from this portion of the waste landform (and shape a concave surface on the remainder of the waste landform plateau to promote water retention and infiltration rather than water shedding).

To ensure encapsulation of residual salt in the evaporation ponds located on the surface of the WRL during the operating phase Polaris (2011) committed to:

- Deeply bury the evaporation ponds once all water has dried to encapsulate the dry salt in the final waste landform.

These recommendations and commitments will inform assessment / design of the final surface cover of the Carina WRL during 2024, with any remedial works planned for implementation in 2025.

9.2.2.3 Carina Extended WRL

As discussed in Section 5.9.6.1 the WRL has been fully rehabilitated. Any rectification works at Carina Extended WRL would necessitate disturbance of rehabilitation which is displaying some positive trends (Section 5.9.3.1). It is acknowledged however that active erosion is still evident at all rehabilitation sites (Section 5.9.3.2.1).

Before proceeding with a plan to disturb establishing rehabilitation at Carina Extended, MinRes propose to:

- Review the two berm capacity modelling studies (Section 5.9.1) and parameters used to refine the recommended minimum berm width (which currently ranges from ~ 9 m to 10 m, based on freeboard of 0.01 m and 0.3 m respectively).
- Complete a more detailed assessment of the as-built berm widths on the Carina Extended WRL. The initial assessment identified the areas where berm width was less than 10 m, but actual berm width was only measured at one cross-section (Figure 76).
- Consider the results of two further years of erosion monitoring data.

Landform assessment identified a non-compliance with Lift 1 height, with the height of lift 1 ranging from 8 m to 18 m (vs planned 15 m) due to the undulating nature of the pre-mining surface. This exceedance is not considered significant and to avoid rehabilitation disturbance, approval for this design variation is sought via this MCP.

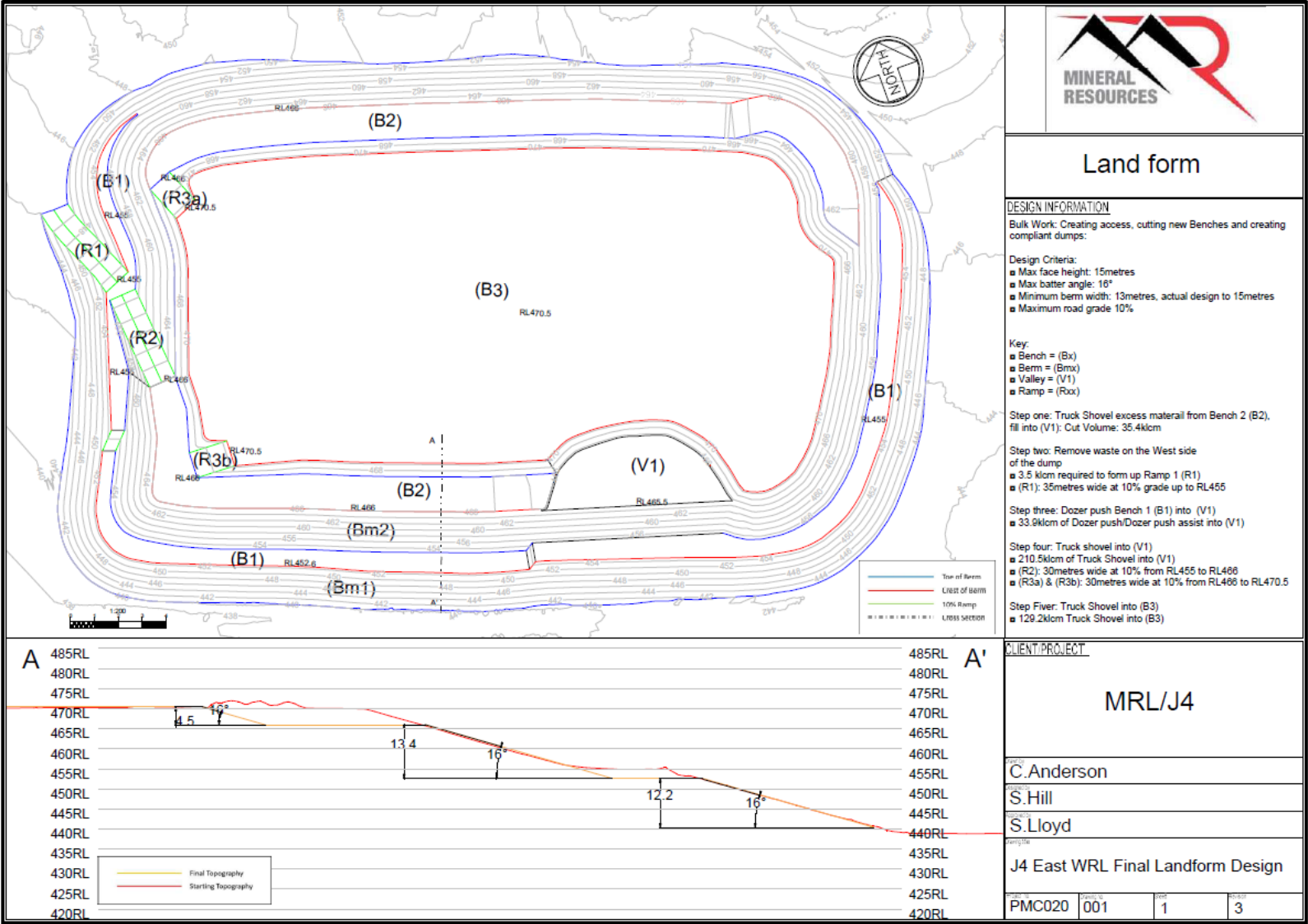
9.2.2.4 J4 East WRL

A preliminary landform rectification plan has been provided to DEMIRS (MinRes, 2023) (Figure 93 to Figure 97) and includes:

- Backfilling of the section on the southeastern side of the WRL.
- Construction of surface water control including back sloping of berms and construction of cell bunds / baffles.

The following forward work program has been identified to progress a final landform design for the J4 East WRL (Section 9.5):

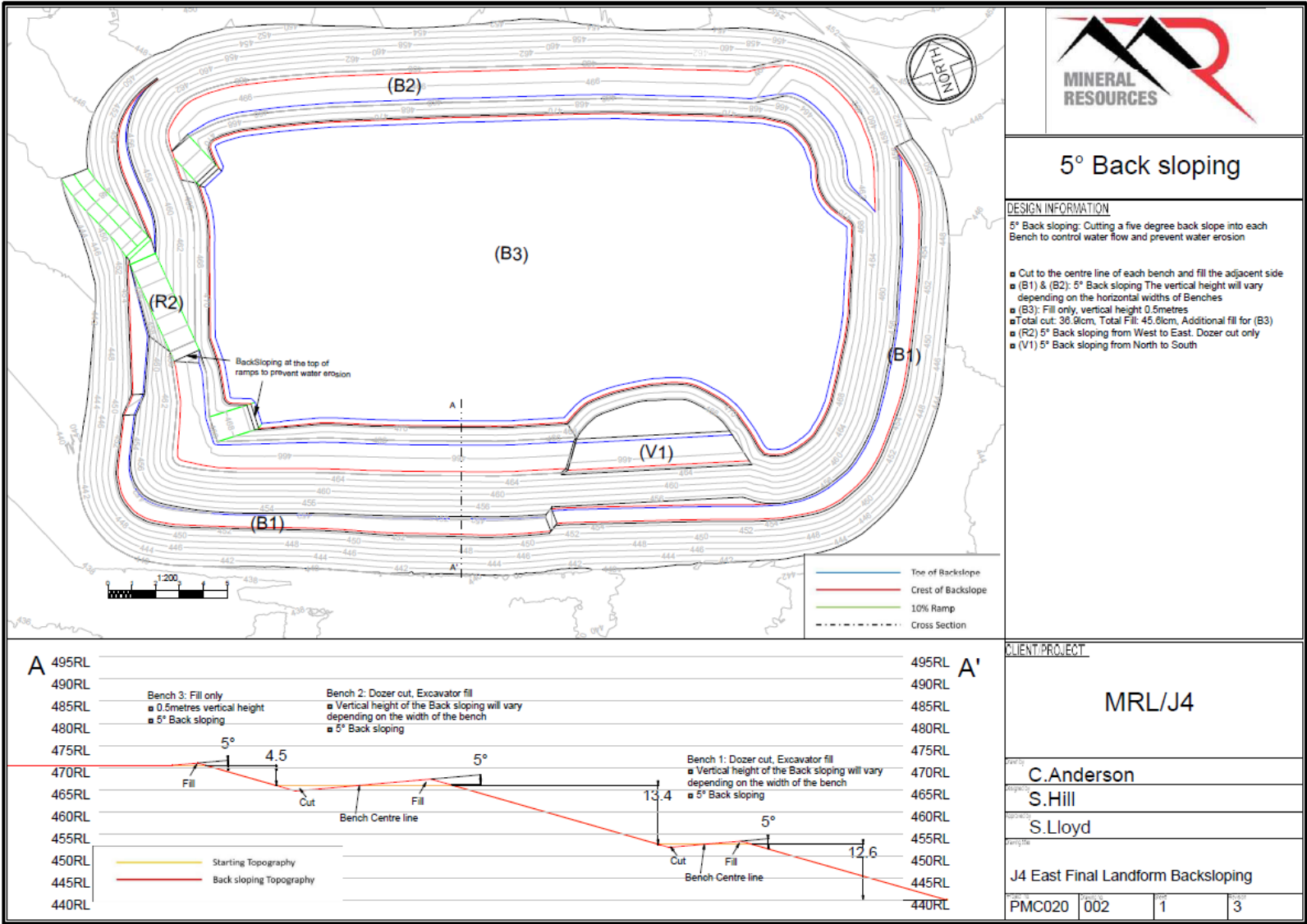
- Assess interaction of the WRL with the ZOI of the final J4 East pit shell.
- Review the cover materials that have been mapped as 'low stability' to determine whether one or a combination of treatments such as ripping, surface water controls or armouring, is the most appropriate treatment.
- Investigate depth of cover material necessary to prevent OAW (salinity) from impacting on revegetation success, where cover is practicable. Where cover is not practicable, use the salinity of the substrate materials (and closure objectives) to inform species selection for revegetation or supplementary seeding.



Source: MinRes (2023c)

Figure 93 Preliminary Design – J4 East WRL

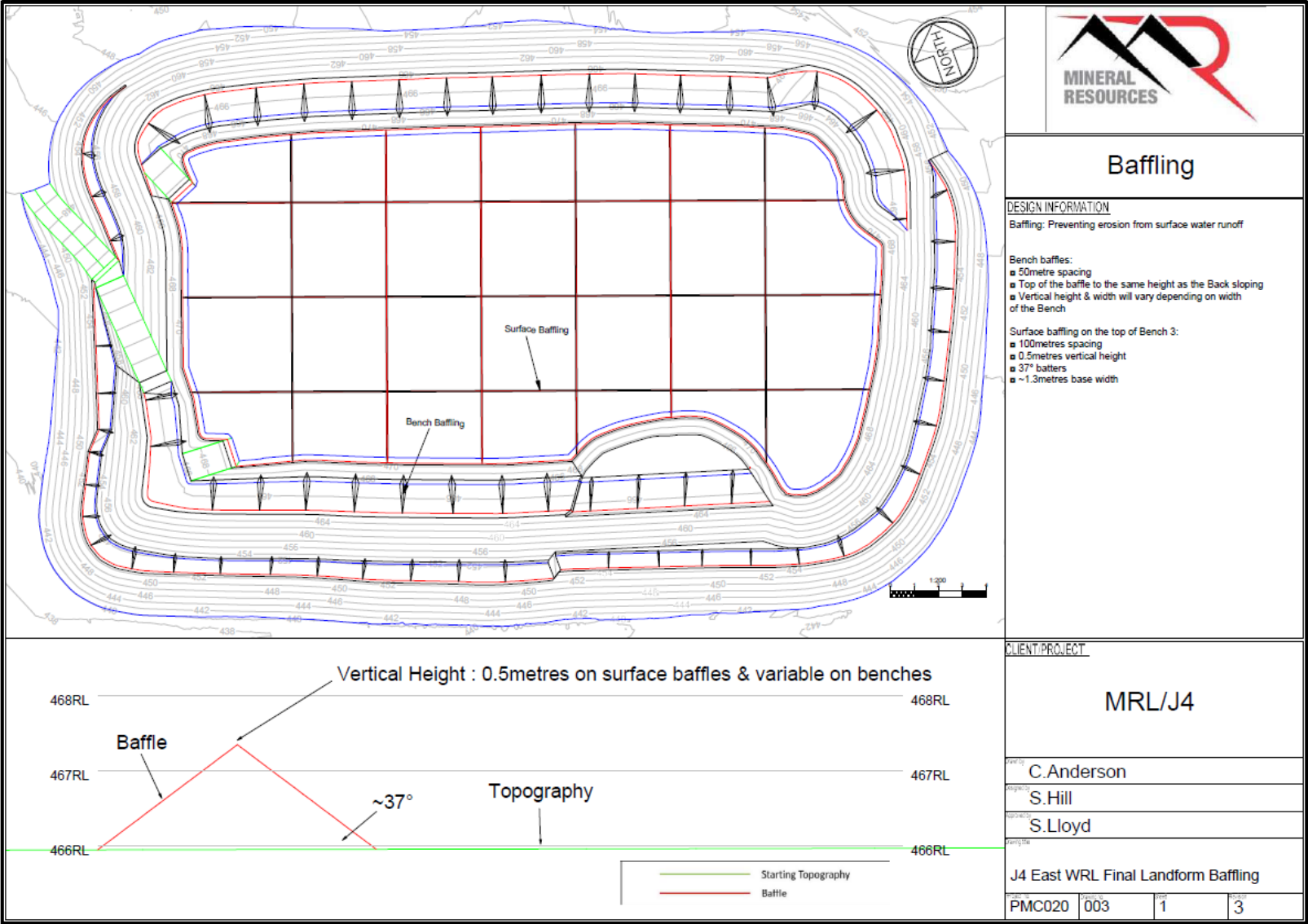
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Source: MinRes (2023c)

Figure 94 Back sloping J4 East WRL

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Source: MinRes (2023c)

Figure 95 Baffles J4 East WRL
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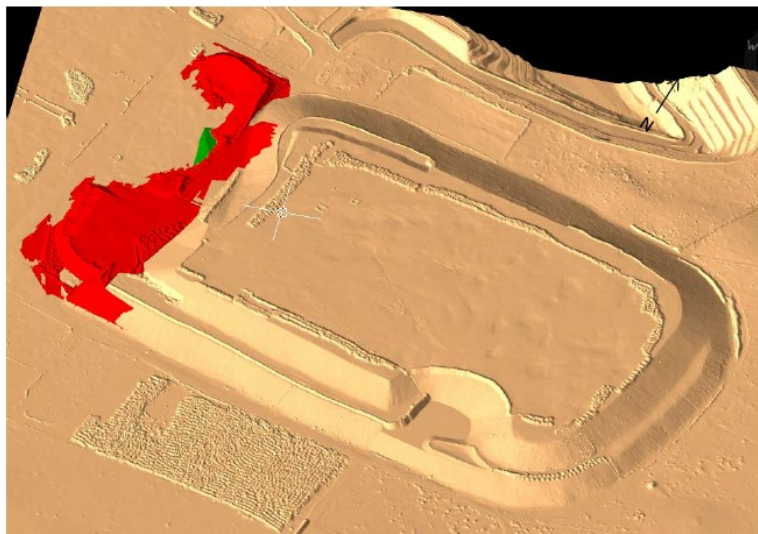


Figure 1 current J4 East WRL with mineralised waste indicated (red) for removal.



Figure 2 J4 East WRL stage 1 filling southeastern void lift 1, cut (red) and fill (green)

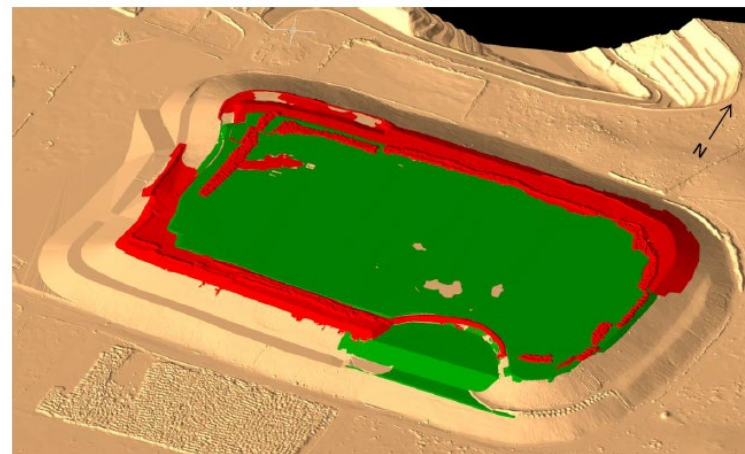


Figure 3 J4 East WRL stage 2 filling southeastern void lift 2, cut (red) and fill (green)

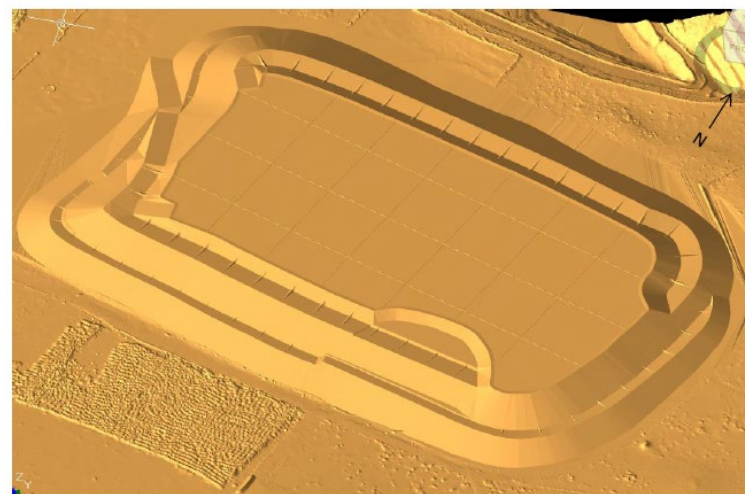


Figure 4 J4 East WRL preliminary closure design with backsloped berms and surface baffling (south-eastern void has been filled)

Source: MinRes (2023c)

Figure 96 J4 East WRL – 3D View of Current surface (top) vs Preliminary Rehabilitated Design (bottom)

9.2.2.5 J4 West WRL

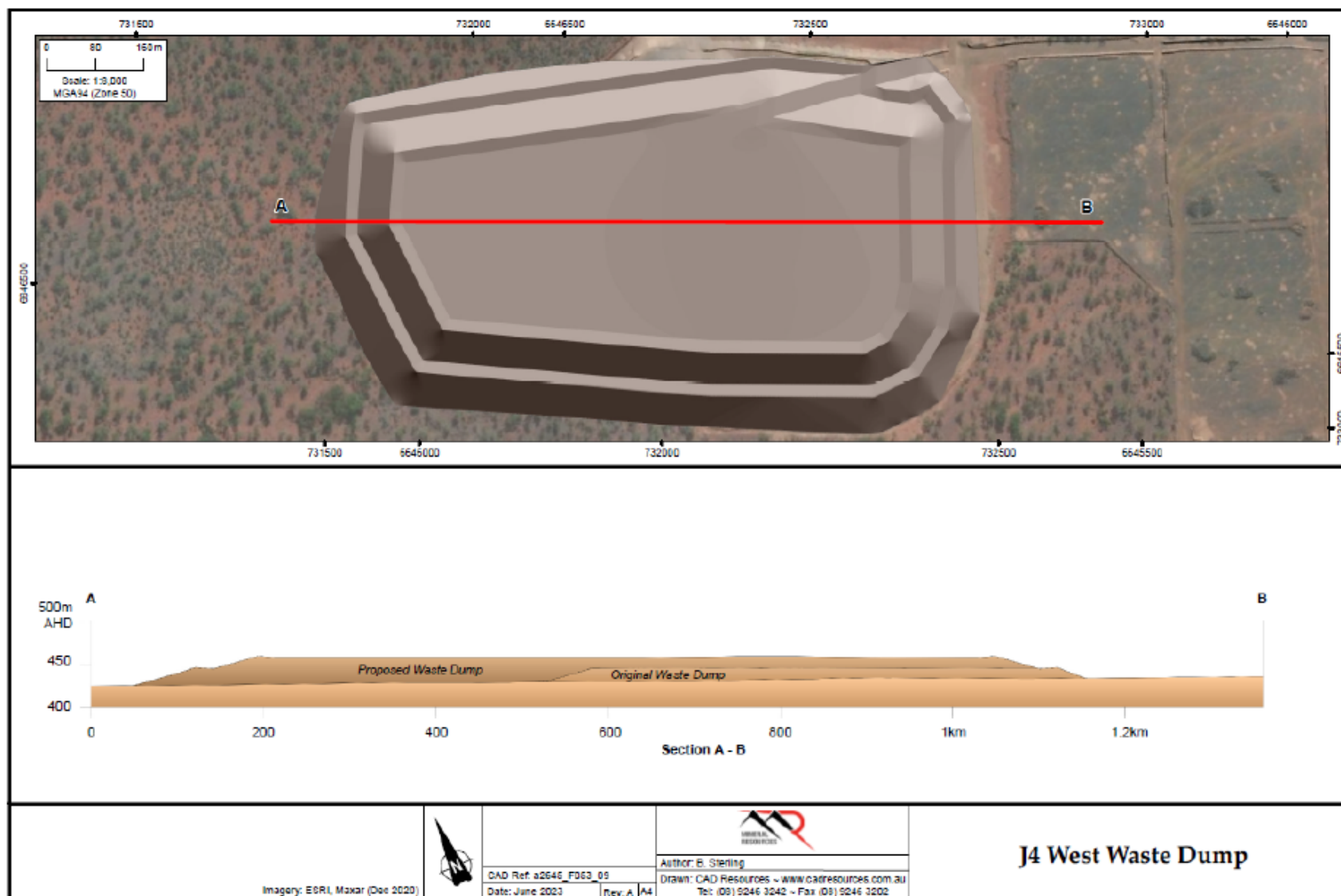
The J4 West WRL will be expanded as part of the J4 East Redevelopment. The indicative design is provided in Figure 97. Rectification of design non-compliances (Section 5.9.3.3) will occur as part of this expansion to achieve the design parameters outlined in the J4 East Redevelopment MP (MinRes, 2023a) (which are consistent with the MCP 2019 and the original J4 MP REG ID 56760 (Polaris Metals, 2015)) and provided below:

- Number of benches: 2
- Bench height: 15 m
- Berm widths to be minimum of 20 m.
- Batter angle no greater than 16°
- Height ~475 m AHD
- Berm to have a minimum 5° backslope (sufficient to store a 1:100- year 72-hour storm event with 50% storage capacity).
- Baffles located every 50 – 100 m along the berms to prevent lateral movement and convergence of surface water flow.

PAF materials from J4 East Pit will be backfilled into the J4 West Pit in the first instance and will only be encapsulated in the J4 West WRL as a contingency. Dispersive materials are not expected to be encountered but if identified would be handled in the same manner as PAF materials. OAW material will be managed subject to the outcomes of the forward work program described for the J4 East WRL (Section 9.2.2.4).

No major limitations were identified for use of the J4 Iron Ore Project stockpiled topsoil or rehabilitated WRL surface soils as a surface rehabilitation material (Mine Earth, 2022) (Section 5.3.5.1). Topsoil previously spread over the upper section of the lower lift batter on the southeastern face of the WRL (no contour ripping has been implemented) will be stripped and stockpiled.

The WRL batter areas dominated by low stability rock (majority of the southern and eastern slopes) will be assessed further to determine whether one or a combination of treatments such as ripping, surface water controls or armouring is the most appropriate treatment.



Source: MinRes (2023a)

Figure 97 Indicative J4 West WRL Design
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9.2.2.6 Aurora WRL

Although the Aurora WRL departs from the design criteria in that it occupies a greater footprint, the resultant lower height is a more desirable outcome for surface stability and rectification to the original design geometry is not recommended (Okane Consultants, 2022b). The poor erosion performance however does require rectification earthworks.

Rectification will involve installation of an adequate crest bunds and cells on the WRL plateau to manage stored water.

Despite installation of the crest bund, localised erosion is still expected to occur as a result of water captured on the slopes themselves. Materials characterisation data is required to assess this risk (Okane Consultants, 2022b) and progress the final landform design.

9.2.3 ROM Pads and Stockpiles

A summary of the ROM Pads and stockpile areas is provided in Table 58. The areas are considered operational or under review and therefore rehabilitation has not commenced. Detailed designs for rehabilitation will be prepared as the areas move towards closure.

Table 58 ROM Pad and Stockpile Status

Feature	Status
Carina ROM Pads (2)	Non-operational / under review
Carina Low Grade Stockpiles (Class 1) (3)	Not rehabilitated
Carina Southern Operations ROM Pad	Operational
J4 ROM Pad	Operational
J4 low-grade ore stockpile (Class 1)	Not rehabilitated / under review
J4 low-grade ore stockpile (Class 2)	Not rehabilitated / under review
Aurora low-grade ore stockpiles (Class 1) (two)	Not rehabilitated / under review

9.2.3.1 Stockpiles

The pathway for progressing remaining stockpiles to closure and completion is to either remove and process the stockpiles or prepare for rehabilitation as outlined below.

- Confirm the physical and geochemical characteristics of stockpiled material and determine whether it:
 - Contains PAF material and requires relocation to a designated area where it can be encapsulated with NAF material, or whether it can be left in place with a cover, or without a cover if NAF.
 - Is susceptible to erosion and requires relocation or the addition of competent waste rock.
- Develop rehabilitation work packs for execution which include provisions for:
 - Relocation of stockpiles and encapsulation with NAF material (if required) and rehabilitation of the underlying ROM pad (Section 9.2.3.2); or
 - Re-profiling the stockpile to erosionally stable slopes (based on material characteristics) that blend with the surrounding area, allow for drainage and address any requirements to encourage water shedding where stockpiles contain PAF material.
 - Covering any PAF stockpiles with NAF material designed to minimise water infiltration.
 - Covering any materials susceptible to erosion with a layer of suitably competent material.

Providing additional erosion protection where required.

Application of topsoil, surface treatments and seeding as outlined in Section 9.1.4.

- Execute rehabilitation and prepare an as-constructed report.
- Continue monitoring and maintenance as described in Section 10 for an agreed period to demonstrate achievement of the full suite of applicable completion criteria (Section 8).

9.2.3.2 ROM Pads

The pathway for progressing the ROM Pad to closure and completion is as follows:

- As the ROM Pad moves into the rehabilitation schedule, develop rehabilitation work packs for execution which include provisions for:
 - Removing remaining windrows or stockpiles to a designated area suitable for the material characteristics (refer to Section 9.2.3.1).
 - Stripping the top surface of the ROM Pad that is likely to contain high concentrations of salt from dust suppression and contaminants from stockpiled ore and removing this to a suitable location.
 - Validation sampling to confirm that there is no residual contamination requiring remediation where PAF materials have been removed.
 - Reprofilling the pad to blend with the surrounding area and allow for drainage.
 - Providing erosion protection where required.
 - Deep ripping to remove compaction.
 - Application of topsoil, surface treatments and seeding as outlined in Section 9.1.4.
- Execute rehabilitation and prepare an as-constructed report.
- Continue monitoring and maintenance as described in Section 10 for an agreed period to demonstrate achievement of the full suite of applicable completion criteria (Section 8).

9.2.3.3 Knowledge Gaps & Forward Work Program

The following task is required to progress the stockpile and ROM pads to an execution plan:

- Assess the geochemical and physical characteristics of the materials that will remain to determine what, if any, capping and / or armouring applications are required.

9.2.4 Infrastructure

Infrastructure features present at the Carina Operations are discussed in Section 2.4 and listed in Table 3. The status of the features within each domain is summarised by site in Table 3. The key tasks associated with the closure of the infrastructure areas are as follows:

- Consultation with stakeholders.
- Works required to transfer infrastructure to a third party.
- Decommissioning and demolition.
- Clean up, earthworks and rehabilitation.

These tasks are described in further detail in Sections 9.2.4.1 to 9.2.4.3.2.

9.2.4.1 Consultation with Stakeholders

MinRes will consult with post-closure land managers and state and local government agencies with regard to interest in retaining and taking responsibility for any infrastructure including but not limited to:

- Communications towers and the associated access tracks.

- Mt Jackson pastoral station regarding the retention of access tracks.
- DBCA regarding access tracks / facilities to be retained on conservation estate.
- Traditional Owners access requirements to areas of cultural value.

9.2.4.2 Works Required to Transfer Infrastructure to a Third Party

No infrastructure (including roads and access tracks) will be transferred to a third party unless there is a formal agreement in place that transfers responsibility for ongoing maintenance of that infrastructure. As part of the process to develop the agreement:

- A condition assessment of the infrastructure will be conducted and any requirements to 'make good' agreed in writing.
- Agreed rectification works will be conducted. Where haul roads are being transferred, rectification works will include reducing the road to an appropriate width if required, such that it can be appropriately maintained by the new owner.
- A written asset transfer agreement will be developed which includes responsibilities for ongoing maintenance of the infrastructure and will be signed by all parties.

9.2.4.3 Decommissioning and Demolition

Unless transferred to third parties as discussed in Section 9.2.4.2, all infrastructure will be decommissioned, demolished / salvaged and removed to a depth of 0.5 m below ground level except for concrete footings which will be removed to a depth of 1.5 m below ground level.

9.2.4.3.1 Decommissioning

As the Carina Operations move into a full-scale decommissioning and demolition phase, a detailed decommissioning plan will be developed which includes consideration of:

- De-energising all plant and equipment.
- Removing all chemicals and hydrocarbons (not required for execution of demolition) in storage vessels, pipelines and process equipment off site.
- Cleaning pipelines, process plant and storage vessels so they are safe for demolition / removal.
- Disposal of wastes generated during cleaning of equipment.
- Allowances for turkeys nests, dams and ponds to dry out and disposal of saline residue within the ponds to an appropriate location that will not impact future rehabilitation works (e.g., to a pit).
- Decommissioning of all groundwater bores in consultation with DWER and the applicable decommissioning guidance (NUDLC, 2020). Note that monitoring bores may be required for some time beyond mine closure to meet monitoring obligations.
- Preventing fauna entrapment during the decommissioning phase.
- Requirements for record keeping and submission of records to authorities (e.g., groundwater bore decommissioning records will be provided to DWER, as required).

9.2.4.3.2 Demolition

Liberty Industrial (2021) conducted a decommissioning and demolition study that included the Carina Operations.

A detailed demolition plan will be developed to guide the execution of demolition activities. This plan will be based on the scope of the Liberty Industrial (2021) study and will include consideration of:

- Methods for safe demolition / removal of all infrastructure.

- Removal of buried fuel, power, water, gas and communication infrastructure to 0.5 m below ground level.
- Removing concrete footings to a depth of 1.5 m below ground level.
- Removal and disposal of bitumen.
- Removal of signage, delineators drains and culverts along haul roads.
- Preventing fauna entrapment during the demolition phase.
- Salvage of infrastructure that has a value for sale to a third party.
- Disposal locations / recycling options for different waste types including (Liberty Industrial, 2021):
 - Removal of turkey nest and pond / dam liners to a landfill on-site.
 - Removal of High Density Polyethylene (HDPE) pipe to an off-site recycling facility.
 - Processing concrete and stockpiling on site for future remediation works or disposal to an on-site landfill.
 - Processing (to export grade), removal of ferrous and non-ferrous materials to the nearest port for salvage.
 - Disposal of all general waste and conveyor belts to the on-site landfill.

9.2.4.4 Clean Up, Earthworks and Rehabilitation

Unless transferred to a third party, detailed clean up, earthworks and rehabilitation plans will be developed for all infrastructure areas which include consideration of:

- Investigation and remediation of contaminated sites. PSIs have been conducted at the Carina Operations and a number of areas requiring further investigation prior to, or during the closure process have been identified (Section 5.7). These will be addressed as outlined in Section 9.1.7.
- Reprofilling of disturbed areas to blend in with the surrounding area and provide for drainage:
 - Prior to recontouring, saline material resulting from use of saline water for dust suppression will be removed and disposed to an appropriate location (e.g., pits) to prevent impacts to revegetation. Particular consideration will be given to saline materials that have collected on the surface of haul roads and associated drains, and around saline water dams and ponds.
 - Road formations will be removed and the area re-profiled.
 - Pond and dam walls will be pushed in and the area reprofiled.
- Rehabilitation as described in Section 9.1.4.
- Some roads /access tracks will need to be retained for monitoring purposes, the schedule for rehabilitation of these areas will accommodate these requirements.
- Landfills will be capped in accordance with the DWER operating licence requirements (Section 3.4 and Appendix A-5).

9.3 Progressive Rehabilitation & Closure

The closure and rehabilitation work schedule for the Carina Operations to 2028 is provided in Table 59.

Table 59 Indicative progressive rehabilitation schedule

Domain	Activity	2024				2025				2026				2027				2028			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
All	Consultation Marlinyu Ghoorlie re PMLU to inform Completion Criteria																				
All	Consultation DBCA re PMLU to inform Completion Criteria																				
All	PMLU Options Assessment																				
All	Seed collection																				
All	Rehabilitation monitoring (aerial and on – ground) to inform refinement of CC and remedial action plans																				
All	Analogue / Reference site selection and Ongoing Refinement of CC																				
All	Review OAW / saline substrate cover depth options and / or seed mix																				
All	Refine reference ecosystem(s) and seed mix for revegetation and supplementary seeding of WRLs																				
All	Investigate methodology for incorporation of timber debris.																				
All	Contaminated Sites DSI																				
Carina ROMs	Earthworks Rehabilitation																				
Carina WRL	Earthworks Rehabilitation																				
Carina Extended WRL	Confirm as-built status & requirements / options for rectification																				
J4E WRL	Earthworks Rehabilitation																				
J4W WRL	Earthworks Rehabilitation																				
Aurora	Investigate closure options																				
Aurora WRL	Earthworks Rehabilitation																				

9.4 Early Closure

Early closure may occur because of economic, environmental, safety or other external pressures and could result in various potential scenarios such as:

- The temporary suspension of operations prior to recommencing operations in the future; or
- Early (unplanned) suspension of operations followed by decommissioning and permanent closure.

Temporary suspension would require the site to be placed onto Care and Maintenance (C & M) and plant and equipment maintained in a state of operational readiness to support recommissioning. Permanent closure may also require the site to be placed onto C & M but with a focus on maintaining a safe, secure, and legally compliant site as an interim measure until engineering designs and approvals are complete and planned closure activities commence. Maintenance activities will differ from those needed for temporary suspension because plant, equipment, and landforms are not expected to be operational again.

Under the Work Health and Safety (Mines) Regulations 2022, a mine operator must give the regulator prior notice of a site being placed on C & M and must provide a description of what the C & M activities entail. If the mine, or part of the mine, will permanently close then the regulations require that written notice is provided, that outlines the closure activities and a description of the measures that will be taken to make the mine safe and secure on a permanent basis.

9.4.1 Early Suspension of Carina Operations

If part or all of the Carina Operations are unexpectedly suspended, MinRes will implement the high-level strategy outlined in Table 60.

Table 60 Strategy for Early Suspension of Carina Operations

Scenario	Task	Time frame
All	Undertake an immediate review of safety obligations and develop measures to meet obligations and manage key safety risks.	Commence review immediately on suspension of operations.
	Notify DEMIRS of the intention to suspend operations temporarily or permanently, as required by the Work Health and Safety (Mines) Regulations 2022.	Immediately on becoming aware the operation will be temporarily or permanently suspended, and prior to C & M or closure activities being implemented.
All	Implement initial control measures that may include (but not be limited to): • Establishment of earthen windrows to close off access to the pit(s). • Erection of fencing and signage to prevent inadvertent access to the operations. • Appropriate storage or removal of chemicals and hydrocarbons from site. • Inspection of hydrocarbon storage areas for adequate freeboard and / or removal and disposal of any contaminated material. • Application of adequate cover material to landfill waste.	Commence implementation immediately on suspension of operations.
Temporary Suspension	Prepare a detailed C & M plan that outlines: • Activities required to meet compliance obligations, including reporting, during temporary suspension. • Other risk mitigation measures identified through an assessment of risks associated with temporary suspension. • Maintenance requirements to meet the planned outcomes for site. • Resourcing, budget and schedule.	Within 3 months of formal notification to the regulator.

Scenario	Task	Time frame
Permanent Closure	Undertake an immediate review of the MCP to address information and / or design gaps resulting from closure being brought forward and update workplans and schedules. If the MCP does not meet the required level of detail to support immediate execution of closure activities, then prepare a detailed C & M Plan as an interim measure that outlines: - Activities required to meet compliance obligations, including reporting, in the interim until permanent closure activities are implemented. - Other risk mitigation measures identified through an assessment of risks associated with interim C & M whilst awaiting closure. - Resourcing, budget, and schedule	Within 3 months of formal notification to the regulator.

9.4.2 Care and Maintenance Planning

9.4.2.1 Care and Maintenance Plan

Processes to be implemented and activities to be undertaken during the C & M period are generally documented in a Care and Maintenance Plan (C & M Plan). The objectives of a C & M Plan are to:

- Identify and manage risks associated with the C & M period.
- Maintain compliance with regulatory and other obligations and / or commitments during the C & M period.
- Support the implementation of effective measures to achieve the planned outcomes for the site following C & M.

The C & M Plan will describe the risks, regulatory setting, maintenance, monitoring and reporting activities and will include resourcing, budgets, and planned schedules.

9.4.2.2 Risk Assessment

A risk assessment will be undertaken to identify and manage potential risks associated specifically with the C & M period. The assessment will build on existing risk assessments conducted for the sites during operations. Management measures for each identified risk will then be included and the risk rating re-categorised. Additional risk mitigation measures will be developed as required.

9.4.2.3 Compliance with Legal and Other Obligations

A review will be completed of applicable legislation, project approvals and existing obligations registers to develop a C & M Obligations and Commitments Register. In particular, the review will consider the *Mines Safety and Inspection Act 1994* and the *Work Health and Safety (Mines) Regulations 2022* which regulate C & M activities in mining in WA. If gaps are identified between existing compliance management measures and those required for C & M, then additional measures will be developed.

9.4.2.4 Stakeholder Engagement

MinRes will undertake consultation with key stakeholders as necessary throughout the C & M period to discuss and address significant issues related to each stakeholder's area of interest.

MinRes will engage with government agencies as required during the C & M period. At these meetings it is expected that environmental and safety issues will be discussed, and decisions made regarding specific follow-up and / or corrective actions.

Ongoing stakeholder engagement specific to the final outcome of the site (closure or recommissioning) will continue under the C & M Plan and outcomes reported through annual reporting requirements to the applicable regulators.

9.4.2.5 Resourcing

MinRes will provide the necessary resources, including personnel and financial resources needed to conduct management, monitoring and mitigation activities at the sites throughout the C & M period.

Operational accountability for implementation of, and compliance with, the C & M Plan will lie with the Registered Manager.

9.4.2.6 Care and Maintenance Activities

The following activities may be required during a period of C & M at the Carina Operations, noting that some activities will depend on the final objective for the site (closure or recommissioning):

- Check that initial control measures (see Table 60) have been implemented.
- Establish and implement additional site security measures to prevent unauthorised access (intended and unintended) to potentially unstable landforms including mine pits.
- Undertake a review of the geotechnical stability of all as-constructed landforms at the time that the operation is suspended and determine if any temporary or permanent remedial works are required to make the facility safe. Landforms will include pit walls, WRLs and stockpiles.
- Remove ore stockpiles from the ROM and either export off-site or relocate to an area on-site where materials can be recovered in the future or integrated into closure landforms. The area selected for ore storage will need to be appropriate to the physical and geochemical characteristics of the ore.
- Operate and maintain water systems to supply camps and non-process infrastructure as required.
- Maintain stormwater and wastewater infrastructure, including drains and sumps, to prevent the uncontrolled release of impacted water.
- Undertake dust suppression activities across operational disturbance areas as required.
- Maintain plant and equipment in a state of operational readiness, if required, for future recommissioning or until the future of the site is determined.
- Continue power generation as required to meet site C & M needs.
- Operate and maintain camps and other services, including wastewater treatment facility infrastructure, until the future outcome of the sites is determined.
- Inspect, maintain and identify corrective works for key infrastructure to support the final outcomes of the site.
- Continue feral fauna management programs, adjusted to support the changed conditions of the site.
- Continue weed control programs, adjusted to support the changed conditions of the site.
- Undertake regular visual inspection of work areas to confirm that any remaining hydrocarbons and / or hazardous materials are stored appropriately and in accordance with relevant legislation.
- Review the monitoring program in Section 10 and as a minimum, continue all monitoring required to confirm that the sites are maintained in a safe, stable and non-polluting condition.
- Continue to undertake all statutory monitoring and reporting requirements.

9.4.3 Permanent Early Closure

The risk assessment in Section 7.2 considers unplanned closure (factored in as a cause of certain risks). The key risk issues considered relevant to unplanned closure are outlined in Table 61. Not all of these issues were rated high risks, either due to information from technical studies that indicate the risk is not significant, or due to the current stage of mining.

Table 61 Unplanned Closure Risks

Risks Considered	Assessment of Significance
Erosion of WRLs limits vegetation success and releases sediment and / or AMD to adjacent land.	The inherent risk associated with erosion of WRLs at Carina, Carina Extended, and J4 has been rated high. The inherent risk is rated as extreme for Aurora because erosion is already evident on the WRL, and rectification options are being considered.
Final landforms, excluding WRLs and associated access ramps erode or have poor drainage post-closure.	The inherent risk for all sites is considered high.
Insufficient or unsuitable growth media results in poor vegetation outcomes.	The inherent risk for all sites is considered extreme, driven by the major consequence of inability to meet post-mining land use, manage visual amenity and manage erosion. A topsoil deficit has been identified across the Carina Operations.
Contamination caused during operations has not been identified and remediated during operations.	The inherent risk associated with all sites has been rated as high. Potential sources of contamination have been identified at the site; the inherent risk associated with all sites has been rated as high.
Unplanned pit lakes (sinks) result in drawdown of groundwater levels that impacts receptor(s). Unplanned pit lakes become temporary throughflow systems with potential to impact on water quality at receptor(s).	BWT mining has occurred at Carina, Carina Extended and J4 East and is planned for J4 West. The inherent risk associated with impacts to groundwater receptors from pit lakes at Carina Operations is considered medium because of the absence of localised groundwater receptors. Groundwater modelling completed to date further reduces the residual risk to low as it demonstrates minimal impact. J4 West Pit is planned to be backfilled to surface. Groundwater modelling at J4 West Pit has been modelled both with and without backfill and the risk rating does not change.
Final landforms interrupt surface water flows.	The inherent risk associated with final landforms interrupting surface water flows has been rated as medium for both Carina and Aurora. Modelling at Carina indicates a portion of the abandonment bund needs to be constructed as flood bund. Modelling at Aurora shows that the proposed abandonment bund is sufficiently sized to prevent both 1 in 2,000 AEP and PMF events floodwaters from overtopping into the pit void. After implementation of abandonment bund and flood bund recommendations, the residual risk is likely to be reduced to low.
Flooding causes pit lakes to overflow.	The inherent risk of overtopping of the pit lake has been rated as 'medium' at Carina because the pit has been modelled to intercept surface water run-off during a flood event. Surface water management controls will need to be designed and implemented to reduce the residual risk to 'low'. Further studies will be completed to inform the designs.
Post-closure landform (haul roads and access roads) disrupt surface water flows post-closure.	The inherent risk associated with haul roads and access roads disrupting surface water flows has been rated as 'medium' because of likely impacts to downstream receptors, demonstrated by modelling. Removal or alterations to the road, in consultation with stakeholders, will be required to reduce the residual risk to low.
Slope failure of WRL impacts on revegetation success (PMLU) and / or surrounding land. Pit wall failure impacts on heritage site.	The inherent risk associated with slope failure of WRLs at Carina has been rated as 'medium' because of the potential for the WRL to not be constructed to design. Geotechnical stability assessments will need to be undertaken to assess this risk. The inherent risk associated with slope failure of WRLs at J4 has been rated as 'extreme' because of the potential for the ZOI of the J4 East Pit (due to the redevelopment) to interact with the J4 East WRL. In addition, a heritage site is located within the current ZOI of the J4 West Pit (the J4 west pit is planned to be backfilled to surface). Further refinement of the location of the ZOI is required to inform mitigation measures if required.
Inadvertent access to unsafe or unstable areas by the community.	Inherent safety risks are 'extreme' for all sites because landforms are not complete and safety bunds are yet to be fully established.
Unused infrastructure is accessible to the public leading to injury or fatality.	Inherent safety risks are 'extreme' for all sites.

In the event of early, permanent closure, the sites will be placed on C & M as outlined in Section 9.4.2 until additional closure planning, design, stakeholder engagement and approval work has been completed.

To develop a closure execution program, MinRes will review the risk assessment in the light of new information arising from technical studies conducted since the last MCP update and prioritise studies to address high and extreme risks which at this stage include:

- The completion of designs and installation of abandonment bunds to improve public safety.
- Development of closure designs for incomplete landforms, which could potentially include J4 East and J4 West WRL, that accommodate their incomplete geometry and the nature of the materials at their surface. Sources of competent materials will need to be identified.
- The completion of studies for Aurora WRL to identify options for closure and develop detailed designs for closure execution.
- In the event that backfill of the J4 West Pit has not been completed to the final design, undertake a geotechnical assessment to refine understanding of the ZOI for the J4 West Pit, and confirm the location of the abandonment bund and proximity to the J4 West WRL and other sensitive receptors such as heritage sites.
- Identify and validate sources of material to be used in abandonment bunds, particularly where flooding has been modelled to occur.
- Assess flood modelling recommendations and install flood bunding and rock armouring where required at Carina.
- Develop a mitigation plan and designs for management of the haul road, in consultation with stakeholders, to eliminate the potential impact to downstream receptors caused by interruptions to surface flows.
- Development of rehabilitation plans prioritising available growth media to areas providing the greatest benefit to overall rehabilitation outcomes.
- Investigation and remediation of contamination remaining at the time of unplanned closure.
- Develop detailed decommissioning and demolition plans for remaining infrastructure.

9.5 Forward Work Program

The forward work program in Table 62 has been collated from the knowledge gaps, forward works and mitigation response measures outlined in Sections 5, 7 and 9. The risk associated with the knowledge gap considers the risk assessment in Section 7 and influences the timing of the forward work program.

Table 62 Forward Work Program

Aspect	Knowledge Gap	Forward Work Program	Timing	Risk Associated with Knowledge Gap
Stakeholder consultation	Stakeholder views	Ongoing consultation with stakeholders in accordance with the program outlined in Section 4.1.3, including: - Post-mining land uses and associated performance objectives. - Proposed completion criteria. - Requirements for: - Haul roads and other infrastructure post-closure. - Safe access post-closure.	2024 and ongoing	The inherent risks associated with failure to consult with stakeholders have been rated as extreme. Priority has been placed on commencing this action, particularly with the Marlinyu Ghoorlie and continuing discussions with DBCA. It is intended for this MCP to be used as a starting point for those discussions. The timing also recognises that stakeholder consultation is an ongoing process that evolves over time and that discussions around infrastructure retention may occur later in the closure timeline.
		Additional consultation with Traditional Owners to discuss: - Cultural values and implications for potential closure designs and outcomes. - Requirements for safe access.	2024 and ongoing	
Obligations and Commitments	Obligations arising from approvals documentation referred to in mining tenement conditions.	Progressively review and update the register of proponent statements for currency and applicability to closure.	Ongoing	The applicability and currency of historic proponent statements on closure in relation to current closure plans is influenced by the outcomes of technical studies (e.g., landform design studies). The timing reflects this evolving knowledge.
	Post-closure access requirements from 3 rd party agreements.	Liaise with Land Access Group in relation to third party agreements that may include post-closure access requirements.	2024 - 2026	The inherent risk associated with failure to factor in access requirements has been rated as high. The timing reflects the timeframe for closure planning of areas that might need to consider these access agreements.
	Land access plan	Develop a Land Access Plan (or similar) in consultation with all relevant stakeholders and to meet the conditions of tenements and third-party agreements.	Ongoing	Timing is linked to the forward action items for stakeholder consultation and obligations and commitments that are a pre-cursor to developing this plan.
Materials characterisation	J4 Low-Grade Stockpile	Carry out additional geochemical assessment if the J4 Low Grade Stockpile material is planned to be used as erosion resistant armouring material, or if this stockpile is not removed prior to closure.	If required	There are no current plans to use this material as armouring, nor leave in place.
	Materials characteristics Aurora	Characterisation of waste materials at the Aurora site to inform landform designs.	2024 - 2025	Inherent risk generation of AMD (including NMD) or saline drainage (SD) rated as medium. Timing reflects that this work is a pre-cursor to the landform rectification work necessary to control surface water run-off and mitigate erosion of the Aurora WRL.
	Materials balance	Identify a suitable source of NAF / non-dispersive material to facilitate the recommendation to increase surface cover depth over the PAF encapsulation cell in the Carina WRL.	2024	Timing reflects the rehabilitation timeline for the Carina WRL.
		Identify and segregate materials to meet armouring requirements.	2024 - 2025	Timing reflects the rehabilitation timeline for the Carina and J4 WRLs.
Radioactive / fibrous materials	Not explicitly addressed in project approvals documentation.	Review of drill assays and testing as required to confirm if fibrous or radioactive minerals are present in the waste rock or mineralised stockpile material. Develop sampling plan based on risk assessment outcomes.	2024	Timing reflects high inherent risk rating and existing availability of drill assay data to complete initial review. The time frame could extend if the review recommended a sampling program.
Geotechnical	Global stability of WRLs	Global geotechnical stability assessment to verify that WRLs meet FOS requirements.	2024 - 2025	Inherent risk is rated as medium to extreme based on potential impacts to adjacent vegetation and dispersive properties of some waste materials.
Flora and Fauna values	Impacts on biodiversity	Apply <i>Phytophthora</i> management plans developed for the Carina Operations areas to closure activities as relevant.	Ongoing to completion	Inherent risk is rated as high. Management requirements are being developed for the operations phase and will be ongoing for closure.
		Investigate additional weed monitoring methods, such as aerial survey techniques, to maximise effectiveness of weed control efforts.	2024 - 2025	This work has commenced and requires time to assess the effectiveness of developing technology. On-ground monitoring and control continues in parallel to this forward work action.
		As closure designs progress into execution plans at Carina / Carina Extended, consider the potential impacts to W22 vegetation community arising from design changes and clearing required for construction access.	2025	The inherent risk has been rated as medium. Timing reflects that there are forward action items that are a pre-cursor to developing execution plans (Carina WRL design, Carina Extended ZOI review for abandonment bund, Flood bund design).
		Conduct a pit lake risk assessment to assess the likelihood of significant numbers of feral fauna being attracted to the lake.	2024 - 2025	The inherent risk of pit lakes attracting feral animals has been rated as medium. A priority has been placed on this study, however, as it informs closure planning.

Aspect	Knowledge Gap	Forward Work Program	Timing	Risk Associated with Knowledge Gap
		Conduct a pit lake risk assessment to assess the likelihood of significant numbers of native fauna being attracted to the lake.	2024 - 2025	The inherent risk of pit lakes to native fauna has been rated as medium. A priority has been placed on this study, however, as it informs closure planning.
Heritage / Cultural Values	Impacts of clearing required for closure designs	Consult with Marlinyu Ghoorlie regarding the outcomes of previous heritage surveys.	2024 - 2025	Inherent risk associated with impacts to cultural heritage is rated as extreme. A priority has been placed on this forward work action.
		As closure designs progress into execution plans, consider the potential impacts to heritage sites arising from design changes and clearing required for construction access.	Ongoing	The inherent risk associated with clearing for closure execution is high. However, the timing reflects the need for locations of additional clearing to be confirmed as closure designs, including the location of abandonment bunds, are completed.
	Impacts of pit instability	Geotechnical assessment of J4 pits.	2024	The inherent risk associated with slope failure of WRLs at J4 has been rated as 'extreme' because of the potential for the ZOI of the J4 East Pit (due to the redevelopment) to interact with the J4 East WRL. In addition, a heritage site is located within the current ZOI of the J4 West Pit (the J4 West pit is planned to be backfilled to surface). Further refinement of the location of the ZOI is required to inform mitigation measures if required.
Groundwater / Pit Lakes	Impacts to groundwater and ecohydrological receptors	Develop groundwater and pit lake monitoring program and implement for the period necessary to validate groundwater and pit lake models.	2024 and ongoing until models validated	The inherent risks associated with groundwater drawdown or impacts to groundwater quality have been rated as medium to low. The inherent risk to fauna from pit lakes has been rated as medium. A high priority has been placed on updating the monitoring program so that adequate data can be collected to allow validation of models.
		Conduct a further review of the potential for density driven flow from pit lakes.	2025	Inherent risks rated as medium to low. Timing to inform risk assessment ahead of next MCP.
		Confirm the nature and status of the potential aquatic GDE, that appears on the GDE Atlas (BoM, 2024d), north east of the Carina Operations.	2025	Inherent risks rated as medium to low. Timing to inform risk assessment ahead of next MCP.
		Gap analysis to inform the requirement to complete additional testing related to long-term pit lake quality.	2024 - 205	The inherent risk of impacts to groundwater is considered medium and the risk to native fauna arising from pit lake quality medium. Priority has been placed on this work as it informs closure planning.
Surface water	Disruption to surface water flow	Complete flood modelling, hydraulic modelling and materials characterisation necessary to inform final landform design for the Infrastructure / General Disturbance domain – including: - o Roadway proposed to be retained at Carina. - o Carina Mine Infrastructure Area.	Two years prior to planned closure	Inherent risk is rated as medium. The timing reflects the closure timeline with decommissioning of major infrastructure linked to the completion date for other MinRes operations in the region.
Contamination	Remediation action plans	A Sampling and Analysis Quality Plan (SAQP) will be prepared to guide a Detailed Site Investigation (DSI). Development of remediation action plans as required as part of closure execution planning. Communication with relevant stakeholders to determine applicable assessment and validation criteria	2024 and ongoing	Potential sources of contamination have identified at the site; the inherent risk associated with all sites has been rated as high. Priority has been placed on commencing this work, but timing reflects that closure execution planning will be linked to closure timeframes for the different sites.
Landform design completion	Erosional stability	Determine requirement for rectification works at Carina Extended WRL based on: - o Assessment of as-built berm widths. - o Refined minimum berm capacity / width. - o Surface stability trajectory.	2024 - 2026	Priority has been placed on completing this work to inform closure strategy but requires further investigation and a longer period of erosion monitoring data for review.
		Material characterisation to inform Aurora WRL rectification plan and abandonment bund design.	2024 - 2025	Timing reflects that this work is a pre-cursor to the landform rectification work necessary to control surface water run-off and mitigate erosion of the Aurora WRL.
	Geotechnical and Erosional stability	Address knowledge gaps to finalise the preliminary landform rectification plan for the J4 WRLs (ZOI (J4 East) and mitigation approach for low stability materials). Rectify design non-compliance at the J4 West WRL & source compliance to plan report.	2024	Review will be ongoing during operations phase. Timing for closure is linked to the J4 East mine life.
	Geochemical, geotechnical & erosional stability	Develop final design for the Carina WRL informed by surface water run-off control & PAF encapsulation requirements, review of berm capacity modelling results, geochemical & geotechnical characteristics of the surface cover materials & design commitments.	2024	Timing reflects that the necessary studies were completed in 2023 and work on developing the final design is in progress.

Aspect	Knowledge Gap	Forward Work Program	Timing	Risk Associated with Knowledge Gap
	Access	Incorporate requirements for safe access and cultural values (where possible) in closure designs.	2024 and ongoing	Designs will be finalised following consultation with Traditional Owners and as areas approach closure. Priority placed on commencement of work as informs closure planning. This MCP proposed as starting point for those discussions
	Final landform designs	Progressive development of final landform designs integrating all domains as areas progress towards full closure.	Ongoing	Designs will be finalised as areas approach closure and forward actions programs for domains are completed.
Abandonment bunds	Final design	Review designs for existing abandonment bunds: - Complete an updated ZOI projection, based on the actual base of weathering, for the Carina Pit shell to determine if relocation of the NE portion of the abandonment bund is required. - Review the potential for erosion to impact on the integrity of the Carina Extension abandonment bund to determine armouring requirement. - Utilise post-mining ZOI assessment of J4 Pit to inform abandonment bund location.	2024 – 2025	Timing reflects the extreme inherent risk rating associated with inadvertent access but recognises that abandonment bunds are largely in place and these actions relate to erosion mitigation activities. This action cannot be undertaken at J4 East Pit until mining operations are complete.
		Finalise design for replacement Aurora Pit abandonment bund, informed by hydraulic modelling and materials characterisation results.	2024 - 2025	The timing reflects the extreme inherent risk rating associated with inadvertent access. Hydraulic modelling was completed in 2023 and materials characterisation work is planned for 2024.
		Identify and validate sources of material to be used in abandonment bunds, particularly where flooding has been modelled to occur.	2024 - 2025	
	Final abandonment bund locations	Assess clearing requirements for abandonment bunds, confirm final locations with DMIRS and DBCA, conduct pre-clearing surveys and seek approval for clearing.	2024 - 2026	Timing reflects the requirement to complete forward work actions for abandonment bunds at each of the Carina Operations site and mine life at J4 East.
		Incorporate plans of abandonment bund locations in the next revision of the MCP.	2024 - 2025	Timing to allow incorporation in next MCP update and linked to J4 East mine life.
Decommissioning and demolition	Detailed decommissioning and demolition plans	Develop detailed decommissioning and demolition plans for infrastructure (including haul roads) that will not be transferred to third parties post-closure.	Prior to closure execution.	Safety risks associated with unused infrastructure is rated an extreme inherent risk. However, decommissioning and demolition is linked to mine life and stakeholder requirements for infrastructure. The timing of this program reflects the timing for closure.
	Aurora underground workings	Confirm that the shaft associated with historic underground workings has been sealed as reported.	2024	Based on previous reporting it is understood that the shaft has been sealed. Timing reflects need to confirm as part of finalising pit abandonment designs.
Rehabilitation	Growth media availability and quality	Salvage topsoil prior to WRL rectification works.	Ongoing	Timing reflects that these actions are linked to operational activities.
		Refine topsoil balance to account for topsoil stockpiled on WRLs, stockpiles at Carina Southern Operations and J4 East topsoil salvage. Investigate alternative growth media where a topsoil deficit remains. Undertake additional soil characterisation to refine soil conditions in reference sites.	2024 - 2026	A priority has been placed on commencing this work given the closure status of the sites and planned WRL rehabilitation programs. The timing reflects the lead time necessary to investigate alternative growth media should that be required.
	Reference ecosystem(s) and seed mixes	Complete a gap analysis to determine if materials characterisation of cover materials is sufficient to inform selection of the reference ecosystem. Refine reference ecosystems (s) and species mix for WRLs with consideration to the properties of the underlying waste rock material, cover materials properties (As a growth substrate) and the PMLU. Include updated seed mix lists in next update of the MCP.	2024	The risk associated with failing to meet ecological completion criteria has been rated as extreme. Work completed to assess the properties of WRL cover materials has been completed enabling this action item to proceed as a priority associated with the closure status of the Carina Operations WRLs.
	Growth substrate enhancement	Review potential application of Carina rehabilitation trial findings to other WRLs. Determine if there is a practicable method of applying timber debris to rehabilitation surfaces that will achieve, but not exceed, the target cover level (10 – 20%) and not enhance erosion. Investigate optimal depth of cover material for revegetation success on underlying OAW / saline substrates, where cover is practicable.	2024 - 2026	A priority has been placed on commencing this work given the closure status of the sites and planned WRL rehabilitation programs. The timing reflects the time necessary to investigate and assess methodologies.
	Aerial seed application potential	Review the results of aerial seeding (using drones) trialled to spread seed at the Yilgarn Operations in 2022 and in 2023 for applicability to the Carina Operations.	2024	This work can proceed as a priority. Records of the seed mix deployed against flight path have been mapped and provided to MinRes.

Aspect	Knowledge Gap	Forward Work Program	Timing	Risk Associated with Knowledge Gap
Completion criteria	Ecological completion criteria	Refine reference ecosystems and refine completion criteria based on landscape-scale remote sensing data, the outcomes of additional technical studies, reference ecosystems and consultation with stakeholders.	Ongoing with aim to complete by 2025	The timing of this program reflects: - o Time to collect sufficient landscape scale data, assess the results of technical studies, identify suitable reference ecosystems and undertake consultation to develop meaningful and achievable completion criteria. - o The closure timeline of the Carina Operations sites. - o The extreme inherent risk rating associated with failure to meet ecological completion criteria.
Completion reviews	Performance against completion criteria	Review the rehabilitation monitoring program when completion criteria are finalised.	2025 and ongoing	Linked to timing for finalising completion criteria and ongoing review of emerging rehabilitation technologies.
		Compliance to plan audits: - o J4 West backfill and PAF encapsulation. - o J4 West WRL construction to design.	2025	Timing is linked to the J4 East mining schedule.

10. CLOSURE MONITORING AND MAINTENANCE

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes the post-mining land use(s) that has been proposed or agreed with key stakeholders, including regulators. The mine closure plan describes how the post-mining land use(s) is:

- *A monitoring framework to monitor the progress of the closure implementation strategies for achieving closure outcomes and completion criteria (Sections 10.1 to 10.2)*
- *Description of proposed post-closure monitoring (Sections 10.1 to 10.2)*
- *A description of the monitoring methodology (Sections 10.1 to 10.2).*

Closure monitoring is implemented across the Carina Operations to evaluate the progress and success of mine closure and rehabilitation towards meeting the completion criteria (Section 8.2) and to ultimately support application for tenure relinquishment.

The results of closure monitoring are also utilised to develop and refine closure strategies, rehabilitation methods and completion criteria, confirm modelling assumptions and guide maintenance and remedial works. This feedback will be incorporated in progressive revisions of the MCP.

Closure monitoring is undertaken during the operations, decommissioning / closure implementation and post-closure phases until completion criteria have been met. Monitoring programs are extended to new areas as they are progressively closed, and are adapted as necessary, based on monitoring results, emerging technologies, stakeholder input and ongoing risk assessment.

Some completion criteria will be assessed by inspection or audit rather than monitoring (Section 10.1). This approach is relevant to those completion criteria assigned the WABSI (Young, et al., 2019) attributes of categorical (C) or installed / built as planned (P).

Ultimately these various sources of verification, will be submitted to demonstrate achievement of completion criteria and support tenure relinquishment in accordance with DMIRS Mine Closure Completion Guidelines (DMIRS, 2021). Prior to seeking relinquishment of tenure, a residual risk assessment will be completed to determine any requirement for continued monitoring and maintenance. Continuing monitoring and maintenance requirements will be included in a post-relinquishment land management plan developed in consultation with the post-relinquishment landowner / manager and the relevant regulators. This plan and documented agreement(s) for implementing the plan, will be submitted to DMIRS to support the determination of post-closure risk and facilitate the tenure relinquishment process.

10.1 Completion Audit and Inspection

Table 63 outlines those completion criteria that will be demonstrated by means other than the results of monitoring programs. Only those verification methods that will be submitted to support completion assessments in accordance with DEMIRS guidelines (DMIRS, 2021) are listed in Table 63. Additional interim audits and inspections will be carried out to determine that performance indicators are being met (Table 54).

Table 63 Completion criteria assessed by audit and inspection

Ref	Closure Outcome	Completion Criteria	Audit / inspection for verification	Corrective actions prior to completion
1	Post – mining land use and management			
1.1	Post-mining land use (PMLU) <i>The post-closure land condition is compatible with the PMLU.</i>	- Monitoring, inspection and audit demonstrate that the closure outcomes have been substantially met, as demonstrated by achievement of the criteria for (C): - Safety (1.2); - Land management (1.3); - Access (1.4); - Visual amenity (1.5); - Landform stability (3); - Surface water, groundwater and contamination (4, 5 and 6); - Rehabilitation (7); - Heritage (8); and - Flora and fauna (9) - Post-closure landowner / manager agrees that completion criteria have been met and accepts land management responsibilities (C).	- Audit at completion: - Demonstrated achievement of safety (1.2), land management (1.3), access (1.4), visual amenity (1.5), landform stability (3), surface water, groundwater and contamination (4, 5 and 6), rehabilitation (7), heritage (8), and flora and fauna (9) criteria (C). - Documented acceptance of the post-closure land condition and land management requirements by the post-closure landowner / manager (C).	If post-closure monitoring and survey reports show that completion criteria are not on the correct trajectory towards meeting the post-closure land use performance requirements, identify the cause of the deviation and apply the appropriate corrective actions (from those listed below) in consultation with post-relinquishment landowner / manager.
1.2	Safety <i>Public health and safety hazards have been mitigated.</i>	Infrastructure - Surface infrastructure, other than that subject to asset transfer agreements has been removed from site (C). - Transferred infrastructure meets the specifications in asset transfer agreements (P). - Buried infrastructure has been removed to a depth of 0.5 m and concrete footings to a depth of 1.5 m below ground level unless otherwise agreed with the post-relinquishment landowners / managers (C). - Bores not required post-relinquishment have been decommissioned as per the Minimum Construction Requirements of Water Bores in Australia (2011) (C). - No waste material or rubbish remains other than in agreed landfill locations (C). - Site has been assessed as safe by the District Mines Inspector (C). Inadvertent Access - Abandonment bunding constructed in accordance with DoIR (1997) and / or in agreement with DEMIRS (C). - Site has been assessed as safe by the District Mines Inspector (C).	- Audit at completion: - Surveys, inspection and demolition contractor reports (C). - Achievement of criterion for post-relinquishment access (1.4) (C). - Documented acceptance of the post-closure land condition and management by the post-closure landowner / manager (C). - Audit at completion: - Reports of inspections post-construction and post-closure (C). - Achievement of criterion for post-relinquishment access (1.4) (C).	If completion criteria will not be met, review the cause and rectify the deficiency, in consultation with third parties to which infrastructure has been transferred or the District Mines Inspector, as applicable.
1.3	Land management <i>Land management requirements are commensurate with the PMLU, or formal arrangements have been made to provide for management of residual risks.</i>	- At completion, land management requirements are typical of the PMLU (Q), or where additional management is required: - These activities have been documented in a post-relinquishment land management plan (C). - Provisions have been made for the additional activities and the post-relinquishment landowner / manager accepts responsibility for implementation of the land management plan (C).	- Audit at completion: - Documented acceptance of the post-relinquishment land management plan by the post-relinquishment landowner / manager (C).	- If land management requirements will not be commensurate with similar land uses in nearby undisturbed areas, investigate the cause of the increased management measures and either: - Rectify the issue in consultation with the post-mining landowner / manager and relevant regulators, or - Agree a land management plan with the landowner / manager and resources for implementing it.
1.4	Post-relinquishment access <i>The post-closure landform includes provision for safe access, where required.</i>	- The post-closure landform provides access to meet tenement conditions and stakeholder agreements (P). - The Safety criterion (1.2) is achieved.	- Audit at completion: - Documented acceptance of the post-closure land condition and access arrangements by the post-closure landowner / manager and third parties with whom there are access agreements (C). - Achievement of Safety criterion (1.2) (C).	If the final landform does not include the agreed access provisions, rectify in consultation with the post-relinquishment landowner or manager.
1.5	Visual amenity <i>The heights of final landforms are compatible with surrounding landforms.</i>	WRLs are constructed substantially to approved design height (P). Where there are significant (> 5 m) departures from the approved design height, these have been agreed with key stakeholders (C). Note other aspects of visual amenity are addressed by achievement of criteria 1.2, 3 and 7.	- Audit at completion: - Final landform height against approved heights or approved variations (P).	- Where design landform heights have been exceeded: - Rectification plans will be implemented as agreed.

Ref	Closure Outcome	Completion Criteria	Audit / inspection for verification	Corrective actions prior to completion
3 Surface Stability				
3.1	Surface stability <i>Rehabilitated surfaces are stable and are not subject to unacceptable rates of erosion.</i>	- WRLs and drainage management features have been built substantially in accordance with the approved designs (P). - Erosion features in rehabilitation areas meet targets: - If erosion is evident, the rate of change of erosion has stabilised over three consecutive assessment periods within a minimum monitoring period of five years (Q). - Erosion or sedimentation from landform has not substantially impacted on adjacent vegetation (Q). - Erosion does not expose encapsulated deleterious materials (Q).	- Audit at completion: - Post-closure monitoring and inspection demonstrates achievement of the completion criteria for three consecutive seasons (Q). - Demonstrated achievement of criteria for geotechnical stability (3.2) and vegetation establishment (7.2) (C).	- If survey and inspection reports detect criteria have not been met: - Prepare rectification plans in consultation with the regulators. - Rectification plans will be implemented as agreed. - If survey and inspection reports indicate that surface water controls have not been completed to design, or are failing, a review of the cause of the failure will be conducted and corrective actions determined in consultation with relevant regulators. Corrective actions will be implemented as agreed.
3.2	Geotechnical stability <i>Landforms are safe and geotechnically stable.</i>	- WRLs have been built substantially in accordance with the approved design geometry as outlined in Section 9 (P). - WRLs are located substantially outside the ZOI of adjacent mine voids such that a slope failure would not impact the PMLU, safe access, the structural integrity of the WRL or expose encapsulated deleterious materials (P). - WRLs / backfill landforms have a FOS ≥ 1.5 (Q). - J4 West Pit backfilled sufficiently so that a pit wall failure would not impact adjacent heritage site (P) - Safety (1.2) and surface stability (3.1) criteria are met (C).	- Audit at completion: - Post construction survey report (C). - Geotechnical reports demonstrating landforms meet criteria (C). - Demonstrated achievement of criteria for safety (1.2) and surface stability (3.1) (C).	Refer to corrective actions for Criteria 1.2 and 3.1.
3.3	Geochemical stability <i>Landforms are non-polluting.</i>	- No visual evidence of AMD run-off or seepage from WRLs and no impacts to health of adjacent vegetation attributable to saline seepage or AMD (Q). - No exposed PAF, radioactive or fibrous material on WRLs (C). - No evidence of mineral scalds in rehabilitation areas (C). - Contamination (5.1), groundwater quality (6.2) and vegetation establishment (7.2) criteria are met (C).	- Audit at completion: - Inspection / monitoring results (C). - Evidence submitted for achievement of criteria for contamination (5.1), groundwater quality (6.2) and vegetation establishment (7.2) (C).	Refer to corrective actions for Criteria 5.1, 6.2 and 7.2.
4 Surface Water				
4.1	Surface water flow <i>The post-closure landform maintains the flow of surface water to key receptors.</i>	- Surface water management controls are established in the post-closure landform to maintain surface water flows around landforms that may significantly impound or capture surface water flow (C). - The criterion for surface stability (3.1) is met (C). - The rehabilitated haul road does not obstruct regional drainage patterns (C).	- At completion: - Verification submitted for achievement of surface stability criterion (3.1)	If survey and inspection reports indicate that surface water controls have not been completed to design, or are failing, a review of the cause of the failure will be conducted and corrective actions determined in consultation with relevant regulators. Corrective actions will be implemented as agreed.
4.2	Surface water quality <i>Overflow from pit lakes does not adversely impact surface water receptors.</i>	- Surface water management infrastructure has been provided, where required, to prevent overflow of pit lakes due to capture of surface water during flood events (C). <i>Note other potential impacts to surface water quality are addressed by:</i> <i>Criterion 3.1 (surface stability)</i> <i>Criterion 3.2 (geochemical stability).</i> <i>Criterion 5.1 (operational contamination)</i>	- Completion audit of: - Demonstrated achievement of criteria for surface water flows (4.1).	
5 Contamination				
5.1	Contamination <i>Contaminated sites have been identified and addressed.</i>	- Contaminated sites, as defined by <i>Contaminated Sites Act 2003</i>, have been remediated in accordance with the PMLU classification (C). - Validation sampling confirms remediation satisfies objectives of the remedial action plan (Q).	- Audit of progressive completion: - Remediation action plans documented in MCP with supporting soil and / or groundwater investigations (C). - Remediation validation reports (C).	Where remediation goals will not be met, implement additional remedial action (where feasible) and/or consider ongoing controls and management to manage residual risks.
6 Ground Water				
6.1	Ground water levels <i>Groundwater levels are acceptable at key receptors.</i>	Post-mining groundwater and pit lake levels are within predicted ranges which have been assessed as not causing unacceptable impacts to receptors (Q).	- Audit at completion: - Model validation reports (C).	If completion criteria are not on a trajectory to being met, a risk assessment will be conducted of the residual risks associated with the departures from the completion criteria and corrective actions (if required) will be formulated in discussion with regulators. Agreed corrective actions will be implemented.

Ref	Closure Outcome	Completion Criteria	Audit / inspection for verification	Corrective actions prior to completion
6.2	Ground water quality <i>Groundwater quality is acceptable at key receptors.</i>	Throughflow - Modelling (validated by monitoring) and source-pathway-receptor assessment shows that pit lakes: - Will not become throughflow systems, or if temporary throughflow conditions occur, contaminants will not impact key ecohydrological receptors (Q). - Will not release density driven flow, or if density driven flow is likely to occur, hydrogeological assessment concludes that contaminants will not impact key ecohydrological receptors (Q). Geochemistry of backfill - Groundwater and / or pit lake monitoring shows that quality is within reference ranges, or where reference ranges are exceeded, source-pathway-receptor models or solute transport modelling show no significant impact to key receptors (Q). - The contamination completion criterion (5.1) has been met (C). Operational Contamination - The contamination completion criterion (5.1) has been met (C).	Audit at completion: - Model validation reports (C). - Achievement of geochemical stability criterion (3.3). Audit at completion: - Demonstrated achievement of contamination criterion (5.1).	If completion criteria are not on a trajectory to being met, a risk assessment will be conducted of the residual risks associated with the departures from the completion criteria and corrective actions (if required) will be formulated in discussion with regulators. Agreed corrective actions will be implemented.
7 Rehabilitation				
7.1	Topsoil / growth media <i>Suitable growth media is available to support achievement of vegetation outcomes.</i>	Growth medium profile is implemented as designed (C).	- Audit of progressive completion: - Topsoil reconciliation reported in progressive MCP updates (C). - Alternative growth media investigations reported in progressive MCP updates (C). - Audit at completion: - Demonstrated achievement of vegetation establishment criterion (7.2).	Refer to corrective actions for Criterion 7.2
7.2	Vegetation establishment and resilience <i>Vegetation in rehabilitated areas is locally native, resilient, reflective of the reference ecosystem and supports native fauna assemblages.</i> <i>Reference ecosystem to be determined through a desktop study, on-ground verification and stakeholder feedback.</i>	- Locally native species present in the reference ecosystem or adjacent ecosystems are seeded on areas to be restored or rehabilitated. - Native vegetation in restored or rehabilitated areas comprises only locally native species that occur in the reference ecosystem or adjacent ecosystems. - Species diversity and composition of native vegetation in restored or rehabilitated areas is within or above the range of variation present in the reference ecosystem at quadrat scale (Q). - Vegetation cover of native perennial species, and the cover of bare ground, in restored or rehabilitated areas is within or above the range of variation present in the reference ecosystem at quadrat scale (Q). - Cumulative native species richness within each closure domain provides at least 50% representation of the native species diversity present in a comparable spatial area of the reference ecosystem. - Evidence from restored or rehabilitated areas or adjacent rehabilitated areas of flowering and seed production from >50% of perennial species at quadrat scale to date (Q). - Species considered keystone to the reference ecosystem are well-represented throughout the rehabilitated area - Restored or rehabilitated areas support assemblages of native fauna.	- Audit at completion: - Monitoring demonstrates achievement of the completion criteria (C).	If the rehabilitation monitoring indicates that completion criteria are not on a trajectory to being met the factors impacting success will be investigated and appropriate corrective actions implemented in consultation with regulators.
7.3	Weeds & Dieback <i>Weeds or Dieback do not compromise revegetation success or surrounding vegetation.</i>	All - Priority weed species have been controlled in accordance with weed management plans (P). - Weeds do not compromise the development of native vegetation on restored or rehabilitated areas and do not represent a significant long-term weed risk to surrounding vegetation (C). - Restored or rehabilitated areas harbour only weeds that occur in the reference ecosystem, if weeds are present (Q). - Average weed cover is not greater in restoration or rehabilitation monitoring quadrats than in quadrats established in the reference ecosystem (Q).	- Audit at completion: - Weed and dieback monitoring demonstrates achievement of the completion criteria (C). - Vegetation establishment criterion (7.2) is met.	If completion criteria are not on a trajectory to being met, additional weed control or dieback management strategies may be implemented, and / or included in a post-relinquishment land management plan with appropriate resources to implement the plan.

Ref	Closure Outcome	Completion Criteria	Audit / inspection for verification	Corrective actions prior to completion
8 Heritage				
8.1	Cultural values <i>Protection of heritage sites.</i>	- Requirements for repatriating artefacts have been met (C). - Protection of heritage sites and post-closure access is facilitated by achievement of the access (1.4), surface (3.1) and geotechnical (3.2) stability criteria (C). <i>Note cultural values will also be considered in refining Closure Outcome 1.1 Post-Mining Land Use and Closure Outcome 7.2. 'Vegetation in rehabilitated areas is locally endemic, resilient, reflective of the reference ecosystem and supports native fauna assemblages'.</i>	- Audit at completion: - Confirmation from Traditional Owners that artefacts have been repatriated (C). - Evidence that landform stability (3) criteria have been met (C).	Develop and implement corrective actions in consultation with Traditional Owners.
9 Flora and Fauna				
9.1	Flora, vegetation and fauna habitat <i>Direct and indirect impacts to conservation significant flora, vegetation and fauna habitat are minimised.</i>	- Protection of flora, vegetation and fauna habitat from indirect impacts is supported by achievement of the weed (7.3) surface stability (3.1), geotechnical stability (3.2) and geochemical stability criteria (3.3) (C). - Closure activities have been completed within approved disturbance envelopes (C). - At completion, feral animal control requirements are typical of the PMLU, or where additional management is required: - These activities have been documented in a post-relinquishment land management plan (C). - Provisions have been made for the additional activities and the post-relinquishment landowner / manager accepts responsibility for implementation of the land management plan (C).	- Audit at completion - Residual risk of feral animal impacts has been assessed and there is documented acceptance of any ongoing management requirements exceeding those typical of the PMLU by the post-relinquishment landowner / manager (C). - Survey reports showing completion to plan (P). - Landform stability (surface, geotechnical and geochemical) (3), vegetation establishment (7.2) and weed (7.3) criteria are met (C). - Monitoring demonstrates achievement of the completion criteria (C).	Develop and implement corrective actions in consultation with post-relinquishment land use manager.
9.2	Influence of pit lakes on native fauna <i>Pit lakes do not adversely impact native terrestrial fauna.</i>	There is no significant pathway at closure for pit lakes to act as a source of contaminants for native terrestrial fauna (C).	- Audit of progressive completion: - Pit lake risk assessment (based on conceptual source-pathway-receptor model) is documented in MCP (C). - Management measures, if required, informed by pit lake risk assessment and consultation with DBCA and approved via MCP (C). - Approved management measures have been completed as planned (P). - Annual monitoring of pit lake quality until trends are established that support assumptions of the source-pathway-receptor model (Q). - Audit at completion: - Pit lake quality monitoring results support assumptions of the source-pathway-receptor model (P).	If the pit lake monitoring indicate that further management measures are required to prevent impacts to native fauna from pit lakes, options for mitigating impacts will be assessed in consultation with relevant regulators, and preferred options implemented. This could include measures to deter or prevent access of fauna to pit lakes. Requirements for maintaining the implemented controls would be incorporated into the post-relinquishment management plan and appropriate resources provided for implementing the plan.

10.2 Closure Monitoring

10.2.1 Rehabilitation Monitoring

10.2.1.1 Objective

The objective of the rehabilitation monitoring program is to collect data that will demonstrate progress towards, and ultimately achievement of, vegetation establishment completion criteria (Table 54) and identify where sites are not on a trajectory to success and remedial actions are required. Monitoring results will also be used to inform future rehabilitation practices as part of adaptive management.

10.2.1.2 Methodology

Review of the current rehabilitation monitoring program, analogue sites and use of remote landscape scale monitoring has commenced to ensure representative data collection for the purpose of assessing progress against completion criteria. This includes ensuring that monitoring data are not inadvertently over-estimating progress. A pre-cursor to completing this work is finalising the completion criteria as discussed in Section 8.2.1. It was anticipated that this review would be completed prior to submission of this MCP but priority has been directed to completing the closure studies for elements that will be fundamental to revegetation success (i.e., geochemical and geotechnical characterisation of WRL surface materials (Sections 5.3.3.2 and 5.3.4), adequacy of WRL surface water run-off controls (Sections 5.9.1 and 5.9.3.3) and learnings from rehabilitation trials (Section 5.9.2)). The results of these studies will inform the final closure strategies / rectifications plans for WRLs which may disturb some areas of existing rehabilitation and delay rehabilitation of other areas. MinRes will give priority to finalising the revegetation completion criteria and accompanying monitoring program in the next twelve months.

10.2.1.2.1 Operational Rehabilitation Monitoring

The methodology used for the current rehabilitation monitoring is outlined in the Vegetation and Rehabilitation Monitoring Plan (Astron, 2020b). The program utilises both on-ground and small fixed wing and multi-rotor unmanned aerial vehicles (UAV) methodologies to determine performance against the requirements of MS 852 and MS 988.

Monitoring is undertaken at:

- rehabilitation sites at borrow pits along the Carina haul road and road infrastructure areas;
- analogue sites in undisturbed vegetation that are comparable to pre-disturbance vegetation of the waste landform rehabilitation areas at Carina and Carina Extended;
- rehabilitation sites at Carina and Carina Extended WRLs;
- along the J4 Haul Road to assess the state of vegetation with relation to disturbance associated with traffic and dust.

The UAV survey covers the broader waste landforms at Carina and Carina Extended and is used to assess the rehabilitation performance of the entire waste landform.

The rehabilitation monitoring program currently assesses 42 sites (Astron, 2023a). Vegetation monitoring is undertaken annually, during periods of active plant growth following rainfall. For the Goldfields region, this is typically during spring, between September and November (Astron, 2020b).

10.2.1.2.2 Rehabilitation Monitoring Sites

Representative rehabilitation sites are installed and monitored as areas are progressively rehabilitated and it is expected that these sites will be monitored until achievement of completion criteria can be demonstrated.

A single transect or quadrat, depending upon the size of the area, is installed at each rehabilitation site, and established at a location representative of the rehabilitation site overall, towards the centre to avoid possible edge effects. Corresponding analogue sites are monitored for comparison. The analogue sites are located in adjacent, undisturbed areas within the vegetation community that corresponds to the dominant pre-disturbance vegetation community mapped at the rehabilitation site.

Monitoring transects consist of one 50 m transect, used to monitor shrubs and herbs, and one 50 m by 50 m quadrat used to monitor overstorey vegetation. Transects are orientated perpendicular to the slope and are comprised of ten quadrats set up at 5 m intervals.

The quadrats are 2 m by 2 m and located on the right-hand side of the transect. Prior to data collection, two measuring tapes are laid along the length of the transect running parallel to each other and 2 m apart to mark the width of each 2 m quadrat. Where the rehabilitation area is too small for a single 50 m transect to run perpendicular to the slope, two 25 m transects are run parallel to each other 50 m apart.

The 50 m by 50 m overstorey quadrat extends 25 m either side of the 50 m transect and runs the length of the transect. Each corner of the overstorey quadrat is permanently marked with a fence dropper. Where the rehabilitation area contains two 25 m transects, the overstorey quadrat is a 100 m by 25 m oblong, which runs perpendicular to the two transects, and extends 25 m beyond each transect.

Smaller 5 m by 5 m quadrats are established where rehabilitation areas are too small for a transect or when rehabilitation is very young and vegetation growth has not yet commenced. For the latter, quadrats are converted to 50 m transects after the first year of monitoring. The smaller quadrats feature a photo point, from which a single site photo is taken. Where a photographic point is established for young rehabilitation, the photo is orientated perpendicular to the direction of resource flow; that is, running downslope or away from roads, allowing this point to be converted to a transect start point in the following year. For rehabilitated road infrastructure sites, the photograph is orientated along the length of the road infrastructure.

A permanent marker is installed where the photograph is to be taken from, and another as a focal point for the photograph, 5 m from the photo point. The quadrat then extends 2.5 m either side of the photo point and runs 5 m to the focal point.

On-ground monitoring collects data on the variables outlined in Table 64.

Table 64 Variables recorded at each transect and quadrat (Astron, 2020b)

Site component	Variable	Description
Transect and 5 m by 5 m quadrats	Site code	Site (S) = transect site, P = quadrat site; Type I) = rehabilitation, C = analogue; Number – consecutively labelled. Fence droppers are labelled with A = start or B = end.
	Site type	Rehabilitation or analogue.
	Location	Universal Transverse Mercator (UTM) coordinates of the sites recorded on a Global Positioning System (GPS) unit (GDA94, Zone 50 or 51).
	Photograph	Two digital photographs taken from the start (A) and end (B) of the transect, orientated on the right-hand side of the transect to capture the 2 m by 2 m quadrats.
	Habitat description	Landform broadly described for rehabilitation areas.
	Vegetation community	Vegetation described and classified.

Site component	Variable	Description
	Vegetation condition	Analogue sites described and classified as excellent, very good, good, poor, very poor, completely degraded.
	Fire	Evidence described.
2 m by 2 m quadrat and 5 m by 5 m quadrat	Quadrat number	Labelled based on distance along transect (i.e., Q00 = quadrat starting at 0 m, Q05 = quadrat starting at 5 m).
	Plant cover	Percent of total vegetation cover.
	Ground cover	Percent cover of boulders, rocks, logs, litter, bare ground.
	Cryptograms	Percent of cryptogam cover.
	Surface crust	Presence of a surface crust.
	Water pooling	Presence of current water pooling or evidence of previous pooling.
	Fauna evidence	Recorded fauna species or group and identified type (e.g., sighting, scats, nest).
	Disturbance	Disturbance scored; extensive (4), moderate (3), low/scattered (2), none (1)
	Erosion	Erosion was scored; extensive (4), moderate (3), low/scattered (2), none (1). Where erosion was observed the following attributes were recorded: number of rill/gullies, maximum depth, maximum width, active (yes/no), stable (yes/no), GPS coordinates and a photograph with soil profile and depth marker where possible.
	Foliar cover	Projected live foliar cover (%) for each species (stems inside or outside quadrat). Trees were not included in any measurements for the 2 m by 2 m quadrats, as these were captured in the overstorey quadrat.
	Abundance	Number of individuals of each perennial native species with stems inside the quadrat.
	Stratum	Stratum expected to be occupied by each species, determined by taxon, not height at time of survey; herb, tussock grass, hummock grass, sedge, low shrub < 1 m, mid shrub 1 – 2 m, tall shrub > 2 m.
	Reproductive state	The most common reproductive state was recorded: flowering, fruiting, flowering and fruiting, or sterile.
	Plant health	The most common plant health was recorded: 1 – dead, 2 – poor, 3 – fair, 4 – good, 5 – excellent.
	Dust	The most common dust loading was recorded: 1 – negligible, 2 – low, 3 – moderate, 4 – high, 5 – extreme
Overstorey quadrat	Tree species cover	Projected live foliar cover (%) of each tree species within each life stage; seedling < 1 m, juvenile– 1 - 2 m, mature > 2 m.
	Tree species abundance	Abundance of all tree species within each life stage (seedling, juvenile, mature): 0 – absent, 1 – sparse, 2 – common, 3 – abundant. Dead trees to be scored separately.
	Weed species cover	Projected live foliar cover (%) of each weed species.
	Weed species abundance	Abundance of each weed species.

