Executive summary

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Cover photograph: Yellow Oriole (Oriolus flavocinctus) on Trial Landform
EXECUTIVE SUMMARY

1 SCOPE AND PURPOSE

This Mine Closure Plan (MCP) is prepared by Energy Resources of Australia Ltd (ERA) to meet its Northern Territory (NT) and Commonwealth regulatory obligations and conditions, as described below. The MCP is prepared for the Minister of Resources and Northern Australia (Commonwealth) and the Minister for Primary Industry and Resources (NT) to meet condition Annex B.2 of the Ranger Authority (Section 3). This MCP is an update to the 2018 MCP, issued May 2018.

The MCP represents the updated Ranger Mine closure strategy following the finalisation of the closure Feasibility Study for the rehabilitation of the RPA (Feasibility Study). ERA, supported by an experienced engineering service provider, undertook the Feasibility Study to further refine scheduled rehabilitation activities and plans. This Feasibility Study, which developed the technical, costing and scheduling aspects of Ranger Mine closure to a very high level of detail, was subject to scrutiny from multiple internal and external reviews.

As well as providing a concise description of the closure strategy, this MCP includes an overview of the rationale and knowledge base used for the development of the document. It must be acknowledged that further studies and works are ongoing, and that these will be utilised to further develop the updates of the plan.

The result of a variation to the Authorisation (0108), issued on 22 June 2018, is the requirement that the MCP is reviewed and updated annually with submission to the Commonwealth Minister and the NT Minister due on or before 1 October each year. The variation details the process for submission and assessment of the MCP (also referred to as a ‘rehabilitation plan’) in accordance with section 34 of the Mining Management Act. This MCP is being submitted to meet these requirements.

The 2018 MCP was subject to stakeholder review and the detailed feedback has been considered for the preparation of this document. ERA has prepared a detailed response to stakeholder feedback on the 2018 Ranger MCP (Appendix A). The substantive changes of content that have occurred in the 2019 MCP, compared to the 2018 version, are outlined in the table at the front of this document. In reviewing this 2019 MCP submission, stakeholders are requested to use the form provided in Appendix 1.1 for feedback for consideration in the next annual review process.

This MCP has been prepared with reference to the Western Australian Guidelines for Preparing Mine Closure Plans (the WA Guidelines) (DMP & EPA 2015) at the request of the Commonwealth Government, and in the absence of any NT closure plan guidelines to date. The WA Guidelines outline a general mine closure planning process and document structure for the MCP. ERA has followed this mine closure planning process throughout its operation and addresses each component of this process in detail throughout this MCP (Section 3.3). The 2019 MCP has been structured to more closely align with the WA Guidelines. It is intended that the 2020 update will follow the same format as 2019, but with updates to sections where new information has been obtained.
Figure ES-1: Regional location of Ranger Project Area
2 PROJECT OVERVIEW

The purpose of this section is to provide background information on the history and status of the Ranger Mine project.

The Ranger uranium mine (Ranger Mine) is located within the Ranger Project Area (RPA) adjacent to Jabiru, approximately 260 km east of Darwin in the Alligator Rivers Region of the NT (Figure ES-1). The RPA is surrounded by Kakadu National Park (NP) 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.

ERA has owned and operated the Ranger Mine since the commencement of operations in 1980. ERA has provided international customers with reliable supply of uranium oxide in the 38 years since production at Ranger Mine began. Ranger Mine has produced in excess of 129,000 T of uranium (ERA 2019) to meet the world uranium demand for fuelling nuclear power plants. ERA production is supplied to power utilities in Asia, Europe and North America in accordance with strict international and Australian safeguards. The ERA shares are publicly held and traded on the Australian Securities Exchange, with Rio Tinto, a diversified resources group, currently holding 68.4 per cent of ERA shares.

The initial discovery of the Ranger Mine deposits was made in October 1969 by an exploration joint venture between Peko-Wallsend Operations Limited (Peko) and Electrolytic Zinc Company of Australasia Ltd (EZ) through aerial radiometric survey. ERA was established in February 1980 as the operator of the Ranger Mine.


