2022 Ranger Mine Closure Plan

Executive Summary

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Cover: Magpie Geese (*Anseranas semipalmata*)

1 PREAMBLE

Energy Resources of Australia Ltd (ERA) produced uranium oxide for the global nuclear energy market for more than 40 years. The Ranger ore body, located on Mirarr country in the Alligator Rivers Region of the Northern Territory, was first discovered in 1969. ERA was established in February 1980, and when floated on the Australian Stock Exchange (ASX) in July 1980 was at that time the largest ever public float in Australian history.

After considerable exploration and site preparation activity, mining started from Pit 1 (Plate ES1), processing soon followed with the plant commissioned in July 1981, and the first drum of uranium oxide was produced on 13 August 1981.

Mining from Pit 1 finished in December 1994 and finished from Pit 3 in November 2012. The last processing of stockpiled ore and the final drum of uranium oxide was produced on 8 January 2021 (Plate ES2), completing the mine's operational stage after producing a total of 132,000 tonnes of uranium oxide.

As the mine transitions to its final stage, ERA's focus is to create a positive legacy and achieve world class, sustainable rehabilitation and closure of its former mine assets.

The first Ranger Mine Closure Plan (MCP) was submitted in May 2018 to the Commonwealth Minister for Resources and Northern Australia, and the Northern Territory Minister for Primary Industry and Resources. The MCP is a live document that is updated annually.

Plate ES1 Pit 1 in 1981

Plate ES2 Final drum of Uranium Oxide

The environmental protection conditions within which ERA has operated and must now close the mine are set out in the Environmental Requirements of the Commonwealth of Australia for the Operation of Ranger Uranium Mine (ERs). These ERs are attached to the Ranger Authority issued under Section 41 of the Atomic Energy Act 1953 (S41). The ERs are also given effect through the Ranger Authorisation issued under the Northern Territory Mining Management Act 2001. The ERs were revised in 1999 to be inclusive of conditions relating to rehabilitation.

The ultimate objective for closing the mine is to prevent impacts to people and the environment, and to rehabilitate the site to a standard that would allow its incorporation into Kakadu National Park.

ERA has worked in close collaboration with many stakeholders over the last 40 years, generating a significant amount of information from research and monitoring. This ongoing information collection and analysis is guiding the rehabilitation activities towards a successful mine closure (Plate ES3 and ES4).

The MCP is ERA's primary mechanism to describe, and seek approval for, the mine's rehabilitation strategy and closure activities. The MCP seeks to consolidate the relevant information from the last 40 years and demonstrate how the current and planned rehabilitation activities will achieve the ERs. To ensure its currency, and to incorporate lessons learnt from ongoing modelling and monitoring studies, it is updated and submitted for approval annually.

Standalone applications for the closure of certain aspects of the mine (e.g. Pit 1, Pit 3, Tailings Storage Facility and Final Landform) are also required. Once approved, key information from these applications is incorporated into the relevant annual update of the MCP.

ERA was exempt from providing a 2021 MCP. As such, the 2022 MCP includes updates from 1 July 2020 to 30 June 2022.

This Executive Summary does not strictly follow the structure of the 2022 MCP main document. Rather, it seeks to inform the reader of the key aspects for this final stage in the journey of the Ranger mine. Figure ES1 shows a simplified approach of how ERA are achieving successful closure.

Plate ES3 Seedlings in ERA's nursery

Plate ES4 Early successful revegetation on Pit 1

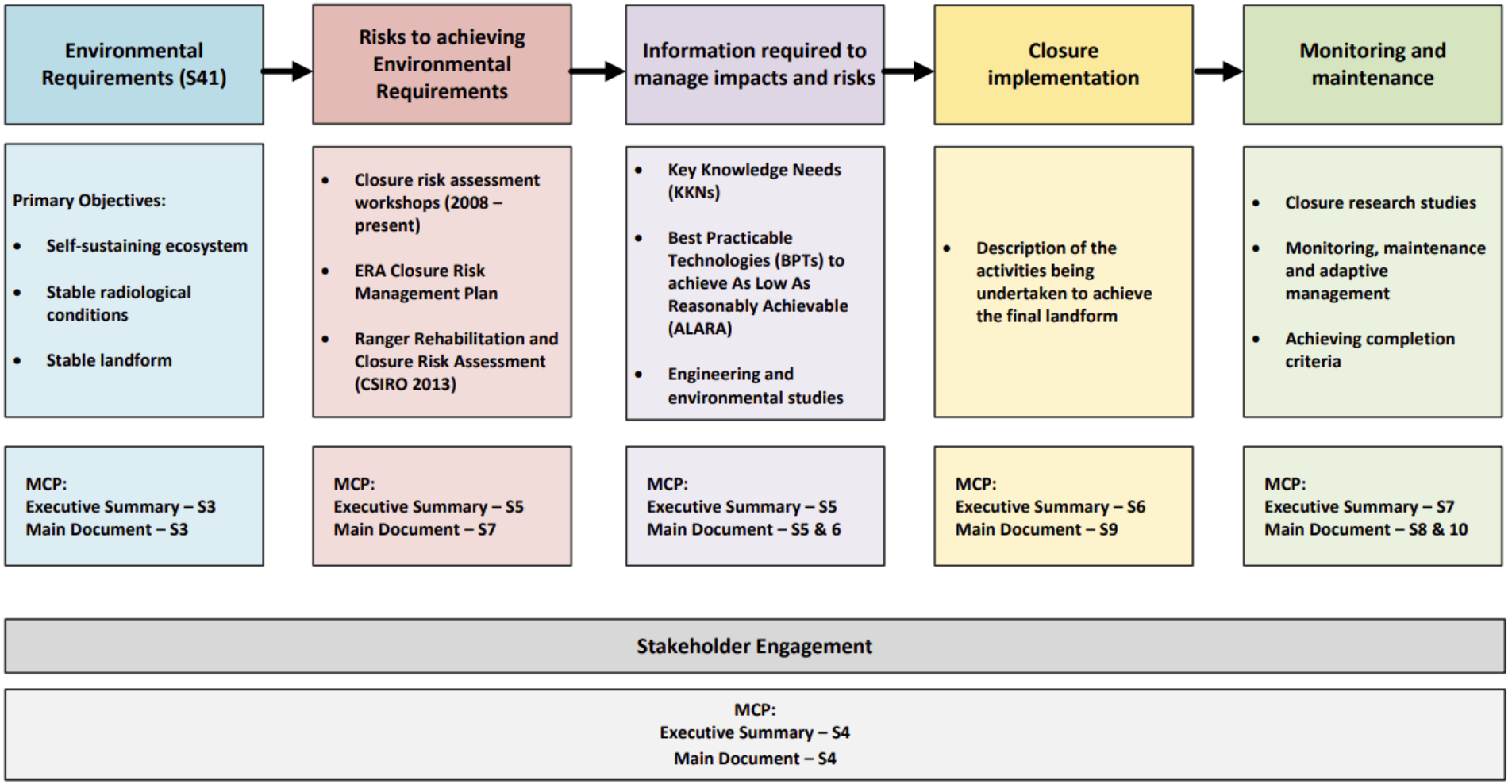

Figure ES1: Simplified approach to delivering successful rehabilitation and closure of the Ranger mine

2 MINE CLOSURE PLAN UPDATES

The 2022 MCP includes both minor and substantial updates to several sections of the document. Sections that have undergone substantial update since the 2020 MCP are listed in Table ES1. The remainder of the 2022 MCP received minor updates, or the information from the 2020 MCP were carried forward as it remains relevant.

Each MCP is subject to stakeholder review and detailed feedback. Feedback is considered and included in the 2022 MCP where possible. On occasions, some feedback requests for specific details that will be understood better when current and future studies are completed. Where this occurs, the requested details will be incorporated into future MCPs as the information becomes available or has been assessed and approved through future standalone activity-specific applications.

Figures ES2 and ES3 provide an indicative sequence of the major closure activities and primary standalone applications respectively to help inform the reader of when certain information is likely to be available, and therefore the corresponding MCP where this information would be discussed in detail. It is emphasised that the timing provided in Figure ES2 is subject to change and indicative only as of 30 June 2022. Appendix A to the main document outlines the stakeholder feedback that was received on the 2020 MCP, as well as the relevant sections within the 2022 MCP where the feedback is addressed.

Table ES1 Substantial Updates from 2020 MCP

Chapter	Description of update
Chapter 1 – Scope and Purpose	In July 2021, ERA commenced a major reforecast of cost and schedule after risks materialised post-completion of the 2019 Feasibility Study. The preliminary findings by ERA from its reforecast exercise based on the Ranger rehabilitation project being completed in accordance with the methodology set out in the 2020 Mine Closure Plan indicates that: (i) the revised total cost of completing the Ranger Project Area rehabilitation, including incurred spend from 1 January 2019, is forecast to be approximately between $1.6 billion and $2.2 billion (undiscounted nominal terms); and (ii) the revised date for completing the Ranger Project Area rehabilitation is forecast to be between Quarter 4, 2027 and Quarter 4, 2028. In May 2022, ERA commenced a feasibility study update in connection with a lower technical risk rehabilitation methodology (primarily relating to the subaerial capping of Pit 3) and to further refine the Ranger Project Area rehabilitation execution scope, risks, cost and schedule. The 2022 Feasibility Study is expected to take approximately 12 months to complete. The 2022 MCP update provides an indicative sequence of major closure activities and estimates of future milestones, with an indicative closure sequence out to Quarter 4, 2028 provided.

Chapter	Description of update
Chapter 1 – Scope and Purpose	Chapter 1 notes that the relevant aspects of the Mining Management Plan (MMP) have been incorporated within the Mine Closure Plan (MCP).
Chapter 5 – Key Knowledge Needs (KKN) Supporting Studies	Substantial updates have been provided for the KKNs that have materially advanced since the submission of the 2020 MCP.
Chapter 6 – Best Practicable Technologies (BPTs)	In response to stakeholder feedback on the 2020 MCP, detailed descriptions of completed BPTs have been removed from the chapter and included as Appendix 6.1. The chapter now focuses on the currently active, yet to be approved, BPT (Pit 3 backfill and capping).
Chapter 7 – Risk Assessment and Management	Risk assessments and updates to the closure risk register occur on a regular and ongoing basis. The chapter and accompanying appendix have been updated to reflect the latest risk updates.
Chapter 8 - Post-mining land use, closure objectives and closure criteria	The ecosystem restoration closure criteria have undergone significant review and stakeholder engagement, and the agreed criteria are included in this chapter.
Chapter 9 – Closure Implementation	Substantial updates have been provided for those aspects of closure implementation that have materially advanced since the submission of the 2020 MCP.
Chapter 10 – Closure Monitoring and Maintenance	Substantial updates have been provided for those aspects that have materially advanced since the submission of the 2020 MCP.
Chapter 11 – Financial Provision for Closure	This chapter has been updated to reflect recent announcements.
Appendix A – Stakeholder Feedback	This appendix has been simplified to remove duplication and provide a cross-reference to the relevant section/s of the 2022 MCP that address the stakeholder feedback on the 2020 MCP, as opposed to including in the appendix a summary of the often complex and lengthy response.