10.2.1.2.3 UAV Survey

MinRes uses specialists to undertake UAV based surveys for rehabilitation monitoring. The area is flown with a UAV equipped with a colour infrared (CIR) sensor to capture near infrared (NIR), red and green light wavelengths. Ground control points (GCP) placed prior to the flight are used to georeference collected UAV imagery. A GCP is a ground location that has been physically marked, typically with a

white cross, and therefore becomes identifiable within the image. The location of the GCP is measured using a GPS system. Measured locations are matched to the corresponding point within the image, which allows the transformation and projection of image data into a spatial coordinate system.

The preliminary product of the UAV survey is a CIR orthomosaic of the waste landform. A high resolution point-cloud is produced as part of the photogrammetric processing pathway. This point-cloud is extracted and processed to produce topographic products. The interpolation of an unfiltered point-cloud produces a digital surface model (DSM). A DSM represents height values that are cumulative sum of the ground level elevation and surface objects. By filtering the point-cloud, surface objects can be identified and excluded in the interpolation phase. This results in a digital terrain model (DTM) that represents only the ground level elevation heights. With additional processing, the filtered surface objects can be retained, and interpolated to generate a canopy height model (CHM) but can also be used to monitor surface stability of landforms (see Section 10.2.3).

MinRes is also investigating aerial image capture utilising manned aircraft. Aerial ultra-high resolution, multispectral imagery along with Digital Elevation Models can be used for analysis of vegetation cover, strata classification, slope analysis and erosion assessment. This remote sensing approach also has the potential to detect Malleefowl mounds over vast areas.

MinRes are in the midst of undertaking this remote sensing trial and will present results in future updates of the MCP to demonstrate the suitability and veracity of this methodology for assessing rehabilitation performance.

10.2.1.3 Corrective Actions

If the rehabilitation monitoring results indicate that an area is not on a trajectory towards meeting completion criteria, a site investigation will be completed to inform remedial actions which could include topsoil amelioration, supplementary seeding, minor drainage works, or erosion control. Monitoring will continue to demonstrate the effectiveness of remedial actions.

10.2.2 Weeds

10.2.2.1 Objective

Weed monitoring is undertaken to demonstrate progress towards, and ultimately achievement of, the completion criteria in Table 54 and provide direction for weed control efforts.

10.2.2.2 Methodology

Operational weed monitoring is used to assess changes to weed species and populations across the operational and surrounding areas as a result of the direct or indirect impacts of operational activities. An annual spring survey is carried out concurrently with the vegetation condition monitoring (Section 10.2.1). Weed species cover and weed species abundance is currently monitored (Section 10.2.1) and will continue until completion criteria are met.

An additional weed monitoring and control event is undertaken between March and September in conditions optimal for weed germination and growth. Controls include manual, mechanical and chemical removal of weeds as required.

Additional weed monitoring methods, such as aerial survey techniques, are also being investigated to maximise effectiveness of weed control efforts.

Weed control will be carried out in accordance with the Weed Hygiene and Control Procedure (MRL-EN-PRO-0007), as adapted to meet the requirements of the closure implementation phase and post-closure phases.

10.2.2.3 Corrective Actions

During the closure implementation phase, weed control will continue to be carried out annually or more frequently, as required. As rehabilitation matures, native species are expected to provide competition to weed species and the weed monitoring and control program will be adapted accordingly.

Any requirement for weed control post-relinquishment, beyond that typically required for the PMLU, will be detailed in a post-relinquishment land management plan.

10.2.3 Landform and Erosion Monitoring

10.2.3.1 Objective

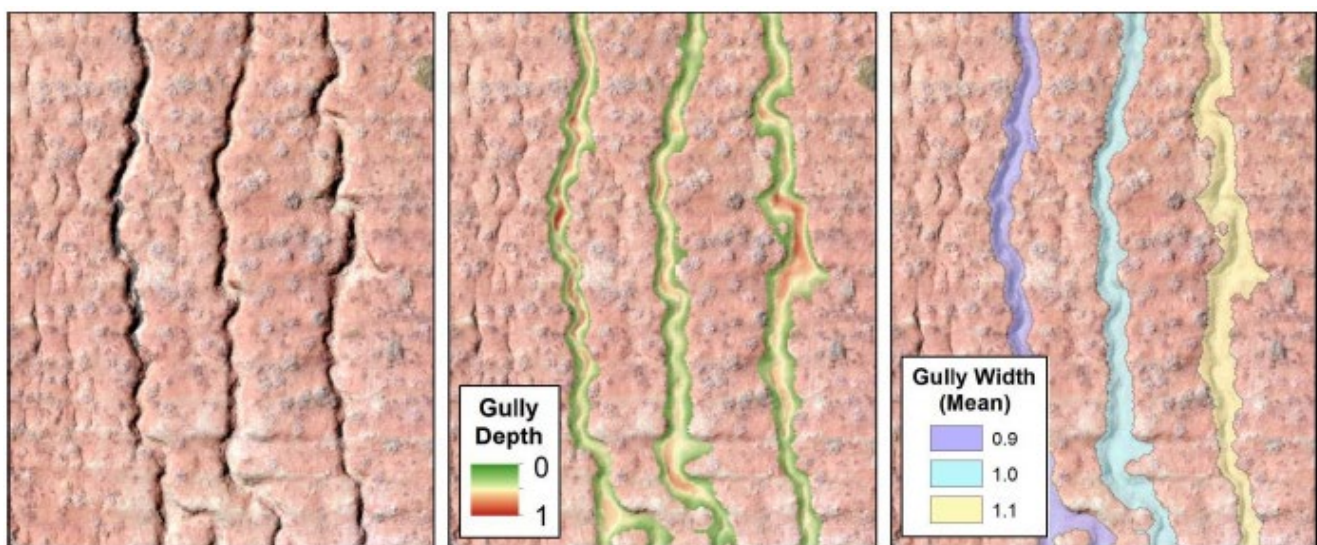
Erosion monitoring and inspection is undertaken to demonstrate progress towards, and ultimately achievement of, the surface stability completion criteria outlined in Table 54, and identify where sites are not on a trajectory to success and remedial actions are required.

10.2.3.2 Methodology

Landscape scale erosion monitoring of rehabilitated landform surfaces is planned to be carried out using techniques currently being trialled. Landform stability is currently assessed annually after the waste landform has been rehabilitated. The required frequency of measurement is potentially reduced as the landform becomes more mature and stable. Rehabilitation Performance Metrics (RPM) have been developed for stability by Astron (2020b) and include metrics of gully depth and mean width and batter ripping deviation from the contour. Monitoring is undertaken by assessing digital elevation models (Section 10.2.1.2). Examples are shown in Figure 98 and Figure 99..

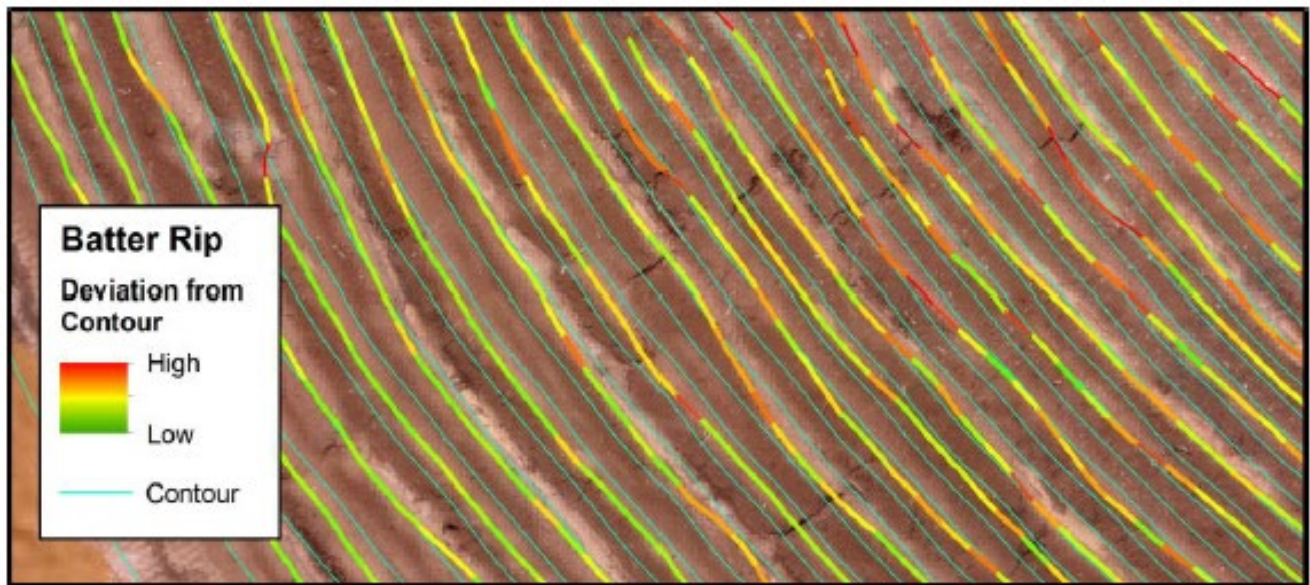
Evidence of erosion is also recorded during routine ground-based rehabilitation monitoring and conditions are recorded as described in Table 64.

The results will be plotted over time and assessed against data on climate, surface materials, landform geometry and vegetation establishment to inform closure strategies, rectification or maintenance requirements and to demonstrate performance against completion criteria.



Source: (Astron, 2020b)

Figure 98 Illustration of gully depth and mean width



Source: (Astron, 2020b)

Figure 99 Illustration of ripping deviation from the contour

10.2.3.3 Corrective Actions

Where monitoring results indicate that identified erosion is not stabilising, threatens geotechnical stability, or is having impacts on adjacent land, corrective actions will be implemented. These actions may include minor land surface re-profiling, modification of drainage features, or implementation of temporary stabilisation measures to allow vegetation to establish.

10.2.4 Groundwater and Pit Lakes

10.2.4.1 Objective

Groundwater and pit lake monitoring will be undertaken to confirm that the pit lakes and groundwater system are functioning as expected. It will also be used to validate the results of the hydrogeological modelling predictions utilised to demonstrate performance against the completion criteria related to groundwater quality and levels as stated in Table 54.

10.2.4.2 Methodology

A limited groundwater monitoring bore network has been installed throughout the Carina Operations to measure the impacts of dewatering activities and assess groundwater quality (Figure 63 and Figure 65). Data from this network has been used to model the behaviour of the groundwater system during operations and following closure at the Carina and J4 pits (Section 5.6.2). This bore network will be selectively utilised to verify that the groundwater systems are functioning as predicted by the closure studies.

Groundwater monitoring that is currently undertaken for operational monitoring will continue after closure until there is a reasonable data set to describe how the groundwater system is functioning. Monitoring frequency will be reviewed and potentially reduced as verification of modelling is established.

Pit lakes will remain at Carina, Carina Extended and the J4 East Pits and all are predicted to be groundwater sinks and therefore pose a low risk to groundwater receptors. Regular pit lake monitoring will be carried out at each of these pit lakes to validate the pit lake models (Section 5.6.2.3.2) and

determine whether the pit lakes are functioning as expected. The monitoring frequency will be reviewed once there is sufficient data to demonstrate performance.

10.2.4.3 Corrective Actions

If monitoring indicates that the groundwater or pit lake systems are not functioning as expected, the potential impacts on groundwater receptors will be reviewed and mitigation measures developed in consultation with the relevant regulators, if required.

10.2.5 AMD Monitoring

10.2.5.1 Objective

The objective of AMD monitoring is to assess the effectiveness of PAF handling measures. These results will be considered in conjunction with the vegetation establishment, surface stability and groundwater quality criteria to determine that the completion criterion (Table 54) are met.

10.2.5.2 Methodology

There is a low risk of AMD occurring at most locations within the Carina Operations because of the predominance of NAF waste materials, therefore, monitoring will be undertaken initially using visual inspection. Where PAF materials have been placed in a WRL, inspection of the slopes and toe of WRLs and adjacent vegetation will be conducted to identify:

- Areas on the WRL exhibiting signs of AMD or saline seepage such as mineral scalds.
- Decline in the condition of adjacent vegetation.

Inspection will be conducted annually or after significant rainfall. The inspection schedule will be reviewed, and revised as conditions become stable and if no evidence of AMD is identified.

10.2.5.3 Corrective Action

If WRL leachate is detected, the source and potential impacts on receptors will be investigated to inform mitigation measures such as containment, treatment or source rectification in consultation with specialist consultants and the relevant regulators.

10.2.6 Feral Animals

10.2.6.1 Objective

Feral animal observations, predominantly in the vicinity of pit lakes, will be undertaken to provide an input to the pit lake risk assessment outlined in Section 9.5 and to inform post-relinquishment land management plans.

10.2.6.2 Methodology

Monitoring of feral animals will be by observation during the annual rehabilitation monitoring program (Section 10.2.1 and Table 64) and opportunistic sightings. The extent of grazing impact from feral animals will also be observed. Polaris maintains a fauna sightings and interactions register which assists with the assessment and management of feral animals. As noted in 0 there has been communication with DBCA regarding the potential for collaboration on feral animal control.

10.2.6.3 Corrective Actions

If the extent of grazing impact on rehabilitation is significant, feral animal control programs currently used operationally will be extended. Installation of fencing as a permanent solution for managing feral animals

is not ideal because fences are prone to damage from large animals such as kangaroos and can be breached by small animals such as rabbits. If significant impact on vegetation continues to be problematic then further advice will be sought from the DBCA on alternative control actions, which may include baiting programs

10.2.7 Public Safety

10.2.7.1 Objective

The objective of security monitoring is to maintain the integrity of public safety measures that have been implemented and to identify new hazards that may arise and require additional controls.

10.2.7.2 Methodology

Post-closure monitoring would include:

- Periodic inspection of abandonment bunds and other safety measures such as fencing and signage.
- Investigate any occurrence of unauthorised public access on site.
- Inspection and audit by District Mines Inspector to confirm that hazards to public safety have been mitigated to their satisfaction.

Any requirement for monitoring to continue post-relinquishment will be determined on the basis of residual risk assessment, discussed with the relevant stakeholders and incorporated in a post-relinquishment land management plan.

10.2.7.3 Corrective Actions

Rectification works will be undertaken:

- If the integrity of abandonment bunds or other safety measures have been compromised to the extent that inadvertent public access could occur.
- Hazard mitigation works (e.g., removal of infrastructure that has not been completed according to plans).

10.3 Management and Maintenance

In addition to the environmental management works applied during operations and closure implementation and corrective actions described in Sections 10.2.1 to 10.2.7 it is recognised that there are a range of routine management and maintenance works associated with responsible land management. The aim of closure is to reduce these management and maintenance works as far as practicable to a level commensurate with that required for land typical of the PMLU. Where this cannot be achieved, a post-relinquishment land management plan will be developed and agreed with the post-relinquishment landowner / manager.

MinRes has made provision for the following management and maintenance works for the Carina Operations:

- Small scale landform remediation.
- Drainage system maintenance.
- Erosion control activities.
- Road and powerline corridor maintenance activities.
- Maintenance and repairs of fences and signage.
- Fire control until revegetation is established.

10.4 Reporting Requirements

10.4.1 Reduction of MRF Levy Commitments

A review of the Carina Operations MRF Levy is undertaken on an annual basis as required under the *Mining Rehabilitation Fund Act 2012*. The Act requires reporting of areas of mining disturbances in rehabilitation liability categories. Land on which rehabilitation has been completed in accordance with closure obligations can be classified as 'rehabilitated land'. This land does not need to be reported for the purposes of the MRF as there is no applicable 'rehabilitation liability category' (DMIRS, 2021).

10.4.2 Annual Environmental Report

As described in Sections 10.2.1 to 10.2.7 there are several environmental monitoring programs that address both operational and closure requirements.

The results of environmental monitoring completed for the Carina Operations are reported in Polaris' AER. Where monitoring data are relevant to demonstrating progress against completion criteria this will be reported in the MCP. Any remedial works undertaken will also be reported in the AER and, where relevant to demonstrating successful closure, will be summarised in the MCP.

10.4.3 Tenement Conditions

The AER is submitted to satisfy the tenement conditions requiring, the lessee to submit a brief annual report outlining the Project operations, mine site environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programs for the next 12 months.

10.4.4 Mines Safety and Inspection Act and Regulations Administration

The *Mines Safety and Inspection Act 1994* and Regulations 1995 are administered by DMIRS. Sections 42(1) (C) and 88(1) of this Act require the Manager of a mine to notify the District Inspector of the intention to abandon a mine and to furnish plans to the State Mining Engineer.

The Mines Safety and Inspection Regulations 1995 require the following actions to be taken with respect to mine closure and abandonment:

- Regulation 3.12 Notification of abandonment.
- Regulation 3.16 Details to be included in the notification of abandonment.
- Regulation 13.8 Adequate geotechnical considerations made in the abandonment of a quarry.

10.5 Completion and Relinquishment

The DEMIRS Mine Closure Completion Guidelines (DMIRS, 2021) '*clarifies what evidence tenement holders should provide to show they have met all the agreed closure outcomes and rehabilitation criteria as outlined in their mine closure plan*'.

These guidelines have informed the measurement and reporting process outlined in Sections 8.2 and 10.

Mine Closure Completion reports can be completed and submitted to DEMIRS in a staged approach as portions of a mine disturbances are rehabilitated, or for the entirety of a mine, and will be required to demonstrate:

- The agreed closure outcomes and completion criteria as outlined in the approved MCP have been met.

- Compliance with relevant environmental, rehabilitation and mine closure tenement conditions.
- Confirmation of adequate consultation and agreements with key stakeholders and post-mining landowners / managers.
- All residual risks have been appropriately considered.

It is noted that the guidelines do not cover the regulatory process under the *Contaminated Sites Act 2003* but that the Mining Act has a role in the management of closure risks including contamination. Section 8.2 outlines closure outcomes for contamination.

As discussed in Sections 8 and 10, determination of post-closure risks will be completed to support tenure relinquishment and the completion report will address 'whether ongoing monitoring or maintenance activities are required to effectively manage the residual risks, how long the activities will be required and who will be responsible for implementation of the activities' (DMIRS, 2021).

11. FINANCIAL PROVISIONS FOR CLOSURE

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes details of closure costing methodology, including clearly documented assumptions and uncertainties (Section 11.1 to 11.10).

11.1 Provisioning Objective

MinRes prepares robust closure cost estimates for its operations to support financial provisioning and life of mine planning. The objective of a financial provision is to ensure that adequate funds are available for decommissioning and rehabilitation of a site. The rules for preparing provisions are provided by International Accounting Standard 37 Provisions, Contingent Liabilities and Contingent Assets (IAS 37). The provision, referred to by MinRes as the Asset Retirement Obligation (ARO), accounts for the cost of executing the closure activities to meet legal obligations for the current disturbance at the time of the estimate.

MinRes also prepares a Life of Mine (LOM) closure cost estimate of the closure of current and future disturbance areas for the full mine plan. This estimate is used for planning purposes.

In 2022, SRK Consulting was engaged to prepare closure cost estimates for the Carina Operations using an industry recognised model called the Standardised Reclamation Cost Estimator (SRCE) model (2.0 Beta 01 Build L v2.0b01L). The SRCE model was initially developed in the United States of America (USA) and is now an established and auditor-accredited costing model which meets IAS 37 requirements. The SRCE model uses first principal methods to estimate quantities, productivities and work hours required for various closure tasks based on site-specific inputs. Costs are generally built-up using cost rates multiplied by the quantity of work to be completed. The work comprises components such as materials, labour, plant, overheads and profit. The quantity of the work may be defined by area, time, depth, volume or other measures, depending on the nature of the work. The estimate is developed using the best available information and any data gaps are addressed using assumptions. This estimate has since been updated in 2023 utilising the same SRCE model. A general description of the basis of the estimates for the Carina Operations is provided in Sections 11.2 to 11.9.

A financial provision for the closure and rehabilitation of the Carina Operations is maintained by MinRes and is based on the cost estimates updated as of 2023. The methodology used for cost estimation, and the basis of the cost estimates is provided in this section.

11.2 Basis of Estimate

11.2.1 Key assumptions

The following overarching assumptions have been applied in the closure cost model:

- The estimate includes all costs for physical closure work for which MinRes is responsible.
- The estimates assume the closure works will be undertaken by a third-party contractor and are therefore considered conservative in nature.
- Cost estimates are provided in Australian dollars, as at the date of the model.

11.2.2 Scope

For each domain and feature, physical measures, such as area, volume of material and landform design details are ascertained from spatial images, engineering drawings, approvals documents and, in some

cases, field measurements. These are then utilised in the cost model in conjunction with unit costs to generate activity costs.

The assumptions used as the basis for the cost estimate are aligned to the scope of works described in the site MCPs. The closure cost will continue to be updated by MinRes annually and the next cost estimate will encompass the new assumptions arising from this MCP and supporting technical documents.

The cost models for the Carina Operations have been developed to align with the closure plan, whereby:

- Each site is divided into closure domains and then further divided into features, which are generally defined by spatial or specific management area boundaries.
- Each feature is divided into activities, which are the specific actions to which units of measure and costs can be applied to form an estimate.

The cost models have been developed to integrate with the closure plan and to be readily adjusted to reflect changes, improvements and refinements to the plan.

The costs are collated according to a standard work breakdown structure which is summarised in Table 65.

Table 65 Work Breakdown Structure

Level 1 Items (Domains)	Level 2 Items (Features)
Waste Rock Landforms	• WRL name
Pits	• Pit name
Quarries and Borrow Pits	• Quarry name
Roads	• Access roads • Haul roads • Pipeline Corridor
Processing ponds	• Dams • Processing Ponds
Yards	• Land and roads under rehabilitation • Borrow pits • Buildings • Flood bunds • ROM Pads and Go Lines • Laydown areas • Core yards • Fire breaks • General clearings
Haul Materials	• Cover material • Rock armour • Removal of flood bund material
Demolition and equipment removal	• Camp • Airstrip • Workshops • Buildings • Fuel storage facilities • Other facilities

Level 1 Items (Domains)	Level 2 Items (Features)
Well abandonment	• Dewatering wells • Monitoring wells
Waste management	• Solid waste removal • Hazardous waste removal • Hydrocarbon contaminated soil removal
Miscellaneous	• Fence removal • Surface pipe removal
Monitoring	• Vegetation and rehabilitation • Erosion and landform • Feral animal • Weed • Abandonment bund integrity • Groundwater
Maintenance	• Revegetation • Cover • Growth media • Road
Mobilisation / demobilisation	• Fleet mobilisation and demobilisation
Studies*	• Hydrogeological modelling • Post closure access plan • Decommissioning report • Relinquishment report • Detailed final closure plan • Contaminated land assessment • Contaminated sites audit report • Landform and geotechnical stability assessment • Surface hydrology and catchment study • Completion criteria assessment • Surface materials characterisation • Materials balance • Alternative growth medium / soil analysis study • Berm capacity and erosion modelling • Pit lake modelling • Rehabilitation and research program for priority flora
Human Resources	• Environment and closure coordinator • Site and closure manager • Work supervisors • Engineering and survey

*Notes: the study program is continually evolving as new information becomes available. The cost estimate will be revised to reflect the new assumptions and plans in this MCP.

11.2.3 Schedule

The cost estimates have been scheduled based on the current intended operating life of each site and the intended completion timeframes of the work based on the site's rehabilitation work plan.

11.3 Cost Model

The cost models for the Carina Operations are aligned with the closure plan, whereby:

- The individual sites are divided into closure domains, which deal with the various spatial and post-closure aspects of the Project.
- Each domain is further divided into features, which are generally defined by spatial or specific management area boundaries.
- Each feature is divided into activities, which are the specific actions that units of measure and costs can be combined to form an estimate.
- From an accounting and cashflow perspective, the closure cost estimate has been assembled into a series of worksheets, which separate costs into tiers of detail, these being:
 - Summary - high level summary costs for each domain.
 - Cashflow - scheduled expenditures for closure costs incurred through time, both before and after cessation of the Project, until obligations associated with Project tenements cease.
 - Details per domain – divides each domain into relevant disturbed areas.
 - Unit and activity cost register – prescribes a dollar value to each unit type.

The cost models have been developed to integrate with the closure plan and to be readily adjusted to reflect changes, improvements, and refinements to the plan.

11.4 Cost Model Assumptions

The following assumptions have been applied to the cost estimation models:

- The cost estimates include all costs for physical work MinRes is responsible for as outlined in this MCP.
- Figures are provided in Australian dollars, as at the date of the model.
- Earthworks during active closure will be undertaken by a third party and fleet will need to be mobilised to and from site. Mobilisation costs are included in the estimates.
- Post closure costs (including environmental monitoring and reporting and rehabilitation maintenance) will be estimated to continue for 10 years after closure activities have been completed. Costs have been scaled down appropriately over this period as it is assumed that completion criteria will gradually be achieved throughout the 10-year period.
- The provision has been estimated for the current footprint liability. Both the life of mine and provision estimates are based on the mine design at the time of MCP development.

11.5 Limitations and Exclusions

The following limitations and / or exclusions have been applied to the cost estimation models:

- The estimate excludes all costs associated with personnel redundancies, repatriation, retraining and outplacement.
- The estimate excludes all costs associated with the removal of non-fixed assets, redundant equipment, scrap and contractor assets. These are assumed to be removed as an operational cost.
- No cost offset has been assumed for the resale of any assets or scrap.
- The estimate makes no allowance for inflation up to closure, calculation of net present value or amortising etc.

11.6 Physical Measures

For each closure domain and feature, physical measures, such as area, volume of material and landform design are ascertained from spatial images, engineering drawings, and, in some cases, field measurements. These are then utilised in the cost models to be combined with unit costs to generate activity costs.

11.7 Equipment Rate

Equipment costs form the basis of many unit and activity costs. Consequently, most unit and activity costs associated with equipment have been derived from 'hourly hire costs' or 'price per volume managed' costs already derived and aligned within the cost estimates. Where these are not available, costs are derived through the utilisation of relevant benchmark or analogue third-party costs derived from recent earthworks activities in the region. These are generally a reliable guide to cost estimating. Hence, where planned closure activities have no contractual precedents on site, costs have been derived from one of the following sources:

- Costs from similar projects in Western Australia where contract or actual costs are available, and services are delivered by a third party.
- Costs derived from first principles using standard cost development methodologies (rental, labour, fuel, wear, preventative maintenance, tyres, supervision, overheads and profit).

11.8 Unit and Activity Cost

Unit costs have been derived from site contract rates or relevant cost experience in the region. Activity rates are usually a combination of units of cost and are measured in lengths and areas, or unit of service for example:

- Hectares of topsoiling.
- Hectares of seeding.
- Kilometres of road rehabilitation.
- Volume of contaminated material managed (m³).
- Report preparation.

Activity rates have been developed for the Carina Operations using local or relevant analogue equipment or unit costs. Owner's management costs include the following cost items:

- Closure Coordinator
- Site and Closure Manager
- Work Supervisors
- Engineering and Survey

All of the above costs have been derived from actual costs, contractor rates or relevant regional analogues from recent projects. Duration estimates have been derived from the volumetric estimates and machine productivity rates, or from the work rates of demolition, earthworks and / or technical teams as required.

- Post-closure project management, in addition to management costs, include:
- Reporting costs which are derived from current actual report preparation costs based on third party consultants providing this service.

- Specialist consultant reports with respect to groundwater, engineering design, designs of surface water control measures, contaminated sites assessments or liability estimating. These are also derived from recent industry experience using third party consultants.
- Lease holding costs were derived using the current mining lease rental costs.
- Vehicle, utility and incidentals were derived using operational costs as a benchmark.

11.9 Contingency

Contingency arrangements have been made in an endeavour to combat uncertainty in estimating, where the level of accuracy or the probability of liability adjustments which cannot currently be forecast. A contingency of 15% has been applied to the estimates for each site associated with the Carina Operations.

11.10 Implementation

MinRes has assigned costs to the tasks associated with closure of the Carina Operations. These costs are incorporated into MinRes budgeting forecast and will be assessed annually by the company's external auditors.

12. MANAGEMENT OF INFORMATION AND DATA

Statement Of Compliance with Guidelines

As per the 'Statutory Guidelines for Mine Closure Plans' (DMIRS, 2020a) the mine closure plan includes a description of data management strategies, including systems and processes for the retention of mine records and all information and data relevant to mine closure.

12.1 Background

Data and reports are collated during the operational phase, as well as the mine closure and post-mining phases of an operation. MinRes has developed records management systems to facilitate effective storage and retrieval of this information as described below.

12.2 Information Management

All relevant documentation associated with the MCP is maintained in the MinRes Records Management System, and is provided to DEMIRS, as required by the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020b).

Other closure related information is stored in various records management systems as follows:

- MinRes GIS database (MRL Maps) - MRF data, site disturbance data and spatial data (including baseline vegetation data, heritage sites, weed mapping etc.).
- MinRes network drives – for all other survey data and aerial imagery. There are plans to integrate this data into MRL Maps where practicable and subject to the capabilities of the system.
- Commercial data portal – for remote sensing data.
- Company SharePoint - approved mine plans, feature designs, environmental monitoring and survey reports, closure studies and approvals documentation are stored in a SharePoint system that facilitates access by internal stakeholders and integrated closure planning. A system to develop rehabilitation work packs (signed implementation reports) has been instigated to capture rehabilitation treatment methodologies. The work packs are stored on the SharePoint.
- Stakeholder Management System – is used to document stakeholder engagements and outcomes. These registers are centrally maintained. The system is being refined to capture stakeholder contact details, be searchable by stakeholder or category and identify where an engagement results in an obligation that needs to be met.
- Closure obligations are stored in an obligations database searchable by obligation type, closure activity (e.g., landform design, topsoil management), closure aspect (e.g., vegetation, safety), domain and feature.

Documents such as Procedures and Management Plans, designed to maintain consistent standards across the operations and meet regulatory requirements, are managed in accordance with the MinRes Document Control Procedure (MRL-DC-PRO-0001), as revised from time to time. Polaris also utilises the MinRes Environmental Management System (EMS) to assist in the strategic management of key environmental risks, a subsection of which is document control and data management.

13. REVIEW OF MINE CLOSURE PLANS

Statement Of Compliance with Guidelines

As per the Statutory Guidelines for Mine Closure Plans, regarding the review or revision of a mine closure plan (DMIRS, 2020b), this section includes:

- *A revision summary table that clearly outlines all changes made in the reviewed mine closure plan (Section 13.1).*
- *A summary table documenting how the aspects identified by the department for improvement in the prior revision of the mine closure plan have been addressed (Section 13.2).*
- *A table documenting how the knowledge gaps identified in the prior revision of the mine closure plan have been addressed, as well as any new gaps identified (Section 13.3).*

13.1 Changes in this Revision of the MCP

Table 66 identifies where key information has been presented in the MCP and the changes that have been made in this version of the MCP. This revision of the MCP has constituted a major update and each section of the MCP has been reviewed to assess the relevance and currency of information presented and to incorporate new information and further detail from historical reports, where this information was previously missing and forms an important input to closure planning. Key changes are summarised below:

- The MCP has been restructured to follow the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020b). As a result, Sections 5, 6, 7 and 8 of this MCP correspond to Sections 7, 5, 8 and 6 respectively of the previous MCP (Astron, 2019b).
- The MCP has been updated to incorporate information presented in MCPs submitted for activities associated with:
 - The J4 redevelopment
 - Haul road tie-in and infrastructure upgrades.
 - East Jaurdi Aerodrome minor expansion.
 - Details of these MCPs are provided in Sections 1.1 and 1.2.
- A review has been conducted to collate a comprehensive register of closure related statements from Mining Proposals (Appendix A-3). These statements are being progressively reviewed for relevance and currency, but key commitments arising from this review along with closure-related obligations arising from other key approval documents (Ministerial Statements) have been considered in the update of this MCP.
- The stakeholder register has been updated with recent consultation, and relevant aspects of consultation have been documented in the closure implementation section of the plan.
- There has been a comprehensive review of historical waste and soils characterisation reports for each site and relevant information has been used to update the MCP. Studies of the geochemical and physical characteristics of wastes and soils have also been conducted at each site since the last MCP update, and the outcomes of these studies have been summarised and used in the development of the closure implementation strategy for each feature.
- The ZOI for the Carina Operations pits has been assessed along with preliminary abandonment bund locations. The current information is presented in the MCP along with assessments of the interactions of WRLs with the ZOIs.
- Biodiversity sections have been updated to inform the selection of reference ecosystems for reconstructed landforms, species lists for native seed collection and vegetation and weeds criteria.

Management programs and procedures implemented through the operations phase (weeds, dieback, feral animal control) that may be relevant to aspects of the closure implementation phase have been referenced in this update.

- The groundwater and surface water sections have been updated with information arising from recent modelling studies.
- A PSI has been conducted across the Carina Operations since the last MCP, and key findings of this study have been incorporated in this revised MCP.
- The results of closure studies completed since 2019 to inform final landform designs and / or rectification plans for the Carina, J4 and Aurora landforms have been summarised in Section 5.9, including:
 - Berm capacity assessment.
 - A comprehensive review of the rehabilitation trial results with recommendations for rehabilitation surface treatment.
 - Progress assessments of the as-built geometry of the constructed or partly constructed WRLs against design commitments.
 - Assessment of PAF encapsulation at the Carina WRL.
- The results of these studies, together with the results of rehabilitation monitoring (also summarised in Section 5.9) have informed the WRL designs, or design objectives presented in Section 9.
- A closure data summary has been added as the last section in Section 5 for each site.
- There has been a comprehensive update of the risk assessment based on the new information incorporated into the MCP.
- Completion criteria have been reviewed to include reference to the key risks to which each set of criteria relate and new information arising from the studies used in the update of this MCP.
- The closure implementation section (Section 9) has been revised to document the closure plans relevant to each domain and key feature. This replaces the information that was provided in Appendix E of the previous version of the MCP. Section 9 also includes updated information on key risks to be managed in the event of unplanned closure.
- There has been a comprehensive update of the monitoring section to align it with revised completion criteria. A completion and relinquishment section has been added (Section 10.5) to reflect the recent DEMIRS Mine Closure Completion Guidelines (DMIRS, 2021).
- The closure cost estimate for the Carina Operations has been updated and information on the assumptions used in the development of the estimate have been incorporated into the MCP.
- Further detail has been added on MinRes' systems for managing closure-related data.

Table 66 Mine Closure Plan Checklist

Q No.	MCP Checklist	Y / N / N/A	Section No.	Changes from Previous Version (Y/N/N/A)	Summary
1	Has the Checklist been endorsed by a senior representative within the tenement holder/operating company? (See bottom of checklist.)	N/A			No longer required
Public Availability					
2	Are you aware that all approved MCPs will be made publicly available?	Y		N/A	
3	Is there any information in this MCP that should not be publicly available?	Y	Appendix C Appendix A-3	Y	This information is commercially sensitive and so has been supplied as separate documents.
4	If "Yes" to Q3, has confidential information been submitted in a separate document/section?	Y		N/A	
Cover Page, Table of Contents					
5	Does the MCP cover page include: - Project Title - Company Name - Contact Details (including telephone numbers and email addresses) - Document ID and version number - Date of submission (needs to match the date of this checklist)	Y	Cover Page	N/A	Project Title has been changed to Carina Operations MCP to distinguish this MCP from the Yilgarn MCP (submitted to cover the Koolyanobbing, Mt Jackson, Windarling, Deception and Parker Range operations).
Scope and Purpose					
6	State why the MCP is submitted (e.g., as part of a Mining Proposal, a reviewed MCP or to fulfil other legal requirements)	Y	Section 1.1	Y	This MCP has been prepared as a comprehensive update to address issues raised by the Department of Mines, Energy, Industry Regulation and Safety (DEMIRS) in Request for Information (RFI) issued to MinRes on 9 February 2023 (DMIRS, 2023a), including that the MCP should follow the Statutory Guidelines for Mine Closure Plans (DMIRS, 2020a) and associated Mine Closure Plan Guidance (DMIRS, 2020b), as required under the <i>Mining Act 1978</i> (Mining Act).
Project Overview					
7	Does the project summary include: - Land ownership details (include any land management agency responsible for the land / reserve and the purpose for which the land / reserve [including surrounding land] is being managed) - Location of the project; - Comprehensive site plan(s); - Background information on the history and status of the project.	Y	Sections 2.1, 2.3 and 2.4	Y	Closure domains have been reviewed and updated to include information on disturbance area and key materials characteristics (Table 2).
Legal Obligations and Commitments					
8	Does the MCP include a consolidated summary or register of closure obligations and commitments?	Y	Section 3 & 0	Y	Section 3 has been reviewed and updated and a comprehensive review has been conducted of closure-related statements made in Mining Proposals. This is provided as Appendix A-3. Tenement conditions have been linked to tenement number as requested.
Stakeholder Engagement					
9	Have all stakeholders involved in closure been identified?	Y	Section 4.1.1	N	
10	Does the MCP include a summary or register of historic stakeholder engagement with details on who has been consulted and the outcomes?	Y	Section 4.1.2 and 0	Y	The stakeholder engagement register has been updated to include the outcomes of recent consultation. A summary of significant engagements conducted since the last MCP update has been provided in Section 4.1.2.
11	Does the MCP include a stakeholder consultation strategy to be implemented in the future?	Y	Section 4.1.3	Y	The stakeholder engagement strategy has been revised to reflect consultation completed since submission of the previous MCP and the current status of closure planning.

Q No.	MCP Checklist	Y / N / N/A	Section No.	Changes from Previous Version (Y/N/N/A)	Summary
			Section 4.2		The internal stakeholder consultation plan has been updated to indicate where outcomes of this consultation are incorporated.
Post mining Land Uses (PMLUs) and Closure Outcomes					
12	Does the MCP include agreed post-mining land use(s), closure objectives and conceptual landform design diagram?	Y	Sections 6 & 8	Y	In response to DMIRS comments (Section 13.2), all Carina Operations features have been provided with a PMLU. Landform design drawings are included in Section 9.2.2.
13	Does the MCP identify all potential (or pre-existing) environmental legacies, which may restrict the post mining land use (including contaminated sites)?	Y	Section 5 & Appendix D	Y	Section 5.3 and Appendix D have been updated to provide further details on historical materials characterisation studies and incorporate information arising from new studies conducted since the last MCP revision. The contaminated sites section (Section 5.7) has been included to reflect a recent PSI conducted for the Carina Operations.
14	Has any soil or groundwater contamination that occurred, or is suspected to have occurred, during the operation of the mine, been reported to DER as required under the <i>Contaminated Sites Act 2003</i> ?	N	Section 5.7	N	To date no sites have been reported to DWER as known or suspected contaminated sites.
Development of Completion Criteria					
15	Does the MCP include an appropriate set of specific completion criteria and closure performance indicators?	Y	Section 8	Y	Completion criteria have been reviewed and updated to be in SMART format and include reference to the key risks to which each set of criteria relate and new information arising from the studies used in the update of this MCP.
Collection and Analysis of Closure Data					
16	Does the MCP include baseline data (including pre-mining studies and environmental data)?	Y	Section 5	Y	There have been updates to: - The climate data section to include climate statistics from the relevant BoM weather stations (Section 5.1.1) and a discussion of climate change and considerations for closure (Sections 5.1.2 and 5.1.3) - Materials characterisation section (Section 5.3) to collate and provide further details on historical waste materials and soils characterisation studies and incorporate information arising from new studies conducted since the last MCP revision. - The topsoil balance (Section 5.3.5.3) has been updated on the basis of a topsoil stockpile reconciliation (volume and quality) completed in 2021. - Seismicity and stability section (Section 5.4.2) has been included to provide information on the ZOI of the pits, address global stability of WRLs (knowledge gap) and interaction of WRLs with ZOIs. - Biodiversity section (Section 5.5) has been updated with recent vegetation (significant flora observations only), weed and <i>Phytophthora</i> monitoring data, changes to significant flora / fauna classifications and the closure planning implications of relevant approval conditions. - Surface water and groundwater sections (Sections 5.6.1 and 5.6.2) have been updated to reflect recent flood, groundwater and pit lake modelling studies. - Site contamination section (Section 5.7) has been included to address this factor and to reflect the recent PSI completed. - Social and heritage values (Section 5.8) information has been updated to address exclusion of a heritage site from the J4 development envelope associated with the J4 Redevelopment Mining Proposal submitted in 2023. - Other closure data sections to include: - Studies completed to inform WRL berm capacity requirements (Section 5.9.1). - A more recent review of the performance of the Rehabilitation Trials on the Carina WRL and implications for surface treatments (Section 5.9.2) - A summary of the WRL closure performance based on the most recent rehabilitation monitoring results (Section 5.9.3.1), erosion performance assessment (Section 5.9.3.2) design geometry assessments completed since submission of the previous MCP (Section 5.9.3.3) and PAF encapsulation assessment (Section 5.9.3.4). - The most recent rehabilitation monitoring results for areas other than WRLs (Section 5.9.4). - Results of other trials and benchmarking (Section 5.9.5).

Q No.	MCP Checklist	Y / N / N/A	Section No.	Changes from Previous Version (Y/N/N/A)	Summary
17	Has materials characterisation been carried out consistent with applicable standards and guidelines (e.g., GARD Guide)?	Y	Section 5.3.3 and Appendix D	Y	There has been a comprehensive update of the geochemical characterisation sections to provide further details from historical materials characterisation studies and incorporate information arising from new studies conducted since the last MCP revision.
18	Does the MCP identify applicable closure learnings from benchmarking against other comparable mine sites?	Y	Section 5.9.5	Y	Benchmarking and Trials (Section 5.9.5) has been added to address MinRes benchmarking and research applicable to the Carina Operations, including a desktop review of salinity tolerance of native vegetation species.
19	Does the MCP identify all key issues impacting mine closure objectives and outcomes (including potential contamination impacts)?	Y	Sections 5 & 7	Y	The considerations for closure and knowledge gap sub-sections in Section 5 (replace Table 22 from the former MCP) and have been updated to articulate key risk issues and management measures that need to be addressed in Section 9. There has been a comprehensive review of the risk assessment (Section 7) based on the updated information provided in Section 5.
20	Does the MCP include information relevant to mine closure for each domain or feature?	Y	Section 9	Y	Section 9 has been updated to document the closure plans relevant to each domain and key feature. This replaces the information that was provided in Table 30 of the previous version of the MCP. The information presented in Section 9 has been updated based on the studies and monitoring data summarised in Section 5.
Identification and Management of Closure Issues					
21	Does the MCP include a gap analysis / risk assessment to determine if further information is required in relation to closure of each domain or feature?	Y	Sections 5, 7 & 9	Y	The knowledge gaps relevant to closure planning have been identified in Section 5 and updated according to the new information incorporated in this MCP. The risk assessment (Section 7) has also been updated and includes forward work program elements required to address knowledge gaps and uncertainties identified during the risk assessment. Some knowledge gaps requiring a forward work program have also been identified in Section 9. The forward actions identified throughout the MCP have been collated in Section 9.5.
22	Does the MCP include the process, methodology, and has the rationale been provided to justify identification and management of the issues?	Y	Section 7	Y	
Closure Implementation					
23	Does the MCP include a summary of closure implementation strategies and activities for the proposed operations or for the whole site?	Y	Section 9	Y	Section 9 has been updated to document the closure plans relevant to each domain and key feature. based on the studies and monitoring data summarised in Section 5.
24	Does the MCP include a closure work program for each domain or feature?	Y	Section 9	Y	Measures that will be undertaken for closure of the WRLs, including potential rectification measures where required, are discussed in Section 9.2.2. Further studies are required to confirm the details of rectification works and these are included in the forward work program (Table 62).
25	Does the MCP contain site layout plans to clearly show each type of disturbance as defined in Schedule 1 of the MRF Regulations?	Y	Section 2.4	Y	Maps reflect the 2023 MRF data.
26	Does the MCP contain a schedule of research and trial activities?	Y	Section 9.5	Y	Studies and investigations proposed to address knowledge gaps identified in Sections 5, 7 & 9 are collated in a Forward Work Program provided in Section 9.5.
27	Does the MCP contain a schedule of progressive rehabilitation activities?	Y	Section 9.3	Y	The schedule has been updated to reflect current plans.
28	Does the MCP include details of how unexpected closure and care and maintenance will be handled?	Y	Section 9.4	Y	The unplanned closure section has been updated with additional information, including key risks to be managed in the event of unplanned closure.
29	Does the MCP contain a schedule of decommissioning activities?	Y	Section 9	Y	Section 9 has been revised based on the studies and monitoring data summarised in Section 5 and current progressive closure / rehabilitation plans.
30	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?	Y	Section 10	Y	There has been a comprehensive update of the monitoring and maintenance section to provide further detail and align monitoring activities with the completion criteria in Section 8.
Closure monitoring and Maintenance					
31	Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance?	Y	Section 10	Y	There has been a comprehensive update of the monitoring and maintenance section to provide further detail and summarise the approach to identification and implementation of corrective actions should monitoring data indicate that they are required.
Financial Provisioning					
32	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?	Y	Section 11	Y	Information on the assumptions used in the development of the estimate have been incorporated into the MCP.

Q No.	MCP Checklist	Y / N / N/A	Section No.	Changes from Previous Version (Y/N/N/A)	Summary
33	Does the MCP include a process for regular review of the financial provision?	Y	Section 11.3,	Y	Information on MinRes processes for reviewing and updating cost estimates has been included.
Management of Information and Data					
34	Does the MCP contain a description of management strategies including systems and processes for the retention of mine records?	Y	Section 12	Y	Further detail has been added on MinRes systems for managing closure-related data.

13.2 Response to Regulator Feedback

Revision 0 of the Carina Operations MCP was submitted to DEMIRS in 2019 and approved on 9th February 2023. The approval included a number of comments to be addressed in the next revision of the MCP. Table 67 lists those comments and notes where they have been addressed in this document.

As discussed in Section 1.1 progress against items listed in Schedule 1 of the J4 Redevelopment approval, granted on 20 October 2023 (DMIRS, 2023b) have been addressed in Section 13.3. Outstanding matters will be addressed in separate correspondence to be provided to DEMIRS by October 2024.

As discussed in Section 1.2 two small mining operations MPs / MCPs have also been approved since 2019, (Polaris Metals, 2022; MinRes, 2020) subject to closure commitments being incorporated in this revision of the Carina Operations MCP. Table 68 addresses the closure commitments raised in the Small Mining Operations MCP and where they have been addressed in this MCP.

Table 67 Response to DEMIR's Comments on Carina Operations MCP (2019b)

Item	MCP 2019 (Rev A) Section	DEMIR's Comments	Rev 1 MCP Response
1	General	The next Mine Closure Plan (MCP) needs to follow the March 2020 Closure Plan Guidelines. https://www.dmp.wa.gov.au/Documents/Environment/REC-EC-111D.pdf	This MCP has been prepared and structured in accordance with the 2020 Closure Plan Guidelines (DMIRS, 2020a; 2020b).
2	General & revision date	Considering that most of the site is in active closure, there needs to be a greater level of detail and designs presented to allow confidence that closure is being well managed. The MCP suggests that J4 is the only operational area, blending low grade stockpiles only, which allows significant areas available for closure and rehabilitation. The next MCP must contain a higher level of detail in all aspects to allow regulator review. Given the extent of work needed for the next revision of the MCP, DMIRS would consider an extension beyond April 2023 if Polaris Metals requested this in writing	A greater level of detail is provided in this MCP and is commensurate with the level of detail available from the phase of closure studies being undertaken. MinRes has undertaken significant work since the previous MCP to address knowledge gaps and improve the knowledge base. This information informed the risk assessment (Table 53) and supported the development of the forward work program (Table 62).
3	Section 3 Closure Obligations and Commitments & Section 9 Closure Implementation	The Obligations and Commitments register is required to be reviewed as it contains repetition. In its current format the register serves only to collate relevant project requirements, it cannot be utilised as a tool for demonstrating compliance or progress toward achievement of legally binding commitments. The next MCP Section 3 must also contain a table including the: - Approval Instrument - Date / Registration ID - Obligations and commitments The table should then be reproduced with the progress included as a column: Compliance progress / estimated date for completion. This table may be best included as part of Section 9 Closure Implementation.	Since the last MCP revision, Mining Tenement conditions, MS conditions and closure related statements from 29 MPs, MP Addendums and NOIs, approved and listed as Environmental Registrations under the <i>Mining Act 1978</i> , have been collated into a working register. A list of the documents reviewed is provided in Appendix A-1, A-2 and A-4 and the full register is provided in Appendix A-3. MinRes will progressively review and update this working register (which includes duplicate and potentially superseded statements) for currency and applicability to the MCP. The register includes the ability to search statements by closure domain, aspect and activity and has been used to provide background to relevant sections throughout this MCP and will continue to inform future revisions of the MCP. This register includes the Approval instrument / Date / Registration ID / Obligations and Commitments. This register will support completion reporting as outlined in 10.5.
4	Section 3 Closure Obligations and Commitments	As part of Appendix 2 Commitments Register, the Tenement Conditions do not specify which tenement the conditions apply to. This table must be reviewed, and an updated version included in the next MCP.	The obligations register has been updated to include the additional information suggested and is provided in Appendix A.
5	Section 4 Stakeholder Engagement & Appendix 3 Stakeholder Engagement Register	General comments on Stakeholder Engagement: - As raised in the 2018 Approval letter, a clear strategy for consultation with DBCA is required. - An update of progress, with the expectation that knowledge gaps would now be closed off and reported. - An updated timeframe for any remaining consultation. - Appendix 3 – There is no Proponent response to the 7/9/2018 DMIRS meeting raising the requirement for regular quarterly progress reports. - Appendix 3 – The actual date of each consultation must be entered, the use of 'ongoing' is not acceptable. - Appendix 3 - Inclusion of the names of persons present in discussions allows for further discussion should DMIRS or others require clarification. These areas are to be addressed in the next MCP submission.	As described in Section 4.1.2 consultation with DBCA was progressed in 2023 with a six-monthly time frame for ongoing consultation proposed. Comment relating to Appendix 3 of the 2019 MCP have been addressed where possible in Appendix B of this Rev 1 MCP. Retrospective dates / names have not been included but have been included for more recent consultation where possible.
6	Section 5 Baseline Closure Data	DMIRS notes that not all mine waste characterisation has been completed and detailed in the MCP, which is critical knowledge when determining landform designs. DMIRS requires an update on finalisation of this for the next MCP.	The knowledge base has been updated to include contemporary materials data (refer Section 5.3) and this information has informed the updated risk assessment (Table 53) and remaining gaps will be addressed through the forward work program (Table 62).
7	Section 6 Post Mining Land Use	DMIRS recognises that the MCP talks about Post Mining Land Use (PMLU) options for each location, but what is missing is a clear map showing what is proposed across the site. Provide a map clearly showing the PMLU areas in the next MCP.	PMLU are shown in Figure 87 to Figure 90.
8	Section 7 Risk Assessment	Table 26 the "Closure Risk Register" is missing. This is an essential part of the MCP and must be included in the next MCP.	The risk register is provided at Table 53.
9	Section 8 Completion Criteria	Completion Criteria are not in SMART format, most lacking a "Time" aspect that allows for an understanding of when they will be achieved. Some lacking "Specific" (example: erosion "does not threaten the integrity of the landform" – what does this actually mean?). This aspect was raised in the 2018 Approval Letter. DMIRS require greater effort to finalise the Completion Criteria considering the timeframe to actual closure. This is to be reported in the next MCP.	Updated completion criteria are discussed in Section 8.2 and provided in Table 54.
10	Section 8 Completion Criteria	The period of monitoring to attain Completion Criteria is not handled consistently throughout the MCP. Periods of '3 years', 'annually' and 'until completion criteria are met' all appear. DMIRS 2020 Guidelines provide an example of 'usually in the order of 10 years'. DMIRS require clarity of the timeframe included in the next MCP, and consistency throughout the document.	Monitoring will be undertaken until completion criteria are met as listed against each criterion in Table 54. Indicative timelines assumptions for each site include a minimum of 10 years of monitoring.

Item	MCP 2019 (Rev A) Section	DEMIR's Comments	Rev 1 MCP Response
11	Section 8 Completion Criteria	Table 4 Yilgarn Operations Completion Criteria "Quantitative standard(s)" require review, as some are marked as 'Not applicable' are important to define accurately. Examples include Zone of Instability (can be reviewed by aerial survey prior to relinquishment to show any failures) and Erosion which is already reported on in the 2022 AER by use of aerial survey techniques. These Quantitative standards are to be reviewed and updates included in the next MCP.	Updated completion criteria are discussed in Section 8.2 and provided in Table 54.
12	Section 9 Closure Implementation	DMIRS notes in the MCP, and the 2022 AER submission, that: - Major erosion exists in historical and recently rehabilitated WRDs. - It is noted that designs show berms are to be backsloping at 5 degrees and 10 m berms (MCP Table 21 states 20 m) or they will fail. - There are several cases in the AER where reshaping of slopes is suggested, or re-digging of berms to meet design. - WRDs have been built above lift height recommendations (22 m or 15 m not 10 m) - Berms were not back sloped in 85% of surveyed areas. - The MCP recognises these issues, but no remedies. DMIRS require an action plan to remedy these identified issues to be included in the next MCP. There is also inconsistency between Table 21 and Figure 15 and the text in section 9 regarding design parameters that requires review and correction where necessary (e.g., depth of topsoil 100-150 mm vs. 50 – 100 mm, width of berms 10 m vs 20 m).	Preliminary WRL 'health checks' were undertaken for the WRLs across Carina Operations to assess their general compliance with the original design and assess their progress towards meeting final closure objectives. The findings of the health checks are discussed in Section 5.9.3.3. Two berm capacity assessments have been completed to refine the understanding of the risk associated with erosion on the WRLs and to inform the assessment of mitigation options where required. The findings of the assessments have been incorporated into the knowledge base (see Section 5.9.1). Erosion continues to be monitored as a component of rehabilitation monitoring (refer to Section 5.9.3.2) and, together with the outcomes of the berm capacity studies and health checks, the results have been used to inform the risk assessment (Table 53). Measures that will be undertaken for closure of the WRLs, including potential rectification measures where required, are discussed in Section 9.2.2. Further studies are required to confirm the details of rectification works and these are included in the forward work program (Table 62).
13	Section 9 Closure Implementation	Landform Design drawings and 'as-built' mapping must be shown to give confidence in the long-term stability of the structures, particularly considering the poor compliance to the design criteria found in the 2022 AER reporting. These are to be included in the next MCP.	Landform design drawings are included in Section 9.2.2.
14	Section 9 Closure Implementation	As raised in the 2018 Approval letter, closure implementation schedules have started but generally do not go beyond 1 year. Considering the progression to closure it is expected that the finalisation of the schedule should be able to be defined to greater detail. This schedule is to be defined in the next MCP.	The rehabilitation schedule is provided in Section 9.3.
15	Section 9 Closure Implementation	DMIRS recognises that the MCP has identified domains for the operation (Table 29) but notes that there is no clear link between these domains and the Implementation Strategy (Table 30). The domain format then returns in Section 9.3 plans. DMIRS require a consistent approach to be utilised in the next MCP.	The domain format has been used consistently throughout this updated version of the MCP.
16	Section 9 Closure Implementation	DMIRS notes that Geochemistry shows the existence of Potentially Acid Forming minerals at Carina and J4. Detailed designs of PAF storage cells and final landform designs are required to be submitted in the next MCP. The method of preventing pit exposures from contaminating Pit Lakes is also required.	An assessment of PAF encapsulation in the Carina WRL has been undertaken and is discussed in Section 5.9.3.4.1. A discussion about the potential for PAF material in the backfill material within Carina Pit is provided in Section 5.3.3.5.1. A discussion about the proposed encapsulation of PAF within the J4 West Pit is provided in Section 5.3.3.5.2 and a description of the proposed PAF encapsulation cell Pit is provided in Section 9.2.1.4 and Figure 92. Pit lake modelling has been undertaken to assess potential risks associated with PAF material included in backfill of the Carina Pit (Section 5.6.2.3). Groundwater modelling has been undertaken to assess the potential risk associated with PAF material being encapsulated in backfill within the J4 West Pit and is discussed in Section 5.6.2.3.2.
17	Section 9 Closure Implementation	Details of Water Management Structures remaining at closure must be provided in the next MCP.	Surface water assessments and flood modelling have been undertaken (refer Section 5.6.1 and Section 5.6.1.4) and the outcomes used to inform the risk assessment (Table 53). The studies completed to date will be used to assess mitigation options and develop detailed designs for flood management infrastructure where this has been identified as necessary. This next stage of design has been included in the forward work program (Table 62).
18	Section 9 Closure Implementation	The MCP notes the development of a Decommissioning Plan for the infrastructure and equipment areas. A copy of this plan is required to be included for the next MCP.	A separate Decommissioning Plan has not been developed for infrastructure areas. The strategy for decommissioning infrastructure is provided in Section 9.2.4.

Item	MCP 2019 (Rev A) Section	DEMIR's Comments	Rev 1 MCP Response
19	Section 10 Monitoring and Maintenance	At various points in the MCP there is reference made to rehabilitation trials, with some results discussed, however the actual reports need to be attached to the next MCP.	The rehabilitation trials are discussed in Section 5.9.2 and copies of the reports are appended to this MCP.
20	Section 10 Monitoring and Maintenance	DMIRS recognises that there are areas of rehabilitation that have now been in place for a number of years and would expect to see inclusion of monitoring information and the implications it has on the closure designs and implementation at the site. An example of this work was submitted in the 2022 AER "2021 Environmental Inspection Report", for all the operations covered in the MCP. This information is to be included in the next MCP, most likely in Section 5 on Closure Data. The implications of the results are to then be reflected in a review of the monitoring program with relation to any change in methodology, timing, locations or duration.	The rehabilitation trials are discussed in Section 5.9.2. The results of rehabilitation monitoring are summarised and discussed in Section 5.9.3.1. The rehabilitation monitoring program, has been reviewed and updated as detailed in Section 10.

Table 68 Incorporation of Commitments / Conditions of Approval from Small Mining Operations MCPs into Rev 1 of the Carina Operations MCP

MCP Section	DEMIR's Comments / MCP Commitment to be Addressed in Rev 1 Carina Operations MCP	Rev 1 MCP Response
REG ID 91650 Mining Proposal MCP for Small Mining Operations - Yilgarn Operations – Haul Road Tie-In and Infrastructure Upgrade Works – Revision 1 (MinRes, 2020)		
General	At the next revision of MRL's site wide Yilgarn MCP (for Environment Group Site S0006591) all disturbances detailed in the Small Mining Operations MCP must be incorporated into the site wide MCP.	Disturbances (applicable to J4) have been incorporated in this MCP Rev 1 including: - Haul Road (Transport corridor) (Section 2.4). The following disturbances are captured in the Yilgarn Operations MCP (MinRes, 2023d) - Construction of a centralised warehouse at Koolyanobbing (Industrial infrastructure). - Widening sections of existing Windarling and Koolyanobbing powerline corridor to improve firebreak and maintenance access (Linear infrastructure). The area where the Koolyanobbing powerline intersects Heritage Site 22644 is excised from the Proposal.
Stakeholder Engagement	MRL must continue to engage with all post mining land users about closure plans, including the reserve vestees within the Koolyanobbing Townsite.	Commitments to future consultation in the small Mining Proposal: ' <i>Consultation with DBCA during Proposal implementation and post implementation will be undertaken through six (6) monthly stakeholder engagement meetings</i> ', is consistent with this Rev 1 MCP. Future stakeholder consultation is addressed in Section 4.1.3. The reserve vestees of the Koolyanobbing townsite are not applicable to the Carina Operations and were addressed in the Yilgarn Operations MCP. The haul road addressed in this Small Mining Operations MP / MCP connects the Carina Operations and the Yilgarn Operations.
Post Mining Land Use	The proposed PMLU for the haul road is grazing of native vegetation to support "Production from Relatively Natural Environments" (ALUM Primary Class 2). This PMLU has been proposed due to the proposed areas located within the Mount Jackson Pastoral Station, where pastoral activities are currently undertaken	The nominated PMLU (for the J4 / Haul Rd section of this proposal) is consistent with this MCP Rev 1 and captured in Section 5.9.7.
Closure Implementation	Haul Road (Transport Corridor) - Rehabilitate where retention is not agreed in the Post-Closure Access Plan. - Remove signage, delineators, windrows, drains and culverts - Rehabilitate disturbed areas using standard rehabilitation method.	These commitments are captured in Sections 9.1.4 and 9.2.4 of this MCP Rev 1.
Closure Monitoring and Maintenance	As detailed in Section 5 of REG ID 91650 MCP.	Closure monitoring and maintenance commitments (Section 5.1 of REG ID 91650 MCP) are consistent with this MCP Rev 1 (Section and 10).
REG ID 113898 Mining Proposal MCP for Small Mining Operations - East Jaurdi Aerodrome Carpark Extension (Polaris Metals, 2022)		
Post-mining land use	The post-mining land use proposed for the Carina Southern Operations is: - Natural vegetation on Crown Land. Infrastructure areas such as the rail loop and airstrip may present a future opportunity for use by stakeholders. The post-mining land use may be revised to include retention and use of infrastructure by third parties if required.	The nominated PMLU for the Carina Southern Operations is consistent with 'Natural Environments' proposed in this MCP Rev 1 (Section 5.9.7). The potential for retention and use of infrastructure by third parties is addressed in Sections 4 and 9.2.4 of this MCP.
Stakeholder Engagement	Continued engagement with key stakeholders	Commitments to future consultation with the key stakeholders listed in (Polaris Metals, 2022), is consistent with this Rev 1 MCP (Section 4.1). Future stakeholder consultation is addressed in Section 4.1.3 of this Rev 1 MCP.
Closure Objectives	Stability: Rehabilitated surfaces are stable and are not subject to unacceptable rates of erosion.	The listed closure objectives for the East Jaurdi Aerodrome are consistent with those for the Carina Operations overall as addressed in Section 8 of this Rev 1 MCP.

MCP Section	DEMIR's Comments / MCP Commitment to be Addressed in Rev 1 Carina Operations MCP	Rev 1 MCP Response
	Water: Disruptions to natural drainage lines have been minimised. All hydrocarbons and chemicals have been removed from site, and any residual site contamination has been remediated or otherwise controlled such that there is no adverse impact on future land use and water resources. Ecosystem Development: Self-sustaining and resilient vegetation that is trending towards the condition of analogue site data has developed on final landforms and other disturbed areas. Beneficial Use: Vehicular access has been maintained as required under tenement conditions or as agreed with key stakeholders (DBCA, Traditional Owners and pastoral lease holders). Where transfer to a third party is not agreed, infrastructure has been decommissioned and removed such that no construction materials remain above ground.	
Closure Monitoring	At the post-closure stage, monitoring will be undertaken annually. The objective of this monitoring is to demonstrate that the completion criteria have been achieved, with the program to cease once completion criteria have been met for a period of three consecutive seasons. Monitoring will be targeted towards those closure issues that directly relate to the given completion criteria.	Commitments to closure monitoring are consistent with those outlined in Section 10 of this Rev 1 MCP.

13.3 Progress Against Improvement Activities Identified in 2019 MCP

Progress against the forward work program identified in Revision 0 of this MCP is summarised in Table 69.

Revision 0 of the J4 Redevelopment Project MCP was submitted in September 2023 and has been integrated into this MCP. Progress against some of the forward work program actions have been provided in Table 69 where works are substantially complete.

Table 69 Progress Against Knowledge Gaps Identified in Revision 0 of this MCP and Revision 0 of the J4 Redevelopment Project MCP

Aspect	Site	Knowledge Gap	Commitments for Rev. 1 MCP Update	Rev. 1 Progress to Address Knowledge Gap
Social and Heritage	All	Limited consultation with key stakeholders regarding: - post-mining land use - infrastructure to be retained - post-mining access requirements - completion criteria - formal closure sign-off and relinquishment mechanism.	- Update Stakeholder Engagement Strategy. - Conduct stakeholder engagement focused on: - post-mining land use - development of Post-Mining Access Plan - infrastructure to be retained - completion criteria - formal closure sign-off and relinquishment mechanism.	The Stakeholder Engagement Strategy is discussed in Section 4.1.3.
Social and Heritage	J4	Impacts to heritage / cultural values during closure works at J4.	Assess potential impacts to heritage sites arising from closure execution works and revise designs to avoid sites. If this is not possible, seek approval for disturbance. The backfill strategy for the J4 West pit will be developed in consultation with Marlinyu Ghoorlie with clearly marked out areas.	Engagement with the Marlinyu Ghoorlie People to date is discussed in Section 4.1.2 and has been ongoing since 2020. Engagement with Marlinyu Ghoorlie has focused on the drafting of a comprehensive claim wide agreement (Indigenous Land Use Agreement). Agreement negotiations are ongoing and future engagement with Marlinyu Ghoorlie will include consultation and engagement regarding mine closure (Section 4.1.3). It is intended for this this MCP to be used as a starting point for those discussions with feedback included in the next update, to allow sufficient time for review and input by Marlinyu Ghoorlie.
Materials Characterisation	Aurora	At the time of writing Revision 0 of this MCP there was an incomplete understanding of the geology of the Aurora mine area and of: - potential for generation of AMD from materials in the pit walls to affect the pit lake water quality. - potential for AMD formation if PAF materials are not identified and managed appropriately in the WRL and low-grade stockpiles. - suitability and availability of materials for rehabilitation of disturbance areas. - grade of low-grade stockpiles and strategy for their closure.	- Review historic data for Aurora. - Determine physical and chemical properties of materials in low-grade stockpiles and WRL at Aurora as part of surface materials characterisation sampling program.	A review of historical data has been completed (Section 5.3.3.1.4) however, limited information has been identified. Studies have been undertaken to further understand the risks associated with Aurora. A pit lake is not expected to form at Aurora and therefore pit lake quality will not be an issue (Section 9.2.1.5). Additionally, flood modelling has demonstrated that a proposed abandonment bund will prevent any floodwaters from overtopping the pit and releasing impacted water (Section 5.6.1.4.3) Geochemical and physical characterisation of waste and low grade ore is included in the forward work program of this MCP (refer Table 62).
Materials Characterisation	Aurora	Geochemistry of waste rock and stockpiled low-grade material at Aurora.	- Conduct materials characterisation program for waste rock and low-grade stockpiles at Aurora. - Develop closure and rehabilitation strategy for Aurora low-grade stockpiles and WRL based on results of materials characterisation program.	Geochemical and physical characterisation of waste and low grade ore is included in the forward work program of this MCP (refer Table 62).
Materials Characterisation	Aurora	Rehabilitation materials available and their volumes at Aurora.	Survey and document location and volume of all rehabilitation materials at Aurora, including competent rock for construction of abandonment bunds.	Identification of rehabilitation materials for Aurora is included in the forward work program of this MCP (refer Table 62).
Materials Characterisation	Aurora	Volume of rehabilitation materials required for remaining disturbance areas at Aurora.	- Determine closure strategy for low-grade stockpiles at Aurora based on grade and cost for rehabilitating. - Survey area of disturbance areas requiring rehabilitation at Aurora. - Based on rehabilitation materials available and experience at Carina and J4, develop rehabilitation method for disturbance areas at Aurora. - Calculate volumes of rehabilitation materials required for rehabilitation of remaining disturbance areas at Aurora based on the material depth in the rehabilitation method and area of disturbance. - Calculate volume of competent rock required to construct abandonment bund to meet regulatory requirements. - Reconcile volumes of rehabilitation materials available with volumes required to rehabilitated remaining disturbance areas at Aurora.	Development of a closure strategy for Aurora is included in the forward work program of this MCP (refer Table 62).
Materials Characterisation	Carina	Documented survey of as-built PAF encapsulation cells at Carina WRL.	Document as-built survey of Carina WRL including PAF encapsulation cells.	A survey was completed by Okane (2022a) and the findings are described in Section 5.9.3.3 and Section 9.2.2.

Aspect	Site	Knowledge Gap	Commitments for Rev. 1 MCP Update	Rev. 1 Progress to Address Knowledge Gap
Materials Characterisation	Carina	Documented survey of PAF encapsulation within in-pit backfill.	Document survey of encapsulation areas within in-pit backfill at Carina.	Since Rev 0 of this MCP, MinRes has focused on understanding the pathways and receptors associated with the risk attributed to encapsulated PAF in the Carina backfill. Groundwater modelling has been completed (Section 5.6.2.2.1) and pit lake modelling conducted (Section 5.6.2.3). Based on the findings of these studies, the risk assessment (Table 53) found the risk of impact to groundwater from backfill PAF at Carina to be low. Therefore, no further assessment of the encapsulated PAF is planned. Ongoing pit lake monitoring will be undertaken to verify the results of modelling as discussed in the forward work program of the MCP (refer Table 62).
Materials Characterisation	J4 and Carina	Updated volume of remaining topsoil stockpiled at Carina and J4 and reconciliation against volume required for rehabilitation of remaining disturbance areas.	- Survey and document location and volume of all remaining topsoil and vegetation stockpiles at Carina and J4. - Calculate volume of topsoil required for rehabilitation of remaining disturbance areas at Carina and J4 based on topsoil depth in rehabilitation method and area of disturbance. - Reconcile volume of topsoil available with volume required to rehabilitate remaining disturbance areas at Carina and J4.	A topsoil balance has been developed as outlined in Section 5.3.5.3
Materials Characterisation	J4	Performance of rehabilitation at J4 utilising topsoil stockpiled during mining, which was not targeted at specific soil types.	- Monitor performance of rehabilitation at J4. - If rehabilitation not trending towards meeting completion criteria, conduct a soil investigation to assess whether soil characteristics are contributing to sub-standard performance. Develop a remedial strategy if required.	Rehabilitation monitoring has not commenced at J4 because rehabilitation is not sufficiently progressed (see Section 5.9.3.1).
Materials Characterisation	J4	Materials balance is required to identify and segregate materials for use for armouring at J4.	Identify sources of suitable material for improving the erosional stability of WRLs where required.	The erosional stability of the J4 WRLs was assessed and is discussed in Section 5.3.4.3 and Section 5.3.5.2.3. The understanding of what types of materials will be suitable on the surface of landforms has been progressed as discussed in Section 5.3.4.5. Identification of sources of suitable material is included in the forward work program of this MCP (refer Table 62).
Materials Characterisation	J4	Further work is required to determine the potential impacts to pit lake water quality arising from any pit wall exposures of PAF material that remain above the water table post mining and the associated risk to potential receptors.	Map pit wall exposures of PAF materials and ascertain risk if any.	Groundwater modelling has been completed (Section 5.6.2.2.25.6.2.2.1) and pit lake modelling conducted (Section 5.6.2.3). Based on the findings of these studies, the risk assessment (Table 53) found the risk of impact to groundwater would be low because the pit lake is expected to form a sink. Additionally, there is no potential for flooding to enter the pits at J4 (see Section 5.6.1.4.2) and therefore overtopping of impacted water from the pit lake does not pose a risk. Ongoing pit lake monitoring will be undertaken to verify the results of modelling as discussed in the forward work program of the MCP (refer Table 62).
Seismicity and Stability	J4	Final ZOI as a result of the ongoing development of the J4 East mine void	ZOI will be refined as mining progresses. Where the final ZOI intersects on the J4 East WRL, remedial earthworks will be carried out such that all landforms are outside the final ZOI.	The ZOI for J4 is discussed in Section 5.4.2.1. Further assessment will be undertaken to confirm the location of the ZOI of the final pit and is described in the forward work program (refer Table 62).
Water	J4	Pit lake modelling / groundwater at J4	Pit lake model to be updated to include the effects of the ongoing development of the J4 East mine void and utilise groundwater monitoring data to refine / calibrate the pit lake model.	Modelling is underway (see Section 5.6.2.3) to assess the effects of the ongoing development of the J4 East mine void. Two scenarios have been modelled, including, backfilling J4 West pit to AWT, and not backfilling the void and allowing a pit lake to remain.
Water	Aurora, Carina Extended and J4	Pit lake post-mining water level, recovery time and water quality at Aurora, Carina Extended and J4 pit lakes.	- Conduct pit lake modelling for Carina Extended and J4 pits as required. - Determine alternative Carina pit monitoring bores for collection of water quality samples. Standing Water Level is only possible from current monitoring bores	Pit lake modelling has been undertaken for Carina Extended and J4 pits and is discussed in Section 5.6.2.3.2. The results have informed the risk assessment (Table 53) which found there is a low risk of impact to groundwater receptors from the pit lakes. A review of groundwater monitoring was completed in 2023 to support development of the groundwater model (Section 5.6.2.3.2) and to refine the optimal locations for future monitoring. Monitoring location targets have been recommended by PSM (2023 Draft) are currently being considered by MinRes.
Biodiversity	Aurora	Baseline fauna data for Aurora.	Review survey work completed in region and commission works as required.	No site-specific fauna baseline survey data is available for Aurora, however, a review of survey data for the other Carina Operation sites, and regional biodiversity values has been undertaken and is described in Section 5.5.2. No listed Threatened Ecological Communities have been recorded in the Carina Operations area (Section 5.5.2.7) however, one threatened fauna species, Malleefowl

Aspect	Site	Knowledge Gap	Commitments for Rev. 1 MCP Update	Rev. 1 Progress to Address Knowledge Gap
				<i>(Leiopa ocellata)</i> , is recorded in the region and will need further consideration during planning for rehabilitation of the Aurora site.
Contamination	J4	Contamination	Further investigation and remediation (if required) as a result of the proposed activities as part of the J4 Expansion.	A Preliminary Site Assessment was completed for the Carina Operations in 2022 (Section 5.7.1). No significant sources of potential contamination were identified at J4.
Contamination	All	Extent of contaminated sites and requirements for remediation.	Conduct contaminated sites assessment at Aurora, Carina and J4 and develop remediation plan if required.	A Preliminary Site Assessment was completed for the Carina Operations in 2022 (Section 5.7.1). No sources of potential contamination were identified at Aurora and so there will be no further assessment at that site. Potential sources of contamination were identified at the Carina and Carina Southern sites. Scoping is underway for a Detailed Site Investigation to address data gaps and to determine the nature and extent of contamination within areas of concern identified by the Preliminary Site Assessment. This work is included in the forward work program (Table 62).
Closure Implementation	Aurora	Approved landform design for Aurora WRL.	Based on results of materials characterisation program, develop landform design to include in Mining Proposal for rehabilitation activities to occur at Aurora.	Landform design and rehabilitation planning is underway. Components of the planning completed to date include a surface water assessment (Section 5.6.1.2.3), flood modelling (Section 5.6.1.4.3). This has informed the risk assessment and the development of mitigation options. Next steps will comprise assessment of materials characteristics to refine the understanding of the waste and identify rehabilitation materials. These activities are included in the forward work program (Table 62).
Rehabilitation	Aurora	Rehabilitation prescription and expected performance of rehabilitation for Aurora: - camp site - WRL - low-grade stockpiles.	- Document rehabilitation method used for Aurora camp site in next version of MCP. - Incorporate Aurora into annual rehabilitation monitoring program. - Develop rehabilitation strategy for Aurora WRL and low-grade stockpiles (if required) based on results of materials characterisation program.	The rehabilitation method used for Aurora camp is consistent with the method outlined in Section 9.2.4. There is limited, historic rehabilitation at Aurora however, it is not considered sufficient to warrant rehabilitation monitoring until substantially more rehabilitation has been completed. Preliminary erosion monitoring was conducted on the WRL in 2022 (Section 5.9.3.2.3) and the data collected will inform further rehabilitation planning for Aurora. Development of a rehabilitation strategy for Aurora will be informed by the data obtained since the previous MCP (Section 5.6.1.2.3 and 5.6.1.4.3) and materials characterising that will be undertaken as part of the forward work program (Table 62).
Rehabilitation	J4	Performance of rehabilitation at J4.	Commence rehabilitation monitoring at J4 in 2020.	Rehabilitation monitoring has yet to commence at J4 because, only partial rehabilitation has been completed and, rehabilitation is not considered progressed enough to warrant monitoring. Erosion performance has been assessed (Section 5.9.3.2.2) and the results will be used to inform future rehabilitation methods at J4.
Rehabilitation	All	Rehabilitation performance monitoring and weed control.	Continue to develop remote sensing capabilities to facilitate landform-scale rehabilitation monitoring including vegetation, weeds and erosion and present results in MCP updates.	Remote sensing capabilities are being developed however results are not sufficiently progressed to include in this MCP. Developments will be communicated in future iterations of the MCP.
Closure Outcomes and Completion Criteria	All	Detailed completion criteria	Refine reference ecosystems and used as the basis of completion criteria and refine completion criteria based on landscape-scale remote sensing data and consultation with stakeholders.	Remote sensing capabilities are being developed however results are not sufficiently progressed to include in this MCP. Developments will be communicated in future iterations of the MCP.
Closure Outcomes and Completion Criteria	All	Performance against completion criteria	Review the performance of rehabilitated areas against completion criteria to identify whether rehabilitation is on trajectory to meeting criteria. Where significant deficiencies are identified, identify the cause of the poor performance and develop remedial action plans.	Rehabilitation performance is described in Section 5.9.2, Section 5.9.3.1 and Section 5.9.4.

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APPENDIX A CLOSURE OBLIGATIONS REGISTER

A-1 Tenement Conditions

Aspect	Site ¹	Tenement (Condition No)	Condition
Mine Closure Plan	C	G15/21(24), L15/303(26), L15/305(31), L15/306(31), L15/310(13), L15/311(24), L15/318(29), L15/319(24), L15/320(24), L15/340(31), L16/91(30), M77/1244(24), M77/1261(22)	A Mine Closure Plan is to be submitted in the Annual Environmental Reporting month specified in tenement conditions in the year specified below, unless otherwise directed by the Executive Director Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety. The Mine Closure Plan is to be prepared in accordance with the Department's "Guidelines for Preparing Mine Closure Plans": 2023
	J	L16/115(26), L77/250(29), L77/252(30), L77/254(26), L77/274(26), M77/1270(22)	
	A	M77/580(24)	
Management of mine closure	C	G15/21(28), L15/303(27), L15/305(32), L15/306(32), L15/310(15), L15/311(25), L15/318(30), L15/319(33), L15/320(32), L15/340(32), L16/91(31), M77/1244(25), M77/1261(23)	Management of mine closure to be undertaken in accordance with the latest, relevant, approved Mine Closure Plan.
	J	L16/115(27), L77/250(30), L77/252(32), L77/254(27), L77/274(27), M77/1270(23)	
	A	M77/580(25)	
Comply with commitments in documentation submitted to DEMIRS	C	G15/21(11), L15/303(14), L15/305(19), L15/306(19), L15/311(12), L15/318(19), L15/319(17), L15/320(17), L15/340(21), L16/91(19), M77/1244(12), M77/1261(10)	The construction and operation of the project and measures to protect the environment being carried out in accordance with the document titled: (refer to Appendix A-2)
	J	L16/115(14), L77/250(18), L77/252(19), L77/254(15), L77/274(15), M77/1270(10)	
	A	M77/580(15)	
Closure outcomes	C	G15/21(20), L15/303(23), L15/305(28), L15/306(28), L15/311(21), L15/318(27), L15/319(22), L15/320(22), L15/340(29), L16/91(27), M77/1244(21), M77/1261(19)	On the completion of operations or progressively, when possible, all waste dumps, tailings storage facilities, stockpiles or other mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of the Executive Director, Environment Division, DMP [OR to the satisfaction of an Environmental Officer DMP.] OR On the completion of operations or progressively, when possible, all mining related landforms must be rehabilitated to form safe, stable, non-polluting structures which are integrated with the surrounding landscape and support self-sustaining, functional
	J	L16/115(23), L77/250(26), L77/252(27), L77/254(23), L77/274(23), M77/1270(31)	

Aspect	Site ¹	Tenement (Condition No)	Condition
			ecosystems comprising suitable, local provenance species or an alternative agreed outcome to the satisfaction of the Executive Director, Environment Division, (DMP)
<i>Closure outcomes (continued)</i>	A	M77/580(20)	At the completion of operations, or progressively where possible, all access roads and other disturbed areas being covered with topsoil, deep ripped and revegetated with local native grasses, shrubs and trees to the satisfaction of the Environmental Officer, DOIR.
Surface water	C	M77/1261(21)	All activities being carried out in such a manner so as to not have a detrimental effect on the natural water flow through the lease and surrounding areas to the satisfaction of the Environmental Officer, DMP.
	J	L16/115(25), L77/250(28), L77/252(29 & 31), L77/254(25), L77/274(25), M77/1270(21)	
	C	L15/320(34)	Any watercourses that are disturbed by mining operations will be restored, as far as practicable, to the pre-disturbance conditions.
Topsoil	C	G15/21(14), L15/303(17), L15/305(22), L15/306(22), L15/311(15), L15/318(22), L15/319(25), L15/320(25), L15/340(24), L16/91(22), M77/1244(15), M77/1261(13)	All topsoil and vegetation being removed ahead of all mining operations and being stockpiled appropriately for later respreading or immediately respread as rehabilitation progresses. OR
	J	L16/115(17), L77/250(21), L77/252(22), L77/254(18), L77/274(18), M77/1270(13)	All topsoil and vegetation being removed ahead of all mining operations from sites such as pit areas, waste disposal areas, ore stockpile areas, pipeline, haul roads and new access roads and being stockpiled for later respreading or immediately respread as rehabilitation progresses.
	A	M77/580(17)	
	C	L15/303(3), L15/305(3), L15/306(3), L15/310(3), L15/311(3), L15/318(15), L15/319(2), L15/320(10), L15/329(12) L15/340(4 & 19), L16/91(3)	All topsoil that may be removed ahead of pipelaying operations to be stockpiled for replacement in accordance with the directions of the Environmental Officer, Department of Mines and Petroleum.
	J	L16/115(5), L77/250(10), L77/251(7), L77/252(9), L77/254(6), L77/274(6)	
Closure implementation (weeds / pathogens)	C	M77/1244(9)	Prior to accessing the lease area, the lessee shall consult with the Regional Environmental Officer, Department of Minerals and Energy, and ensure that where required all vehicles and equipment entering the designated area are washed down to remove soil and plant propagules and adhering to such conditions specified for the prevention of the spread of soil-borne diseases.
	A	M77/580 (12)	

Aspect	Site ¹	Tenement (Condition No)	Condition
	C	M77/1244(10)	Access to and from and the movement of vehicles within the lease area being restricted to ground or seasonal conditions and routes approved under the program or otherwise agreed by the Regional Environmental Officer, Department of Minerals and Energy.
	A	M77/580(13)	
<i>Weeds / pathogens (continued)</i>	C	L15/319(26), L15/320(26)	All reasonable and practicable measures will be taken to prevent the spread of dieback and weeds.
Closure implementation (dust)	C	G15/21(21), L15/303(20), L15/305(25), L15/306(25), L15/311(18), L15/318(25), L15/319(21), L15/320(21), L15/340(27), L16/91(25), M77/1244(18), M77/1261(16)	The lessee / licensee taking all reasonable and practicable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities to the satisfaction of an Environmental Officer, DMP.
	J	L16/115(20), L77/250(24), L77/252(25), L77/254(21), L77/274(21), M77/1270(16)	OR The lessee / licensee taking all reasonable measures to prevent or minimise the generation of dust from all materials handling operations, stockpiles, open areas and transport activities.
	C	G15/21(18), L15/303(21), L15/305(26), L15/306(26), L15/311(19), L15/318(26), L15/340(28), L16/91(26), M77/1244(19), M77/1261(17)	Where saline water is used for dust suppression, all reasonable measures being taken to avoid any detrimental effects to surrounding vegetation and topsoil stockpiles, to the satisfaction of an Environmental Officer, DMP.
	J	L16/115(21), L77/250(25), L77/252(26), L77/254(22), L77/274(22), M77/1270(17)	OR Where saline water is used for dust suppression, all reasonable measures being taken to avoid any detrimental effects to surrounding vegetation and topsoil stockpiles.
Closure implementation (contamination)	C	L15/319(28), L15/320(28)	All hydrocarbon spills or chemical spills will be contained and cleaned up within a timely manner.
	C	L15/305(15), L15/306(15), L15/318(5), L15/319(13 & 27), L15/320(5 & 27), L16/91(13)	All reasonable measures will be taken to ensure all hydrocarbons, environmentally hazardous chemicals, process water and other environmentally hazardous substances or waste are stored and managed in a manner to prevent discharges to the environment. OR The storage and disposal of hydrocarbons, chemicals and potentially hazardous substances being in accordance with the Department of Water's Guidelines and Water Quality Protection Notes.

Aspect	Site ¹	Tenement (Condition No)	Condition
Closure implementation (waste)	C	G15/21(16), L15/303(19), L15/305(24), L15/306(24), L15/311(17), L15/318(24), L15/319(20), L15/320(20), L15/340(26), L16/91(24), M77/1244(17), M77/1261(15)	All rubbish and scrap are to be progressively disposed of in a suitable manner, to the satisfaction of an Environmental Officer, DMP / Executive Director, environment Division DMP
	J	L16/115(19), L77/250(23), L77/252(24), L77/254(20), L77/274(20), M77/1270(15)	
	A	M77/580(19)	
Closure implementation (safety)	C	L15/303(8), L15/305(8), L15/306(8), L15/310(8), L15/311(8), L15/318(9), L15/329(17), L15/340(15), L16/91(10)	The holder shall maintain the road from time to time as shall be required to ensure that it is safe for the purpose that it is constructed.
	J	L16/115(9), L77/250(14), L77/251(12), L77/252(14), L77/254(11), L77/274(11)	
	C	L15/303(6), L15/305(6), L15/306(6), L15/310(6), L15/311(6), L15/318(12), L15/319(7), L15/320(16), L15/329(15), L15/340(9), L16/91(6)	At the direction of the Special Inspector of Mines - Electrical, DMP the holder shall clear such area about any powerline as determined by the Inspector of any dry or other growth considered by the Inspector to be a potential risk for fire or for any other reason the Inspector may deem is necessary
	J	L16/115(7), L77/250(8), L77/251 (10), L77/252(12), L77/254(9), L77/274(9)	
	J	L77/250(15)	The road is to be clearly signposted as a private road and the signposting is to be regularly maintained at the licence holder's expense
Closure implementation (surface water)	C	L15/320(33)	All activities to be undertaken so as to avoid or minimise damage, disturbance or contamination of waterways, including their beds and banks, riparian and other water dependent vegetation.
	C	G15/21(6)	No interference with the drainage pattern, and no parking, storage or movement of equipment or vehicles used in the course of mining within the Safety Zone established by Condition (3) hereof without the prior approval of the operator of the railway on corridor land.
		L16/91(14)	Measures such as effective sediment traps and stormwater retention facilities being implemented to preserve the natural values of receiving catchments and those of adjacent areas of native vegetation.