During the same period, much of the Alligator Rivers Region was declared a National Park (NP) and Aboriginal people were given a major role in the Kakadu NP management. The Commonwealth Government introduced laws covering the Alligator Rivers Region (Commonwealth Environment Protection (Alligator Rivers Region) Act 1978) and established several research bodies and committees to overview the environmental regulation of mining in the region. These included the Supervising Scientist and the Environmental Research Institute of the Supervising Scientist (ERISS), the Alligator Rivers Region Advisory Committee (ARRAC) and the Alligator Rivers Region Technical Committee (ARRTC). 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.

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2 The functions of these committees and research bodies are described further in Section 5.
Mining of Pit 1 finished in December 1994. During that time, 19.78 million tonnes of uranium ore was mined. Mining from Pit 3 commenced in July 1997 and concluded in November 2012. Since mining finished in Pit 3, ERA has produced uranium oxide from stockpiled ore.

The processing of stockpiled ore will continue during the operations phase through the Ranger Mine processing plant, where uranium is leached from the ore using sulfuric acid. The uranium is then purified, concentrated, precipitated, calcined (dried), placed into drums and exported. Components of the mining and processing operations in the context of closure domains are shown in Figure 2-2 and Figure 2-3 and include:

- processing area including a power station (which also provides power to the town of Jabiru), administration and maintenance facilities (Section 2.2.2)
- Ranger 3 Deeps (R3D) exploration decline (Section 2.2.3),
- a tailings storage facility (TSF) (historically referred to as the 'tailings dam') (Section 2.2.5)
- two mined-out pits – Pit 1 (Section 2.2.6) and Pit 3 (Section 2.2.7)
- ore and waste rock stockpiles (Section 2.2.8)
- several water retention ponds, water storage structures and constructed wetland filters (Section 2.2.9)
- water treatment plants (WTPs) (Section 2.2.9)
- irrigation areas for the disposal of managed release water (Section 2.2.9)
- an access road and service tracks, and
- Jabiru Airport, Jabiru East and associated infrastructure. It is noted that whilst the closure of Jabiru East area and the Jabiru Airport are not considered within this MCP, discussions with stakeholders are progressing (Section 2.2.10).

Water management is the most significant environmental and operational aspect of the Ranger Mine and is an integral part of the ERA Health, Safety and Environment Management System. It encompasses all aspects of water capture, storage, supply, distribution, use and disposal. Section 2.2.9 provides an overview of this system and describes the water management facilities within the RPA, which include:

- retention ponds
- water treatment ponds
- wetland filters
- land application areas
- Brine Concentrator (BC), and
- Brine Squeezer.
Water is managed according to the Ranger Water Management Plan (RWMP), which describes the method used to control water on site. The RWMP fulfils the requirements of the Ranger Authorisation (0108-18) and is approved annually by regulators.

Water management and closure planning at the Ranger Mine has been supported since 2006 by a dynamic water and solute balance model. The model considers the characteristics, connectivity and operational rules associated with the material elements of the process and pond water circuits at the Ranger Mine, and the planned changes to the nature of those elements through to 2026, as described in Section 12.

3 CLOSURE OBLIGATIONS AND COMMITMENTS

This section provides an overview of the closure obligations and commitments that are applicable to ERA in relation to the RPA. Section 3 also identifies the external guidelines, standards, codes of practice and stakeholder input, along with internal corporate policies and standards relevant to the MCP.

Closure of the Ranger Mine is governed by both Commonwealth and NT legislation and regulations, and the legal obligations of the closure of the Ranger Mine are detailed in Section 3. The key instrument that governs operations at the Ranger Mine on a day-to-day basis is the authority (the Ranger Authorisation) issued under the NT Mining Management Act 2018 (Mining Management Act). The main Commonwealth authority issued under section 41 of the Atomic Energy Act 1953 (Cth) (Atomic Energy Act), provides the key tenure and land access approval required for the operations (the section 41 Authority).

Title to the RPA was granted to the Kakadu Aboriginal Land Trust in 1978, in accordance with the Commonwealth Aboriginal Land Rights (Northern Territory) Act 1976 (Aboriginal Land Rights Act). Prior to the Commonwealth Minister approving the Ranger Mine, the Commonwealth Government entered the section 44 Agreement with the NLC under the Aboriginal Land Rights Act. The section 41 Authority (described above) was granted on 9 January 1979.