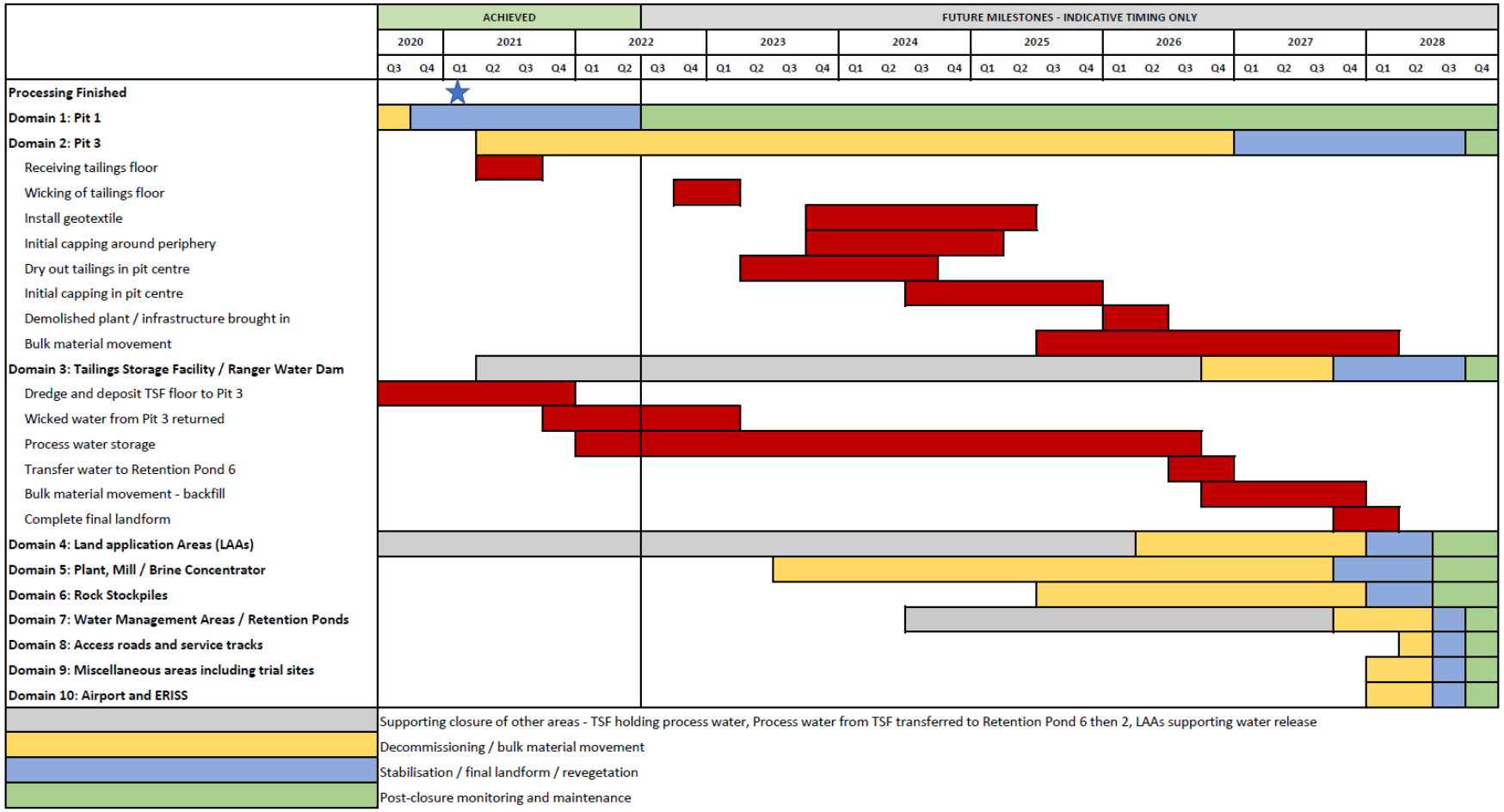

Figure ES2 Indicative sequence of major closure activities - as of 30 June 2022

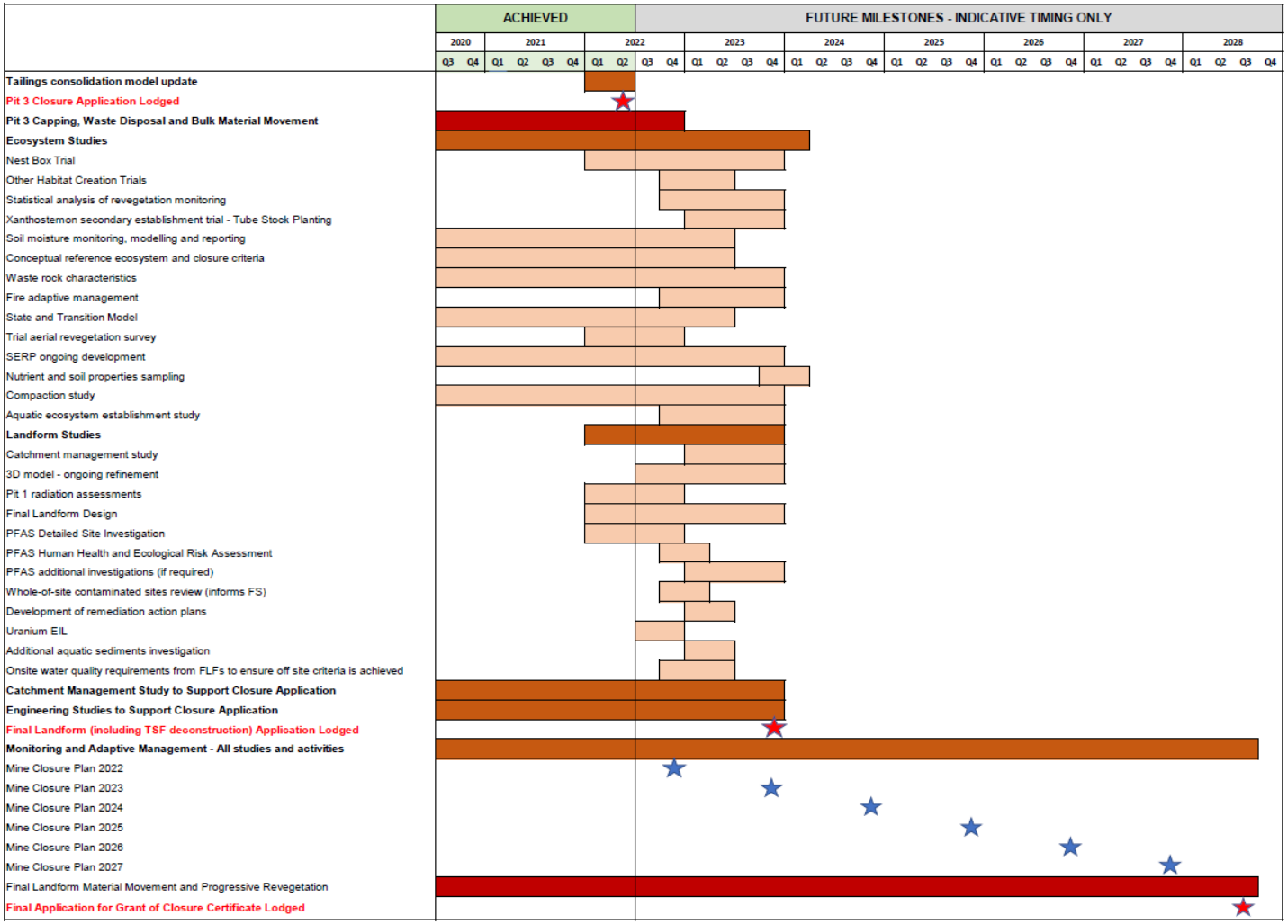

Figure ES3 Indicative timing of key studies and approvals

3 OVERVIEW OF THE MINE AND CLOSURE DOMAINS

The Ranger uranium mine (Ranger Mine) is located within the Ranger Project Area (RPA) adjacent to Jabiru, approximately 260 km east of Darwin on Mirarr country in the Alligator Rivers Region of the Northern Territory (Figure ES4). The RPA is surrounded by Kakadu National Park and is bounded on the east and north by Magela Creek and its tributaries, and on the west by Gulungul Creek and its tributaries. Access to the mine is via the Arnhem Highway (Figure ES5).

The Commonwealth Government announced approval of the project under the, now repealed, Commonwealth *Environmental Protection (Impact of Proposal) Act 1974* (*EPIP Act*) in August 1977, following submission of an Environmental Impact Statement (EIS) and associated supplements under this Act. Construction of the Ranger Mine began in 1979 and the mine came into full production in 1981.

During the same period, much of the Alligator Rivers Region was declared a National Park and Aboriginal people were given a major role in the management of Kakadu National Park. In 1978, title to the RPA was granted to the Kakadu Aboriginal Land Trust, in accordance with the Commonwealth *Aboriginal Land Rights (Northern Territory) Act 1976* (*Aboriginal Land Rights Act*) and the Commonwealth Government entered an agreement with the Northern Land Council (NLC) to permit mining to proceed.

The Mirarr people are the Traditional Owners of the lands on which the Ranger mine operates. Mirarr country encompasses the RPA, the Jabiluka Mineral Lease, the town of Jabiru, and parts of Kakadu National Park including the wetlands of the Jabiluka billabong country. In 1995, the Mirarr established the Gundjeihmi Aboriginal Corporation (GAC), an incorporated body, to assist them to manage a balance between sustainable development and traditional practice on their land. The GAC represents the Mirarr Traditional Owners in discussions and negotiations with ERA.

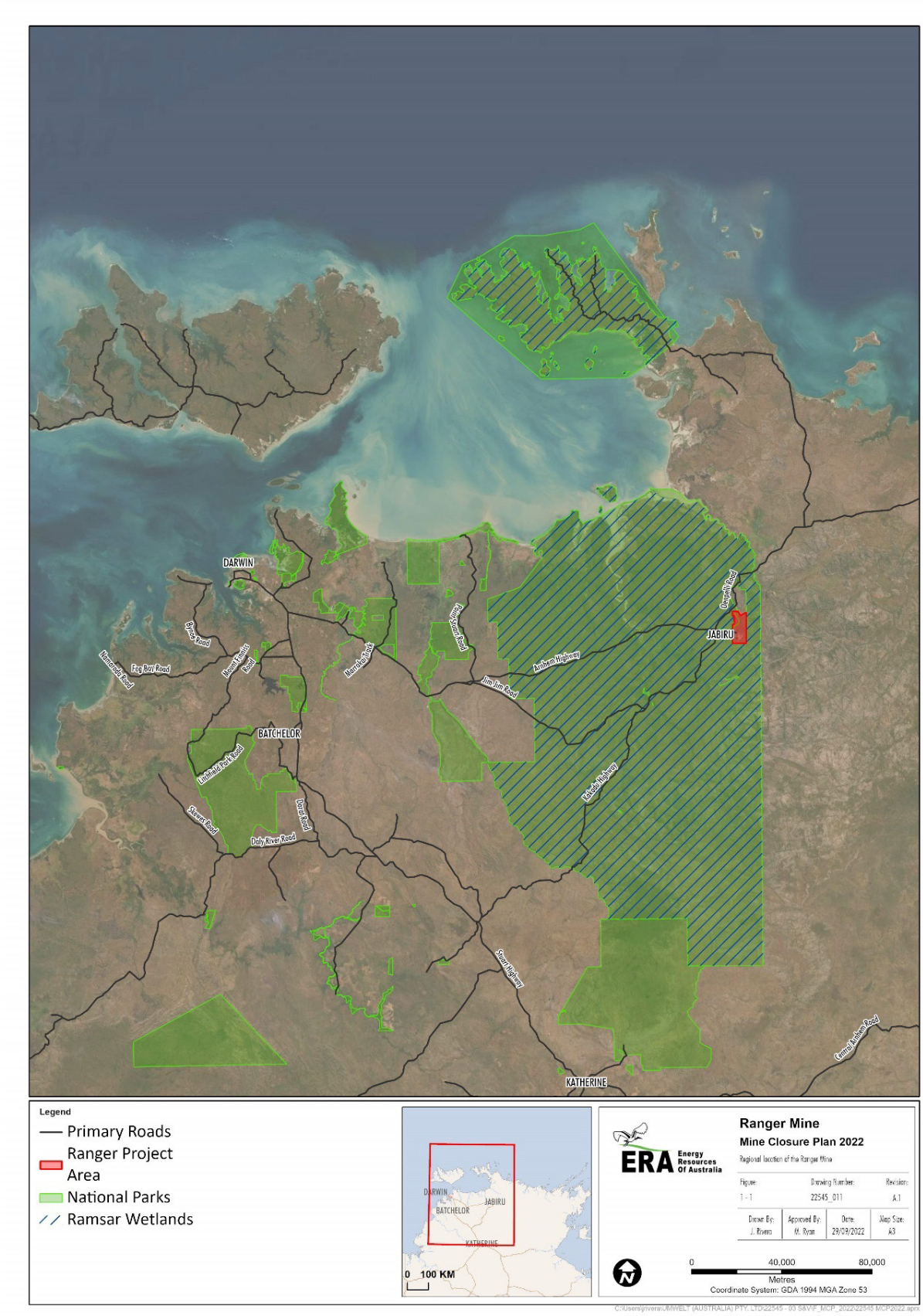

Figure ES4: Regional location of Ranger Project Area

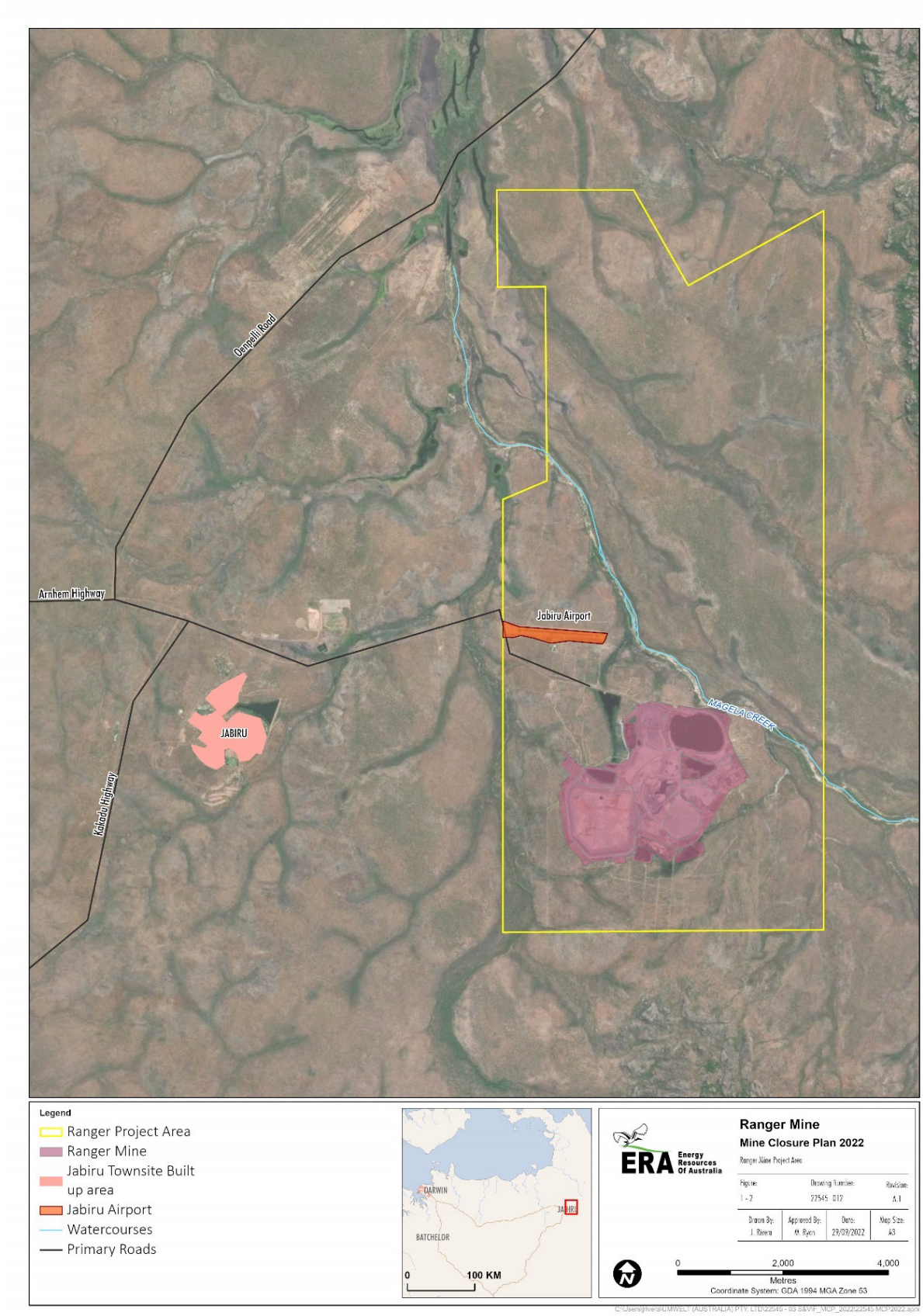

Figure ES5: Ranger Mine Project Area and nearby Jabiru Township

With the completion of on-site processing, ERA's primary focus is now the successful rehabilitation and closure of the mine. Areas of the mine site that have similar features, decommissioning and/or rehabilitation requirements for closure have been grouped into Closure Domains. These Domains are shown on Figure ES6 and comprise the following:

- Domain 1: Pit 1
- Domain 2: Pit 3
- Domain 3: Tailings storage facility (TSF) / raw water dam (RWD)
- Domain 4: Land application areas – these areas are used for irrigation of treated water during the dry season
- Domain 5: Processing plant, water treatment plant, power station, administration and maintenance facilities
- Domain 6: Rock stockpiles
- Domain 7: Water retention ponds, water storage structures and constructed wetlands
- Domain 8: Linear infrastructure corridors supporting access roads and service tracks
- Domain 9: Miscellaneous areas that include trial sites
- Domain 10: Jabiru Airport and offices of the Environmental Research Institute of the Supervising Scientist (ERISS)
- Domain 11: Residual Ranger Project Area (RPA). This area encompasses the balance of the RPA (i.e. all areas not included in another closure domain). It is largely undisturbed but was subject to exploration activities (e.g. historic exploration drill holes, access tracks). It also contains monitoring wells and sampling stations. Parts of this domain will be the first areas that ERA seeks progressive relinquishment under the *Mining Management Act* (section 46).

Figure ES2 provides a high-level sequence for the main stages of closure for each of these domains.

Figure ES6: Location and extent of Closure Domains

4 STAKEHOLDER ENGAGEMENT

The ERA approach to stakeholder engagement is centered on maintaining our relationships based on mutual respect, active partnership, transparency and long-term commitment. ERA will continue to connect with and respect Mirarr culture and the aspirations of local communities as we create a positive legacy and achieve world class, sustainable rehabilitation of the Ranger mine.

Our approach to stakeholder engagement has fostered collaboration and cooperation with a diverse range of stakeholders on the following key aspects of closure and rehabilitation:

- the overall planning process and schedule
- engineering and design criteria for technical aspects of closure such as water treatment, tailings transfer, backfilling of mine pits and the final landform design
- post-mining land use, closure objectives and closure completion criteria
- legal requirements and obligations associated with the various agreements for the mine and Jabiru township
- land tenure and governance.

Figure ES7 illustrates the matrix of stakeholders engaged in two-way conversations regarding the closure of the Ranger mine. These discussions are coordinated through the forums listed in Table ES2.

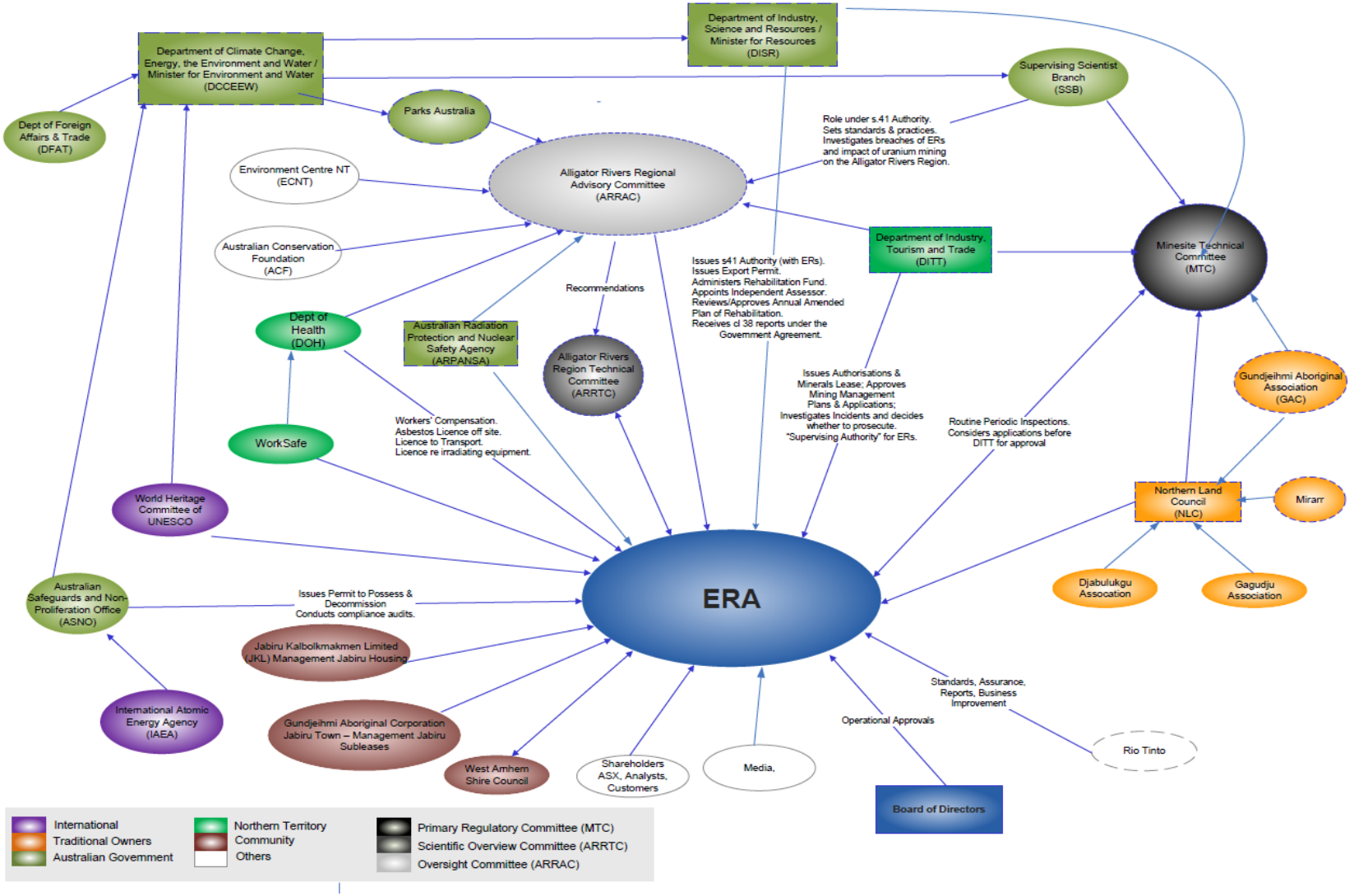

Figure ES6 Ranger Mine Stakeholder Matrix

Table ES2 Stakeholder Engagement Forums

Engagement forum	Frequency	Comment
Minesite Technical Committee (MTC)	Bi-annually (additional meetings held as required)	The MTC is the formal forum for key advisory and stakeholder groups to discuss and resolve technical environmental management matters relating to the closure of the Ranger Mine, regulatory functions of the NT Government, functions of the Supervisory Scientist, and the views of the Mirarr and other affected Aboriginal people. It includes representatives of the Northern Territory Department of Industry, Tourism and Trade (DITT) (Chair), Commonwealth Department of the Climate Change, Energy, the Environment and Water (DCCEEW), Supervising Scientific Branch (SSB), Energy Resources of Australia Ltd (ERA), Gundjeihmi Aboriginal Corporation (GAC) and the Northern Land Council (NLC) (the Commonwealth Department of Industry, Science & Resources (DISR) are invited as an observer).
Ranger Closure Consultative Forum (RCCF)	Monthly	The RCCF is a forum for ERA to discuss progress and matters relating to the closure of the Ranger Mine with the key stakeholder group representatives from the DISR, SSB, DITT, and the NLC/GAC. The purpose of the forum is to provide ongoing updates of closure activities, confidence in the closure strategy for achieving environmental requirements, information on upcoming approvals, and to receive feedback from stakeholders on studies, applications and the close-out progress of Key Knowledge Needs (KKN).
Alligator Rivers Region Technical Committee (ARRTC)	Bi-annually	The ARRTC was established under the Commonwealth *Environment Protection (Alligator Rivers Region) Act 1978* and reviews the appropriateness and quality of scientific research conducted by Northern Territory and Commonwealth Government agencies, ERA and others relating to protection of the environment from the potential impacts of uranium mining in the Alligator Rivers Region. Members include an independent Chairperson, the Supervising Scientist, independent scientific members, a member representing the NLC and a member representing environmental non-government organisations. http://www.environment.gov.au/science/supervising-scientist/communication/committees/arrtc
Alligator Rivers Region Advisory Committee (ARRAC)	Bi-annually	The ARRAC was established under the Commonwealth *Environment Protection (Alligator Rivers Region) Act 1978* and facilitates communication between Government, industry and community stakeholders on environmental issues associated with uranium mining in the Alligator Rivers Region. Members include an independent Chairperson, the Supervising Scientist, representatives from several Northern Territory Government departments, Office of the Administrator of the Northern Territory, several Commonwealth Government departments, non-government organisations (NGOs), ERA and other uranium mining/exploration companies that operate in the region. http://www.environment.gov.au/science/supervising-scientist/communication/committees/arrac.
Ecosystem Restoration Forum	Fortnightly	Communication and consultation with stakeholders focusing on ecosystem restoration closure criteria and KKNs.
Investor briefings	Bi-annually	Briefings provided by the ERA Chief Executive regarding ERA operations to all company shareholders.

Engagement forum	Frequency	Comment
Relationship Committee	Quarterly	The Relationship Committee was established under the Ranger Mining Agreement between ERA and the NLC in 2013 to review processes and ensure effective information sharing between ERA and the Mirarr Traditional Owners and their representatives.
Ministerial briefings	Regularly as required	Briefings are provided to both Federal and Northern Territory Ministers and senior advisors on operations of the Ranger Mine, including aspects of closure.
Kakadu Board of Management	Quarterly, ERA update provided bi-annually	Kakadu National Park (NP) is a park jointly managed by Parks Australia and the Traditional Owners of Kakadu. A board of management has been established as part of the governance structure for the NP and consists of Commonwealth Government representatives, Park Management and Traditional Owners from each region in the NP. ERA provides a regular operations update, including mine closure status, and consults with the broader Indigenous population through this forum.
State of the Nation	Quarterly	Presentations and question and answer sessions provided to all ERA personnel and contractors on ERA operations by either the Chief Executive or General Manager Operations including aspects of closure, Jabiru and stakeholder engagement.
Closure Criteria Working Group	No longer required	The Closure Criteria Working Group was established by the MTC for the purpose of developing the closure criteria for the rehabilitation of the Ranger Mine. The Closure Criteria Working Group also had sub-groups responsible for the development of the technical criteria for each of the following elements: landform, radiation, water and sediment, flora and fauna, soils and cultural. The MTC decided that closure criteria had progressed enough that this working group was no longer required. Rather, the specific technical groups would continue to develop criteria and report directly into the MTC.
Water and Sediment Working Group (WASWG)	No longer required	Communication and consultation with stakeholders focusing on surface water and sediment closure criteria and KKNs. These discussions now occur in each of the above-mentioned relevant forums.
Monitoring Evaluation and Research Review Group (MERRG)	No longer required	MERRG was formed in response to the submission of the application to progress Pit 1 final landform, in order to further communicate and consult with stakeholders regarding Pit 1 revegetation monitoring activities. Pit 1 has now undergone initial rehabilitation and monitoring success is reported in the above-mentioned relevant forums.

5 RISK ASSESSMENTS, KNOWLEDGE BASE AND SUPPORTING STUDIES

The benefit of operating a mine, collaborating with stakeholders, and conducting research and monitoring for over 40 years, is an in-depth understanding and substantial base of knowledge on which closure activities, rehabilitation and supporting studies can be guided.