Aspect	Site ¹	Tenement (Condition No)	Condition
Groundwater monitoring	C	L16/91(15)	Groundwater quality monitoring bores being installed, maintained and utilised for water quality monitoring on and near the mine-site and downstream where aquifers are present.
Landform stability	C	G15/21(19), L15/303(22), L15/305(27), L15/306(27), L15/311(20), M77/1244(20), M77/1261(18)	Placement of waste material must be such that the final footprint after rehabilitation will not be impacted upon by pit wall subsidence or be within the zone of instability (to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety).
	J	L16/115(22), M77/1270(30)	
Closure disturbance (closure footprint)	C	G15/21(13), L15/303(16), L15/305(21), L15/306(21), L15/311(14), L15/318(21), L15/319(19), L15/320(19), L15/340(23), L16/91(21), M77/1244(14), M77/1261(12)	The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform. OR The development and operation of the project being carried out in such a manner so as to create the minimum practicable disturbance to the existing vegetation and natural landform, to the satisfaction of an Environmental Officer, DMP [OR to the satisfaction of the Executive Director, Environment Division, DMP.]
	J	L16/115(16), L77/250(20), L77/252(21), L77/254(17), L77/274(17), M77/1270(12)	
	A	M77/580(16)	
	C	G15/21(12), L15/303(15), L15/305(20), L15/306(20), L15/311(13), L15/318(20), L15/319(18), L15/320(18), L15/340(22), L16/91(20), M77/1244(13), M77/1261(11)	Any alteration or expansion of operations within the lease boundaries beyond that outlined in the above document(s) not commencing until a plan of operations and a program to safeguard the environment are submitted to the Executive Director, Environment Division, Department of Mines and Petroleum, DMP [DOIR] for his assessment and until his written approval to proceed has been obtained.
	J	L16/115(15), L77/250(19), L77/252(20), L77/254(16), L77/274(16), M77/1270(11)	
	A	M77/580(21)	
	J	M77/1270 (25)	All ground disturbance approved by a Mining Proposal submitted on or after 3 March 2020 to be undertaken within the disturbance envelope as presented within the latest, relevant approved Mining Proposal/s.
	J	M77/1270 (26)	No alteration or expansion of mining operations beyond the activities described within the Activity, and Key Mine Activity tables of the latest, relevant approved Mining Proposal/s unless a subsequent Mining Proposal

Aspect	Site ¹	Tenement (Condition No)	Condition
			is submitted, in the form defined in section 700 of the <i>Mining Act 1978</i> , to cover the alteration or expansion, and until such Mining Proposal is approved by the Executive Director, Resource and Environmental Compliance Division, Department of Mines, Industry Regulation and Safety.
	C	L15/319(29), L15/320(29)	Clearing of large, mature trees will be avoided, where practicable.
	C	L15/305(13), L15/306(13), L15/318(3), L15/319(11), L15/320(3)	Any significant waterway (flowing or not), wetland or its fringing vegetation that may exist on site not being disturbed or removed without prior written approval from the Department of Water.
	A	M77/580(2)	Compliance with the provisions of the <i>Aboriginal Heritage Act, 1972</i> to ensure that no action is taken which would interfere with or damage any Aboriginal site.
Closure disturbance (closure footprint) (continued)	C	G15/21(4)	No surface excavation approaching closer to the boundary of the Safety Zone established by Condition (3) hereof than a distance equal to three times the depth of the excavation without the prior written approval of the State Mining Engineer, DMP.
	C	G15/21(7)	The Lessee not excavating, drilling, installing, erecting, depositing or permitting to be excavated, drilled, installed, erected or deposited within the Safety Zone established in Condition (3) hereof, any pit, well, pavement, foundation, building, or other structure or installation, or material of any nature whatsoever without the prior written consent of the State Mining Engineer, DMP.
	C	L15/305(16), L15/306 (16)	Unless permission is first obtained from the Department of Water ground breaking activities are prohibited within the floodway and within a lateral distance of: -50 metres from a perennial waterway; and -30 metres from a seasonal waterway.
Closure communication	C	L15/329 (1)	The Lessee / Licensee notifying the holder of any underlying pastoral or grazing lease by telephone or in person, or by registered post if contact cannot be made, prior to undertaking airborne geophysical surveys or any ground disturbing activities utilising equipment such as scrapers, graders, bulldozers, backhoes, drilling rigs; water carting equipment or other mechanised equipment.
	J	L77/250(1), L77/251(1), L77/252 (1) M77/1270(6)	

Aspect	Site ¹	Tenement (Condition No)	Condition
Decommissioning and rehabilitation	C	G15/21(27), L15/319(31), L15/320(31), M77/1244(4), M77/1261(4)	All waste materials, rubbish, plastic sample bags, abandoned equipment and temporary buildings being removed from the mining tenement prior to or at the termination of exploration program.
	J	M77/1270(4)	
	A	M77/580(5)	
	C	G15/21(15), L15/303(18), L15/305(23), L15/306(23), L15/311(16), L15/318(23), L15/340(25), L16/91(23), M77/1244(16), M77/1261(14)	At the completion of operations, all buildings and structures being removed from site or demolished and buried to the satisfaction of the Executive Director, Environment Division, DMP [OR to the satisfaction of Environmental Officer DMP / DOIR.]
	J	L16/115(18), L77/250(22), L77/252(23), L77/254(19), L77/274(19), M77/1270(14)	OR
	A	M77/580(18)	At the completion of operations, all buildings and structures being removed from site or demolished are to be buried to the satisfaction of the Executive Director, Environment Division DMP
	C	L15/318(11), L15/319(9), L15/320(15), L15/340(20)	On the completion of the life of mining operations in relation to (or connection with) this licence the holder shall:
Decommissioning and rehabilitation (continued)	J	L16/115(10), L77/250(17), L77/251(13), L77/252(15), L77/254(12), L77/274(12)	- remove all installations constructed pursuant to this licence; - cover over all wells and holes in the ground to such degree of safety as shall be determined by the Environmental Officer, Department of Mines and Petroleum; and - on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Environmental Officer, Department of Mines and Petroleum and properly maintain same until the Environmental Officer advises regrowth is self-supporting; - unless the Mining Registrar orders or consents otherwise [OR unless the Minister responsible for the <i>Mining Act 1978</i> orders or consents otherwise.]
	C	L15/303(12), L15/305(9), L15/306(9), L15/310(9), L15/311(9), L15/318(17), L15/319(5), L15/320(7), L15/329(18), L15/340(6 & 10), L16/91(12)	On the completion of the life of mining operations in relation to (or connection with) this licence the holder shall: -remove all installations constructed pursuant to this licence; and -on such areas cleared of natural growth by the holder or any of its agents, the holder shall plant trees and/or shrubs and/or any other plant as shall conform to the general pattern and type of growth in the area and as directed by the Environmental Officer, Department of Mines and Petroleum

Aspect	Site ¹	Tenement (Condition No)	Condition
			and properly maintain same until the Environmental Officer advises regrowth is self-supporting; -unless the Mining Registrar orders or consents otherwise [OR -unless the Minister responsible for the <i>Mining Act 1978</i> orders or consents otherwise.]
	C	L15/319 (32), L15/320(32)	All chemicals and hydrocarbons will be removed from site prior to or at the termination of the operation.
	C	L15/319 (30), L15/320(30)	All excavations will be backfilled and/or closed to ensure they are stable and safe to the satisfaction of the Executive Director, Resource and Environmental Compliance Division, DMIRS.
Access	C	L15/303(4), L15/305(4), L15/306(4), L15/310(4), L15/311(4), L15/318(16), L15/319(16), L15/320(11), L15/329(13), L15/340(5), L16/91(4)	Ingress and egress of pastoralists and tenement holders to be preserved by the construction of vehicular access crossings over any pipeline constructed pursuant to this licence. OR Ingress and egress of tenement holders to be preserved by the construction of vehicular access crossings over any pipeline constructed pursuant to this licence.
	J	L16/115(6), L77/250(11), L77/251(8), L77/252(10), L77/254(7), L77/274(7),	
Access (continued)	C	L15/303(5), L15/305(5), L15/306(5), L15/310(5), L15/311(5), L15/318(7), L15/329(14), L15/340(13), L16/91(8)	Wherever any part of a road intersects an existing fence, the holder shall, where necessary, construct a gate or livestock grid having such dimensions and be constructed of such materials and be of such standard as agreed with the pastoralist or as determined by the Environmental Officer, DMP.
	J	L77/250(12), L77/251(9), L77/252(11), L77/254(8), L77/274(8),	
	C	L15/305(14), L15/306(14), L15/318(4), L15/319(12), L15/320(4)	The rights of ingress to and egress from the Licence being at all reasonable times preserved to officers of the Department of Water for inspection and investigation purposes.
	C	G15/21(9)	The rights of ingress to and egress from the rail corridor land being at all times preserved to the employees, contractors and agents of the operator of the railway on corridor land, and the Public Transport Authority of WA.
			The rights of ingress to and egress from [the following tenure] being at all times preserved to the licensee and no interference with the purpose or installations connected to the licence.
	C	L15/329(20)	Miscellaneous Licence 15/306

Aspect	Site ¹	Tenement (Condition No)	Condition
	J	L16/115(13)	Miscellaneous Licences 15/305, 77/254 & 77/275
	J	L77/250(3)	Miscellaneous Licence 77/251
	J	L77/251(3), M77/1270(9)	Miscellaneous Licence 77/250
	J	L77/252(3)	Miscellaneous Licence 77/184
	J	L77/254(3)	Miscellaneous Licences 15/305, 77/252 and 77/253
	J	L77/274(3)	Miscellaneous Licence 77/254
Exploration disturbance (progressive rehabilitation / reporting)	C	G15/21(25), M77/1244(3), M77/1261 (3)	All costeans and other disturbances to the surface of the land [OR All disturbances to the surface of the land] made as a result of exploration, including drill pads, grid lines and access tracks, being backfilled and rehabilitated to the satisfaction of the Environmental Officer (DMP). Backfilling and rehabilitation being required no later than 6 months after excavation unless otherwise approved in writing by the Environmental Officer, DMIRS / DOIR / DMP. All surface holes drilled for the purpose of exploration are to be capped, filled or otherwise made safe after completion.
	J	M77/1270(3)	
	A	M77/580(4)	
	C	M77/1244(2), M77/1261(2)	
<i>Exploration disturbance (progressive rehabilitation / reporting) (continued)</i>	J	M77/1270(2)	The lessee, at his expense, capping or filling all holes drilled, rehabilitating all areas cleared or otherwise disturbed and backfilling all volumes excavated during the term of the lease to the satisfaction of the Environmental Officer, DOIR. Backfilling and rehabilitation being required no later than six months after excavation unless otherwise approved in writing by the Environmental Officer, DOIR. Drill holes are to be capped or filled immediately after completion.
	A	M77/580(3)	
	A	M77/580(10)	In respect to DEC - Managed Lands P5H/34, Proposed 5(1)(H) Reserve Conservation and Mining the following conditions apply: The lessee submitting to the Director of Environment, Department of Mines and Petroleum (DMP), and to the relevant Regional Manager, Department of the Environment and Conservation (DEC-R) a project completion report outlining the project operations and rehabilitation work undertaken in the
	C	M77/1261(9)	

Aspect	Site ¹	Tenement (Condition No)	Condition
			program. This report is to be submitted within six months of completion of the exploration activities.
Closure reporting	C	G15/21(21), L15/303(24), L15/305(29), L15/306(29), L15/310(12), L15/311(22), L15/318(28), L15/319(23), L15/320(23), L15/340(30), L16/91(28), M77/1244(8 & 22), M77/1261(20)	At agreed intervals, not greater than 12 monthly, the lessee providing a brief report to the Director, Environment, DMP outlining the progress of the operation and rehabilitation program and the proposed operations and rehabilitation programs for the next 12 months. OR The Lessee / Licensee submitting to the Executive Director, Environment Division, DMP, a brief annual report outlining the project operations, mine site environmental management and rehabilitation work undertaken in the previous 12 months and the proposed operations, environmental management plans and rehabilitation programs for the next 12 months. This report to be submitted each year in: April.
	J	L16/115(24), L77/250(27), L77/252(28), L77/254(24), L77/274(24) M77/1270(20)	
	A	M77/580(11)	

Note:1. C (Carina), J (Mt Jackson 4), A (Aurora)

A-2 Mining Proposals Reviewed to Develop Internal Closure Obligations Register

REG ID / Mining Proposal Title	Description	Granted Date	Tenement (s)
15025 (mp_1623) NOI to Mine Aurora Prospect M77/580	Proposal to mine the small high grade Aurora deposit down to a depth of 40 metres by open pit.	2/09/1994	M77/580
15320 (mp_1919) NOI Low Impact Mining Operation 77/580 Bungalbin	Proposal to mine ore below the existing Aurora open pit by underground methods.	17/05/1995	M77/580
28616 Carina Iron Ore Project (M777/1244, L15/305, L15/303, L15/306, L15/310, L15/311 and G15/21)	Proposal to develop the Carina iron ore deposit involving the following components: open cut mining from a single pit, - ore haulage approximately 50 kilometres to a siding on the existing trans Australian railway, - dry crushing and screening, and - train loading at the siding.	21/02/2011	G15/21, L15/303, L15/305, L15/306, L15/310, L15/311, M77/1244
31325 Mining Proposal: East Jaurdi Aerodrome: L15/319 & L15/320	Proposal to construct an aerodrome on tenements L15/319 and L15/320 for use by its (Crushing Services International) workforce serving mining clients in the Yilgarn region.	7/10/2011	L15/319, L15/320
36609 Carina Iron Ore Project - Mining Proposal Amendment - Changes to Site Layout - Revised Version 3, M77/1244, L16/91" dated 16 April 2013.	This mining proposal amendment is submitted to seek retrospective approval for variations to the site layout and disturbance areas for the Carina Iron Ore Project. Polaris is seeking approval for the following changes to the project: - changes to disturbance types to incorporate haul roads and other specific infrastructure, and changes to the location of the mine infrastructure area (M77/1244); and - inclusion of the offices, medical centre, communications tower and drill rig workshop components of the existing exploration infrastructure (L16/91).	2/07/2013	L16/91, M77/1244
39874 Mining Proposal Amendment: Carina Iron Ore Project – Haul Road and Accommodation Village L15/303, L15/305 and L15/311	Mining Proposal amendment submitted to seek retrospective approval for variations to the site layout and disturbance areas for the Carina Iron Ore Project. Seeking approval for the following changes: - increased clearing areas required for the haul road (L15/305), within existing tenement areas; and - increased clearing areas required for the accommodation village (L15/303), within existing tenement conditions.	1/08/2013	L15/303, L15/305, L15/311
41730 Mining Proposal: Carina Extended Iron Ore Project M77/1261 and M77/1244, dated 18 October 2018	Proposal to develop the Carina Extended iron ore deposit. The project involves the following components: - open cut mining from one pit: ore haulage 2 km to tie into the existing Carina logistics system consisting of: - ore haulage approximately 52 km to a siding on the existing trans Australian railway - dry crushing and screening, - and train loading at the siding.	24/12/2013	M77/1244, M77/1261
41955 Mining Proposal: Carina Iron Ore Project -Yilgarn Region WA L16/91 and M77/1244-1, Revision 3 dated 24 September 2019	Mining Proposal seeking approval for the following changes to the project: changes to disturbance types to incorporate haul roads and other specific infrastructure, and changes to the location of the mine infrastructure area (M77/1244).	22/10/2013	L16/91, M77/1244
45594 Letter of Intent: Change to Disturbance Locations under MP Reg ID 41955, 9 January 2013	Letter of intent seeking minor change to the flood bund footprint: - The footprint changes are within the approved disturbance quota (no additional disturbance is required); - The disturbance is within Ministerial Statement 957 (formerly MS 852) Project Boundary; and - The disturbance will not result in impact to the W22 vegetation type.	17/01/2013	L16/91, M77/1244
45952 Amendment - Carina Iron Ore Project - Rail Siding Area, Access Road and Powerline Corridor and Contractor Yard, dated February 2014.	Mining Proposal amendment submitted to seek retrospective approval for variations to the site layout and disturbance areas for the Carina Iron Ore Project. Seeking approval for the following changes: - additional clearing undertaken within the rail siding / ore processing area; - a new ancillary infrastructure component; a service corridor from the power station at the rail siding to the accommodation village; and - clearing undertaken within L15/340 for the contractor yard, consisting of an office, workshop and washdown bay. The contractor yard also extends onto G15/21 which contains the contractor fuel storage facility.	21/08/2014	G15/21, L15/318, L15/340

REG ID / Mining Proposal Title	Description	Granted Date	Tenement (s)
50795 Mining Proposal Amendment - In-Pit Disposal of Waste Rock in the Carina Pit Under MP Reg ID 41955, dated 8 July 2014	Proposal seeking approval for the inclusion of in-pit disposal of waste rock material at the Carina Iron Ore project as an amendment to Mining Proposal REG ID 41955.	12/08/2014	M77/1244
51085 Mining Proposal Amendment - Construction of a Crib, Ablution and Supervisor Facility under MP Reg ID 41955, Tenement M77/1244, dated 6 August 2014.	Proposal for the inclusion the following activities as an amendment to Mining Proposal Reg ID 41955: - an MRL owned portable crib and ablution facility at the HV Go line for 25 personnel, - an MRL owned portable supervisor's office; and - a potable water pipeline connecting the facility to the existing Reverse Osmosis (RO) plant situated at the existing infrastructure area.	19/08/2014	M77/1244
52261 Mining Proposal Amendment: Additional In-Pit Disposal of Waste Rock in the Carina Pit under MP REG ID 41955, Tenement M77/1244	As part of a review of pit operation at the Carina Iron Ore Project (Carina), Polaris Metals has identified an opportunity to include the option of further in-pit disposal of waste rock material. Approval is sought from the DMP for the inclusion of this activity as an amendment to Mining Proposal Reg ID 41955.	24/09/2014	M77/1244
53360 Mining and Mine Closure Plan: J4 Iron Ore project M77/1270, L77/250, L77/252, L77/254 and L15/305, dated 2 February 2015	Proposal to develop an iron ore mine at J4 deposit. The proposal comprises open-cut mining from two adjacent and connected pits with ore haulage 75 km to existing facilities associated with the Carina operation. These facilities include dry crushing and screening of ore in preparation for export and loading of ore trains at the Mt Walton siding on the Trans-Australia railway. The J4 deposit will yield a total estimated 20 Mt of iron ore of 57 % Fe average grade.	16/02/2015	L15/305, L77/250, L77/252, L77/254, L77/274, M77/1270
53420 MP Reg ID 45852 Mining Proposal Amendment - Power Generation, dated 6 January 2015	Proposal seeking approval for the use of Liquefied Natural Gas to assist with power generation at the Carina Iron Ore Project as an amendment to Mining Proposal Reg ID 45952 (itself an amendment of the original mining proposal Reg ID 28616)	16/02/2015	G15/21
54354 Aurora Mine - Temporary Accommodation Revised Mining Proposal, dated 29 April 2015	Proposal to develop temporary accommodation for the initial stages of the construction of the J4 Iron Ore Project. The accommodation will be constructed on Mining Lease M77/580 and comprise the installation of 8 x 4-person accommodation vans (32 rooms), 2 x laundry blocks, 2 x shower/toilet blocks, 2 x 32 kilolitre sewage holding tanks, 2 x 23 kilolitre potable water tanks and 1 x generator to supply power to the facilities.	4/05/2015	M77/580
54393 Mining Proposal Amendment - Additional Changes to Power Generation Facility, dated 30 March 2015	Proposal seeking approval for minor alteration to the location of the LNG infrastructure approved under MP REG ID 53420, leading to a need to clear a small area (300 m2) of native vegetation to allow for access to the facility.	13/05/2015	G15/21
55418 Addendum to Mining Proposal Reg ID 53360, dated 3 June 2015	An addendum to MP REG ID 53360 providing details on the proposed section of haul road on L16/115 and some additional disturbance on L77/252.	3/07/2015	L16/115, L77/252
55935 20150804_J4 Accom MP_MRL-TS-RP-0025_Rev 1, dated 31 August 2015	Proposal to expand the existing Aurora Exploration Camp to 102 rooms to support the J4 Iron Ore Project. The accommodation will be situated on ML 77/580.	11/09/2015	M77/580
56387 20150918_Aurora Camp_MP_Rev0, dated 13 October 2015	Proposal to install a containerised Reverse Osmosis (RO) Plant to supply potable water to the Aurora camp and dispose of reject water (brine) into the abandoned Aurora gold pit.	23/10/2015	M77/580
56620 Addendum to Mining Proposal Reg ID 55418 - J4 Carina Haul Road, dated 15 October 2015	Addendum to Mining Proposal REG ID 55418 detailing proposed variation to the alignment of the J4 Haul Road and Carina Haul Road intersection on L16/115.	2/11/2015	L16/115
56760 Mining Proposal: J4 Iron Ore Project M77/1270, L77/250, L77/252, L77/254, M77/1244 & L15/305, dated 30 October 2015	Mining Proposal submitted to amend REG ID 53360 to include changes to the approved Waste Rock Landform design, additional clearing of minor areas of native vegetation within the mining lease to facilitate safe traffic management and dewatering of the J4 Pit with surplus dewater being disposed of in the Carina Pit.	25/11/2015	L15/305, L77/250, L77/252, L77/254, M77/1244, M77/1270
59804 Mining Proposal Amendment - Change to Describe Disturbance under MP Reg ID 53360, dated 21 June 2016	Mining Proposal amendment seeking approval for a changed to the description of clearing disturbance approved under MP Reg ID 53360 to allow for additional ROM disturbance on an area already approved for disturbance as a waste dump.	15/06/2016	M77/1270
61216 Mining Proposal Amendment: Changes to Haul Road under MP Reg ID 41730, 3 November 2016	Mining Proposal to amend haul road route (and reduce associated clearing requirement) approved under REG ID 41730 and allow for the construction of infrastructure.	23/11/2016	M77/1244, M77/1261

REG ID / Mining Proposal Title	Description	Granted Date	Tenement (s)
69968 20170927_CE_MP_Abandonment Bund Amendment Rev 0, dated 27 September 2017	Mining Proposal to amend the layout of the abandonment bunds approved under REG ID 41730 due to reduced extent of development of the Carina Extended Pit.	24/10/2017	M77/1244, M77/1261
87235 Mining Proposal for Small Mining Operations, East Jaurdi Aerodrome Transition Surface Works - Revision 1, dated 10 July 2020	Mining Proposal seeking approval to undertake new clearing to establish additional transition surface areas around the East Jaurdi aerodrome to comply with CASA MOS 139 requirements. Key activities associated with this Proposal include: • New clearing, using raised blade techniques of a total of 9.50 ha (L15/319 – 2.79 ha; L15/320 – 6.71 ha) • No topsoil stockpiling.	22/07/2020	L15/319, L15/320
91650 MINING PROPOSAL FOR SMALL MINING OPERATIONS - Yilgarn Operations - Haul Road Tie-In and Infrastructure Upgrade Works - Revision 1, dated 21 December 2020.	Mining Proposal seeking approval to: • Undertake new clearing to widen an existing powerline infrastructure corridor to provide improved firebreak controls and site access. • Undertake new clearing to develop a section of haul road that 'ties in' the J4/Carina and Koolyanobbing haul roads. • Undertake new clearing for the construction of a centralised warehouse to support the wider Yilgarn Operations. New disturbance totalling of 7.98 ha is required for this Proposal.	24/12/2020	L77/250, L77/252
113898 East Jaurdi Aerodrome Carpark Expansion, dated 20 September 2022	Mining Proposal for Small Mining Operations for the extension of the existing carpark at the East Jaurdi Aerodrome located within the Carina Project Area.	3/11/2022	L15/320
117948 J4 East Redevelopment Mine Proposal Amendment, Mining Proposal - Revision 0, Version 2, dated 12 September 2023	This Mining Proposal (MP) submission involves the removal of an Aboriginal heritage site (Site ID 29778) from the current approved development envelope and backfilling of the J4 West mine void for improved closure and rehabilitation outcomes. Development of the J4 East mine void and West WRL will continue within existing approved areas which form part of the J4 Iron Ore Project (the Project) area.	20/10/2023	M77/1270

A-3 Mining Proposal Statements Related to Closure

This appendix is not publicly available and is supplied separately.

A-4 Ministerial Statement Conditions

Aspect	Condition No.	Condition
Ministerial Statement 988 - Jackson 4 (J4) Iron Ore Mine and Haul Rd on M77/1242, L77/250, L77/252 AND L77/254 (published 24 October 2014)		
Approved disturbance area	1-1	When implementing the proposal, the proponent shall not exceed the authorised extent of the proposal as defined in Column 3 of Table 2 in Schedule 1, unless amendments to the proposal and the authorised extent of the proposal has been approved under the EP Act.
Compliance assessment and reporting	4-1	The proponent shall prepare and maintain a compliance assessment plan to the satisfaction of the CEO.
	4-3	The proponent shall assess compliance with conditions in accordance with the compliance assessment plan required by condition 4-1.
	4-4	The proponent shall retain reports of all compliance assessments described in the compliance assessment plan required by condition 4-1 and shall make those reports available when requested by the CEO.
	4-5	The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.
	4-6	The proponent shall submit to the CEO the first compliance assessment report 15 months from the date of issue of this statement addressing the twelve (12) month period from the date of issue of this statement and then annually from the date of submission of the first compliance assessment report, or as otherwise agreed in writing by the CEO. The compliance assessment report shall: 1. be endorsed by the proponent's CEO or a person delegated to sign on the CEO behalf; 2. include a statement as to whether the proponent has complied with the conditions; 3. identify all potential non-compliances and describe corrective and preventative actions taken; 4. be made publicly available in accordance with the approved compliance assessment plan; and 5. indicate any proposed changes to the compliance assessment plan required by condition 4-1.
Public availability of data	5-1	Subject to condition 5-2, within a reasonable time period approved by the CEO of the issue of this Statement and for the remainder of the life of the proposal the proponent shall make publicly available, in a manner approved by the CEO, all validated environmental data (including sampling design, sampling methodologies, empirical data and derived information products (e.g., maps)) relevant to the assessment of this proposal and implementation of this statement.
	5-2	If any data referred to in condition 5-1 contains particulars of: 1. a secret formula or process; or ii. confidential commercially sensitive information;

Aspect	Condition No.	Condition
		the proponent may submit a request for approval from the CEO to not make this data publicly available. In making such a request the proponent shall provide the CEO with an explanation and reasons why the data should not be made publicly available.
Haul Road	6-2	The proponent shall ensure that the design, construction and operation of the Haul Road does not impact the surrounding environment and existing infrastructure from the effects of surface water flow impedence, dust, use of saline water, weed encroachment and fire.
	6-5	At the completion of mining and related activities at the mine site, the proponent shall completely remove and rehabilitate the Haul Road to the requirements of the CEO on the advice of Parks and Wildlife, unless an alternate arrangement for the retention of the Haul Road is approved to the requirements of the CEO.
Access requirements potentially applicable to closure implementation	6-6	The design and operation of the Haul Road shall ensure continued access to the Mount Manning – Helena-Aurora Ranges Conservation Park to the requirements of the CEO on the advice of Parks and Wildlife for the following publicly accessible access tracks: (1) Bullfinch-Evanston Road to the Helena-Aurora Ranges via Marda Dam (referred to in condition 8); (2) southern access to the Helena-Aurora Ranges from Koolyanobbing; and (3) northern and southern access through the former Jaurdi Pastoral Lease.
	8-4	The proponent shall ensure that access along the Diverted Access Track is maintained to a standard suitable for single vehicular use during the life of mining operations and related activities at the mine site.
Ministerial Statement 852 - Carina Iron Ore Mine (published 28 January 2011)		
Approved disturbance area	1-1	The proponent shall implement the proposal as documented and described in schedule 1 [superseded by Attachment 3] of this statement subject to the conditions and procedures of this statement.
Compliance assessment and reporting	4-1	The proponent shall prepare and maintain a compliance assessment plan to the satisfaction of the CEO.
	4-3	The proponent shall assess compliance with conditions in accordance with the compliance assessment plan required by condition 4-1.
	4-4	The proponent shall retain reports of all compliance assessments described in the compliance assessment plan required by condition 4-1 and shall make those reports available when requested by the CEO.
	4-5	The proponent shall advise the CEO of any potential non-compliance within seven days of that non-compliance being known.
	4-6	The proponent shall submit to the CEO the first compliance assessment report fifteen months from the date of issue of this statement addressing the twelve month period from the date of issue of this statement and then annually from the date of submission of the first compliance assessment report, or as otherwise agreed in writing by the CEO. The compliance assessment report shall:

Aspect	Condition No.	Condition
		1. be endorsed by the proponent's CEO or a person delegated to sign on the CEO behalf; 2. include a statement as to whether the proponent has complied with the conditions; 3. identify all potential non-compliances and describe corrective and preventative actions taken; 4. be made publicly available in accordance with the approved compliance assessment plan; and 5. indicate any proposed changes to the compliance assessment plan required by condition 4-1.
Protection of vegetation	5-1	The proponent shall implement the proposal so that it does not adversely affect vegetation, in particular S2 and W22 vegetation communities, outside the proposal boundary as shown in Figure 2 and delineated by MGA co-ordinates listed in Schedule 2.
	5-2	[deleted] refer Ministerial Statement 957
	5-3	The proponent shall monitor prior to disturbance and every 12 months the health and condition of vegetation located within 1 kilometre of the proposal boundary as shown in Figure 2 and delineated by MGA coordinates listed in Schedule 2. This monitoring is to be carried out to the satisfaction of the CEO on advice of the DEC.
	5-4	Should the potential impact sites show a 25 per cent (or greater) decline in cover or productivity, the proponent shall provide a report to the CEO within 21 days of the decline being identified which: 1 describes the decline; 2 provides information which allows determination of the likely root cause of the decline; and 3 if likely to be caused by activities undertaken in implementing the proposal, states the actions and associated timelines proposed to remediate the decline.
	5-5	The proponent shall, on approval of the CEO, implement the actions identified in 5-4 (3) and continue to implement such actions until the CEO determines that the remedial actions may cease.
Fauna	6-1	Prior to ground disturbing activities the proponent shall prepare & submit strategies to avoid fauna deaths in areas of mining, the haul road, the rail siding & other areas associated with the proposal on advice of DEC and to the satisfaction of the CEO.
	6-2	The proponent shall implement the strategies as required by condition 6-1.
	6-3	The proponent shall produce a report with details of fauna mortalities including the cause, location, number and type of species to the CEO as part of the compliance assessment report required by condition 4- 6 and provide a report to the DEC.
	6-4	The proponent shall produce a report with details of fauna mortalities including the cause, location, number and type of species to the CEO as part of the compliance assessment report required by condition 4- 6 and provide a report to the DEC.
	6-5	The proponent shall review and revise the strategies required by condition 6-1 as required by the CEO.

Aspect	Condition No.	Condition
Environmental management plan	9-1	Prior to ground disturbing activities the proponent shall prepare a Project Environmental Management Plan to the satisfaction of the DEC. The objectives of the plan are to ensure that the adverse impacts from mining and associated activities do not unnecessarily threaten conservation values within the mining lease and prevent impacts outside of the mining lease. The project environmental management plan will address: 1 Hygiene management measures to prevent the introduction of weeds and dieback disease. 2 Management of feral animals. 3 Company protocols to authorise disturbance and clearance of vegetation. 4 Limiting and authorising access to areas within the mining lease; 5 Fire prevention and response. 6 Management and monitoring of saline water used for dust suppression.
Environmental Management Plan (continued)	9-2	The proponent shall implement the Project Environmental Management Plan required by condition 9-1.
Weeds	10-1	The proponent shall ensure that: 1 No new species of weeds (including both declared weeds and environmental weeds) are introduced into the proposal area as a result of the implementation of the proposal. 2 Prior to ground disturbing activities the proponent shall undertake a baseline weed survey to determine the species and extent of weeds (including both declared weeds and environmental weeds) present within the proposal area to the requirements of the CEO on advice of the DEC. 3 Within 12 months of the date of publication of this statement the proponent shall establish at least three reference sites on undisturbed land (not impacted by the proposal) at each of the mine, haul road, rail siding and accommodation facilities. Reference sites are to be chosen in consultation with the DEC. The reference sites are to be monitored every 2 years to determine whether changes in weed cover and type within and up to 1 kilometre from the Project Boundary (as shown in Figure 2 and delineated by MGA co-ordinates listed in Schedule 2) are as a result of project implementation or broader regional changes. 4 The species and extent of weed cover within the proposal area shall not exceed that identified in the baseline survey identified in condition 10-1(2) or exceed that existing on comparable, nearby land, determined by condition 10-1(3) which has not been disturbed during implementation of the proposal, whichever is less.
Rehabilitation	11-1	The proponent shall undertake progressive rehabilitation over the life of the proposal to achieve the following outcomes: 1 The waste material landforms shall be non-polluting and shall be constructed so that their stability, surface drainage, resistance to erosion and ability to support local native vegetation are similar to undisturbed natural analogue landforms as demonstrated by Ecosystem Function Analysis or other methodology acceptable to the CEO. 2 The waste material landforms and other areas disturbed through implementation of the proposal (excluding mine pits), shall be progressively rehabilitated with vegetation composed of native plant species of local provenance.

Aspect	Condition No.	Condition
		3 Within 12 months of the date of publication of this statement the proponent shall conduct surveys of each of the vegetation communities that will be impacted by the proposal to collect adequate information in preparation for setting completion criteria for rehabilitation to the requirements of the CEO on advice of the DEC. 4 The methodology of the survey required in condition 11-1(3) shall be prepared in consultation and to the satisfaction of the DEC. 5 Within 18 months of mining commencing the proponent will develop completion criteria for rehabilitation to the requirements of the CEO on advice from the DEC. 6 The percentage cover of living self-sustaining native vegetation in all rehabilitation areas shall be comparable to that of undisturbed natural analogue sites as demonstrated by Ecosystem Function Analysis and species diversity as demonstrated by other methodology acceptable to the CEO. 7 No new species of weeds (including both declared weeds and environmental weeds) are introduced into the rehabilitated areas as a result of the implementation of the proposal. 8 The cover of weeds (including both declared weeds and environmental weeds) in rehabilitated areas shall not exceed that identified in the baseline survey condition 10-1(2) or exceed that existing on comparable, nearby land, determined by condition 10-1(3) which has not been disturbed during implementation of the proposal, whichever is less.
Rehabilitation (continued)	11-2	The proponent shall monitor progressively the rehabilitation for a range of sites against the criteria developed pursuant to condition 11- 1(5) with appropriately timed surveys as agreed with the DEC, until the completion criteria are met. The surveys shall be conducted annually unless otherwise agreed by the CEO, on advice from the DEC.
	11-3	The proponent shall include the results of the rehabilitation monitoring required pursuant to condition 11-2 in the compliance assessment report referred to in condition 4-6 commencing from the date rehabilitation was commenced. The report shall address the following: 1 The progress made towards meeting the completion criteria developed pursuant to condition 11-1(5); and 2 Contingency management measures in the event that the completion criteria required by condition 11-1(5) are unlikely to be met.
	11-4	The proponent shall make the monitoring reports required by condition 11-2 publicly available in a manner approved by the CEO.
Conceptual closure strategy	12-1	Prior to construction of the waste dump, the proponent shall submit a detailed and project-specific Mine Plan and Preliminary Closure Strategy to the requirements of the CEO on advice of the DMP and DEC.
	12-2	The Mine Plan and Preliminary Closure Strategy shall include detailed results of geochemical and geophysical characterisation of materials, in particular the potential for acid drainage, metalliferous drainage, and of the occurrence of dispersive materials and asbestiform minerals. Testing for materials with potential to cause acid and/or metalliferous drainage shall include static and kinetic testing carried out using techniques and timeframes consistent with national and international standards (Leading Practice Sustainable Development Program for the Mining Industry – Managing Acid and Metalliferous Drainage 2009 – Department of Industry, Tourism and Resources; The Global Acid Rock Drainage Guide 2009 – International Network for Acid Prevention).

Aspect	Condition No.	Condition
	12-3	The Mine Plan and Preliminary Closure Strategy shall provide detailed technical information on proposed management measures to prevent pollution, environmental harm or human health impacts during implementation of the proposal and after mine completion and closure.
	12-4	The Mine Plan and Preliminary Closure Strategy shall include maps and diagrams showing the proposed placement, dimensions, design and proposed methods of construction and closure of waste disposal facilities, mine pits and evaporation pond.
	12-5	The Mine Plan and Preliminary Closure Strategy shall demonstrate that waste disposal facilities will be located, designed and constructed to ensure that they are non-polluting and so that their final shape, height, stability and ability to support native vegetation are comparable to natural landforms in the area.
	12-6	The proponent shall implement the Mine Plan and Preliminary Closure Strategy referred to in conditions 12-1 to 12-5.
	12-7	The proponent shall make the Mine Plan and Preliminary Closure Strategy referred to in conditions 12-1 to 12-5 publicly available in a manner approved by the CEO.
Final closure and decommissioning plan	13-1	At least 3 years prior to mine completion, the proponent shall prepare and submit a Final Closure and Decommissioning Plan to the requirements of the CEO, on advice of the DEC and DMP.
	13-2	The Final Closure and Decommissioning Plan shall be prepared consistent with: 1 ANZMEC/MCA 2000, Strategic Framework for Mine Closure Planning; and Department of Industry Tourism and Resources 2006 Mine Closure and Completion (Leading Practice Sustainable Development Program for the Mining Industry), Commonwealth Government, Canberra;
	13-3	The Final Closure and Decommissioning Plan shall provide detailed technical information on the following: 1 Final closure of all areas disturbed through implementation of the proposal so that they are safe, stable and non-polluting. 2 Details of a monitoring program to be carried out to inform final closure procedures for the pit void such that the standing water body does not cause environmental harm by: - attracting native fauna which may be subsequently harmed; or - attracting fauna which may harm native fauna populations and/or surrounding native vegetation. 3 Management actions to be undertaken based on the findings under condition 13-3(2). 4 Decommissioning of all plant and equipment. 5 Disposal of waste materials. 6 Final rehabilitation of: - the mine site including waste material landforms and other areas outside the mine pit; and - the haul road and accommodation facilities. 7 Management and monitoring following mine completion. 8 Inventory of all contaminated sites and proposed management.

Aspect	Condition No.	Condition
	13-4	The proponent shall make the Final Closure and Decommissioning Plan required by conditions 13-1 to 13-3 publicly available in a manner approved by the CEO.
	13-5	The proponent shall close, decommission and rehabilitate the proposal in accordance with the Final Closure and Decommissioning Plan required by conditions 13-1 to 13-3.
Ministerial Statement 957 – Carina Iron Ore Mine (published 12 December 2013)		
Removal of condition from MS 852	-	The implementation of the proposal to which the above report of the Environmental Protection Authority relates is subject to the conditions and procedures contained in Ministerial Statement No. 852, as amended by the following: Condition 5-2 is deleted.

A-5 Operating Licence Conditions

Aspect	Condition	Requirement
L8596/2011/1		
Information	5.1 Records 5.1.1 Information	All information and records required by the Licence shall: • be legible; • if amended, be amended in such a way that the original and subsequent amendments remain legible or are capable of retrieval; • except for records listed in 5.1.1(d) be retained for at least 6 years from the date the records were made or until the expiry of the Licence or any subsequent licence; and • for those following records, be retained until the expiry of the Licence and any subsequent licence: • off-site environmental effects; or • matters which affect the condition of the land or waters.
L8837/2014/1		
Waste processing	1.2.7 Waste processes (Table 1.2.4)	All waste types - Shall only take place within the landfill area shown on the Map in Schedule 1. No waste shall be temporarily stored or landfilled within 35 metres from the boundary of the Premises. The separation distance between the base of the landfill and the highest groundwater level shall not be less than 2 m.
		Tyres shall only be landfilled: • in batches separated from each other by at least 100 mm of soil and each consisting of not more than 40 cubic metres of tyres reduced to pieces; or • in batches separated from each other by at least 100 mm of soil and each consisting of not more than 1,000 whole tyres. Note 1: Requirements for landfilling tyres are set out in Part 6 of the <i>Environmental Protection Regulations 1987</i>. Note 2: Additional requirements for the acceptance and landfilling of controlled waste (including asbestos and tyres) are set out in the <i>Environmental Protection (Controlled Waste) Regulations 2004</i>.
	1.2.9 Cover requirements (Table 1.2.5)	Putrescible waste and Inert Waste Type 1 - covered with inert and combustible material to a depth sufficient to ensure the waste is completely covered and that no waste is exposed. Weekly or as soon as practicable after deposit and prior to compaction.
		Inert Waste Type 2 (Tyres¹) – to be covered with inert waste Type 1 or soil to a depth of 500 mm, as soon as practicable after deposit. Note 1: Additional requirements for the covering of tyres are set out in Part 6 of the <i>Environmental Protection Regulations 1987</i>.
	1.2.10	The Licensee shall ensure that no waste is burnt on the premises

Aspect	Condition	Requirement				
Ambient environmental monitoring	3.3.1 Ambient groundwater quality (Table 3.8.1)	Monitoring point reference	Parameter	Unit	Frequency	Method
		WRD1 WRD2 WRD3	SWL	m AHD	Monthly	Spot sample
			pH	-	Spot sample	
			Electrical conductivity	µS/cm		
			Aluminium (Al), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), mercury (Hg), nickel (Ni), selenium (Se), silver (Ag), zinc (Zn), sodium (Na), potassium (K), chloride (Cl), carbonate (CO ₃), bicarbonate (HCO ₃), nitrate (NO ₃), sulfate (SO ₃).	mg/L		
Information	4.1 Records 4.1.1 Information	All information and records required by the Licence shall: • be legible; • if amended, be amended in such a way that the original and subsequent amendments remain legible or are capable of retrieval; • except for records listed in 4.1.1(d) be retained for at least 6 years from the date the records were made or until the expiry of the Licence or any subsequent licence; and • for those following records, be retained until the expiry of the Licence and any subsequent licence: • off-site environmental effects; or • matters which affect the condition of the land or waters.				
L8945/2016/2						
Waste processing	1.1.6 Waste processes (Table 1.1.3)	All waste types - Shall only take place within the landfill area shown in Schedule 1, Figure 1. No waste shall be temporarily stored or landfilled within 35 metres from the boundary of the Premises. The separation distance between the base of the landfill and the highest groundwater level shall not be less than 2 m. Note 1: Requirements for landfilling tyres are set out in Part 6 of the <i>Environmental Protection Regulations 1987</i> .				

Aspect	Condition	Requirement
		Note 2: Additional requirements for the acceptance and landfilling of controlled waste (including asbestos and tyres) are set out in the <i>Environmental Protection (Controlled Waste) Regulations 2004</i> .
		Hydrocarbon contaminated waste ³ .: All bioremediation areas are located: - o at least 50 m from surface water bodies; - o at least 50 m from any odour sensitive receptors; and - o in an area where groundwater is at a depth of greater than 3 m below ground surface. Ensure waste is bioremediated by aerating soil at least monthly when the facility is in use. Note 3: Bioremediated soil will be required to meet specifications for Class II landfills as outlined in the Landfill Waste Classification and Waste Definitions 1996 (as amended December 2019) before being landfilled.
	1.1.7	The Licence Holder shall ensure that all leachate run-off at the bioremediation pad is directed to, and contained within, an impermeable leachate collection sump with capacity to contain a 1 in 100-year, 72-hour duration rainfall event.
	1.1.9 Cover requirements (Table 1.1.4)	Putrescible waste and Inert Waste Type 1 - covered with inert and combustible material to a depth sufficient to ensure the waste is completely covered and that no waste is exposed. Fortnightly or as soon as practicable after deposit and prior to compaction. Inert Waste Type 2 (Tyres ¹) – to be covered with inert waste Type 1 or soil to a depth of 500 mm, as soon as practicable after deposit. Note 1: Additional requirements for the covering of tyres are set out in Part 6 of the <i>Environmental Protection Regulations 1987</i> .
	1.1.10	The Licensee shall ensure that no waste is burnt on the premises
Information	3.1 Records 3.1.1 Information	All information and records required by the Licence shall: • be legible; • if amended, be amended in such a way that the original and subsequent amendments remain legible or are capable of retrieval; • except for records listed in 4.1.1(d) be retained for at least 6 years from the date the records were made or until the expiry of the Licence or any subsequent licence; and • for those following records, be retained until the expiry of the Licence and any subsequent licence: • off-site environmental effects; or • matters which affect the condition of the land or waters.



APPENDIX B

STAKEHOLDER ENGAGEMENT REGISTER

Date	Stakeholder (s)	Description of Engagement	Items discussed	Outcomes	Where addressed in MCP Rev 1
02/06/2023	Marlinyu Ghoorlie	Meeting	MinRes met with Marlinyu Ghoorlie to provide a Project Update. Discussion included consultation on MinRes proposed 2-year mine plan.		Section 4.1.3
18/08/2023	DPLH – T Butler (Director of Heritage Operations) MinRes – M Franklin, A Rowley	Meeting	J4 Redevelopment Proposal Provided timeline of events that occurred in 2014.	Nil issues raised. MinRes will continue to liaise with DPLH if any questions arise.	-
20/04/2023	Mt Jackson Pastoral Lease – Dale Vernon Min Res – N Constable	Phone conversation	Update regarding J4 Mining Proposal including mine development, backfilling and ongoing development of the WRL.	Nil issues raised	-
29/03/2023	DBCA (M Baker, C Reynolds, R Ong, N Vennik) MinRes – N Constable, P de San Miguel, A Cross, S Prakash Lakkur	Meeting	Operations / Closure update for the Yilgarn Hub. Presentation included: - Overview of current operations - Abandonment bund plans - Pest / feral fauna management - Commencement of rehabilitation program after extensive baseline planning phase - MinRes' vision for Closure - Summary of the work undertaken in 2022 - Overview of forward works, studies & rehabilitation to 2027 - Closure as a socioecological endeavour - Discussion around progressive rehabilitation, post-mining land use, and use of machine learning in rehabilitation monitoring.	DBCA preference is to meet at least every 6 months. DBCA preference is for MinRes to tie abandonment bunds into existing ridge lines / waste rock landforms where possible thereby reducing the need to disturb more land to construct the bunds. DBCA's key interest would be to avoid disturbance to priority / threatened flora in the region. DBCA will come back to MinRes re opportunities to collaborate on feral animal management. Suggestion that DBCA preference is for 'natural environment' PMLU. MinRes provided DBCA with link to recent paper on emerging eDNA technology. DBCA will share information on species diversity and trends in the region.	Section 4.1.3 Section 9.2.1.1 Section 10.2.6 Section 6.2 Section 5.9.5
7/02/2023	DMIRS (Travis Inman, Danielle Risbey, Demelza Dravnieks, Nathan Sumner) MinRes – Celine Mangan, Les Purves, Cole Thurley	Meeting	Closure and Rehabilitation update for the Yilgarn Hub. Presentation included: - MinRes' vision for Closure - Summary of the work undertaken in 2022 - Overview of forward works, studies & rehabilitation for the next three years - Discussion around progressive rehabilitation, post-mining land use, indigenous procurement, use of machine learning in rehabilitation monitoring.	DMIRS requested that the rehab review letter that was provided to DMIRS in March 2022 be updated with the latest information.	Section 5.9.6
20/07/2022	Shire of Yilgarn Community Forum	Meeting held for contracting, tourism &, mining company representatives, sporting grant recipients, Southern Cross Police.	Projects, Closure and Rehabilitation update for the Yilgarn Hub. Presentation included - Key Yilgarn project updates - MinRes' vision for Closure - Summary of the studies and progressive rehabilitation undertaken in 2022 (including Carina PAF cell investigation & Carina WRL planned earthworks) - Post mining land use / Closure criteria - Overview of forward works, studies & rehabilitation for the next three years - Discussion around progressive rehabilitation, indigenous procurement, use of machine learning in rehabilitation monitoring. - Community engagement	No matters raised specific to Carina Operations (feedback restricted to other Yilgarn Hub operations – Parker Range and Koolyanobbing).	-
27 June 2022	DMIRS (Nathan Sumner, Dan Endacott, Travis Inman, Karen Caple) and DWER (Alanah Kidd,	Meeting	Meeting focused on Closure and Rehabilitation, Approvals and Assessment. Topics related Closure and Rehabilitation included: - Update on progress of rehabilitation in the Yilgarn - Three-year rehabilitation schedule discussed - Update on remote sensing monitoring and seed bank management	No major issues raised	-

Date	Stakeholder (s)	Description of Engagement	Items discussed	Outcomes	Where addressed in MCP Rev 1
	Robert Hughes, Ed Shuller) MinRes – Joshua Thurlow, Adam Parker, Peter de San Miguel, Jemimah Pullin, Angela Murphy, Celine Mangan		Update on current studies in the Yilgarn and upcoming work		
2 June 2022	DMIRS (Matt Cann, Nathan Sumner) MinRes – Celine Mangan, Nathaniel Constable, Sai Prakash Lakkur	Meeting	Presented proposed approach to abandonment bunds.	DMIRS responded (2nd and 9th September) as follows: - DMIRS is generally not supportive of tying in abandonment bunds with Waste Rock Landforms as we consider the WRLs insufficient in preventing 4WD access. The purpose of the abandonment bunds is to prevent inadvertent access to the open pit areas, primarily by people driving a vehicle as this would be harder to stop should it gain access to the edges of the pit and driving at speed. - However, DMIRS will consider proposals that are outside of guidance. But the actual acceptability and decision on that proposal would be made during assessment, when all of the details are in front of us and a technical review can take place, particularly when it comes to unusual proposals. When it comes to ridgelines, MRL will have to ensure they are compliant with the 1997 Guidelines for safety bunds. This will be up to MRL to demonstrate. If the ridgeline cannot be used as a bund and MRL wish to deviate from the guidelines (i.e., within the zone of instability), further geotechnical work may be required to demonstrate that the bund is on safe and stable ground and will last in perpetuity.	Section 9.2.1.1
16 March 2022	DMIRS	Meeting	Bi-monthly meeting focused on Closure and Rehabilitation, Approvals and Compliance. Topics related Closure and Rehabilitation included: - Update on progress of exploration rehabilitation across the entire business - Summary of total rehabilitation (ha) across the Yilgarn along with planned upcoming rehabilitation - Update on current studies in the Yilgarn and upcoming work - Update on the development of a Rehabilitation Work Pack	No major issues raised	-
16 February 2022	Wildflower society of WA MinRes – Celine Mangan, Kelly Chalwell, Dan Barker, Sam Tonkin	Meeting	Presented the 8 December 2021 presentation that Wildflower Society representative unable to attend.	Closure related feedback predominantly relates to Yilgarn Operations (See Yilgarn Operations MCP). Preferred time for CCG meeting is August Would like to see MinRes support the Helena Aurora National Park and said MinRes is standing in the way of this and holding up the process Copy of 8th Dec presentation forwarded on 16th February as requested.	-
12 January 2022	DMIRS (Karen Caple, Dan Endacott, Melissa Harrison) and DWER (Robert Hughes, Ed Schuller, Lauren Edmands) MinRes – Tim Berryman, Celine	Meeting	Bi-monthly meeting focused on Closure and Rehabilitation, Approvals and Compliance. Topics related Closure and Rehabilitation included: - Update on progress of exploration rehabilitation across the entire business - Completion of earthworks on the W7 WRL. Drone seeding planning underway - Update on current studies in the Yilgarn and upcoming work - Update on use of Machine Learning in Rehabilitation Monitoring	No major issues raised	-

Date	Stakeholder (s)	Description of Engagement	Items discussed	Outcomes	Where addressed in MCP Rev 1
	Mangan, Adam Parker, Peter de San Miguel				
8 December 2021	CRG DBCA Yilgarn Shire WA Salt Toodyay Naturalists Club	Meeting	Meeting at Koolyanobbing to provide update on approvals, operations and projects, rehabilitation, environment updates and community engagement for all Yilgarn Hub operations.	No major issues raised	-
10 November 2021	DMIRS (Karen Caple, Dan Endacott, Melissa Harrison) MinRes – Joshua Thurlow, Peter de San Miguel, Adam Parker, Celine Mangan	Meeting	Bi-monthly meeting focused on Closure and Rehabilitation, Approvals and Compliance. Topics related Closure and Rehabilitation included: - Update on progress of exploration rehabilitation across the entire business - Update on current studies in the Yilgarn and upcoming work Update on use of Machine Learning in Rehabilitation Monitoring	No major issues raised	-
8 September 2021	DMIRS (Karen Caple, Dan Endacott, Melissa Harrison) and DWER MinRes – Joshua Thurlow, Adam Parker, Celine Mangan	Meeting	Bi-monthly meeting focused on Closure and Rehabilitation, Approvals and Compliance. Topics related Closure and Rehabilitation included: - Increase in Human Resourcing - Increased internal engagement with management and site teams - Update on progress of exploration rehabilitation - Update on current studies and activities in the Yilgarn	No major issues raised	-
August 2021	EPA	Meeting	MinRes presentation of plans for the next five years across whole of operations. Included high-level discussion around Closure and Rehabilitation	No major issues raised	-
5 May 2021	DMIRS (Karen Caple), DWER (Rebecca Kelly, Ed Schuller, Tony Sinclair, Liesl Rohl) and EPA (Robert Hughes) MinRes – Joshua Thurlow, Les Purves, Adam Parker, Celine Mangan	Meeting	MinRes presentation of upcoming approvals across whole of operations. In addition to approvals discussion, the following key points were presented in relation to closure and rehabilitation: - MinRes' vision for Closure - Upcoming studies being planned for the Yilgarn Operations	No major issues raised	-
7/9/2018	DMIRS	Meeting	Request for the provision of a publicly available quarterly progress report in relation to mine closure and rehabilitation. Request for monthly update in relation to progress with rehabilitation and closure	First quarterly rehabilitation progress meeting held 01 November 2018. MCP submitted to DMIRS and to DWER on 20th November 2018	DEMIRS has revised schedule to annual updates
2018	Tellus Holdings	Meeting	Discuss tenure and bore installation at Carina	Bore constructed	-
2018	DBCA	Face to face meetings and site visits	Consultation on final land use objectives, closure criteria and progressive rehabilitation has been undertaken in relation to the closure aspects of Ministerial Statement 852.	MCP updated to address the DPaW review of the 2015 MCP.	Refer Section 6 and Section 8.2
2018	EPA / OEPA	Phone conversations and	OEPA commented that closure aspects of Ministerial Statement 852 can be assessed on OEPA's behalf by DPaW.	DPaW to review on behalf of OEPA.	Section 4.1.1

Date	Stakeholder (s)	Description of Engagement	Items discussed	Outcomes	Where addressed in MCP Rev 1
		email correspondence			
2018	Conservation Council of Western Australia Inc.	Face to face meetings	CCWA raised the potential issue that the post-closure pit lake could act as a source of drinkable water which may support additional population of feral animals. This would have a negative impact on native troglodfauna.	Additional studies have been conducted to determine the occurrence of a pit lake post-closure and likely water quality. An assessment of potential impact of feral animals has been undertaken, with the Carina Pit being identified as having non-drinkable groundwater.	Section 5.5.3 Section 5.6.2.3.2 Section 7 Section 9.5
12/04/2017	DMP / DPaW	Meeting	Meeting to discuss regulator expectations for completion criteria for Carina MCP. Given similarities of land use to J4, extension of completion criteria for Carina to J4 is appropriate.	Polaris to incorporate DMP/DPaW expectations around completion criteria in J4 MCP revision.	Section 8
24/10/2014	DMP	Meeting	Meeting to present the findings of the J4 soil and geochemical characterisation and discuss suitability of the information for inclusion in the MP/MCP. Also discussed the J4 access track diversion, and the difficulty obtaining appropriate tenure over the alignment.	DMP not able to provide a response immediately and requested follow-up email. DMP subsequently indicated it was happy with the level of detail presented.	-
22/10/2014	Shire of Yilgarn	Teleconference	Discuss LAA non-PAR tenure options with the Shire of Yilgarn re the J4 access diversion track i.e., possibility of Shire supporting either a public easement or gazettal of road.	Matter to be raised with Shire of Yilgarn Works Manager and/or Council, but support for either proposal is unlikely.	-
22/10/2014	Department of Lands	Meeting	Meeting to discuss appropriate LAA tenure for construction of the J4 access diversion track. DoL advised that PAR not appropriate and not recommended and that any public easement or gazettal of the road would need the support of the Shire of Yilgarn and would need to connect to an existing gazetted road.	-	-
14/10/2014	OEPA	Meeting	Meeting to discuss requirement for s45C submission regarding alternative accommodation village for J4. OEPA advised a s45C would be required to amend Statement 988. Also discussed use of Aurora Camp for construction of J4 -	Floyd indicated he would go back to DPaW (Sandra Thomas) and advise them of Polaris' intentions.	Aurora Camp used and since decommissioned (Section 2.4)
26/09/2014	DMP	Meeting	Discussed development of J4 MPMCP, and sought feedback on soil and geochemical characterisation studies, as well as preferred approach for presenting assessment of environmental impacts.	-	Section 5.3.5.1.3
21/08/2014	DMP	Meeting	Discussed timing and process for submitting/assessing the J4 MPMCP. DMP indicated that it is reluctant to parallel process the application prior to EP Act approval and tenure being granted. The content of the MPMCP needs to demonstrate how the lessons learnt at Carina will be addressed at J4 to provide the DMP with confidence that these issues will not occur.	Recommended that we discuss the scope of the MPMCP with DoW with respect to groundwater impacts. Follow up meetings on a monthly basis to be held as required to further scope the MP/MCP.	-
16/04/2014	OEPA	Meeting	Meeting to discuss J4 draft conditions and preparation for EPA Board meeting on 17/04.	-	-
15/04/2014	Helena Aurora Range Advocates	Meeting	Met at HARA's request to discuss MRL support for upgrading MMHARCP to a National Park with no mining.	-	-
24/03/2014	OEPA	Meeting	Discussed J4 approval timeframes	-	-
4/10/2013	DPaW EMB	Meeting	DPaW expressed preference to have accommodation camp located at J4, not expansion of Aurora Camp	-	Aurora Camp used and since decommissioned (Section 2.4)
09/09/2013	Shire of Yilgarn	Mining	No specific concerns stated - Shire of Yilgarn is comfortable with Polaris' exploration and mining activities in the Shire.	-	-
16/08/2013	Wilderness Society	Meeting	Wilderness Society reiterated position that conservation arrangements should be as per previous EPA recommendations and other reports. This is not so much about expanding the conservation reserves but increasing the level of protection for these reserves, particularly the HAR, to Class A reserves.	-	-

Date	Stakeholder (s)	Description of Engagement	Items discussed	Outcomes	Where addressed in MCP Rev 1
15/08/2013	DPaW EMB	Meeting	Discussed possibility of upgrading Aurora Camp as the base for J4 workforce, and the need to use the access track south to the proposed haul road Status of management planning for the reserves, current understanding is that management will be released at end of 2013.	-	Section 2.1
14/08/2013	OEPA	Meeting	OEPA want to receive quality reporting and surveys that meet BIF protocol and current guidance.	-	-
06/08/2013	Wildflower Society	Meeting	Exploration/mining activities and related approvals requirements relevant to J4. No specific concerns raised in relation to J4, but it was stated that there is community concern with respect to Bungalbin East.	-	-
25/07/2013	DEC EMB OEPA	Meeting	Discussed the requirement for additional spring flora/fauna work at J4 and Chameleon.	-	-
15/03/2013	DEC EMB	Meeting	DEC reiterated the conservation significance of Helena – Aurora Conservation Park and the importance of surveying the full extent of flora for effective EIA.	-	-
19/02/2013	Wildflower Society	Meeting	Exploration / mining activities and related approvals requirements relevant to J4. Concerns regarding mining in the Banded Iron Formations	-	-
22/10/2012	DEC OEPA	Meeting	Fauna survey methodology and expectation of regulatory agencies	-	-
03/10/2012	DEC EMB OEPA DMP	Letter	Letter sent 17th October 2012 accepting DEC's expectations around methodologies. Flora/fauna survey methodology and expectation of regulatory agencies	No Response required	-



APPENDIX C

TECHNICAL REPORTS

This appendix is not publicly available and is supplied separately.



APPENDIX D

GEOCHEMISTRY

D-1 Carina Deposit

Geochemical characterisation for the Carina deposit was undertaken by Polaris (2011) prior to mining. GHD (GHD, 2013) completed a desktop review of the geochemical assay database and previous geochemical test work. Periodic assays of exploration and resource definition drill samples, which covered both ore and waste profiles, provided assay records for assessment. To further assess the AMD characteristics of the waste materials 20 representative samples were analysed in 2011 as indicated in Table D.1. The results of these baseline assessments are summarised in Table D.2.

The results of baseline geochemical characterisation led to a commitment to encapsulate mined PAF in the Carina WRL (Polaris Metals, 2011).

Table D.1: Summary of Geochemical Testing at Carina Deposit and Carina WRL

Review / Testing	No. of Samples	Analysis
Initial static geochemical screening	1,583	Total sulfur (Total S)
Additional static geochemical testing	20	Total S Total sulfate (Total SO ₄ -) Static Net Acid Generation (NAG) Acid Neutralising Capacity (ANC)
Subsequent static geochemical screening	7, 521	Total sulfur (Total S)

Source: Polaris Metals (2011), GHD (2013)

Table D.2: Geochemical Assessment Results for Carina Deposit

Analysis	Assessment of results
Total S	Polaris included Total S content in periodic assays of drill samples, which covered both ore and waste profiles. Of the 1,583 assay results assessed in 2011, 185 samples (11%) had total S values > 0.3%, with 69 of these reporting total S > 1%. Similarly, the 2013 assessment found that more than 90% of sulfur assay values had total S values of <0.3%. The average total sulfur value was 0.78%. Drilling logs showed the main source of PAF material to be the contact zone around a major fault on the western side of the ore body, estimated to be 1.2 % of total mine waste by volume. This unoxidized sulfide material is found below the base of weathering (approximately 80 m), i.e., at the lower levels of the mine. If material from the fault zone is removed from the 2013 dataset, the average total S of waste material is 0.13% but specific samples containing elevated sulfur still remain meaning that PAF was not restricted to the fault zone. Of the 20 additional samples of waste material analysed, all but 5 had total S significantly < 0.3%. Three samples from the fault / transition zone ranged from 5 – 22 % total S.
Acid Neutralising Capacity	All 20 samples assessed in 2011 had some neutralising capacity. The ANC/MPA ratio is frequently greater than 2, indicating samples tested have a greater capacity to neutralise than generate acid. Two samples tested had significant acid consuming (AC) potential with ANC/MPA ratios > 40.
Acid Base Account	2011 assessment All but 3 of the 20 samples had low potential acidities, with MPA < 10 kg H₂SO₄/t. All but 3 samples had NAPP ≤ 0 kg H₂SO₄/t. All mafic schist and BIF/chert samples had a NAPP ≤ 0. The three exceptions, all from the fault / transition zone, recorded MPA values between 152 and 673.6 kg H₂SO₄/t and NAPP values of 151 to 625 kg H₂SO₄/t. 2013 assessment

Analysis	Assessment of results
	The 2013 assessment more conservatively assumed that all sulfur present is in the form of reactive sulfur to calculate MPA. On this basis it was determined on assessment of the drillhole assay set that: • 26.2% of samples have a NAPP < 0 kg H₂SO₄/t (likely NAF). • 65.4% of samples returned a NAPP between 0 – 10 kg H₂SO₄/t (PAF-LC) • 8.4% of samples had significantly high NAPP 10 - > 100 H₂SO₄/t (PAF-HC) and likely associated with the fault zone. • These results do not consider non-contributing Ca and S species.
Net Acid Generation	13 of the 20 additional samples of waste material analysed had NAGpH ≥ 4.5 and are therefore not likely to be PAF. 7 of the samples had NAGpH < 4.5 and likely to be PAF. Of these, the three fault / transition zone samples (that also recorded high total S) recorded NAGpH in the range 2 – 2.2).

Source: Polaris Metals (2011), GHD (2013)

Geochemical classification

Geochemical classification of the waste types at Carina can be summarised as follows (GHD, 2013):

- Approximately 26.2% of the material in the pit was classified (using the available Ca and S data in the assay database) as having a NAPP value of <0 kg H₂SO₄/t indicating that these materials are not likely to be acid forming (NAF).
- Approximately 65.4% of the samples had a conservative NAPP value (these results do not consider non-contributing Ca and S species) of between 0-10 kg H₂SO₄/t, indicating these materials are potentially acid forming, but at low levels (PAF-LC).
- Approximately 8.4% of the samples had a NAPP value of > 10 kg H₂SO₄/t indicating these materials are likely to be potentially highly acid forming (PAF-HC).
- The NAF and PAF-LC results are associated with the major waste types (mafic schist and BIF/chert/ultramafic bedrock) which combined comprise approximately 98% by volume of mine waste.
- The PAF-HC results are associated with material from the fault zone which represents approximately 2% by volume of mine waste.

Table D.3: Analysis and acid base accounting of mine waste types

Line	Hole	Depth	category	Total S (%)	Total SO ₄ (mg/kg)	Total SO ₄ -S (%)	ANC (kg H ₂ SO ₄ /t)	NAG pH ox (pH)		NAG ph 4.5 (Kg H ₂ SO ₄ /t)	(net) MPA (Kg H ₂ SO ₄ /t)	NAPP (Kg H ₂ SO ₄ /t)	ANC/MPA	Characterisation result
4	52	28-30	bif/cht-ox	0.03	420	0.014	126	9.2	<	0.1	0.5	-126	257	Acid consuming
4	66	30-32	bif/cht-ox	0.03	260	0.009	65.5	8.7	<	0.1	0.7	-65	100	Acid consuming
7	51	104-106	mas-fr	0.36	1470	0.049	13.0	4		1	9.5	-3	1	Non acid forming
7	51	116-118	mas-fr	0.34	1230	0.041	19.7	4		1.1	9.1	-11	2	Non acid forming
7	50	78-80	mas-ox	0.03	370	0.012	7.1	6	<	0.1	0.5	-7	13	Non acid forming
8	25	118-120	fault/trans-HS	22.4	11600	0.387	49.0	2		293	673.6	625	0	PAF-HC
10	45	14-16	bif/cht-ox	0.13	250	0.008	4.0	3		3.2	3.7	0	1	Non acid forming
11	84	110-112	bif/cht-ox	0.09	320	0.011	29.6	8.4	<	0.1	2.4	-27	12	Non acid forming
11	81	70-72	bif/cht-fr	0.03	100	0.003	4.5	8	<	0.1	0.8	-4	6	Non acid forming
14	43	120-122	fault/trans-HS	0.10	500	0.017	4.0	6.3	<	0.1	2.6	-1	2	Non acid forming
14	43	32-34	mas-ox	0.08	1200	0.040	3.3	5.2	<	0.1	1.2	-2	3	Non acid forming
15	79	58-60	bif/cht-fr	0.06	370	0.012	3.4	6.1	<	0.1	1.5	-2	2	Non acid forming
17	83	20-22	bif/cht-fr	0.12	1980	0.066	1.3	4.2		0.3	1.7	0	1	Non acid forming
17	167	116-118	fault/trans-HS	13.0	16400	0.547	28.4	2.2		179	381.1	353	0	PAF-HC
18	40	72-74	mas-ox	0.06	1150	0.038	6.8	6.9	<	0.1	0.7	-6	10	Non acid forming
18	40	78-80	mas-ox	0.03	780	0.026	4.3	6.7	<	0.1	0.1	-4	35	Non acid forming
18	41	104-106	mas-fr	0.02	180	0.006	4.6	6.6	<	0.1	0.4	-4	11	Non acid forming
18	41	74-76	mas-fr	0.05	740	0.025	5.0	8.2	<	0.1	0.8	-4	6	Non acid forming
20	34	100-102	fault/trans-HS	5.12	3840	0.128	2.0	2.1		114	152.8	151	0	PAF-HC
22	58	90-92	bif/cht-fr	0.01	290	0.010	2.6	5.3	<	0.1	0.0	-3	255	Non acid forming

Source: Polaris Metals (2011); GHD (2013)

D-2 Carina Extended Deposit

As a geological extension of the Carina orebody, waste characteristics for Carina Extended were expected to be similar to those reported by Polaris Metals (2011) and summarised in Appendix D-1.

Further analysis of major waste types and profiles was undertaken as described in Table D.4. Samples comprised all major waste types and were selected to be representative of the complete mine waste profile both horizontally and vertically. The results of the assessment are summarised in Table D.5.

Table D.4: Summary of Geochemical Testing at Carina Extended Deposit

Testing	No. of Samples	Analysis
Static geochemical testing	39	Total Oxidisable Sulfur (TOS) % Static Net Acid Generation (NAG) Acid Neutralising Capacity (ANC)
Additional static geochemical testing (of UM, BLT and CHT waste types)	16	Total S % NAG ANC
Acid leachate testing	16	Metals (As, Cd, Cu, Cr, Pb, Ni, Se, Zn)
Kinetic testing: - of samples classed as PAF by static testing; and - a selection of basalt and chert samples classed as NAF by static testing	9	K NAG

Source: Polaris Metals (2013a)

Table D.5: Geochemical Assessment Results for Carina Extended Deposit

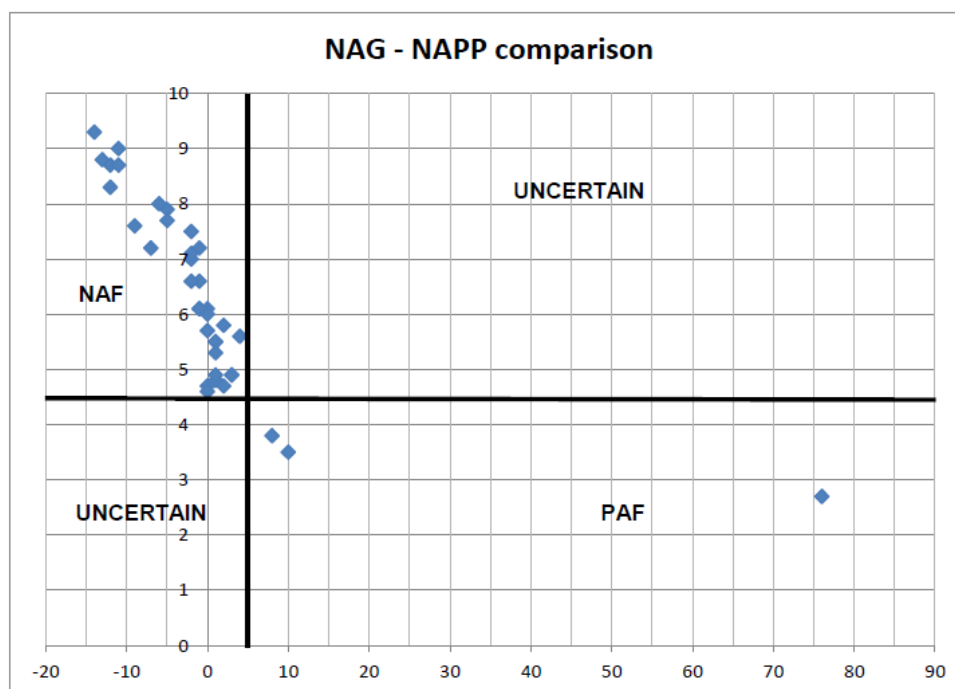
Analysis	Assessment of results
Total Oxidisable S	Of the 39 additional samples of waste material analysed, 80% of samples recorded total TOS < 0.1%. Most are an order of magnitude (0.03%) less than the literature threshold of 0.3%. The three samples that exceeded this threshold had TOS values ranging from 0.52 – 30% with the highest levels associated with samples from 120 to 130 m below ground level.
Acid Neutralising Capacity	The results from the initial 39 and subsequent 16 samples show that ultramafic waste generally shows good ANC characteristics.
Acid Base Account	Net Acid Producing Potential (NAPP) = MPA – ANC. All 16 samples had NAPP ≤ 0 kg H ₂ SO ₄ /t with one sample (NAPP of -40 H ₂ SO ₄ /t and NAG _{pH} of 9.8 regarded as acid consuming (AC).
Net Acid Generation	Reflecting the generally low total S results, all but 4 of the 20 additional samples of waste material analysed had NAG _{pH} ≥ 4 and NAG _{pH4.5} < 0.5. The four exceptions recorded NAG _{pH} ranging from 1.8 to 3.8 and NAG _{pH4.5} ranging from 2.2 - 430. The literature threshold of 0.3 % sulfur for significant acid generating capacity holds true for the samples taken. All samples with TOS % of 0.27 or greater are PAF and all samples less than this are NAF or have ANC.
Acid leachate testing	This test simulates potential metalliferous drainage under acid conditions caused by ARD. The ultramafic waste produced elevated copper (42 – 130 mg/L), chromium (510 – 1500 mg/L), nickel (220 – 820 mg/L) and zinc (25 – 85 mg/L) levels significantly higher than the other two main waste types. Note that these levels alone do not indicate that metalliferous drainage will be problematic.

Analysis	Assessment of results
Kinetic NAG testing	The kinetic NAG (KNAG) test provides a qualitative indication of the lag to onset of AMD from a sample. Material that had been identified by static testing as PAF-HC (used for KNAG test No. 12 – Table x 11) showed a very rapid reaction time to pH 4 and continued to a final pH of 2 in a period of minutes indicating the material would be regarded as immediate / rapid oxidising and high acid forming. The rapid reaction is highly exothermic. Conductivity rapidly increases with increasing acidity, either from sulfate ions in solution, increased mobilisation of metals or other elements in the sample Material that had been identified by static testing as PAF (used for KNAG test No. 19 – Table x 11) took approximately 1,400 minutes to reach pH4, equating to greater than a decade. The very slow reactivity of this material is too slow to produce a recordable elevation in temperature and conductivity results show a slow, minor linear increase but still within the fresh water range. This indicates no significant elevated leaching. This material should be regarded as PAF-LC. Material that had been identified by static testing as NAF (used for KNAG test No. 1 – Table x 11) showed an immediate slight acid neutralising capacity reaction to a pH of approximately 5.5 and then no further reactivity. Reaction temperatures reflected ambient temperatures. EC remained within fresh water quality range with no long-term elevated leaching. The very slow reactivity of this material is too slow to produce a recordable elevation in temperature and conductivity results show a slow, minor linear increase but still within the fresh water range. All waste other than very high sulfur content waste (i.e., pyrite waste) is either benign (NAF) or acid forming over a very long time period.

Source: Polaris Metals (2013a)

Geochemical classification

Geochemical classification of the waste types at Carina Extended is illustrated in Figure D.1 (based on static testing results from Table D.7) and summarised by lithology in Table D.6.



Source: Polaris Metals (2013a)

Note: Sample CXRC0007 (at 930 kg H₂SO₄/t) is omitted as including it compressed the graph axis which caused clarity on other results to be lost.

Figure D.1: Carina Extended Geochemical Classification – Static Test Comparison

There is a strong correlation of geochemical classification with waste lithology. Waste logged as basalt (BLT) and chert (CHT) is NAF; ultramafic (UM) waste generally shows good ANC characteristics. PAF waste is associated with zones containing pyrite, logged as a combination of lithology types.

Table D.6: Geochemical Classification of Carina Extended Waste Types

Lithology	% by volume	Geochemical classification
Basalt (BLT)	50	Non-acid forming (NAF)
Ultramafic (UM)	19	NAF / ANC
Chert (CHT)	7	NAF
Regolith	5	-
Low grade goethite (IG)	18	-
Pyrite (PY) (associated with MKB and BLT)	1	PAF
TOTAL	100	

Source: Polaris Metals (2013a)

Metalliferous drainage

Results of acid leachate tests showed that the ultramafic waste produced higher levels of copper, chromium, nickel and zinc when compared with the other two main waste types (Table D.8).

These levels alone do not indicate that metalliferous drainage will be problematic. The natural background concentration of these metals in upper soil / rock samples (0-2 m) currently exceed Ecological Investigation Levels (EILs) for metals in soils as specified by the DEC (2010) (Polaris Metals, 2013a).

Table D.7: Geochemical Assessment Results for Carina Extended Deposit (Waste Characterisation sorted by line number)

Line #	Hole ID CXRC	From	To	Lithology	TOS %	ANC (kg H ₂ SO ₄ /t)	NAPP (kg H ₂ SO ₄ /t)	NAG pH	NAG pH4.5 (kg H ₂ SO ₄ /t)	Result	KNAG test No.
5	0010	20	30	CHT	0.014	<1	0	5.7	<0.5	NAF	1
5	0010	80	90	CHT	0.21	<1	1	5.3	<0.5	NAF	
7	0034	20	30	BLT	0.009	6.5	-6	8	<0.5	ANC-LC	
7	0036	30	40	BLT	0.051	<1	2	5.8	<0.5	NAF	
7	0036	60	70	BLT	0.029	1.7	-1	6.6	<0.5	NAF	
7	0036	70	80	CHT	0.024	<1	0	6	<0.5	NAF	
8	0033	10	20	BLT	<0.005	<1	0	4.6	<0.5	NAF	
9	0003	40	50	UM	0.029	13	-13	8.8	<0.5	ANC	
9	0007	30	40	BLT	0.034	<1	2	4.7	<0.5	NAF	9
9	0007	80	90	MKB	0.012	5	-5	7.7	<0.5	NAF	10
9	0007	100	110	MKB+PY	0.032	3.5	-2	6.6	<0.5	NAF	
9	0007	120	130	MKB+PY	30	<1	930	1.8	430	PAF - HC	12
11	0030	30	40	UM	0.025	10	-9	7.6	<0.5	ANC-LC	
11	0030	50	60	UM	0.014	14	-14	9.3	<0.5	ANC	
11	0038	40	50	BLT	0.27	<1	8	3.8	2.2	PAF-LC	14
11	0038	50	60	BLT+IG	0.029	1.5	-1	6.1	<0.5	NAF	
12	0046	50	60	MKB	0.008	11	-11	8.7	<0.5	ANC	
12	0048	20	30	BLT	0.018	<1	0	4.7	<0.5	NAF	
12	0048	70	80	BLT+PY	0.52	5.4	10	3.5	4.8	PAF	19
12	0049	130	140	BLT+PY	2.7	5.2	76	2.7	26	PAF - HC	18
13	0014	10	20	BLT	0.034	3.2	-2	7.1	<0.5	NAF	
13	0014	30	40	UM	0.011	2.2	-2	7.5	<0.5	NAF	
13	0016	20	30	BLT	0.026	<1	1	4.8	<0.5	NAF	
14	0029	10	20	BLT	0.033	<1	1	4.9	<0.5	NAF	26
14	0029	40	50	CHT	0.018	<1	1	5.5	<0.5	NAF	
14	0029	60	70	CHT	0.018	<1	1	5.5	<0.5	NAF	
14	0039	50	60	BLT	0.023	2.2	-1	7.2	<0.5	NAF	
16	0056	10	20	CHT	0.021	<1	0	6.1	<0.5	NAF	
16	0056	40	50	UM	0.008	12	-12	8.3	<0.5	ANC	
16	0057	30	40	CHT	0.12	<1	4	5.6	<0.5	NAF	
16	0058	50	60	BLT	0.009	2.4	-2	7	<0.5	NAF	31
17	0002	40	50	BLT	0.009	7.5	-7	7.2	<0.5	NAF	
17	0018	20	30	UM	0.006	13	-12	8.7	<0.5	ANC	
17	0067	20	30	BLT	0.026	<1	1	4.8	<0.5	NAF	
18	0069	10	20	BLT	0.14	<1	3	4.9	<0.5	NAF	
20	0063	30	40	BLT	0.013	1.3	-1	6.1	<0.5	NAF	
20	0063	70	80	UM	0.01	11	-11	9	<0.5	ANC	
20	0064	60	70	BLT	0.012	5.6	-5	7.9	<0.5	NAF	
20	0066	30	40	BLT	0.077	<1	3	4.9	<0.5	NAF	

Note: TOS row 2 is a typo, the correct figure should be 0.021 - See Appendix 2 REG ID 41730 (Polaris Metals, 2013a)

Source: Polaris Metals (2013a)

Table D.8: Acid Leach Test Results - Carina Extended Deposit Waste Rock (Waste Characterisation and Leachate)

Line	Hole ID CXRC00..	from-to m	Lithology	ANC (Kg H ₂ SO ₄ /t)	NAPP (Kg H ₂ SO ₄ /t)	TOS	NAG ph4.5 (Kg H ₂ SO ₄ /t)	NAG ph	As (mg/L)	Cd (mg/L)	Cu (mg/L)	Cr (mg/L)	Pb (mg/L)	Ni (mg/L)	Se (mg/L)	Zn (mg/L)
0	85	40-50	UM	8.6	-8	0.008	<0.5	6.3	1	0.5	42	720	2	620	<1	85
		150-160	UM	4.7	-4	0.026	<0.5	3.9	4	0.7	70	650	3	380	<1	26
	83	40-50	UM	40	-40	0.008	<0.5	9.8	<1	0.4	40	860	<1	410	<1	25
		110-120	UM	7.2	-7	0.013	<0.5	7.7	2	0.8	100	1100	2	330	2	41
13	84	110-120	UM	11	-10	0.021	<0.5	9.1	47	1.4	50	510	4	220	3	24
17	75	90-100	UM	5.7	-5	0.012	<0.5	7	7	0.7	30	1500	1	710	<1	76
18	76	10-20	UM	12	-12	0.014	<0.5	7	<1	0.5	61	1200	1	820	<1	78
	77	40-50	MKB	6.4	-6	0.021	<0.5	6.4	3	0.4	52	1100	1	570	<1	81
10	71	50-60	BLT	<1	1	0.012	<0.5	6.2	6	0.2	8	6.4	3	26	<1	3
11	80	20-30	BLT	<1	0	<0.005	<0.5	4.7	4	0.4	39	24	4	6.8	<1	9
		80-90	BLT	19	-18	0.033	<0.5	9.4	1	0.3	28	290	<1	320	<1	9
16	74	40-50	CHT	<1	1	0.038	<0.5	7	<1	<0.1	1	4.5	1	1.9	<1	<2
		80-90	CHT+IG	<1	1	0.022	<0.5	6.2	7	<0.1	3	23	2	13	<1	22
		70-80	CHT+IG	<1	32	1	<0.5	6.2	13	0.1	3.9	20	1	11	<1	8
12	82	20-30	CHT+IG +CLY	<1	0	0.012	<0.5	6	2	0.2	21	210	2	39	<1	7
0	87	10-20	MKB	<1	0	<0.005	<0.5	5.1	4	0.2	22	20	1	11	<1	14

Source: Polaris Metals (2013a)

D-3 J4 Deposit

Geochemical characterisation for the J4 deposit was undertaken by Polaris Metals (2015) and Soil Water Consultants (2014a) prior to mining as described in Table D.9. More detail about sample collection and acid base accounting methodology are provided in as supporting internal report (Polaris Metals, 2013b). Preliminary AMD investigation comprised assessment of 83 composite samples collected over a 10 m interval of drilled material. Subsequently 465 samples from ten geological drill holes were tested and the results used to select a total of 20 samples for AMD assessment. A further subset of ten samples were subject to multi-element analysis and static leach testing (Table D.9). The results of the assessment are summarised in Table D.10.

A post-closure assessment of the J4 deposit resource drilling database has also been completed (SRK, 2023) as described in Table D.9 and discussed in Table D.10.

Table D.9: Summary of Geochemical Testing at J4 Deposit

Review / testing	No. of Samples	Analysis ¹
Preliminary AMD investigation	83 composite samples	Total sulfur (Total S) % Net Acid Producing Potential (NAPP) Net Acid Generation (NAG) Acid Neutralising Capacity (ANC) Multi-element – As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Ni, Se, V and ZN
Initial static geochemical screening	465 drill hole samples	Paste pH and Electrical Conductivity (EC) pH _{ox} Total S %
Additional static geochemical testing	20	Total sulfur (Total S) % Chromium reducible sulfur (S _{CR}) Static Net Acid Generation (NAG) Acid Neutralising Capacity (ANC) Total inorganic carbon
	10 (sub-set of the 20 samples above)	Multi-element composition (Ag, Al, As, B, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, Pb, Sb, Se, Sn, Sr, Th, U, V, Zn) Static leach testing under both neutral and acidic conditions
Post-closure review (2023)	Drill hole assays (2001 – 2016) Total in-pit cumulative drill hole lengths are 6, 339 m (J4 East Pit and 6, 259 m J4 West Pit)	Review Total S % (assays available for 90% of the in-pit waste logged length)

Source: SWC (2014a), SRK (2023)

Notes: 1. Methodology summarised in SRK (2023)

Table D.10: Geochemical Assessment Results for J4 Deposit

Analysis	Assessment of results
pH and pH _{ox}	The pH results ranged from 2.6 (strongly acidic) to 9.8 (moderately alkaline) with an average of 6.37 (slightly acidic). The extremely low in situ pH values at depth within several drillholes (below 100 to 150 m), when combined with high Total S results were attributed to oxidation of sulfides contained within a formation of black shale and / or the host massive pyrite unit. The pH_{ox} results varied from 10 (extremely alkaline) to 1.3 (extremely acidic) with an average of 5.26. Acidic pH values were interpreted as evidence of the presence of secondary stored acidity resulting from oxidation of sulfides; with little or no change in the pH_{ox} (relative to the paste pH result) indicating limited or no residual sulfide content. The data are not consistent across all drillholes indicating a complex weathering system / geometry.
Electrical Conductivity	EC ranged from < 20 mS/m (non-saline) to 1089 (extremely saline), with an average of 83 mS/m (moderately saline). The upper profile (0 – 100 m) is generally non-saline (< 80 mS/m) but with isolated exceptions of elevated EC values. The highest paste EC values (> 600 mS/m) occurred in weathered zones at depth in a subset of the drill holes coincident with high sulfur contents and considered indicative of the presence of oxidation products.
Total S	Total S ranged from <0.01% - 25.2% with ten of the twenty samples containing > 0.3% Total S. Elevated sulfur was recorded in all of the lithologies tested with the exception of the Clay samples. All of these elevated readings occurred relatively deep with the profile (> 70 m down drill hole). The highest values were associated with black shale at appreciable depth within the profile. <u>Post-closure review</u> Assessment of logged waste samples in the drillhole database found in-pit waste had generally low sulfur with median <0.1% in both pits with the exception of saprock (SAP) with median 0.137% S. Of the logged waste samples: • 63% of samples from J4 East Pit and 85% of samples from J4 West Pit waste recorded <0.1% S. • 7% of samples from J4 East Pit and 0.5% of samples from J4 West Pit recorded ≥ 0.3% S. Highest sulfur values were predominantly associated with weathered materials of the upper 50 m of the pit. This sulfur was assumed to occur as sulfates, but no mineralogical assessment was completed to verify sulfur species present. Of the 103 samples assessed prior to mining, 24 samples were from drill hole intervals within the mined volume from J4 East and West pits. These latter samples had Total S ranging from <0.01 to 1.47% S (median 0.055% S). The majority of high sulfur samples (0.1 to 25.2% S; median 3.4% S) were outside the mined pit volumes – primarily within fresh material below the J4 pit shells.
Chromium Reducible Sulfur (S _{CR})	Results of S_{CR} analysis further support the weathering control on sulfur content, with only those samples sourced from within un-oxidised areas reporting appreciable S_{CR} contents (i.e., > 0.03%). S_{CR} accounts for between 17% to 83% of the total sulfur (median 72%). The variation in this parameter is dominated by the depth of the sample within the profile not lithology. S_{CR} results indicate that sulfide-sulfur is typically the dominant form of sulfur below 50 m.
Acid Neutralising Capacity	ANC values ranged from <0.5 to 102 kg H₂SO₄/t and a median ANC value of 3.4 kg H₂SO₄/t. The Carbonate Neutralising Potential (CarbNP) calculated from Total Inorganic Carbon generally mirrored the ANC results.
Acid Base Account	The NAPP varied from -102 – 770.9 kg H₂SO₄/t (Total S). Given the generally low ANC, NAPP correlated well with Total S. The ANC/MPA ratio was not a useful indicator of AMD potential by lithology. Rather, increased acid producing potential was positively associated with increased depth of sampling.
Net Acid Generation	NAG_{pH} for the 20 samples varied from 1.7 to 9.4 with an average of 4.8. Eleven of the 20 samples recorded NAG_{pH} < 4.5 (PAF), across all of the lithologies tested and including all of the black shale material samples. These samples were mostly located below 100 m in the profile.