The Ranger Environmental Requirements (ERs) are appended to the section 41 Authority and set out environmental objectives which establish the principles by which the Ranger Mine operation is to be conducted, closed and rehabilitated and the standards that are to be achieved. The Mining Management Act also requires the Ranger Authorisation to incorporate, by reference, the ERs. The ERs were revised in 1999 to be inclusive of conditions relating to rehabilitation.

It is implicit that ERA will comply with all necessary legal obligations and uphold internal standards during closure to ensure the ongoing protection of the environmental values surrounding Kakadu NP; the health and safety of the community and preservation of cultural values. ERA is committed to protecting these values by implementing the required management controls. These management controls are described and discussed in Section 11.

A table describing the ERA key legislative instruments and agreements is included in Appendix 3-1 to provide an overview of the ERA regulatory framework. As per the Western
Australia Mine Closure Guideline, a Closure Legal Obligations Register has been developed and included within Appendix 3-2. This register forms a subset of the overarching ERA legal register for all operations at Ranger Mine.

The transition into closure will involve applying for regulatory approvals to authorise new requests or to modify the currently authorised activities that have the potential to result in an environmental impact to either intact or undisturbed areas of the RPA; or downstream and/or offsite. It is assumed that no areas outside of the existing footprint will be disturbed during closure and, as such, no additional permits or approvals relating to land disturbance will be required. Permits for decommissioning works, post-closure and access approvals will be submitted to the relevant authority as needed.

4 ENVIRONMENTAL AND SOCIAL SETTING

Section 4 provides an overview of the physical, environmental and social setting of the Ranger Mine. The section provides the context to planning mine closure and is a summary of a substantial dataset that has been accumulated by ERA and regulators from more than 30 years of environmental, safety and health monitoring and research investigations of the site and surrounding environment.

The RPA is surrounded by Kakadu NP. The Kakadu region has had at least 65,000 years of indigenous occupation, with increasing contact between the region's Aboriginal people and other cultures from around the 17th century and a more permanent non-indigenous presence evident from the late 1800s (Section 4.4). Historical land use within the Alligator Rivers Region has included indigenous occupation, buffalo hunting, missions, pastoral grazing, agriculture, mining exploration, uranium mining and tourism. The RPA is within the Magela catchment, within the Alligator Rivers Region (Figure 4-1), and currently contains several land use types, including Kakadu NP, mining and native title lands. Kakadu NP is a World Heritage listed area and Ramsar wetland site (Section 4.3.2).

The description of the physical environment (Section 4.2) includes an overview of the RPA climate, land systems, surface water resources, groundwater and radiation. The description of the biological environment (Section 4.3) includes an overview of the bioregions, NPs and protected areas, terrestrial ecosystems and aquatic fauna and ecosystems which the RPA is sited within.

The climate of the Alligator Rivers Region (Section 4.2.1), within which the Ranger Mine is located, is dominated by a seasonal wet-dry monsoon cycle with the large inter-annual and intra-seasonal variability largely associated with the effects of the El Niño Southern Oscillation, the Madden-Julian Oscillation and tropical cyclone activity. The wet season generally extends from late October to early April with predominantly westerly winds, whilst the dry season is dominated by easterly to south-easterly winds and extends from May to September.

Surface water management will be a key focus of rehabilitation and closure, as it is one of the pathways for constituents of potential concern (COPC) to enter the environment (Section 4.2.3.1). The Ranger Mine is located within the 1,600 km² of the Magela catchment and adjacent to Magela Creek (Figure 4-5). Two tributaries of Magela Creek are also located in close proximity to the mine: Gulungul Creek to the west and Corridor Creek to the south.
Magela Creek is a seasonally flowing tributary of the East Alligator River, with a catchment originating from headwaters on the Arnhem Land Plateau.

The tropical, monsoon climate of the NT creates seasonal changes that drive groundwater flow into and out of the Ranger Mine area (Section 4.2.4). Groundwater occurrence and flow through the RPA consists of a shallow groundwater flow system, within the relatively permeable alluvium and weathered rock, and a deeper bedrock groundwater flow system with relatively low permeability, in which groundwater is encountered within faulted, sheared, cracked and brecciated rocks. Groundwater also occurs in intermediate layers of weathered bedrock between the shallow and deeper groundwater flow systems. The natural background hydrochemistry of groundwater of the RPA typically exhibits relatively low concentrations of total dissolved constituents.