Having said that, ERA understand that risks to an operating mine are considerably different to successfully rehabilitating and closing a mine. To facilitate successful closure, ERA has held regular risk assessment workshops since 2008 to identify key risks specific to the closure of the Ranger mine. Of note:

- CSIRO led ERA and key stakeholders through the Ranger Rehabilitation and Closure Risk Assessment in 2013. This risk assessment, along with the significant knowledge base gained from operating the mine for 40 years, helped to inform ERA and the Supervising Scientist Branch (SSB) of the environmental research programs to be undertaken to better understand and manage the impacts and risks associated with mine closure. The various studies identified through this process were captured in a list of Key Knowledge Needs (KKNs). Table ES3 in Section 5.1 provides a summary of the KKNs.

- A risk workshop held in August 2016 identified a range of assessments that would further the understanding of Best Practicable Technology (BPT). BPT may be interpreted as the technology that is consistent with achieving the ERs and ranks highest when considering world's best practice, cost-effectiveness, proven effectiveness, Ranger's location, the age of equipment, and social factors. Table ES4 in Section 5.2 provides a summary of the completed and active BPTs.

- During 2018, several assessments were undertaken as part of the Ranger closure Feasibility Study, with the outcomes presented in the form of a risk register in the 2018 Mine Closure Plan (MCP). The risk register was updated in the 2020 MCP to incorporate comments received from stakeholders (it is noted that the Feasibility Study itself was not subject to stakeholder review) and continues to be regularly reviewed and updated. Section 5.3 provides a summary of the current risk register.

5.1 Key Knowledge Needs (KKNs)

A total of 35 KKNs were identified and grouped under the following five themes:

- Landform
- Water and sediment
- Radiation
- Ecosystem rehabilitation
- Cross-theme matters such as cumulative risk.

The 35 KKNs were then further divided into 63 specific questions and responsibility to answer the questions was assigned to ERA, the SSB, or to both, as follows:

- 22 questions have been addressed / completed
- 41 questions remain and are the subject of studies being undertaken by:
    - ERA: 18 questions
    - Both: 12 questions
    - SSB: 11 questions.

Section 5 of the 2022 MCP main document details the existing environmental conditions of the RPA and surrounds, and describes each of the studies being undertaken by ERA (either solely or in collaboration with SSB) to address the KKNs and outstanding questions.

Table ES3 provides a summary of the KNNs, and the 30 active questions and associated studies being undertaken by ERA (either solely or in collaboration with SSB).

Table ES3 Summary of the KNNs, outstanding questions and ERA supporting studies

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
Landform Theme				
LAN2	Understanding the landscape-scale processes and extreme events affecting landform stability	LAN2B. How will these landscape-scale processes impact the stability of the rehabilitated landform (e.g. mass failure, subsidence)?	Both	A likelihood and consequence assessment was undertaken and is being carried through into the site's environmental risk assessment.
LAN3	Predicting erosion of the rehabilitated landform	LAN3A. What is the optimal landform shape and surface (e.g. rip lines, substrate characteristics) that will minimise erosion?	Both	The final landform shape was initially developed in 2003 and is subject to ongoing refinement as results from studies become available (e.g. completed trial landforms and current studies targeting Pit 1 and Stage 52 (the area between Pit 1 and the services corridor on the southern wall of Pit 3)).
		LAN3B. Where, when and how much consolidation will occur on the landform?	ERA	Landform evolution modelling (LEM) to assess the stability of the final landform, erosion and surface water runoff has been undertaken by the SSB since 2015. ERA engaged resources in mid-2019 and added in-house modelling capacity in 2021 to support the SSB in the ongoing refinement of key model inputs to provide increased confidence in the model predictions out to 10,000 years post closure. The LEM incorporates findings from other relevant modelling studies, including the Pit 1 tailings consolidation models undertaken from 2003 to 2017. Tailings consolidation modelling for Pit 3 started in 2014 and is currently being updated and refined as closure activities in the pit continue and additional monitoring information is available.
		LAN3E. How much suspended sediment will be transported from the rehabilitated site (including land application areas) by surface water?	Both	This question is also being addressed by the LEM, which is being strengthened by ERA studies on particle size distribution, sediment runoff and vegetation cover.

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
Water and Sediment Theme				
WS1	Characterising contaminant sources on the RPA	WS1A. What contaminants (including nutrients) are present on the rehabilitated site (e.g. contaminated soils, sediments and groundwater; tailings and waste rock)?	ERA	These are collectively termed Constituents of Potential Concern (COPC) and the following 20 are relevant: aluminium (Al), calcium (Ca), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), nickel (Ni), nitrate (NO3-N), lead (Pb), total phosphorus (P total), polonium-210 (210Po), radium-226 (226Ra), selenium (Se), sulfate (SO4), total ammoniacal nitrogen (TAN), uranium (U), vanadium (V), and zinc (Zn).
		WS1B. What factors are likely to be present that influence the mobilisation of contaminants from their source(s)?	ERA	The capacity of these COPC to be dissolved in surface water and groundwater (i.e. their solubility) is the primary mechanism and pathway for mobilisation from their source.
WS2	Predicting transport of contaminants in groundwater	WS2B. What factors are likely to be present that influence contaminant (including nutrients) transport in the groundwater pathway?	ERA	Local groundwater movement and solute transport can be influenced by geological, groundwater flow and transport characteristics. Local groundwater movement at the site is well understood via a calibrated numerical groundwater flow model that covers 29 km2 and 800 m vertically and comprising 612,940 active cells. The model can simulate groundwater pathways through 19 hydrolithologic units (HLUs), each representing a different geological, groundwater flow and transport characteristic within the three main regional groundwater zones (alluvial, weathered and bedrock).

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
WS3	Predicting transport of contaminants in surface water	WS3F. What are the predicted concentrations of suspended sediment and contaminants (including nutrients) bound to suspended sediments in surface waters over time?	Both	Understanding surface water, and the interaction between groundwater and surface water, are critical for mine closure because these are the main pathways for COPC to enter the receiving environment. This modelling is well underway and being informed by over 40 years of surface water monitoring. From the perspective of groundwater to surface water catchments, the mine site is divided into the catchments of Corridor Creek (principally Pit 1), Coonjimba Creek (principally the TSF/RWD), Magela Creek (principally Pit 3 and the northern side of Magela Creek) and Gulungul Creek (some land application areas but largely undisturbed areas to the west of the TSF). Each of these is the subject of detailed modelling studies to address the questions raised in WS3. Aquatic sediments at the mine site and the Magela catchment have been studied since the late 1970s. This includes research projects as well as routine monitoring to understand metal concentrations and bio-geochemical pathways, spatial distribution (vertically and within and between catchments), changes over time, and potential bioavailability.
		WS3H. Where and when will suspended sediments and associated contaminants accumulate downstream?	ERA	
WS5	Determining the impact of contaminated sediments on aquatic biodiversity and ecosystem health	WS5A. Will contaminants in sediments result in biological impacts, including the effects of acid sulfate sediments?	Both	Concentrations of metals has not increased in sediments in the offsite billabongs in the Magela catchment, with concentrations within natural variation (at the low end of the range). There are three key constituents that contribute to the potential formation of acid sulfate soils (ASS): the potential water-logged conditions, elevated sulfate concentration (≥10 mg/L), and sufficient organic matter to establish the chemically reducing environment. Although considerable historical studies of ASS exist from the Magela Plain and lowland areas surrounding the mine, a few studies are continuing to fully understand the ASS conditions as they relate to closure.

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
WS6	Determining the impact of nutrients in surface water on aquatic biodiversity and ecosystem health	WS6C. Will the total loads of nutrients (N and P) to surface waters cause eutrophication?	ERA	The primary sources of nutrients to the water system at the mine are from waste rock, ammonia and phosphate (in lime) added to the mill process circuit, residual nitrates from blast residue in waste rock, and fertiliser application. The risk of nutrient loading has been low during the operational phase as waters are segregated and treated before release. Concentrations of ammonia, nitrate and phosphate entering the surface water environment post closure are being assessed through solute transport modelling. The risk of eutrophication is being addressed through this modelling.
WS7	Determining the impact of contaminants in surface and groundwater on aquatic biodiversity and ecosystem health	WS7B. What is the risk associated with emerging contaminants?	Both	Closure risks have been identified and continue to be revisited as information from studies becomes available. ERA will be undertaking another environmental risk assessment in 2023 to ensure exposure pathways and potential effects to human and ecosystem health are informed by the latest study results.
WS9	Optimisation of water quality monitoring programs and assessment methods	WS9A. How do we optimise methods to monitor and assess ecosystem health and surface and groundwater quality?	ERA	Ongoing review and innovation are being applied to ensure that the methods used in the water quality monitoring program are providing useful and reliable information and are cost-effective. This includes data collection, data management practices and analytical techniques. Ensuring the use of proven state-of-the-art technologies for equipment, instruments and methods is a key requirement for optimisation.

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
Health Impacts of Radiation Theme				
RAD1	Radionuclides in the rehabilitated site	RAD1A. What are the activity concentrations of uranium and actinium series radionuclides in the rehabilitated site, including waste rock, tailings and land application areas?	ERA	Baseline radiological conditions for eleven areas of the mine, seven groundwater units and nine local bush foods are provided in Section 5 of the MCP main document. As expected, the pre-mining radiological baseline over the orebodies that led to Pits 1 and 3 was much higher than the surrounding area. The impact assessment required to assess the radiological impact to members of public and terrestrial and aquatic wildlife is largely dependent on the outcomes of other studies such as the groundwater/surface water solute transport modelling. These studies are now well advanced and will be informing the radiation assessment.
RAD6	Radiation dose to wildlife	RAD6E. What is the sensitivity of model parameters on the assessed radiation doses to wildlife?	ERA	
RAD7	Radiation dose to the public	RAD7A. What is the above-background radiation dose to the public from all exposure pathways traceable to the rehabilitated site?	ERA	
		RAD7B. What is the sensitivity of model parameters on the assessed doses to the public?	ERA	
RAD8	Impacts of contaminants on wildlife	RAD8A. Will contaminant concentrations in surface water (including creeks, billabongs and seeps) pose a risk of chronic or acute impacts to terrestrial wildlife?	ERA	
RAD9	Impacts of contaminants on human health	RAD9D. What is the dietary exposure of, and toxicity risk to, a member of the public associated with all contaminant sources, and is this within relevant Australian and/or international guidelines?	ERA	

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
Ecosystem Restoration Theme				
ESR1	Determining the requirements and characteristics of terrestrial vegetation in natural ecosystems adjacent to the mine site, including Kakadu National Park.	ESR1A. What are the compositional and structural characteristics of the terrestrial vegetation (including seasonally inundated savanna) in natural ecosystems adjacent to the mine site, how do they vary spatially and temporally, and what are the factors that contribute to this variation?	ERA	The RPA and surrounds are primarily within the Pine Creek Bioregion, which comprises hilly ridges with undulating plains within the foothills of the Arnhem Land Massif. Vegetation types consist of tall eucalypt woodlands, dominated by Darwin woollybutt (*Eucalyptus miniata*) and Darwin stringybark (*E. tetrodonta*) with patches of monsoon forests, riparian vegetation and tussock grasslands. Section 5 of the MCP main document details and maps the location of the four vegetation types specific to the RPA and the characteristics that define these types.
ESR2	Determining the requirements and characteristics of a terrestrial faunal community similar to natural ecosystems adjacent to the mine site, including Kakadu National Park	ESR2A. What faunal community structure (composition, relative abundance, functional groups) is present in natural ecosystems adjacent to the mine site, and what factors influence variation in these community parameters?	Both	Kakadu National Park contains over one third of Australia's bird species (271), one quarter of Australia's land mammals (77), 132 reptile species, 27 frog species and over 246 fish species recorded in tidal and freshwater areas. Vegetation types and the tropical monsoon weather pattern influence the distribution of fauna throughout the area. Approximately 90% of the average annual rainfall (1,565 mm/a) occurs in the wet season from November to March.
		ESR2B. What habitat, including enhancements, should be provided on the rehabilitated site to ensure or expedite the colonisation of fauna, including threatened species?	ERA	One objective of the final landform rehabilitation is to provide habitats that support fauna assemblages similar to the surrounding Kakadu National Park and that contain culturally important bush foods. Fauna refuge areas in the form of a boulder pile have been included in the Pit 1 landform and nest box trials are underway.
		ESR2C. What is the risk of introduced animals (e.g. cats and dogs) to faunal colonisation and long-term sustainability?	ERA	Feral cats and cane toads have contributed to the decline of mammals in Kakadu National Park and populations of these introduced animals, along with dogs, may influence faunal colonisation of the final landform.
ESR3	Understanding how to establish native terrestrial vegetation, including understory species.	ESR3A. How do we successfully establish terrestrial vegetation, including understory (e.g. seed supply, seed treatment and timing of planting)?	ERA	Considerable success has already been seen in the trial landform areas and more recently on Pit 1. The Trail Landform (TLF) and Pit 1 are two of ERA's key ecosystem research programs and are critical components of the Species Establishment Research Program (SERP).