Source: SWC (2014a), SRK (2023)

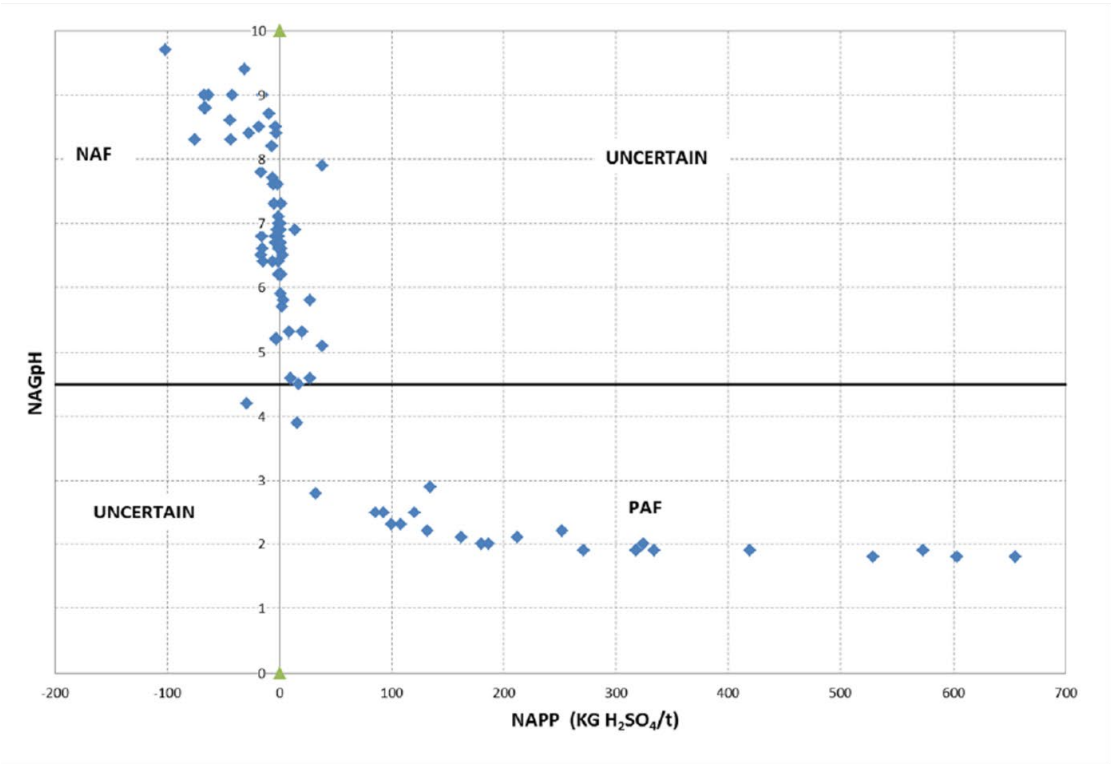
Geochemical classification

Geochemical classification of the waste types at J4 prior to mining is presented in Figure D-2.

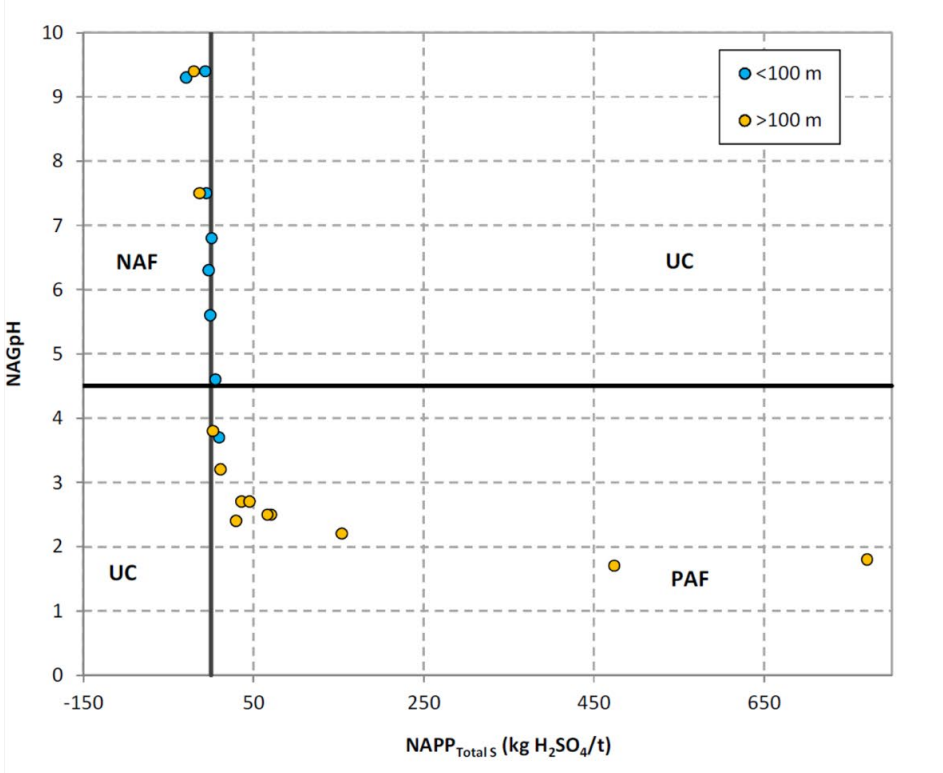
The preliminary AMD classification work classified the 83 composite samples as shown in Figure D-2. Subsequent block modelling showed that the majority of the modelled distribution of PAF was located towards the base of the deposit, primarily on the northern footwall (Figure D-2). Blocks below the water table with Total S > 0.3 % were designated as PAF. Areas that fell outside the zone of drilling were allocated a Total S value of 0.919 %, based on the average of all waste material Total S assay grades. It was noted that this value likely represented an over estimation of the contained Total S (and therefore PAF material) within these blocks, particularly as they were in the upper portion of the deposit. For the purposes of estimating waste volumes, material which was modelled as having Total S > 0.3 % which occurred above the water table, was reported separately as Oxidised Acidic Waste (OAW) but still noted as requiring special management (Figure D-4). In total 13.2 % of the total waste material was modelled as PAF and 22.5% as OAW.

Subsequent testing of 20 composite sample also showed that the majority of samples (7 out of 8) from the upper 100 m of the profile were NAF (or UC in the case of clay samples), whilst the majority of the samples (10 out of 12) from below 100 m in the profile reported a classification of PAF.

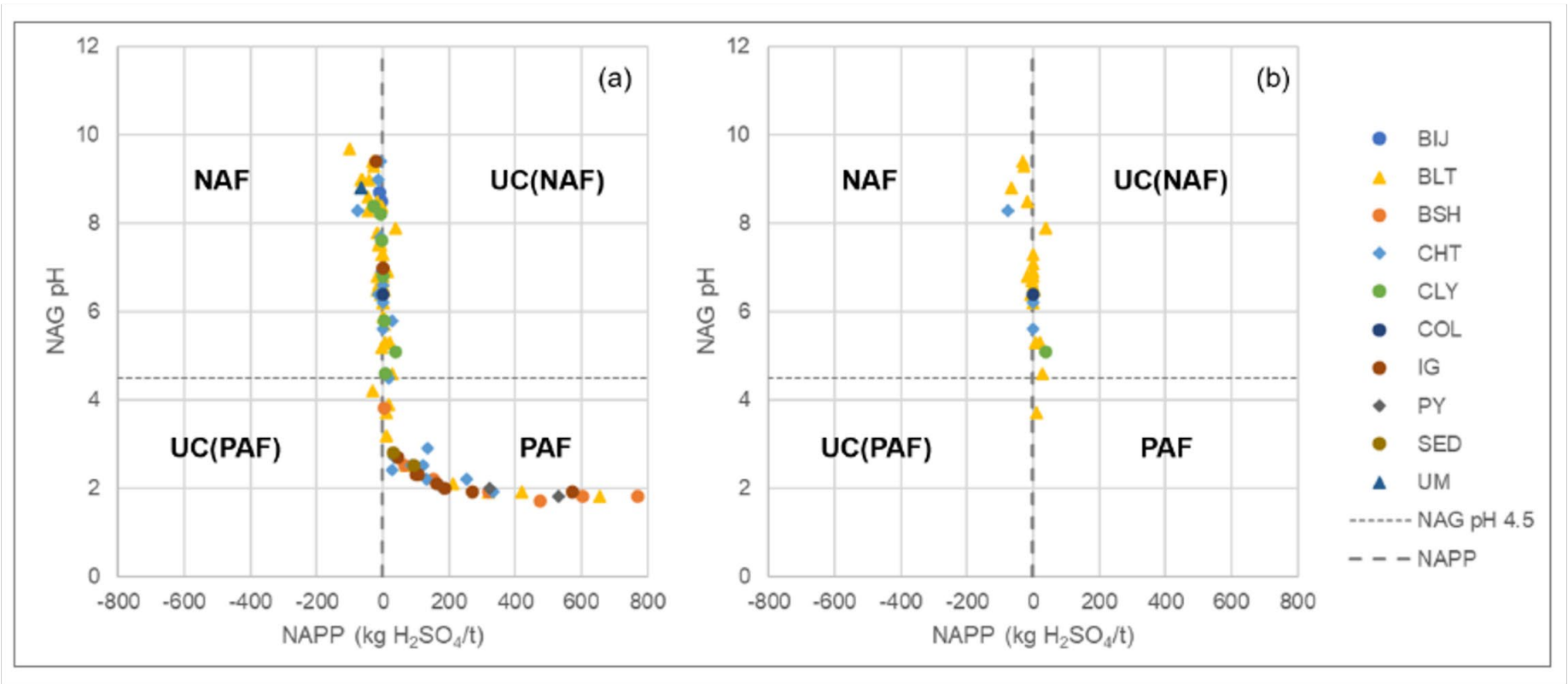
Post-mining review of the data found that of the 103 samples assessed prior to mining, 24 samples were from drill hole intervals within the mined volume from J4 East and West pits. These in-pit samples were predominantly NAF (15 samples) or UC (NAF), with one PAF-LC sample (Table D.10 and Figure D-2. (SRK, 2023). The sulfur contents of the in-pit NAF samples range from 0.01-0.09% S, whereas the UC (NAF) (0.04–1.47% S) and PAF-LC (0.33%S) classed samples had higher sulfur contents. SRK (2023) concluded that based on the limited dataset of samples within the pit volumes, and the sulfur distribution of these samples, there is insufficient data to verify a robust sulfur cut-off value, however it was noted that the PAF-LC sample would be flagged OAW based on sulfur content.



Preliminary (2013) geochemical classification



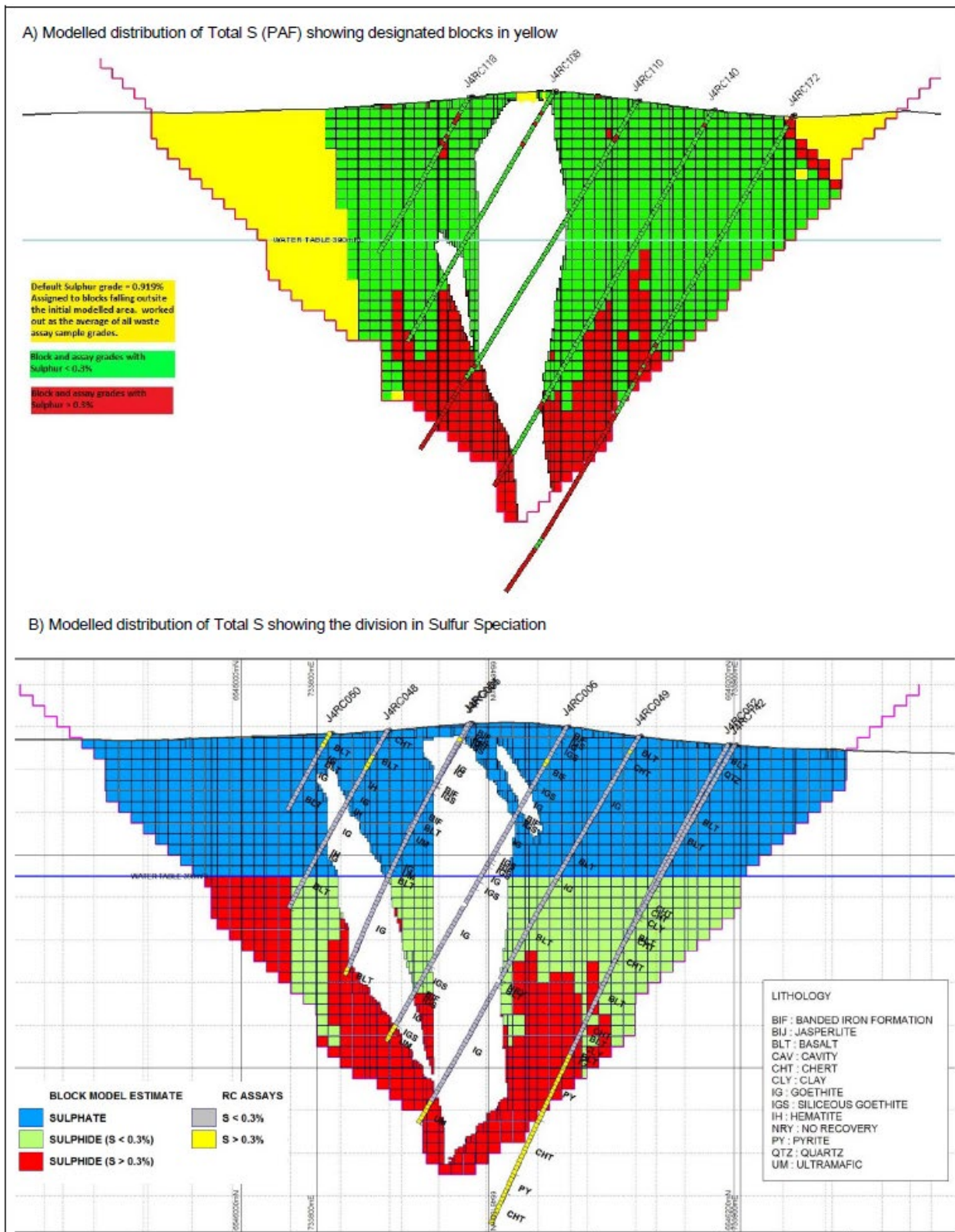
Pre-mining (2014) geochemical classification by depth



Pre-mining (2014) geochemical classification by lithology
All geochemical samples (left) vs in-pit samples only (right)

Source: SWC (2014a), SRK (2023)

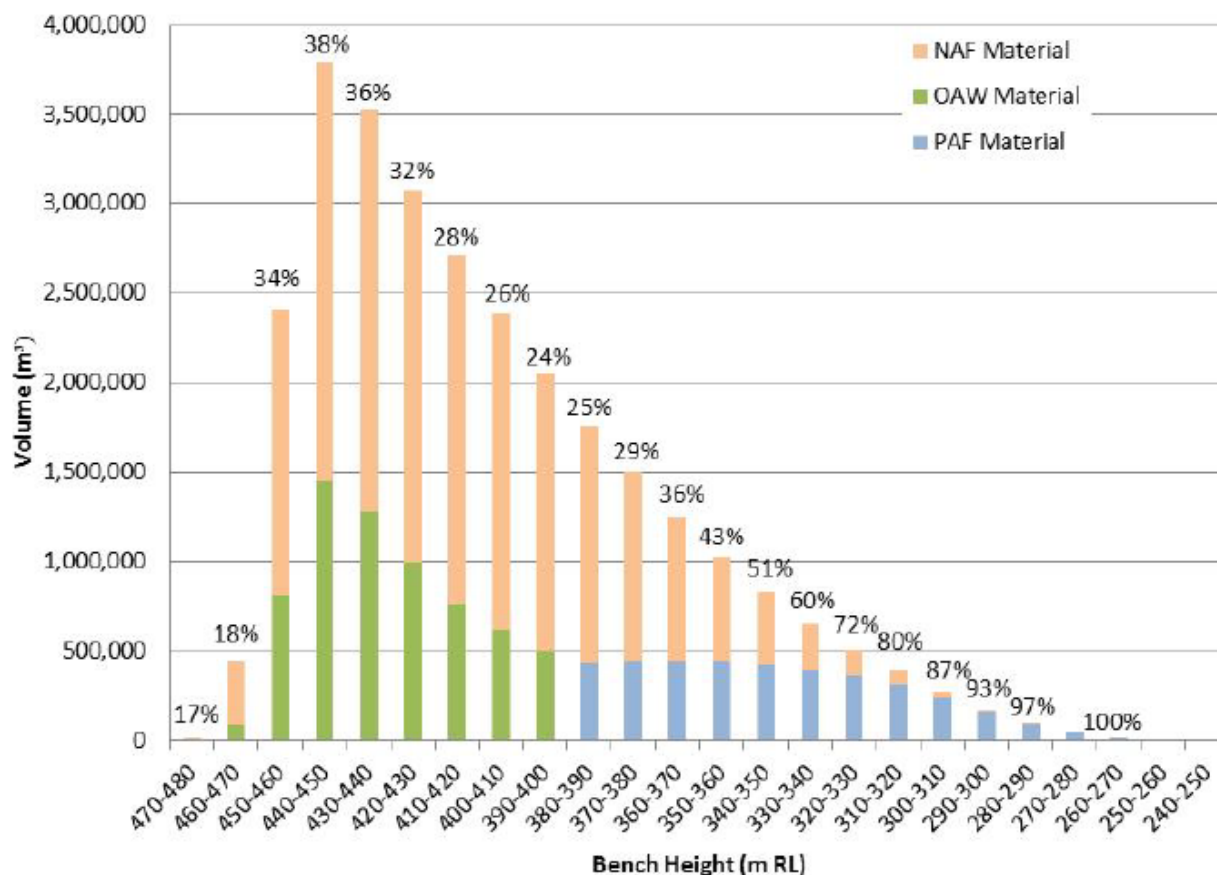
Figure D.2: Geochemical Classification Plots



Source: SWC (2014a)

Notes: These pre-mining block model sections show pit shell designs that extend to depths of around 240 mRL. As-mined pit extents were 344 mRL and 355 mRL, for the J4 East and West pits respectively (SRK, 2023).

Figure D.3: Model Distribution of PAF – J4 Deposit



Source: SWC (2014a)

Figure D.4: Model Distribution of PAF / NAF and OAW – J4 Deposit

Multi-element composition

The multi-element analysis results of 10 waste samples from the SWC (2014a) assessment is provided in Table D.11, together with the calculated Geochemical Abundance Index (GAI) and associated Ecological Investigation Level (EIL).

‘Enriched’ elements that were present in concentration 12 times more than average crustal abundance (or with GAI ≥ 3) (Table D.11) included As, B, Cd, Co, Cr and Cu (SRK, 2023).

Element contents which exceed the EIL for a given sample are highlighted in bold Table D.11. While some samples exceed the EIL for elements As, Cd, Co, Cr, Cu, Mn, Ni, V and Zn only those samples with As and Cd levels which exceed the EIL levels are also considered to be significantly enriched when compared with natural background levels (ACA). The elevated levels of As are restricted to the mineralised and black shale materials, whilst the Cd is also present within the basalt, clay and chert. The As is likely to be associated with the elevated Total S contents as it is widely present as an accessory element in many sulfide minerals (e.g., galena, pyrite, sphalerite) (SWC, 2014a).

Leach testing

The SRK (2023) review of the leach testing findings of SWC (2014a), discussed below, noted that the trace metals concentrations recorded in the leach test solutions were typically at or close to detection limits, however the ASLP leach tests were carried out using a high liquid to solid ration

(20:1) which generate dilute solution and identification of key solutes of concern may have been limited by analytical detection limits. It was also noted that the final pH of the leach test solutions was not reported; the solubility of many metals is strongly pH dependent and is typically very low in the pH neutral to alkaline range.

The results of leach testing completed on 6 samples using acetic acid (pH 2.9) and de-ionised water (circum-neutral) are presented in Table D.12 and Table D.13.

SWC (2014a) reported, as noted above, that for the majority of the materials and elements tested under neutral conditions, the amount leached was low with values $\leq 10\%$ (many elements were below detection limits within the collected leachate). The exceptions to this were samples of goethite, chert and black shale which had slightly elevated rates of leaching within different samples for the elements Cd (17%), Co (13-18%), Cu (12-16%), Mn (15-33%) and Ni (12%). The samples which did display higher rates of leaching as a percentage of solid phase content Co, Cu, Mn and Ni had relatively low solid phase contents of these elements (i.e., $GAI \leq 3$), making the total amount of these metals mobile within the leachate low. SWC (2014a) noted that the Cd leachate results, combined with the GAI, highlight the potential for black shale to produce leachate of environmental concern.

Simulated acidic leaching conditions generally produced lower leaching rates as a percentage of solid phase content than the neutral leachate, with Cd, Co, Cu, Mn and Ni, all showing decreased leaching rates. SWC (2014a) concluded that this is likely due to be an effect of adsorption onto Fe oxides which occurs more readily at acidic pH and can be removed from solution by precipitates occurring within the leachate sample. This result suggests that the mobility of element is likely to be restricted to some extent under acidic conditions when compared with neutral conditions (SWC, 2014a).

Table D.11: Multi-element composition of selected samples J4

Depth	LOR / ACA*	Ag		Al		As		B		Ba		Cd		Co		Cr		Cu		Fe		Hg		Mn	
		2	0.07	50	82000	5	1.5	50	10	10	500	1	0.11	2	20	2	100	0.1	50	50	41000	0.1	0.05	5	950
	Lithology	mg/kg	GAI**	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI
151	Goethite	<2	0	37200	0	63	5	110	3	<10	0	7	5	146	2	217	1	1100	3	185000	2	0.2	1	388	0
33	Basalt	<2	0	4330	0	<5	0	60	2	<10	0	2	4	4	0	1060	3	40	0	86300	0	<0.1	0	109	0
89	Chert	<2	0	950	0	<5	0	<50	0	<10	0	1	3	<2	0	15	0	17	0	43600	0	<0.1	0	54	0
143	Basalt	<2	0	66100	0	<5	0	70	2	<10	0	4	5	41	0	103	0	110	1	107000	1	<0.1	0	825	0
165	Black Shale	<2	0	4230	0	137	6	60	2	<10	0	6	5	106	2	34	0	390	2	93400	1	0.1	0	29	0
17	Clay	<2	0	14600	0	<5	0	90	3	100	0	4	5	31	0	561	2	25	0	149000	1	<0.1	0	665	0
113	Black Shale	<2	0	1590	0	7	2	<50	0	<10	0	<1	0	<2	0	22	0	33	0	16100	0	<0.1	0	51	0
213	Black Shale	<2	0	44600	0	225	7	110	3	<10	0	11	6	177	3	142	0	543	3	286000	2	0.3	2	368	0
131	Chert	<2	0	23600	0	<5	0	50	2	30	0	2	4	153	2	74	0	119	1	61700	0	<0.1	0	3900	1
235	Goethite	<2	0	4710	0	143	6	100	3	<10	0	9	6	58	1	47	0	221	2	251000	2	0.3	2	28	0
Ecological Investigation Level		-	-	-	-	20	-	-	-	300	-	3	-	50	-	400	-	100	-	-	-	1	-	500	-

Depth (m)	LOR / ACA*	Mo		Ni		Pb		Sb		Se		Sn		Sr		Th		U		V		Zn	
		2	1.5	2	80	5	14	5	0.2	5	0.05	5	2.2	2	370	0.1	12	0.1	2.4	5	160	5	75
	Lithology	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI	mg/kg	GAI
151	Goethite	<2	0	219	1	18	0	<5	0	<5	0	<5	0	9	0	2.3	0	0.5	0	111	0	143	0
33	Basalt	<2	0	101	0	<5	0	<5	0	<5	0	<5	0	6	0	0.4	0	<0.1	0	43	0	6	0
89	Chert	<2	0	5	0	<5	0	<5	0	<5	0	<5	0	<2	0	0.2	0	<0.1	0	9	0	10	0
143	Basalt	<2	0	119	0	<5	0	<5	0	<5	0	<5	0	3	0	0.1	0	<0.1	0	245	0	256	1
165	Black Shale	2	0	160	0	24	0	<5	0	<5	0	<5	0	6	0	1.4	0	0.4	0	168	0	7	0
17	Clay	<2	0	46	0	<5	0	<5	0	<5	0	<5	0	5	0	<0.1	0	<0.1	0	70	0	17	0
113	Black Shale	<2	0	6	0	<5	0	<5	0	<5	0	<5	0	<2	0	0.4	0	<0.1	0	18	0	6	0
213	Black Shale	7	2	355	2	51	1	<5	0	<5	0	7	1	16	0	1.6	0	0.3	0	177	0	99	0
131	Chert	<2	0	193	1	<5	0	<5	0	<5	0	<5	0	16	0	0.3	0	<0.1	0	168	0	103	0
235	Goethite	3	0	182	1	22	0	<5	0	<5	0	<5	0	19	0	1.2	0	<0.1	0	32	0	10	0
Ecological Investigation Level		40	-	60	-	600	-	-	-	-	-	50	-	-	-	-	-	-	-	50	-	200	-

*Average Crustal Abundance

Source: SWC (2014a)

Table D.12: J4 Leach Testing Results (Neutral Conditions)

Depth (m)	LOR	Ag		Al		As		B		Ba		Cd		Co		Cr		Cu		Fe		Hg	
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%
151	Goethite	<0.1	BDL	13.2	0.4	<0.01	BDL	0.3	2.7	<0.1	BDL	0.016	2.3	2.22	15.2	<0.01	BDL	18.2	16.5	8.34	0.0	<0.0001	BDL
33	Basalt	<0.1	BDL	0.48	0.1	<0.01	BDL	0.2	3.3	<0.1	BDL	<0.005	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.0001	BDL
89	Chert	<0.1	BDL	<0.10	BDL	<0.01	BDL	<0.1	BDL	<0.1	BDL	<0.005	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	0.06	0.0	<0.0001	BDL
143	Basalt	<0.1	BDL	3.29	0.0	<0.01	BDL	<0.1	BDL	<0.1	BDL	<0.005	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	4.9	0.0	<0.0001	BDL
165	Black Shale	<0.1	BDL	32.4	7.7	0.01	0.1	0.1	1.7	<0.1	BDL	0.103	17.2	1.94	18.3	0.04	1.2	4.9	12.6	29.7	0.3	<0.0001	BDL
17	Clay	<0.1	BDL	0.13	0.0	<0.01	BDL	0.2	2.2	0.1	1.0	<0.005	BDL	0.01	0.3	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.0001	BDL
113	Black Shale	<0.1	BDL	0.23	0.1	<0.01	BDL	<0.1	BDL	0.2	BDL	<0.005	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	0.44	0.0	<0.0001	BDL
213	Black Shale	<0.1	BDL	6.66	0.1	<0.01	BDL	<0.1	BDL	<0.1	BDL	<0.005	BDL	1.61	9.1	<0.01	BDL	7.83	14.4	13.6	0.0	<0.0001	BDL
131	Chert	<0.1	BDL	70.2	3.0	<0.01	BDL	0.3	6.0	0.3	10.0	<0.005	BDL	0.08	0.5	0.2	2.7	0.17	1.4	113	1.8	<0.0001	BDL
235	Goethite	<0.1	BDL	45.7	9.7	0.01	0.1	<0.1	BDL	<0.1	BDL	<0.005	BDL	0.76	13.1	0.24	5.1	0.85	3.8	158	0.6	<0.0001	BDL

Depth (m)	LOR	Mn		Mo		Ni		Pb		Sb		Se		Sn		Sr		Th		U		Zn	
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%
151	Goethite	0.47	1.2	<0.01	BDL	1.18	5.4	<0.01	BDL	<0.01	BDL	0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	0.003	6.0	0.26	2.3
33	Basalt	0.1	0.9	<0.01	BDL	0.05	0.5	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.01	BDL
89	Chert	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.01	BDL
143	Basalt	0.03	0.0	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	0.01	0.0
165	Black Shale	0.96	33.1	<0.01	BDL	1.91	11.9	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	0.004	10.0	0.14	0.8
17	Clay	0.38	0.6	<0.01	BDL	0.04	0.9	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	0.1	1.4
113	Black Shale	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.01	BDL
213	Black Shale	2.16	5.9	<0.01	BDL	1.57	4.4	<0.01	BDL	<0.01	BDL	0.01	BDL	<0.01	BDL	<0.1	BDL	<0.001	BDL	0.002	6.7	0.94	5.3
131	Chert	1.36	0.3	<0.01	BDL	0.31	1.6	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	0.003	10.0	<0.001	BDL	0.17	1.0
235	Goethite	0.44	15.7	<0.01	BDL	1.02	5.6	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.01	BDL	<0.1	BDL	0.004	3.3	0.007	BDL	0.21	6.6

Source: SWC (2014a)

Table D.13: J4 Leach Testing Results (Acidic Conditions)

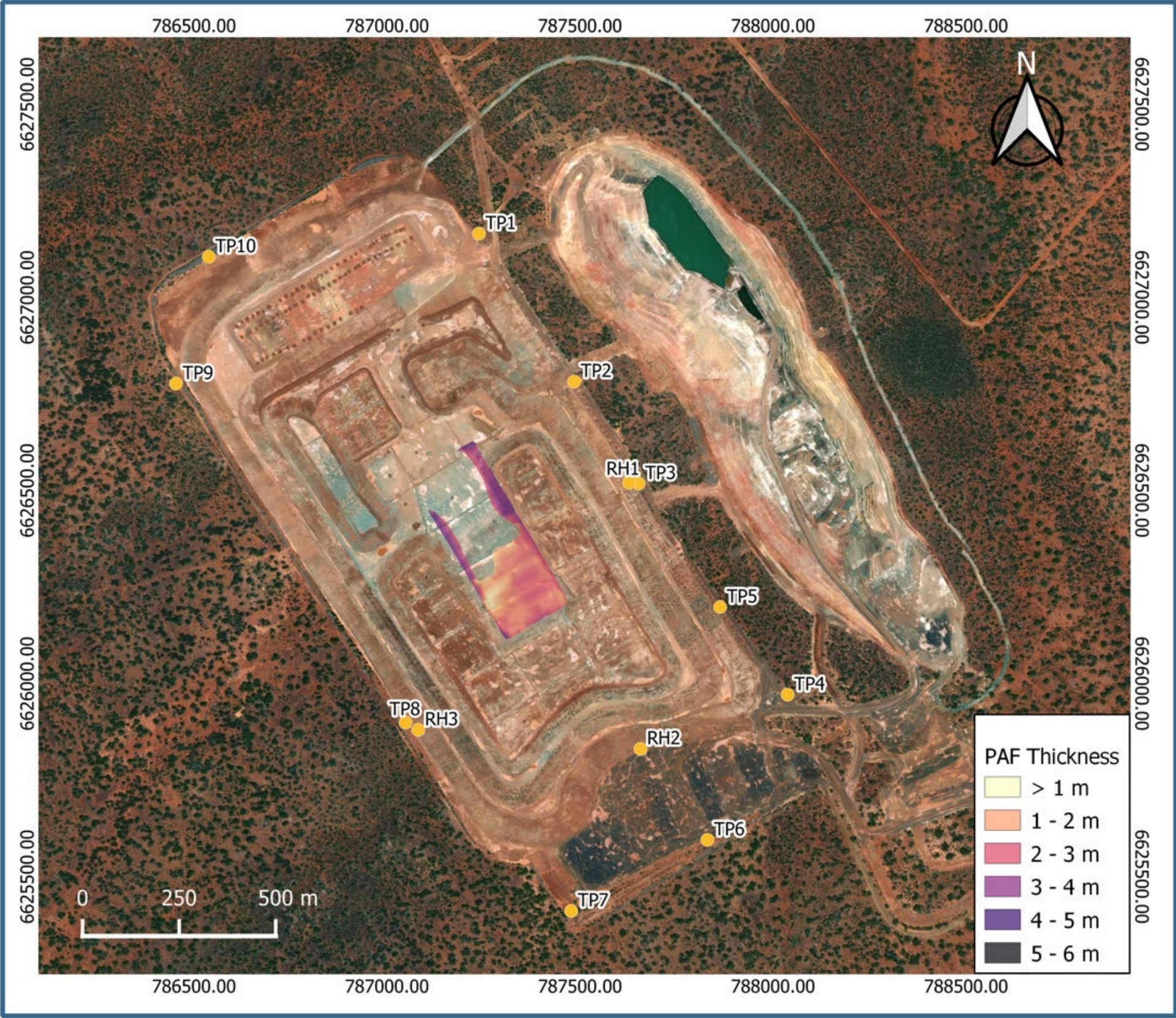
Depth (m)	LOR	Ag		Al		As		B		Ba		Cd		Co		Cr		Cu		Fe		Hg	
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%
151	Goethite	<0.1	BDL	0.1	0.0	<0.1	BDL	0.3	2.7	<0.1	BDL	<0.05	BDL	2	13.7	<0.1	BDL	8.1	7.4	<0.1	BDL	<0.0010	BDL
33	Basalt	<0.1	BDL	<0.1	BDL	<0.1	BDL	0.1	1.7	<0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.0010	BDL
89	Chert	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	2.2	0.1	<0.0010	BDL
143	Basalt	<0.1	BDL	<0.1	BDL	<0.1	BDL	0.1	1.4	0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.0010	BDL
165	Black Shale	<0.1	BDL	0.4	0.1	<0.1	BDL	<0.1	BDL	<0.1	BDL	0.09	15.0	1.5	14.2	<0.1	BDL	1.4	3.6	<0.1	BDL	<0.0010	BDL
17	Clay	<0.1	BDL	<0.1	BDL	<0.1	BDL	0.1	1.1	<0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.0010	BDL
113	Black Shale	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.0010	BDL
213	Black Shale	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.05	BDL	1.3	7.3	<0.1	BDL	3.7	6.8	<0.1	BDL	<0.0010	BDL
131	Chert	<0.1	BDL	<0.1	BDL	<0.1	BDL	0.3	6.0	<0.1	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.0010	BDL
235	Goethite	<0.1	BDL	1.2	0.3	<0.1	BDL	<0.1	BDL	<0.1	BDL	<0.05	BDL	0.6	10.3	<0.1	BDL	<0.1	BDL	0.2	0.0	<0.0010	BDL

Depth (m)	LOR	Mn		Mo		Ni		Pb		Sb		Se		Sn		Sr		Th		U		Zn	
		mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%	mg/L	%
151	Goethite	0.4	1.0	<0.01	BDL	1.1	5.0	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	0.001	2.0	0.2	1.8
33	Basalt	<0.1	BDL	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.1	BDL
89	Chert	0.3	5.6	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.1	BDL
143	Basalt	0.2	0.2	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	0.2	0.8
165	Black Shale	0.8	27.6	<0.01	BDL	1.7	10.6	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	0.002	1.4	0.002	5.0	<0.1	BDL
17	Clay	0.3	0.5	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.1	BDL
113	Black Shale	0.2	3.9	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.1	BDL
213	Black Shale	1.8	4.9	<0.01	BDL	1.4	3.9	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	0.002	6.7	0.6	3.4
131	Chert	0.2	0.1	<0.01	BDL	<0.1	BDL	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	<0.001	BDL	<0.1	BDL
235	Goethite	0.4	14.3	<0.01	BDL	1	5.5	<0.01	BDL	<0.01	BDL	<0.05	BDL	<0.1	BDL	<0.1	BDL	<0.001	BDL	0.004	BDL	0.1	3.1

Source: SWC (2014a)

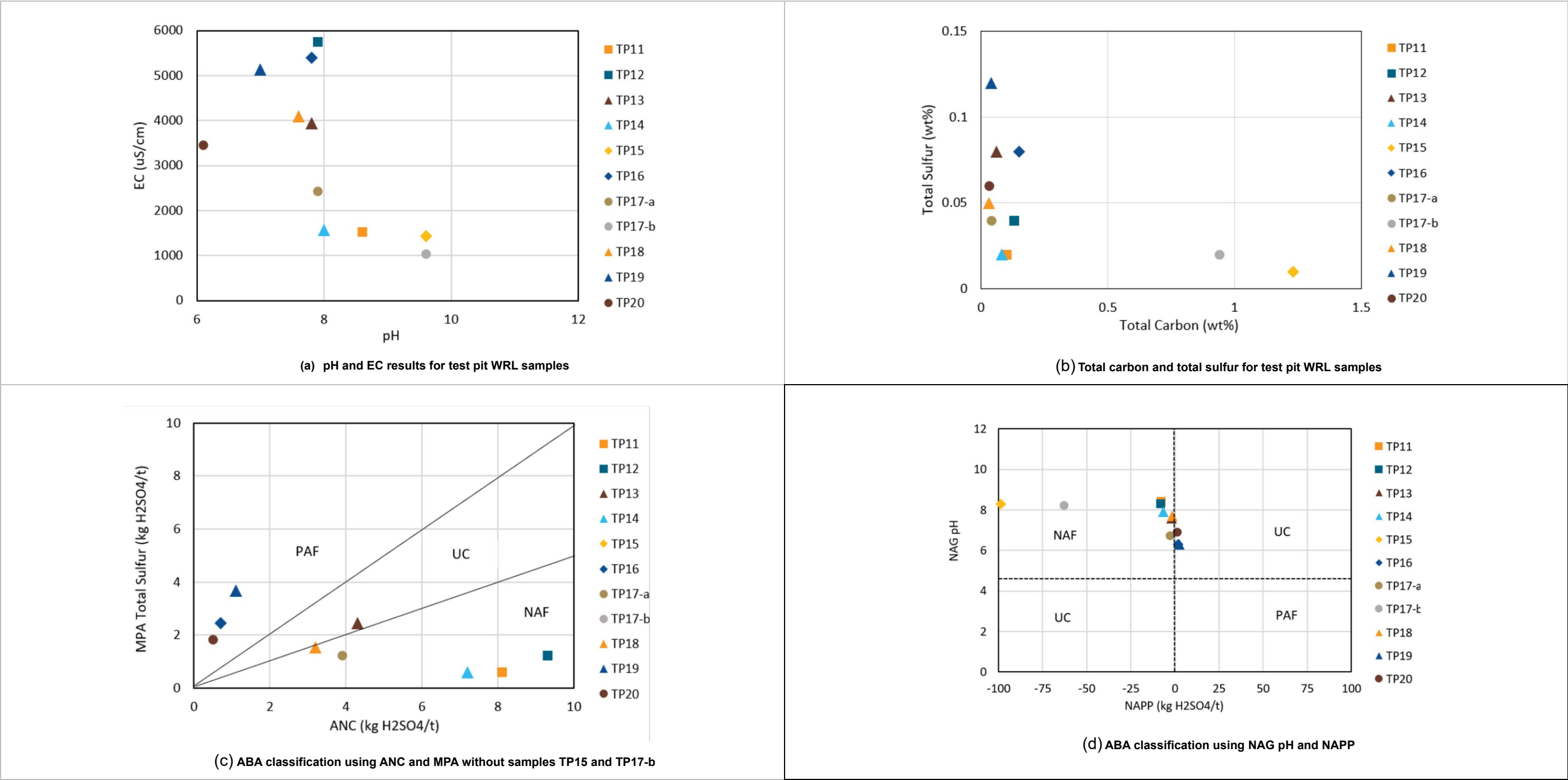
D-4 Carina Operations WRL Cover Materials AMD Assessment

D-5-1 Carina WRL



Source: Okane Consultants (2023a)

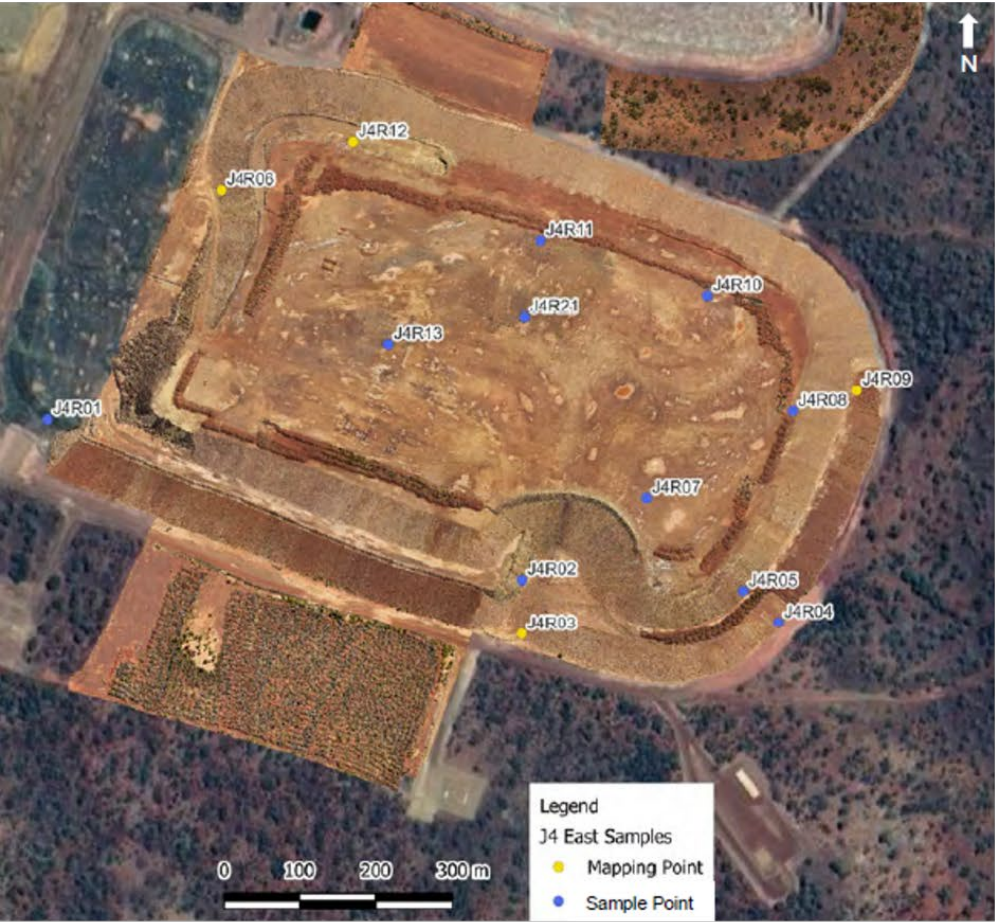
Figure D.5: Carina WRL Cover Materials Test Pit Locations (sample depth 0.5 m) Model



Source: Okane Consultants (2023a)

Figure D.6: Results Carina WRL Cover Materials Geochemical Classification

D-5-2 Carina Extended, J4 East and J4 West WRL Cover Material Characterisation



J4 East WRL



J4 West WRL



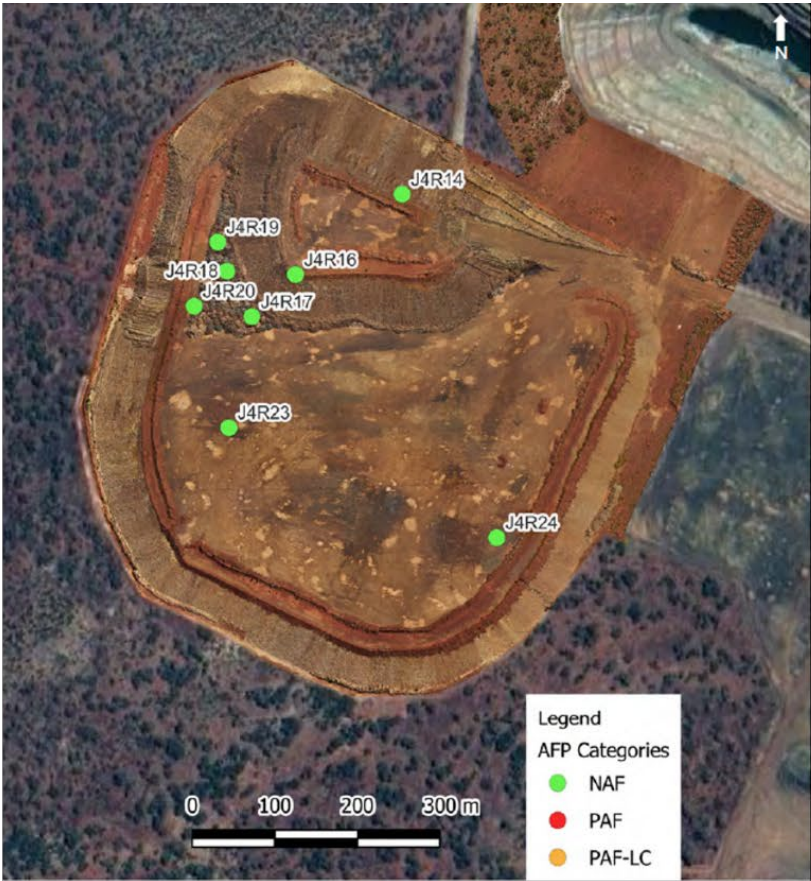
Carina Extended WRL

Source: Mine Earth (2022)

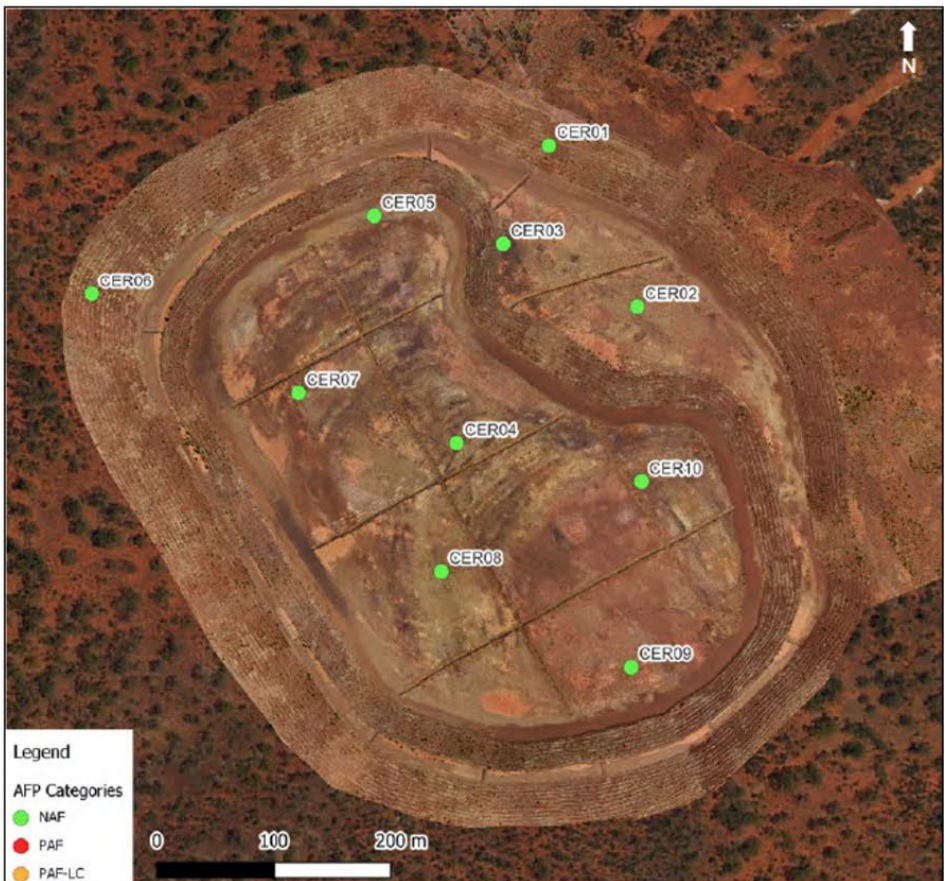
Figure D.7: WRL Waste Rock Surface Cover Characterisation – Sample Locations



J4 East WRL



J4 West WRL



Carina Extended WRL

Source: Mine Earth (2022)

Figure D.8: Geochemical Characterisation Results for Surface Samples Collected from the J4 East, J4 West and Carina Extended WRLs

Table D.14: Geochemical Characterisation Results (Acid Formation Potential) for Surface Samples Collected from the J4 East, J4 West and Carina Extended WRLs

SampleID	Oxidation	Lithology	pH (1:2)	EC (1:2) [mS/cm]	Total-S (%)	Total-C (%)	CO3-C 80% of C	C-ANC kg H2SO4/tonne	ANC ITK	NAG-pH 4.5 kg H2SO4/tonne	NAG-pH 7.0 kg H2SO4/tonne	NAG-pH	MPA	ANC / MPA	NAPP	ANC / MPA	NAPP	AFP Category
			ITK	ITK	ITK	ITK	estimate	estimate	ITK	ITK	ITK	ITK	calc	estimate	estimate	calc	calc	
J4 East																		
J4R01	Tr-Ox	BIF, mineralisation, minor laterite, or oxidised saprock	8.9	0.05	0.02	1.25	1	82	100	<1	<1	9.2	-	-	-	-	-	NAF
J4R02	Ox	BIF, chert, limonite, dolerite (ox), saprolite	7.3	0.67	0.02	0.07	0.056	5	8	<1	<1	8.2	-	-	-	-	-	NAF
J4R04	Ox	Mineralisation, BIF, saprock	5.6	<0.01	0.15	0.09	0.072	6	3	<1	<1	7.1	4.6	1.3	-1.3	0.7	1.6	NAF
J4R05	Ox	Mineralisation, BIF, chert, saprolite	7.6	1.40	0.04	0.53	0.424	35	41	<1	<1	10.1	-	-	-	-	-	NAF
J4R07	Tr-Ox	BIF, mineralisation, saprock, clay	7.3	<0.01	0.16	0.5	0.4	33	38	<1	<1	9.1	4.9	6.7	-27.8	7.8	-33.1	NAF
J4R08	Ox	Saprock, BIF, laterite, Mineralisation (hem), minor dolerite	6.8	1.52	0.1	0.25	0.2	16	19	<1	<1	8.6	3.1	5.3	-13.3	6.2	-15.9	NAF
J4R10	Tr-Ox	BIF, mineralisation, laterite, clay	7.5	<0.01	0.09	0.99	0.792	65	85	<1	<1	8.9	-	-	-	-	-	NAF
J4R11	Tr	BIF, chert, saprock	7.5	1.47	0.05	0.29	0.232	19	26	<1	<1	9.3	-	-	-	-	-	NAF
J4R13	Tr	BIF, dolerite	7.2	0.68	0.05	0.02	0.016	1	19	<1	<1	7.9	-	-	-	-	-	NAF
J4R21	Fr-Ox	BIF, chert, mineralisation (hematite), saprolite	7.3	1.11	0.04	0.11	0.088	7	4	<1	<1	7.1	-	-	-	-	-	NAF
J4 West																		
J4R14	Tr-Ox	BIF, chert, saprolite, saprock	8.3	0.15	0.02	0.23	0.184	15	25	<1	<1	9.5	-	-	-	-	-	NAF
J4R16	Tr-Ox	BIF, chert, saprock, dolerite	7.4	0.69	0.02	0.12	0.096	8	23	<1	<1	8.6	-	-	-	-	-	NAF
J4R17	Tr	Mineralisation, BIF, minor dolerite	7.8	0.07	<0.01	0.14	0.112	9	13	<1	<1	8.6	-	-	-	-	-	NAF
J4R18	Ox	Mineralisation, chert, BIF	7.3	0.11	<0.01	0.08	0.064	5	4	<1	<1	8	-	-	-	-	-	NAF
J4R19	Ox	Mottled, pallid, saprolite	6.8	<0.01	0.01	0.02	0.016	1	7	<1	<1	7.7	-	-	-	-	-	NAF
J4R20	Tr-Ox	BIF, minor saprock, dolerite	7.4	0.14	0.02	0.07	0.056	5	13	<1	<1	7.8	-	-	-	-	-	NAF
J4R23	Tr-Ox	Mineralisation (hem), BIF, chert	7.0	0.32	<0.01	0.06	0.048	4	18	<1	<1	7.7	-	-	-	-	-	NAF
J4R24	Tr-Ox	BIF, dolerite, saprock, minor chert, mineralisation (hem)	7.3	0.53	0.13	0.08	0.064	5	20	<1	<1	7.4	4.0	1.3	-1.3	5.0	-16.0	NAF
CE																		
CER01	Tr-Ox	Mineralisation (hem), saprolite, mafic schist, saprock, BIF	9.0	0.22	0.03	0.13	0.104	8	13	<1	<1	7.9	-	-	-	-	-	NAF
CER02	Tr-Ox	Mineralisation (hem), saprock, mafic schist, minor dolerite, minor SiltST, BIF	6.8	1.83	0.04	0.05	0.04	3	18	<1	<1	7.9	-	-	-	-	-	NAF
CER03	Tr-Ox	Mineralisation (hem), BIF, minor mafic schist, dolerite	6.7	0.88	0.06	0.06	0.048	4	5	<1	<1	7.3	-	-	-	-	-	NAF
CER04	Tr	Mineralisation (hem), chert, BIF, minor mafic schist, saprock	6.9	1.70	0.06	0.12	0.096	8	13	<1	<1	8.3	-	-	-	-	-	NAF
CER05	Tr-Ox	Mineralisation (hem), BIF, chert, dolerite, mafic schist, minor saprock, saprolite	7.2	<0.01	0.3	0.3	0.24	20	17	<1	<1	6.6	9.2	2.1	-10.4	1.9	-7.8	NAF
CER06	Tr-Ox	BIF, saprock, mafic schist, saprolite	7.7	0.13	0.03	0.07	0.056	5	18	<1	<1	8.9	-	-	-	-	-	NAF
CER07	Tr	BIF, mineralisation (hem), mafic schist, saprock	7.1	1.05	0.07	0.07	0.056	5	15	<1	<1	7.5	-	-	-	-	-	NAF
CER08	Tr	Cherty BIF, chert, mineralisation (hem), mafic schist, minor saprock	7.6	0.49	0.03	0.1	0.08	7	14	<1	<1	8.5	-	-	-	-	-	NAF
CER09	Ox	Pisolith, mineralisation (hem), BIF, minor mafic schist	7.8	1.10	0.07	0.2	0.16	13	16	<1	<1	8.4	-	-	-	-	-	NAF
CER10	Tr	Chert, mineralisation (hem), BIF	7.2	<0.01	0.07	0.09	0.072	6	7	<1	<1	8.2	-	-	-	-	-	NAF

Note: CE = Carina Extended
Source: Mine Earth (2022)

Table D.15: Geochemical Characterisation Results (Multi-Element) for Surface Samples Collected from the J4 East, J4 West and Carina Extended WRLs

SampleID	Lith Code	Lithology	S (%)	Ca (%)	Mg (%)	K (%)	Na (%)	Fe (%)	Al (%)	Ti (%)	As (ppm)	Sb (ppm)	Mo (ppm)
Average Crustal Abundance Analytical Laboratory			ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	1.5 ITK	0.2 ITK	1.5 ITK
J4 East													
J4R01	Tr-Ox	BIF, mineralisation, minor laterite, or oxidised saprock	0.02	2.22	1.15	0.01	0.01	51.87	0.88	0.02	90	12	<2
J4R02	Ox	BIF, chert, limonite, dolerite (ox), saprolite	0.02	0.05	0.67	0.23	0.29	28.37	3.46	0.11	45	<5	<2
J4R04	Ox	Mineralisation, BIF, saprock	0.16	0.05	0.11	0.12	0.21	42.89	4.31	0.20	54	13	<2
J4R05	Ox	Mineralisation, BIF, chert, saprolite	0.04	0.96	0.48	0.04	0.11	39.56	3.42	0.21	123	24	3
J4R07	Tr-Ox	BIF, mineralisation, saprock, clay	0.17	0.98	0.73	0.05	0.53	29.28	4.68	0.14	386	44	8
J4R08	Ox	Saprock, BIF, laterite, Mineralisation (hem), minor dolerite	0.10	0.39	0.50	0.18	0.18	33.89	5.19	0.15	106	13	<2
J4R10	Tr-Ox	BIF, mineralisation, laterite, clay	0.09	2.01	1.38	0.14	0.91	21.6	4.71	0.24	107	24	3
J4R11	Tr	BIF, chert, saprock	0.05	0.55	0.72	0.27	0.20	14.05	2.65	0.11	59	11	<2
J4R13	Tr	BIF, dolerite	0.05	0.06	2.00	0.36	0.21	15.96	6.11	0.17	11	<5	<2
J4R21	Fr-Ox	BIF, chert, mineralisation (hematite), saprolite	0.04	0.06	0.13	0.14	0.09	22.78	1.42	0.08	77	14	<2
J4 West													
J4R14	Tr-Ox	BIF, chert, saprolite, saprock	0.02	0.40	1.08	0.42	0.07	16.66	3.92	0.18	56	5	<2
J4R16	Tr-Ox	BIF, chert, saprock, dolerite	0.02	0.16	1.86	0.31	0.11	25.32	4.18	0.14	62	8	<2
J4R17	Tr	Mineralisation, BIF, minor dolerite	0.01	0.09	0.35	0.27	0.05	47.52	1.24	0.02	82	<5	<2
J4R18	Ox	Mineralisation, chert, BIF	<0.01	0.04	0.06	<0.01	0.01	59.67	0.49	0.01	73	9	<2
J4R19	Ox	Mottled, pallid, saprolite	0.02	0.06	0.72	1.62	0.22	10.61	7.07	0.28	17	8	<2
J4R20	Tr-Ox	BIF, minor saprock, dolerite	0.02	0.05	0.51	0.34	0.02	27.5	1.58	0.07	37	<5	<2
J4R23	Tr-Ox	Mineralisation (hem), BIF, chert	0.01	0.05	1.84	0.10	0.05	43.78	3.80	0.15	112	8	<2
J4R24	Tr-Ox	BIF, dolerite, saprock, minor chert, mineralisation (hem)	0.15	0.10	1.19	0.72	0.06	17.51	3.72	0.17	43	<5	<2
CE													
CER01	Tr-Ox	Mineralisation (hem), saprolite, mafic schist, saprock, BIF	0.03	0.16	1.17	0.23	0.09	33.98	4.34	0.25	157	15	3
CER02	Tr-Ox	Mineralisation (hem), saprock, mafic schist, minor dolerite, minor SiltST, BIF	0.05	0.07	3.23	0.46	0.37	20.09	5.23	0.30	110	<5	3
CER03	Tr-Ox	Mineralisation (hem), BIF, minor mafic schist, dolerite	0.06	0.02	0.17	0.03	0.11	57.36	0.95	0.03	350	38	5
CER04	Tr	Mineralisation (hem), chert, BIF, minor mafic schist, saprock	0.06	0.15	1.06	0.09	0.23	39.63	1.73	0.10	361	12	<2
CER05	Tr-Ox	Mineralisation (hem), BIF, chert, dolerite, mafic schist, minor saprock, saprolite	0.30	0.29	1.54	0.36	0.53	33.11	4.72	0.19	207	13	3
CER06	Tr-Ox	BIF, saprock, mafic schist, saprolite	0.03	0.37	3.88	0.18	0.33	18.45	3.56	0.30	67	9	<2
CER07	Tr	BIF, mineralisation (hem), mafic schist, saprock	0.07	0.05	1.70	0.33	0.21	35.45	3.65	0.23	321	9	3
CER08	Tr	Cherty BIF, chert, mineralisation (hem), mafic schist, minor saprock	0.03	0.16	1.39	0.04	0.13	19.21	1.55	0.11	183	9	3
CER09	Ox	Pisolith, mineralisation (hem), BIF, minor mafic schist	0.08	0.39	0.57	0.33	0.21	27.72	7.71	0.35	110	6	<2
CER10	Tr	Chert, mineralisation (hem), BIF	0.07	0.11	0.26	0.16	0.29	29.34	2.47	0.06	316	12	8

Notes: ACA = Average Crustal Abundance
Reimann, C. and Caritat, P., 1998. *Chemical elements in the environment*. 1. Berlin: Springer-Verlag.

	exceedance of the ACA by a factor of ten to one hundred
	exceedance of the ACA by a factor of more than one hundred

Note: CE = Carina Extended
Source: Mine Earth (2022)

Table D.16: Geochemical Characterisation Results (Multi-Element) for Surface Samples Collected from the J4 East, J4 West and Carina Extended WRLs

SampleID	Lith Code	Lithology	Cu (ppm)	Zn (ppm)	Cd (ppm)	Pb (ppm)	Ni (ppm)	Cr (ppm)	Co (ppm)	Mn (ppm)	Ag (ppm)	Bi (ppm)	P (ppm)	Sr (ppm)	Ba (ppm)	Sn (ppm)	V (ppm)	Tl (ppm)
Average Crustal Abundance			50	75	0.1	14	80	100	20	950	0.07	0.05	1,000	370	500	2.2	160	0.6
Analytical Laboratory			ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK	ITK
J4 East																		
J4R01	Tr-Ox	BIF, mineralisation, minor laterite, or oxidised saprock	87	123	<0.5	24	383	267	24	1417	1.3	<5	1363	13	26	<5	50	<5
J4R02	Ox	BIF, chert, limonite, dolerite (ox), saprolite	85	111	<0.5	13	565	1265	201	3816	0.9	<5	345	16	65	<5	131	<5
J4R04	Ox	Mineralisation, BIF, saprock	100	157	<0.5	24	156	677	57	3154	<0.5	<5	1130	7	53	<5	196	<5
J4R05	Ox	Mineralisation, BIF, chert, saprolite	146	122	<0.5	46	140	1005	15	574	1.2	<5	597	26	33	<5	218	<5
J4R07	Tr-Ox	BIF, mineralisation, saprock, clay	1328	618	<0.5	67	121	627	24	323	1.1	<5	898	58	18	<5	465	<5
J4R08	Ox	Saprock, BIF, laterite, Mineralisation (hem), minor dolerite	186	132	<0.5	37	244	1111	21	476	0.9	<5	442	11	74	<5	169	<5
J4R10	Tr-Ox	BIF, mineralisation, laterite, clay	251	182	<0.5	55	130	318	30	768	0.7	<5	492	44	38	<5	175	<5
J4R11	Tr	BIF, chert, saprock	153	131	<0.5	18	296	417	24	708	0.6	<5	298	17	49	<5	82	<5
J4R13	Tr	BIF, dolerite	39	100	<0.5	<5	752	1502	97	2410	<0.5	<5	394	13	38	<5	198	<5
J4R21	Fr-Ox	BIF, chert, mineralisation (hematite), saprolite	210	127	<0.5	42	263	122	14	490	0.9	<5	670	12	40	<5	41	<5
J4 West																		
J4R14	Tr-Ox	BIF, chert, saprolite, saprock	56	169	<0.5	13	269	53	19	844	<0.5	<5	366	10	63	<5	29	<5
J4R16	Tr-Ox	BIF, chert, saprock, dolerite	41	134	<0.5	15	371	562	47	5871	<0.5	<5	562	11	75	<5	83	<5
J4R17	Tr	Mineralisation, BIF, minor dolerite	36	129	1.1	26	206	289	114	69015	1.3	<5	1170	45	439	<5	40	<5
J4R18	Ox	Mineralisation, chert, BIF	27	185	<0.5	20	364	67	17	918	1.6	<5	3037	<1	13	<5	34	<5
J4R19	Ox	Mottled, pallid, saprolite	102	190	<0.5	17	220	32	10	423	<0.5	<5	492	15	174	<5	29	<5
J4R20	Tr-Ox	BIF, minor saprock, dolerite	27	123	<0.5	13	214	27	17	4988	<0.5	<5	962	9	56	<5	18	<5
J4R23	Tr-Ox	Mineralisation (hem), BIF, chert	79	174	<0.5	26	426	111	19	795	1.1	<5	1006	6	20	<5	38	<5
J4R24	Tr-Ox	BIF, dolerite, saprock, minor chert, mineralisation (hem)	87	121	<0.5	14	155	108	15	1498	<0.5	<5	298	12	111	<5	38	<5
CE																		
CER01	Tr-Ox	Mineralisation (hem), saprolite, mafic schist, saprock, BIF	117	52	<0.5	26	337	1075	36	517	0.7	<5	226	12	51	<5	314	<5
CER02	Tr-Ox	Mineralisation (hem), saprock, mafic schist, minor dolerite, minor SiltST, BIF	101	83	<0.5	23	640	1175	74	834	<0.5	<5	169	6	65	<5	236	<5
CER03	Tr-Ox	Mineralisation (hem), BIF, minor mafic schist, dolerite	70	23	<0.5	53	193	167	26	752	1.2	<5	573	<1	8	<5	89	<5
CER04	Tr	Mineralisation (hem), chert, BIF, minor mafic schist, saprock	77	34	<0.5	21	288	535	29	375	1.1	<5	349	1	14	<5	107	<5
CER05	Tr-Ox	Mineralisation (hem), BIF, chert, dolerite, mafic schist, minor saprock, saprolite	111	47	<0.5	31	295	720	39	540	0.7	<5	225	16	58	<5	291	<5
CER06	Tr-Ox	BIF, saprock, mafic schist, saprolite	67	76	<0.5	12	724	1728	60	615	<0.5	<5	160	15	36	<5	201	<5
CER07	Tr	BIF, mineralisation (hem), mafic schist, saprock	111	62	<0.5	24	383	703	48	887	0.8	<5	344	3	43	<5	218	<5
CER08	Tr	Cherty BIF, chert, mineralisation (hem), mafic schist, minor saprock	71	25	<0.5	16	334	638	29	317	<0.5	<5	146	2	9	<5	97	<5
CER09	Ox	Pisolith, mineralisation (hem), BIF, minor mafic schist	133	41	<0.5	15	258	1925	32	255	0.5	<5	176	29	70	<5	418	<5
CER10	Tr	Chert, mineralisation (hem), BIF	92	26	<0.5	23	104	195	12	236	0.6	<5	184	5	19	<5	113	<5

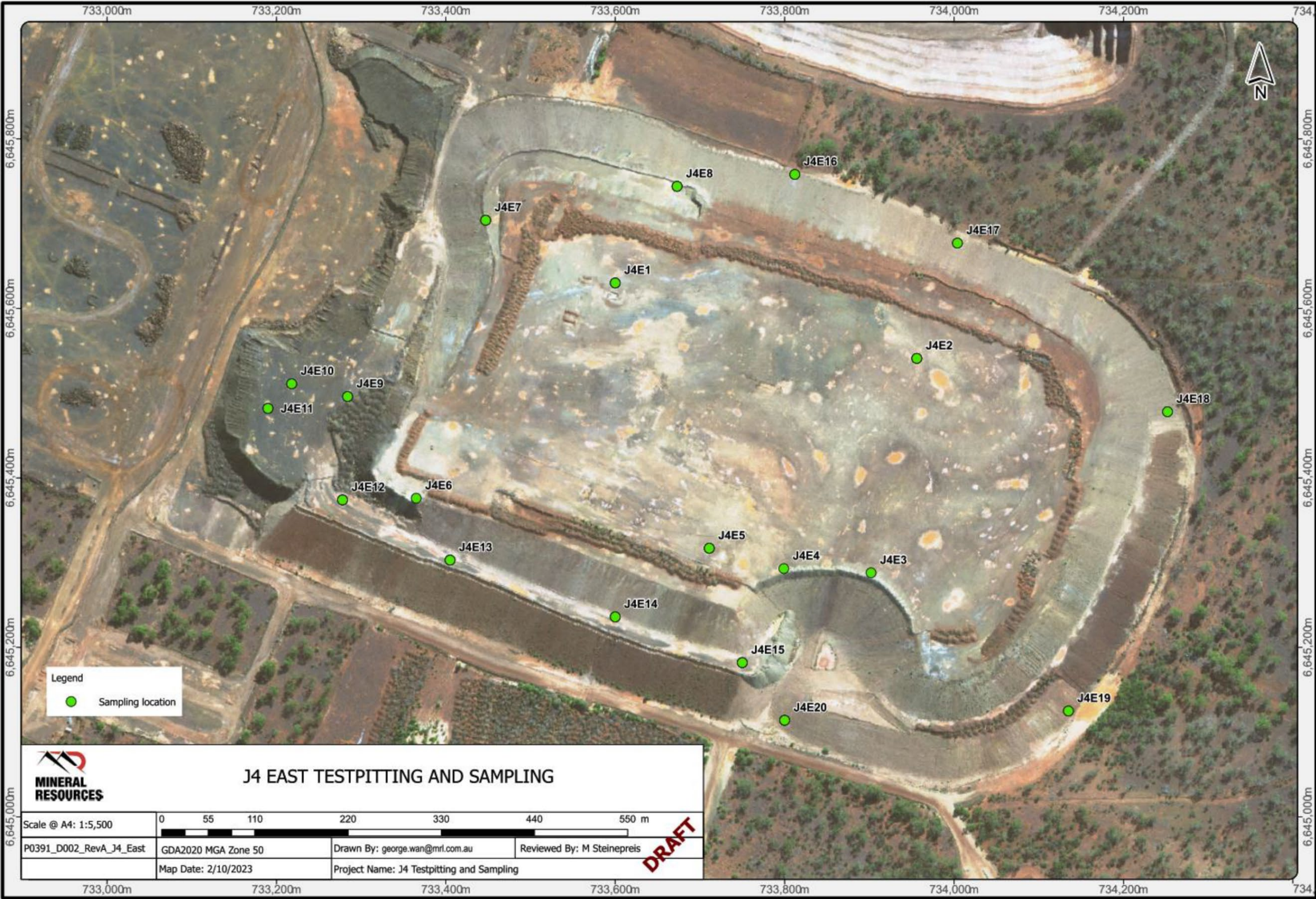
Notes: ACA = Average Crustal Abundance
Reimann, C. and Caritat, P., 1998. *Chemical elements in the environment*. 1. Berlin: Springer-Verlag.

 exceedance of the ACA by a factor of ten to one hundred

 exceedance of the ACA by a factor of more than one hundred

Note: CE = Carina Extended
Source: Mine Earth (2022)

D-5-3 J4 East & J4 West WRL Test-Pitting Results



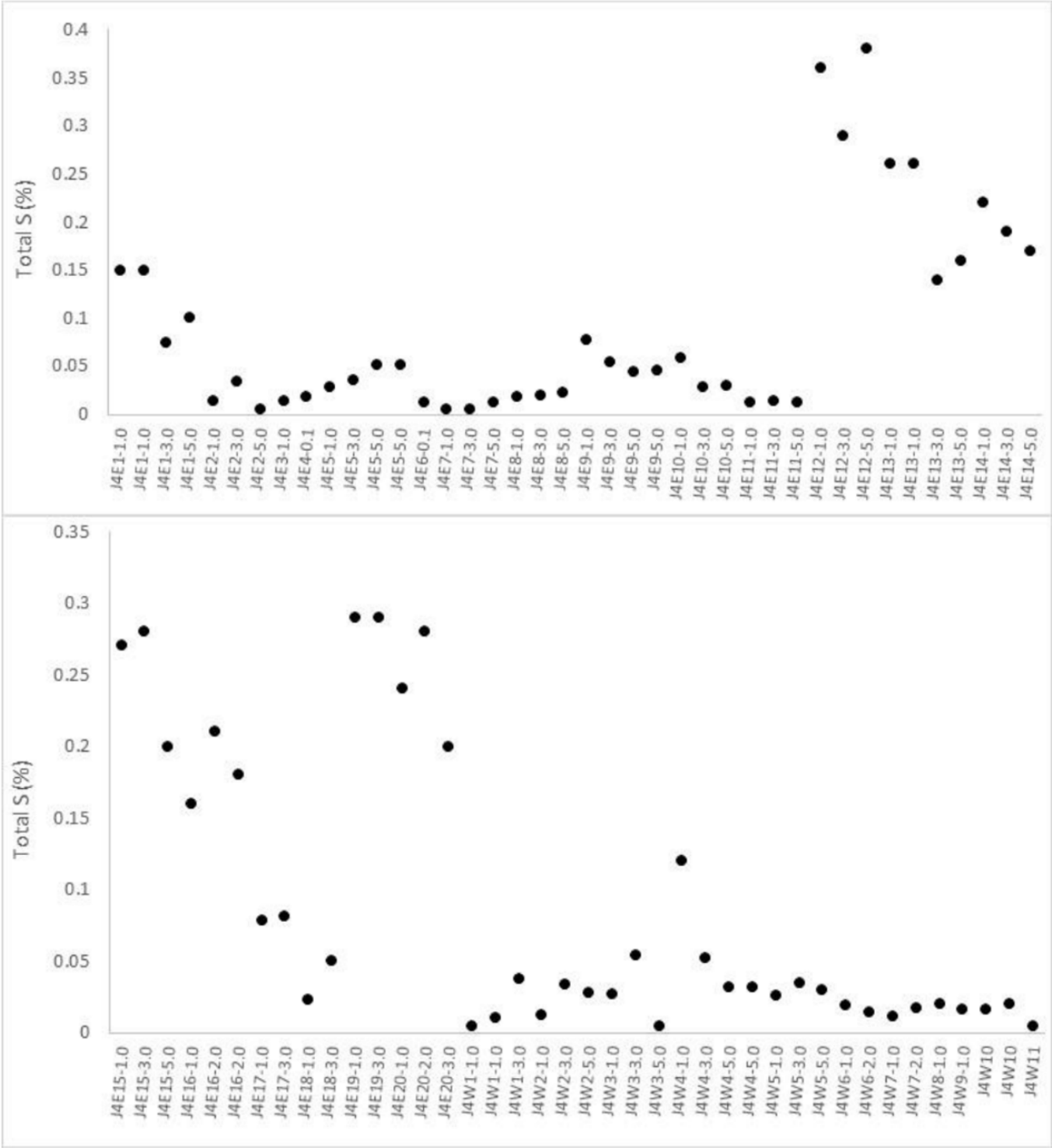
Source: MinRes (2024)

Figure D.9: J4 East Test Pit Locations

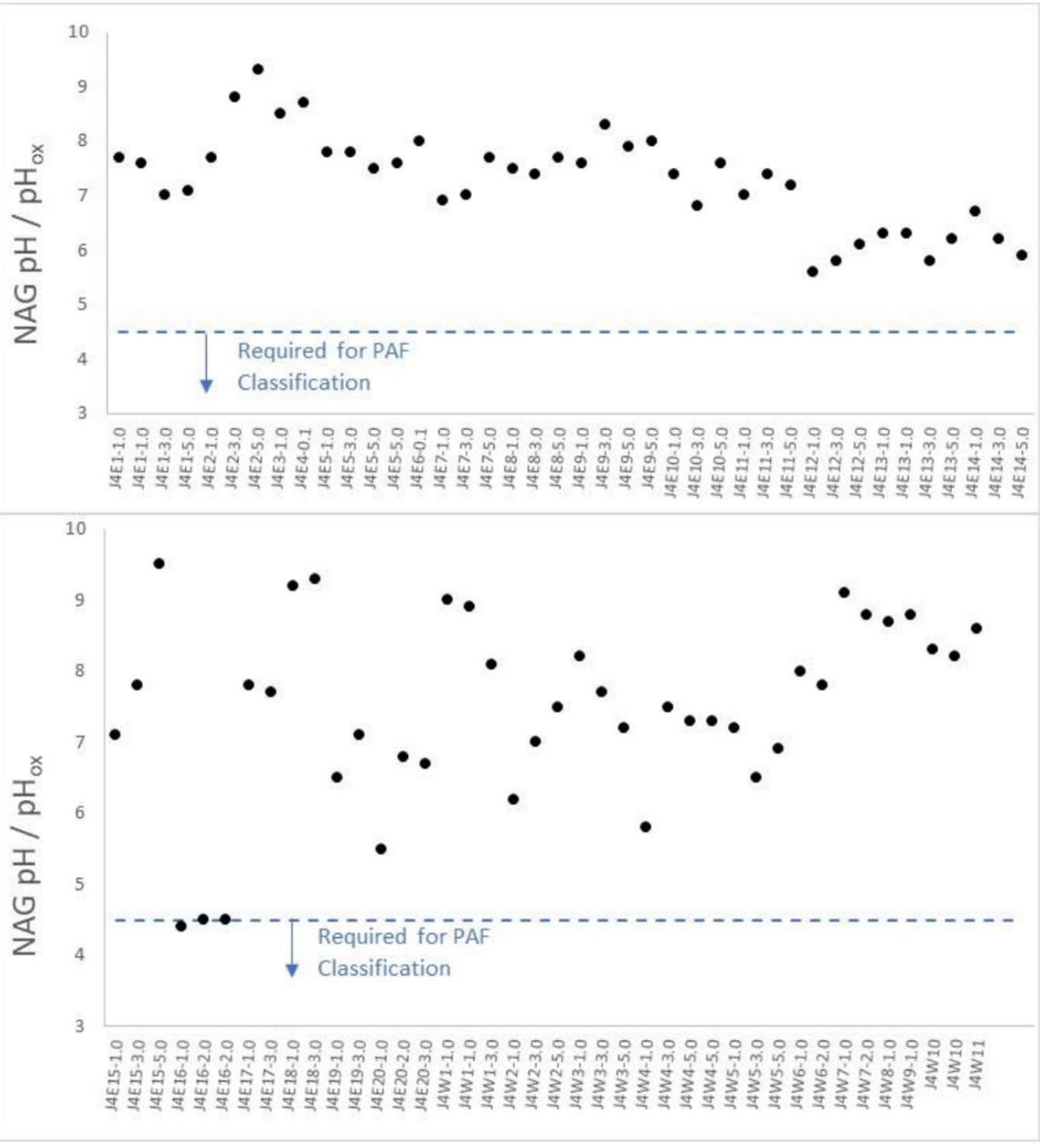


Source: MinRes (2024)

Figure D.10: J4 West Test Pit Locations



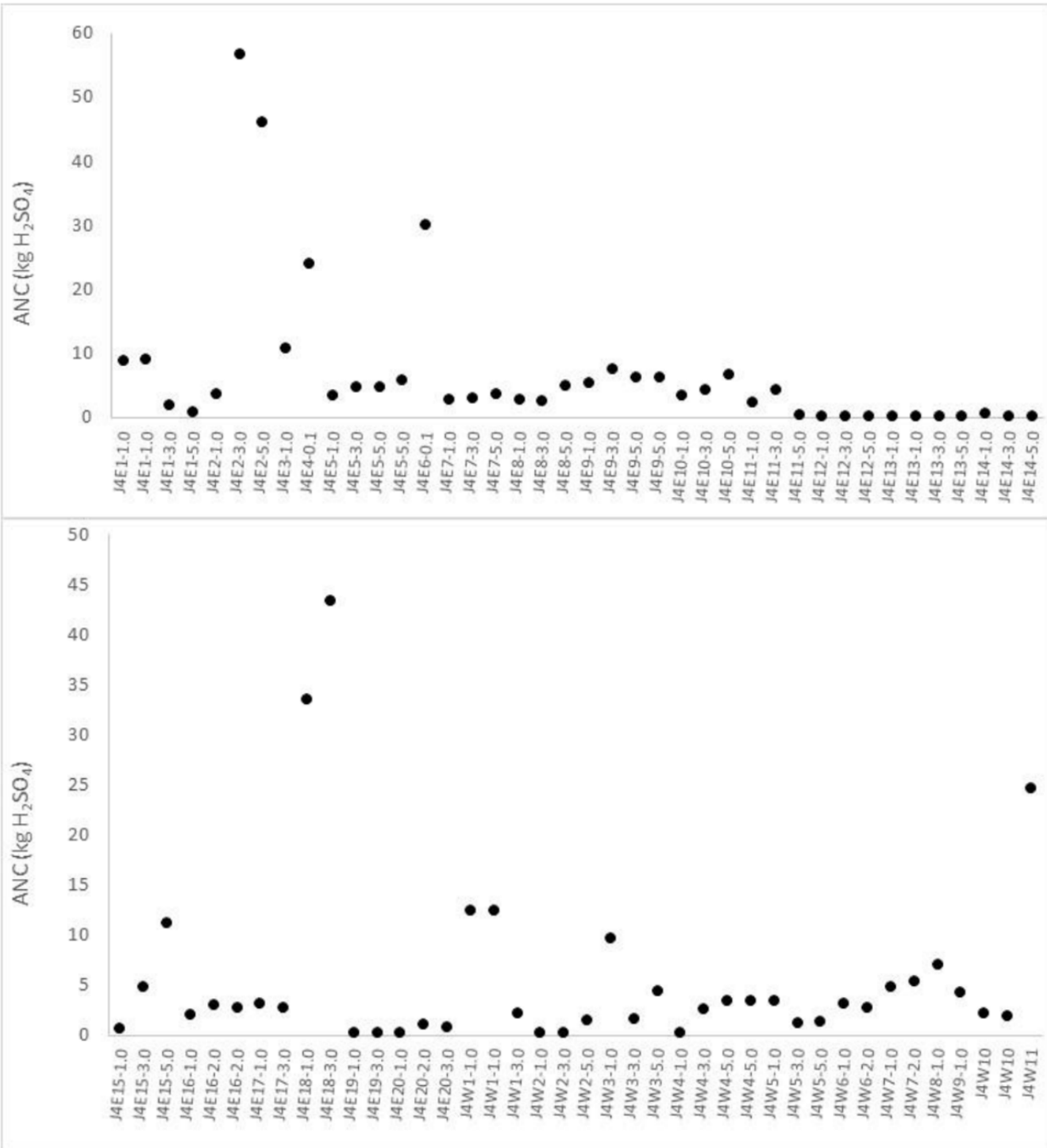
(a) Total sulfur content results. Two results for the sample location indicates a replicate test.



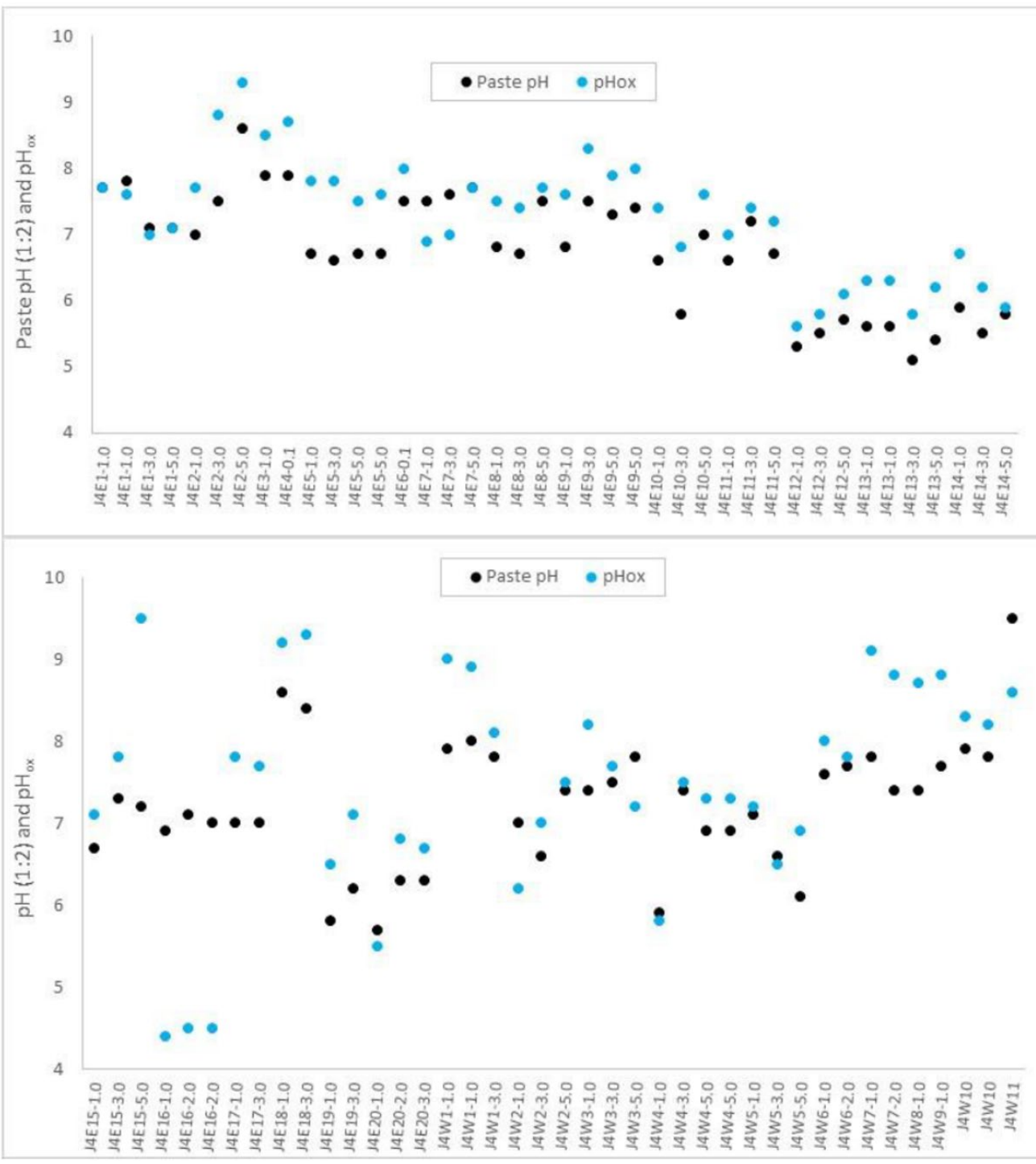
(b) NAG_{pH} Results. Two results for the sample location indicates a replicate test.

Source: MinRes (2024)

Figure D.11: J4 East & West WRLs Test Pit Sample Analysis Results (Total S and NAG_{pH})



(a) Acid neutralisation capacity results. Two results for the sample location indicates replicate test.