There has been a substantial survey and monitoring of the terrestrial flora across the RPA over the past 15 years. In a 2013 survey of lowland riparian and woodland areas within the RPA, 292 flora species from 30 families were identified. These species are common in surrounding Kakadu NP and did not include any threatened or rare species. Approximately 1,600 terrestrial and aquatic flora species have been recorded in Kakadu, including 15 species considered rare or threatened. These conservation significant species have not been recorded within the RPA.

The RPA has been surveyed by ERA annually for weeds since 2003, and approximately 80 species have been recorded during this time. Weeds of National Significance (WoNS) are categorised under the Federal EPBC Act. Gamba Grass (*Andropogon gayanus*) is the only WoNS previously recorded in the RPA with the recorded presence restricted to isolated plants on roadsides or in the vicinity of the Jabiru Airport. With successful weed control, there has been no plants or viable seeds of this species detected for a number of years. A new weed to Australia, Indian Pinkroot (*Spigelia anthelmia*) was discovered onsite in April 2019 and an eradication program has been implemented. More information on native and invasive flora is provided in Section 4.3.3.2.

A number of conservation significant fauna species (including a large number of mostly bird species listed under various migratory agreements) have been recorded on the RPA during previous surveys (Section 4.3.3.3, Table 4-8). The identified species include the conservation listed Northern Quoll *Dasyurus hallucatus* (Endangered; Critically Endangered) and the Partridge Pigeon *Geophaps smithii smithii* (Vulnerable; Vulnerable) (the EPBC Act and Territory Parks and Wildlife Conservation Act).

Fire within the RPA is managed by ERA for asset protection and weed control, and includes fuel reduction burns, excluding fire from certain areas and maintaining a network of graded firebreaks and is described in Section 4.3.3.4.

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3 Brecciated means rock that has been mechanically broken by faulting and shearing, resulting in angular fragments
5 STAKEHOLDER ENGAGEMENT

ERA has a diverse and complex range of stakeholders as detailed in Section 5. (The generic term “stakeholder” is used in this MCP to cover all interested and affected external parties, including Traditional Owners and regulatory agencies. It is noted that in other contexts Traditional Owners and regulators may be differentiated from the broader stakeholder groups). These stakeholders have interests in specific areas of the closure process or outcomes and/or in the more general closure objectives and successful achievement of the planned post-mining land use. The ERA approach to stakeholder engagement is outlined in Section 5.1 and is focused on building enduring relationships based on mutual respect, active partnership, transparency and long-term commitment.

ERA representatives are in frequent, regular contact with the Gundjeihmi Aboriginal Corporation (GAC), NLC, NT Department of Primary Industry and Resources (DPIR), Commonwealth Department of Industry, Innovation and Science (DIIS) and Supervising Scientist Branch (SSB), both informally and formally through various stakeholder committees, including the Minesite Technical Committee (MTC). There are documented communications via forums including the ARRTC and ARRAC, which date back to 2001. Public communication on aspects of mine rehabilitation and closure can be traced back to the first ERA annual report in 1981.

Throughout the life of the Ranger Mine, ERA has engaged, communicated and consulted with multiple stakeholder groups through various engagement activities and range from formal, often regulatory based, processes to informal consultative processes. This stakeholder consultation aims to both provide information and to seek feedback on closure plans. These engagement forums are outlined in Section 5.1 and detailed in the Stakeholder Consultation Register (Appendix 5.1).

Section 5.2 discusses managing the socio-economic impacts of the mine closure planning process. Section 5.3 discusses the process that ERA Ranger Mine is undertaking regarding the impacts of the cessation of Ranger Mine operations.

6 POST-MINING LAND USE AND CLOSURE OBJECTIVES

The post-mining land use for the RPA (Section 6.1) is determined by the Environmental Requirements (ERs), which are conditions of the section 41 Authority issued under the Atomic Energy Act 1953 and appended to the Ranger Authorisation (as Annex A) issued under the Mining Management Act 2018 (NT) (Section 3.1.3) (Table ES-1).