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
ESR5	Develop a restoration trajectory for Ranger mine	ESR5A. What are the key sustainability indicators that should be used to measure restoration success?	Both	Ecosystem restoration closure criteria is now being finalised with key stakeholders.
		ESR5B. What are possible/agreed restoration trajectories (flora and fauna) across the Ranger mine site; and which would ensure they will move to a sustainable ecosystem similar to those adjacent to the mine site, including Kakadu National Park?	Both	State and transition (S&T) models are non-linear conceptual models that organise information about ecosystem change. A S&T model describing desirable and undesirable transitions along possible rehabilitation trajectories at Ranger mine was developed by scientific, industry and local ecology experts at a workshop in April 2019. Another key element of S&T models is the development of adaptive management plans for ecosystem rehabilitation that is linked to and guides monitoring and maintenance activities. Ecosystem attributes related to structure, composition, function, abiotic and landscape characteristics are have been modelled and will continue to be studied to deliver a final landform that contains a self-sustaining ecosystem.
ESR6	Understanding the impact of contaminants on vegetation establishment and sustainability	ESR6A. What concentrations of contaminants from the rehabilitated site may be available for uptake by terrestrial plants?	Both	The groundwater/surface water solute transport modelling discussed in WS1-WS3 will inform this KKN. Also, studies on plant establishment and growth rates for specific species may inform future management practices that could mitigate nutrient and toxicity effects. These studies are currently being undertaken by SSB in collaboration with the National Environmental Science Program (NESP) and Charles Darwin University.
		ESR6B. Based on the structure and health of vegetation on the Land Application Areas, what species appear tolerant to the cumulative impacts of contaminants and other stressors over time?	ERA	Groundwater solute plumes at the land application areas (LAAs) developed from application of RP2 pond water is being assessed to inform COPCs in this area. ERA presented to ARRTC (May 2018) results of vegetation growing in areas exposed to pond water, with observations and studies of the LAAs, irrigated with pond water for over a decade, indicating no observed negative effects on vegetation from waste rock contaminants.

KKN	KNN Title	Question	Responsibility	Supporting study being undertaken
ESR7	Understanding the effect of waste rock properties on ecosystem establishment and sustainability	ESR7B. Will sufficient plant available water be available in the final landform to support a mature vegetation community?	Both	Developing waste rock 'soil' to a level able to sustain native vegetation is a result of complex interactions between the waste rock, plant roots, leaf litter, a range of microbial organisms and other environmental and climatic factors. Production of rock fines through weathering forms an important component of this process, as does generation and infiltration of organic matter. Weathering of the waste rock over time increases both the proportion of fines in the soil profile as well as water holding capacity. Observations indicate the waste rock used on the trial landform has been breaking down since its initial placement as a consequence of physical, chemical and biological weathering processes, vegetation establishment and litter accumulation, and decomposition by microbial activity in the substrate. The increased proportion of fines will provide a suitable substrate to support understorey development. Some natural establishment of understorey species in the waste-rock-only section of the trial landform has been observed 4-5 years after revegetation supporting the theory. Monitoring and studies on waste rock properties and rehabilitation success are ongoing.
ESR8	Understanding fire resilience and management in ecosystem restoration	ESR8A. What is the most appropriate fire management regime to ensure a fire resilient ecosystem on the rehabilitated site?	Both	Fire is a major exogenous feature of Australian eucalypt-dominated ecosystems, especially subtropical savanna woodlands. The fire management plan for Kakadu National Park from 2016 to 2026 aims to reduce the area impacted by large fires and the risk of wildfires entering, spreading, or leaving the park; it also plans for reduced frequency of large severe fires and reduced average fire patch size. The management plan also identifies the importance of maintaining long-unburnt patches for vegetation regeneration and wildlife habitat. Frequent fires tend to simplify vegetation structure leading to the presence of a dominant tree layer and an understorey of grasses and resprouting shrubs and trees. By contrast, a regime of less frequent fires will provide greater opportunities for saplings to escape the flame zone and for a mid-stratum to develop.

5.2 Best Practicable Technology (BPT)

A BPT is a process of analysing currently available technologies against specified criteria to identify the preferred option or approach for undertaking major closure activities at the mine.

The identification and use of BPTs are a key component of the legal framework for the closure of the Ranger Mine supporting applications to the Minesite Technical Committee (MTC) and demonstrating that impacts on the RPA are as low as reasonably achievable (ALARA).

A BPT score is generated for each technology option assessed. The score is calculated using the rank against each applicable criterion, whereby:

- an option that achieves the highest possible rating for all criteria would score 100
- an option that meets standards for all criteria would score 0
- an option that achieves the lowest possible rating for all criteria would score -100.

The criteria applied to BPT assessments is provided in Table ES4, and Table ES5 provides a summary of the selected option for each BPT.

Table ES4 Criteria applied in a Best Practicable Technology assessment

Aspect	Criteria applied to the assessment
Traditional Owner culture and heritage	• Would the adoption of the option have adverse impacts on the cultural practices, traditions and customs of the local Aboriginal communities? • Would the option threaten, in any way, the integrity of sacred sites, rock art or any other aspect of the cultural heritage of the region?
Protection of people and the environment	• Would the option give rise to adverse impacts on the health and safety of Aboriginal or non-Aboriginal members of the local community? • Would the option have any adverse socio-economic impacts on the communities in the town of Jabiru or in the broader Kakadu region? • Would the option achieve protection of the natural World Heritage and Ramsar status of Kakadu NP? • While disturbance and environmental impact is inevitable on the project area, would adoption of the option minimise such onsite impacts?
Fit for Purpose	• Does the option use proven technology? (proven and demonstrated technology would be ranked higher than very new, unproven or theoretical technology). • How effective is the technology used in the option in meeting its desired output objective? (effective, highly robust options would rank highly). • How robust or sensitive is the option to variation in external factors such as weather and relevant factors (e.g. expected ground strengths, result of predecessor activities, higher or lower flows)? • Does the standard of environmental protection achieved by the option meet the highest standards achieved in uranium mining elsewhere in the world?
Operational Adequacy	• Would adoption of the practice ensure the ongoing health and safety of the workforce? • Would the option require extensive control and support effort to construct? • Is the process operationally reliable? That is, will it have high availability, or will it have features whose inherent sensitivity may impact availability? • Would the option be difficult to maintain? • Would the complexity of construction create cost risks arising from schedule uncertainty?

Aspect	Criteria applied to the assessment

Rehabilitation and Closure	• Would the option promote or detract from the ability to:
	  ○ Revegetate the mine site with local native species and resulting in a low maintenance regime?
	  ○ Establish stable radiological conditions that will ensure health risks to the public from the principal exposure pathways are ALARA?
	  ○ Establish erosion characteristics on the site that, as far as can reasonably be achieved, do not vary significantly from those of comparable landforms in surrounding undisturbed areas?
	  ○ Meet agreed water quality criteria in creeks draining the mine site and achieve appropriate ecosystem restoration standards for water bodies on the rehabilitated landform?
	  ○ Ensure that for 10,000 years all tailings produced at the Ranger site are physically isolated from the environment and contaminants arising from the tailings do not result in any detrimental environmental impact off the RPA?
	  ○ Meet operational deadlines to achieve closure within a period that meets stakeholder expectations any legal requirements?
	• Would adoption of the option result in closure costs that significantly detract from overall project value?

Table ES5 Summary of Best Practicable Technology option assessments

BPT Description	Number of Options/Sub-options Assessed	Preferred Option No.	Description of Preferred Option	Rating of Preferred Option	Application Approved
Completed BPTs					
Integrated tailings, water and closure (ITWC)	9 – PFS1 8 – PFS2 (Stage 1) 4 - PFS2 (Stage 2) 8 – Supp ITWC	Dredging 1B/1C 1B A3	Tailings reclamation via Dredging Two options carried forward for brine injection Brine injection, thickened tailings and milling until 2020 Unthickened tailings with wicks to accelerate consolidation	41.3	2013-2016
Salt treatment and disposal	10	1B	8 options were assessed in Stage 1, the top 2 options plus 2 additional options were assessed in Stage 2. The preferred option is brine injection to the underfill without rock screening.	19	October 2018
Brine Squeezer	27	BM2	Addition of the Osmoflo Brine Squeezer to treat Water Treatment Plant (WTP) brines to minimise additions to the pond water and process water inventory, and to optimise pond and process water treatment and disposal mechanisms.	23	April 2019
Closure of ranger 3 Deeps	7 - Decline 3 - Portal 9 - Ventilation Shaft	A7 B2 C9	A7 Decline: waste rock placed only in the weathered zone (i.e. up to surface ~40 vertical m). B2 Portal: Partially remove portal structure to just below ground level, backfill portal to ground level and cover with waste rock. C9 Ventilation Shaft: Crushed waste rock up to weathered zone, then 10 m cemented rock fill and then 10 m of crushed rock to surface; concrete collar removed.	41.7 30.8 39.5	April 2019

BPT Description	Number of Options/Sub-options Assessed	Preferred Option No.	Description of Preferred Option	Rating of Preferred Option	Application Approved
Progress Pit 1 to final landform	Multiple	NA	Requirement to maintain pre-mining drainage and catchment areas and to ensure that it does not degrade unduly as a result of climate change. Each version of the landform undergoes landform evolution and erosion modelling by the SSB and is peer reviewed by ARRTC. The studies, reviews and subsequent modelling done to address landform design and backfill planning are consistent with the general practice of BPT assessment.	NA	May 2019
Tailings deposition into Pit 3 for Mill tailings and dredge tailings	3 Mill 4 Dredge	M2 D2	M1: Subaerial deposition from the current, multiple discharge points (one at a time, infrequently changing) D1: Dredge 1 and 2 subaerial	35.4 16.7	July 2019
Remnant tailings transfer – TSF to Pit 3	10	3	Scrape clean TSF floor and walls, transfer by truck, and deposit into Pit 3 south west end via a constructed tip head.	17	Included within tailings transfer approval
High density sludge (HDS) plant recommissioning	12	11	No change to the method approved by DITT in February 2020. That is, indirect treatment by releasing HDS product into the pond water inventory (i.e. RP2), for subsequent treatment through any of the pond water treatment plants (WTPs).	44.4	February 2020
TSF North Notch Stage 3	6	A2	Construct North Notch 3 to RL 37.3 m (clay core RL 36.8 m) and construct clay bund in dry season if required as determined by process water inventory predictions for the following wet season.	0	June 2020
TSF subfloor material management	14	1a	Leave material *in situ*. TSF subfloor material left undisturbed in situ. All visible tailings removed. TSF is then used for process water storage.	38.2	August 2020

BPT Description	Number of Options/Sub-options Assessed	Preferred Option No.	Description of Preferred Option	Rating of Preferred Option	Application Approved
Blackjack (gear oil) waste disposal	5	A1	Transport the blackjack drums in containers via road trains to the selected geological repository (multi-barrier safety case) located at Sandy Ridge (WA) to permanently isolate the waste from the biosphere. The waste will be pre-treated to immobilise contaminants prior to disposal in a bed of low permeability clay.	50	NA
Active BPTs					
Pit 3 Capping	7	D	Hybrid + East platform - Wicking completed sub-aqueously in Zone 1, 2, & 3 only. Sub-Aerial (accelerated dry out by mechanical assistance) with no wicking and sub-aerial Capping Method in Zone 4 and perimeter. Sub-Aerial (passive dry out) Capping Method to cap Zone 1,2,3 after wicking.	23	Application lodged April 2022

5.3 Risk assessment and management

Risk assessments for the closure of the RPA have been held since 2008 and will continue to be undertaken throughout closure as results of monitoring and technical studies become available and are used to refine ERA's understanding of risk. ERA developed the Hazard Identification and Risk Management Standard (ERS003) to ensure that strategies are developed to identify and manage hazards and risks. This standard is integrated within the ERA Health, Safety and Environmental Management System, which has been certified to meet the requirements of the AS/NZ ISO14001:2015 and AS4801 national standards.

A risk matrix is used to determine the overarching risk classification for each identified risk event or threat. The risk classification is a function of the consequence and likelihood ratings determined by subject matter experts within risk workshops. The overarching risk classification is determined to be either Class I (Low), Class II (Moderate), Class III (High) or Class IV (Critical) as per the risk matrix shown in Table ES6. The risk classification identifies the level of management action that must be taken to mitigate the risk as shown in Table ES7.

Table ES6 - Risk Classification Determination

Likelihood	Consequence Severity				
	Very low	Low	Moderate	High	Very high
Almost certain	Class II	Class III	Class IV	Class IV	Class IV
Likely	Class II	Class III	Class III	Class IV	Class IV
Possible	Class I	Class II	Class III	Class IV	Class IV
Unlikely	Class I	Class I	Class II	Class III	Class IV
Rare	Class I	Class I	Class II	Class III	Class III

Table ES7 - Management response

Risk Class	Response
Class I	Risks are acceptable and do not require active management
Class II	Risks are on the threshold of acceptance and require active monitoring
Class III	Risks exceed the risk acceptance threshold and require proactive management
Class IV	Risks significantly exceed the risk acceptance threshold and require urgent and immediate attention

At the time of writing this 2022 MCP, there are 45 environmental and technical risks related to mine closure. The number of risks per class are:

- 5 Class IV (Critical) risks
- 21 Class III (High) risks
- 14 Class II (Moderate) risks
- 5 Class I (Low) risks.

Table ES8 provides a summary of the current risk register for the Class IV and Class III risk events.

Considerable attention and work have been placed on the identification and management of closure risks for the Ranger mine since 2008. ERA acknowledges that this work is not finished, it is continuing and will be subject to ongoing reviews and updates as more information becomes available from the KKN studies and from monitoring activities. ERA will undertake another significant review of the environmental risks (including controls, planned activities and contingency measures) in 2023.