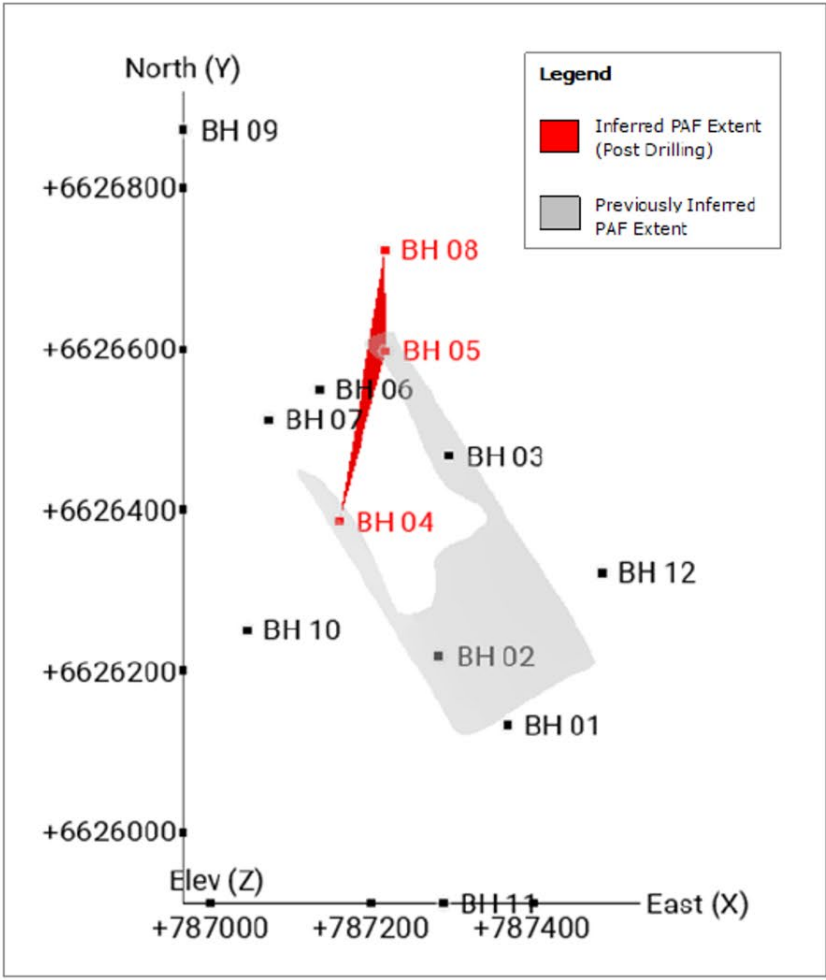


(b) Paste pH and pH_{ox}. Two results for the sample location indicates a replicate test.

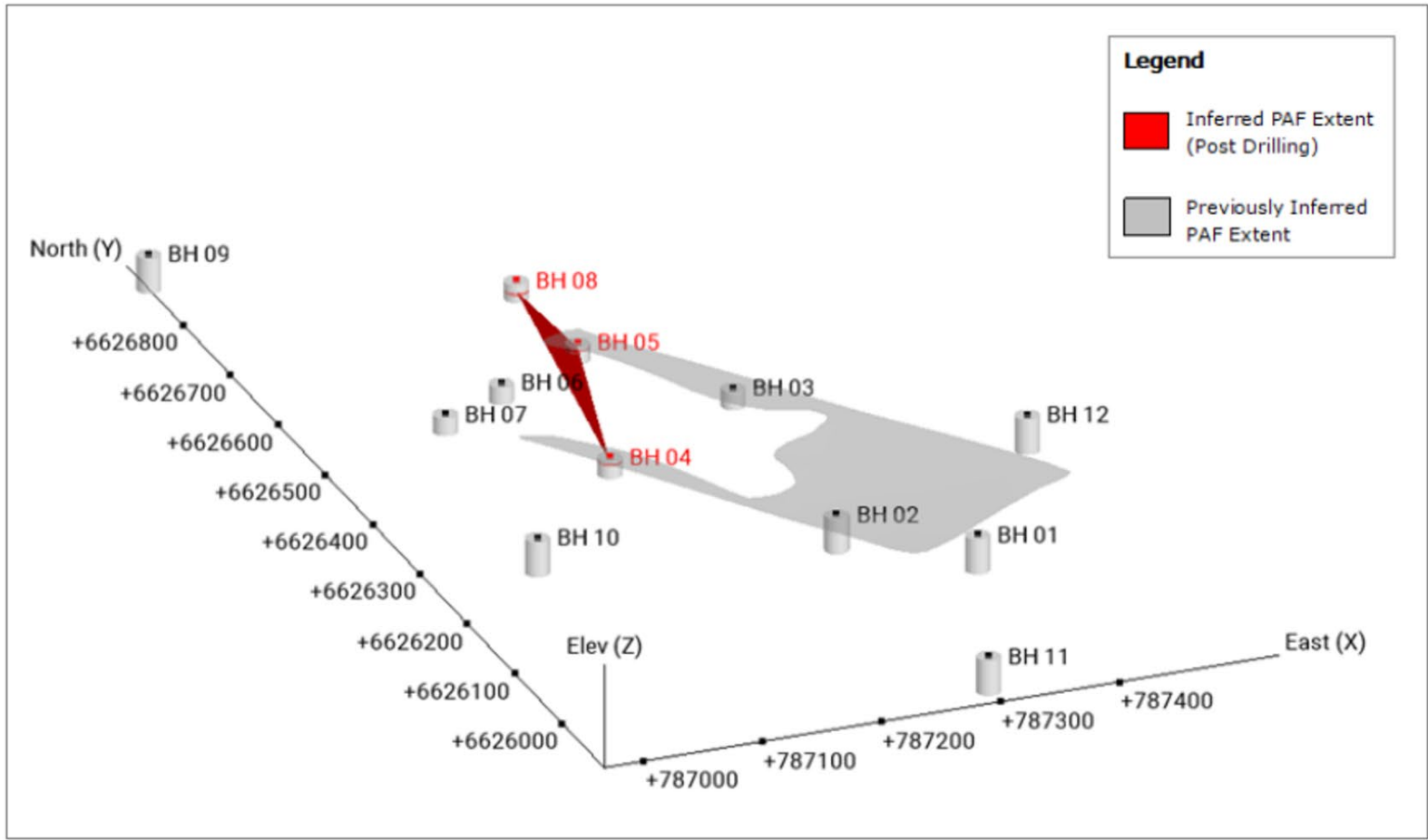
Source: MinRes (2024)

Figure D.12: J4 East & West WRLs Test Pit Sample Analysis Results (ANC & Paste pH vs pH)

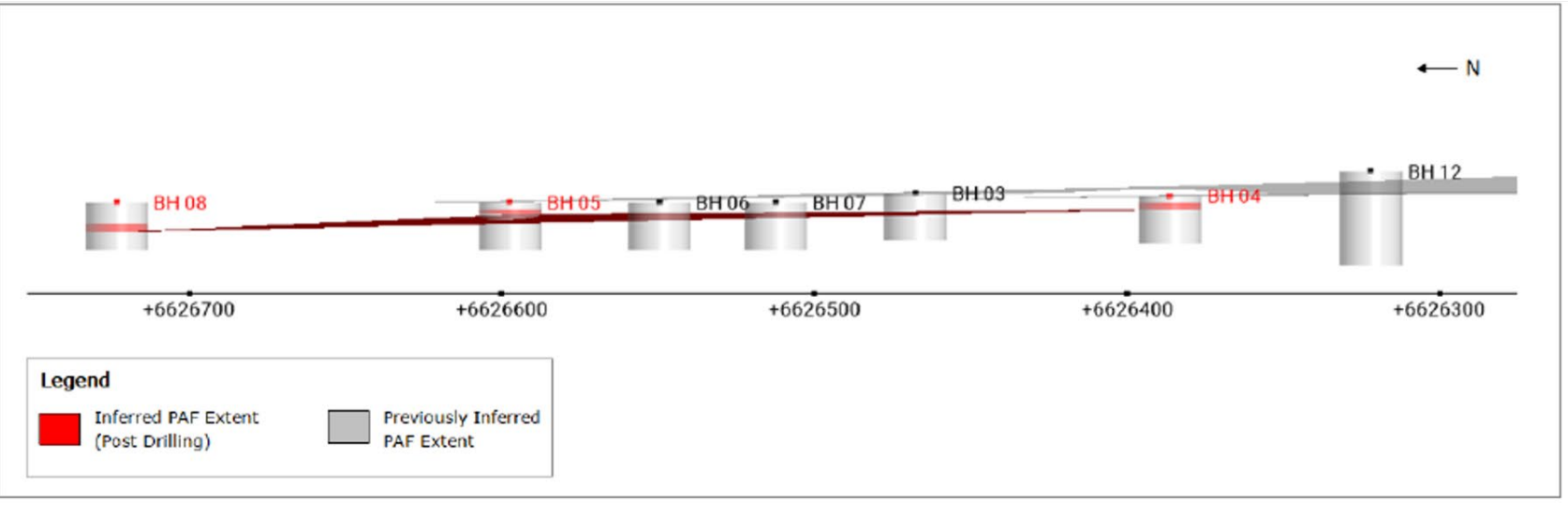
D-6 Carina WRL As-Built Assessment of the PAF Encapsulation Cell



PAF Extent Plan View



PAF Extent Offset from North
Viewing angle: Plunge = + 25 Azimuth = 022.



PAF Extent Looking East
Note new inferred PAF material is shallow and situated further North.

Source: Okane Consultants (2023b)

Figure D.13: Inferred Extent of PAF Encapsulation Cell Carina WRL



APPENDIX E

GEOTECHNICAL INFORMATION

E-1 Carina Deposit

Table E.1: Test Pit Samples PSD Summary

Sample ID	RL (m)	Cobble and Gravel % (>4.75 mm)	Sand % (4.75 – 0.075 mm)	Clay and Silt % (<0.075 mm)
TP11	494	57	11	32
TP12	496	54	18	28
TP13	496	35	18	47
TP14	493	41	19	40
TP15	486	65	27	8
TP16	485	51	37	12
TP17-a	494	33	21	46
TP17-b	493	64	30	6
TP18	486	38	30	32
TP19	488	50	17	33
TP20	477	28	27	45

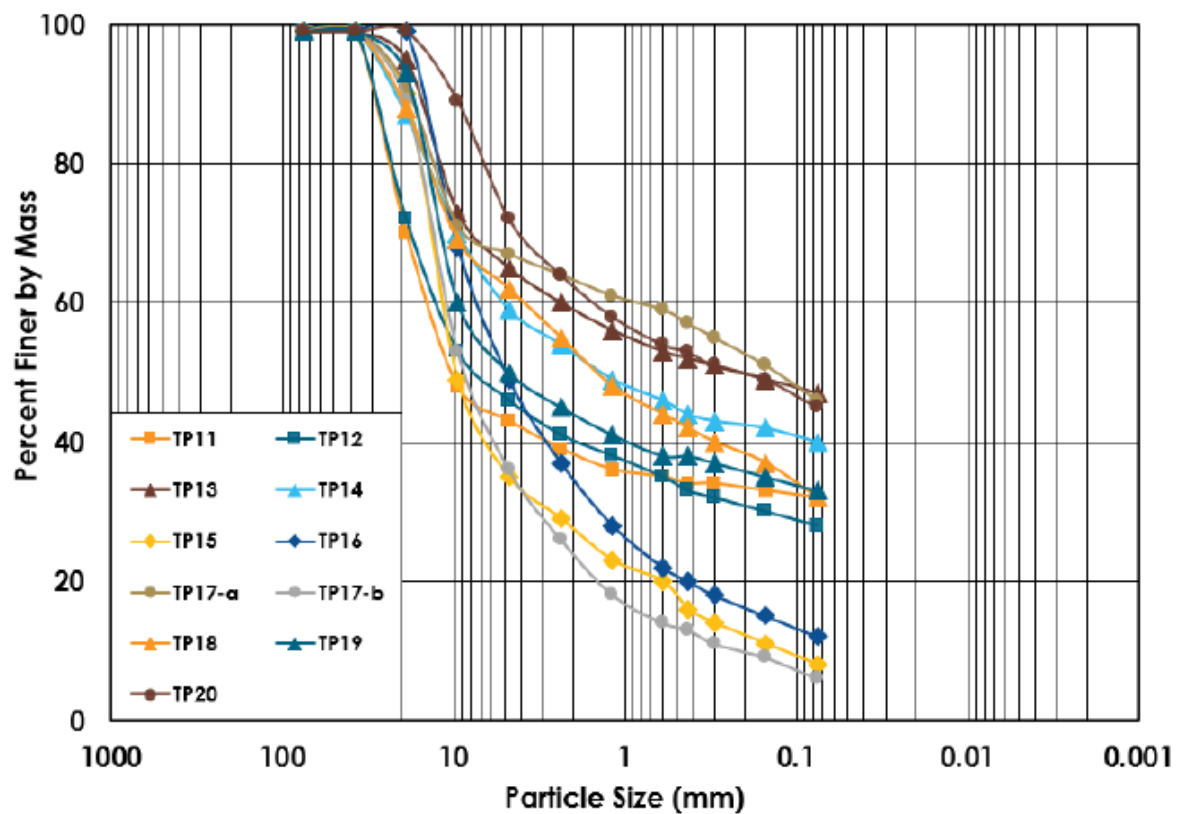


Table E.2: Test Pit Samples Emerson Aggregate Test Summary

Sample ID	RL (m)	Emerson Classification	Colour (Munsell)	Texture
TP11	494	2	Yellowish Red	Clay Loam Sandy
TP12	496	4	Reddish Brown	Clay Loam Sandy
TP13	496	2	Reddish Brown	Clay Loam Sandy
TP14	493	2	Strong Brown	Sandy Clay Loam
TP15	486	2	Reddish Brown	Sandy Clay Loam
TP16	485	2	Red	Clay Loam Sandy
TP17-a	494	2	Brown	Sandy Loam
TP17-b	493	2	Olive Gray	Clay Loam Sandy
TP18	486	2	Red	Clay Loam Sandy
TP19	488	2	Red	Sandy Clay Loam
TP20	477	4	Reddish Brown	Clay Loam Sandy

Colour based on Munsell Soil Colour System (Munsell, 2010).

Source: Okane (Okane Consultants, 2023a)



APPENDIX F

SOILS INFORMATION

F-1 Soils - Carina Extended

Table F.1: Topsoil Analysis Data – Carina Extended

No.	H	Cond.	Salinity	Emerson	>2mm	<2mm– 75um	<75um	Na	K	Ca	Mg	CEC
		uS/cm	mg/kg		Gravel	Sand	Silt & Clay	Meq %				
1	8.4	140	450	3	34	38	29	0.25	1.5	22	4.1	28
2	8.4	89	300	3	41	32	27	0.14	1.1	9.5	4.1	15
3	7.3	60	200	3	40	29	30	0.26	1.2	8	3	12
4	8.4	130	420	3	51	30	18	0.1	0.95	22	2.5	26
5	5.7	36	120	3	17	51	33	0.07	0.46	2.5	0.67	3.8
6	6.1	25	81	3	24	46	31	0.07	0.51	3	1.2	4.9

Source: (Polaris Metals, 2013a)

Table F.2: Summary of soil characteristics for Carina Extended

Carina Extended Soils	Sample ref	Particle size distribution (%)				EC (dS/m)	pH (H ₂ O)	Plant-available nutrients (mg/kg)					Org. C (%)	Exchangeable cations (meq/100g)				eCEC (meq/100g)	ESP (%)	Emerson Class	Ksat (mm/hr)	Total metals (mg/kg)						
		Coarse	Sand	Silt	%Clay			NH ₄ ⁺	NO ₃ ⁻	P	K	S		Ca	K	Mg	Na					As	Cd	Cr	Co	Pb	Mo	Se
Stockpiled soils	CES02	20	-	-	-	0.243	7.9	< 1	26	6	328	18.0	1.00	10.43	0.64	3.12	0.18	14.37	1	5	93.9	-	-	-	-	-	-	-
Rehab. soils	CES01	25	58.9	11.8	29.3	0.497	7.8	3	26	6	209	82.2	0.57	12.21	0.42	2.72	0.69	16.04	4	3b	65.3	22.4	0.03	1036.9	12.8	19.9	1.0	0.8
	CES03	30	63.7	10.1	26.2	0.749	8.8	22	21	3	143	432.6	0.95	4.84	0.22	0.99	0.18	6.23	3	5	52.2	23.3	0.02	888.0	7.8	21.3	1.2	1.0
	CES04	35	-	-	-	6.306	6.7	10	112	7	216	394.7	1.00	12.19	0.3	3.42	0.6	16.51	4	-	-	-	-	-	-	-	-	-
	CES05	40	64.8	11.8	23.5	0.230	7.7	6	7	6	178	15.4	1.05	7.93	0.34	1.86	0.28	10.41	3	3b	55.5	61.6	0.02	631.8	9.0	17.4	1.6	0.9
	CES06	10	-	-	-	0.719	8.5	1	40	7	223	99.1	0.80	14.32	0.44	2.89	0.68	18.33	4	-	-	-	-	-	-	-	-	-
	CES07	15	62.9	17.6	19.5	0.227	8.5	< 1	24	6	220	17.0	0.87	12.65	0.44	2.3	0.21	15.60	1	5	129.2	13.1	0.03	690.8	10.0	27.0	1.2	0.5
	CES08	40	-	-	-	1.257	8.6	6	33	6	206	281.7	0.85	10.45	0.34	2.09	0.33	13.21	2	-	-	-	-	-	-	-	-	-
	CES09	30	62.3	10.0	27.8	0.519	8.0	10	14	3	107	75.6	0.73	3.86	0.22	1.53	0.22	5.83	4	5	71.8	30.3	0.02	1174.1	12.3	20.3	1.5	0.7
	CES10	40	-	-	-	0.748	6.1	2	24	5	229	75.0	0.57	10.71	0.35	2.35	0.65	14.06	5	-	-	-	-	-	-	-	-	-
	Average	29.4	62.5	12.3	25.3	1.3	7.9	6.7	33.4	5.4	192.3	163.7	0.8	9.9	0.3	2.2	0.4	12.9	3.3	-	74.8	30.1	0.0	884.3	10.4	21.2	1.3	0.8
	Std. Dev.	10.4	2.0	2.8	3.5	1.8	0.9	6.4	29.2	1.4	39.4	152.6	0.2	3.4	0.1	0.7	0.2	4.2	1.2	-	28.1	16.7	0.0	204.2	1.9	3.2	0.2	0.2

For the purpose of calculating the average and standard deviation, for analysis where the value is less than the limit of reporting (LOR), 0.5*LOR was used.

Source: Mine Earth (2022)

F-2 Soils - J4

Table F.3: Gravel content and particle size distribution of soils in SMU 1 – J4

Trench ID	Depth (cm)	% Gravel (> 2mm soil fraction)	Particle particle distribution (< 2 mm soil fraction)			
			% Sand	% Silt	% Clay	Texture
T6	0 - 10	43.17	84.7	6.5	8.8	Loamy Sand
T7	0 - 10	27.39	84.8	8.3	6.9	Loamy Sand
T16	0 - 10	53.40	77.6	6.9	15.6	Sandy loam
T20	0 - 10	46.50	83.0	7.7	9.3	Loamy Sand
T6	10 - 20	38.45	69.3	9.6	21.1	Clay loam
T20	10 - 20	52.39	75.6	8.3	16.2	Sandy loam
T18	20 - 30	45.52	83.2	4.5	12.2	Sandy loam

Source: (SWC, 2014b)

Table F.4: Bulk density, permeability and structural stability of soils in SMU 1 – J4

Trench ID	Depth (cm)	Bulk density (g/cm ³)	Ksat (m/day)	Structural stability	
				Macro-structural (Slaking)	Micro-structure (Dispersion)*
T6	0 - 10	1.6	> 2	Very poor	Class 5
T7	0 - 10	-			
T16	0 - 10	1.4			
T20	0 - 10	-			
T6	10 - 20	-			
T20	10 - 20	1.7			
T18	20 - 30	1.62			

* Emerson Dispersion Class

Source: (SWC, 2014b)

Table F.5: Water retention characteristics of soils in SMU 1 (not adjusted for gravel) – J4

Trench ID	Depth (cm)	Volumetric water content (%)					PAW (%)*
		0 kPa	10 kPa	33 kPa	100 kPa	1,500 kPa	
T6	0 - 10	50.9	30.6	21.3	15.1	11.3	10.0
T7	0 - 10	44.2	26.8	18.8	14.5	9.8	8.9
T16	0 - 10	49.7	34.2	21.7	15.6	10.1	11.6
T20	0 - 10	52.7	31.9	24.0	17.4	13.0	11.1

* PAW = Plant available water (PAW = 33 kPa – 1,500 kPa)

Source: (SWC, 2014b)

Table F.6: EC and pH data for soil in SMU 1 – J4

Trench ID	Depth (cm)	pH	EC (mS/m)
T1	0 – 10	4.77	1.45
	10 – 20	5	1.59
	20 – 30	5.22	1.78
T2	0 – 10	4.93	2.29
T3	0 – 10	5.86	2.63
T4	0 – 10	5.94	1.22
T6	0 – 10	5.61	1.55
	10 – 20	5.72	2.22
T7	0 – 10	6.44	1.34
T16	0 – 10	5.39	1.04
T18	0 – 10	6.75	2.93
	10 – 20	6.93	2.79
	20 – 30	6.68	4.35
T19	0 – 10	6.19	8.55
	10 – 20	5.63	38.50
	20 – 30	5.82	24.80
T20	0 – 10	6.38	0.84
	10 – 20	6.92	1.38
	20 – 30	7.14	2.01
T21	0 – 10	6.15	1.35

Source: (SWC, 2014b)

Table F.7: Nutrient properties of soils in SMU 1 – J4

Trench ID	Depth (cm)	Mineralised N (mg/kg)		Colwell P (mg/kg)	Colwell K (mg/kg)	KCl ext. S (mg/kg)	Organic C (%)
		NH ₄ -N	NO ₃ -N				
T6	0 - 10	2	1	< 2	159	8.8	1.14
T7	0 - 10	1	2	3	163	2.6	0.75
T16	0 - 10	< 1	< 1	2	101	5.3	0.62
T20	0 - 10	< 1	< 1	3	131	4.0	1.00
T6	10 - 20	1	2	< 2	108	15.6	1.32
T20	10 - 20	< 1	< 1	< 2	149	5.1	1.10

Source: (SWC, 2014b)

Table F.8: Exchangeable cation content of soil in SMU 1 – J4

Trench ID	Depth (cm)	Exchangeable cations (meq/100g)					CEC (meq/100g)	ESP (%)
		Ca	Mg	Na	K	Al		
T6	0 - 10	2.79	0.51	0.05	0.41	0.12	3.76	1.33
T7	0 - 10	5.95	0.95	0.09	0.35	0.04	7.34	1.23
T16	0 - 10	2.13	1.02	0.08	0.26	0.27	3.49	2.29
T20	0 - 10	2.86	1.48	0.06	0.33	0.10	4.73	1.27
T6	10 - 20	3.72	0.57	0.11	0.28	0.10	4.68	2.35

Trench ID	Depth (cm)	Exchangeable cations (meq/100g)					CEC (meq/100g)	ESP (%)
T20	10 - 20	6.58	2.50	0.23	0.38	0.16	9.69	2.37

Source: (SWC, 2014b)

Table F.9: Microbial properties of soil in SMU 1 – J4

Replicate	Environment*	Soluble Organic Carbon (mg/kg)	Microbial Biomass Carbon (mg/kg)
1	Open	32	21
	Covered	40	36
2	Open	36	26
	Covered	75	43

* 'Open' means there was no overhead vegetation canopy and thus the site was exposed to direct sunlight during the day. 'Covered' means that the site was located under the vegetation canopy and below a leaf litter layer; hence protected from direct solar radiation.

Source: (SWC, 2014b)

Table F.10: Gravel content and particle size distribution of soils in SMU 2 – J4

Trench ID	Depth (cm)	% Gravel	Particle particle distribution (< 2 mm soil fraction)			
		(> 2mm soil fraction)	% Sand	% Silt	% Clay	Texture
T8	0 - 10	24.18	73.3	16.6	10.1	Loamy Sand
T13	0 - 10	34.72	83.0	9.5	7.5	Loamy Sand
T14	0 - 10	22.12	84.8	8.7	6.5	Loamy Sand
T17	0 - 10	53.72	85.0	5.5	9.5	Sandy loam
T8	10 - 20	34.25	77.7	15.6	6.7	Loamy Sand
T13	10 - 20	43.15	82.8	8.6	8.6	Loamy Sand
T14	10 - 20	27.00	-	-	-	-
T17	10 - 20	69.30	81.3	6.5	12.2	Sandy loam
T13	40 - 50	59.97	77.7	10.4	11.8	Sandy loam
T8	60 - 70	44.48	85.9	9.7	4.4	Loamy Sand
T15	70 - 80	54.03	77.7	6.9	15.4	Sandy loam

Source: (SWC, 2014b)

Table F.11: Bulk density, permeability and structural stability of soils in SMU 2 – J4

Trench ID	Depth (cm)	Bulk density (g/cm ³)	Ksat (m/day)	Structural stability	
				Macro-structural (Slaking)	Micro-structure (Dispersion)*
T8	0 - 10	1.5	2.64	Very poor	Class 5
T13	0 - 10	-	-		
T14	0 - 10	-	-		
T17	0 - 10	1.65	1.66		
T8	10 - 20	-	-		
T13	10 - 20	1.86	0.58		
T17	10 - 20	-	-		
T13	40 - 50	1.77	0.89		
T15	70 - 80	1.40	1.43		

* Emerson Dispersion Class

Source: (SWC, 2014b)

Table F.12: Water retention characteristics of soils in SMU 2 (not adjusted for gravel) – J4

Trench ID	Depth (cm)	Volumetric water content (%)					PAW (%)*
		0 kPa	10 kPa	33 kPa	100 kPa	1,500 kPa	
T8	0 - 25	60.6	40.6	28.3	22.1	14.5	13.8
T12	0 - 50	49.1	29.1	19.5	14.4	9.3	10.2
T8	50 - 80	71.3	51.6	37.6	30.2	18.4	19.2
T12	50 - 80	50.4	31.5	23.2	16.4	13.2	10.0
T14	50 - 60	42.7	27.4	17.3	12.0	9.2	8.0

* PAW = Plant available water (PAW = 33 kPa – 1,500 kPa)

Source: (SWC, 2014b)

Table F.13: Microbial properties of soil in SMU 2 – J4

Replicate	Environment*	Soluble Organic Carbon (mg/kg)	Microbial Biomass Carbon (mg/kg)
1	Open	14	20
	Covered	26	38
2	Open	5	12
3	Open	25	30

* 'Open' means there was no overhead vegetation canopy and thus the site was exposed to direct sunlight during the day. 'Covered' means that the site was located under the vegetation canopy and below a leaf litter layer; hence protected from direct solar radiation.

Source: (SWC, 2014b)

Table F.14: Nutrient properties of soils in SMU 2 – J4

Trench ID	Depth (cm)	Mineralised N (mg/kg)		Colwell P (mg/kg)	Colwell K (mg/kg)	KCl ext. S (mg/kg)	Organic C (%)
		NH ₄ -N	NO ₃ -N				
T8	0 - 10	< 1	27	3	333	11.5	1.24
T13	0 - 10	< 1	1	5	216	4.1	0.31
T14	0 - 10	< 1	1	2	160	4.9	0.58
T14	0 - 30	< 1	< 1	< 2	119	10.0	0.52
T17	0 - 10	2	2	< 2	108	8.5	0.41
T8	10 - 20	< 1	58	2	268	16.7	0.73
T13	10 - 20	< 1	3	< 2	148	4.7	0.26
T17	10 - 20	< 1	2	< 2	89	12.8	0.40
T13	40 - 50	< 1	18	< 2	93	6.9	0.27
T8	60 - 70	< 1	295	< 2	83	42.4	0.28
T15	70 - 80	1	56	< 2	56	12.7	0.20

Source: (SWC, 2014b)

Table F.15: Exchangeable cation content of soil in SMU 2 – J4

Trench ID	Depth (cm)	Exchangeable cations (meq/100g)					CEC (meq/100g)	ESP (%)
		Ca	Mg	Na	K	Al		
T8	0 - 10	10.63	1.95	0.54	0.85	0.08	13.97	3.87
T13	0 - 10	3.15	0.85	0.04	0.45	0.26	4.49	0.89
T14	0 - 10	1.68	0.32	0.03	0.37	0.46	2.40	1.25
T14	0 - 30	1.54	0.23	0.03	0.29	0.56	2.09	1.44
T17	0 - 10	1.24	0.43	0.03	0.27	0.53	1.97	1.52

Trench	Depth	Exchangeable cations (meq/100g)					CEC	ESP
T8	10 - 20	17.43	2.03	1.03	0.69	0.05	21.18	4.86
T13	10 - 20	5.47	0.82	0.10	0.35	0.09	6.74	1.48
T17	10 - 20	1.52	0.43	0.05	0.23	0.64	2.23	2.24
T13	40 - 50	9.41	1.33	0.29	0.23	0.13	11.26	2.58
T8	60 - 70	20.62	2.90	0.95	0.21	0.03	24.68	3.85
T15	70 - 80	5.05	2.07	1.00	0.14	0.15	8.26	12.11

Source: (SWC, 2014b)

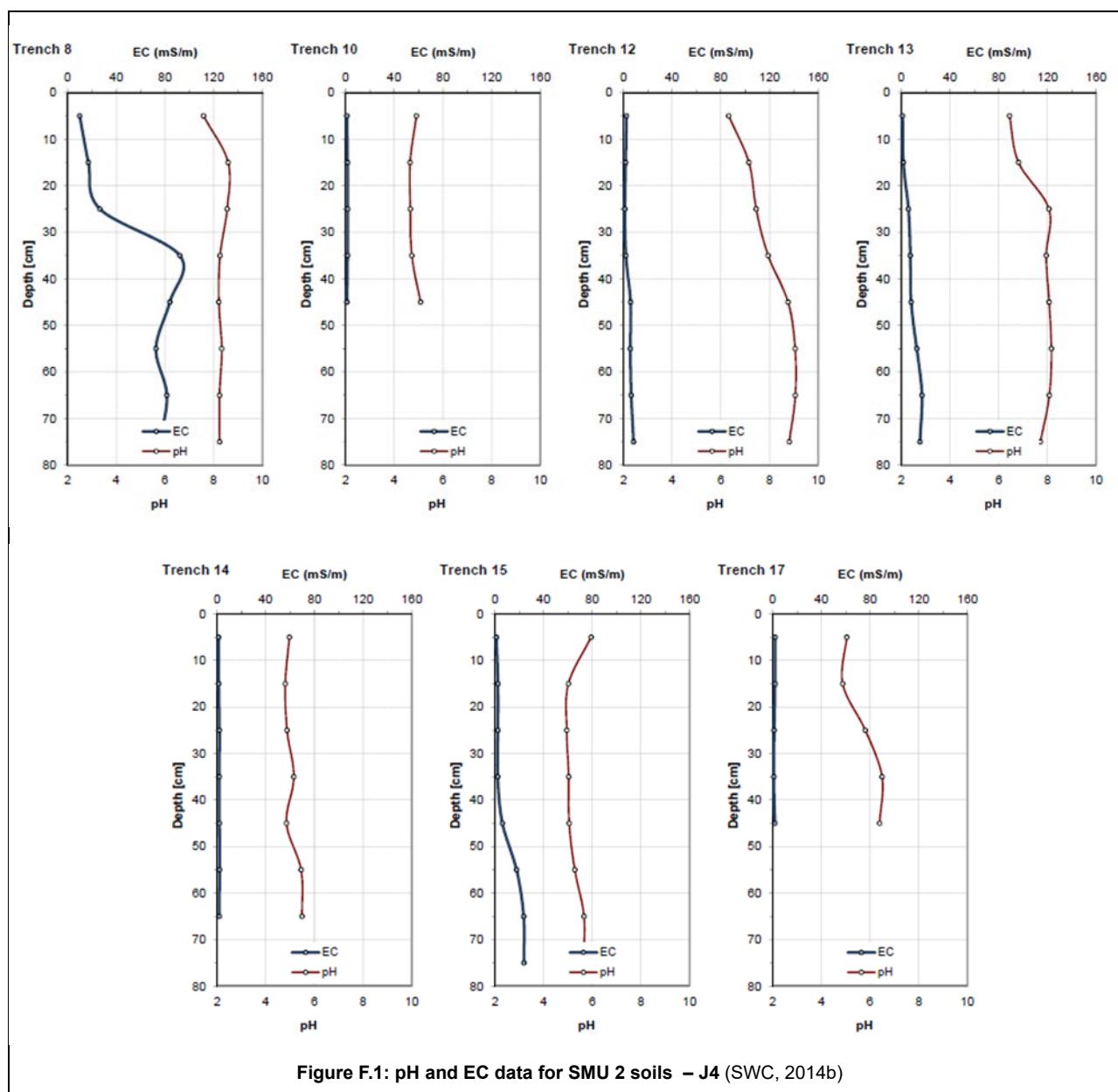


Figure F.1: pH and EC data for SMU 2 soils – J4 (SWC, 2014b)

Table F.16: Gravel content and particle size distribution of soils in SMU 3 – J4

Trench ID	Depth (cm)	% Gravel (> 2mm soil fraction)	Particle particle distribution (< 2 mm soil fraction)			
			% Sand	% Silt	% Clay	Texture
T5	0 - 10	10.99	73.5	13.8	12.6	Loam
T9	0 - 10	10.16	71.8	12.4	15.8	Loam
T22	0 - 10	12.42	72.9	7.1	20.1	Sandy clay loam
T22	0 - 10	17.45	54.1	18.7	27.2	Clay loam
T22	10 - 20	7.93	55.1	6.9	38.0	Clay
T5	20 - 30	22.78	81.7	5.9	12.4	Sandy loam
T22	20 - 30	11.41	53.8	8.3	37.9	Clay
T5	50 - 60	25.89	68.4	10.7	21.0	Loam

Source: (SWC, 2014b)

Table F.17: Bulk density, permeability and structural stability of soils in SMU 3 – J4

Trench ID	Depth (cm)	Bulk density (g/cm ³)	Ksat (m/day)	Structural stability	
				Macro-structural (Slaking)	Micro-structure (Dispersion)*
T5	0 - 10	1.33	0.95	Very poor	Class 5
T9	0 - 10	1.58	0.62		Class 2
T22	0 - 10	-	-		Class 2
T22	0 - 10	1.48	0.25		Class 2
T22	10 - 20	1.63	0.14		Class 5
T5	20 - 30	1.58	0.18		Class 5
T22	20 - 30	1.69	0.08		Class 5
T5	50 - 60	1.79	0.02		Class 5

* Emerson Dispersion Class

Source: (SWC, 2014b)

Table F.18: Water retention characteristics of soils in SMU 3 (not adjusted for gravel) – J4

Trench ID	Depth (cm)	Volumetric water content (%)					PAW (%)*
		0 kPa	10 kPa	33 kPa	100 kPa	1,500 kPa	
T5	0 - 10	54.0	37.8	27.6	19.2	13.8	13.8
T9	0 - 10	57.7	38.2	29.2	20.9	15.1	14.1
T5	20 - 30	50.2	34.1	25.5	18.4	14.1	11.4
T9	20 - 50	69.2	47.1	38.7	33.0	25.2	13.6

* PAW = Plant available water (PAW = 33 kPa – 1,500 kPa)

Source: (SWC, 2014b)

Table F.19: Nutrient properties of soils in SMU 3 – J4

Trench ID	Depth (cm)	Mineralised N (mg/kg)		Colwell P (mg/kg)	Colwell K (mg/kg)	KCl ext. S (mg/kg)	Organic C (%)
		NH ₄ -N	NO ₃ -N				
T5	0 - 10	< 1	1	6	240	8.0	0.82
T9	0 - 10	< 1	4	4	246	4.7	0.68
T22	0 - 10	< 1	2	8	264	2.1	0.84
T22	0 - 10	< 1	< 1	3	462	2.7	1.80
T22	10 - 20	< 1	32	2	223	9.6	1.21
T5	20 - 30	< 1	19	< 2	84	7.9	0.41
T22	20 - 30	1	75	3	179	31.0	0.91
T5	50 - 60	< 1	32	< 2	63	9.2	0.26

Source: (SWC, 2014b)

Table F.20: Exchangeable cation content of soil in SMU 3 – J4

Trench ID	Depth (cm)	Exchangeable cations (meq/100g)					CEC (meq/100g)	ESP (%)
		Ca	Mg	Na	K	Al		
T5	0 - 10	4.81	0.92	0.05	0.62	0.16	6.40	0.78
T9	0 - 10	7.40	4.20	0.99	0.63	0.09	13.22	7.49
T22	0 - 10	7.96	6.25	1.37	0.67	0.07	16.25	8.43
T22	0 - 10	18.05	12.03	1.05	1.18	0.09	32.31	3.25
T22	10 - 20	14.24	9.73	5.74	0.57	0.06	30.28	18.96
T5	20 - 30	5.70	1.21	0.13	0.21	0.19	7.25	1.79
T22	20 - 30	14.89	9.71	9.08	0.46	0.08	34.14	26.60
T5	50 - 60	6.02	1.78	0.17	0.16	0.12	8.13	2.09

Source: (SWC, 2014b)

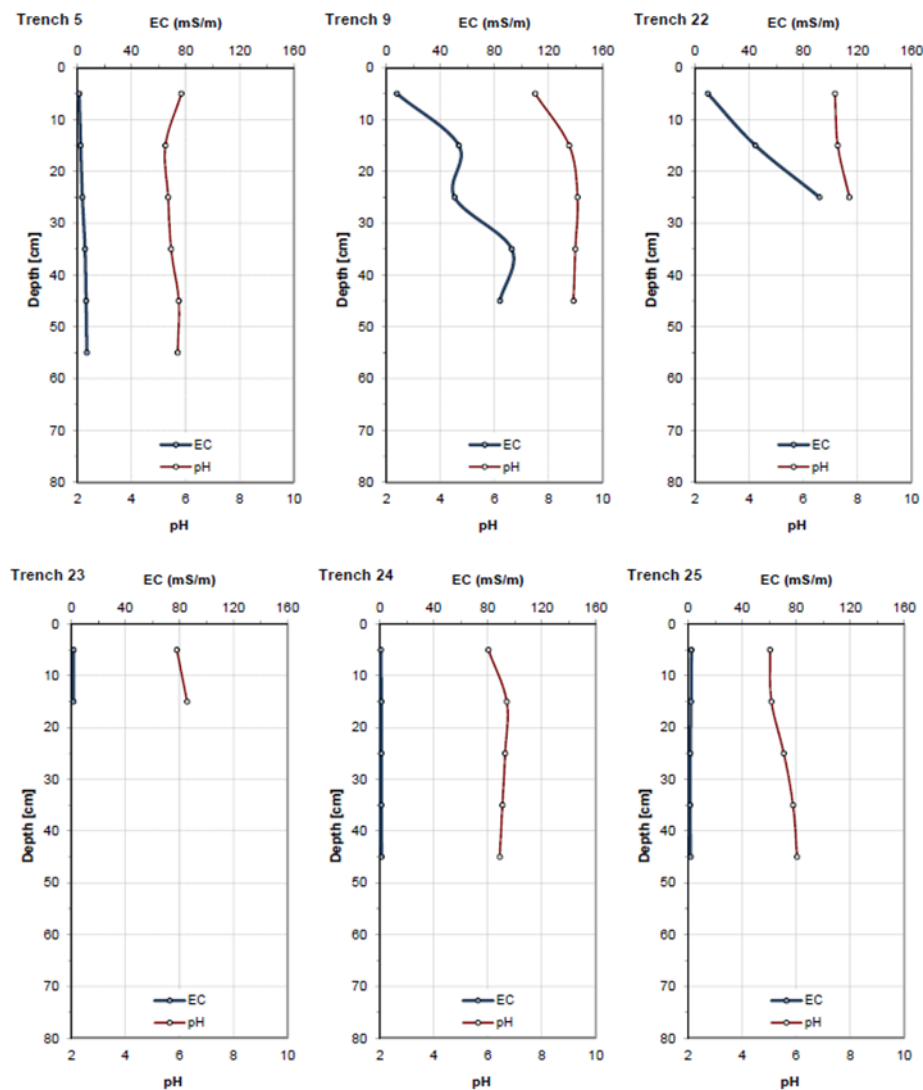


Figure F.2: EC and pH data for soil in SMU 3 – J4 (SWC, 2014b)

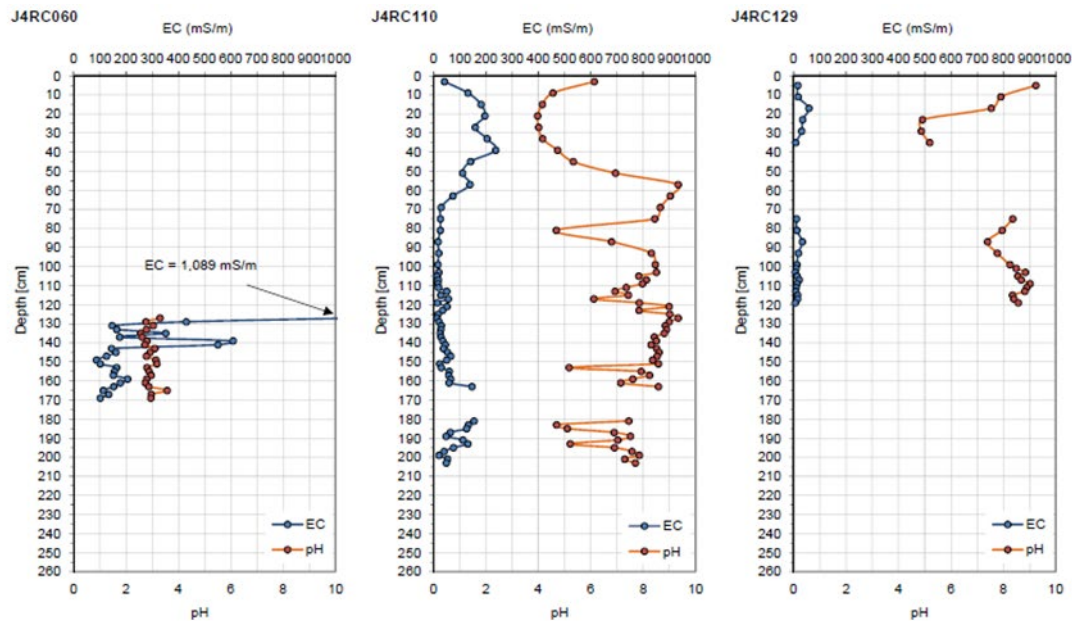


Figure F.3: pH and EC plots for drillholes J4RC060, 110 and 129 – J4 (SWC, 2014b)

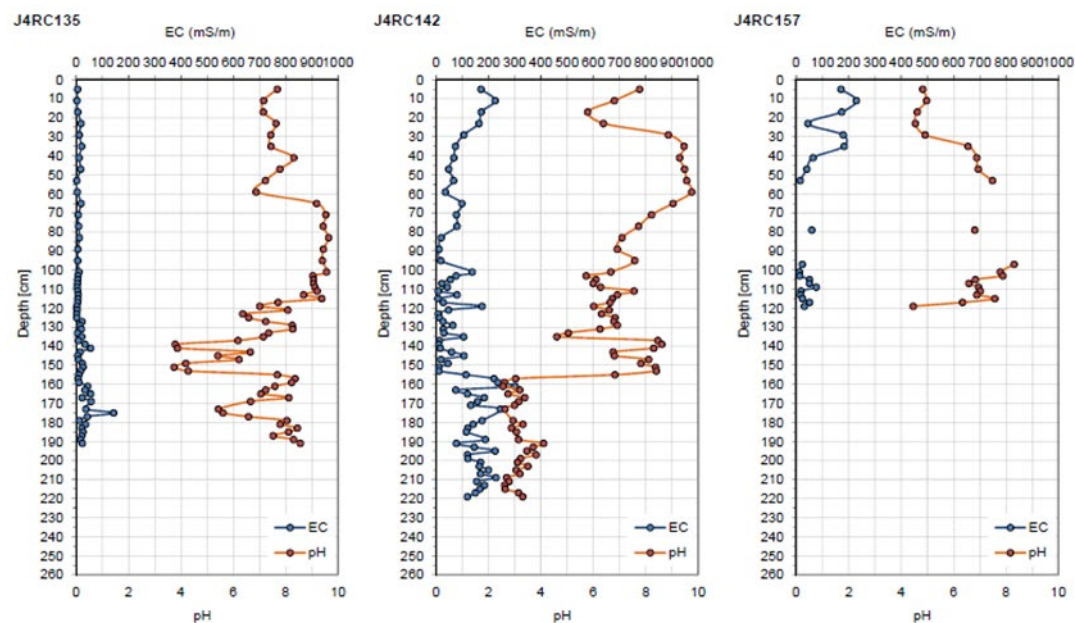


Figure F.4: pH and EC plots for drillholes J4RC 135, 142 and 157 – J4 (SWC, 2014b)

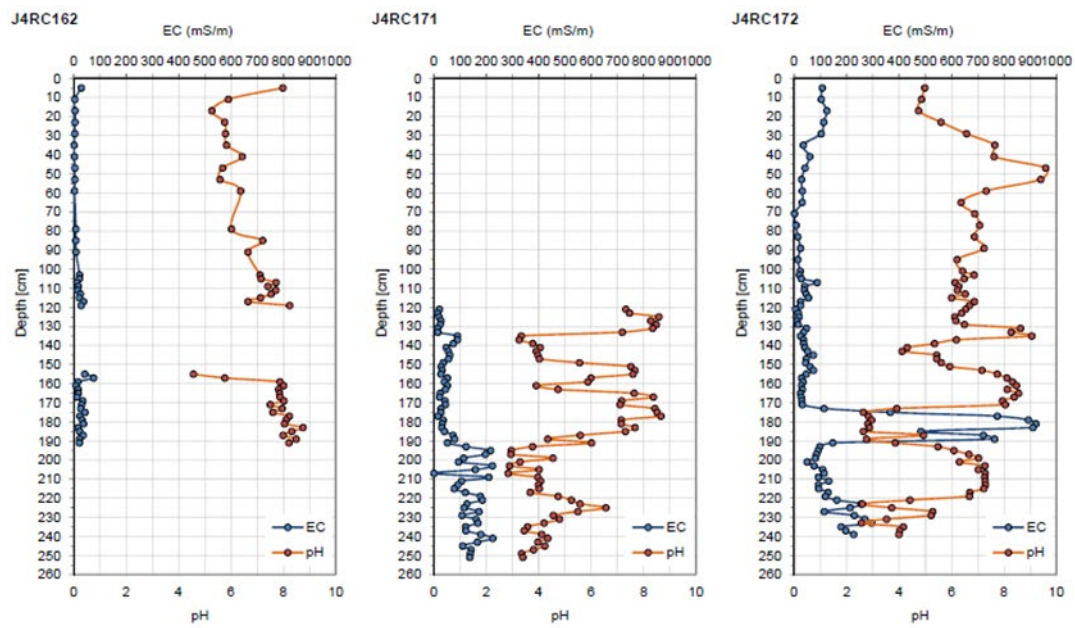


Figure F.5: pH and EC plots for drillholes J4RC 162, 171 and 172 – J4 (SWC, 2014b)

Table F.21: Summary of stockpiled soil characteristics for J4 East

J4 East Soils	Sample ref	Particle size distribution (%)				EC (dS/m)	pH (H ₂ O)	Plant-available nutrients (mg/kg)					Org. C (%)	Exchangeable cations (meq/100g)				eCEC (meq/100g)	ESP (%)	Emerson Class	Ksat (mm/hr)	Total metals (mg/kg)							
		Coarse	Sand	Silt	Clay			NH ₄ ⁺	NO ₃ ⁻	P	K	S		Ca	K	Mg	Na					As	Cd	Cr	Co	Pb	Mo	Se	
Stockpiled soils	J4S02	15	-	-	-	4.473	7.9	1	12	6	250	3263	0.75	26.5	0.5	5.5	1.7	34.1	5	-	-	-	-	-	-	-	-	-	
	J4S03	10	65.1	9.7	25.2	0.071	6.3	2	11	5	252	15.6	0.88	3.8	0.4	1.0	<0.1	5.2	<1	3b	65.2	12.5	0.03	1586	11.3	18.5	1.1	0.5	
	J4S04	10	-	-	-	0.069	6.4	2	14	4	221	15.1	0.59	3.4	0.4	0.8	<0.1	4.6	<1	-	-	-	-	-	-	-	-		
	J4S05	10	61.6	7.7	30.7	0.171	7.7	2	9	6	254	8.5	0.82	10.7	0.5	1.3	<0.1	12.5	<1	3b	41.8	7.4	0.05	1043	9.3	17.3	1.1	0.9	
	J4S06	15	-	-	-	0.052	7.6	2	3	7	342	4.5	0.66	5.0	0.6	1.4	0.2	7.2	2	-	-	-	-	-	-	-	-		
	J4S07	10	62.9	7.8	29.3	0.139	7.4	5	18	7	241	18.6	0.69	5.4	0.4	1.3	0.1	7.3	2	3b	55.5	8.1	0.04	1300	10.3	29.1	1.1	0.4	
	J4S09	15	66.8	17.6	15.6	0.123	8.4	1	3	6	351	4.3	1.04	14.4	0.6	1.6	<0.1	16.7	<1	3b	91.3	11.1	0.06	1109	16.2	16.2	0.7	0.8	
	J4S10	20	-	-	-	0.121	7.6	1	24	6	228	7.9	0.74	6.5	0.4	1.2	0.1	8.2	1	-	-	-	-	-	-	-	-		
	Average	13.1	64.1	10.7	25.2	0.7	7.4	2.0	11.8	5.9	267.4	417.2	0.8	9.5	0.5	1.8	0.3	12.0	1.5	-	63.5	9.8	0.0	1259.5	11.8	20.3	1.0	0.7	
	Std. Dev	3.5	2.0	4.1	5.9	1.4	0.7	1.2	6.7	0.9	47.0	1075.6	0.1	7.3	0.1	1.4	0.5	9.2	1.5	-	18.1	2.1	0.0	210.8	2.7	5.2	0.2	0.2	
Stockpiled soils on WRL	J4S11	30	75.7	3.8	20.5	0.193	7.0	7	19	5	151	13.3	0.74	3.8	0.3	1.3	0.1	5.5	2	3b	88.8	15.3	0.03	2203	5.8	18.7	1.4	0.7	
	J4S13	25	61.6	11.6	26.9	0.273	8.7	1	10	5	280	14.5	1.15	14.4	0.6	3.6	0.3	18.8	2	3b	62.0	4.0	0.05	236	6.9	18.6	0.9	0.7	
	J4S14	30	-	-	-	0.224	8.5	2	9	4	245	13	0.99	12.7	0.5	2.4	0.2	15.9	2	-	-	-	-	-	-	-	-		
	J4S15	25	65.2	15.5	19.3	0.141	8.5	<1	3	8	288	6.3	0.90	12.9	0.5	2.6	0.2	16.2	1	3b	44.4	13.3	0.06	1080	12.7	20.9	1.0	0.7	
	J4S16	20	-	-	-	0.184	8.9	2	4	6	306	5.8	1.02	13.7	0.6	3.1	0.2	17.6	1	-	-	-	-	-	-	-	-		
	J4S17	20	63.4	7.7	28.9	0.359	8.6	2	23	7	247	19.3	0.62	11.6	0.4	2.7	0.3	15.1	2	3b	36.6	14.7	0.04	2333	11.0	22.9	1.1	0.5	
	J4S18	20	-	-	-	0.258	8.6	2	5	7	344	9.5	1.08	13.3	0.6	3.1	0.2	17.2	1	-	-	-	-	-	-	-	-		
	Average	18	65.3	10.2	24.5	0.46	7.9	2.3	11.1	5.9	266	228	0.84	10.5	0.5	2.2	0.3	13.5	2	-	60.7	10.8	0.04	1361	10.4	20.3	1.1	0.7	
	Std Dev.	4.2	5.5	4.4	4.1	0.1	0.6	2.0	7.2	1.3	56.6	4.5	0.2	3.4	0.1	0.7	0.1	4.1	0.5	-	20.0	4.6	0.0	859.8	2.8	1.8	0.2	0.1	
Rehab. Soils	J4S01	15	62.4	7.9	29.7	0.393	6.6	6	14	5	222	24.7	0.82	6.3	0.4	1.9	0.4	8.9	4	3b	52.2	13.0	0.03	1197	11.3	19.6	1.0	1.4	
	J4S08	25	-	-	-	0.088	6.8	2	5	<2	131	21.9	0.47	2.9	0.2	0.7	<0.1	3.9	1	-	-	-	-	-	-	-	-		

J4 East Soils	Sample ref	Particle size distribution (%)				EC (dS/m)	pH (H ₂ O)	Plant-available nutrients (mg/kg)					Org. C (%)	Exchangeable cations (meq/100g)				eCEC (meq/100g)	ESP (%)	Emerson Class	Ksat (mm/hr)	Total metals (mg/kg)							
		Coarse	Sand	Silt	Clay			NH ₄ ⁺	NO ₃ ⁻	P	K	S		Ca	K	Mg	Na					As	Cd	Cr	Co	Pb	Mo	Se	
	J4S12	40	-	-	-	0.437	6.5	4	36	5	169	36.2	0.77	4.2	0.3	1.5	0.1	6.1	2	-	117.5	-	-	-	-	-	-	-	
	Average	27	-	-	-	0.31	6.6	4	18.3	5	174	27.6	0.69	4.5	0.3	1.4	0.2	6.3	2	-	84.8	-	-	-	-	-	-	-	
	Std. Dev.	10.3	-	-	-	0.2	0.1	1.6	13.0	1.9	37.3	6.2	0.2	1.4	0.1	0.5	0.2	2.0	1.2	-	32.7	-	-	-	-	-	-	-	

Note: For the purpose of calculating the average and standard deviation. For analytes where the value is less than the limit of reporting (LOR), 0.5 was used.

Source: Mine Earth (2022)

Table F.22: Summary of stockpiled soil characteristics for J4 West

J4 West Soils	Sample ref	Particle size distribution (%)				EC	pH	Plant-available nutrients (mg/kg)					Org. C	Exchangeable cations (meq/100g)				eCEC (meq/ 100g)	ESP	Emer-son Class	Ksat	Total metals (mg/kg)							
		Coarse	Sand	Silt	Clay	(dS/m)	(H2O)	NH4 ⁺	NO3 ⁻	P	K	S	%	Ca	K	Mg	Na		%		(mm/hr)	As	Cd	Cr	Co	Pb	Mo	Se	
Stockpiled soils on WRD	J4S19	20	63.0	15.6	21.4	0.267	8.6	2	< 1	5	355	9.0	1.12	14.1	0.7	3.2	0.3	18.4	2	3b	65.2	6.2	0.06	647	11.7	17.7	0.9	0.2	
	J4S20	15	-	-	-	0.170	9.1	< 1	2	6	284	3.2	0.98	14.6	0.6	3.3	0.3	18.7	1	-	-	-	-	-	-	-	-		
	J4S21	10	50.2	16.0	33.9	0.717	8.4	3	34	6	368	105.5	0.86	13.3	0.7	4.1	0.5	18.7	3	3b	29.4	7.1	0.07	358	19.3	13.9	0.7	0.4	
	J4S22	15	-	-	-	0.181	8.5	1	4	6	373	4.4	1.06	11.6	0.7	3.4	0.5	16.3	3	-	-	-	-	-	-	-	-		
	J4S23	15	67.5	11.5	21.0	0.103	7.8	1	3	6	217	3.6	0.73	7.4	0.4	1.3	< 0.1	9.1	1	3b	71.8	5.9	0.03	788	8.2	24.0	1.1	0.4	
	J4S24	40	-	-	-	0.051	6.6	< 1	9	3	138	6.1	0.57	3.9	0.2	0.8	< 0.1	5.0	1	-	-	-	-	-	-	-	-		
	J4S25	45	62.4	9.9	27.7	0.131	6.4	2	17	4	137	8.6	0.65	4.5	0.2	1.2	< 0.1	6.0	1	3b	58.7	5.7	0.02	718	8.0	20.9	1.0	0.6	
	Average	22.9	60.8	13.3	26.0	0.2	7.9	1.4	9.9	5.1	267.4	20.1	0.9	9.9	0.5	2.5	0.3	13.2	1.7	-	56.3	6.2	0.02	627.8	11.8	19.1	0.9	0.4	
	Std. Dev.	12.8	6.4	2.6	5.3	0.2	1.0	0.9	11.1	1.1	96.7	34.9	0.2	4.2	0.2	1.2	0.2	5.8	0.9	-	16.2	0.5	0.05	163.5	4.6	3.7	0.1	0.1	

Note: For the purpose of calculating the average and standard deviation. For analytes where the value is less than the limit of reporting (LOR), 0.5 was used.

Source: Mine Earth (2022)

F-3 Stockpiled Topsoil Condition Scale

Rating	Description	Example
Excellent	• Very high (+ 75%) vegetation cover. • Diverse range of species present and evidence of self-seeding. • High timber / vegetation content. • Soil is good quality, contains a variety of particle sizes including gravel and rocks, not prone to erosion. • All stockpiles are to a maximum 2 m in height. • No weeds present. • No evidence of erosion. • No evidence of contact by saline water.	
Good	• 50% to < 75% vegetation cover. • Reasonable species diversity. • Some timber / vegetation content. • Most soil is good quality. • All stockpiles are to a maximum 2 m in height. • No weeds present. • Minimal evidence of erosion. • No evidence of contact by saline water.	
Moderate	• 25% to < 50% vegetation cover. • Dominated by a few species. Weeds may be present. • Minimal timber / vegetation mixed with the soil. • Some stockpiles exceed the recommended 2 m height. • Soil has poor structure (i.e., sodic and / or prone to becoming "bulldust"). • May be some contact with saline water.	
Poor	• < 25% vegetative cover, dominated by one or two species (i.e., <i>Maireana brevifolia</i>, <i>Atriplex</i> spp). • Weeds present. • Little or no timber / vegetation mixed with the soil. • Most stockpiles exceed the recommended 2 m height. • Soil has poor structure and is prone to, or impacted by, erosion. • Evidence of contact with saline water.	

Source: Ecotec (2022)



APPENDIX G GROUNDWATER

G-1 Groundwater Quality Data

Table E1 – Mt Jackson J4 Water Bores Water Quality Data

BHID	Analyte	pH	EC	TDS	Hardness	Total Alkalinity (CaCO3)	Al	NH3	HCO3	Ca	CO32-	Cl	OH-	Fe	Mg	Mn	NO3	PO4	K	SiO2	Si	Na	SO4
ANZG (Mar-2021)		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		6.5 - 8.5	-	600	200	-	0.2	-	-	-	-	250	-	0.3	-	0.1	50	-	-	80	-	180	250
J4VWB002	10/01/2017	7.9	13000	6500	1900	-	<0.02	<0.01	790	140	<1	3400	-	<0.02	370	0.23	5.3	0.005	69	19	8.8	2400	810
	30/07/2018	-	12000	4400	900	690	<0.01	<0.05	840	40	<1	1900	-	<0.01	200	8	23	0.05	53	21	-	1300	540
	29/05/2019	7.4	7700	4000	800	720	<0.01	<0.005	720	35	<5	1800	<5	<0.01	170	-	5.1	0.03	51	22	-	1300	480
	16/07/2020	7.2	7400	4600	820	730	<0.01	0.01	730	35	<5	1700	<5	<0.01	180	-	4.6	0.02	49	22	-	1300	460
	13/08/2021	7.13*	6296*	4400	790	780	<0.01	0.007	780	31	<5	1800	<5	<0.01	170	<0.005	24	0.023	51	22	-	1200	460
J4VWB003	10/01/2017	7.6	44000	25000	11000	-	<0.1	0.53	470	1600	<1	16000		<0.1	1600	0.51	0.7	<0.005	94	16	7.4	7600	1900
J4VWB004	10/09/2020	7.1	16000	10000	2500	760	<0.01	0.11	760	120	<5	4500	<5	0.06	530	0.09	0.006	0.04	65	46	-	2900	1200
	13/08/2021	7.04*	14140*	10000	2500	800	<0.01	0.11	800	130	<5	4700	<5	0.12	520	0.092	<0.02	0.018	64	46	-	2700	1300

* Field Measurement



Table E2 – Carina Waste Rock Dam Monitoring Bores Water Quality Data

BHID	Date	pH	EC	TDS	Hardness	Total Alkalinity (CaCO3)	Al	NH3	As	HCO3	Cd	Ca	CO32-	Cl	Cr	Cu	OH-	Fe	Pb	Mg	Mn	Hg	Ni	NO3	K	Se	Ag	Na	SO4	Zn
ANZG (Mar-2021)		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		6.5 - 8.5	-	600	200	-	0.2	-	0.01	-	0.002	-	-	250	0.05	1	-	0.3	0.01	-	0.1	0.001	0.02	50	-	0.01	0.1	180	250	3
Carina WRD MB1	22/12/2014	7.1	45000	30000	-	420	-	-	<0.1	510	<0.005	-	<1	-	<0.025	<0.025	-	-	<0.1	-	-	<0.00005	0.051	-	-	-	-	-	-	0.07
	24/03/2015	7.2	45000	31000	-	420	<0.1	-	<0.1	520	<0.005	-	<1	16000	<0.025	<0.025	-	<0.1	<0.1	1400	0.11	<0.00005	0.063	0.5	150	<0.25	<0.025	8700	3100	0.07
	26/05/2015	7.5	42000	-	-	420	<0.1	-	<0.1	520	<0.005	-	<1	16000	<0.025	<0.025	-	<0.1	<0.1	1600	0.12	<0.00005	0.074	0.48	150	<0.25	<0.025	8900	2900	<0.05
	4/08/2015	7.1	43000	29000	-	420	<0.1	-	<0.1	510	<0.005	-	<1	16000	<0.025	<0.025	-	<0.1	<0.1	1400	0.11	<0.00005	0.065	0.6	150	<0.25	<0.025	8300	2900	0.11
	27/10/2015	7.1	38000	-	-	-	<0.1	-	<0.1	530	<0.005	-	<1	16000	<0.025	<0.025	-	<0.1	<0.1	1400	0.1	<0.00005	0.061	0.8	150	<0.25	<0.025	8300	2900	0.08
	14/03/2016	7.2	43000	-	-	-	<0.1	-	<0.1	520	<0.005	-	<1	16000	<0.025	<0.025	-	<0.1	<0.1	1400	0.13	<0.00005	0.06	<0.2	150	<0.25	<0.025	7700	2800	0.07
	20/06/2016	7.1	45000	-	-	-	0.03	-	<0.02	510	<0.001	-	<1	15000	<0.005	0.013	-	<0.02	<0.02	1600	0.29	<0.00005	0.045	0.6	140	<0.05	<0.005	9000	2800	0.12
	27/08/2016	7.3	43000	-	-	-	0.02	-	<0.02	520	<0.001	-	<1	14000	<0.005	0.011	-	<0.02	<0.02	1500	0.27	<0.00005	0.048	0.8	160	<0.05	<0.005	8000	2900	0.11
	5/12/2016	7.2	46000	-	-	-	0.03	-	<0.02	520	<0.001	-	<1	16000	<0.005	0.009	-	<0.02	<0.02	1600	0.22	<0.00005	0.054	0.7	150	<0.05	<0.005	8500	2800	0.09
	7/02/2017	7.4	44000	-	-	-	0.02	-	<0.02	540	<0.001	-	<1	13000	<0.005	<0.005	-	<0.02	<0.02	1700	0.26	<0.00005	0.045	0.8	180	<0.05	<0.005	8000	3000	0.13
Carina WRD MB2	22/12/2014	7.4	53000	33000	-	710	-	-	<0.1	870	<0.005	-	<1	-	<0.025	0.026	-	-	<0.1	-	-	<0.00005	0.068	-	-	-	-	-	-	<0.05
	24/03/2015	7.5	52000	36000	-	710	<0.1	-	<0.1	870	<0.005	-	<1	18000	<0.025	0.043	-	<0.1	<0.1	1600	0.43	<0.00005	0.073	<0.2	180	<0.25	<0.025	10000	3600	<0.05
	26/05/2015	7.7	49000	-	-	720	<0.1	-	<0.1	880	<0.005	-	<1	20000	<0.025	0.05	-	<0.1	<0.1	1700	0.46	<0.00005	0.074	<0.05	190	<0.25	<0.025	10000	3700	<0.05
	4/08/2015	7.4	49000	35000	-	720	<0.1	-	<0.1	880	<0.005	-	<1	19000	<0.025	0.051	-	<0.1	<0.1	1500	0.41	<0.00005	0.076	<0.2	170	<0.25	<0.025	9800	3500	<0.05
	27/10/2015	7.5	49000	-	-	-	<0.1	-	<0.1	880	<0.005	-	<1	18000	<0.025	0.06	-	<0.1	<0.1	1700	0.36	<0.00005	0.068	0.2	190	<0.25	<0.025	10000	3600	<0.05
	14/03/2016	7.5	51000	-	-	-	<0.1	-	<0.1	880	<0.005	-	<1	19000	<0.025	0.063	-	<0.1	<0.1	1600	0.31	<0.00005	0.061	<0.2	170	<0.25	<0.025	9000	3500	0.07
	20/06/2016	7.4	53000	-	-	-	0.03	-	0.03	880	0.002	-	<1	17000	<0.005	0.055	-	<0.02	<0.02	1700	0.42	<0.00005	0.043	0.1	160	<0.05	<0.005	11000	3800	0.06
	27/08/2016	7.2	51000	-	-	-	0.02	-	0.03	870	0.002	-	<1	15000	<0.005	0.06	-	<0.02	<0.02	1600	0.43	<0.00005	0.044	0.4	170	<0.05	<0.005	10000	3700	0.06
	5/12/2016	7.3	52000	-	-	-	0.02	-	0.03	880	0.002	-	<1	18000	<0.005	0.055	-	<0.02	<0.02	1600	0.38	<0.00005	0.052	0.3	180	<0.05	<0.005	12000	3600	0.06
	7/02/2017	7.2	52000	-	-	-	0.03	-	0.03	850	<0.001	-	<1	15000	<0.005	<0.005	-	<0.02	<0.02	1600	0.46	<0.00005	0.048	0.5	160	<0.05	<0.005	9000	3500	0.05
	16/01/2018	7.6	36000	-	-	-	<0.050	-	0.03	930	0.0014	-	<1	18000	<0.010	0.037	-	<0.050	<0.010	1500	0.11	<0.00005	0.03	1.3	140	<0.010	<0.010	8600	3500	<0.050
	9/07/2018	7.6	52000	-	-	710	<0.1	-	0.031	870	<0.002	-	<1	18000	<0.02	0.046	-	<0.1	<0.02	1600	0.1	<0.00005	0.032	0.3	140	<0.02	<0.02	9500	3500	<0.1
	29/05/2019	7	50000	-	-	-	<0.01	-	0.03	730	0.0016	-	<5	19000	<0.001	0.041	-	<0.001	<0.001	1700	0.074	<0.00005	0.024	0.14	150	0.002	<0.001	11000	3400	0.026
	8/10/2019	6.9	48000	-	-	-	<0.01	-	0.03	710	0.0019	-	<5	19000	<0.001	0.045	-	<0.01	<0.001	1600	0.067	<0.00005	0.025	<25	140	0.002	<0.001	11000	3500	0.026
	15/07/2020	6.7	51000	-	7600	730	<0.02	-	0.028	730	0.0015	430	<5	18000	<0.002	0.036	<5	<0.02	<0.002	1600	0.068	<0.00005	0.021	0.022	140	<0.002	<0.002	-	3300	0.016
	18/03/2021	6.39*	49650*	27980*	7800	750	<0.02	-	0.004	750	0.0014	420	<5	19000	<0.002	0.007	<5	0.08	<0.002	1700	0.18	<0.0005	0.037	<25	140	0.002	<0.002	11000	3600	0.74
	20/06/2021	8.09*	52358*	-	6600	770	<0.02	-	0.025	770	0.0013	380	<5	17000	<0.002	0.036	<5	<0.02	<0.002	1400	0.05	<0.00005	0.015	<50	110	<0.002	<0.002	8700	2900	0.014



BHID	Date	pH	EC	TDS	Hardness	Total Alkalinity (CaCO3)	Al	NH3	As	HCO3	Cd	Ca	CO32-	Cl	Cr	Cu	OH-	Fe	Pb	Mg	Mn	Hg	Ni	NO3	K	Se	Ag	Na	SO4	Zn
ANZG (Mar-2021)		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		6.5 - 8.5	-	600	200	-	0.2	-	0.01	-	0.002	-	-	250	0.05	1	-	0.3	0.01	-	0.1	0.001	0.02	50	-	0.01	0.1	180	250	3
Carina WRD MB3	22/12/2014	7.3	53000	36000	-	540	-	-	<0.1	660	<0.005	-	<1	-	<0.025	<0.025	-	-	<0.1	-	-	<0.00005	0.12	-	-	-	-	-	-	<0.05
	24/03/2015	7.4	53000	37000	-	540	<0.1	-	<0.1	650	<0.005	-	<1	19000	<0.025	<0.025	-	<0.1	<0.1	1600	0.33	<0.00005	0.11	<0.2	160	<0.25	<0.025	11000	3700	<0.05
	26/05/2015	7.7	49000	-	-	540	<0.1	-	<0.1	660	<0.005	-	<1	20000	<0.025	<0.025	-	0.34	<0.1	1700	0.38	<0.00005	0.056	<0.05	170	<0.25	<0.025	11000	3500	<0.05
	4/08/2015	7.3	49000	36000	-	540	<0.1	-	<0.1	660	<0.005	-	<1	19000	<0.025	<0.025	-	<0.1	<0.1	1600	0.37	<0.00005	0.041	<0.2	160	<0.25	<0.025	9900	3700	<0.05
	27/10/2015	7.3	43000	-	-	-	<0.1	-	<0.1	660	<0.005	-	<1	19000	<0.025	<0.025	-	0.34	<0.10	1600	0.31	<0.00005	0.033	0.3	170	<0.25	<0.026	10000	3700	<0.05
	14/03/2016	7.5	51000	-	-	-	<0.1	-	<0.1	650	<0.005	-	<1	19000	<0.025	<0.025	-	0.4	<0.1	1500	0.34	<0.00005	0.033	<0.2	160	<0.25	<0.025	9100	3600	<0.05
	20/06/2016	7.3	53000	-	-	-	0.03	-	<0.02	660	<0.001	-	<1	18000	<0.005	<0.005	-	0.85	<0.02	1600	0.47	<0.00005	0.01	0.28	140	<0.05	<0.005	11000	3800	0.05
	27/08/2016	7.3	52000	-	-	-	0.03	-	<0.02	650	<0.001	-	<1	17000	<0.005	<0.005	-	0.5	<0.02	1500	0.45	<0.00005	0.01	0.3	150	<0.05	<0.005	10000	3700	0.06
	5/12/2016	7.5	51000	-	-	-	0.03	-	<0.02	680	<0.001	-	<1	19000	<0.005	<0.005	-	0.6	<0.02	1400	0.39	<0.00005	0.01	0.25	140	<0.05	<0.005	10000	3900	0.05
	7/02/2017	7.3	52000	-	-	-	0.03	-	<0.02	640	<0.001	-	<1	16000	<0.005	<0.005	-	0.45	<0.02	1600	0.48	<0.00005	0.01	0.5	160	<0.05	<0.005	10000	3800	0.07
	16/01/2018	7.5	36000	-	-	-	<0.050†	-	<0.010	640	<0.0010	-	<1	18000	<0.010	<0.010	-	0.053	<0.010	1400	0.33	<0.00005	0.023	1.4	120	<0.010	<0.010	8600	3600	<0.050†
	9/07/2018	7.4	53000	-	-	500	<100	<20	-	610	-	-	-	18000	<0.02	<0.02	-	0.65	<0.02	1600	0.27	<0.00005	<0.02	8.3	130	<0.02	<0.02	9600	3500	<0.1
	29/05/2019	7	50000	-	-	-	<0.02	-	0.009	530	<0.0002	-	<5	19000	<0.002	<0.002	-	1.1	<0.002	1700	0.24	0.00007	0.011	0.16	140	<0.002	<0.002	11000	3500	0.018
	8/10/2019	6.7	48000	-	-	-	<0.01	-	0.002	500	0.0002	-	<5	20000	<0.001	0.002	-	0.16	<0.001	1600	0.25	<0.00005	0.015	<25	130	<0.001	<0.001	11000	3600	0.017
	15/07/2020	6.6	51000	-	-	540	<0.02	-	0.004	540	<0.0002	460	<5	19000	<0.002	<0.002	<5	0.3	<0.002	1600	0.24	<0.00005	0.021	0.37	130	<0.002	<0.002	11000	3500	0.009
	18/03/2021	6.27*	49650*	27630*	7700	560	<0.02	-	0.002	560	<0.0002	430	<5	19000	<0.002	<0.002	<5	0.29	<0.002	1600	0.25	<0.00005	0.039	<25	130	<0.002	<0.002	11000	3600	0.73
	20/06/2021	6.93*	46667*	-	7100	540	<0.02	-	0.003	540	<0.0002	430	<5	21000	<0.002	<0.002	<5	<0.02	<0.002	1500	0.25	<0.00005	0.037	<50	110	<0.002	<0.002	9600	3600	0.012

* Field Measurement

Table E3 – Carina Production Bores Water Quality Data

BHID	Analyte	pH	EC	TDS	Hardness	Total Alkalinity (CaCO3)	Al	NH3	As	HCO3	Cd	Ca	Cl	Cr	Cu	Fe	Pb	Mg	Mn	Hg	Ni	NO3	PO4	K	SiO2	Si	Na	SO4	Zn
ANZG (Mar-2021)		pH Units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
		6.5 - 8.5	-	600	200	-	0.2	-	0.01	-	0.002	-	250	0.05	1	0.3	0.01	-	0.1	0.001	0.02	50	-	-	80	-	180	250	3
Bore 7	21/05/2013	7	47000	31700	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	0.00008	0.058	-	-	-	-	-	-	-	<0.05
	16/07/2013	7.2	39000	31000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.066	-	-	-	-	-	-	-	<0.05
	13/08/2013	7.1	48000	31000	-	-	-	-	<0.02	-	<0.001	-	-	<0.005	<0.005	-	<0.02	-	-	<0.00005	0.022	-	-	-	-	-	-	-	0.02
	10/09/2013	7.3	47000	31000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.05	-	-	-	-	-	-	-	<0.05
	19/11/2013	7.5	46000	29000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.054	-	-	-	-	-	-	-	0.07
Bore 8	2/02/2015	7.4	48000	35000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.043	-	-	-	-	-	-	-	0.05
	9/11/2015	7.5	46000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.044	-	-	-	-	-	-	-	0.09
Bore 9	17/12/2013	7.6	48000	34000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	0.00059	<0.025	-	-	-	-	-	-	-	<0.05
	14/01/2014	7.5	46000	27000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	0.039	-	<0.1	-	-	0.0053	0.058	-	-	-	-	-	-	-	0.08
	11/02/2014	7.5	47000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.031	-	-	-	-	-	-	-	<0.05
	25/03/2014	7.6	46000	32000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.041	-	-	-	-	-	-	-	<0.05
	22/04/2014	7.8	47000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.041	-	-	-	-	-	-	-	<0.05
	3/06/2014	7.6	47000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	0.00018	0.043	-	-	-	-	-	-	-	<0.05
	12/08/2014	7.5	47000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.048	-	-	-	-	-	-	-	0.14
	14/10/2014	7.9	46000	33000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.044	-	-	-	-	-	-	-	<0.05
	9/11/2015	7.7	47000	34000	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.047	-	-	-	-	-	-	-	<0.05
	18/11/2015	7.6	46000	30000	8300	530	0.03	4.2	-	660	-	470	14000	-	-	43	-	1700	2.1	-	-	<0.05	<0.01	140	11	7.8	9300	3800	-
	22/02/2016	7.3	48000	31000	8400	520	0.04	4.8	-	640	-	470	14000	-	-	46	-	1700	2.1	-	-	<0.05	<0.01	150	15	7.6	9600	3600	-
	14/03/2016	7.7	46000	-	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.041	-	-	-	-	-	-	-	<0.05
	20/05/2016	7.4	49000	32000	8600	510	0.04	4.9	-	620	-	470	16000	-	-	49	-	1800	2.1	-	-	<0.05	<0.01	150	15	7.1	9800	3500	-
CAWB009A /Bore 9A	25/05/2015	7.9	44000	-	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.054	-	-	-	-	-	-	-	0.21
	4/08/2015	7.7	45000	-	-	-	-	-	<0.1	-	<0.005	-	-	<0.025	<0.025	-	<0.1	-	-	<0.00005	0.046	-	-	-	-	-	-	-	<0.05

* Field Measurement



G-2 Pit Lake Quality Data

Table G1 – Mt Jackson J4 and Carina Pit Lakes Water Quality Data

Analyte	Units	ANZG (2018)	Mt Jackson J4						Carina													
			J4 West				J4 East		Carina Pit Lake										Carina Extended Pit			
			29/05/2019	16/07/2020	13/08/2021	3/11/2021	29/05/2019	16/07/2020	3/11/2017	28/11/2017	9/07/2018	29/05/2019	8/10/2019	15/07/2020	10/12/2020	18/03/2021	20/06/2021	26/10/2021	3/11/2021	29/05/2019	8/10/2019	15/07/2020
pH	pH Units	6.5 - 8.5	8.1	8.1	8.11*	8.43	8.2	8	7.8	7.7	7.7	7.2	6.9	7.2	6.07 *	6.54*	8.28*	7.6	7.93	7.9	7.9	7.8
Electrical Conductivity (EC)	µS/cm	-	14000	14000	13452*	15400	19000	21000	49000	45000	52000	55000	48000	53000	51770 *	50980*	38922*	53000	53200	52000	45000	49000
Total Dissolved Solids (TDS)	mg/L	600	8100	9900	10000	10600	12000	16000	35000	35000	34000	37000	41000	42000	29020 *	27990*	28690*	41000	39100	33000	37000	37000
Hardness (CaCO3)	mg/L	200	2000	2400	2400	2620	3000	3500	-	9000	8800	9600	8800	9100	9600	9100	-	7900	9560	7400	7700	7700
Total Alkalinity (CaCO3)	mg/L	-	400	410	420	391	470	460	-	<1	210	130	220	100	140	170	-	260	216	410	460	420
Aluminium (Al)	mg/L	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	-	<0.1	<0.02	<0.01	0.02	<0.02	0.02	-	<0.02	<0.05	<0.02	<0.01	<0.02
Ammonia (NH3)	mg/L	-	0.019	<0.005	0.008	0.03	<0.005	0.023	-	-	0.14	0.23	0.37	0.22	0.17	0.16	0.21	0.29	0.04	<0.005	<0.005	0.011
Arsenic (As)	mg/L	0.01	-	-	-	0.001	-	-	<0.02	-	-	-	-	-	-	-	-	-	<0.005	-	-	-
Barium (Ba)	mg/L	2	-	-	-	-	-	-	-	<0.02	-	-	-	-	-	-	-	-	-	-	-	-
Bicarbonate (HCO3 as CaCO3)	mg/L	-	400	410	420	360	470	460	-	260	260	130	220	100	140	170	330	260	216	410	460	420
Boron (Bo)	mg/L	4	-	-	-	4.42	-	-	-	11	-	-	-	-	-	-	-	-	10.2	-	-	-
Cadmium (Cd)	mg/L	0.002	-	-	-	<0.0001	-	-	0.002	-	-	-	-	-	-	-	-	-	0.0008	-	-	-
Calcium (Ca)	mg/L	-	85	92	94	94	140	150	-	540	530	560	510	540	540	490	470	420	562	360	380	390
Carbonate (CO32- as CaCO3)	mg/L	-	<5	<5	<5	31	<5	<5	-	-	-	<5	<5	<5	<5	<5	<5	<5	<1	<5	<5	<5
Chloride (Cl)	mg/L	250	3800	4300	4900	4760	6200	6700	-	18000	17000	20000	19000	19000	20000	19000	-	20000	19100	18000	18000	18000
Chromium (Cr)	mg/L	0.05	-	-	-	0.004	-	-	<0.005	-	-	-	-	-	-	-	-	-	<0.005	-	-	-
Cobalt (Co)	mg/L	-	-	-	-	<0.001	-	-	-	-	-	-	-	-	-	-	-	-	0.223	-	-	-
Copper (Cu)	mg/L	-	-	-	-	0.002	-	-	0.2	-	-	-	-	-	-	-	-	-	0.028	-	-	-
Fluoride (F)	mg/L	1.5	-	-	-	0.3	-	-	-	<0.1	-	-	-	-	-	-	-	-	0.1	-	-	-
Hydroxide (OH- as CaCO3)	mg/L	-	<5	<5	<5	<1	<5	<5	-	-	-	<5	<5	<5	<5	<5	-	<5	<1	<5	<5	<5
Iron (Fe)	mg/L	0.3	<0.01	<0.01	<0.01	<0.05	<0.01	<0.01	-	1.5	<0.1	<0.02	<0.01	0.02	<0.02	<0.02	-	<0.02	<0.25	<0.02	<0.01	<0.02
Lead (Pb)		0.01	-	-	-	<0.001	-	-	<0.02	-	-	-	-	-	-	-	-	-	<0.005	-	-	-
Magnesium (Mg)	mg/L	-	440	520	530	580	650	760	-	1800	1800	2000	1800	1900	2000	1900	1700	1700	1980	1600	1600	1600
Manganese (Mn)	mg/L	0.1	-	<0.005	0.035	0.004	-	0.11	-	0.39	0.42	-	-	0.59	0.54	0.69	-	0.25	0.48	-	-	0.12
Mercury (Hg)	mg/L	0.001	-	-	-	<0.0001	-	-	0.0018	-	-	-	-	-	-	-	-	-	<0.0001	-	-	-
Nickel (Ni)	mg/L	0.02	-	-	-	0.010	-	-	0.48	-	-	-	-	-	-	-	-	-	0.307	-	-	-
Nitrate (NO3)	mg/L	50	4.4	1.9	3.3	0.48	8.5	4.5	-	8.9	7.4	1.8	<25	1.3	<25	<25	<50	2.3	0.61	<0.005	<25	<0.005
Phosphate (PO4)	mg/L	-	<0.005	<0.005	<0.005	<0.10	<0.005	<0.005	-	-	<0.002	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.10	<0.005	<0.005	<0.005
Potassium (K)	mg/L	-	70	70	76	86	93	83	-	130	130	150	130	140	150	130	110	74	142	130	130	130
Selenium (Se)	mg/L	0.01	-	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.05	-	-	-
Silica (SiO2)	mg/L	80	15	13	12	10.1	20	17	-	8.4	8.8	7.4	13	5.8	6.4	6.1	-	12	7.4	13	13	11
Silicon (Si)	mg/L	-	-	-	-	4.70	-	-	-	-	-	-	-	-	-	-	-	-	3.44	-	-	-
Sodium (Na)	mg/L	180	2100	2400	2400	2580	3400	3700	-	8400	9100	11000	10000	11000	12000	11000	9000	10000	10800	9800	9600	9500
Strontium (Sr)	mg/L	-	-	-	-	-	-	-	-	4.6	-	-	-	-	-	-	-	-	-	-	-	-
Sulphate (SO4)	mg/L	250	840	970	1200	966	1200	1300	-	4000	3900	4200	4100	4300	4400	4300	-	4200	3970	3200	3200	3200
Titanium	mg/L	-	-	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.05	-	-	-
Vanadium	mg/L	-	-	-	-	<0.01	-	-	-	-	-	-	-	-	-	-	-	-	<0.05	-	-	-
Zinc (Zn)	mg/L	3	-	-	-	0.008	-	-	<0.01	-	<0.1	-	-	-	-	-	-	-	<0.025	-	-	-

* Field Measurement

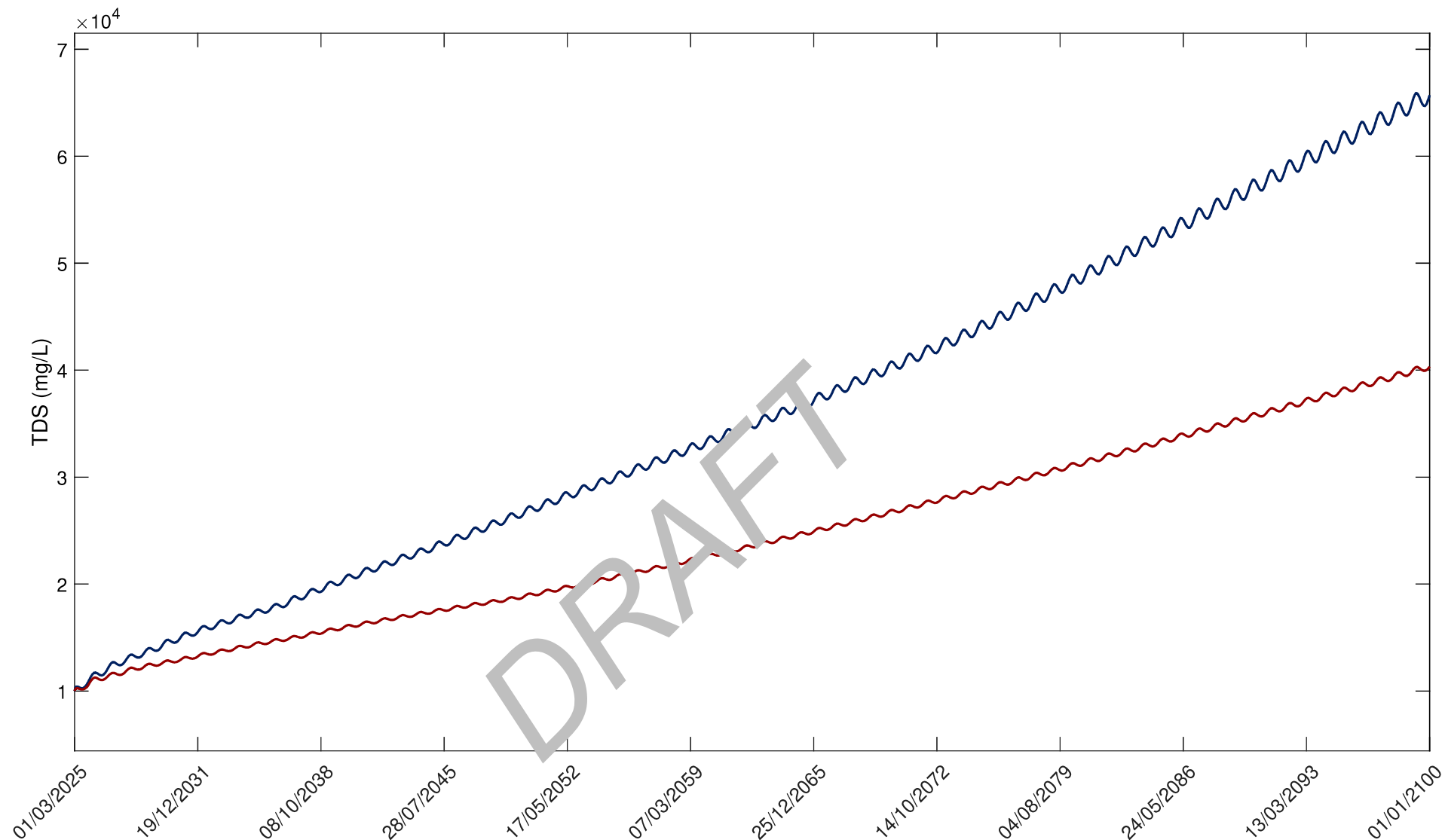
G-3 Pit Lake Salinity Modelling Results

Table 11 – Comparison of Equivalent Freshwater Heads in Groundwater to Pit Lakes

Pit	Groundwater					Lower Bound Pit Lake					Upper Bound Pit Lake				
	Head (m AHD)	TDS (mg/L)	Density (20C; kg/m ³)	Specific Gravity	Fresh Water Head (m AHD)	Elevation (m AHD)	TDS (mg/L)	Density (20C; kg/m ³)	Specific Gravity	Fresh Water Head (m AHD)	Elevation (m AHD)	TDS (mg/L)	Density (20C; kg/m ³)	Specific Gravity	Fresh Water Head (m AHD)
J4E	405	10,000	1,002	1.00	405	357	66,000	1,049	1.05	360	376	41,000	1,029	1.03	378
Carina	405	32,000	1,023	1.02	408	357	180,000	1,142	1.14	367	370	135,000	1,104	1.10	378
Carina Ext.	405	32,000	1,023	1.02	406	365	SL	1,308	1.31	365	388	SL	1,308	1.31	395

SL: Exceeds solubility limit

DRAFT



— J4 East (Lower Bound Median)

— J4 East (Upper Bound Median)



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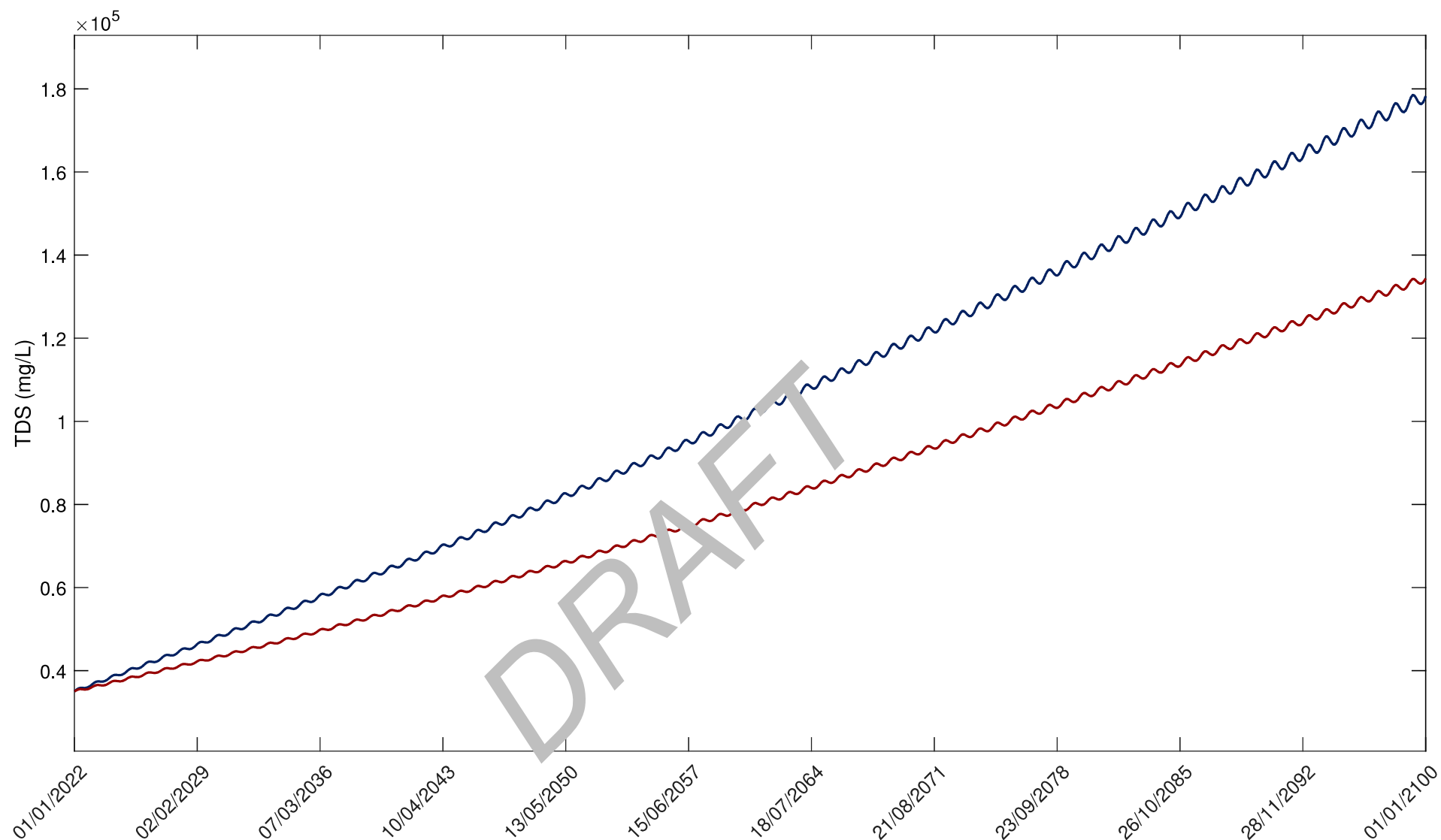
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Yilgarn Operations MCP
Hydrogeological Considerations

Predicted Pit Lake Water Salinity
Mt Jackson J4
J4 East

PSM4553-006R

Figure I1



— Carina (Lower Bound Median)

— Carina (Upper Bound Median)



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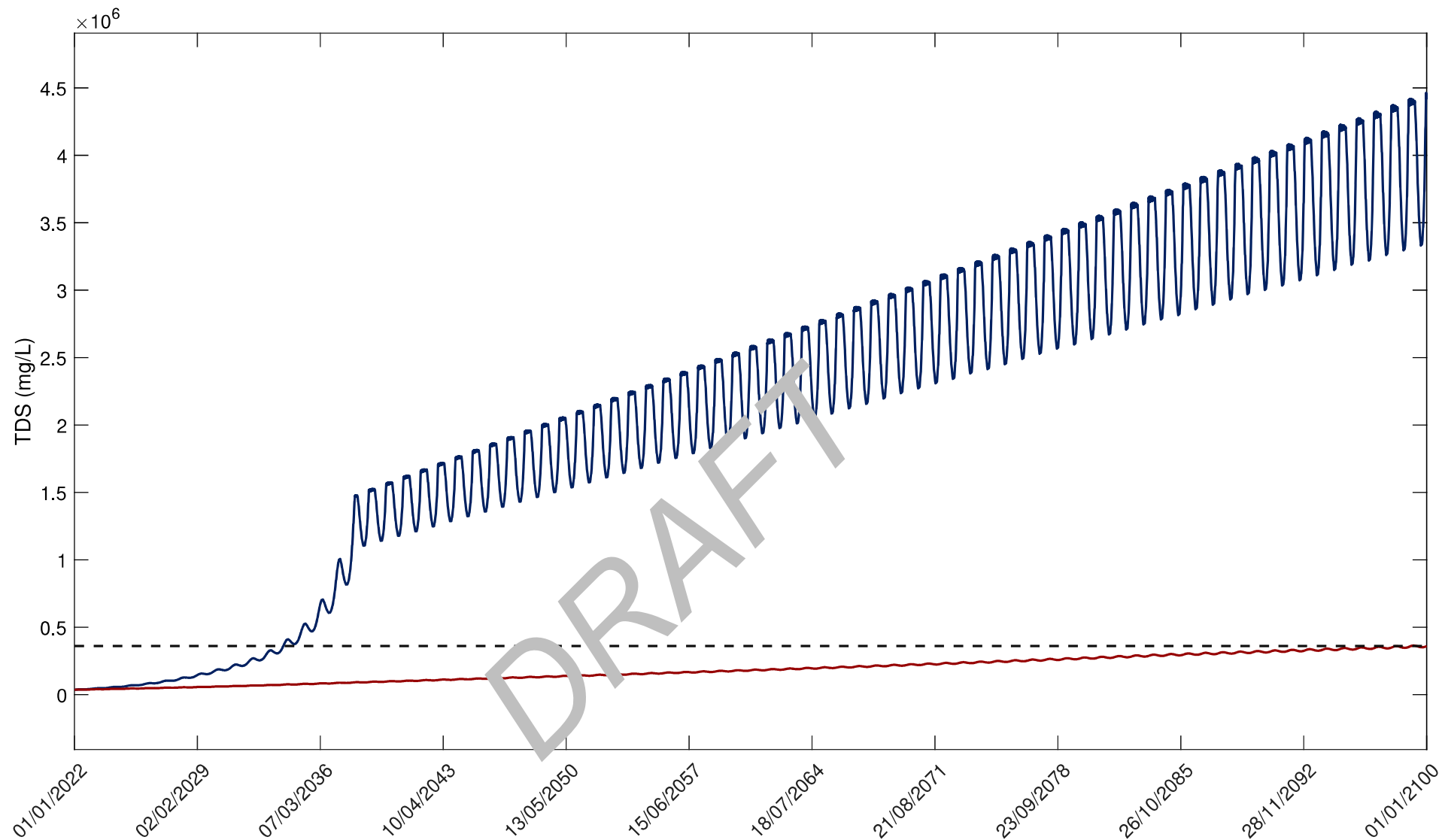
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Yilgarn Operations MCP
Hydrogeological Considerations

Predicted Pit Lake Water Salinity
Carina
Carina Pit

PSM4553-006R

Figure I2



— Carina Extended (Lower Bound Median)

— Carina Extended (Upper Bound Median)

- - - Typical Solubility Limit



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Yilgarn Operations MCP
Hydrogeological Considerations

Predicted Pit Lake Water Salinity
Carina
Carina Extended

PSM4553-006R

Figure I3



APPENDIX H

WRL PERFORMANCE

H-1 Vegetation Performance Data

Table H.1: Location, type and corresponding vegetation community of 2022 monitoring sites

Site setup	Location	Vegetation community code	Site type	Site name	Zone	Easting	Northing	Year rehabilitation completed	Year monitoring established	No. transects (length (m))	No. quadrats within transect	No. overstorey quadrats
Transect	Haul road borrow pit (Carina)	W31	Rehabilitation	SR01	51	225060	6609045	2014	2015	2 (25)	10	1
			Analogue	SC01	50	741039	6588076	n/a		1 (50)	10	1
		W30	Rehabilitation	SR02	51	233609	6597388	2015		2 (25)	10	1
			Analogue	SC02	51	233843	6597360	n/a		1 (50)	10	1
		W15	Rehabilitation	SR03	51	215278	6623924	2014		1 (50)	10	1
			Analogue	SC03	51	215216	6623872	n/a		1 (50)	10	1
		W33	Rehabilitation	SR04	51	221806	6614149	2012		2 (25)	10	1
			Analogue	SC04	51	222094	6613619	n/a		1 (50)	10	1
	WRL (Carina)	W2	Rehabilitation	SR21	50	786757	6626468	2018	2018	1 (50)	10	1
				SR22	50	787006	6626191	2015		1 (50)	10	1
				SR23	50	787658	6626475	2015		2 (25)	10	1
				SR24	50	787484	6626679	2015		1 (50)	10	1
				SR25	50	787290	6626492	2015		2 (25)	10	1
		W4	Analogue	SC05	50	787024	6625806	n/a	2015	1 (50)	10	1
		W22	Analogue	SC06	50	787944	6626239		2017	1 (50)	10	1
		W2	Analogue	SC10	50	786461	6626351		2018	1 (50)	10	1
	WRL (Carina Extended)	W2	Rehabilitation	SR26	50	785612	6629058	2018	2018	1 (50)	10	1
				SR27	50	785634	6628656			1 (50)	10	1
				SR28	50	786163	6628823			2 (25)	10	1
				SR29	50	785955	6628889			2 (25)	10	1
				SR30	50	785948	6628556			2 (25)	10	1
			Analogue	SC07	50	786300	6628604	n/a	2017	1 (50)	10	1

Site setup	Location	Vegetation community code	Site type	Site name	Zone	Easting	Northing	Year rehabilitation completed	Year monitoring established	No. transects (length (m))	No. quadrats within transect	No. overstorey quadrats
			Analogue	SC11	50	785585	6629395		2018	1 (50)	10	1
			Analogue	SC12	50	785314	6628500		2018	1 (50)	10	1
Quadrat	Road infrastructure (Carina)	S15	Rehabilitation	PR01	51	231750	6599665	2015	2015	N/A	1	0
			Analogue	PC01	50	769188	6621354	n/a			1	0
		S14	Rehabilitation	PR02	51	232374	6598878	2015			1	0
			Analogue	PC02	51	232411	6598881	n/a			1	0
		W1	Rehabilitation	PR03	51	233067	6598107	2015			1	0
			Analogue	PC03	51	233079	6598119	n/a			1	0
		S13	Rehabilitation	PR04	51	236525	6594560	2015			1	0
			Analogue	PC04	51	236516	6594538	n/a			1	0
		S12(b)	Rehabilitation	PR05	51	239361	6591519	2015			1	0
			Analogue	PC05	51	239348	6591523	n/a			1	0
		S11	Rehabilitation	PR06	51	241647	6588660	2015			1	0
			Analogue	PC06	51	241666	6588666	n/a			1	0
		W22	Rehabilitation	PR07	51	212050	6625871	2015	2016		1	0
			Analogue	PC07	51	212132	6625991	n/a	2017		1	0
		W4	Rehabilitation	PR08	51	212234	6625477	2015	2016		1	0
			Analogue	PC08	51	212282	6625481	n/a	2017		1	0
		W12	Rehabilitation	PR09	51	212796	6625800	2015	2016		1	0
			Analogue	PC09	50	212804	6625895	n/a	2017		1	0

Source: Astron (2023a)

Erosion Performance Data

Table H.2: Erosion monitoring at Carina Extension WRL rehabilitation sites (2018 - 2019)

Site	Year	Average no. rills	Average maximum rill width (m)	Average maximum rill depth (m)
SR26	2018	0.30 (1)	0.07 (0.13)	0.05 (0.06)
	2019	0.10 (1)	0.14 (0.14)	0.05 (0.05)
SR27	2018	0.60 (1)	0.14 (0.21)	0.08 (0.17)
	2019	0.40 (1)	0.14 (0.20)	0.06 (0.10)
SR28	2018	0.30 (1)	0.20 (0.25)	0.11 (0.14)
	2019	0.50 (1)	0.19 (0.36)	0.09 (0.17)
SR29	2018	0.20 (1)	0.14 (0.20)	0.06 (0.06)
	2019	0.40 (1)	0.14 (0.30)	0.04 (0.08)
SR30	2018	0.30 (1)	0.20 (0.45)	0.07 (0.12)
	2019	0.20 (1)	0.11 (0.12)	0.07 (0.08)

Note: (Parenthesis denotes maximum recorded with a single quadrat)
Source: Astron (2020a)

Table H.3: Erosion monitoring at Carina WRL rehabilitation sites in (2018 - 2019)

Site	Year	Average no. rills	Average maximum rill depth (m)	Average maximum rill width (m)
SR21	2018	0.20 (1)	0.13 (0.19)	0.11 (0.11)
	2019	0.90 (2)	0.49 (0.80)	0.62 (1.65)
SR22	2018	0.60 (2)	0.07 (0.13)	0.12 (0.16)
	2019	0.50 (2)	0.08 (0.15)	0.24 (0.50)
SR23	2018	1.60 (3)	0.09 (0.19)	0.20 (0.48)
	2019	1.60 (4)	0.09 (0.20)	0.24 (0.50)
SR24	2018	1.30 (5)	0.09 (0.16)	0.24 (0.44)
	2019	0.70 (3)	0.11 (0.20)	0.30 (0.62)
SR25	2018	0.70 (2)	0.08 (0.17)	0.19 (0.29)
	2019	1.00 (3)	0.07 (0.15)	0.26 (0.46)

Note: (Parenthesis denotes maximum recorded with a single quadrat)
Source: Astron (2020a)

Table H.4: Erosion monitoring at Carina WRL rehabilitation sites (2020 - 2022)

Site	Year	Average no. rills	Average rill width (m)	Average rill depth (m)	Active (%)	Stable (%)
SR21	2020	1.10 (2)	0.49 (1.70)	0.29 (0.80)	50.0	40.0
	2022	1.33 (2)	0.67 (1.20)	0.32 (0.50)	100.0	0.0
SR22	2020	0.40 (2)	0.10 (0.72)	0.03 (0.15)	0.0	100.0
	2022	0	0	0	NA	NA
SR23	2020	1.80 (4)	0.22 (0.53)	0.07 (0.22)	75.0	80.0
	2022	1.25 (2)	0.32 (0.50)	0.27 (0.80)	100.0	20.0
SR24	2020	0.40 (2)	0.09 (0.40)	0.02 (0.10)	0.0	100.0
	2022	0	0	0	NA	NA
SR25	2020	1.00 (2)	0.20 (0.60)	0.04 (0.08)	12.5	87.5
	2022	1.00 (1)	0.40 (0.40)	0.10 (0.10)	100.0	0.0

Note: (Parenthesis denotes maximum recorded with a single quadrat)

Source: Astron (2023a)

Table H.5: Erosion monitoring at Carina Extended WRL rehabilitation sites (2020 - 2022)

Site	Year	Average no. rills	Average rill width (m)	Average rill depth (m)	Active (%)	Stable (%)
SR26	2020	0.60 (1)	0.10 (0.22)	0.04 (0.12)	16.7	83.3
	2022	1.00 (1)	0.20 (0.20)	0.09 (0.10)	100.0	0.0
SR27	2020	1.00 (2)	0.27 (0.62)	0.13 (0.45)	55.6	33.3
	2022	1.25 (2)	0.94 (2.50)	0.31 (0.40)	100.0	0.0
SR28	2020	0.60 (2)	0.28 (1.12)	0.11 (0.44)	33.3	50.0
	2022	1.00 (1)	0.38 (0.71)	0.20 (0.28)	100.0	0.0
SR29	2020	0.40 (1)	0.19 (0.96)	0.03 (0.17)	50.0	50.0
	2022	1.00 (1)	0.57 (0.57)	0.12 (0.12)	100.0	0.0
SR30	2020	0.60 (2)	0.15 (0.45)	0.05 (0.13)	0.0	100.0
	2022	1.00 (1)	0.24 (0.26)	0.11 (0.13)	100.0	0.0

Note: (Parenthesis denotes maximum recorded with a single quadrat)

Source: Astron (2023a)



APPENDIX I

RISK MATRICES

CONSEQUENCE DESCRIPTIONS

		Factor	Consequence Descriptor					
			Insignificant	Minor	Medium	Major	Severe	
MCP	MP	Biodiversity	Alteration or disturbance to an isolated area with no effect on habitat or ecosystem.	Alteration or disturbance to <10% of a habitat or ecosystem resulting in a recoverable impact within 2 years.	Alteration or disturbance to 10-40% of a habitat or ecosystem resulting in a recoverable impact within 2-5 years.	Alteration or disturbance to 40-70% of a habitat or ecosystem resulting in a recoverable impact within 5-15 years.	Alteration or disturbance to >70% of a habitat or ecosystem resulting in a recoverable impact >15 years.	
			Loss of an individual plant / animal of conservation significance.	Loss of multiple plants / animals of conservation significance.	Loss of <50% known local population of plant / animal of conservation significance.	Loss of >50% known local population of plant / animal species with possible loss of entire local population.	Local loss of conservation significant or listed species. Extinction of a species.	
		Water Resources	Negligible change to hydrological processes, water availability or water quality.	Short-term modification of hydrological processes, water availability and quality within project tenure, but no change in beneficial use.	Medium-term modification of hydrological processes, water availability and water quality within project tenure, but no change in beneficial use.	Long-term modification of hydrological processes, water availability and water quality within project tenure, but no change in beneficial use.	Long-term or permanent modification of hydrological processes, water availability or water quality outside project tenure, with impacts to a water-dependent environmental value and/or change in beneficial use.	
					Short-term modification of hydrological processes, water availability and water quality outside project tenure, but no change in beneficial use.	Medium-term modification of hydrological processes, water availability and water quality outside project tenure, with change in beneficial use		
		Land and Soils	Clean-up by site personnel, rectified immediately. Confined to immediate area around source.	Clean-up by site personnel, remediation within 1 year. Confined to operational area.	Clean-up by site personnel, remediation within 1-3 years.	Clean-up requiring external specialist, remediation within 3-10 years.	Clean-up requiring external specialist. Remediation >10 years, or permanent residual impact.	
					Minor impact outside disturbance envelope or minor impact to soil stockpiles.	Impact has migrated outside the disturbance envelope or contamination of soil stockpiles.	Impact outside the tenement boundary.	
		Rehabilitation & Mine Closure	Site is safe, stable a non-polluting.	Site is safe, all major landforms are stable, and any stability or pollution issues are contained and require no residual management.	Site is safe, and any stability or pollution issues require minor, ongoing maintenance by end land-user.	Site cannot be considered safe, stable or non-polluting without long-term management or intervention.	Site is unsafe, unstable and/or causing pollution or contamination that will cause an ongoing residual affect.	
			Post mining land use is not adversely affected.	Post mining land use is not adversely affected.	Post mining land use cannot proceed without some management.	Post mining land use cannot proceed without ongoing management.	Post mining land use cannot be achieved.	
			Reputation	Minor public concern restricted to local individual complaints. Infrequent scrutiny / attention from regulator.	Infrequent local public or media attention and complaints. Infrequent scrutiny / attention from regulator.	Frequent adverse attention from local media and/or heightened concern by local community. Ongoing scrutiny / attention from regulator. Some difficulties in gaining approvals for future projects.	Significant adverse national media / public attention. Licence to operate threatened. Significant difficulties in gaining approvals for future projects.	Ongoing adverse public or media outcry (international coverage). May temporarily lose license to operate. Reputation adversely affected. Share price may be affected.
			Social / Community	Nil or minor disturbance of local community / social structures.	Low impacts on local community / social structures, fully repairable (e.g. single community / stakeholder complaint).	Ongoing local community / social issues, mostly repairable (e.g. isolated complaints from several local community members / stakeholders).	Significant adverse community impact and reaction (e.g. organised community protests threatening business continuity).	Major adverse community impact and reaction affecting long term business continuity. “License to operate” revoked or under jeopardy.
	Legal / Regulatory		Questionable or minor noncompliance with legal obligations. No fine or prosecution. Unlikely to attract regulatory interest. Easy to resolve	Non-compliance with legal obligations. Could attract low level administrative response from regulator. No court appearance required	Minor breach of local or national law with potential prosecution by regulator. Continuing occurrence of minor breaches.	Significant breach of local or national law. Prosecution or penalties by regulator likely. Short term threat to operations continuing. Civil action initiated.	Major breach of national or international law with potential prison sentences. Operations suspended or cease (short or long term). Licenses withdrawn or revoked. Class action initiated.	
	Safety		No treatment or First Aid Injury (FAI).	Medical Treatment Injury (MTI) Restricted Work Injury (RWI)	Lost Time Injury (LTI). Direct breach of MRL Cardinal Rule(s)	Single permanent disability or single fatality. Direct breach of MRL Cardinal Rule(s) over multiple periods	Multiple permanent disabilities or fatalities	
	Material Losses		Minor impact, easily corrected with no loss of operations, and/or < \$20,000 asset damage / material loss.	Minor damage to equipment or infrastructure with minimal loss of operations (< 1 day), > \$20,000 and/or ≤ \$100,000 asset damage / material loss.	Damage to equipment or infrastructure causes temporary loss of operations (<1 week), > \$100,000 and/or ≤ 500,000 asset damage / material loss.	Significant damage to equipment or infrastructure causes operations to cease (< 1 month), > \$500,000 and/or ≤\$1,000,000 asset damage / material loss.	Major damage to equipment or infrastructure causes operations to cease (> 1 month), and/or > \$1,000,000 asset damage / material loss.	

LIKELIHOOD DESCRIPTIONS

Likelihood	Frequency for Operations	Description	Frequency for Closure
Almost Certain	Twice or more per year	Event will occur during the Project / period under review	one in 1
		High number of known incidents	
Likely	Once per year	Event likely to occur during the Project / period under review	one in 5
		Regular incidents known	
Possible	Once in 5 years	Event may occur in some instances during the Project / period under review	one in 10
		Occasional incidents known	
Unlikely	Once in 10 years	Event is not likely to occur during the Project / period under review	one in 20
		Some occurrences known	
Rare	Once in 20 years	Event will occur in exceptional circumstances during the Project / period under review	one in 100
		Very few or no known occurrences	

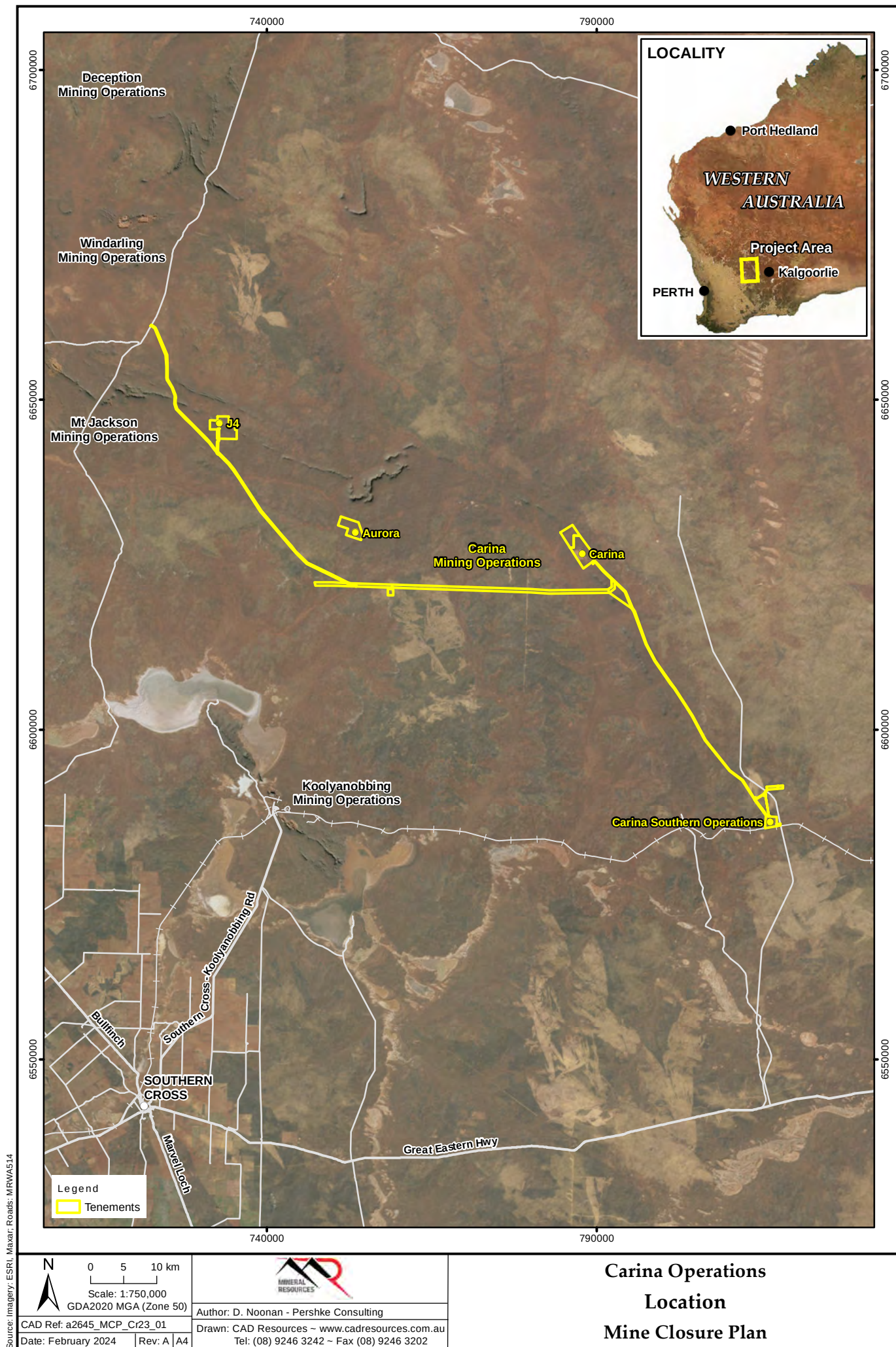
RISK MATRIX TABLE

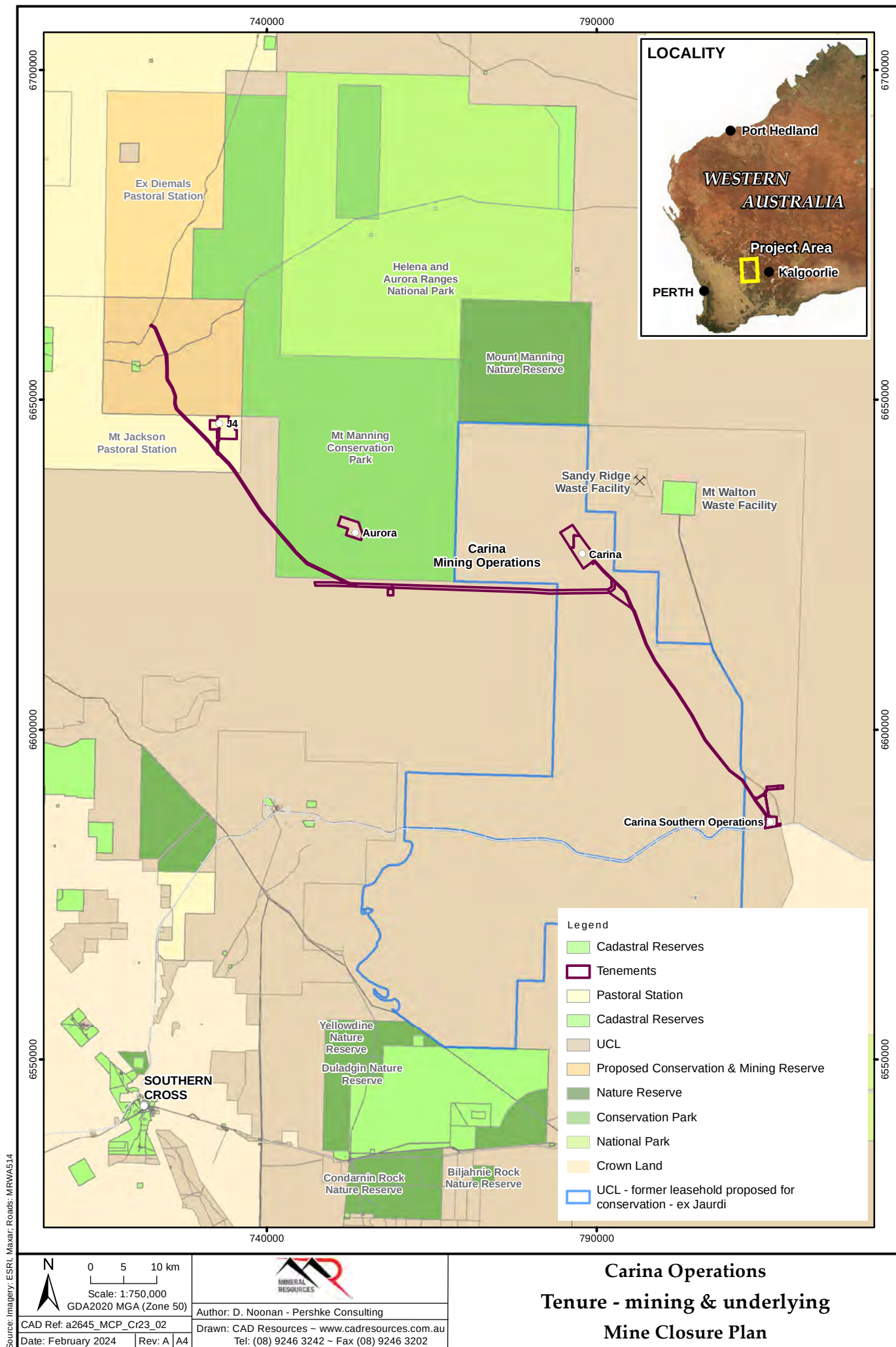
		Consequences				
		Insignificant	Minor	Medium	Major	Severe
Likelihood	Rare	Low	Low	Low	Medium	Medium
	Unlikely	Low	Low	Medium	Medium	High
	Possible	Low	Medium	Medium	High	High
	Likely	Medium	Medium	High	High	Extreme
	Almost Certain	Medium	High	High	Extreme	Extreme

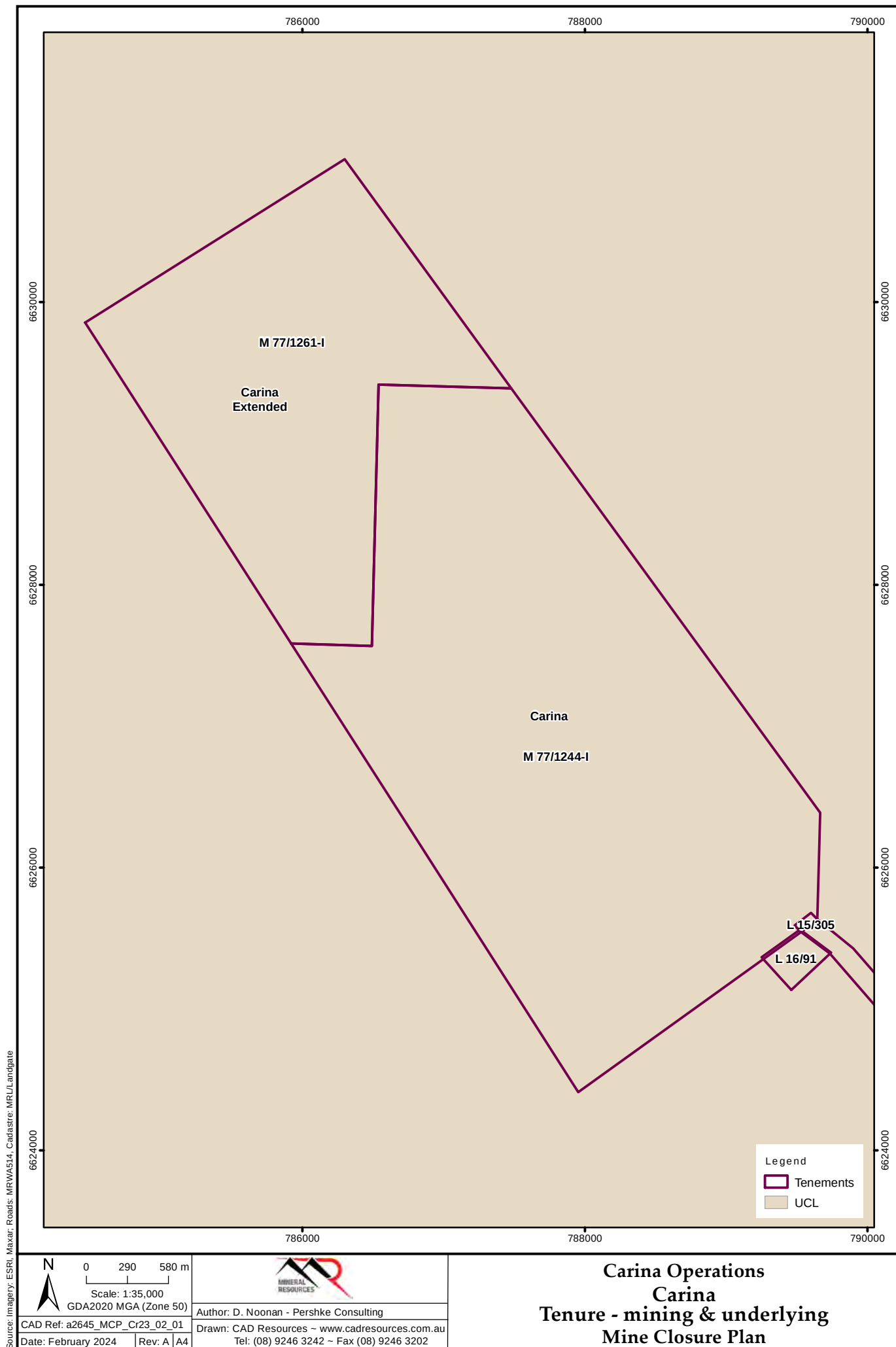


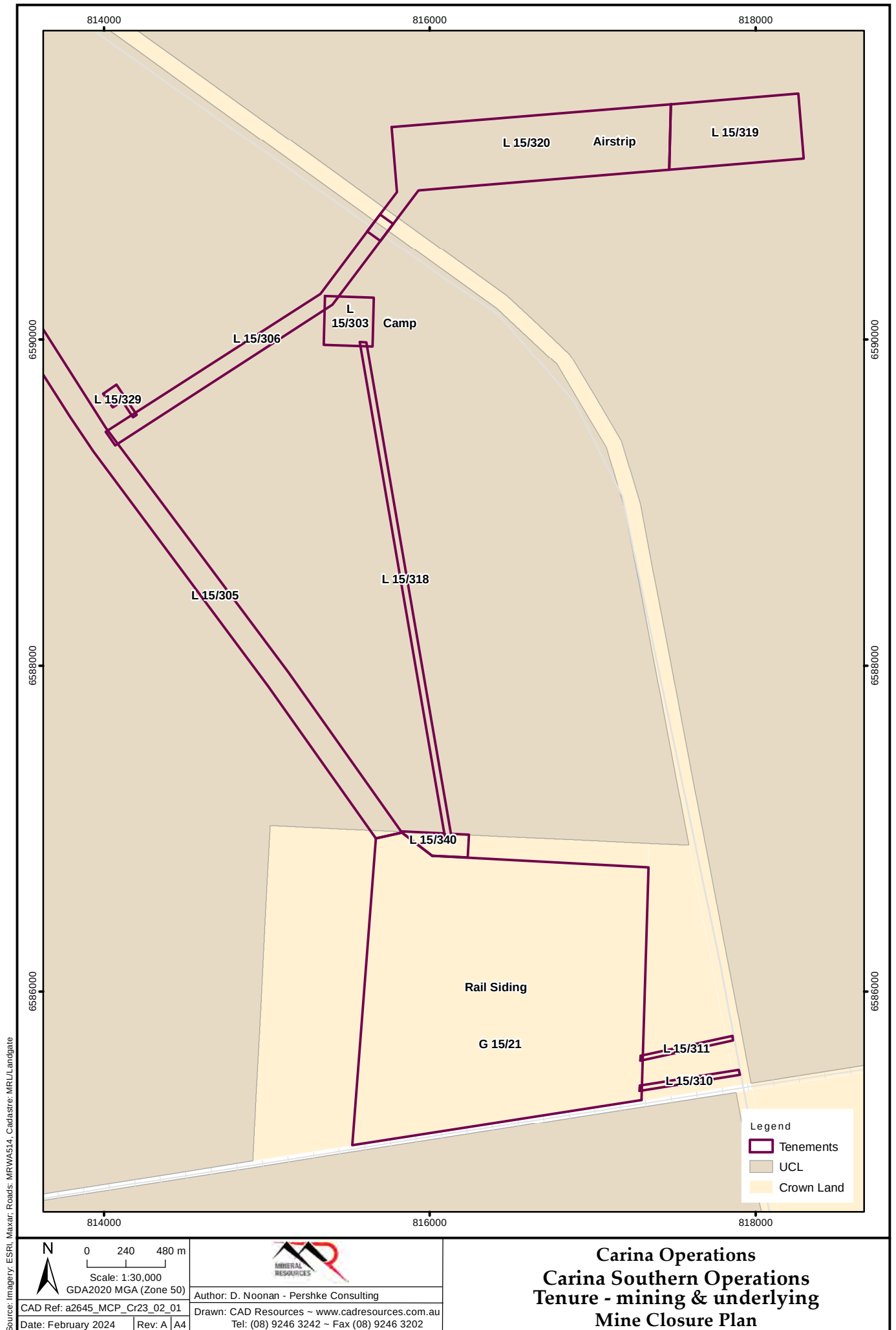
APPENDIX J

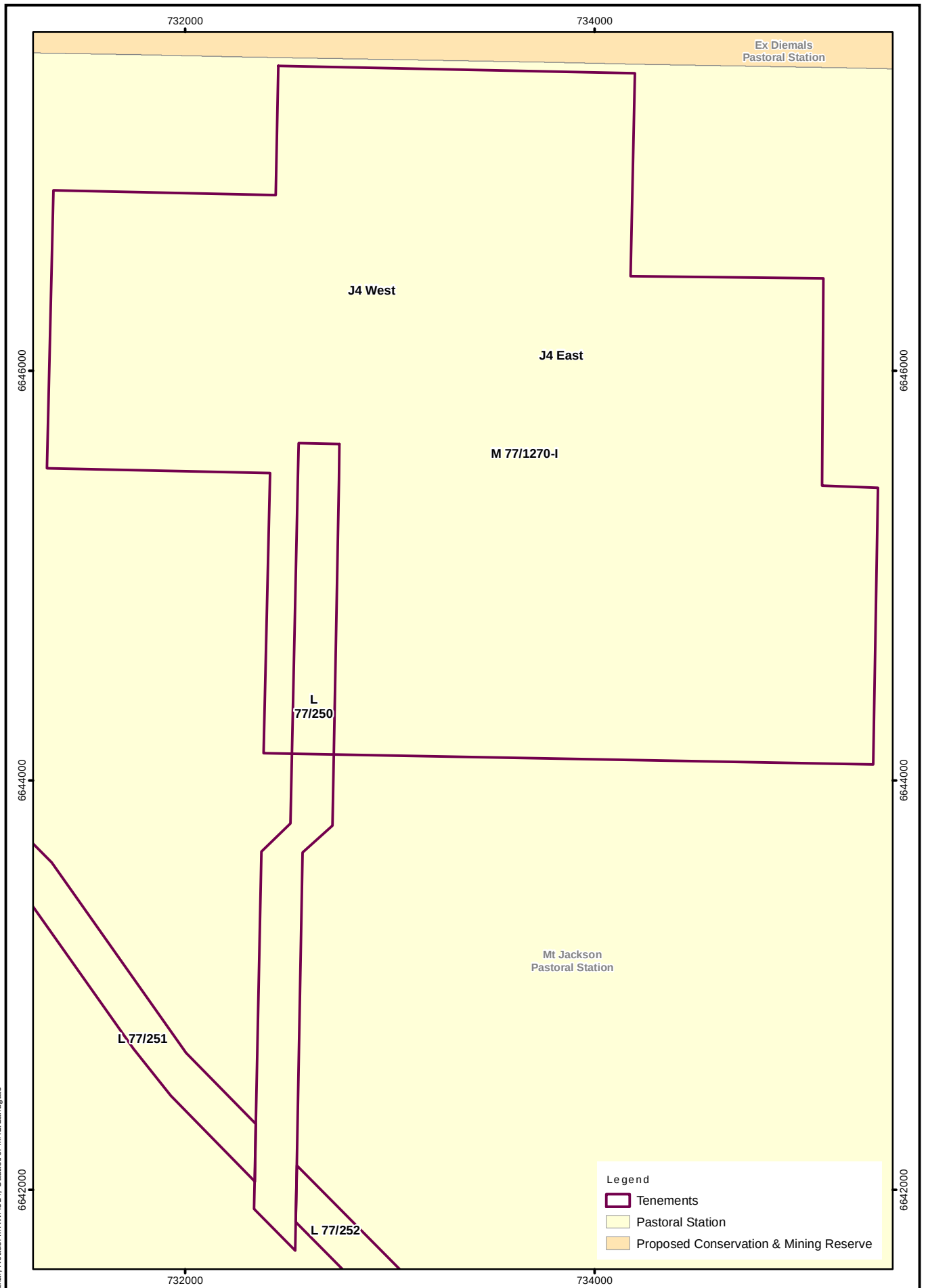
MAPS











Source: Imagery: ESRI, Maxar, Roads: MRWAS14, Cadastre: MRL/Landgate



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Scale: 1:25,000
GDA2020 MGA (Zone 50)



Author: D. Noonan - Pershke Consulting

CAD Ref: a2645_MCP_Cr23_02_01

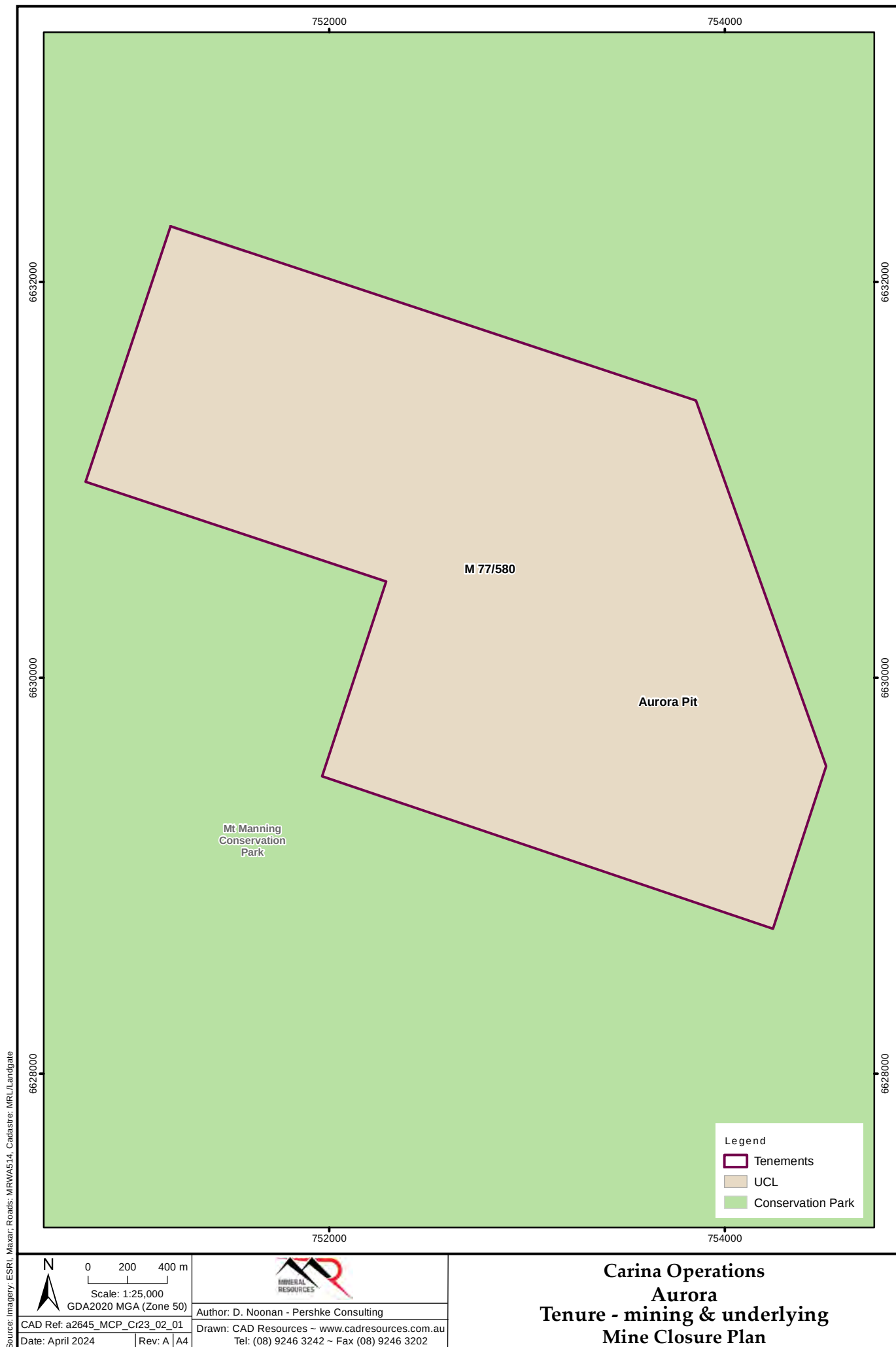
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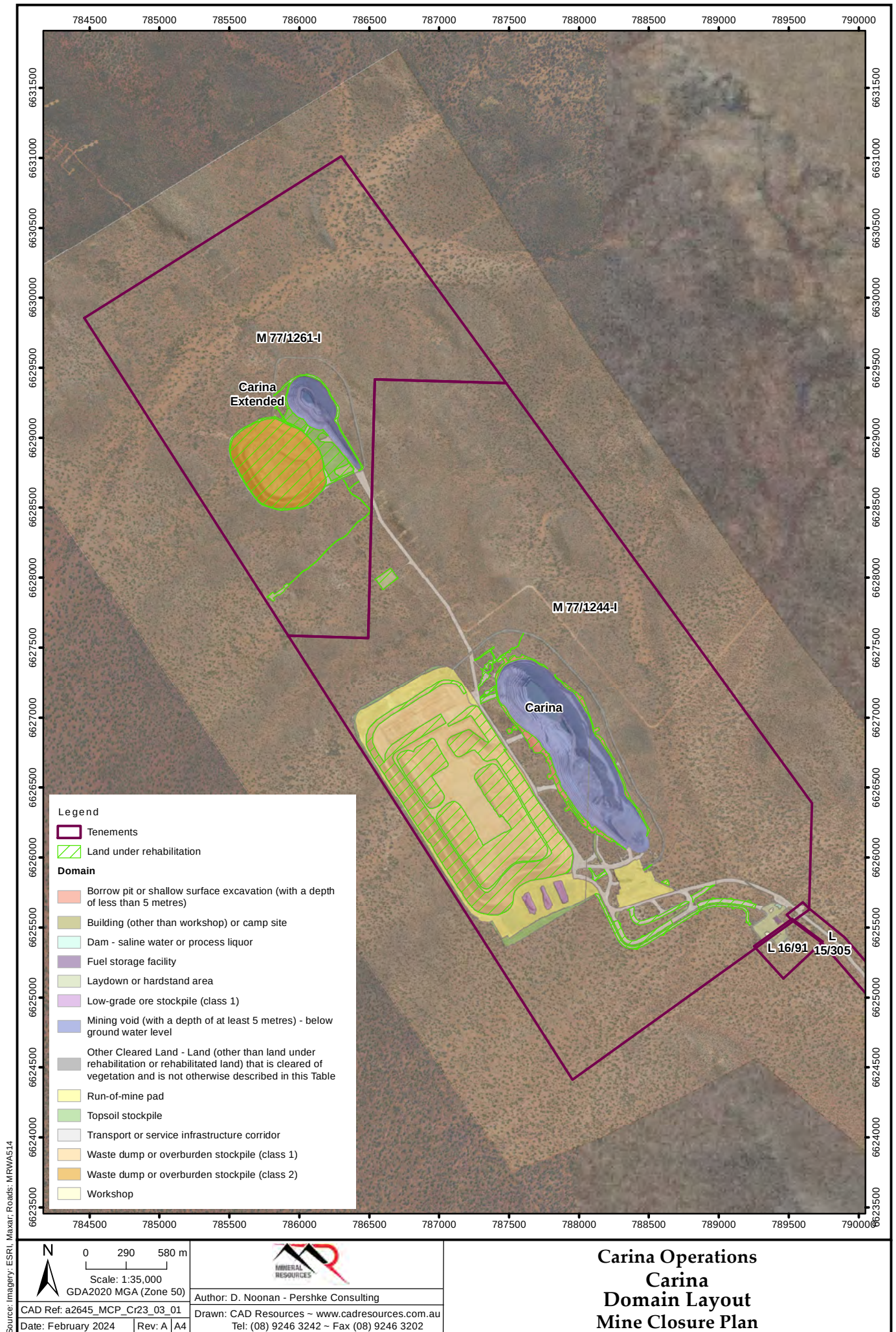
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Rev: A | A4

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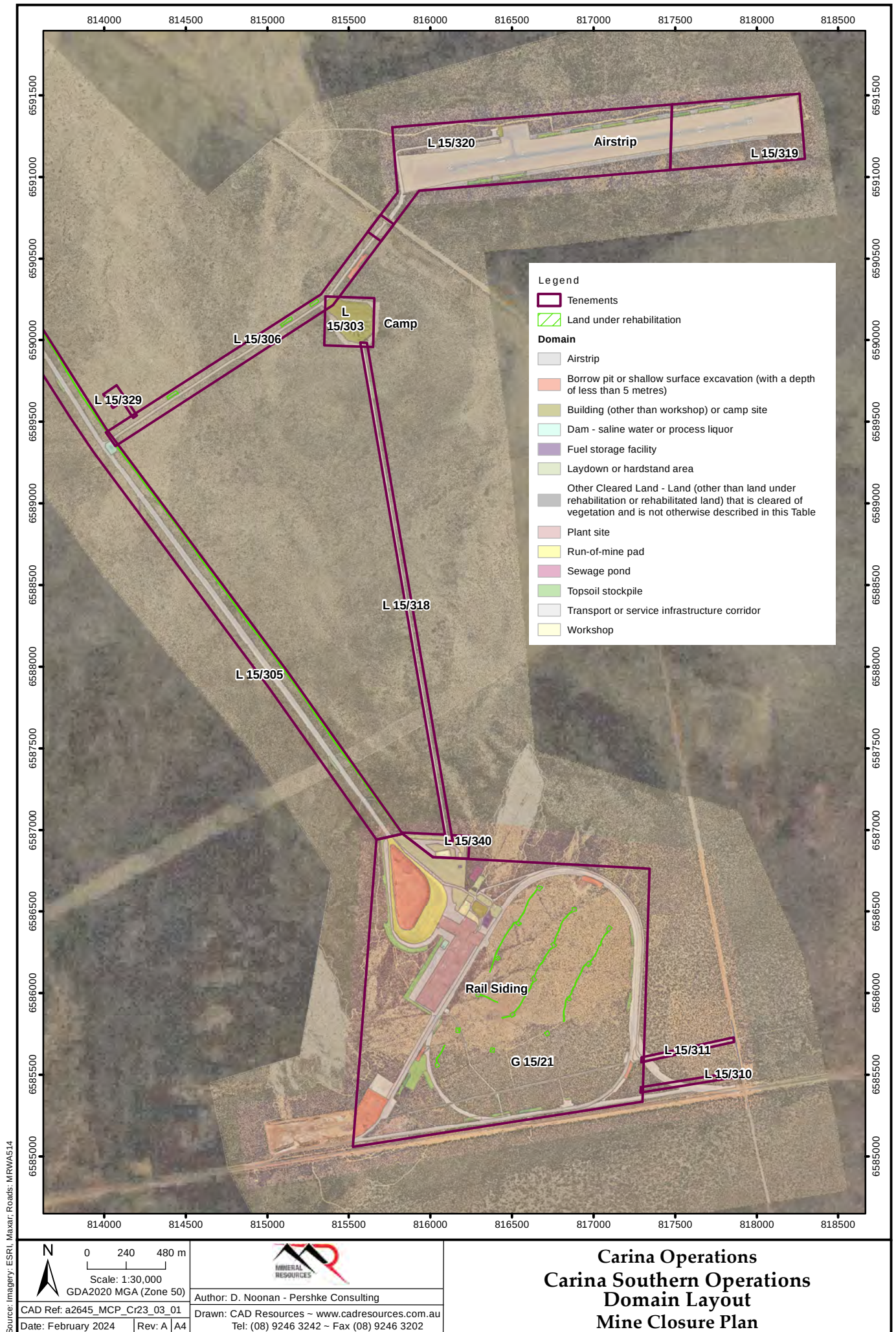
Carina Operations J4 Tenure - mining & underlying Mine Closure Plan

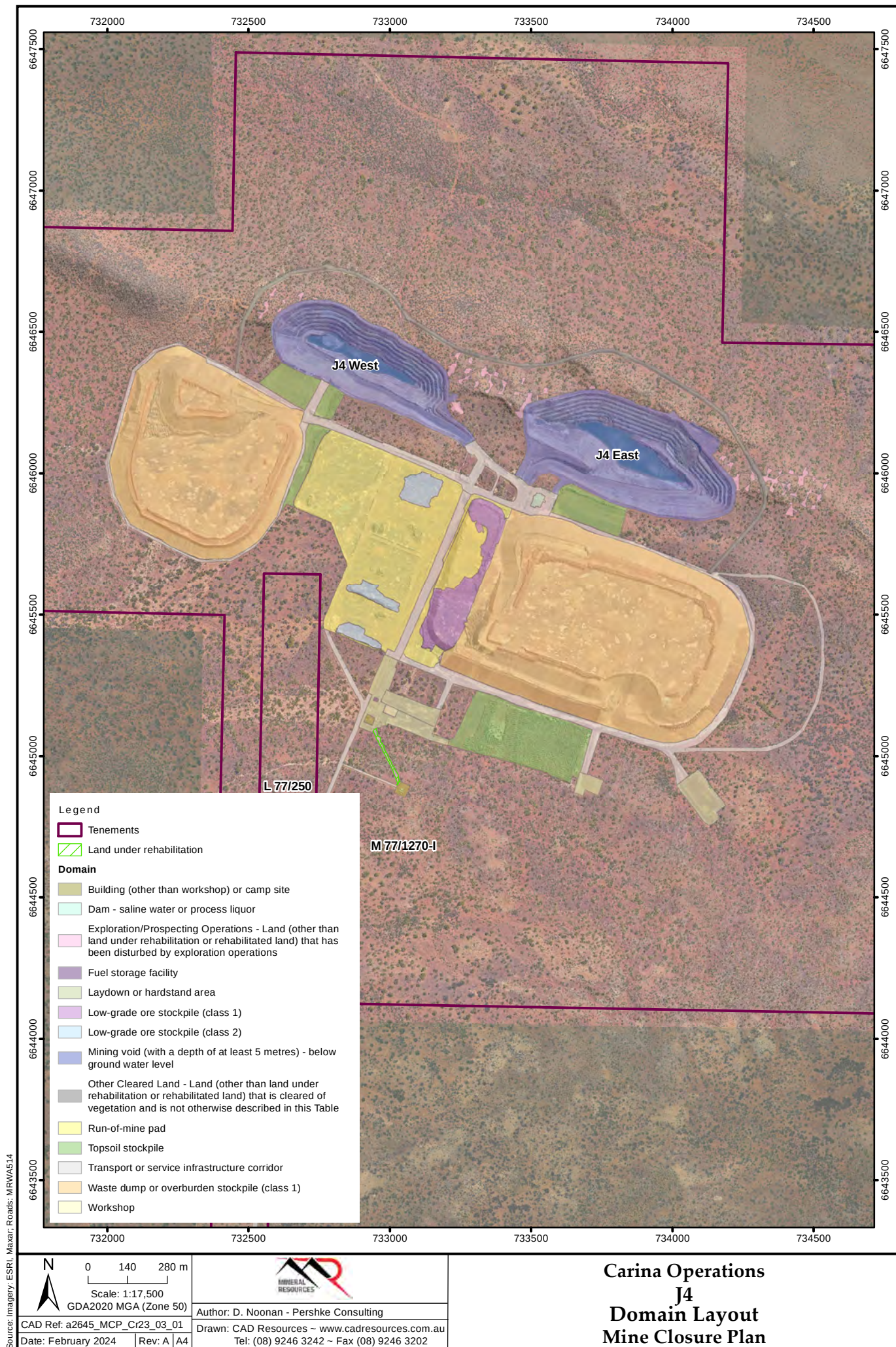


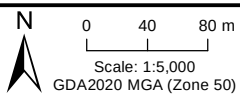
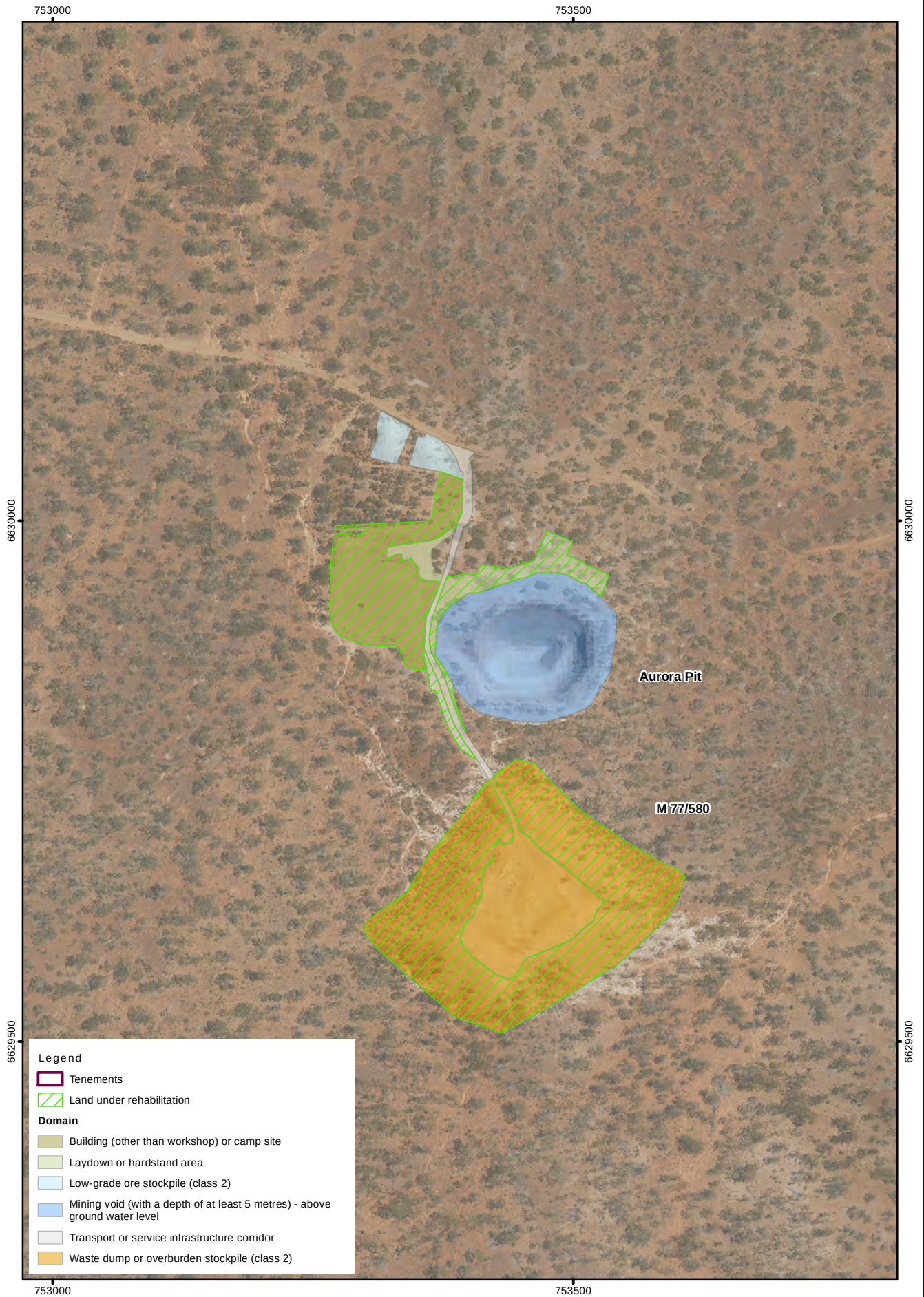


Carina Operations Carina Domain Layout Mine Closure Plan

CAD Ref: a2645_MCP_Cr23_03_01
Date: February 2024
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A4





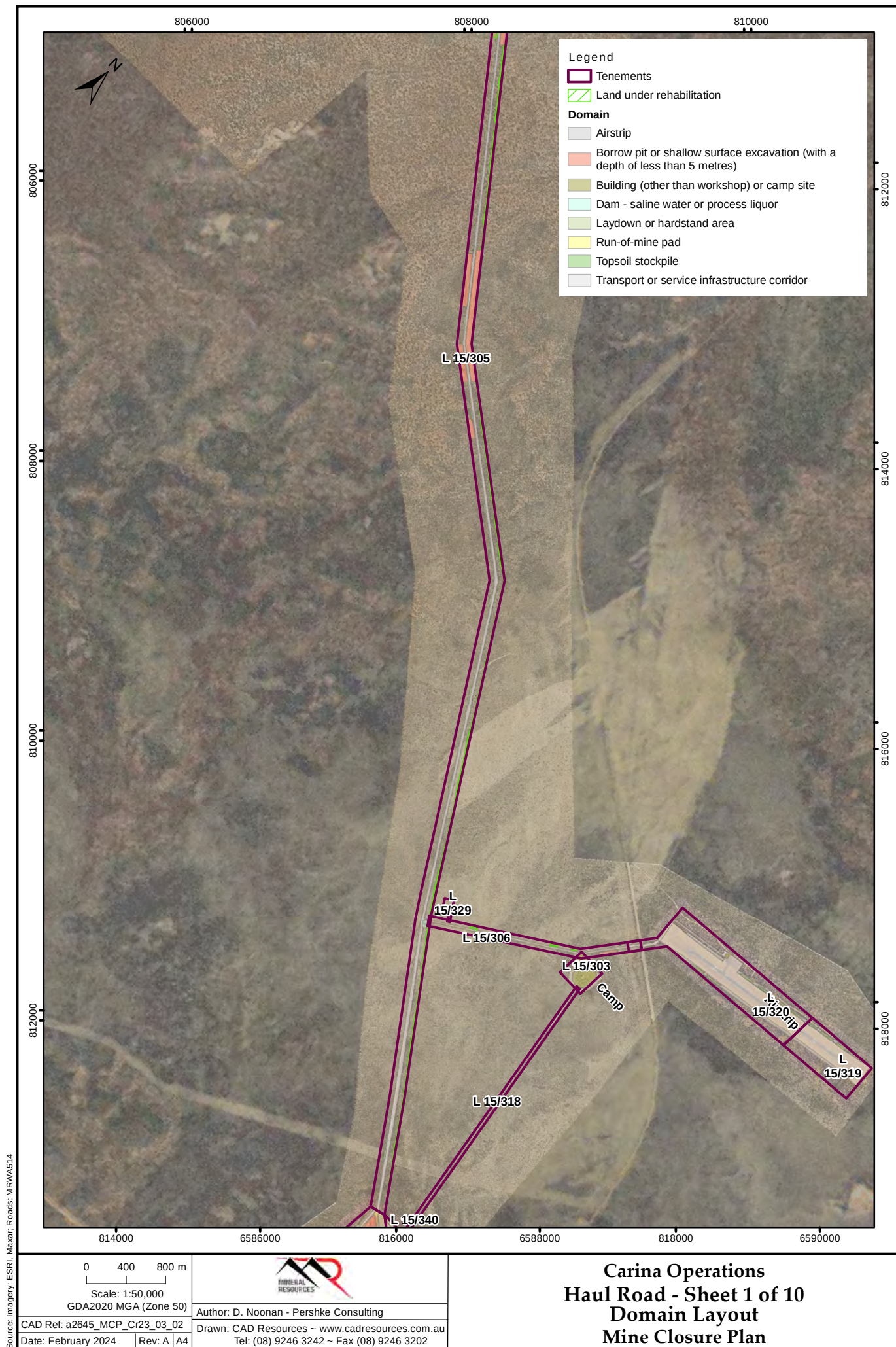


Author: D. Noonan - Pershke Consulting
 Drawn: CAD Resources ~ www.cadresources.com.au
 Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

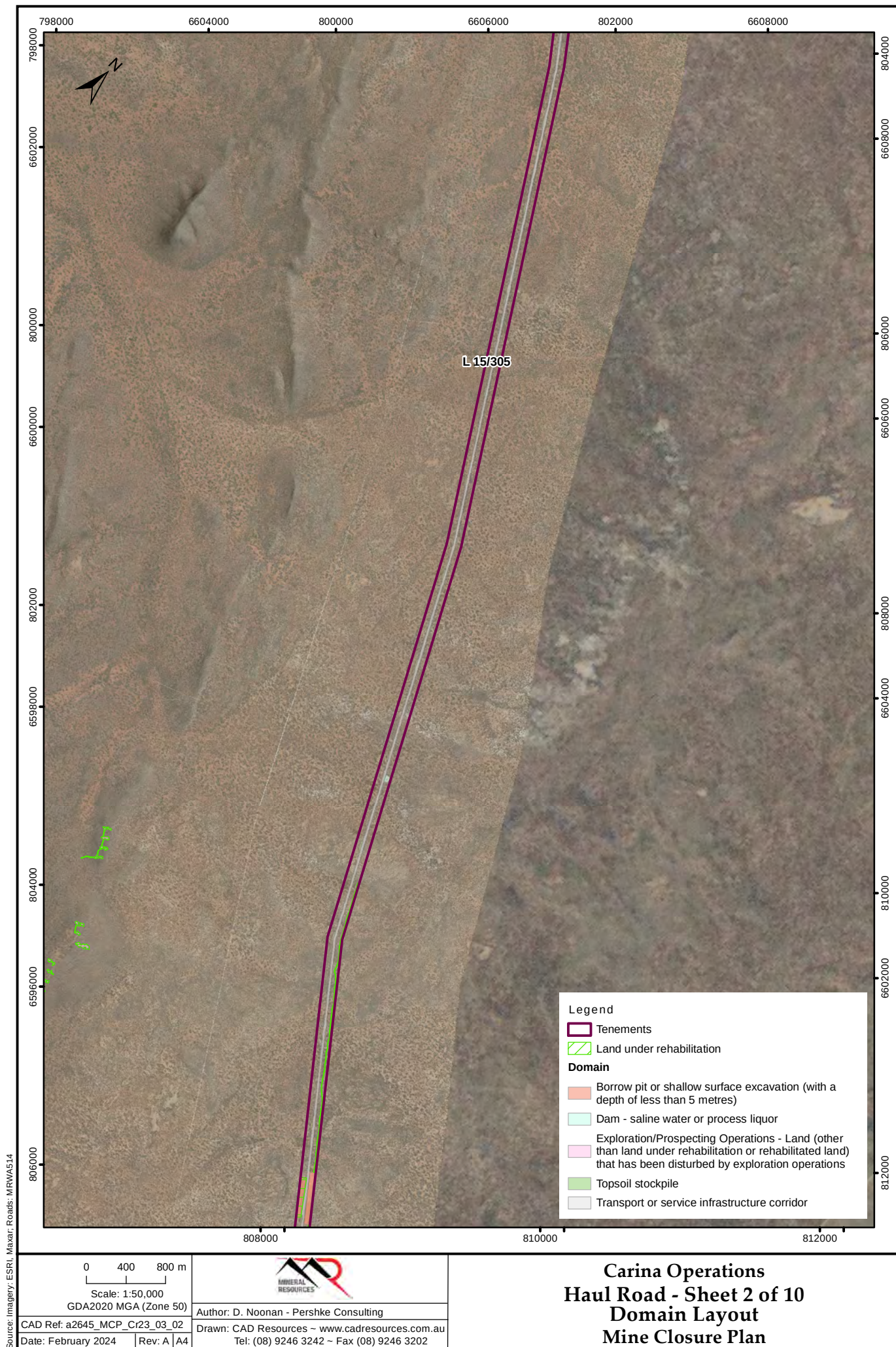
Carina Operations Aurora Domain Layout Mine Closure Plan

Source: Imagery: ESRI Maxar Roads: MRWAS14

CAD Ref: a2645_MCP_Cr23_03_01
 Date: February 2024 Rev: A A4



Source: Imagery: ESRI, Maxar, Roads: MRWAS14



Source: Imagery: ESRI, Maxar, Roads: MRWAS14

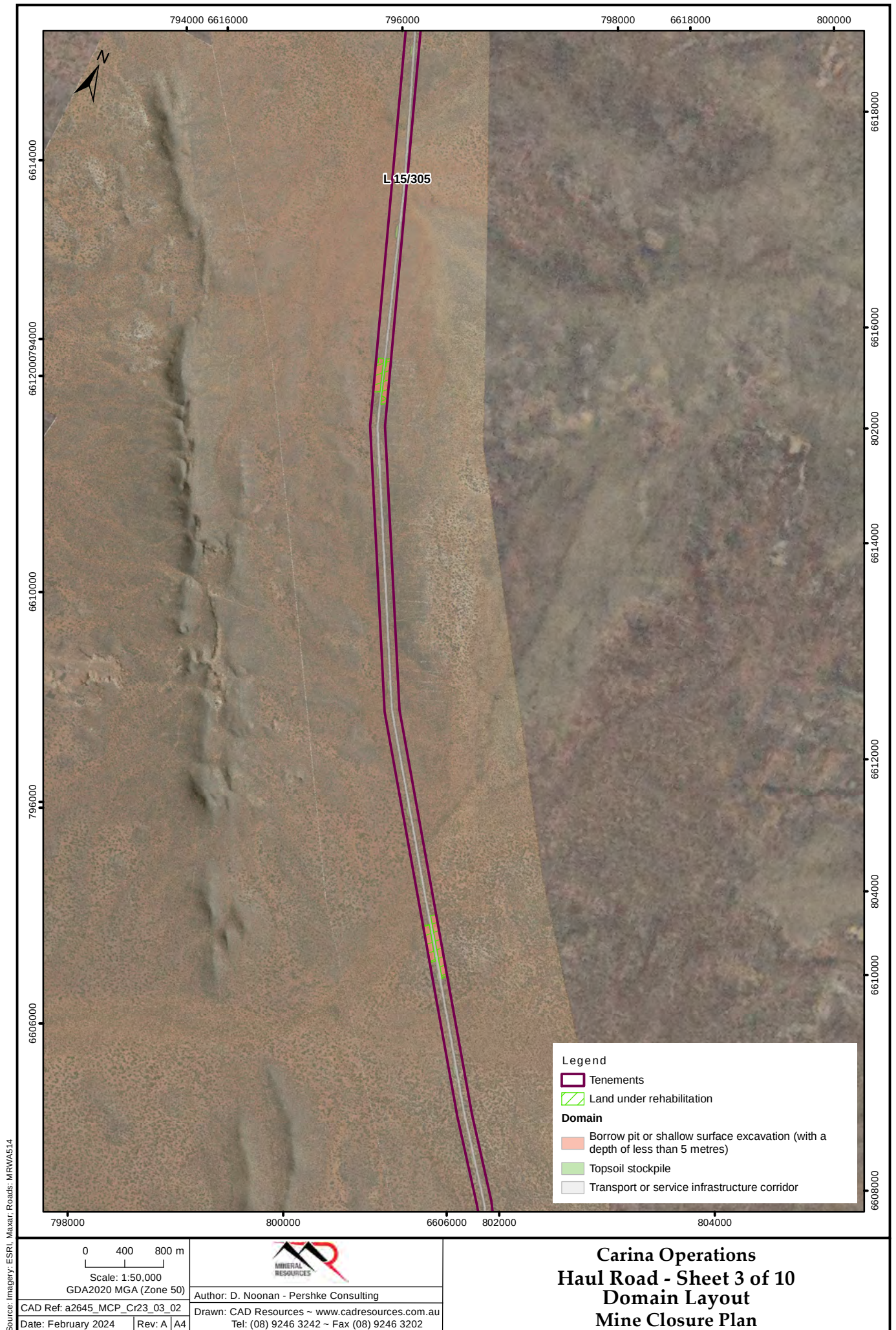
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GDA2020 MGA (Zone 50)

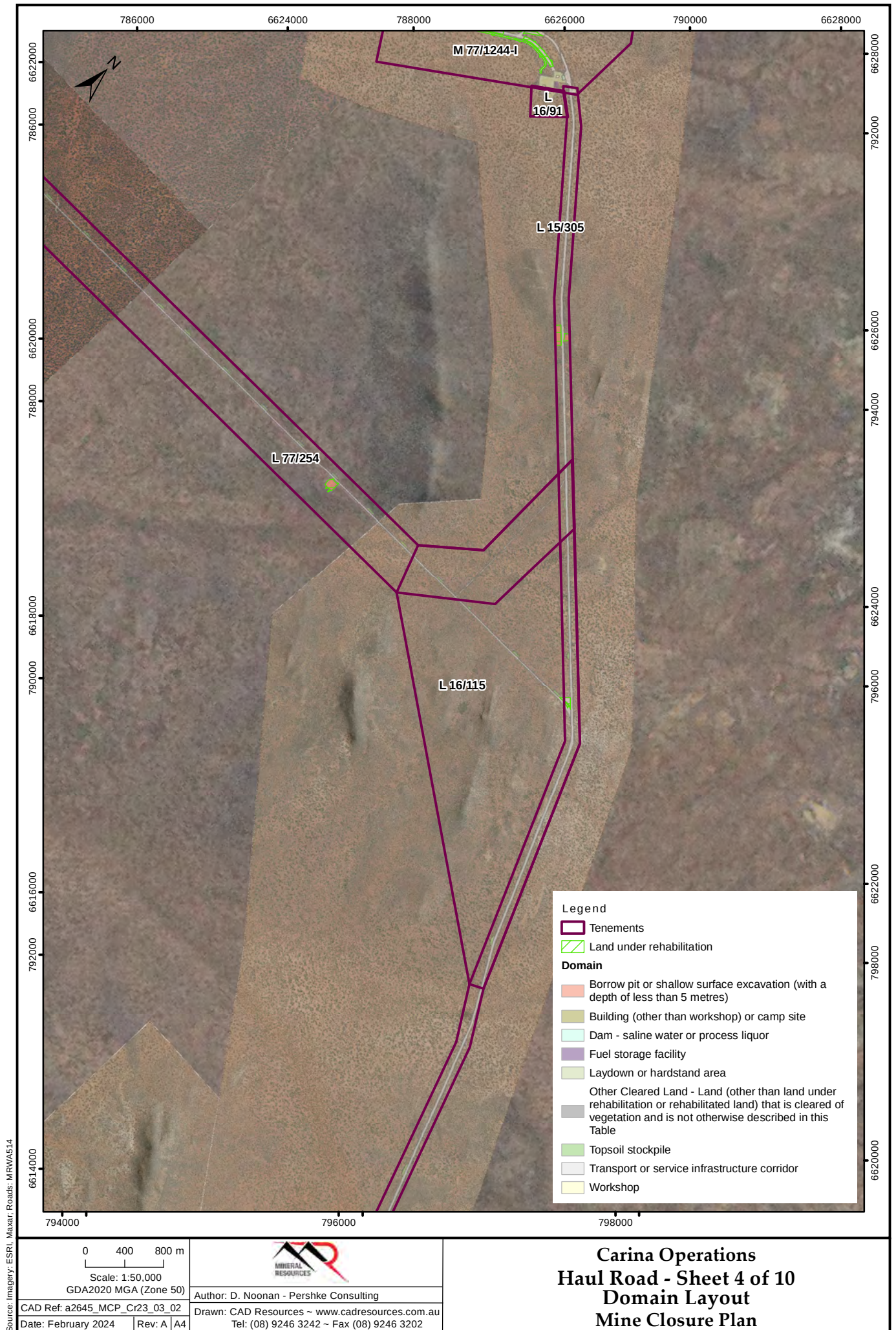


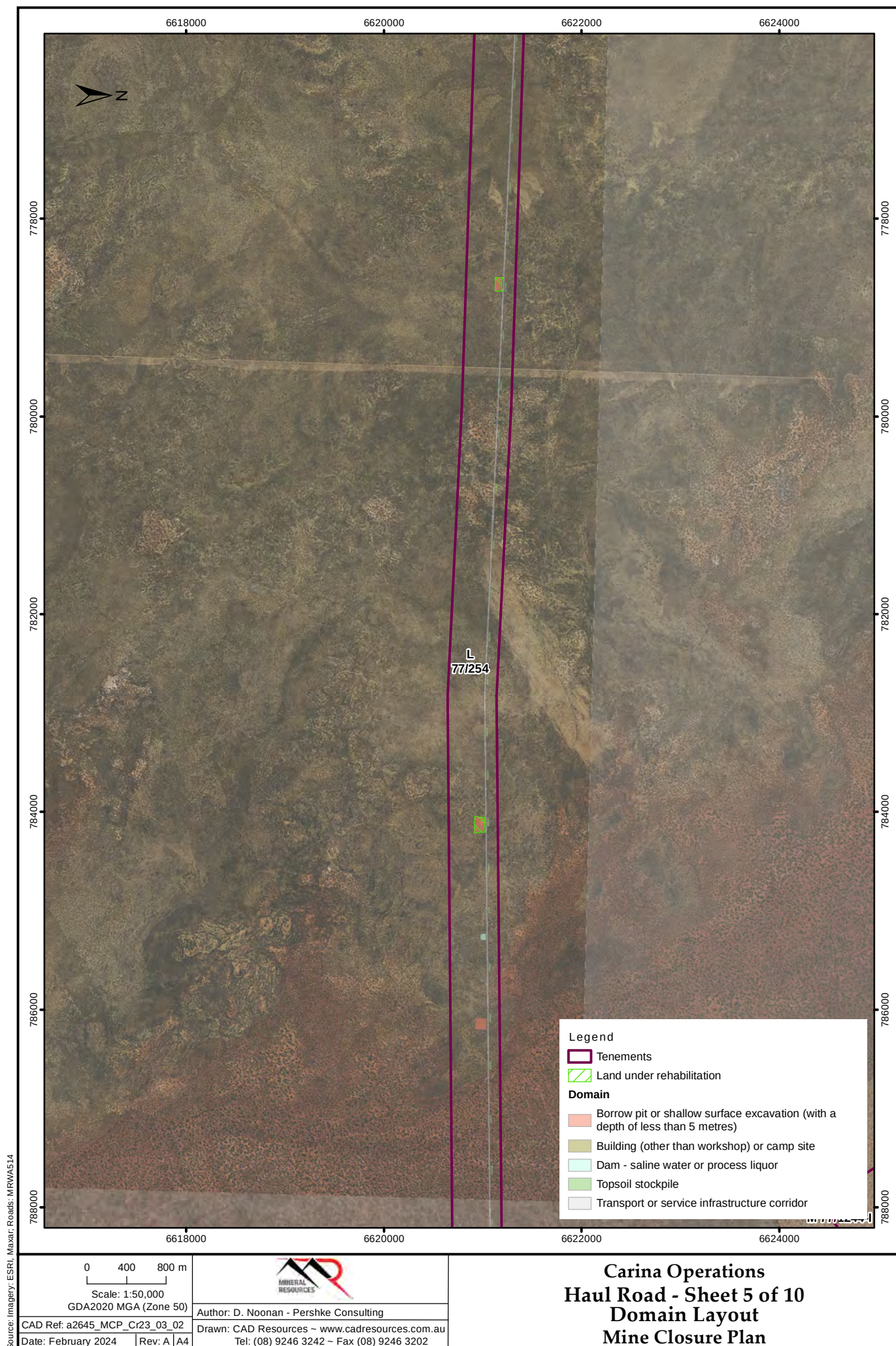
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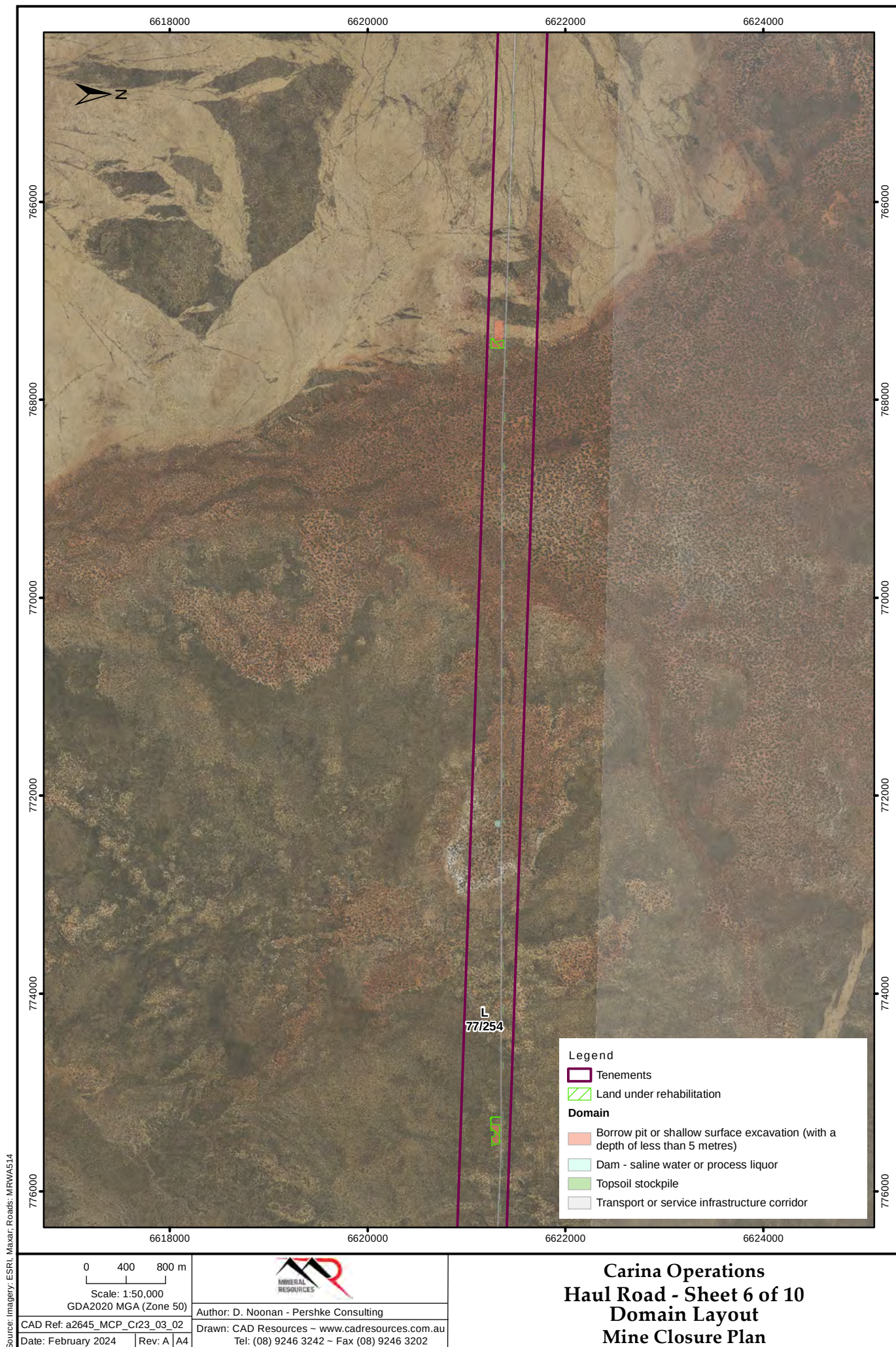
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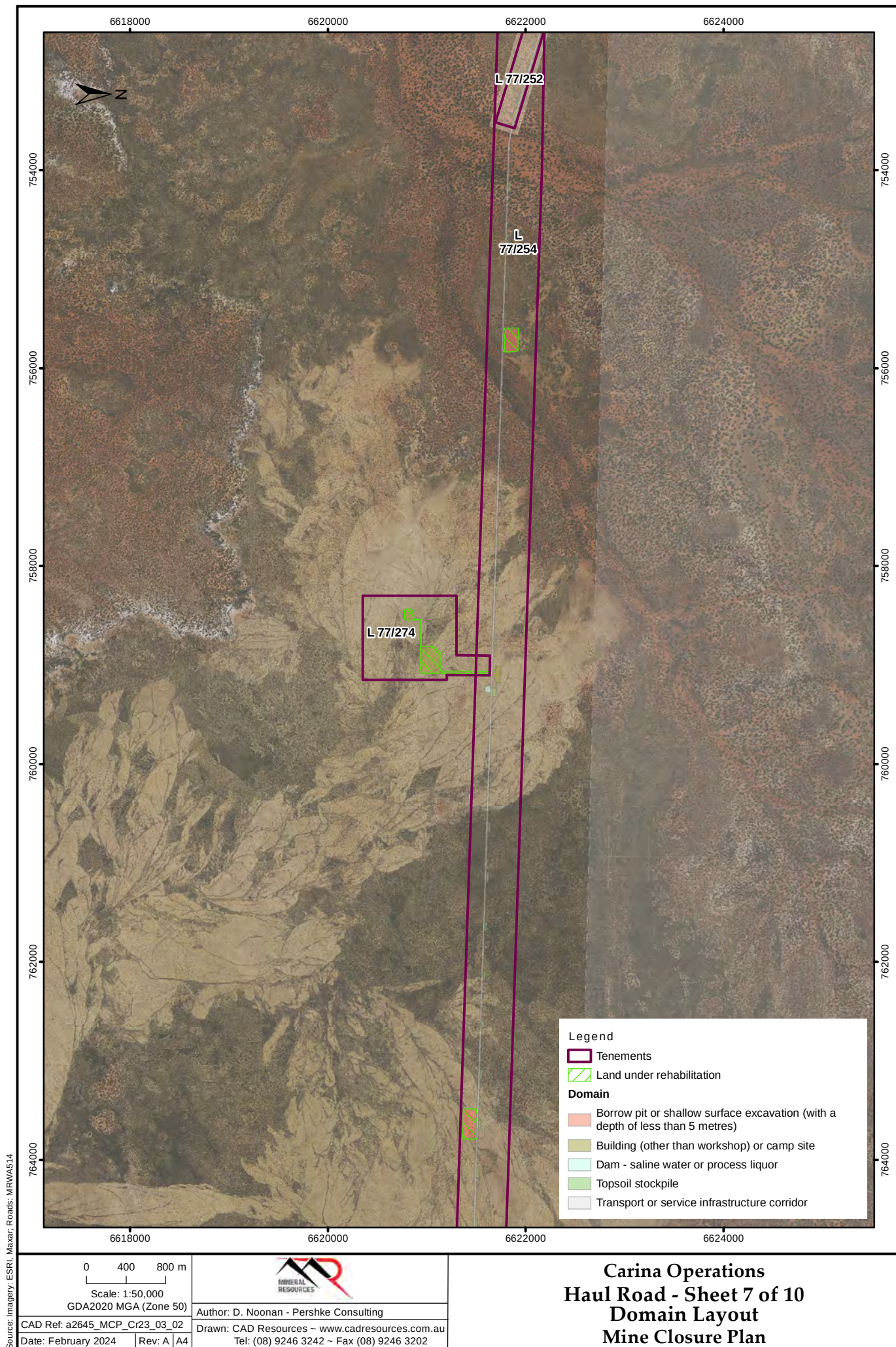
Carina Operations Haul Road - Sheet 2 of 10 Domain Layout Mine Closure Plan