With specific regard to risk management, the current risk register provided in Appendix 7.1 of the main document shows that for the 45 risks:

- 351 existing controls are in place
- the effectiveness of the control currently in place is identified for one (1) risk as ‘weak’, twelve (12) risks as ‘marginal’, nineteen (19) risks as ‘satisfactory’, ten (10) risks as ‘good’, and three (3) risks are currently unrated
- two (2) risks have an ‘increasing’ risk trend (i.e. risk classification has increased over time), thirty-nine (39) risks have a ‘stable’ trend (i.e. have retained the same risk classification), and four (4) risks has a ‘decreasing’ trend (i.e. risk classification has improved)
- with regards to those risk events that are in a class that requires further management action (i.e. Class IV and Class III risks):
    - for the five (5) Class IV risks, 9 actions, additional to the ongoing successful implementation of the existing controls, are identified
    - for the twenty-two (22) Class III risks, 65 actions, additional to the ongoing successful implementation of the existing controls, are identified.

Table ES7 – Summary of the risk register for Class IV (Critical) and III (High) risks

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Class IV (Critical)			
Extraction of process water from pit 3 takes longer than planned	• Assurance of consolidation model being completed by stakeholders (2 independent reviews). [504190] • Continued stakeholder engagement via ongoing presentations to stakeholders through MTC and RCCF. [1083233] • CPT Testing to inform consolidation model and wick design. [504194] • Ongoing monitoring and modelling of tailings during deposition phase. [602110] • Pit 1 actual consolidation rates known and model adjusted to suit; ongoing monitoring. [504193] • Pit 3 design is based on the learning of Pit 1. [602105] • Placement of bulk backfill will be undertaken to lead to timely completion of consolidation. [602107] • Prefabricated vertical drains (wicks) installed to maximise consolidation. [602106] • Specialist consultant employed on consolidation modelling. [504189]	Satisfactory	• Monitoring the success of existing decant towers, pumping systems, and the number and distribution of the settlement towers, which may also be equipped with pumps. • Beyond the use of the settlement towers, risk contingency is installation of additional extraction and/or monitoring bores, following completion of capping and backfill works.
Inadequate pond water storage availability	• Continuous monitoring of pond water level and volumes [700068] • Developing catchment conversion plan for BMM operations [1047332] • OPSIM Water Balance model and forecast. [597533] • RWMP001 Ranger Water Management Plan. [700052] • Water model validated throughout operations [1047331] • Weekly water treatment plant operational coordination meeting [1047329]	Marginal	• Develop detailed plan for catchment management (inc. catchment conversion). Develop a water management plan for bulked and final landform construction, and a post closure sediment management plan. • Plan and execute wet season preparation activities for 2022-2023 wet season.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Unable to inject brine into underfill	• Ability to directionally drill additional steel-cased bores, with accessible headworks and positive-displacement pump injection capability. [504877] • Additional pipe available on-site to allow faster installation of replacement. [504880] • Assurance Plan with production metrics developed. . [504878] • Conductivity meter on the under-drain water flow. [602390] • Contingency plan for blocked well head [936477] • Data gathering plan for performance of brine injection. [504882] • Delivery lines (to manifold with original system, to headworks with replacement bores) able to be pigged and flushed. [1047291] • Full pump replacement held on-site as critical spare. [504881] • HDS plant incorporated into water model, removes salt from circuit. [602389] • Once Pit 3 capping and backfill is complete, ability to vertically drill additional bores through capping and tailings into underfill [1047293] • Pigging strategy. [504883] • Underfill engineered with a 20% contingency for brine storage (based on 100% of process water treated via BC) [602387] • Underfill volume review of as-built undertaken (Mark Goghill Nov. 2016) and determined contingency of 20% [602388] • Water model capable of forecasting TDS. [504879]	Marginal	• Brine storage options study • Contingency plan for brine injection system development
Failure to contain and/or eradicate *Spigelia* weed from the operations area causing infestation in Kakadu NP	• Clear procedures around vehicle hygiene (e.g. washdowns)Dedicated resources to manage treatment [616678] • External Stakeholder monitoring, managing and regular consultation [616681] • Mini ipads for weed monitoring [936385] • Monthly reporting to weeds Branch of Gov [597593] • Polaris ATV used for weed management [607791] • Regular monitoring and surveys of *Spigela* weed [597592] • Weed Management Plan [597591] • Weed specific training (exclusive to *Spigela*) [597594]	Marginal	• Investigate the opportunity for partial coverage of *Spigelia* through final landform development

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Rainfall is greater than planned in the Water Model (P50) increasing the process water inventory to manage/treat leading to later completion of process water treatment than planned	• Industry established tool used (water model) with model assured. [504167] • OBS upgrade for process water treatment[936453] • Process water volume tracked against water model prediction [602101] • Regular Water Model update. [504171] • Scenario of extreme weather event late in the closure schedule assessed during feasibility study and included in water management plans. [504174] • Water inventory sensitivity to rainfall is well understood via model based on significant data base (>100 years of data). [504168] • Water Model uses significant historical data records from local monitoring location. [504169]	Satisfactory	• Complete a concept level study to determine a suitable location and design for RP7, including in TSF options as contingency • Confirm the P50 values that are to be taken into the Feasibility Reforecast.
Class III (High)			
Solutes and sediments from surface runoff from final rehabilitated site enters off-site water bodies at greater than closure criteria. (surface water)	• Bathymetry and I-site scanning of billabongs [936473] • Characterisation of LAA and billabong sediments (partially complete). [504627] • Historic and ongoing studies into erosion. [504625] • Landform flood study informs sedimentation controls design. [504624] • Post-closure Management Plan. [504628] • Ranger Conceptual Model (RCM) and solute transport modelling completed. [504623] • Source term review. [936474] • Surface water pathways risk assessment [936475] • TSF solute transfer study completed by Intera. [504626]	Currently Unrated	• Conduct study to review the confidence and suitability of TSS sensors. • Consider reactive transport for Manganese, Ammonia, Uranium and Radium in Solute Transport Model

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Over time climate change causes a significant shift to the expected environmental baseline of the RPA restricting ERA in meeting its environmental requirements	• Current groundwater modelling incorporates considerations for climate change [936484] • Early understorey growth and survival will be monitored and remediated as required during the management period. [936483] • Irrigation strategy creates cyclone resistance (encourage deep root development). [1069939] • Landform Evolution Model (LEM) has climate change scenarios and a synthetic rainfall data set for 10,000 years. [1092045] • Monitor climate projections and ensure that new information is accounted for when selecting plant species for revegetation. [936482] • Monitor performance of revegetation actions and make adjustments as required. [936481] • Ongoing liaison with KNP regarding fire, weed and feral animal management strategies [1092052] • Ongoing review of climate risk assessment following IPCC updates. [1047337] • Revegetation Adaptive Management Plan [1047336] • Revegetation management plan draft. [1092066] • Revegetation strategy designed to meet closure criteria for resilience (e.g. species mix, irrigation, weed monitoring) [1092069] • State and Transition model for revegetation [1047335] • Weed management plan [1092077] • YFM001 Fire Management Plan [1092080]	Weak	• Develop agreed scenario for climate change, with Stakeholders, so unknowns or reduced and appropriately considered. • Revegetation Adaptive Management Plan to improve Revegetation Management Plan. • Review climate risk assessment for Ranger in light of the 2022 IPCC report.
Planned active process water treatment tactics (i.e. plant capacity) do not meet the assumed productivities modelled for site inventory reduction.	• BC evaporator vessel scaling issue understood and addressed. [504649] • BC fan upgrade completed . [504652] • BC operation reached a sustained rate of 115% with no fan upgrade. [504651] • BC seed cyclones upgraded. [504650] • Brine squeezer being implemented - schedule in Water Model. [504653] • Regular review and update of the water model [1092057] • Performance guarantees from vendor for BC upgrade. [1093480] • Sensitivity analysis on current water model complete. [504658]	Marginal	• Develop a compendium of past water treatment plans and current status. • Develop Brine Concentrator Recovery Execution Plan. • Develop/revise Asset Management Plan • Feasibility Reforecast to review planned performance of water treatment tactics. • Installation of the Brine Squeezer upgrade.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Elevated levels of contaminants (metals) in bush tucker.	• Alligator Rivers Region Technical Committee (ARRTC) process and key knowledge needs developed. [500616] • Bush food consumption restrictions to particular areas of the RPA may apply post closure. [694655] • Bush food monitoring program [1047356] • Closure criteria working group [507828] • Diet confirmed through consultation [1047354] • Singular RP1 additional sediments investigation. [988328] • Site specific concentrations factors (BRUCE database) [1047355] • Site specific research undertaken against identified knowledge gaps. [499956] • Stakeholder communication strategy and management e.g. Traditional Owners (TOs), Minesite Technical Committee (MTC), Alligator Rivers Region Advisory Committee (ARRAC), Alligators Rivers Region Technical Committee (ARRTC), technical working groups, community engagement. [693662] • Stakeholder engagement. [518282] • Water Pathways Risk Assessment to inform additional contamination knowledge gaps [988327]	Marginal	• Review diet assumptions and concentration factors for manganese - consider peer assessment • Determine an appropriate uranium environmental investigation level (EIL). • Undertake additional sediment sampling at RP1 and Coonjimba billabong. • Undertake aquatic vegetation investigation as a part of the Bushtucker Investigation & Assessment study. • Undertake faunal bushtucker investigation as a part of the Bushtucker Investigation & Assessment study. • Undertake flora assessment of on-site fruit as a part of the Bushtucker Investigation & Assessment study.
Tailings consolidation is slower than expected.	• Assurance of completion of consolidation model to stakeholders (2 independent reviews). [1105989] • CPTu, sampling and test work to inform consolidation model and wick design. [1105992] • Norwegian Geotechnical Institute separate 2D consolidation model. [1105990] • Ongoing presentations to stakeholders through MTC and RCCF platforms. [1105993] • Pit 1 actual consolidation rates understood with adjustment to model; ongoing monitoring. [1105991] • Specialist consultant employed for consolidation modelling. [1105988]	Marginal	• Continue to monitor and update model as required.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Insufficient volume or quality of trees from nursery for revegetation.	• 20% allowance for infill. [505250] • Alternative off site nursery available if required. [602401] • CDM.03-0000-NH-PLN-00002 Ranger Closure Revegetation Plan (Final Landform). [694601] • Disease control activities in nursery. [505254] • Expert propagation knowledge and implementation provided by existing contractor. [602399] • Interative allowances for unviable seeds per species is factored into seed collection requirements. [505251] • Learnings from Pit 1 will be taken into remaining work - lead time for additional seeds & seedlings. [505256] • Management of combustables in nursery area. [505253] • Nursery secured. [505252] • Planting and propogation trials successfully completed. [505255] • Primary nursery (expansion) [829839] • Primary nursery (fit for purpose). [693556] • Primary nursery constructed on site [602400] • Revegetation handover checklist [1092063]	Marginal	• Consider accelerating revegetation packages for LAAs and final landform.
Process water exceeds Maximum Operating Limit (MOL) in Pit 3.	• Approved MOL based on surrounding head data to ensure Pit 3 remains a sink. [504642] • Monitoring of water levels in Pit 3 [1047327] • Pumps in pit 3 maintained through the wet season to allow pump back. [973177] • Regular bathymetric surveys to determine process water inventory. [504644] • Tailings quantities well understood - production data and Fugro survey. [504643] • Significant capacity in the Ranger Water Dam (converted from TSF)	Marginal	• Continue to monitor (risk trending down now Ranger Water Dam operational)
Uncertain terms of access to RPA from 9th January 2026, including Traditional Owner Access to significant areas.	• General agreement to proposed amendment (i.e. GAC, Traditional Owners, cross government, DISER) [1046045] • Multiple mechanisms for stakeholder discussion (i.e. MTC, ARRTC, ARRAC, Relationship Committee). [1046048] • Supportive letter from Minister received [1046046] • Atomic Energy Act amendment bill	Marginal	• Continued engagement with Commonwealth, GAC and NLC on term sheets for section 41, section 44 and mining agreement.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Insufficient volume or quality of viable seed stock available for whole of site revegetation.	• Backup air-conditioning in seed storage room. [504584] • Current seed collection permit with Kakadu National Park with KNPS [504576] • Dedicated equipment for collecting grass seed [557230] • Dedicated equipment for collection of seed i.e. EWP, brush harvester. [693553] • ERA conducts annual and opportunistic seed collection on the Ranger Project Area (RPA). [504585] • Main planting for shrubs and trees will be planted via tube-stock rather than direct seeding (significantly less seed required) [602122] • MTO and schedule of seed requirements complete (including by species). [504586] • Nursery expansion including seed storage facility. [504583] • Ongoing collection and storage of seed stock by third party. [504575] • Ongoing review and update of seed collection and propagation plan regarding seed viability (including storage, handling, duration of viability). [797817] • Primary fit for purpose seed storage facility including climate control, security etc. [693557] • Quality assurance process applied to see management (viability testing regime). [693559] • Secondary fit for purpose seed storage facility. [726843] • Secure Contract in place with third party seed and plant provider [936388] • Seed management database, collection schedule and metric to manage performance. [504578] • Stakeholder agreed tree and shrub species list. [504580] • Emergency management / security plans and fire protection in place for seed storage • Seed collection and management procedures	Marginal	• Ongoing review and update of Species Establishment and Research Plan to inform seed requirements.
Slope failure in Pit 3 or stockpiles.	• Bi-annual geotechnical inspection, assessment and review of the slope stability in Pit 3 and stockpiles. [592105] • Prism monitoring of Pit 3. [927855] • Slope dump management plan updated annually through geotechnical consultant. [505719] • Vehicle standards. [505721]	Satisfactory	• Conduct risk assessment for upcoming wicking works. • Geotechnical investigation, assessment and review of the slope stability in Pit 3 and stockpiles.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Damage occurs to cultural heritage site during rehabilitation works.	• Aboriginal Areas Protection Authority (AAPA) certificate. [505865] • Access restricted to sites through signage and / or fencing. [505868] • Cultural Heritage Management Plan includes corrective actions for unplanned solute or sediment load at sacred site. [1045954] • Cultural Heritage Management system including general induction and heritage induction, mitigation measures, incident process and additional security of sensitive sites [505864] • Database of cultural heritage sites. [505867] • Land Disturbance Permit system. [505866] • Maintain multiple ERA representatives with relationships to specific stakeholders i.e. GAC [696045] • Solute transport modelling to understand issue and design controls. [1045956]	Satisfactory	• Complete all actions from 2019 CH audit. • Develop sediment and water quality control plan • Ensure that Feasibility Reforecast reflects the final landform design to address stakeholder recommendations. • Land disturbance process to be reviewed against CH requirements and rehabilitation process. • Undertake role review for the Cultural Heritage training matrix.
Unplanned contaminated materials found on RPA.	• Asbestos Register available for consultation. [1101007] • FS generated Contaminated Sites Management Plan. [989604] • PFAS is no longer used on the RPA. [989600] • Resources available to manage circumstance. [989602] • RT PFAS specific E15 Guidance note. [989601]	Satisfactory	• Consultant undertaking PFAS Assessment
Closure of Ranger Mine impacts on local economics causing reputational damage.	• Engagement with stakeholders on future state. [504049] • SIA (social impact assessment) [504048] • Stakeholder Engagement and Communications Plan [1033370]	Satisfactory	• Complete SIA review and communicate any changes to the relevant stakeholders. • Continue local employment programs to build a future employable workforce.
Inaccuracies or simplifications in the water model, excluding rainfall and water treatment rates (managed in other risks), leads to inadequate water treatment tactics.	• Consolidation model. [506949] • Regular bathymetric surveys of free process water inventory used to validate model. [504368] • Water Model validation (external assurance). [504369]	Satisfactory	• Assurance plan to be developed for water model for FR. • Complete a concept level study to determine a suitable location and design for RP7, including in TSF options for contingency • Stage and/or phasing plans to better detail catchments and simplifications for input into the water model.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Inaccuracies or simplifications in the water model, excluding rainfall and water treatment rates (managed in other risks), leads to inadequate water treatment tactics.	• Consolidation model. [506949] • Regular bathymetric surveys of free process water inventory used to validate model. [504368] • Water Model validation (external assurance). [504369]	Satisfactory	• Assurance plan to be developed for water model for FR. • Complete a concept level study to determine a suitable location and design for RP7, including in TSF options for contingency • FR to document, in an auditable form, the basis of water model, setting out the inputs, constraints and assumptions for water model. • Stage and/or phasing plans to better detail catchments and simplifications for input into the water model.
Large scale fire or natural disaster (e.g. cyclone) destroys immature vegetation.	• Deep rooting of trees [607821] • Delayed introduction of high biomass grasses, reduces fire risk. [602392] • Fire breaks and access tracks. [505242] • Introduction of cool burns 5-10 years post planting. [602394] • Irrigation strategy creates cyclone resistance (encourages deep root development). [505241] • LAAs have planned annual burn if not prevented. [505244] • Ongoing active management of revegetation [505243] • Ongoing liaison with KNP regarding fire, weed and feral animal management strategies [1092051] • Ongoing review and update of seed collection and propagation plan regarding seed viability (including storage, handling, duration of viability). [1092053] • Restricted access to revegetation areas [607816] • Revegetation strategy designed to meet closure criteria for resilience (e.g. species mix, irrigation, weed monitoring) [1092068] • State and Transition Model [936391] • Waste rock surface has low fire risk for 5-7 years post-planting. [505240] • Weed Management Plan [1049161]	Satisfactory	• Develop weed hygiene package to address prevention and management of weed spread on the RPA. • Integration of weed management plan.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Site condition does not meet Stakeholder expectations resulting in rework.	• Site specific recognised scientific research undertaken against identified knowledge gaps. [500615] • 3D printed physical model of final landform used to demonstrate final landform topography. [693665] • Alligator Rivers Region Technical Committee (ARRTC) process and Key Knowledge Needs developed. [1092006] • Application of BPT processes [1092007] • BPT and approvals process. [500625] • Agreed closure criteria • Closure Plan updates to incorporate stakeholder recommendations [500630] • Communication fora (e.g. ARRTC, ARRAC, MTC, stakeholder workshops). [1092016] • Continued stakeholder engagement via ongoing presentations to stakeholders through MTC and RCCF. [504195] • Early engagement with stakeholders [602094] • GIS study undertaken to model the potential view lines which has been approved by stakeholders. [602100, 693666] • Iterations of the Mine Closure Plan with updated closure criteria are submitted to Minister for approval annually. [936465] • Landform design cultural closure criteria. [693663] • Physical site visits undertaken by stakeholders i.e. Pit 1, Trial landform [936464] • Rehabilitation Animation [608175] • Socio-economic impact assessment [602098] • Stakeholder communication strategy and management e.g. Traditional Owners (TOs), Minesite Technical Committee (MTC), Alligator Rivers Region Advisory Committee (ARRAC), Alligators Rivers Region Technical Committee (ARRTC), technical working groups, community engagement. [1092073] • Stakeholder engagement has occurred to understand their needs and the ability to meet these needs [602099] • Stakeholder Engagement Plan developed. [500621] • Tiered assessment framework. [500628] • Trial landform established and results transparent to TO's. Jabiluka rehabilitation provides precedent. [500622]	Satisfactory	• Continue to engage with TOs on site conditions post closure. • Investigate opportunities to demonstrate the construction of a stable landform to stakeholders.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Groundwater solute transport outcomes are not as expected.	• Closure execution and post closure groundwater monitoring to inform model validation and updates. [1105980] • Detailed assessment via Water Pathway Receptors Risk Assessment and Vulnerability Assessment Framework (VAF). [1105968] • Groundwater and Surface Water interaction Study. [1105972] • Monitoring of bores / site groundwater during closure to to track the performance of the model. [1105967] • Non conservative assessments available for certain Constituents of Potential Concern (COPCs), including reactive transport and bioavailability modelling. [1105976] • Ongoing engagement/peer review with stakeholders through presentation of water studies at RCCF and ARRTC forums. [1105979] • Review source term for magnesium, manganese, ammonia, uranium and radium. [1105977] • Short term deviations (approx. 5 years) can be handled by decant operations. [1105966] • Significant database of site hydrogeological characteristics. [1105961] • Tailings consolidation model updates to improve predictive capability of the model. [1105962] • Uncertainty analysis of Intera Model. [1105960] • Update of Solute Source Terms Conceptual Models. [1105981] • Validation of ground water model through monitored real data informing the update of Ranger Conceptual Model and Groundwater Uncertainty Analysis. [1105978] • Verified the tailings consolidation model from geotechnical and geophysical investigations. [1105963]	Satisfactory	• Review and verify tailings consolidation model. • Consider reactive transport for Manganese, Ammonia, Uranium and Radium in Solute Transport Model