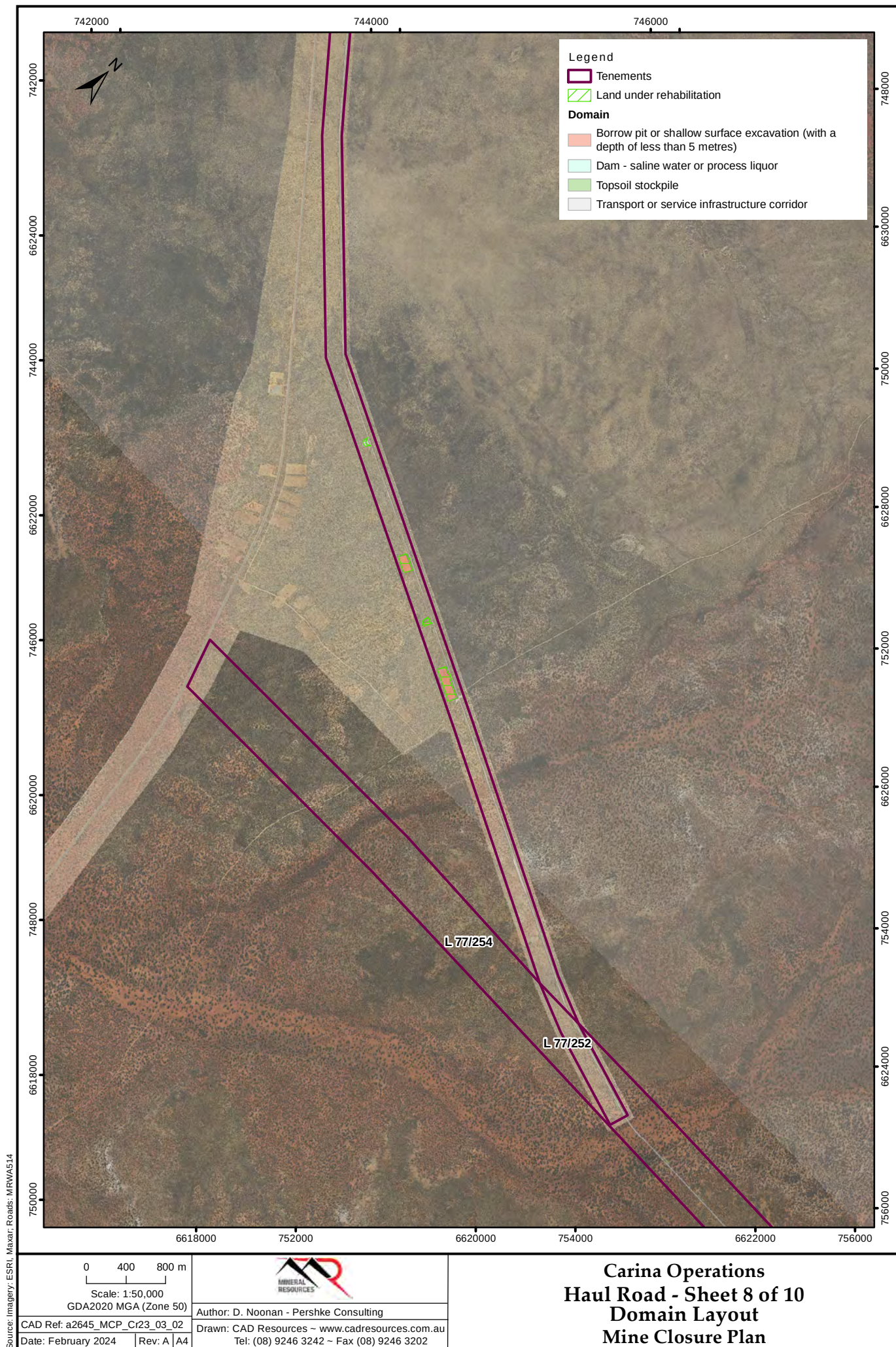


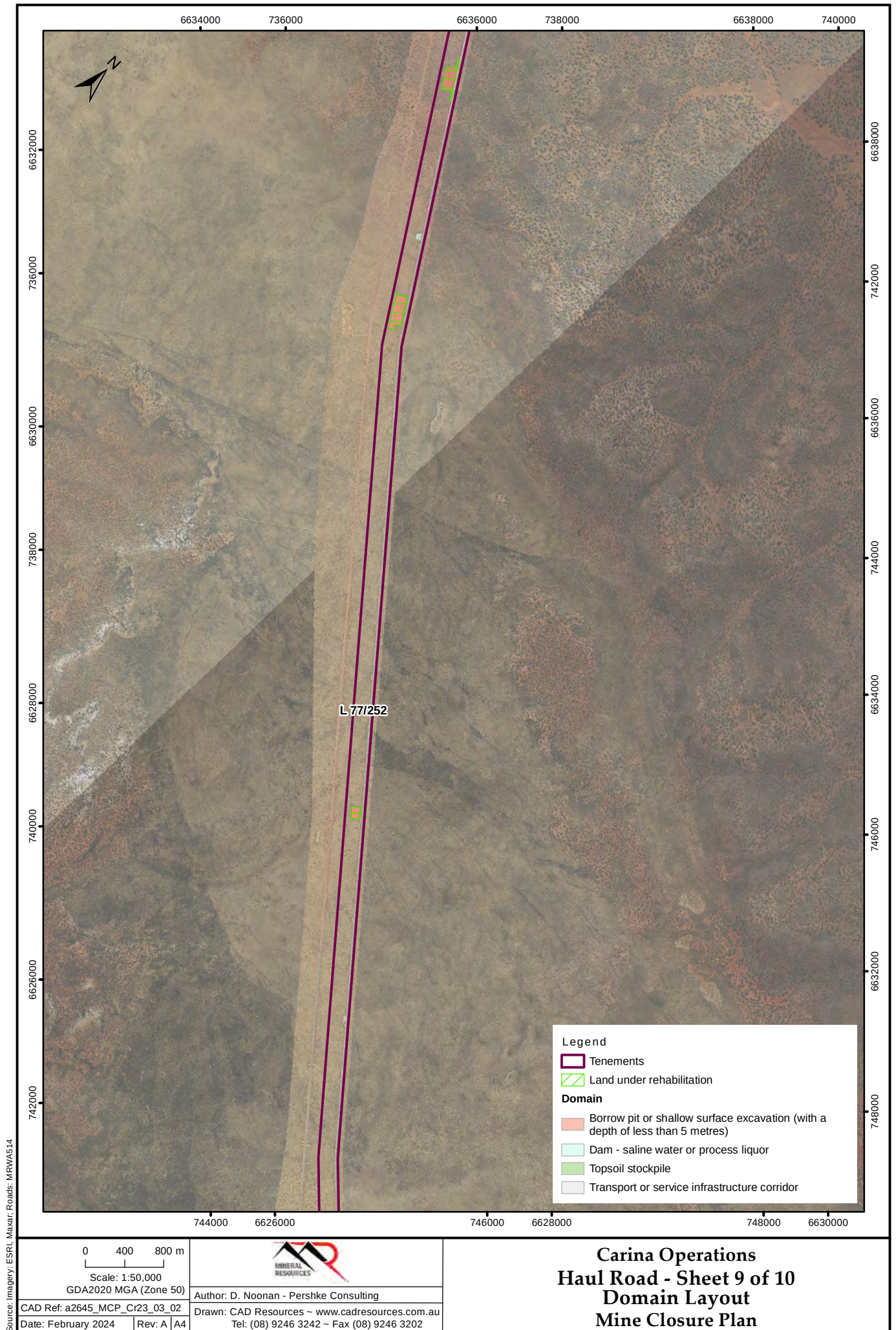


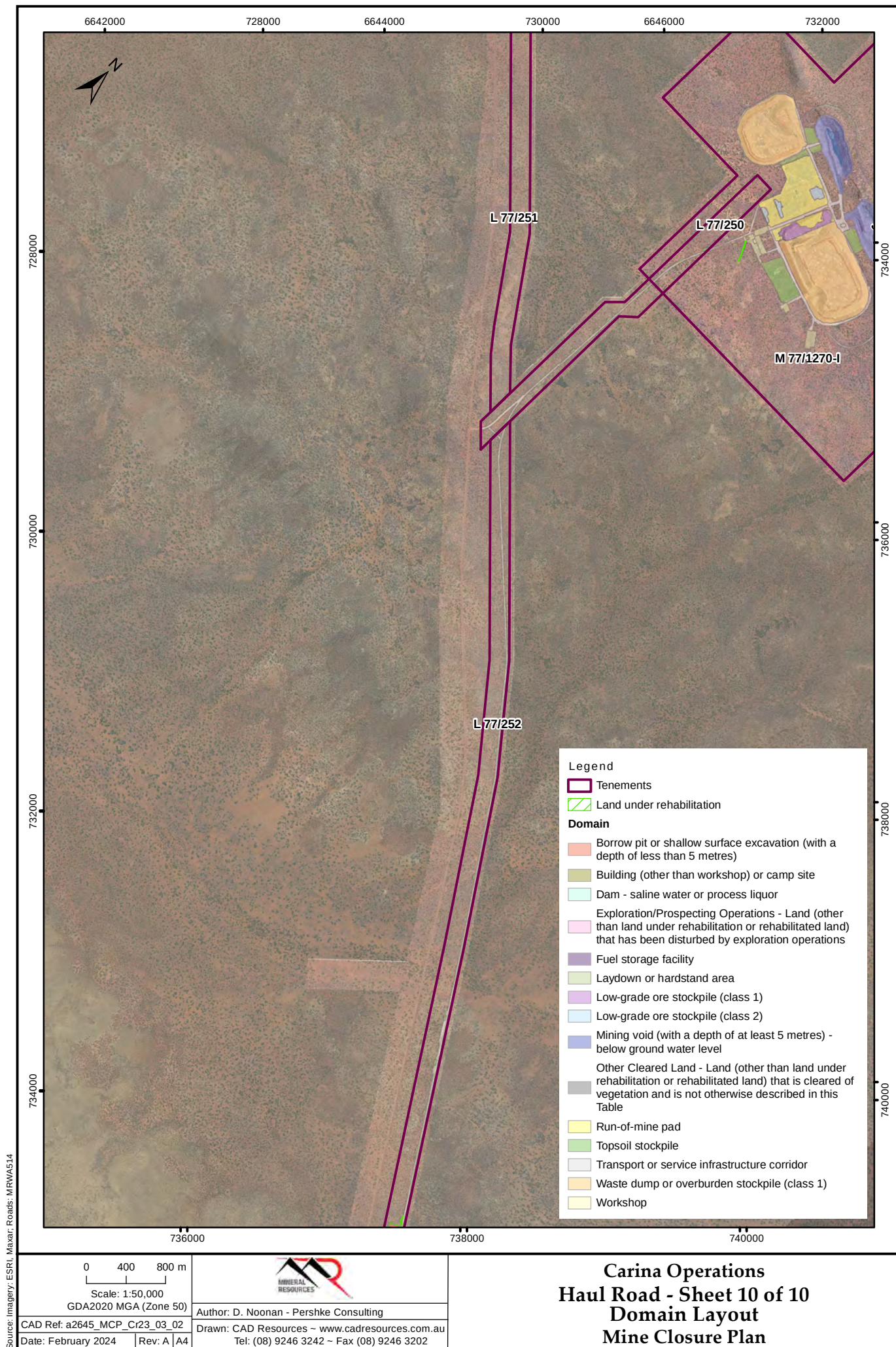


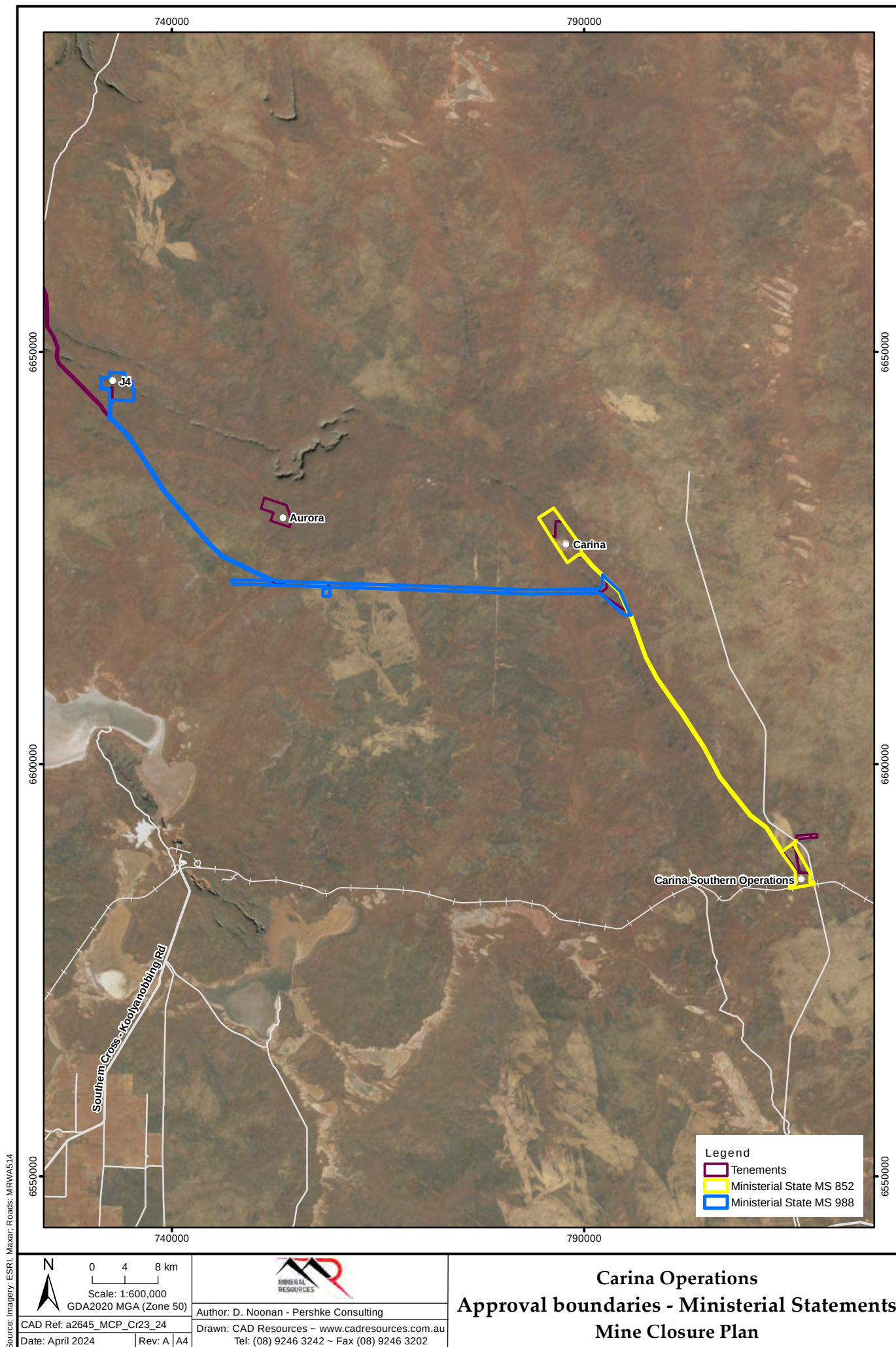


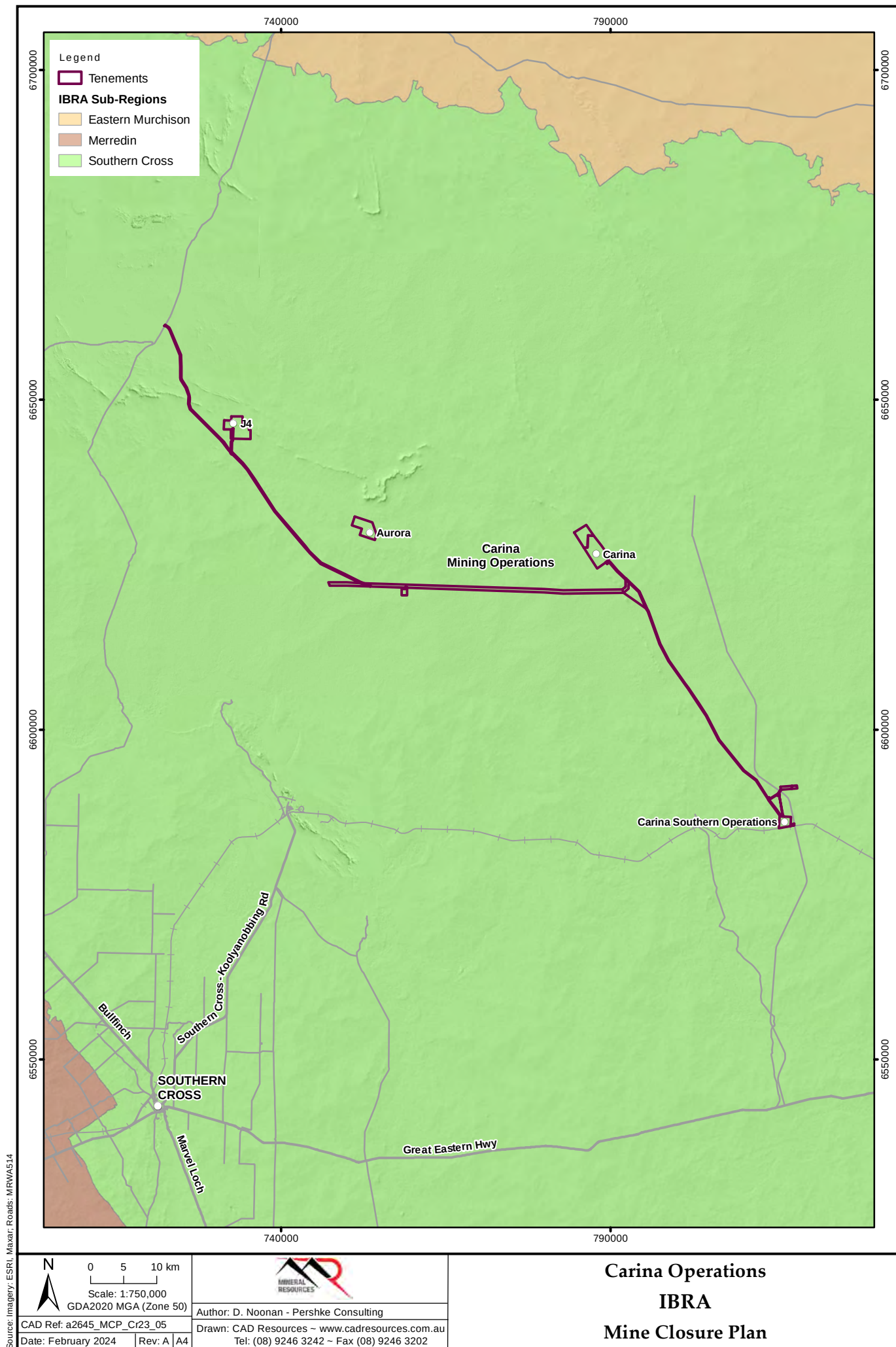




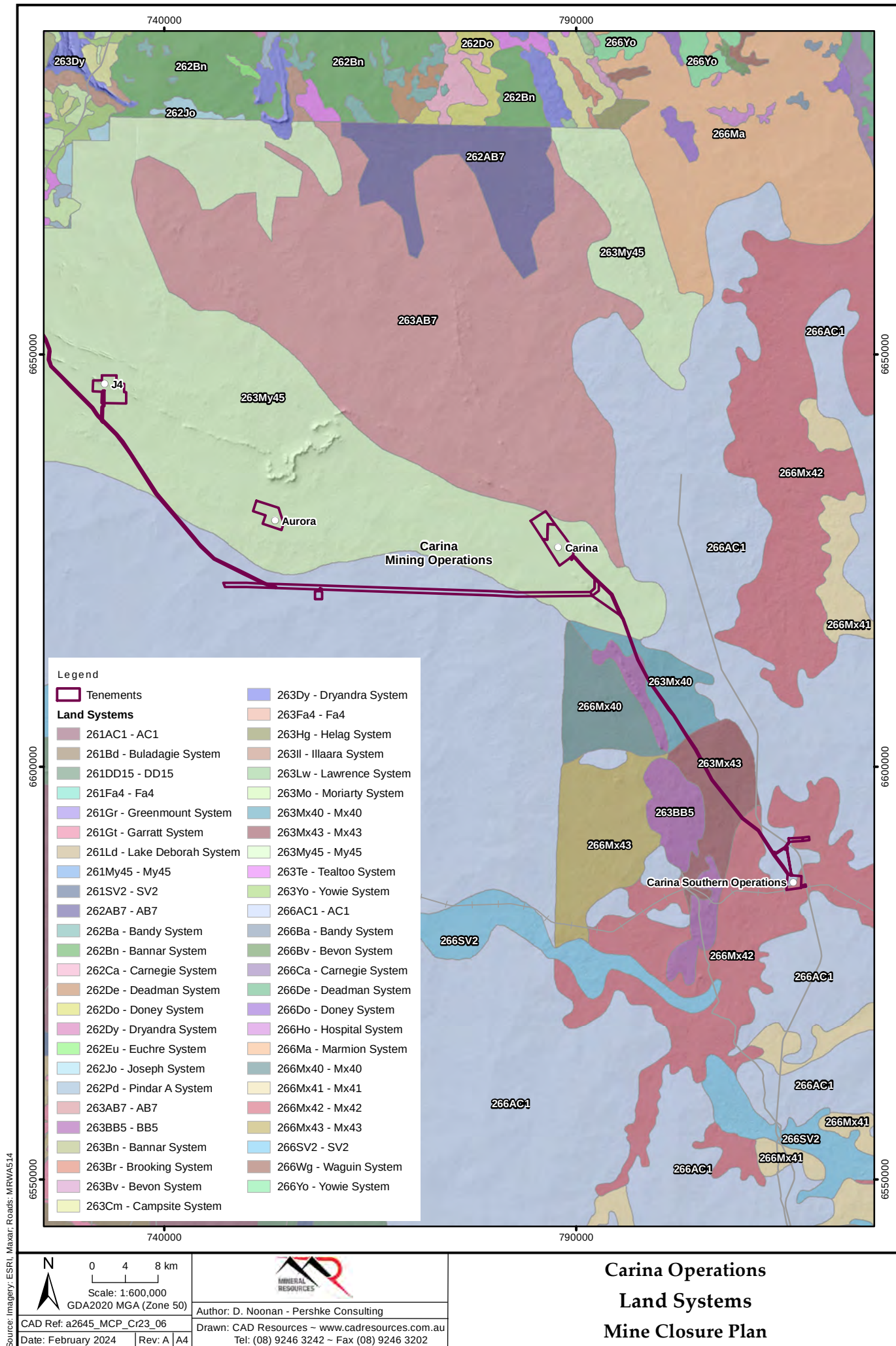


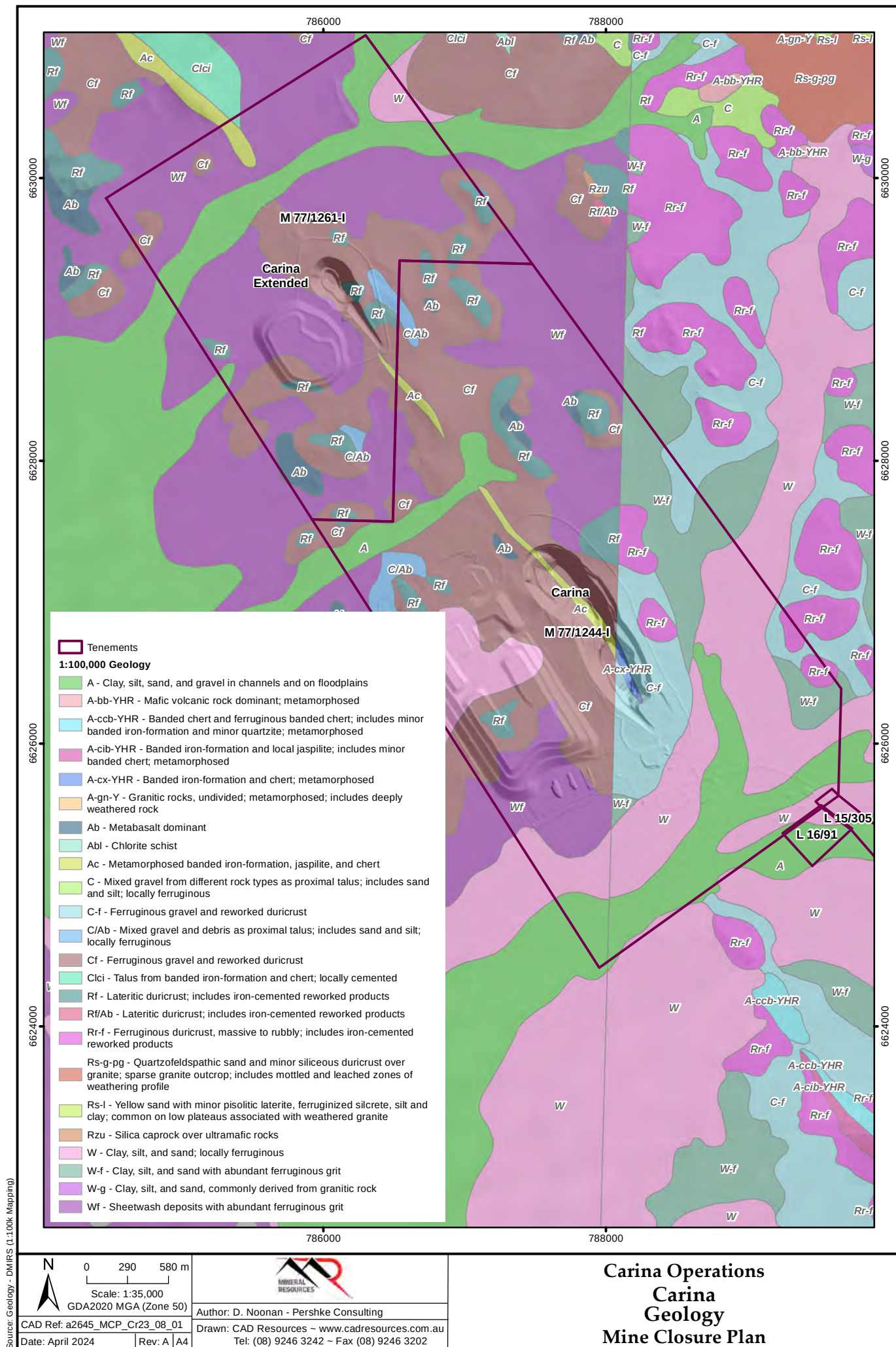


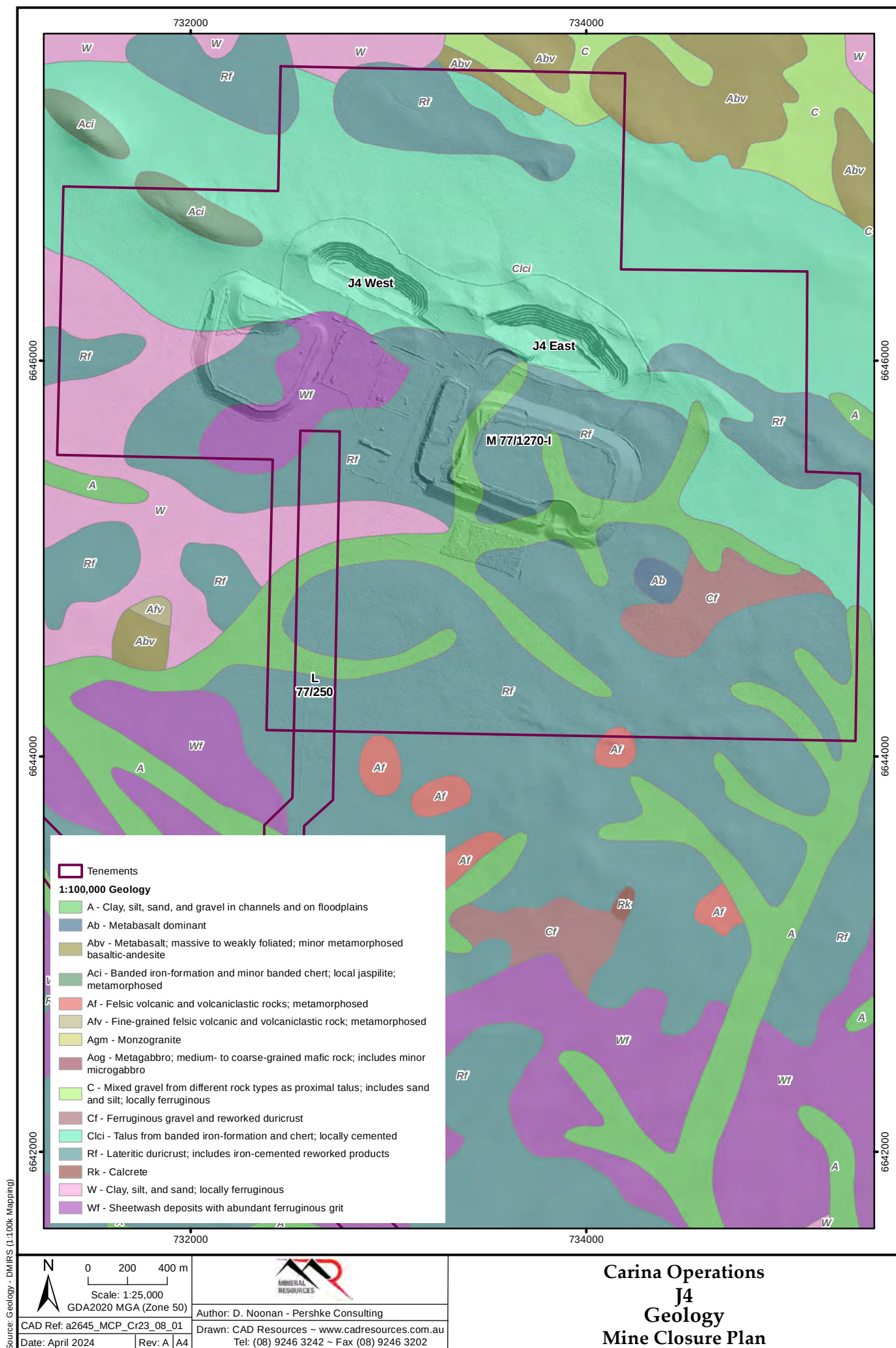


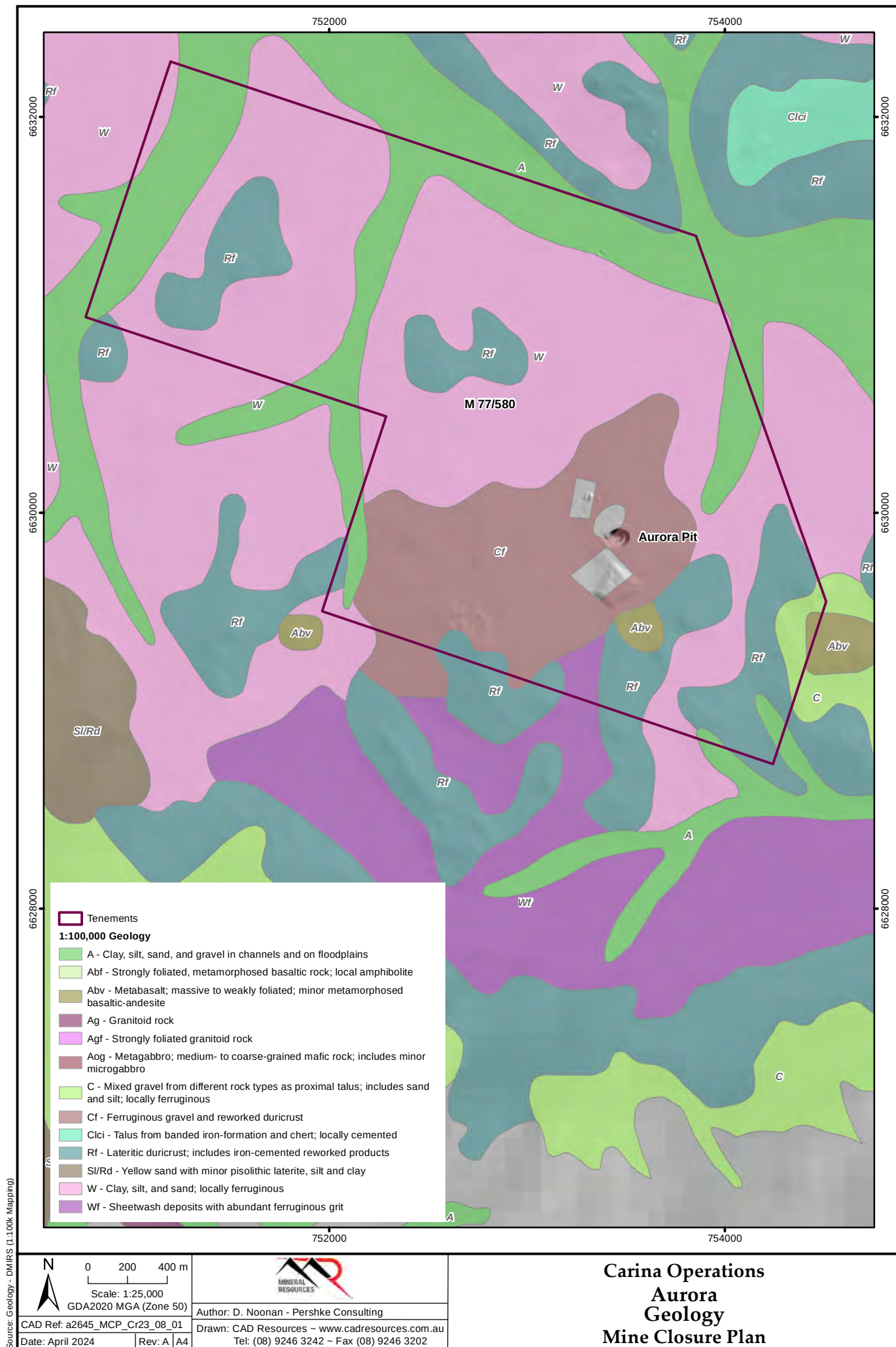


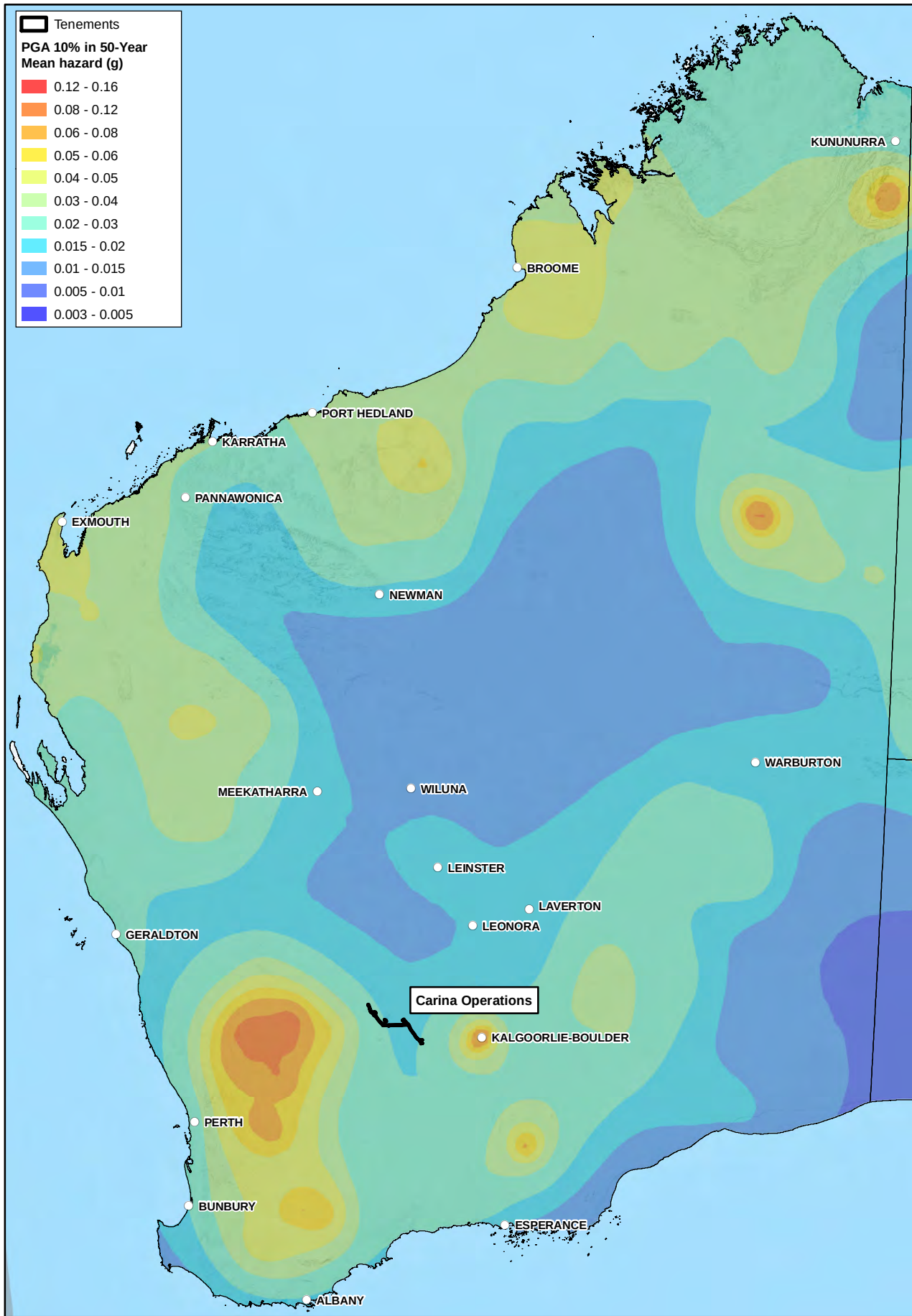
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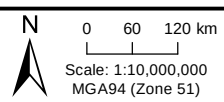








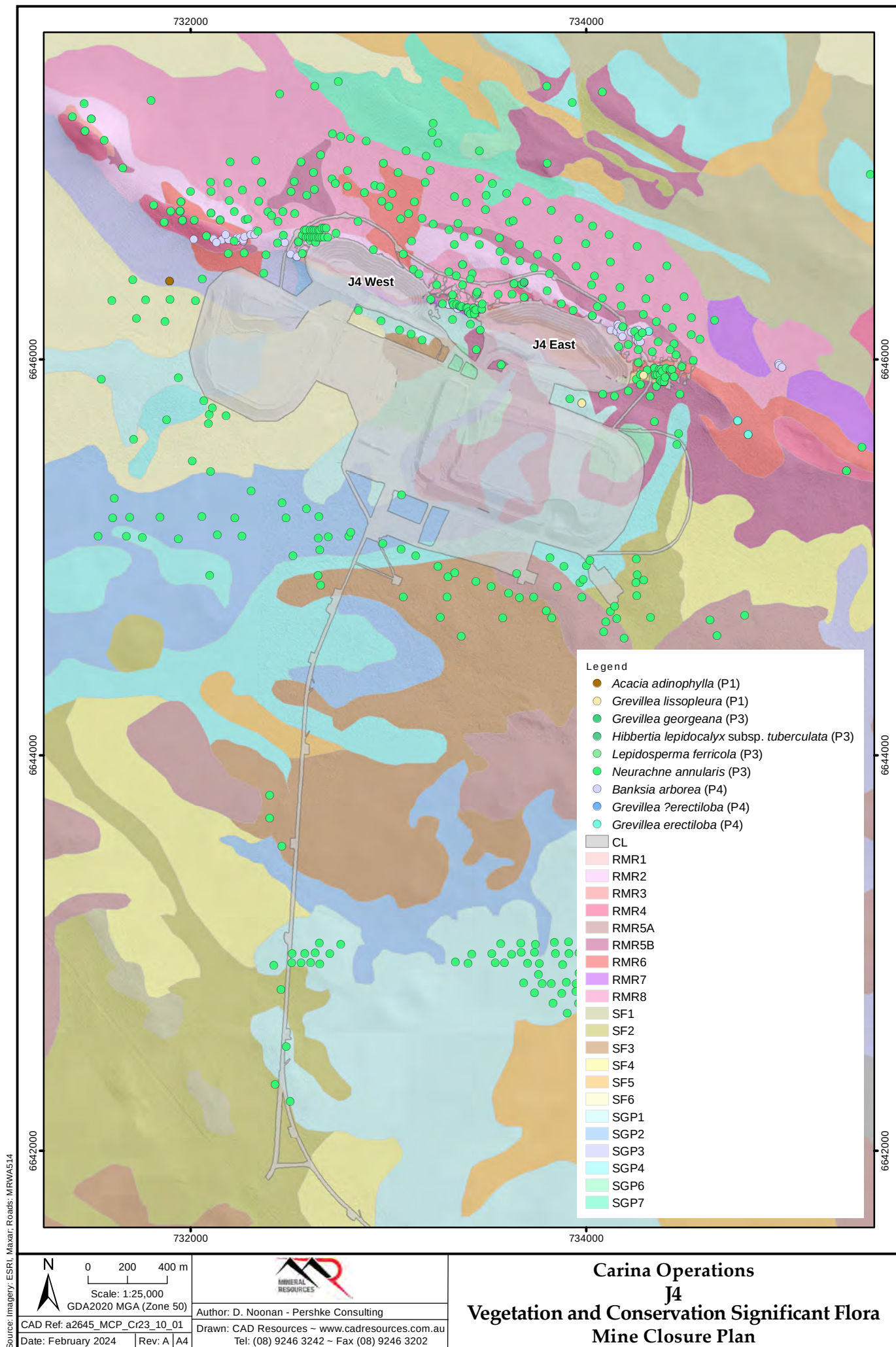
Source: Seismic Hazard: Geoscience Australia



Author: D. Noonan - Pershke Consulting
 Drawn: CAD Resources ~ www.cadresources.com.au
 Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

CAD Ref: a2645_MCP_Cr23_09
 Date: February 2024
 Rev: A
 A4

Carina Operations Seismic hazard map in PGA 10% in 50 yr hazard Mine Closure Plan



Legend

	MIPL1	<i>Eucalyptus ebbanoensis</i> subsp. <i>ebbanoensis</i> (with or without) open woodland, over <i>Acacia resinimarginea</i> and <i>Hakea minyma</i> tall shrubland, over <i>Olearia pimelioides</i> and <i>Phebalium canaliculatum</i> mid open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> sparse tussock grassland
	MIPL2	<i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) tall shrubland, over <i>Olearia pimelioides</i> and <i>Prostanthera grylloana</i> mid open shrubland, over <i>Amphipogon carcinus</i> subsp. <i>carcinus</i> sparse tussock grassland
	MIPL3	Mixed <i>Eucalyptus</i> spp. open woodland, over <i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) and <i>Alyxia buxifolia</i> tall shrubland, over <i>Olearia muelleri</i> , <i>Scaevola spinescens</i> , and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid open shrubland, over mixed tussock grasses
	MIPL4	<i>Eremophila caperata</i> , <i>Olearia exiguifolia</i> , <i>Olearia muelleri</i> , <i>Westringia cephalantha</i> var. <i>cephalantha</i> shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> sparse tussock grassland, with or without <i>Triodia scariosa</i> sparse hummock grassland
	MIPL5	<i>Eucalyptus yilgarnensis</i> open woodland, over <i>Muehlenbeckia florulenta</i> open shrubland, over <i>Sclerolaena diacantha</i> low open shrubland
	MIPL6	<i>Acacia hemiteles</i> tall open shrubland, over <i>Atriplex vesicaria</i> mid open shrubland, over <i>Austrostipa</i> spp. and <i>Rytidosperma caespitosum</i> sparse tussock grassland
	MIPL8	<i>Eucalyptus ebbanoensis</i> subsp. <i>ebbanoensis</i> or <i>Callitris preissii</i> open woodland, over <i>Westringia cephalantha</i> var. <i>cephalantha</i> mid open shrubland, with or without <i>Alyxia buxifolia</i> mid open shrubland, over <i>Triodia scariosa</i> or <i>Triodia rigidissima</i> sparse hummock grassland
	PCS1	<i>Eucalyptus salmonophloia</i> and/or <i>Eucalyptus salubris</i> open woodland, over <i>Atriplex nummularia</i> , <i>Atriplex vesicaria</i> , <i>Eremophila scoparia</i> , <i>Olearia muelleri</i> , and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid open shrubland, over <i>Maireana trichoptera</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses
	PCS2	Mixed <i>Eucalyptus</i> spp. open woodland, over <i>Acacia erinacea</i> , <i>Atriplex nummularia</i> , <i>Atriplex vesicaria</i> , <i>Eremophila scoparia</i> and <i>Olearia muelleri</i> mid open shrubland, over <i>Sclerolaena diacantha</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses
	PCS4	<i>Eucalyptus longicornis</i> open woodland, with or without <i>Eucalyptus salubris</i> , over <i>Atriplex nummularia</i> , <i>Atriplex vesicaria</i> and <i>Eremophila</i>

scoparia mid shrubland, over *Austrostipa elegantissima* or *Austrostipa platychaeta* isolated tussock grasses

- | | | |
|---|-------------|---|
|  | PCS5 | <i>Atriplex vesicaria</i> and <i>Atriplex nummularia</i> mid open shrubland, over <i>Maireana georgei</i> , <i>Maireana trichoptera</i> and <i>Sclerolaena diacantha</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PCS6 | <i>Eucalyptus salubris</i> open woodland, over <i>Atriplex vesicaria</i> and <i>Eremophila scoparia</i> mid open shrubland, over <i>Maireana trichoptera</i> and <i>Sclerolaena diacantha</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PCS7 | <i>Eucalyptus ravida</i> open woodland, over <i>Atriplex vesicaria</i> mid open shrubland, over <i>Maireana trichoptera</i> and <i>Sclerolaena diacantha</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PNC1 | <i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831) and <i>Acacia tetragonophylla</i> tall open shrubland, over <i>Acacia erinacea</i> , <i>Olearia muelleri</i> and <i>Scaevola spinescens</i> mid open shrubland, over <i>Neurachne annularis</i> sparse tussock grassland, with or without <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated grasses |
|  | PNC3 | <i>Eucalyptus corrugata</i> open woodland, over <i>Atriplex nummularia</i> , <i>Olearia muelleri</i> , and <i>Senna artemisioides</i> subsp. <i>filifolia</i> mid open shrubland, over <i>Maireana trichoptera</i> and <i>Ptilotus obovatus</i> low open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PNC5 | Mixed <i>Eucalyptus</i> spp. open woodland, over <i>Exocarpos aphyllus</i> , <i>Grevillea acuaria</i> and <i>Senna artemisioides</i> subsp. <i>filifolia</i> tall open shrubland, over <i>Olearia muelleri</i> mid open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PNC6 | Mixed <i>Eucalyptus</i> spp. open woodland, over <i>Eremophila oppositifolia</i> subsp. <i>angustifolia</i> tall open shrubland, over <i>Acacia erinacea</i> , <i>Eremophila scoparia</i> , <i>Olearia muelleri</i> , and <i>Scaevola spinescens</i> mid open shrubland, with or without <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PNC7 | <i>Eucalyptus transcontinentalis</i> or <i>Eucalyptus oleosa</i> subsp. <i>oleosa</i> woodland, over <i>Eremophila oppositifolia</i> subsp. <i>angustifolia</i> tall open shrubland, over <i>Atriplex nummularia</i> and <i>Olearia muelleri</i> mid open shrubland, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | PNC8 | <i>Acacia</i> sp. narrow <i>phyllode</i> (B.R. Maslin 7831), <i>Acacia tetragonophylla</i> , and <i>Alyxia buxifolia</i> tall open shrubland, over <i>Eremophila decipiens</i> and |

Senna artemisioides subsp. *filifolia* mid open shrubland, over *Austrostipa elegantissima* or *Austrostipa platychaeta* isolated tussock grasses

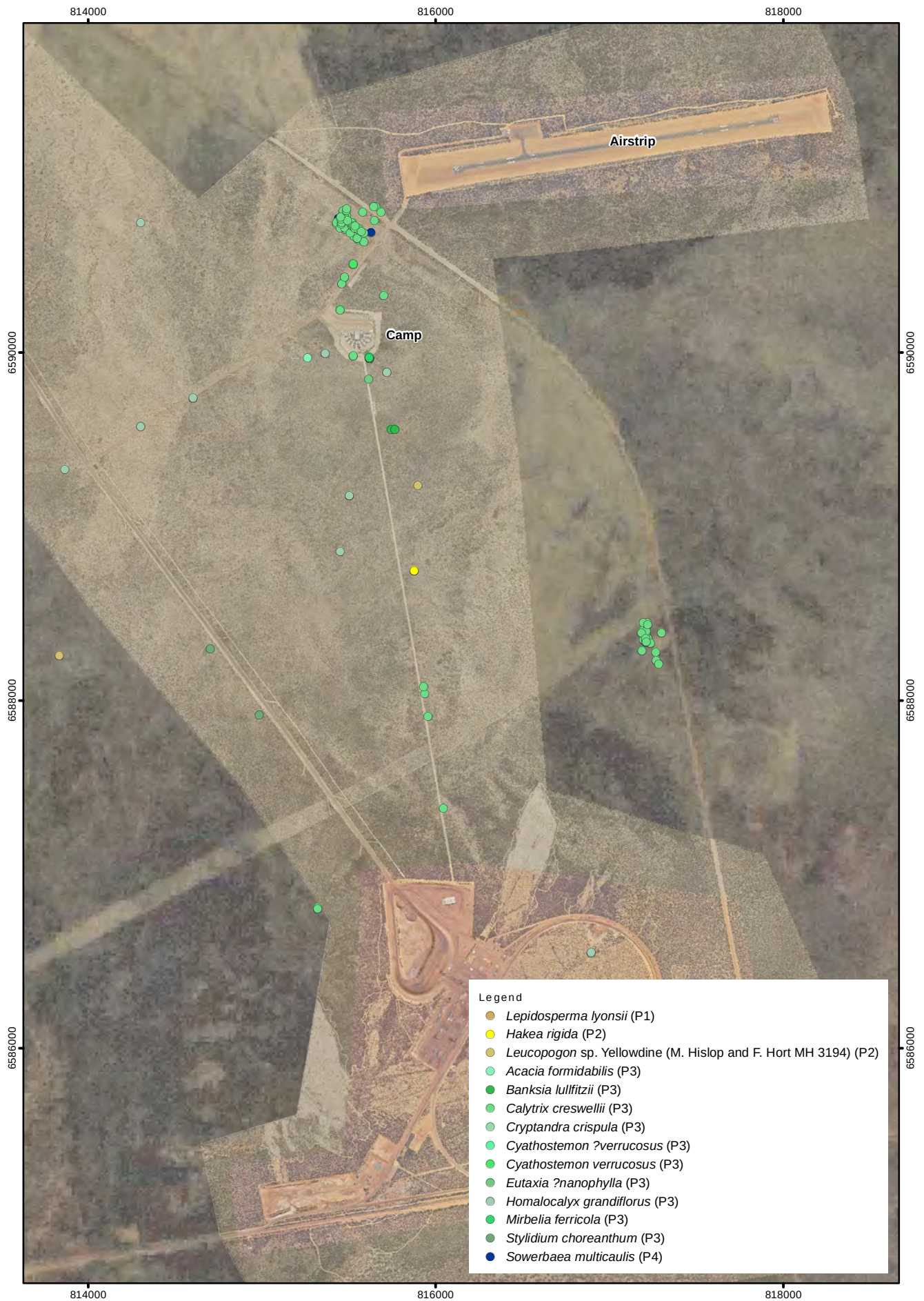
-  **PNC9** *Acacia* sp. narrow *phyllode* (B.R. Maslin 7831) and *Acacia tetragonophylla* tall open shrubland, over *Atriplex vesicaria*, *Rhagodia drummondii* mid open shrubland, over *Ptilotus obovatus*, *Sclerolaena diacantha* low open shrubland, over *Austrostipa elegantissima* or *Austrostipa platychaeta* and *Austrostipa trichophylla* isolated tussock grasses
-  **PNC10** *Acacia* sp. narrow *phyllode* (B.R. Maslin 7831) and *Acacia prainii* tall open shrubland, over *Senna artemisioides* subsp. *filifolia*, *Eremophila decipiens* subsp. *decipiens* mid open shrubland, over *Ptilotus obovatus* low open shrubland, over *Austrostipa elegantissima* or *Austrostipa platychaeta* isolated tussock grasses
-  **PSRN0** *Eucalyptus corrugata* and *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Acacia erinacea*, *Olearia muelleri* and *Ptilotus obovatus* low open shrubland (with or without *Eremophila interstans* subsp. *interstans*) or over *Eremophila clarkei*, *Olearia pimelioides* and *Ptilotus obovatus* low open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN1** *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Eremophila oppositifolia* subsp. *angustifolia* tall open shrubland, over *Olearia muelleri* mid open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN2** *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Grevillea zygomorpha* and *Scaevola spinescens* mid open shrubland, over *Acacia adinophylla* low open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN6** *Banksia arborea* and *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Alyxia buxifolia* mid open shrubland, over *Comesperma integerrimum* and *Ptilotus obovatus* low open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN7** *Eucalyptus capillosa* subsp. *capillosa* open woodland, over *Alyxia buxifolia* tall open shrubland, over *Olearia muelleri* and *Ptilotus obovatus* low open shrubland, over *Austrostipa elegantissima* or *Austrostipa platychaeta* isolated tussock grasses
-  **PSRN8** *Eucalyptus longissima* and *Allocasuarina acutivalvis* subsp. *acutivalvis* open woodland, with or without *Neurachne annularis* sparse tussock grassland
-  **PSRN9** *Eucalyptus corrugata* and *Eucalyptus loxophleba* subsp. *lissophloia* open woodland, over *Acacia* sp. narrow *phyllode* (B.R. Maslin 7831) tall open shrubland, over *Neurachne annularis* sparse tussock grassland

-  **PSRN12** *Eucalyptus ewartiana* (with or without) open woodland, over *Acacia* sp. narrow *phyllode* (B.R. Maslin 7831) tall open shrubland, over *Ptilotus obovatus* low open shrubland, over *Dianella revoluta* var. *divaricata* isolated herbs, over *Neurachne annularis* and *Austrostipa elegantissima* or *Austrostipa platychaeta* sparse tussock grassland
-  **PSRN13** *Acacia* sp. narrow *phyllode* (B.R. Maslin 7821) tall open shrubland, over *Solanum nummularium* isolated shrubs, over *Aristida contorta* and *Austrostipa elegantissima* or *Austrostipa platychaeta* sparse tussock grassland
-  **PSRN14** *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland (with or without), over *Eremophila georgei*, *Grevillea zygomorpha*, *Leucopogon* sp. Clyde Hill (M.A. Burgman 1207) and *Philothea brucei* subsp. *brucei* mid shrubland, over *Dianella revoluta* var. *divaricata* isolated herbs, over *Neurachne annularis* sparse tussock grassland
-  **PSRN17** *Acacia quadrimarginea* and *Melaleuca nematophylla* tall open shrubland, over *Calycopeplus paucifolius* mid open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN18** *Acacia quadrimarginea* tall open shrubland, over *Eremophila decipiens* subsp. *decipiens* and *Scaevola spinescens* mid open shrubland, over *Dianella revoluta* var. *divaricata* isolated herbs, over *Neurachne annularis* sparse tussock grassland
-  **PSRN19** *Acacia ramulosa* var. *ramulosa* tall open shrubland, over *Eremophila decipiens* subsp. *decipiens* mid open shrubland, over *Neurachne annularis* sparse tussock grassland *Acacia aneura* tall open shrubland, over *Neurachne annularis* sparse tussock grassland
-  **PSRN20** *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Acacia quadrimarginea* tall open shrubland, over *Calycopeplus paucifolius*, *Eremophila georgei*, and *Philothea brucei* subsp. *brucei* mid open shrubland, over *Dianella revoluta* var. *divaricata* isolated herbs, over *Neurachne annularis* sparse tussock grassland
-  **PSRN21** *Allocasuarina acutivalvis* and *Eucalyptus ebbanoensis* (with or without) open woodland, over *Acacia quadrimarginea* and *Melaleuca nematophylla* tall open shrubland, over *Calycopeplus paucifolius*, *Philothea brucei* and *Stenanthemum newbeyi* mid open shrubland, over *Hibbertia lepidocalyx* subsp. *tuberculata* low open shrubland, over *Dianella revoluta* var. *divaricata* isolated herbs, over *Neurachne annularis* sparse tussock grassland
-  **PSRN22** *Allocasuarina acutivalvis* subsp. *acutivalvis* and *Eucalyptus ebbanoensis* subsp. *ebbanoensis* open woodland, over *Alyxia buxifolia*, *Melaleuca leiocarpa* and *Melaleuca nematophylla* tall shrubland, over *Mirbelia ferricola* and *Stenanthemum newbeyi* mid shrubland, over *Lepidosperma*

bungalbin open sedgeland, with or without *Neurachne annularis* sparse tussock grassland

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|---|---------------|--|
|  | PSRN23 | <i>Allocasuarina acutivalvis</i> subsp. <i>acutivalvis</i> , <i>Banksia arborea</i> and (with or without) <i>Eucalyptus ebbanoensis</i> subsp. <i>ebbanoensis</i> open woodland, over <i>Alyxia buxifolia</i> and <i>Melaleuca nematophylla</i> tall shrubland, over <i>Stenanthemum newbeyi</i> mid open shrubland, over <i>Dianella revoluta</i> var. <i>divaricata</i> isolated herbs, over <i>Neurachne annularis</i> sparse tussock grassland |
|  | PSRN24 | <i>Allocasuarina acutivalvis</i> subsp. <i>acutivalvis</i> open woodland, over <i>Leucopogon</i> sp. Clyde Hill (M.A. Burgman 1207), <i>Melaleuca nematophylla</i> , <i>Philotheca brucei</i> subsp. <i>brucei</i> , and <i>Prostanthera grylloana</i> mid shrubland, over <i>Dianella revoluta</i> var. <i>divaricata</i> isolated herbs, over <i>Austrostipa elegantissima</i> or <i>Austrostipa platychaeta</i> isolated tussock grasses |
|  | RSWN1 | <i>Allocasuarina corniculata</i> and <i>Callitris preissii</i> open woodland, over <i>Acacia resinimarginea</i> and <i>Baeckea elderiana</i> tall open shrubland, with or without <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |
|  | SPAB2 | <i>Allocasuarina corniculata</i> and <i>Callitris preissii</i> open woodland, over <i>Acacia resinimarginea</i> and <i>Baeckea elderiana</i> tall open shrubland, with or without <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |
|  | SPAC1 | <i>Acacia effusifolia</i> tall open shrubland, over <i>Leucopogon</i> sp. Clyde Hill (M.A. Burgman 1207) and <i>Prostanthera campbellii</i> mid open shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> and <i>Neurachne annularis</i> sparse tussock grassland |
|  | SPAC2 | <i>Acacia effusifolia</i> or <i>Acacia coolgardiensis</i> open shrubland, over <i>Phebalium canaliculatum</i> and <i>Leucopogon</i> sp. Clyde Hill (M.A. Burgman 1207) mid open shrubland, over <i>Dianella revoluta</i> var. <i>divaricata</i> isolated herbs, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |
|  | SPAC3 | <i>Acacia effusifolia</i> tall open shrubland, over <i>Phebalium canaliculatum</i> mid open shrubland, over <i>Triodia scariosa</i> sparse hummock grassland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |
|  | SPAC5 | <i>Acacia resinimarginea</i> tall open shrubland, over <i>Phebalium canaliculatum</i> , <i>Homalocalyx thryptomenoides</i> , <i>Keraudrenia velutina</i> mid open shrubland, over <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |
|  | SPAC6 | <i>Eucalyptus leptopoda</i> subsp. <i>subluta</i> open woodland, over <i>Acacia effusifolia</i> tall open shrubland, over <i>Baeckea</i> sp. Bungalbin Hill (B.J. Lepschi, L.A. Craven 4586) and <i>Phebalium canaliculatum</i> mid open shrubland, with or without <i>Amphipogon caricinus</i> var. <i>caricinus</i> sparse tussock grassland |





Source: Imagery: ESRI, Maxar, Roads: MRWAS14



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GDA2020 MGA (Zone 50)



Author: D. Noonan - Pershke Consulting

Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

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Carina Operations Carina Southern Operations Conservation Significant Flora Mine Closure Plan



Source: Imagery: ESRI, Maxar, Roads: MRWAS14

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Scale: 1:25,000

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MINERAL
RESOURCES

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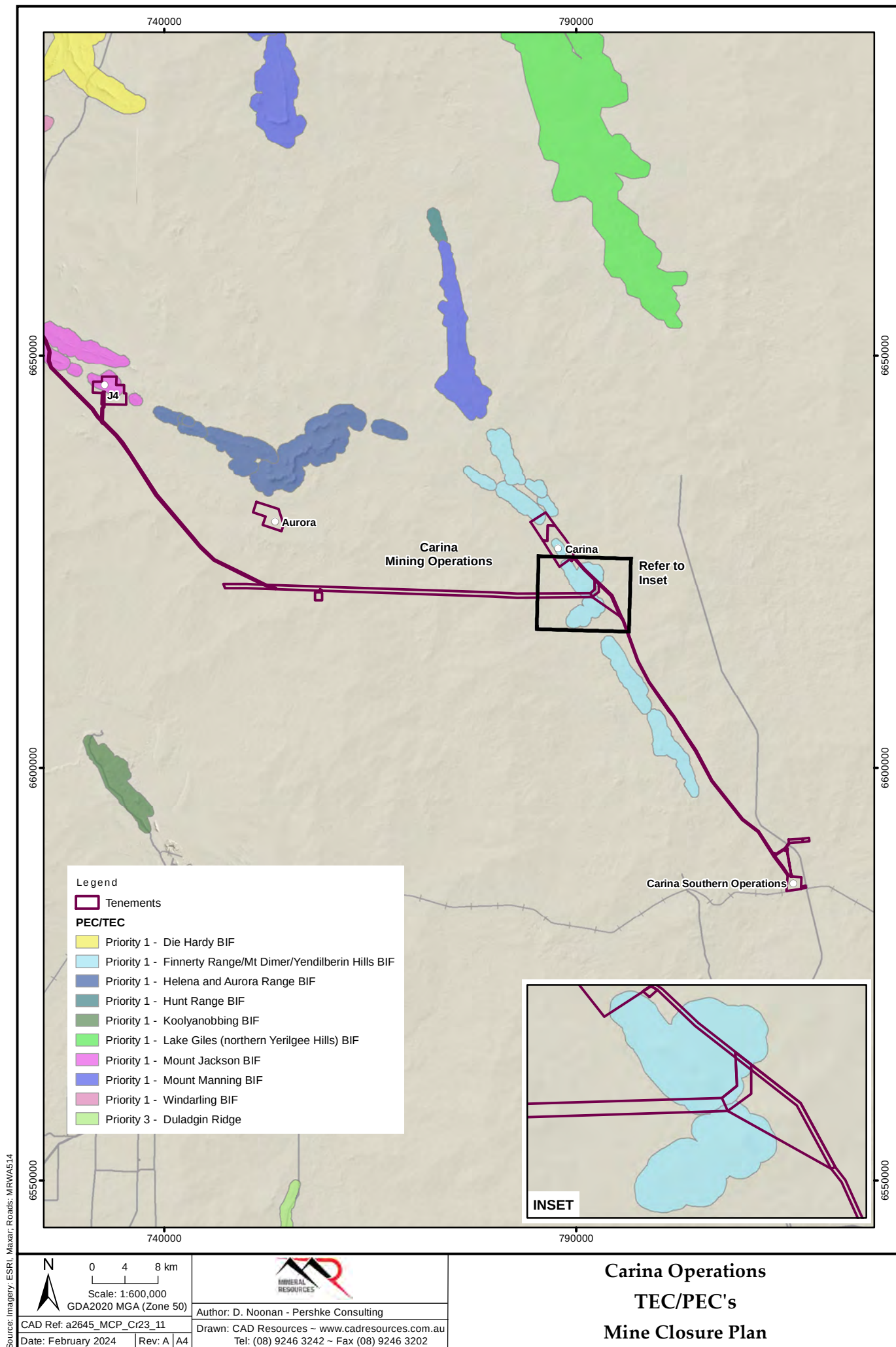
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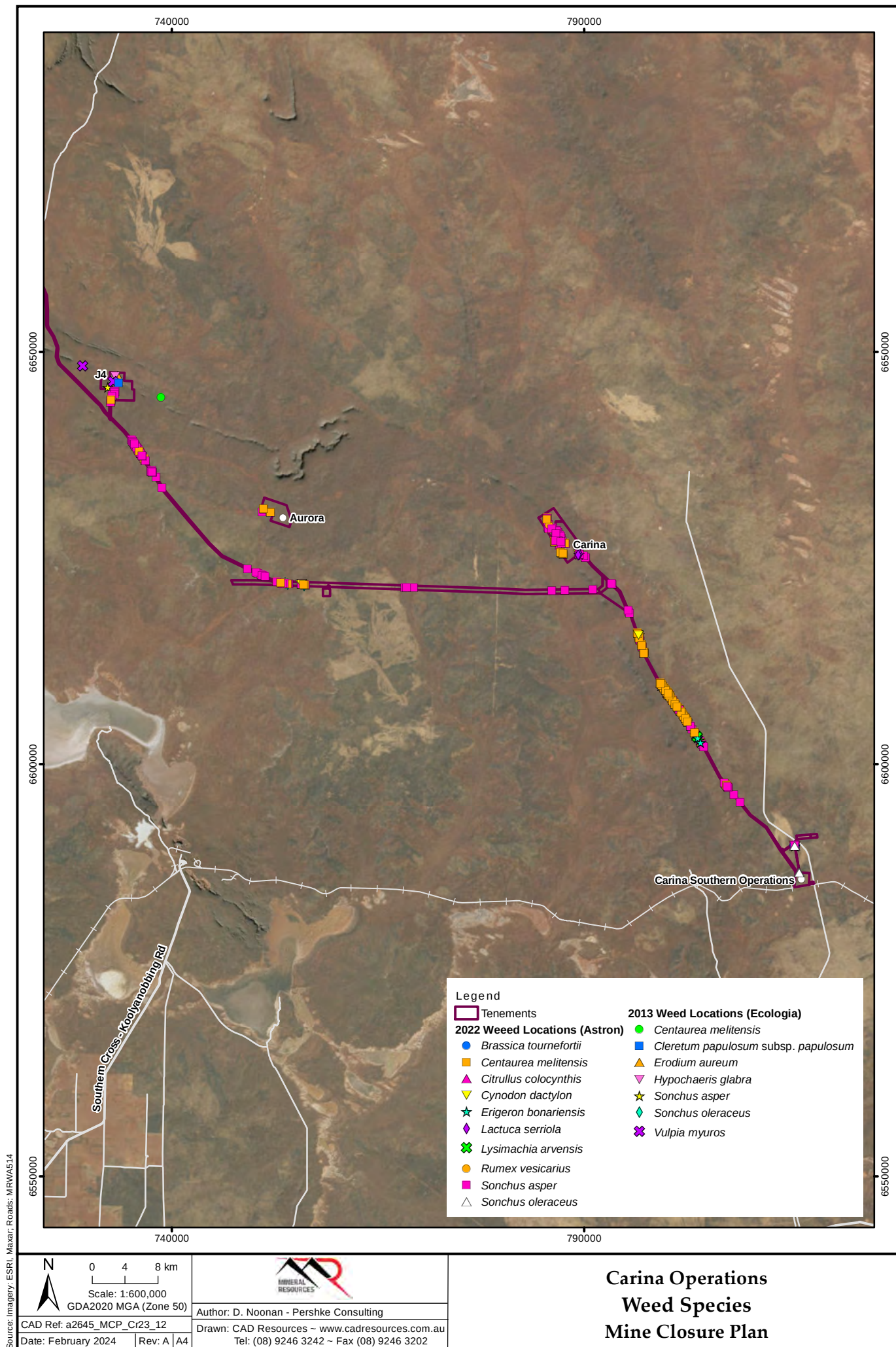
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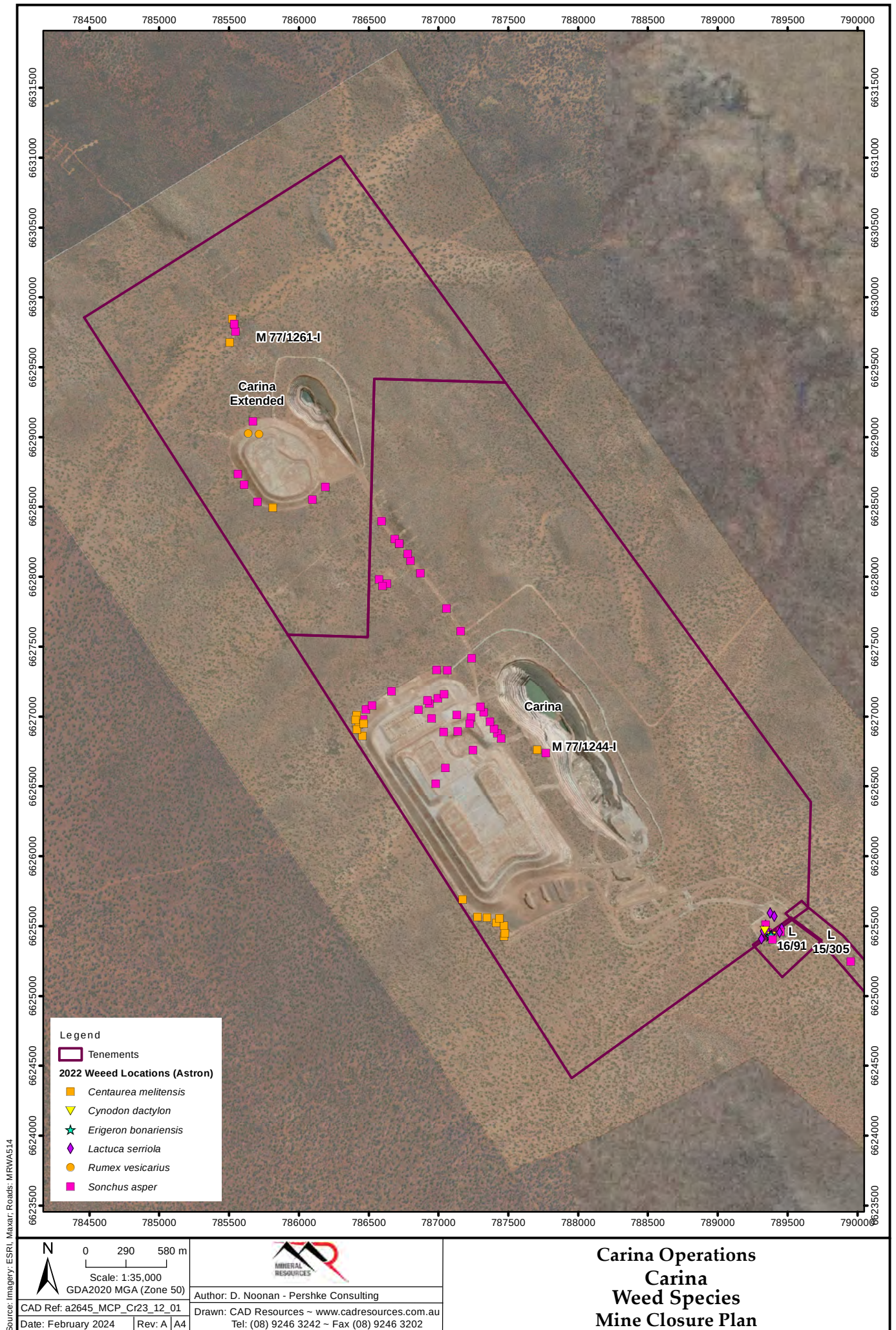
Aurora

Conservation Significant Flora

Mine Closure Plan







Source: Imagery: ESRI, Maxar, Roads: MRWAS14

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GDA2020 MGA (Zone 50)

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Rev: A

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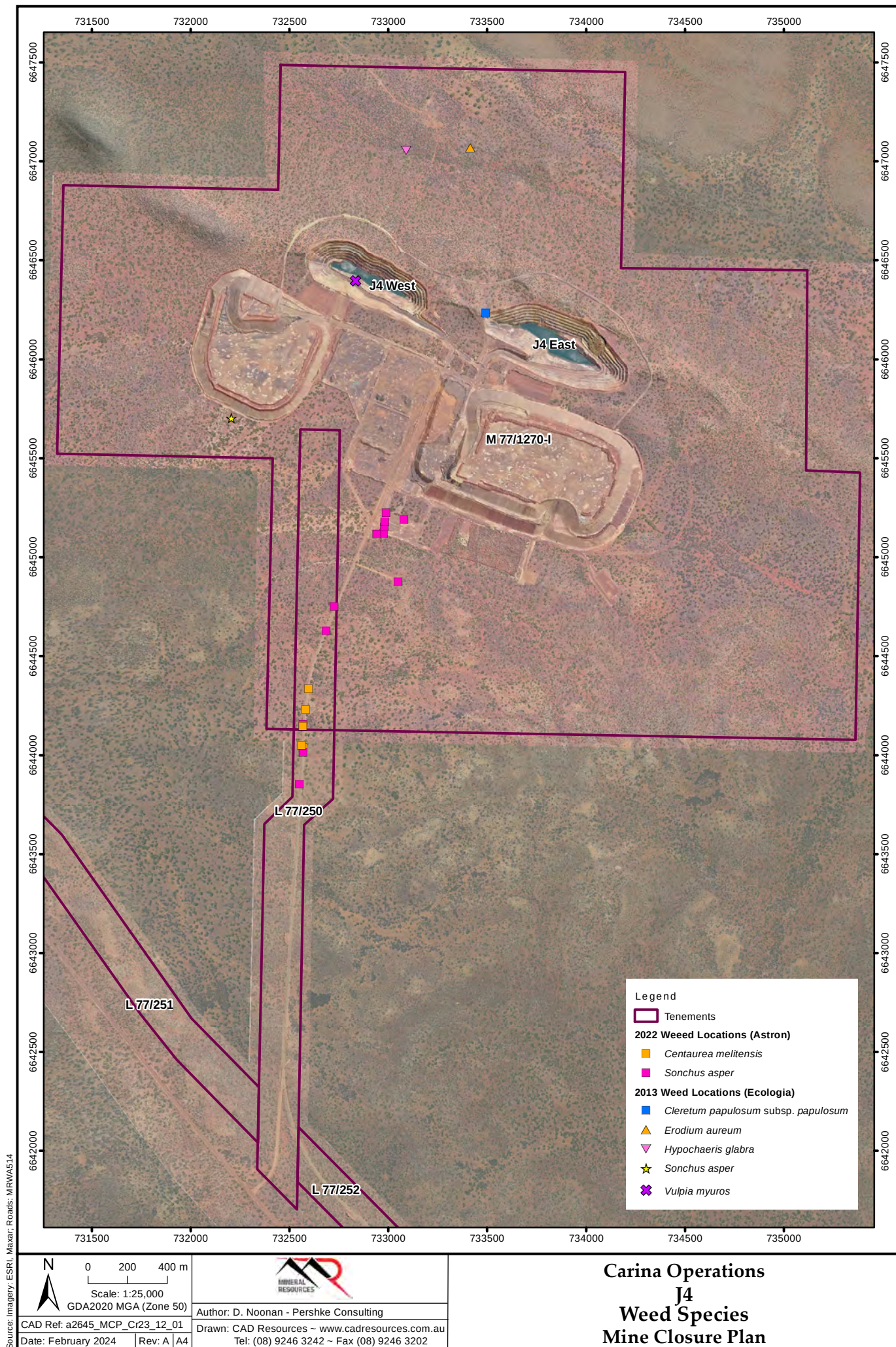
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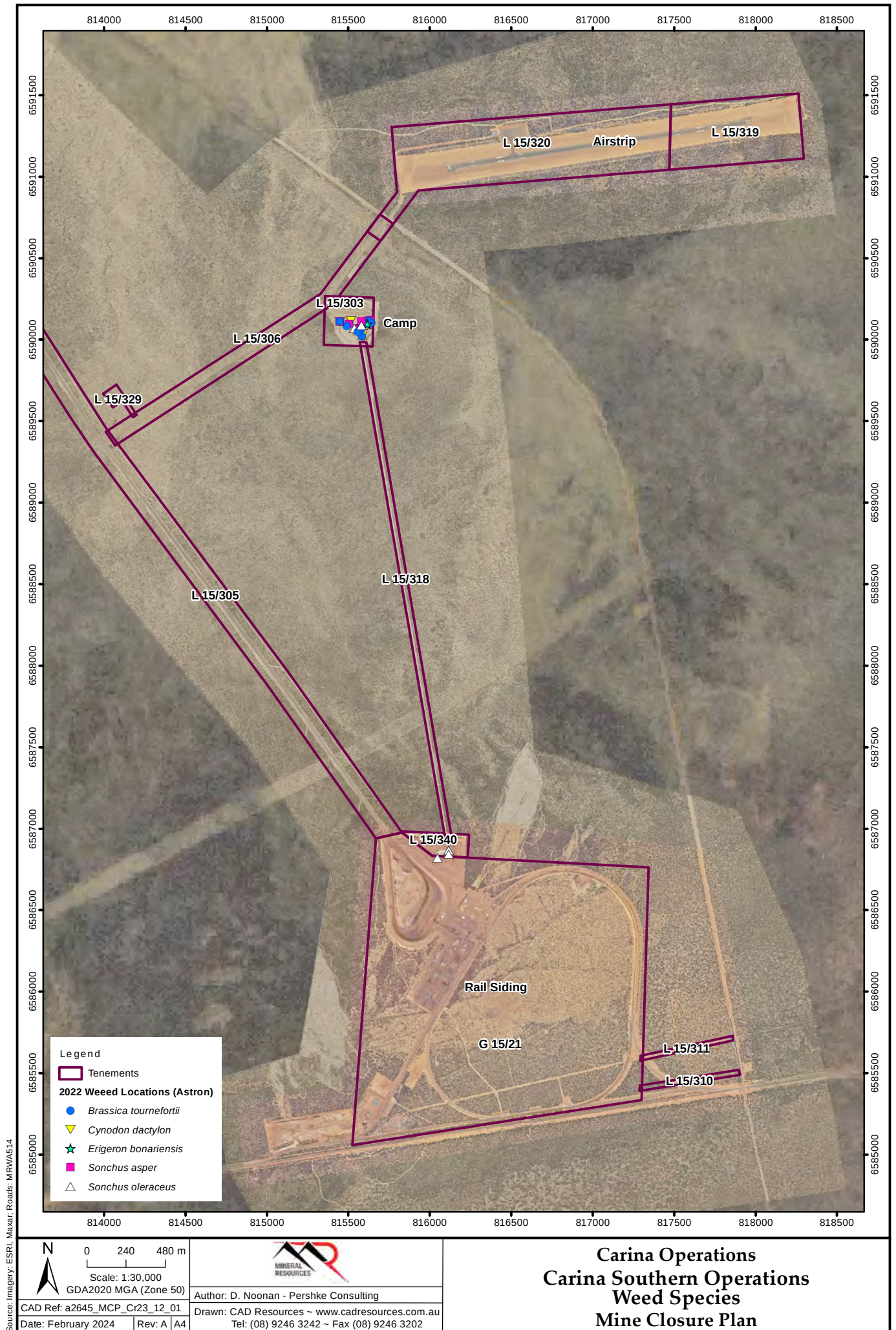
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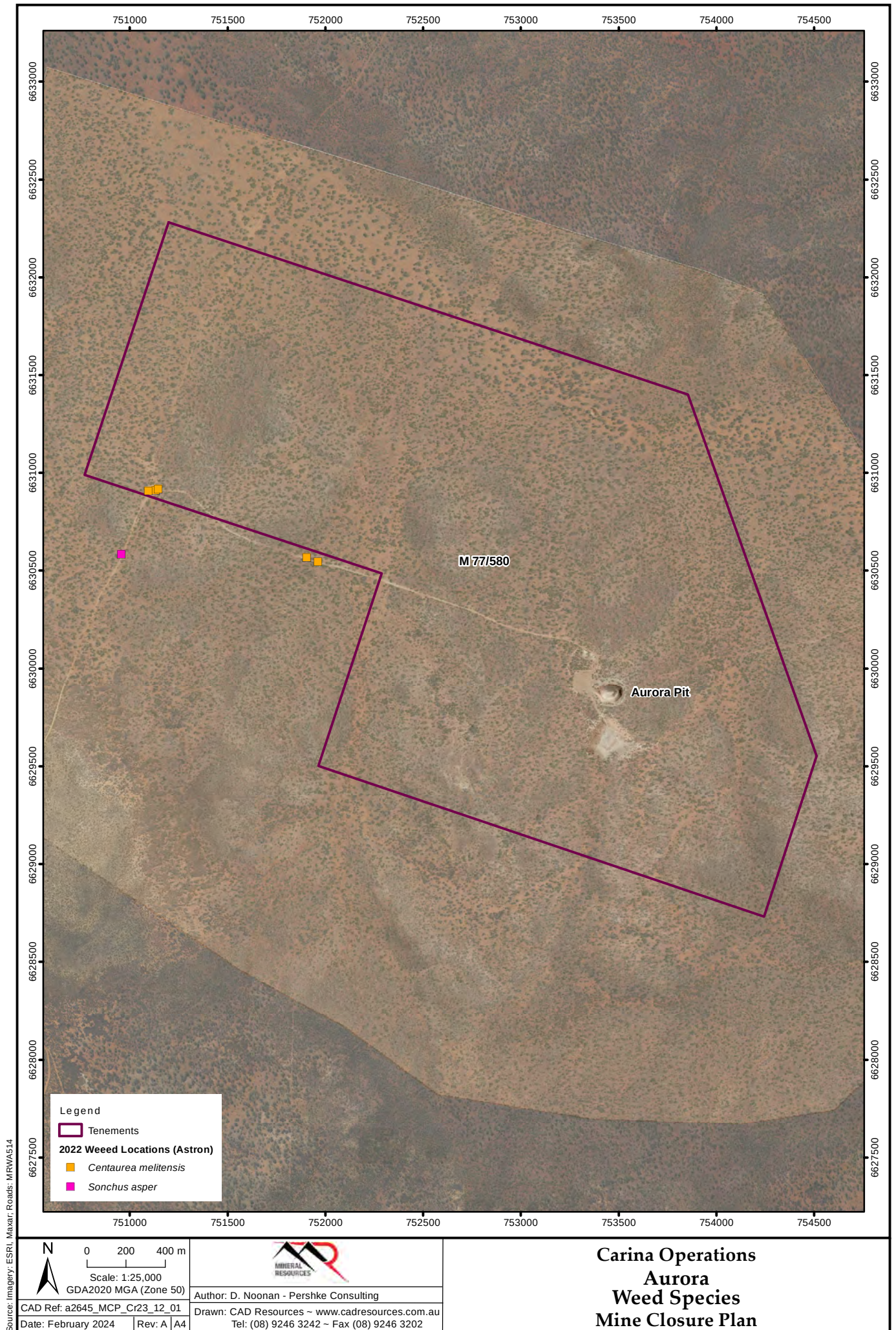
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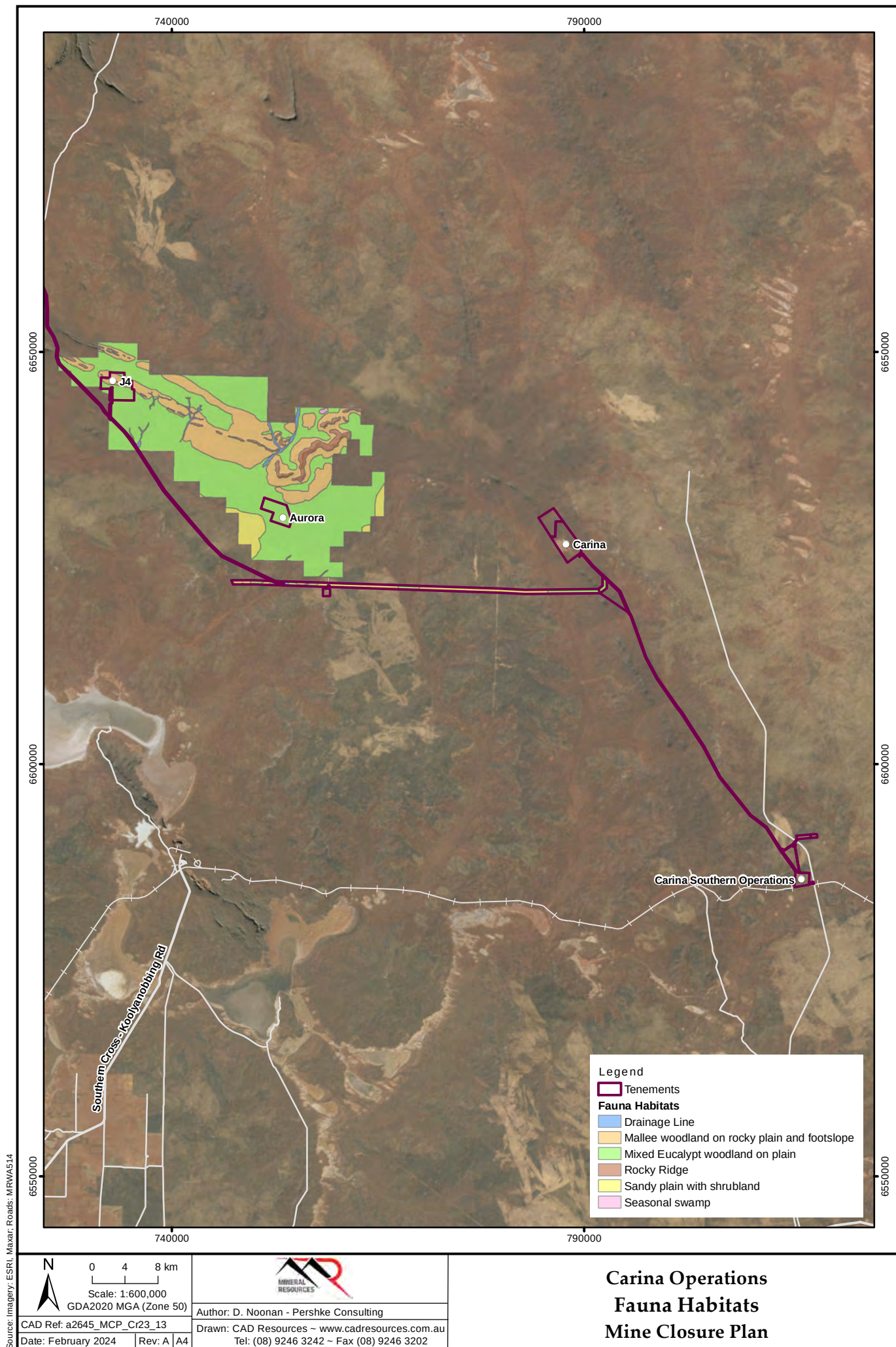
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Mine Closure Plan