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Requirement for more extensive remediation / removal of contaminated plumes than planned.	• Application of BPT processes [602095] • Closure Contaminated sites management plan. [504381] • Engagement underway with regulator on remediation plan. Contaminated sites management plan. [504421] • Existing audits of LAA, wetland filters provide an accurate indication of potential scope and contamination level. [504420] • Ground water monitoring program for mill and fuel farm has provided specific information. [504410] • Initial TSF plume characterisation and impact assessment completed (Intera). [504412] • Ranger conceptual model developed and accepted by stakeholders. (Confirms Mill plume can stay in situ, TSF plume needs further investigation) [504411] • Surface water pathway risk assessment [936463]	Good	• Characterise contamination of wetland filters and billabongs • Conduct an Independent Assurance Audit on TSF deconstruction methodology (post-FR). • Conduct stakeholder engagement and obtain stakeholder acceptance on plume remediation plan. • Develop the TSF deconstruction methodology/plan. • Ensure this risk is reviewed in detail under the Feasibility Reforecast. • Following a risk based approach determine remediation required for PFAS contamination.
Tailings Storage Facility wall breached during deconstruction works or while still in use.	• Additional monitoring and instrumentation for drawdown [602112] • Advanced notice through bore monitoring. [504392] • Compliance and auditing against compliance to RT D5 Standard. [504391] • Dedicated dam engineer oversiting and approving all plans (Coffey). [504386] • Downstream raise dam constructed with clay core [602113] • Engineering supervision of construction works. [1092028] • Independent review of all engineering. [504387] • Interception trenches installed around west wall of the TSF. [504390] • Maintain appropriate MOL. [504395] • Modelling to understand impact [602114] • Process safety CCMP's include TSF failure which references drawdown rates on facility. [504389] • Process safety controls for dredging. [504393] • Successful completion of Eastern wall notch. [504394] • Technical review complete for use of TSF as a water storage facility. [504396]	Good	• Conduct an Independent Assurance Audit on TSF deconstruction methodology (post-FR). • Develop the TSF deconstruction methodology/plan.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Excessive erosion impacts landform stability and revegetation success.	• Access tracks designed to minimise erosion and/or not cause erosion. [602120] • Compaction of waste rock on Pit 1/Stage 13 results incorporated into Material Movement Plan. [971916] • Contour ripping in high erosion areas. [602119] • Controls on Material Movement to ensure built landform matches design. [504478] • Final designed landform does not contain slopes > 4%. [504480] • Flood study informs erosion control design. [504482] • Landform Evolution Model (LEM) has climate change scenarios and a synthetic rainfall data set for 10,000 years. [504477] • Landform Evolution Model (LEM) model has informed both landform design, erosion controls and sediment traps. [504476] • Monitoring of backfill during landform construction [1047338] • Revegetation handover checklist [1092062] • Revegetation plan updated with outcomes of Pit 1 and Stage 13 trails [1047339] • Revegetation strategy tailored to landform elements (e.g slopes, gullies, etc). [602118] • Ripping Management Plan. [971917] • Scheduling of landform to decrease erosion output and landform design includes no gully formation over tailings. [971915] • Traffic and logistics management plan [1047340] • Updated consolidated model with Pit 1 validation from monitoring data and CPT testing. Ongoing updates. [504481] • Validation of consolidation models. [504479]	Good	• Develop detailed plan for catchment management (inc. catchment conversion). Develop a water management plan for bulked and final landform construction, and a post closure sediment management plan. • Ensure components are in line with BMM schedule. • Ensure revegetation strategy tailored to landform elements (e.g slopes, gullies, etc). • Incorporate stage 13 results into revegetation plan • Update final landform to include concave slopes and first order drainage lines. • Update MNP126 Specification for Design and Construction of Mine Roads Procedure to ensure erosion is highlighted. • Update scarification/ripping plan to incorporate contour ripping in high erosion areas and pit 1 learnings.

Description of risk event	Current controls [ERA Reference Number]	Control Effectiveness	Actions
Perception amongst local community of downstream contamination from Ranger closure impacting ability to engage in traditional activities. Includes radiation, contamination.	• ARRAC meeting discussed and presented by DITT and SSB. [1101057] • Community and Stakeholder Engagement plan. [1092018] • Cultural reconnection steering committee [1046097] • Management Actions included in the Communities and Stakeholder Engagement Plan. [1069955] • Relationship committee meetings. [503405] • Water monitoring program. External Relations team is on mailing list for enviro water monitoring to proactively manage media. [503404]	Good	• Develop and implement internal communications to address perceptions on Ranger Mine's potential impact to the environment. • Include water quality model in 3D landform model • Undertake aquatic vegetation investigation as a part of the Bushtucker Investigation & Assessment study. • Undertake faunal bushtucker investigation as a part of the Bushtucker Investigation & Assessment study. • Undertake flora assessment of on-site fruit as a part of the Bushtucker Investigation & Assessment study.

Class II (Moderate) risks – 14 risks – see Chapter 7 of MCP main document

Class I (Low) risks – 5 risks – see Chapter 7 of MCP main document

6 CLOSURE IMPLEMENTATION

Throughout the 40+ years of operation, the Ranger mine has disturbed 1,062 hectares of land. ERA recognises that indirect impacts may have also occurred in areas surrounding the mine's disturbance footprint. Figure ES4 shows the location and spatial extent of each of the closure domains and Figure ES1 provided an indicative timeline for their progressive closure.

Table ES8 summarises the completed, current and future activities being undertaken within each of the closure domains as they progress towards final landform (noting that ongoing monitoring and weed management as required are common to all domains and is not included in the table). The table also identifies which of the activities are new to a MCP. This information is important as the MCP is the mechanism by which most activities are considered and approved by the Australian and Northern Territory governments. On this basis, those activities that are highlighted as being new to an MCP are described in further detail in Section 9 of the MCP main document. The exceptions to this process are the significant activities that are subject to a standalone application and approval (i.e. Pit 1 backfill, Pit 3 backfill, and TSF deconstruction/Final Landform).

Table ES8: Closure implementation work program

Domain	Completed Activity	Current Activity	Future Activity
1: Pit 1 (~41 ha)	• Mining of Pit 1 ended in December 1994 (Plate ES5) • Underdrain installed in preparation to receive tailings • Tailings deposition began in August 1996 and ended Q4 2008 (Plate ES6) • Wicking to assist dewatering and consolidation of tailings • Installation of geotextile layer and initial capping in 2013-14 • Full backfill started in May 2019 and final landform achieved in August 2020 (Plate ES7) • Scarification of the landform started in November 2020 and rehabilitation plantings started in 2021 (Plate ES8) • Creation of habitat via rock/boulder features (Plate ES9)	• Removal of pit tailings flux (process water) via decant wells • Monitoring, maintenance and adaptive management activities to inform surface water runoff and ecosystem re-establishment. This work will enable ERA to apply lessons learnt to other landforms as they are progressively established	• Remove/relocate associated infrastructure from Pit 1 (e.g. decant wells, asbestos, laydown yard, Orica yard, transfer station, Omega pump) into Pit 3 • Contour perimeter drain to final landform • Removal of corridor creek road, associated bund and high voltage (HV) power • Relocation of central services corridor
2: Pit 3 (~107 ha)	• Mining started in 1997 and ended in November 2012 (Plate ES11) • Underfill, underdrain and dewatering systems completed 2012-2014 (Plate ES12) • Brine injection bores installed into the underfill zone in 2015 and injection started in 2016 • Tailings deposition from mill processing started in 2015 and ended 2021 • Tailings transfer from TSF started in 2016 and ended 2021 • Tailings floor transferred via truck and dozer • Wicking to assist dewatering and consolidation of tailings	• Brine injection into the underfill zone via pit wall directional drilling (Plate ES13) • Ongoing wicking followed by dewatering and drainage	• Installation of geotextile and initial backfill • Placement of demolished plant and other infrastructure / materials • Progressive capping, waste disposal and bulk backfill (standalone approval Pit 3 application lodged April 2022) • Final 6m of landform (standalone approval application for Final Landform) • Revegetation of final landform

Domain	Completed Activity	Current Activity	Future Activity
3: TSF / RWD (~185 ha)	• Tailings transfer into Pit 1 ended 2008 and into Pit 3 in 2021 • Cleaning of remnant tailings from walls in 2019-21 (Plate ES14) • Approval in 2020 to leave subfloor material in-situ • Dredging floor ended February 2021 (Plate ES15) • RWD wall notches installed and process water received from Pit 3 in 2022 • One dredge removed, decontaminated and removed off-site	• Process water storage and evaporation	• Progressively remove HV power supply and telemetry • TSF deconstruction and dredge disposal (standalone approval application for TSF deconstruction / Final Landform) • Final landform (standalone approval application for Final Landform) • Revegetation of final landform
4: Land Application Areas (~158 ha)	• These areas support ongoing disposal of release water	• Ongoing disposal of release water	• Progressive removal of infrastructure • Progressive remediation of any contamination • Progressive revegetation
5: Process plant, water treatment plants & other infrastructure (~39 ha)	• Decommissioning of infrastructure associated with the leaching and solvent extraction circuits and areas of calcination, drying and product packing	• Progressive contaminated material recovery • Ongoing use of water treatment facilities (including brine concentrator, brine squeezer, high density sludge plant, reverse osmosis plant.0), fuel storage, power station and administration buildings	• Demolition of plant / crusher • Treatment of water - progressively transfer sections from process water to pond water • Remediation of contamination sites • Revegetation
6: Stockpiles (~268 ha)	• Stockpiled waste rock used to backfill Pit 1 in 2020 • Progressive rehabilitation of Areas A (0.6 ha) and C (2.4 ha)	• Stockpiled waste rock being used to create Stage 52 final landform	• Initial capping and bulk material movement for Pit 3 backfill (standalone approval Pit 3 application lodged April 2022) • Bulk material movement for RPA final landform (standalone approval application for TSF deconstruction / Final Landform)

Domain	Completed Activity	Current Activity	Future Activity
7: Water management areas (~125 ha)	• These areas are supporting ongoing water storage, dust suppression and management	• These areas are supporting ongoing water storage, dust suppression and management, including authorised release of treated (pond) water during the wet season	• Progressive remediation, backfill, rehabilitation of retention ponds, water storages, wetland filters and on-site billabongs
8: Linear infrastructure (~40 ha)	• Two redundant tracks (3.6 ha) and six drill pads (0.8 ha) have been rehabilitated • Bulk of this domain is supporting ongoing activities	• None - these areas are supporting ongoing activities	• Progressive removal and rehabilitation as aspects of this domain are no longer required
9: Miscellaneous areas (~55 ha)	• Trail landform constructed in 2009 to investigate rehabilitation success into Ranger waste rock (Plate ES16) • Closure of the Ranger 3 Deeps (R3D) approved April 2019. Ventilation shaft backfilled and decline allowed to flood naturally to -20mRL. Decline backfilled 350 m from ground level in 2021. • Ranger mine village contractor camp and adjacent workshop (1.4 ha) rehabilitated in 2020 • Several old domestic landfills to the north of Pit 1 were covered with waste rock in 2020 as part of the Pit 1 backfill • All explosives have been removed from the magazine area and the site has been de-registered	• Ongoing use of the plant nursery, trial landforms (Plate ES17), Magela Creek levee and some landfill sites	• Relocating office space/gate house to maximise demolition efficiency • Plant nursery expansion/core yard decommissioned and rehabilitated • R3D decline, ventilation shaft pad and associated infrastructure progressively removed/rehabilitated for final landform (within standalone approval application for TSF deconstruction / Final Landform) • Progressive decommissioning, remediation, backfill and rehabilitation of miscellaneous areas

Domain	Completed Activity	Current Activity	Future Activity
10: Airport and Environmental Institute for the Supervising Scientist (ERISS) (~44 ha)	• Ongoing use	• Ongoing use	• Final decommissioning and closure to be determined via the socio-economic assessment
11. Residual RPA	• Largely undisturbed	• Water monitoring	• Progressive relinquishment of undisturbed areas • Progressive rehabilitation of disturbed areas

Plate ES5: Pit 1 (1992)

ES6: Pit 1 after tailings deposition (2008)

Plate ES7: Pit 1 being backfilled (2014)

Plate ES8: Pit 1 backfilled (2022)

Plate ES9: Pit 1 fauna habitat features added as boulder piles (2021)

Plate ES10: Pit 1 perimeter drain (2021)

Plate ES10: Pit 1 perimeter drain (2021)

Plate ES12: Pit 3 underfill (2014)

Plate ES13: Pit 3 tailings deposition (2016)

Plate ES13 Directional drilling for brine injection into Pit 3 underfill (2022)

Plate ES14 Cleaning remnant tailings from walls of tailings storage facility (2020)

Plate ES15: Ranger Water Dam in final stages of remnant tailings removal from floor (2021)

Plate ES16: Trial landform constructed (2009)

Plate ES17: Trial landform as of March 2022

7 COMPLETION CRITERIA, MONITORING AND MAINTENANCE

This is arguably the most important aspect of successfully closing the Ranger mine. It is critically important to:

- agree with the Traditional Owners and all other relevant stakeholders the post-mining land use and criteria against which the material aspects of closure and rehabilitation will be measured
- undertake regular monitoring so that:
    - the previously acquired monitoring results and those to be collected over the next few years can be used to test the accuracy of current predictions and influence the closure and rehabilitation activities up until the creation of the final landform
    - monitoring undertaken after the creation of the final landform can be used to test the progress/achievement of the closure criteria and trigger adaptive management and/or contingency measures if required
- implement maintenance activities to ensure, and where possible accelerate:
    - the return of useful land to the Mirarr people
    - the achievement of closure criteria
    - a positive legacy for ERA.

Chapters 8 and 10 of the MCP main document provide extensive discussion on the closure criteria, research, monitoring and adaptive management relevant to the following themes: Landform; Radiation; Water and sediment; Soil; Ecosystem; Cultural.

Table ES9 provides a summary of the closure criteria and the relevant studies that are being undertaken to inform and address these criteria.

Table ES9: Summary of completion criteria and monitoring

Completion Criteria Objective	Relevant Study / Monitoring (refer Table ES3 for KKN numbering)
Landform (criteria finalised – approved 30 September 2021)	
The tailings are physically isolated from the environment for at least 10,000 years	• Landform evolution modelling (LEM) to assess the stability of the final landform, erosion and surface water runoff (LAN3)
Erosion characteristics of the rehabilitated landform, as far as can reasonably be achieved, do not vary significantly from comparable landforms in surrounding undisturbed areas	• Erosion and sediment transport sampling from Pit 1 and Stage 52 area (LAN1) • Landscape-scale processes and extreme events (LAN2) • Land evolution modelling to assess the stability of the final landform (LAN3)
Radiation (criteria finalised – approved 30 September 2021)	
Stable radiological conditions on areas impacted by mining so that, the health risk to members of the public, including Traditional Owners, is as low as reasonably achievable; members of the public do not receive a radiation dose which exceeds applicable limits recommended by the most recently published and relevant Australian standards, codes of practice, and guidelines; and there is a minimum of restrictions on the use of the area.	• Radiation dose assessment (RAD6 and RAD7)
The company must ensure that operations at the Ranger do not result in: • change to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area. Such change is to be different and detrimental from that expected from natural biophysical or biological processes operating in the Alligator Rivers Region; and • environmental impacts within the Ranger Project Area which are not as low as reasonably achievable, during mining excavation, mineral processing, and subsequently during and after rehabilitation.	• Assessment of radionuclides in the rehabilitated site (RAD1, RAD9), aquatic ecosystems (RAD2), drinking water (RAD9) and bushfoods including wildlife (RAD3, RAD8, RAD9) • Radon progeny in air (RAD3)

Completion Criteria Objective	Relevant Study / Monitoring (refer Table ES3 for KKN numbering)
Water and Sediment (criteria to be finalised)	
• The company must ensure that operations at Ranger are undertaken in such a way as to be consistent with the following primary environmental objective: 1.1(c) Protect the health of Aboriginals and other members of the regional community • The company must ensure that operations at Ranger do not result in: 1.2(c) An adverse effect on the health of Aboriginals and other members of the regional community by ensuring that exposure to radiation and chemical pollutants is as low as reasonably achievable and conforms with relevant Australian law, and in particular, in relation to radiological exposure, complies with the most recently published and relevant Australian standards, codes of practice, and guidelines.	• Assessments that characterise the constituents of potential concern (COPC) in the rehabilitated site (WS1), groundwater (WS2) and surface water (WS3) • Assessments of radionuclides and radiation dose assessment noted above
• The company must ensure that operations at Ranger are undertaken is such a way as to: maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes • The company must ensure that operations at Ranger do not result in: change to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area. Such change is to be different and detrimental from that expected from natural biophysical or biological processes operating in the Alligator Rivers Region. • Final disposal of tailings must be undertaken, to the satisfaction of the Minister with the advice of the Supervising Scientist on the basis of best available modelling, in such a way as to ensure that: any contaminants arising from the tailings will not result in any detrimental environmental impacts for at least 10,000 years.	• Studies that characterise the baseline aquatic biodiversity (WS4) and impacts on this diversity (WS5) • Studies that assess the impact of COPCs in surface water and groundwater on biodiversity values (WS6 and WS7) • Groundwater/surface water interaction, and fate and transport modelling, to determine the concentrations of constituents of concern (COPC) entering the receiving environment (WS2)
• The company must ensure that operations at Ranger do not result in: environmental impacts within the Ranger Project Area which are not as low as reasonably achievable, during mining excavation, mineral processing, and subsequently during and after rehabilitation. • The company must rehabilitate the Ranger Project Area to establish an environment similar to the adjacent areas of Kakadu National Park such that, in the opinion of the Minister with the advice of the Supervising Scientist, the rehabilitated area could be incorporated into the Kakadu National Park.	• These are addressed by the options analysis completed for the Best Practicable Technology (BPT)(Table ES4) and many of the KKNs listed above • Cumulative assessments of the site and surrounds conducted for CT1 and CT2

Completion Criteria Objective	Relevant Study / Monitoring (refer Table ES3 for KKN numbering)
Soil (criteria finalised – approved 30 September 2021)	
The company must ensure that operations at Ranger do not result in: environmental impacts within the Ranger Project Area which are not as low as reasonably achievable, during mining excavation, mineral processing, and subsequently during and after rehabilitation.	• These are addressed by the options analysis completed for the Best Practicable Technology (BPT)(Table ES4) and many of the KKNs listed above
Ecosystem (criteria finalised August 2022 – yet to be approved)	
Revegetation of the disturbed sites of the Ranger Project Area using local native plant species similar in density and abundance to those existing in adjacent areas of Kakadu National Park, to form an ecosystem the long-term viability of which would not require a maintenance regime significantly different from that appropriate to adjacent areas of the park.	• All of the studies conducted for the ecosystem restoration theme address this objective (ESR1-8)
Cultural (developed with GAC and NLC)	
• The company must ensure that operations at Ranger are undertaken in such a way as to be consistent with the following primary environmental objectives: (a) maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list • The company must rehabilitate the Ranger Project Area to establish an environment similar to the adjacent areas of Kakadu National Park such that, in the opinion of the Minister with the advice of the Supervising Scientist, the rehabilitated area could be incorporated into the Kakadu National Park.	• Genuine engagement with the Mirarr people, Gundjeihmi Aboriginal Corporation (GAC) and Northern Land Council (NLC) • Cumulative assessments of the site and surrounds conducted for CT1 and CT2