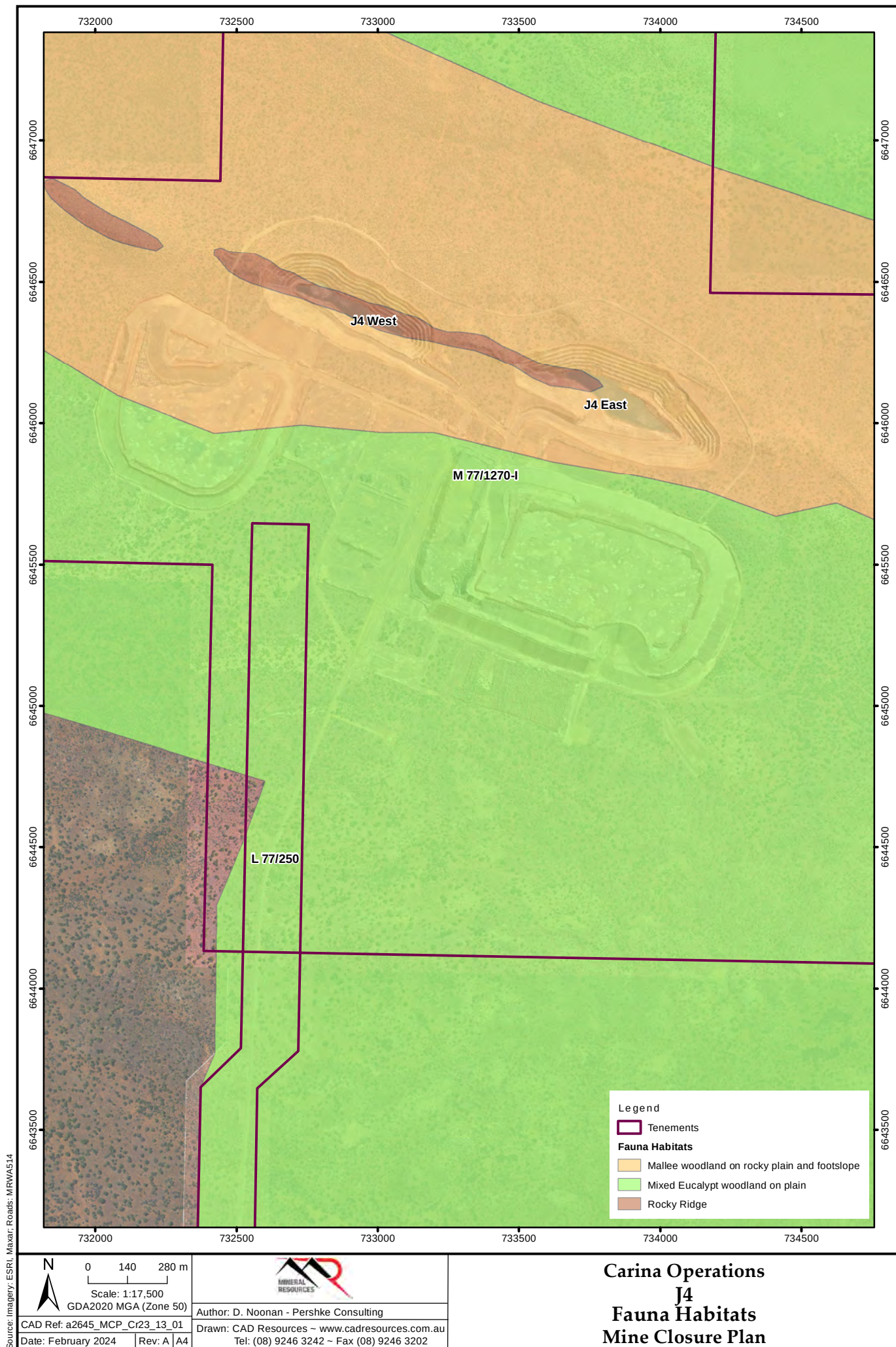


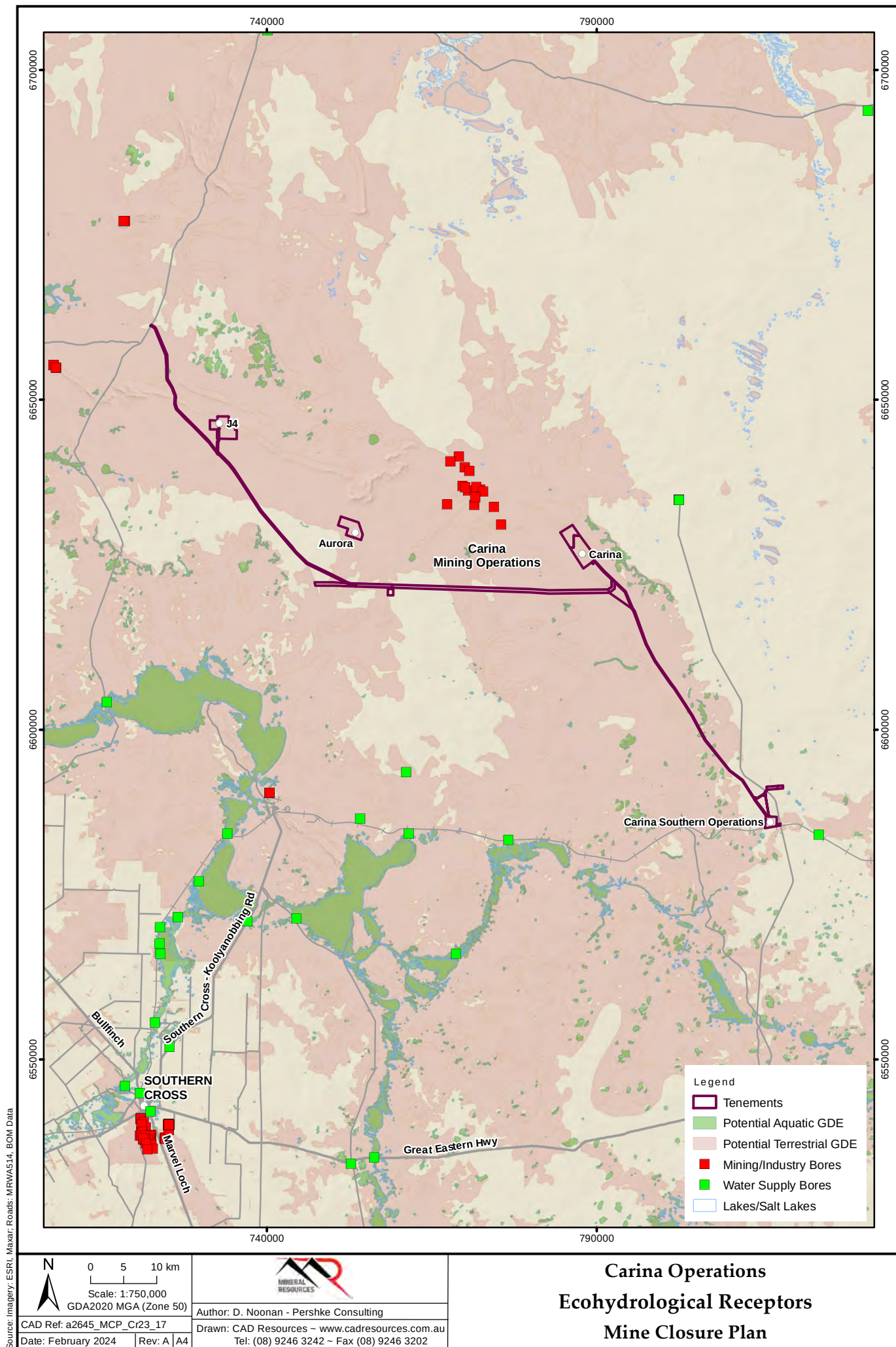


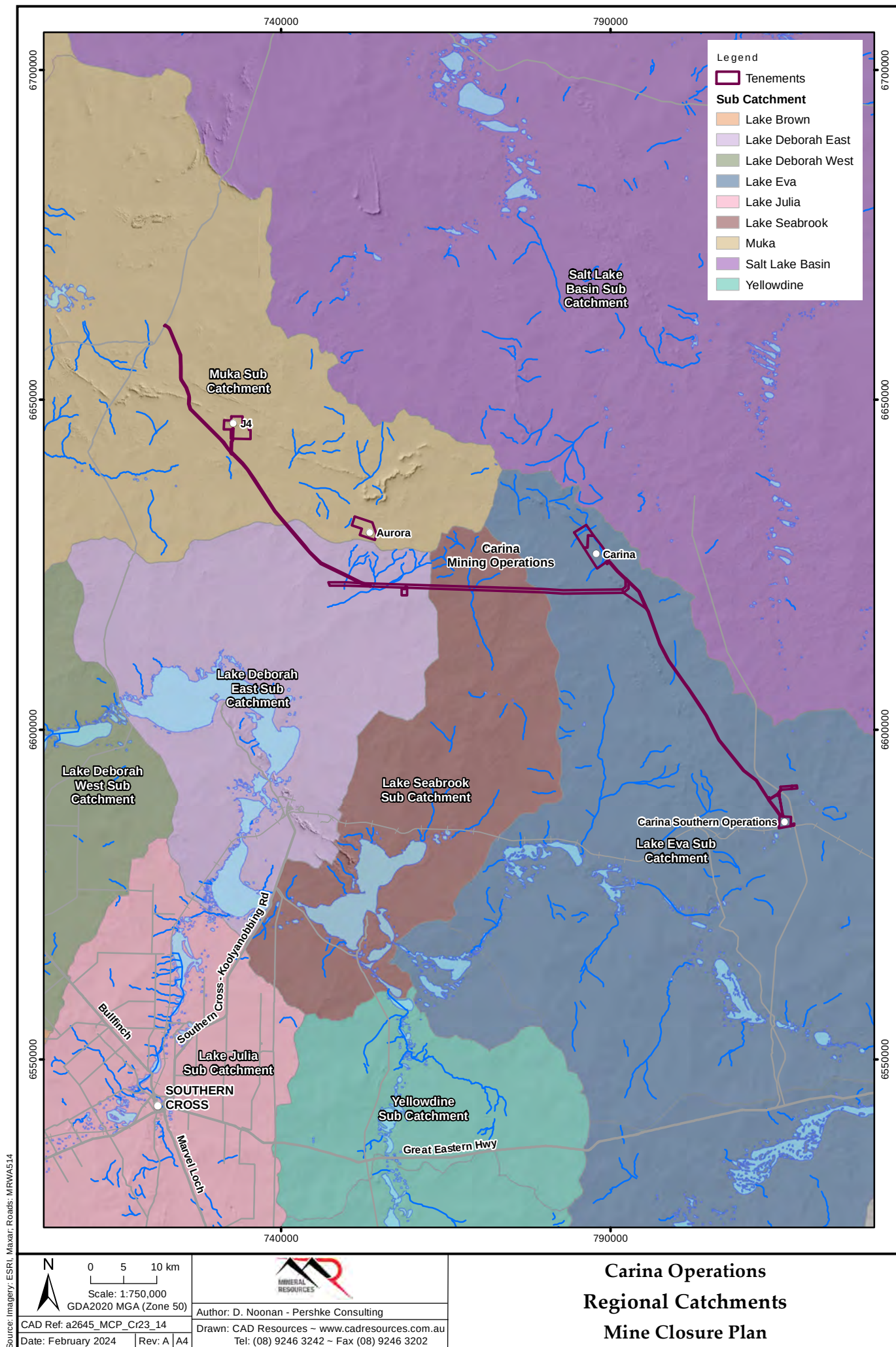


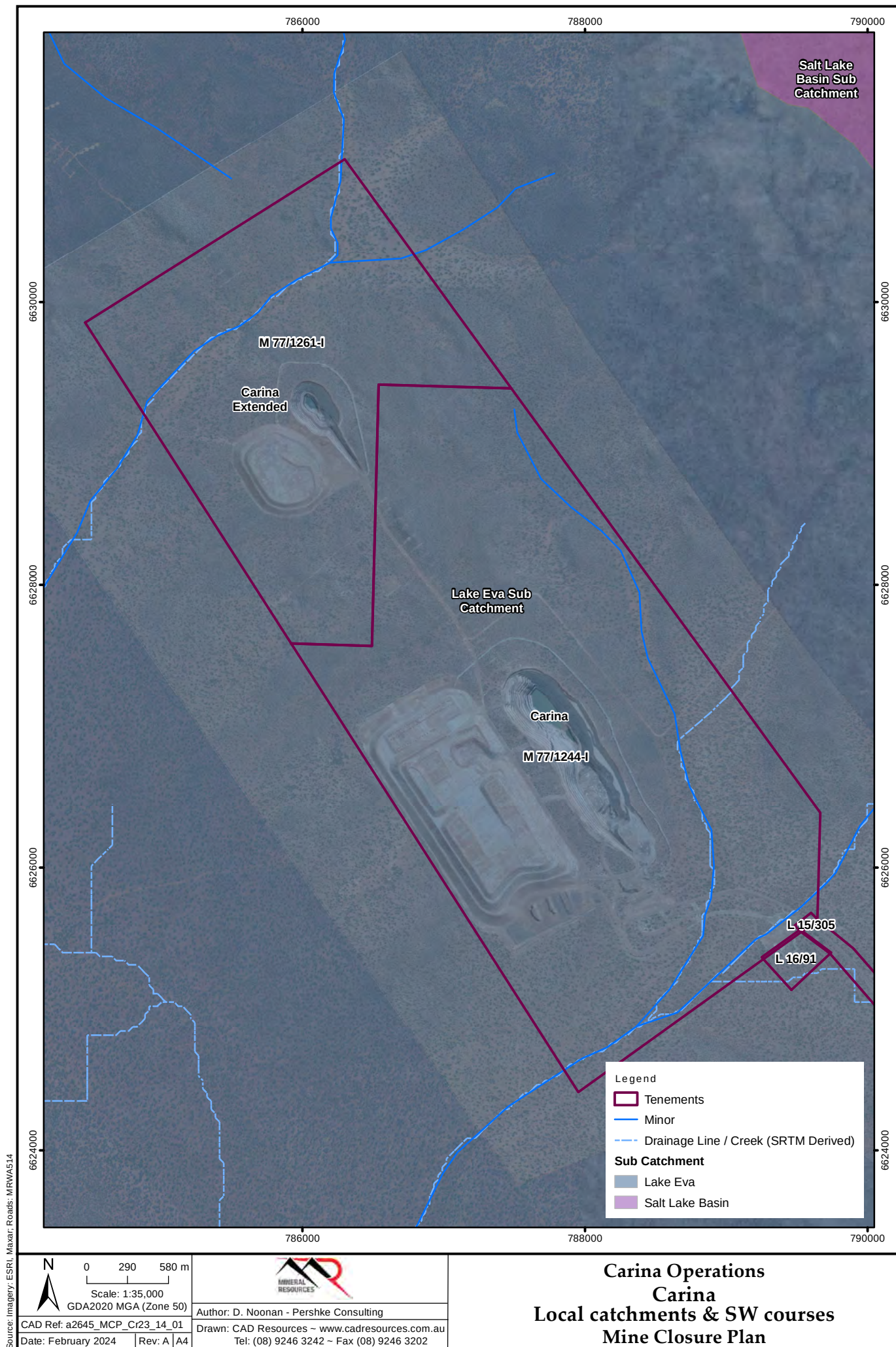


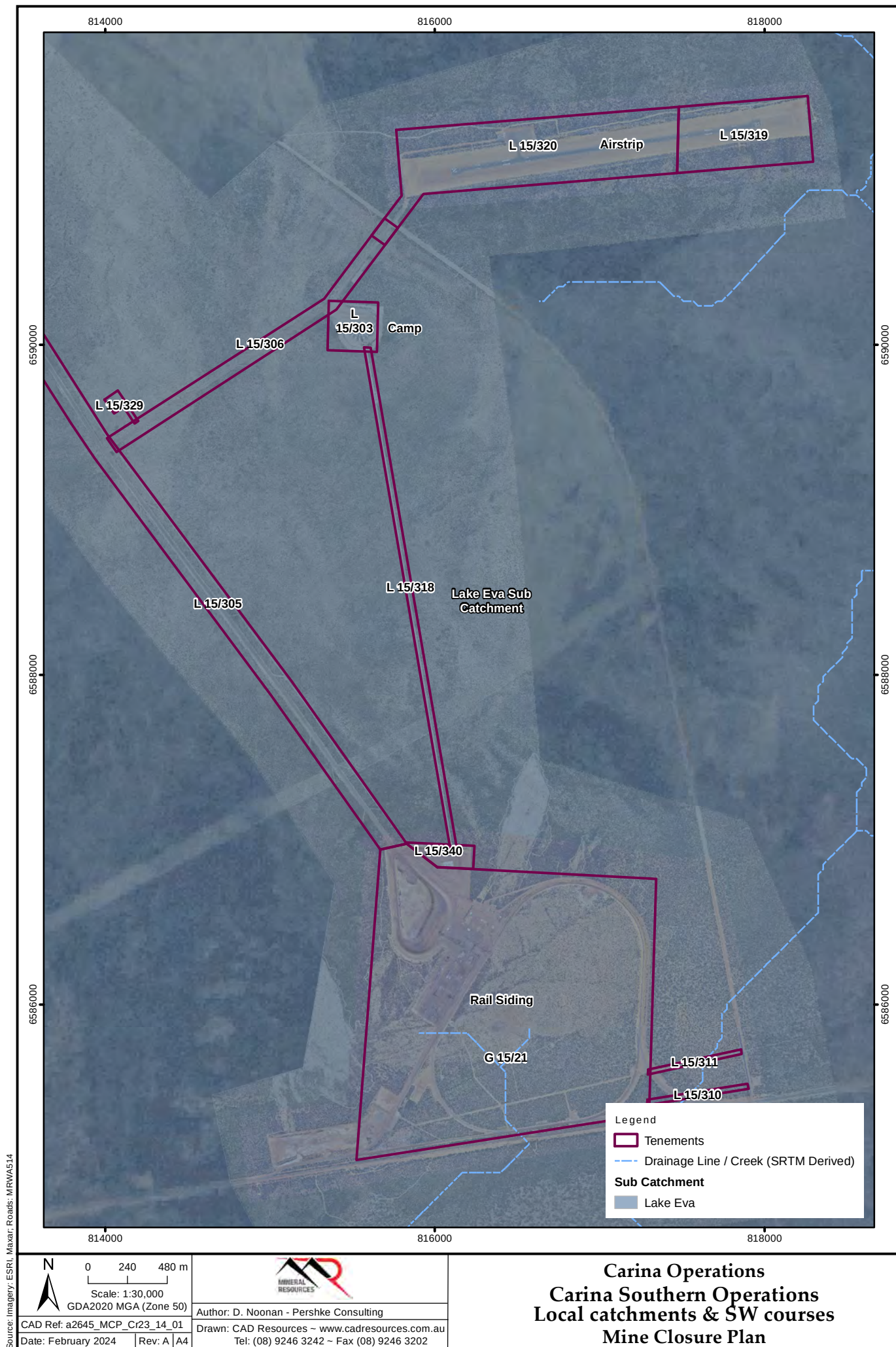
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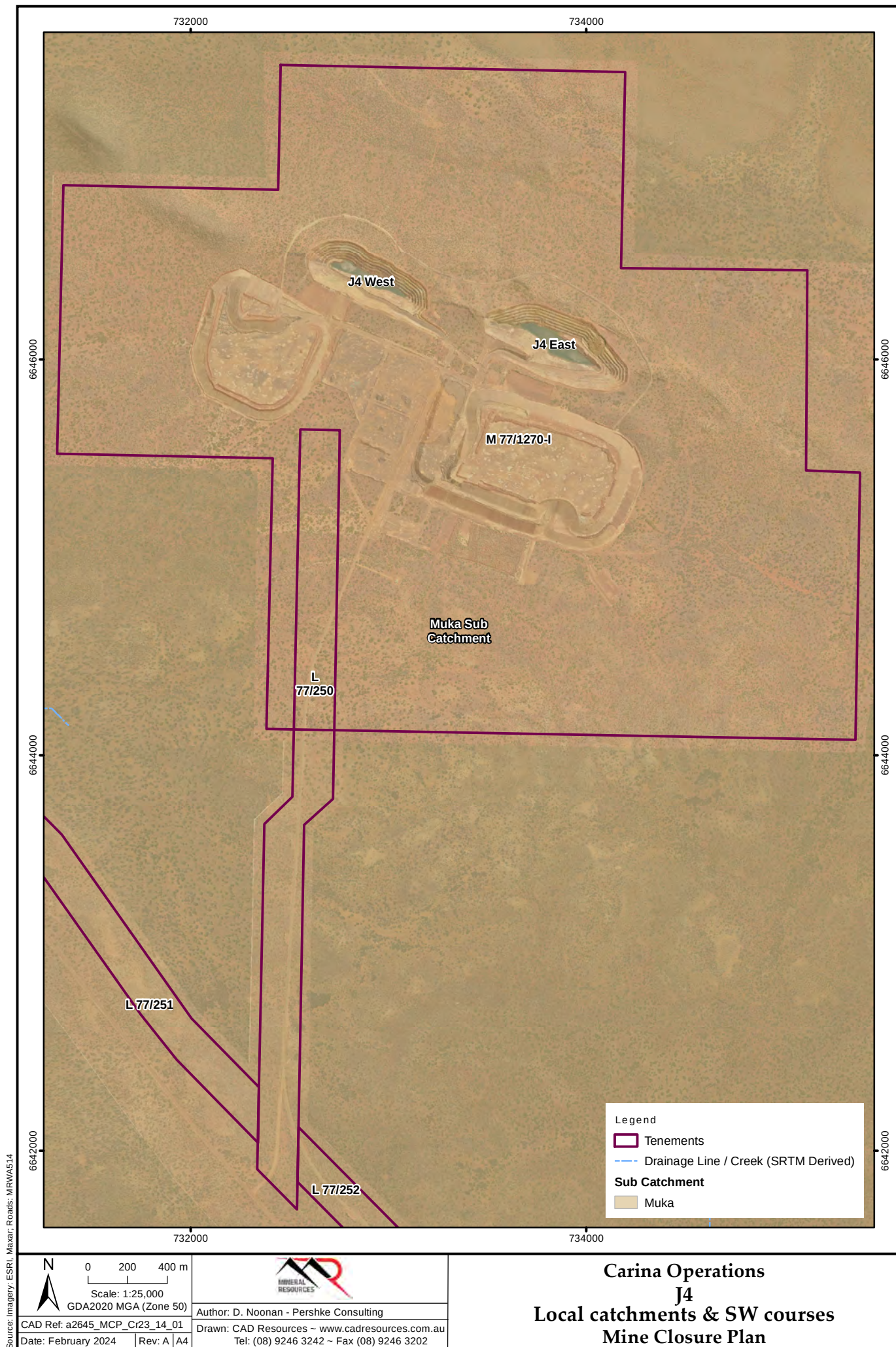












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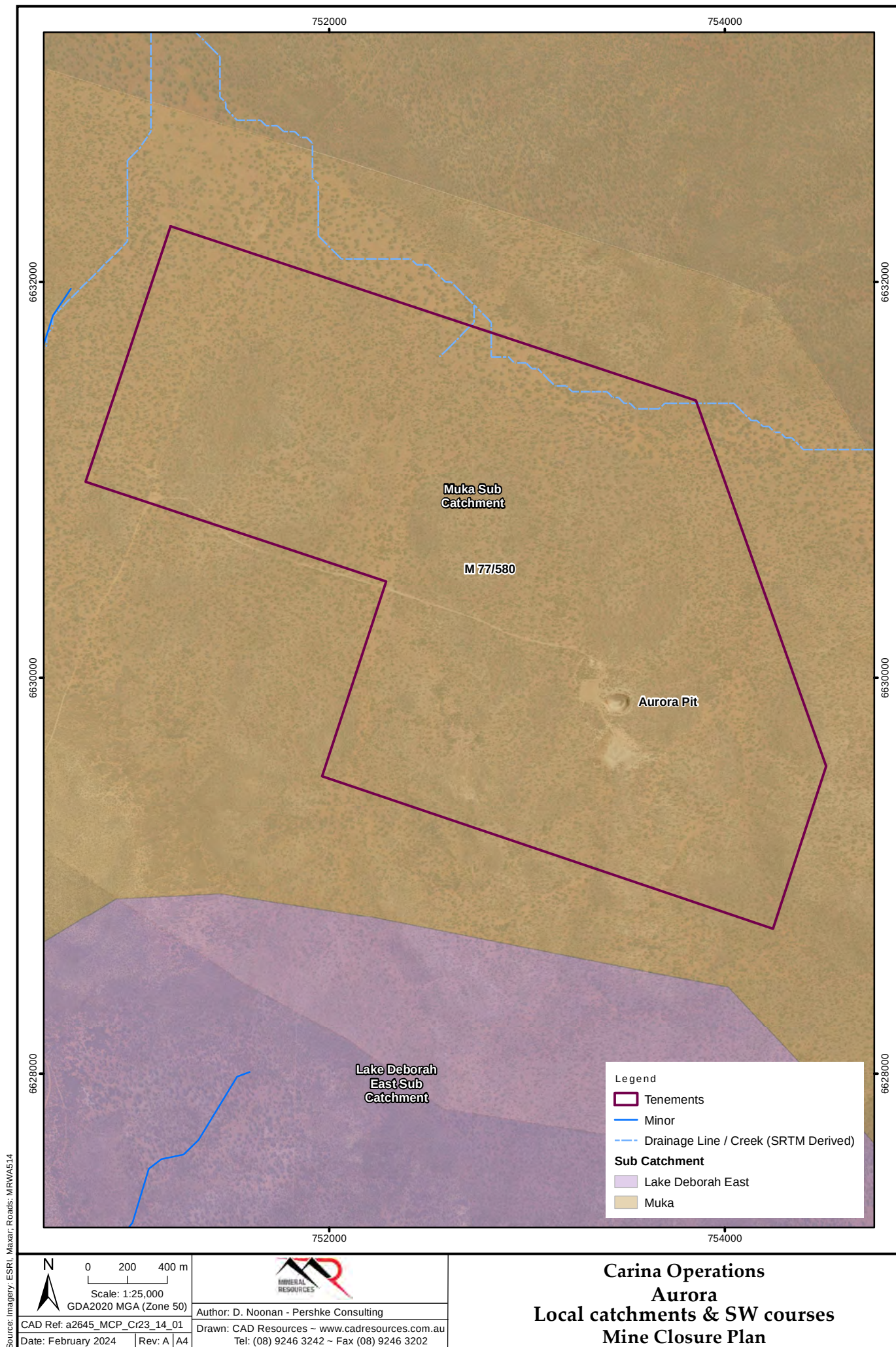
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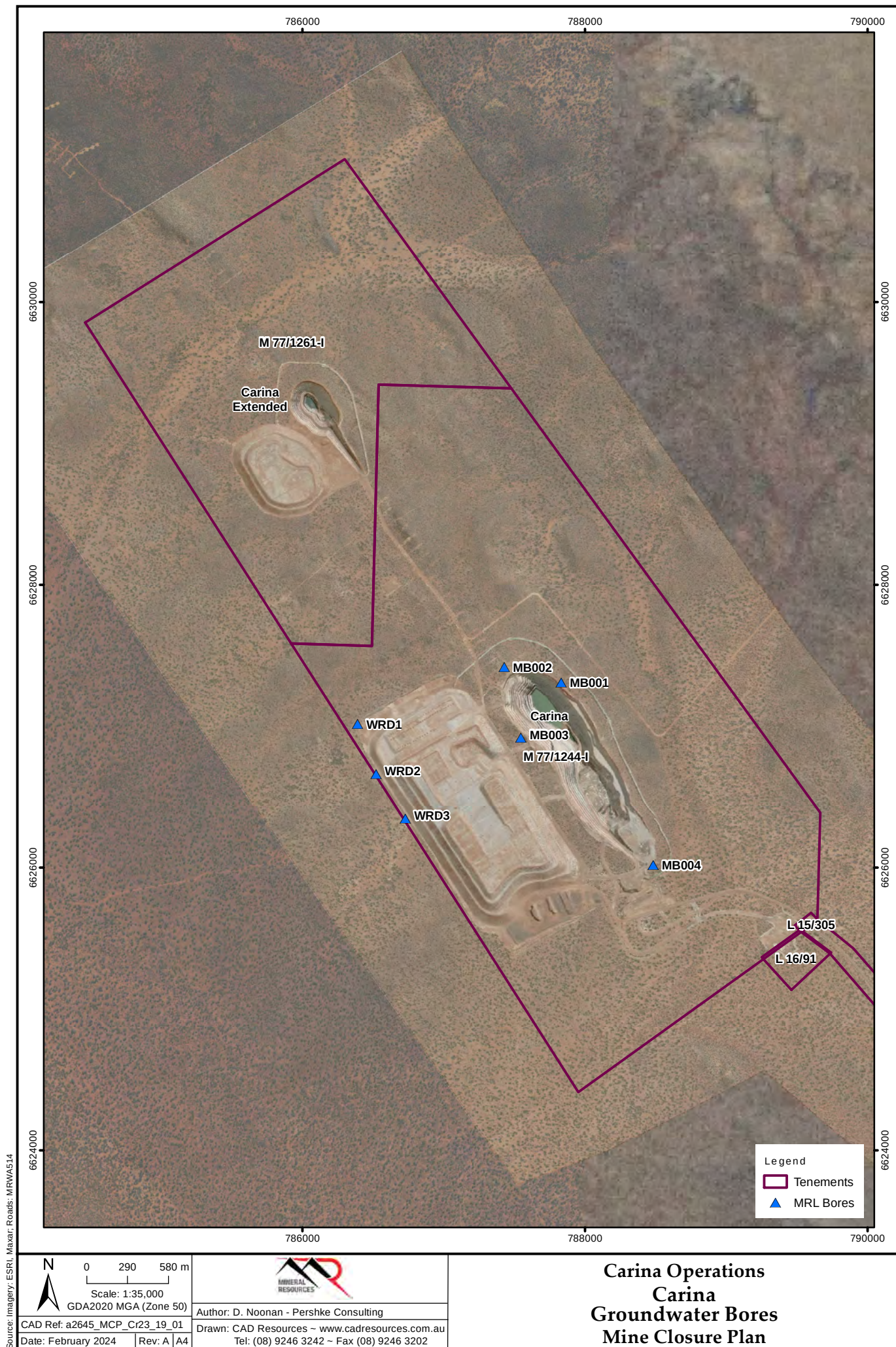


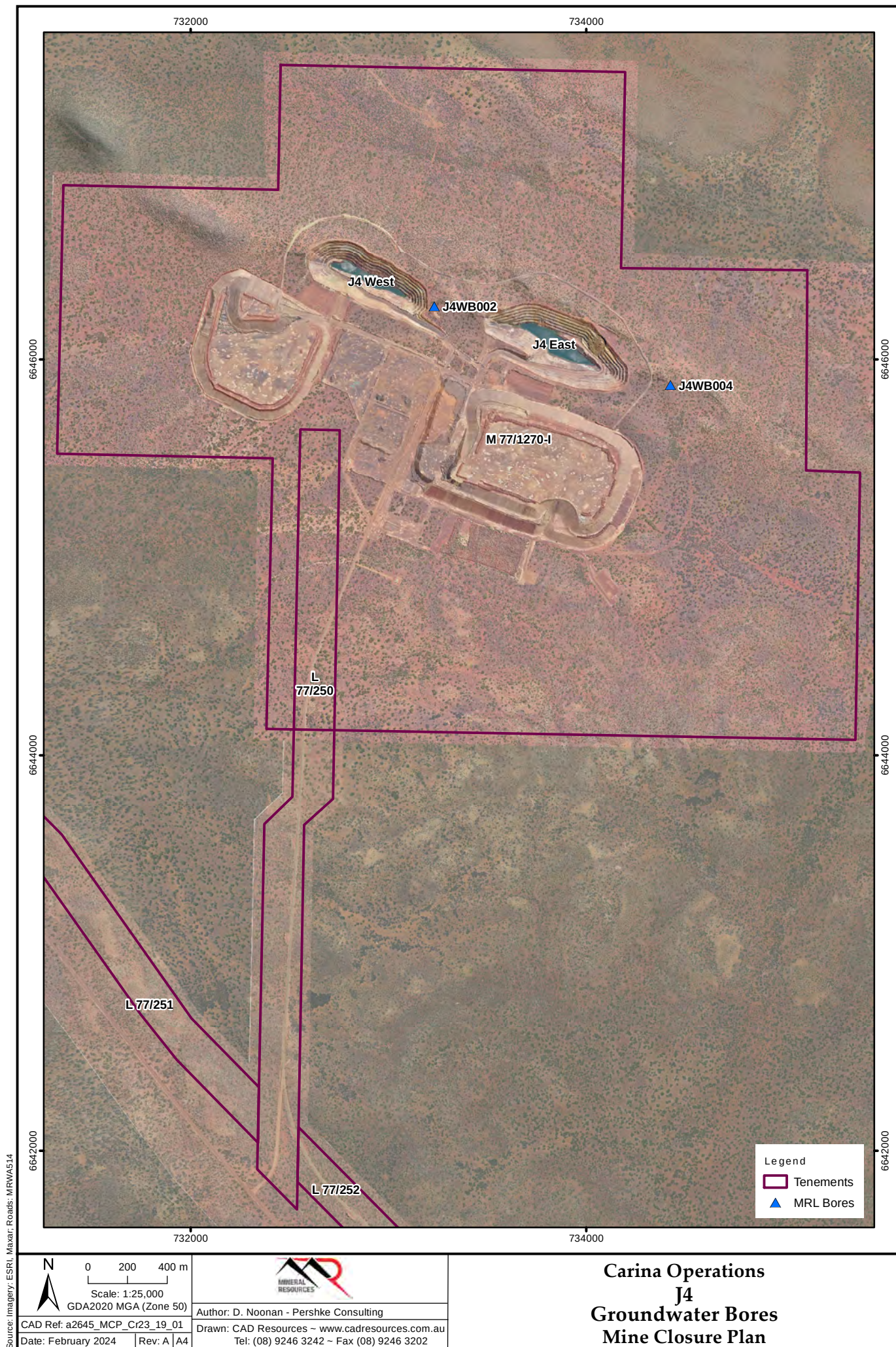
Author: D. Noonan - Pershke Consulting
Drawn: CAD Resources ~ www.cadresources.com.au
Tel: (08) 9246 3242 ~ Fax (08) 9246 3202

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Carina Operations J4 Local catchments & SW courses Mine Closure Plan







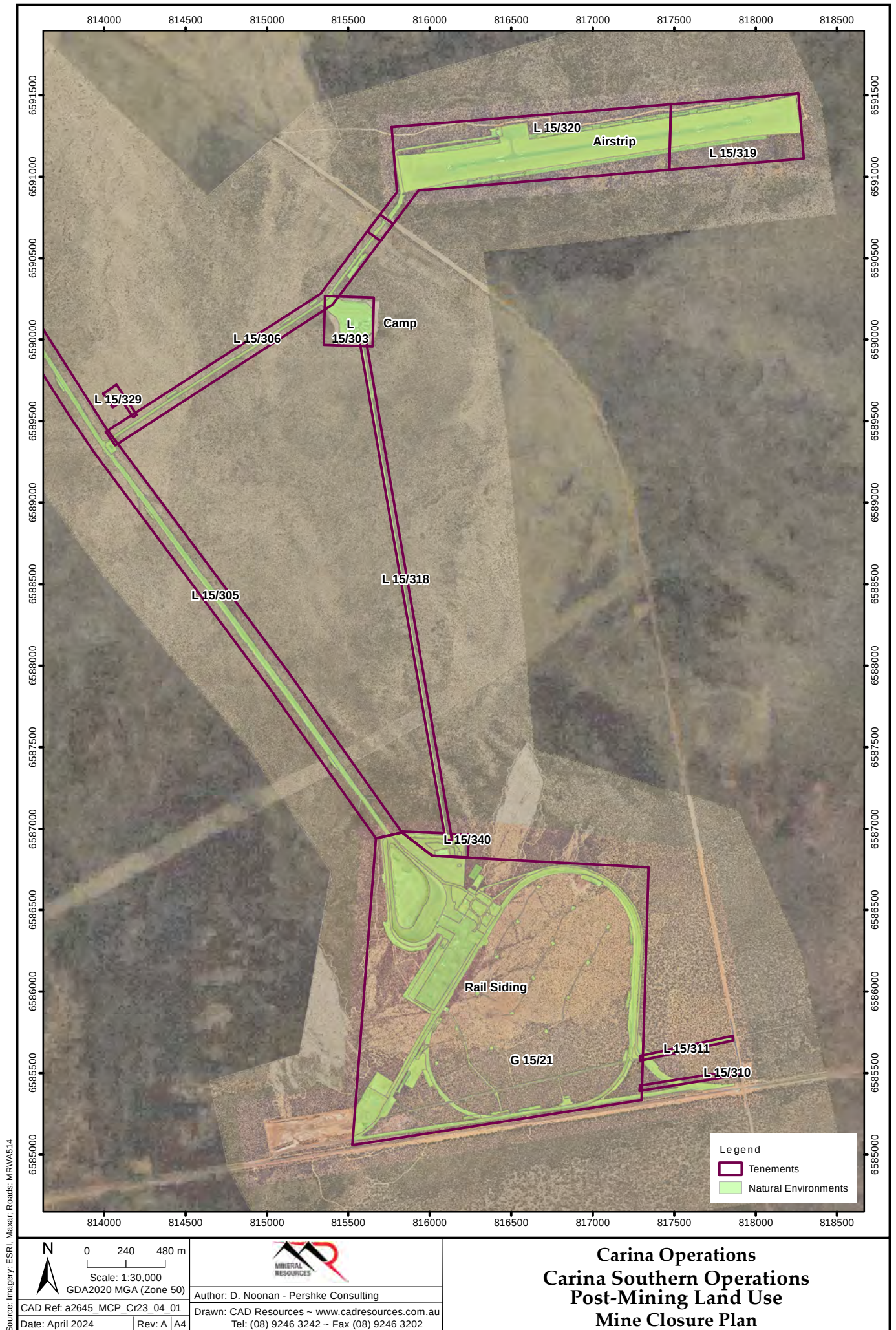


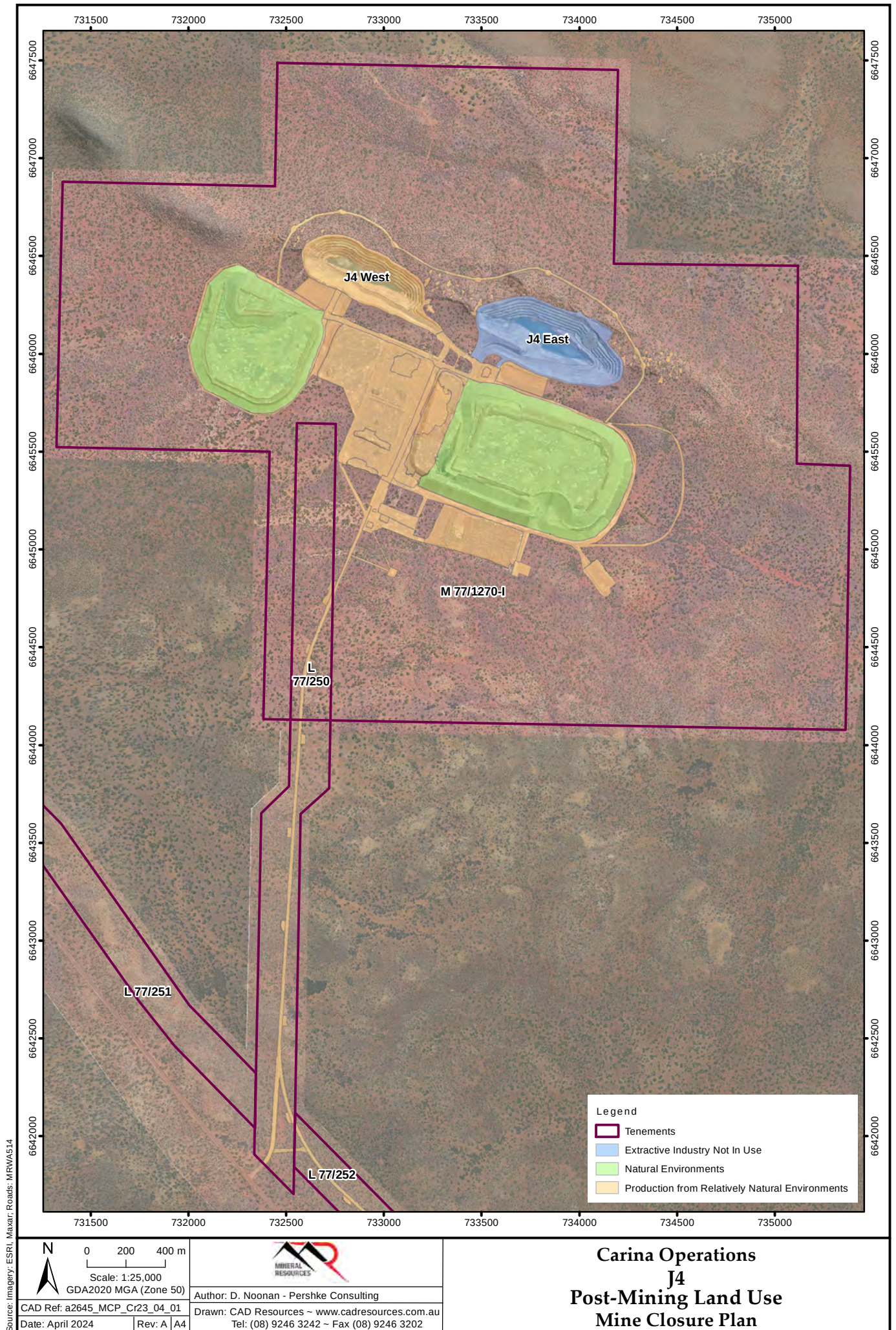
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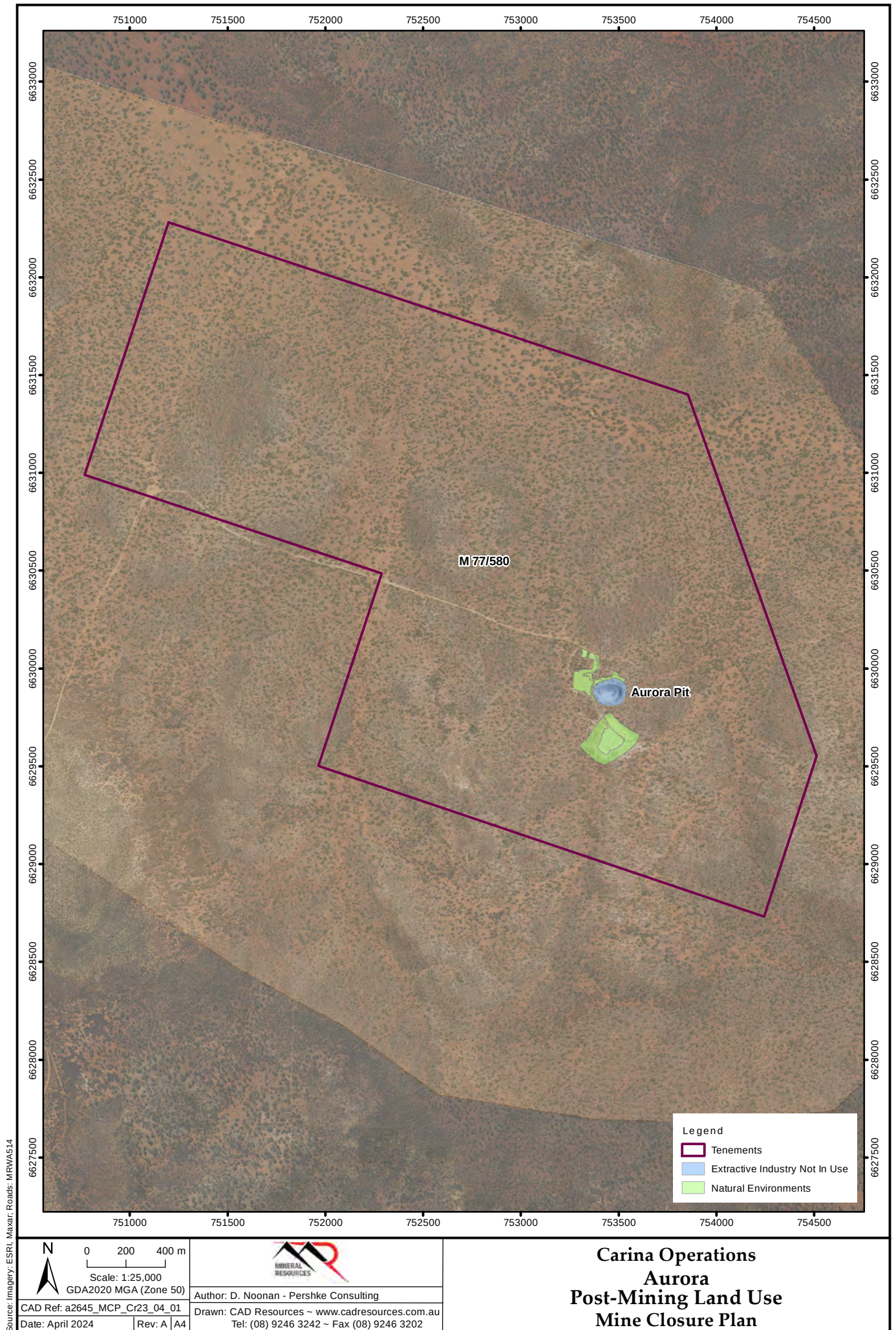


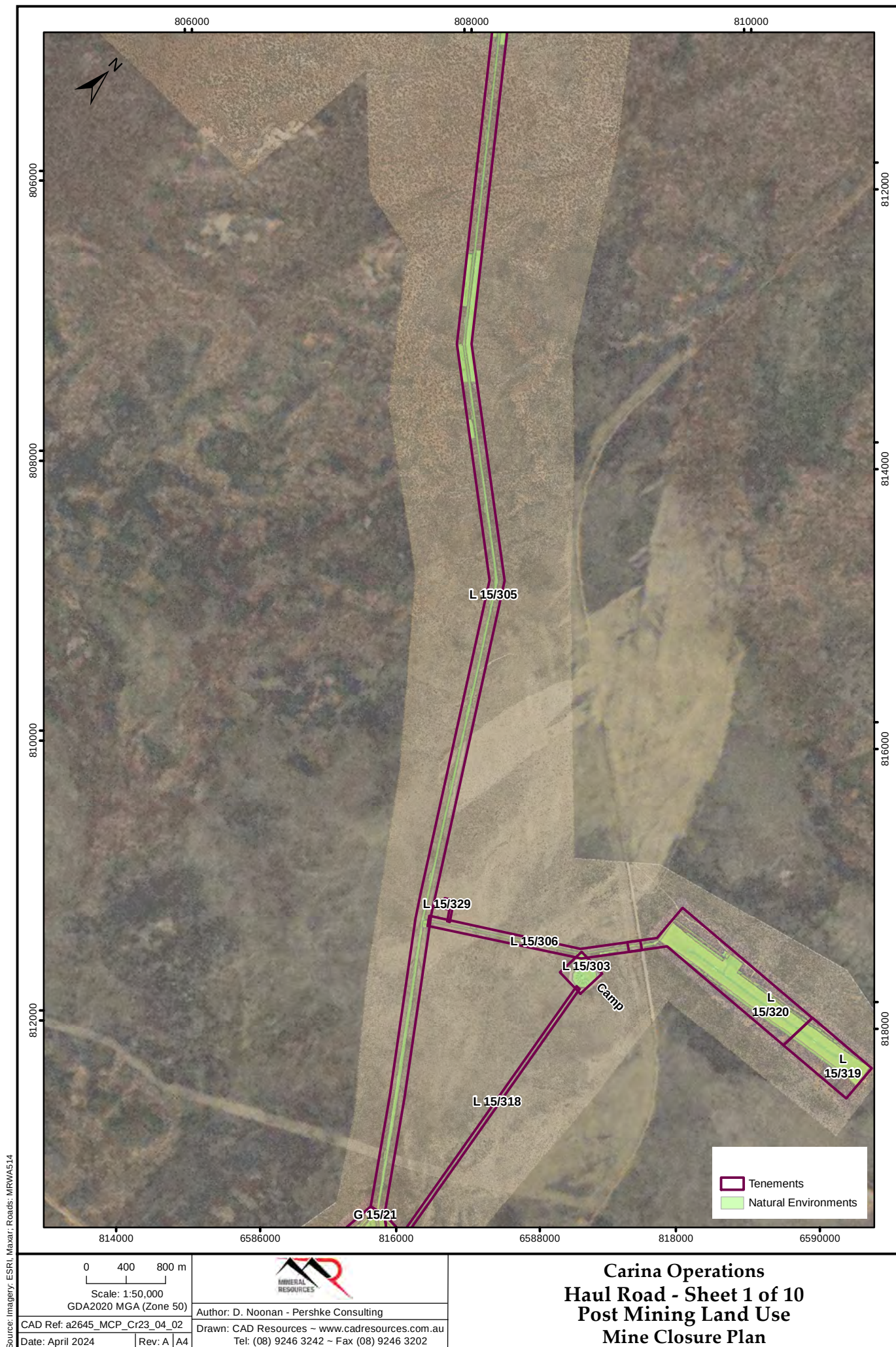
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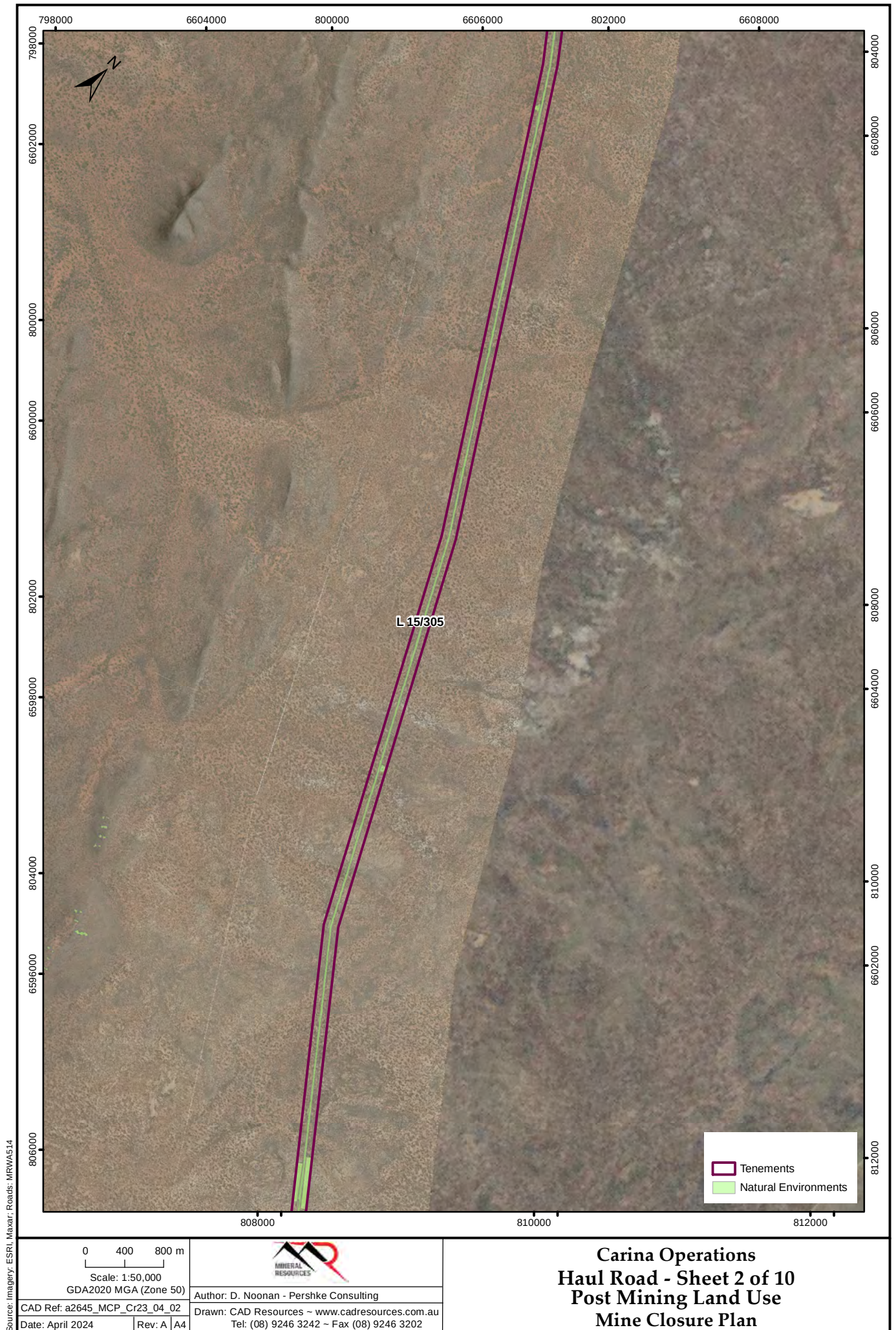
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Rev: A
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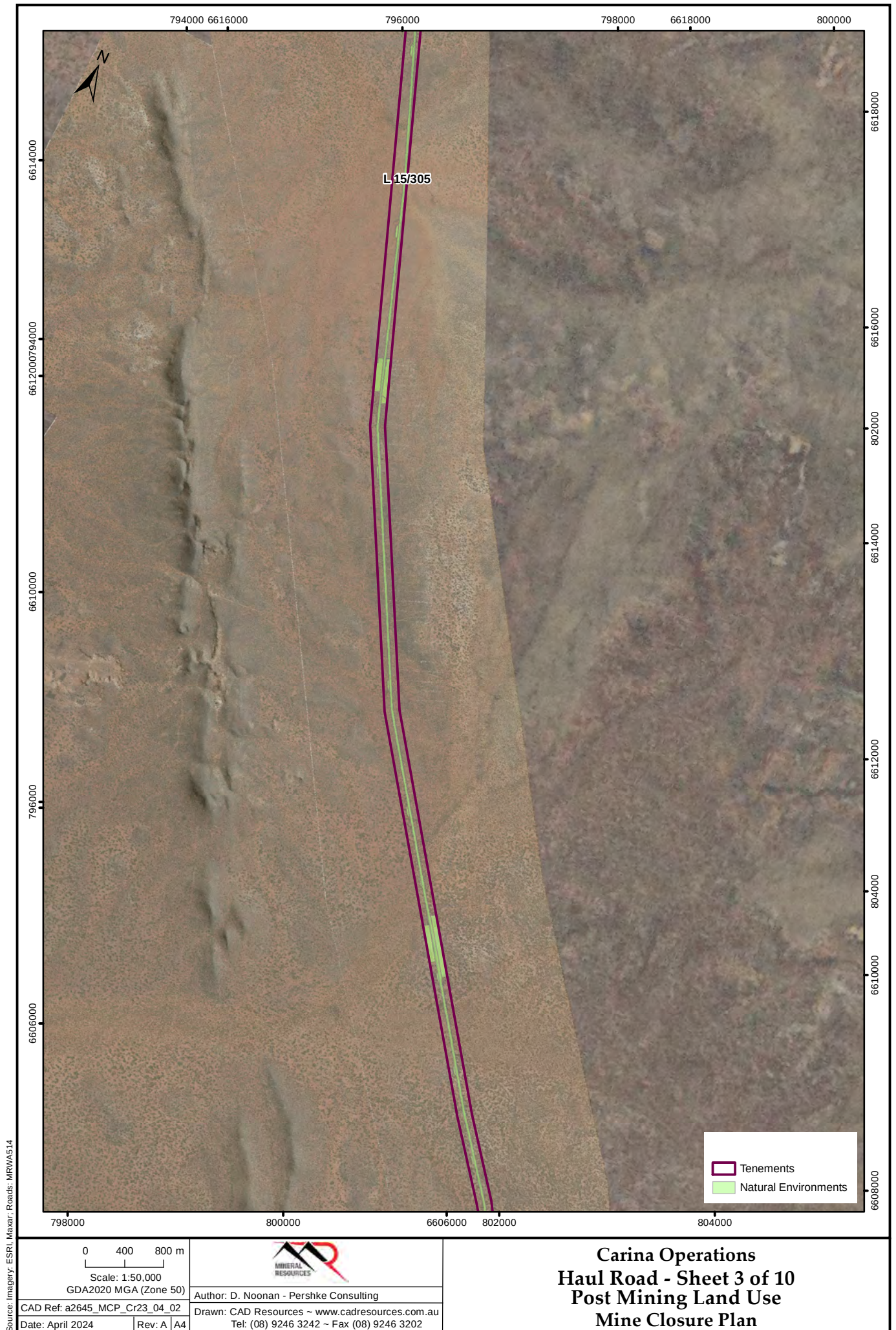




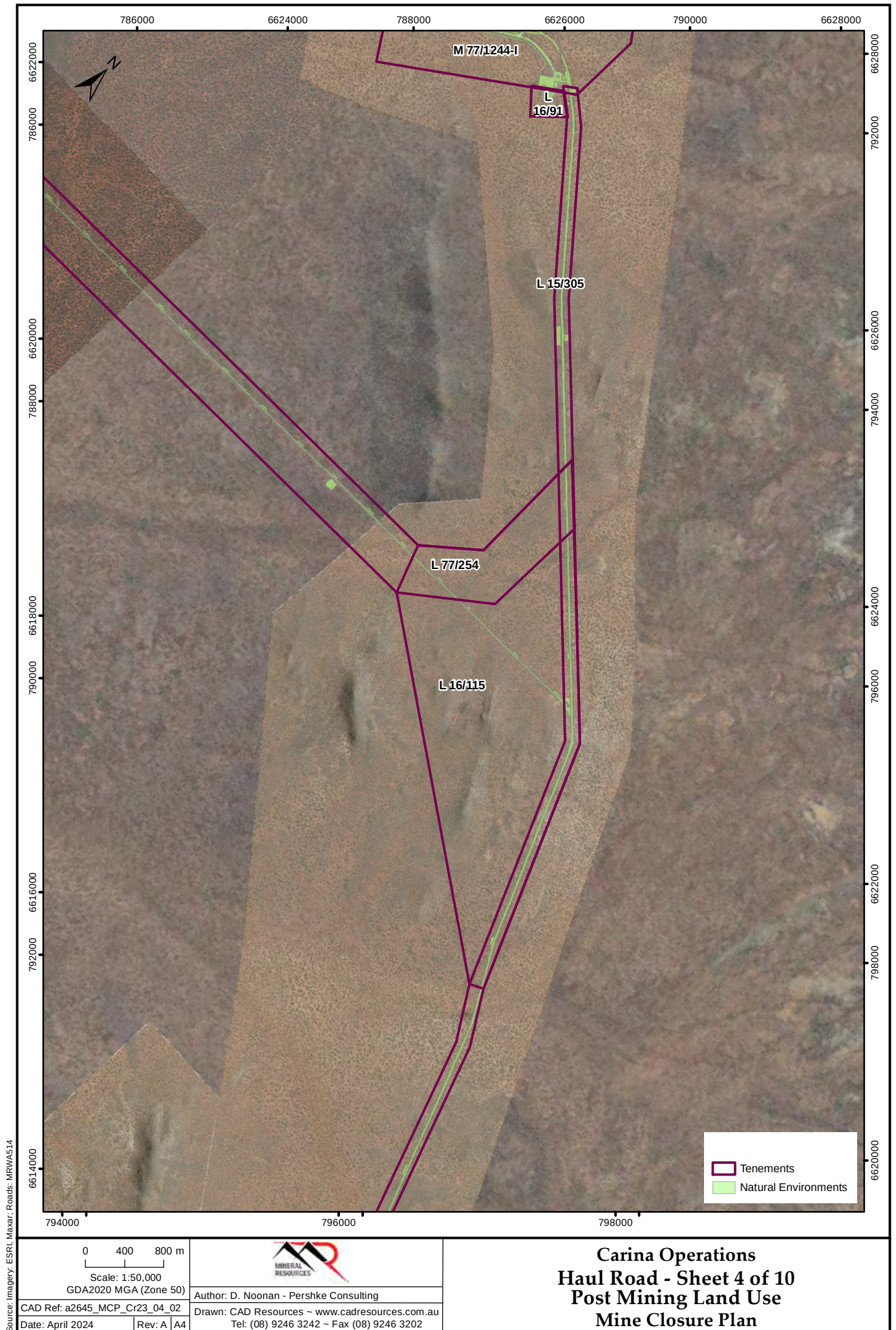


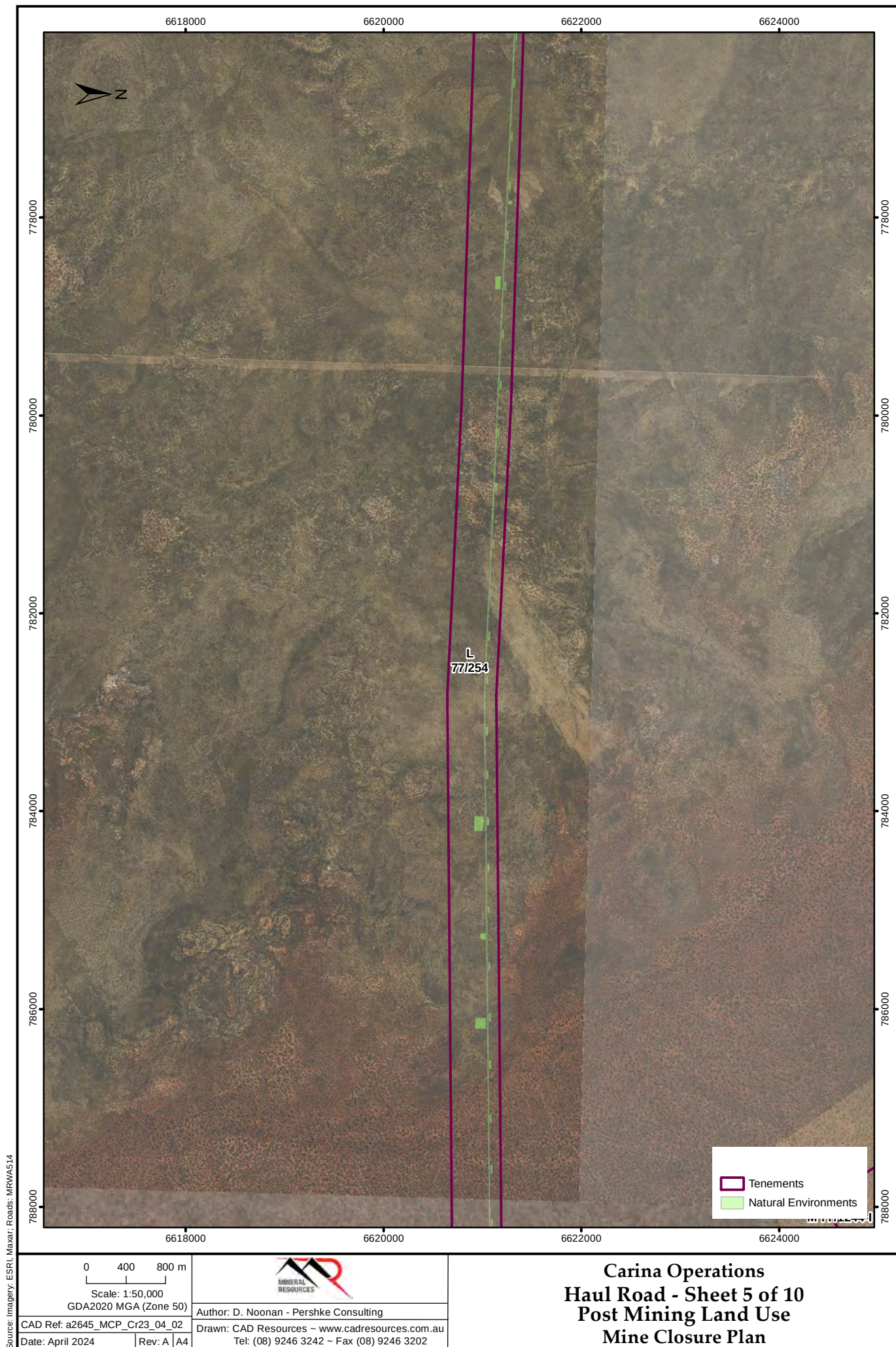


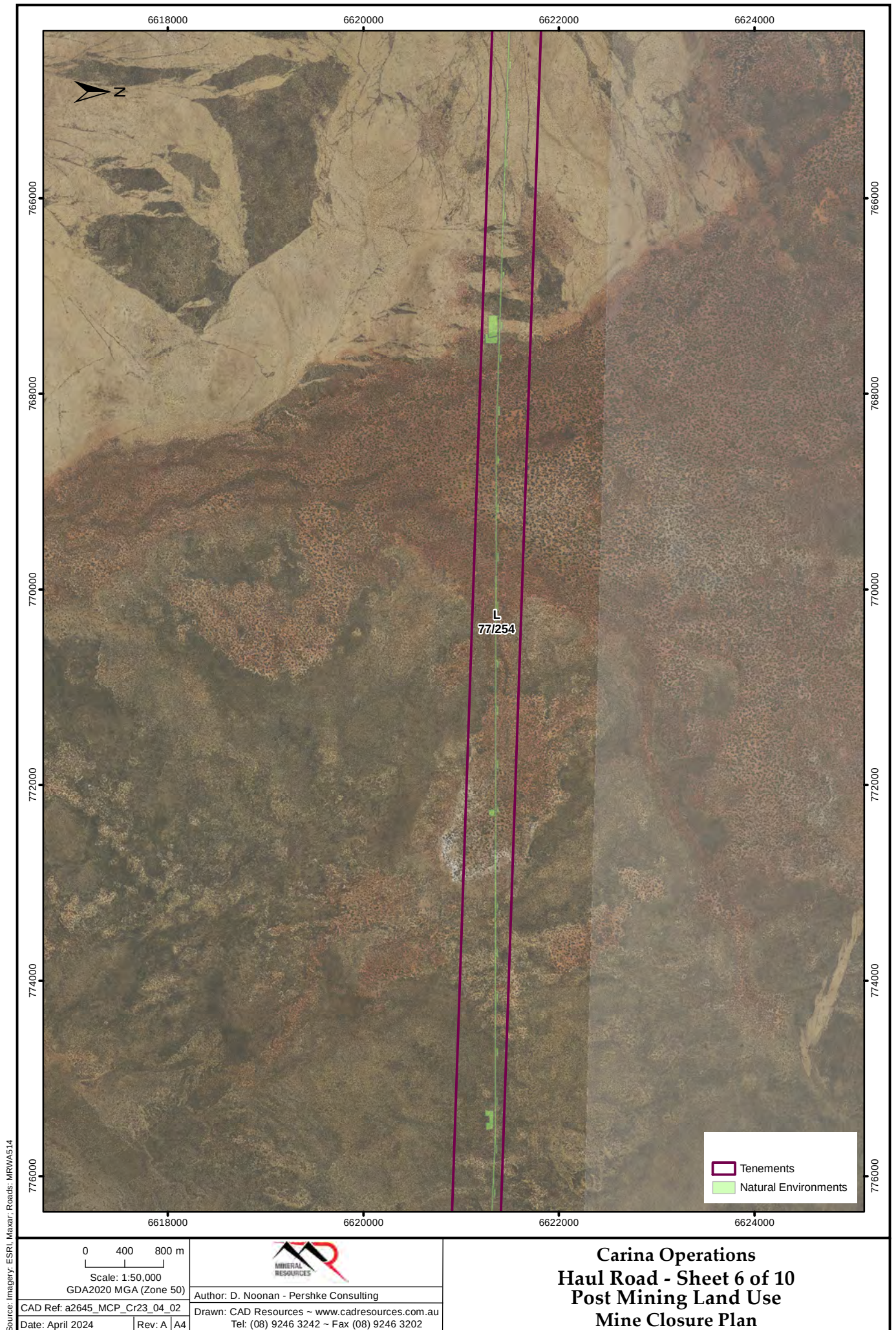


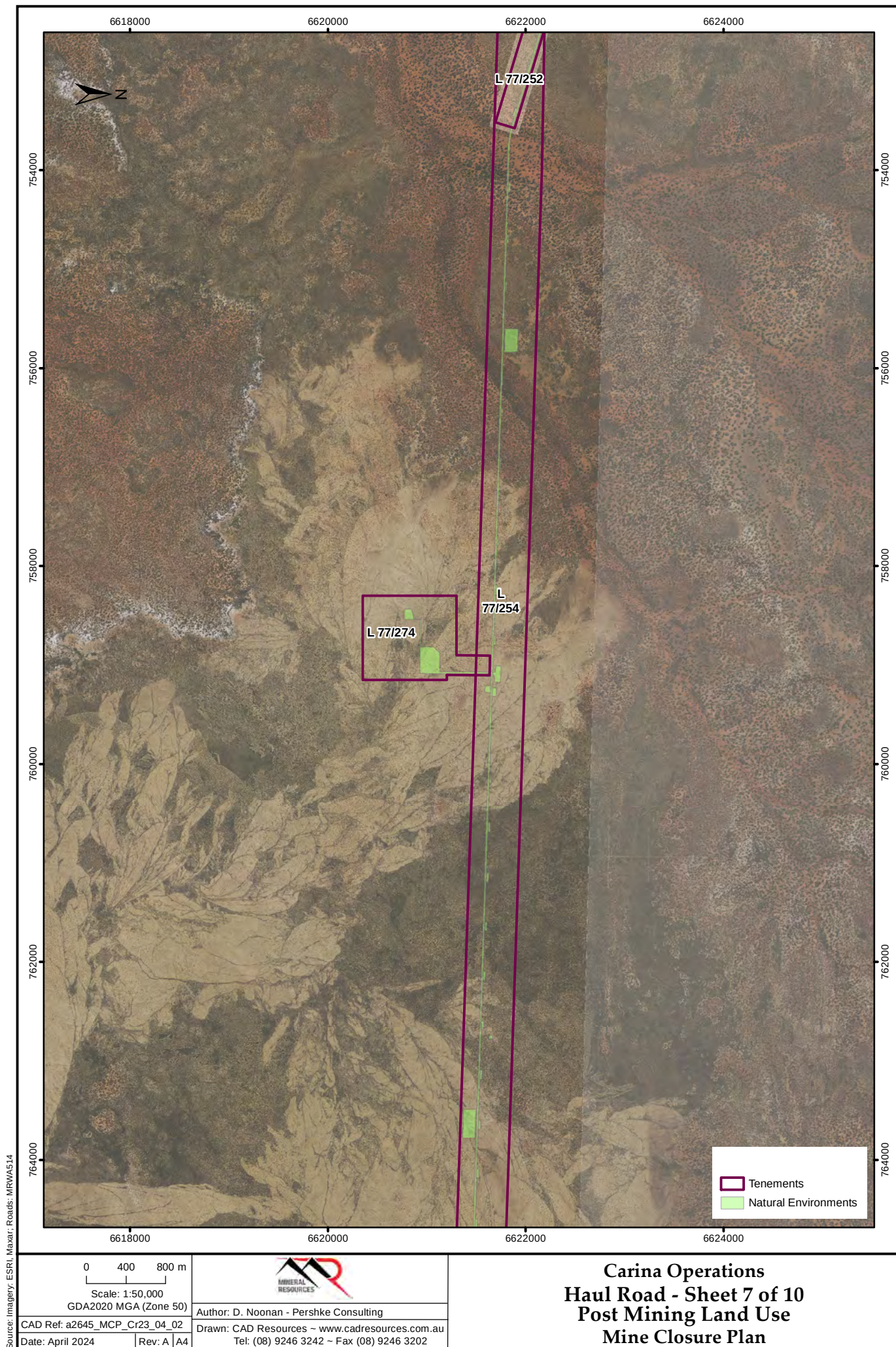


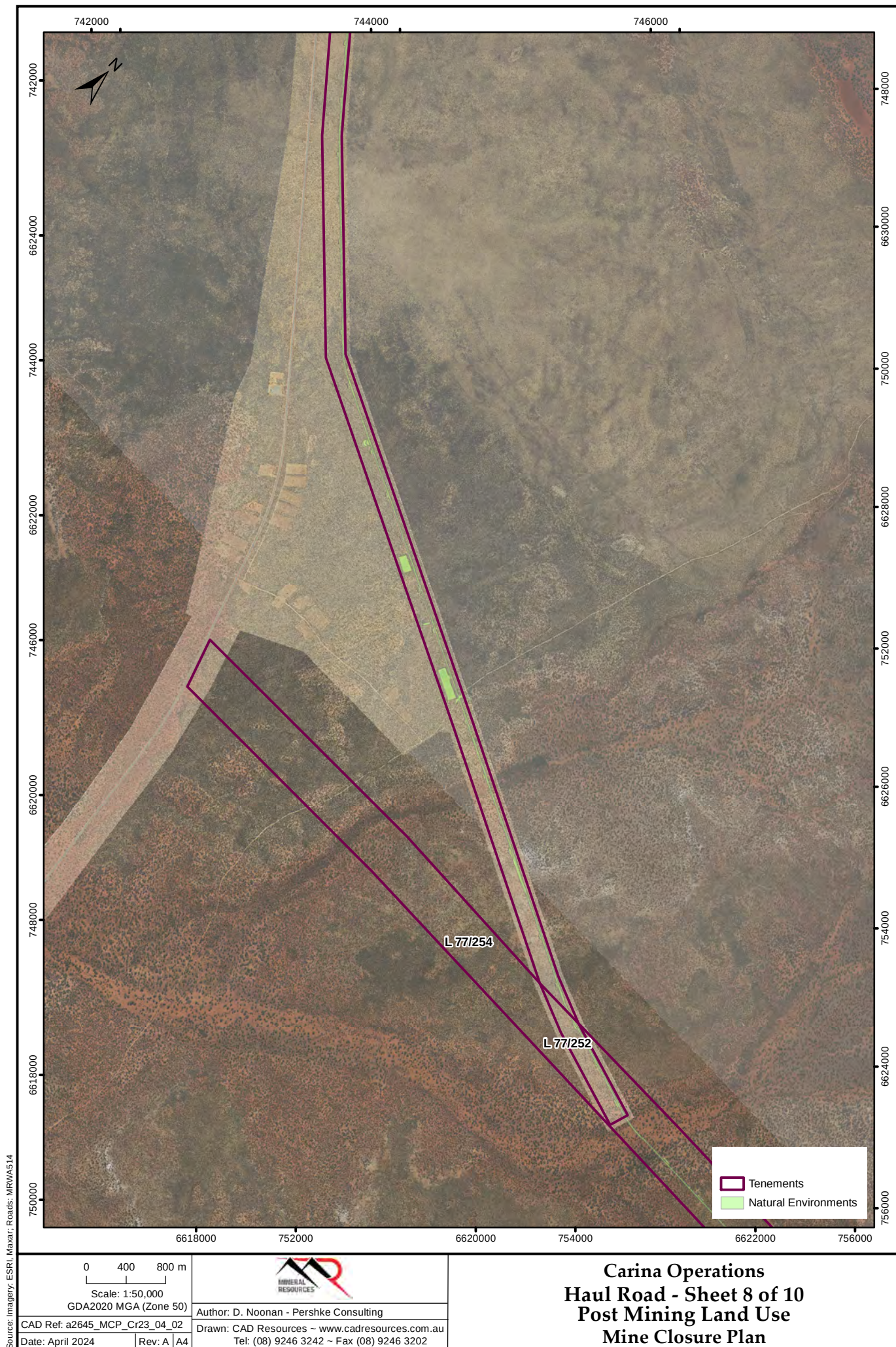
Carina Operations
Haul Road - Sheet 3 of 10
Post Mining Land Use
Mine Closure Plan

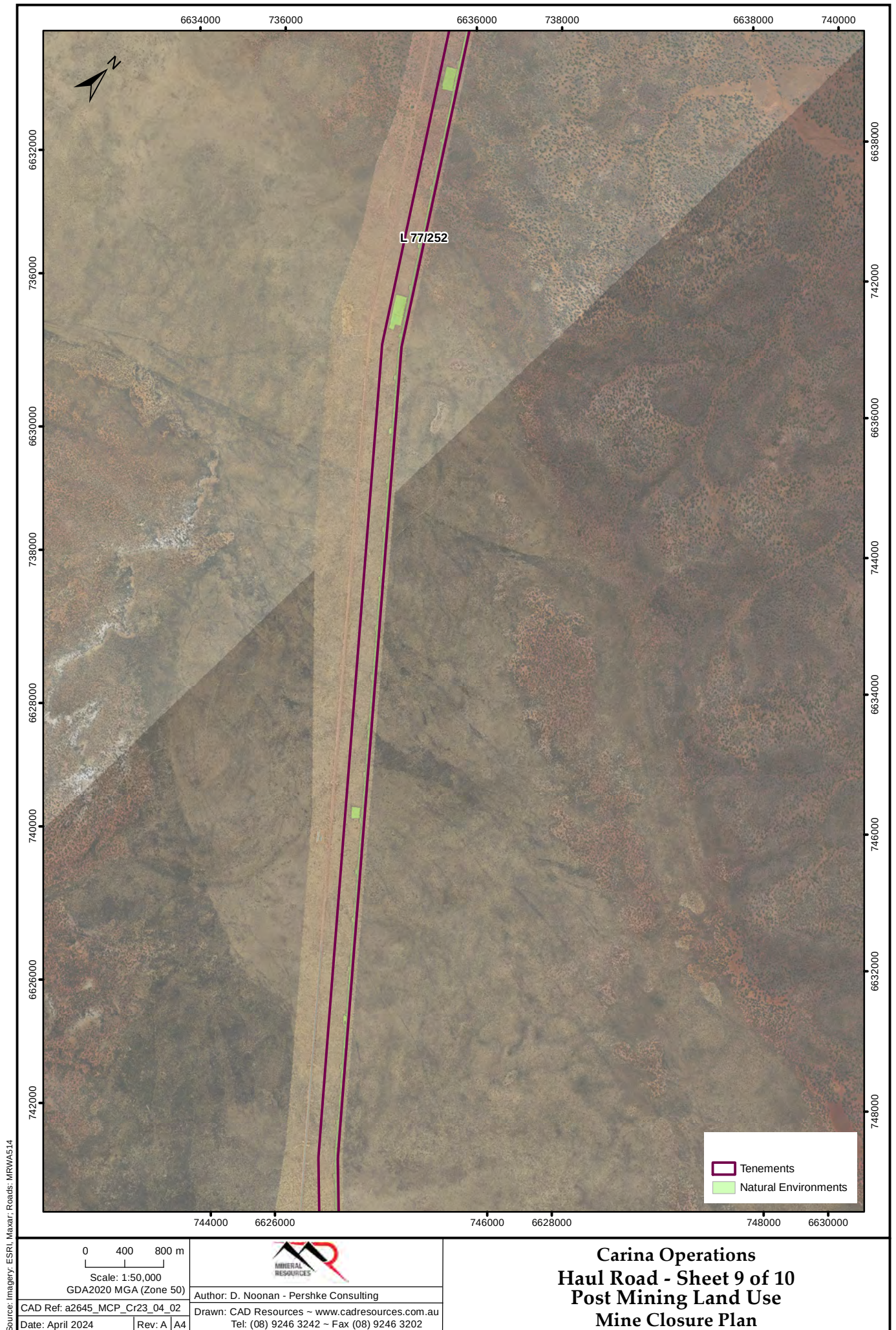


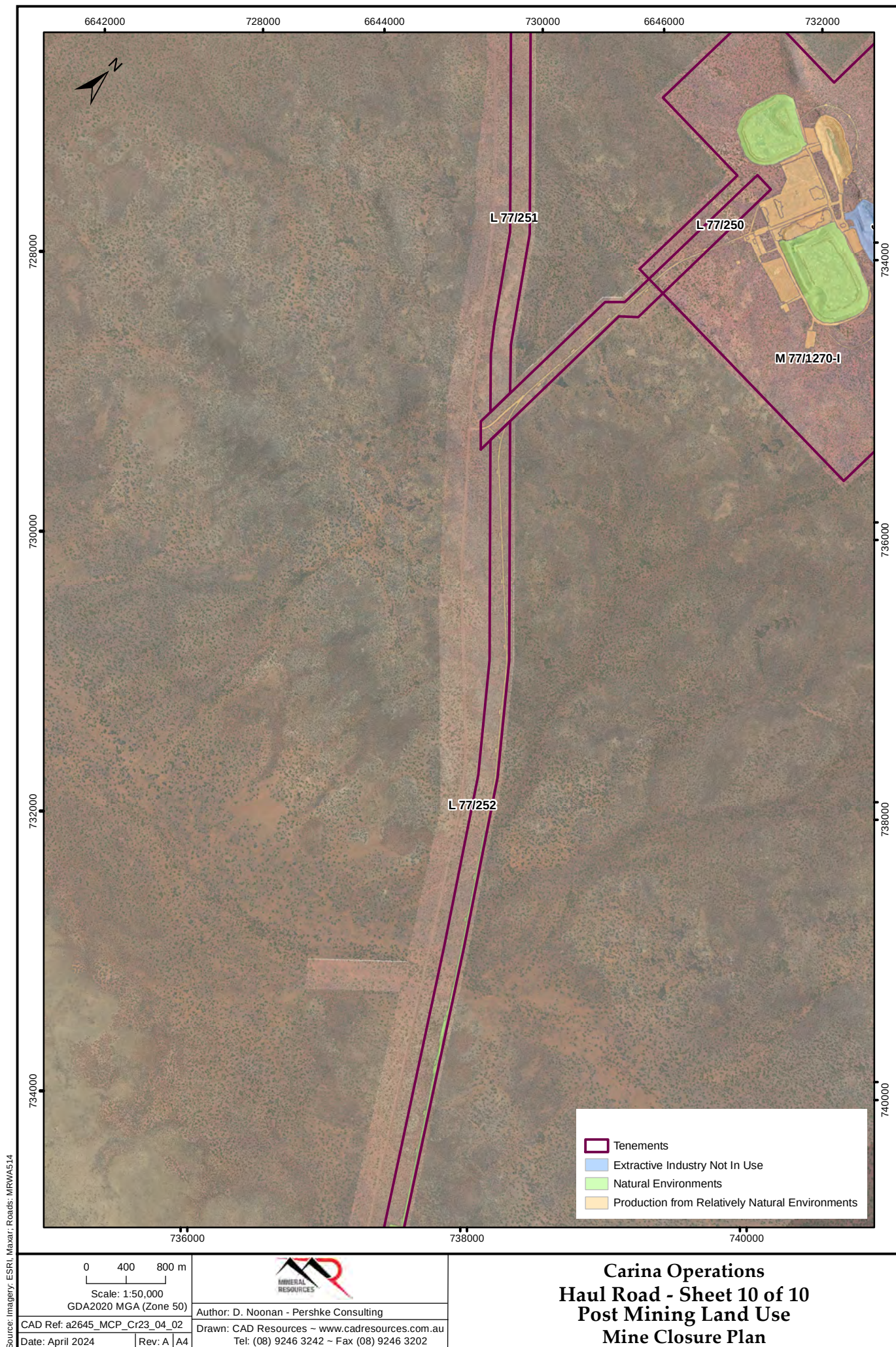














Mineral Resources Limited

20 Walters Drive
Osborne Park Perth 6017

Locked Bag 13, Osborne Park DC, WA 6916

P +61 8 9329 3600

E reception@mineralresources.com.au

W www.mrl.com.au