<table>
<thead>
<tr>
<th>#</th>
<th>LAND USE OF THE REHABILITATED RANGER PROJECT AREA</th>
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<tbody>
<tr>
<td>1</td>
<td>The potential incorporation into the Kakadu National Park (Kakadu NP)</td>
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<tr>
<td>2</td>
<td>Cultural use of the area by the Mirarr</td>
</tr>
<tr>
<td>3</td>
<td>Recreational use of the area by the Mirarr and other community members</td>
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</table>
The pre-determined post-mining land use of the rehabilitated RPA includes the “potential incorporation into the Kakadu NP”. It should be noted that any decision on the actual incorporation of the RPA to Kakadu NP will be made by the relevant authority in consultation with Traditional Owners and may not eventuate until sometime after closure.

Consultation has indicated that the Mirarr are likely to return to the area for:

- customary harvesting of bush foods and medicine
- recreation
- land management activities, and
- cultural site visitation and ritual responsibilities.

To meet these post-mining land uses, the closure of the Ranger Mine is required to fulfil a number of closure objectives. The ERs (discussed above) provide specific regulated closure objectives, which align to the post-closure land uses (discussed in Section 6.1). These objectives were developed at the time of mining authorisation with the post-mining land use in mind, and have been reviewed with stakeholders (Section 5) throughout the project and agreed as being appropriate for the project impacts and proposed land uses.

7 SUPPORTING STUDIES

Studies and monitoring programs within the RPA have been conducted since before mining commenced. The outcomes of this substantive body of work have:

- informed the overarching closure strategy and approach
- informed the development of closure criteria (Section 8)
- informed strategies for closure implementation aligned to best environmental practice and the ERs (Section 9)
- informed identification and rank of closure risks to ensure the ongoing management of potentially high risks and an iterative approach to mine closure risk assessment (Section 10)
- informed the construction of a final landform (Section 11)
- provided baseline data against which to measure closure performance (Section 12), and
- highlighted knowledge gaps and/or alternative options to previous elements of the closure strategy.

The Key Knowledge Needs (KKNs) have been identified, by stakeholders and ERA, as the information gaps that are required to be addressed for the effective closure of the Ranger Mine. Both ERA and the SSB will implement KKN projects, either independently or cooperatively, depending upon the project. A summary of the ERA KKNs is provided in Appendix 7.1.

An overview of the ERA closure-related studies is provided in Section 7, and a summary provided below (Table ES- 2).
### Table ES-2: Summary of supporting studies

<table>
<thead>
<tr>
<th>Area of study</th>
<th>Summary of studies</th>
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| **Tailings**  | Comprehensive test work and characterisation of tailings has been undertaken on the Ranger Mine tailings, including *in situ* testing in both Pit 1 and Pit 3 since 2003. This large body of work has underpinned the development of a tailings consolidation model for Pit 1 and Pit 3. The Pit 1 model has been constantly validated throughout the backfill of Pit 1 through a series of settlement plates installed at the commencement of backfill activities and provided a high level of confidence in the model.  

The consolidation model enables the prediction of final tailings elevations and expected process water volumes in Pit 1 and Pit 3. The model output includes density, permeability, void ratio and effective stress profiles at user defined times and cumulative consolidation flows to the surface and base.  

Validation and verification of the consolidation model using monthly tailings settlement readings in Pit 1 and *in situ* test data in Pit 3 demonstrates that the model is still valid. The validated model suggests that the target 95% of process water removal from the tailings in Pit 1 and Pit 3 will occur by January 2026. A solute mass balance based on recovered volumes from the decant well and magnesium further indicate that all tailings consolidation flux will be recovered for treatment by 2026. |
| **Radiation** | In order to determine the achievement of criteria for both human health and environmental protection ERA and SSB have developed a pre-mining radiation baseline. All assessments against radiation criteria will be made based on the above-background mine-sourced radiation dose.  

A radiation dose assessment for the post closure phase is currently in progress. The dose assessment includes two phases of modelling and will consider potential radiation exposure to members of the public as well as terrestrial and aquatic biota. The radiation dose assessment is expected to be completed by the end of quarter 2, 2020. |
| **Contamination** | ERA maintains a register of potentially contaminated sites, identified on the basis of site activities including use and storage of chemicals. Targeted assessments have been undertaken at some known contaminated sites to assess the type and extent of contamination and inform remediation requirements, if necessary. ERA plans to undertake a whole of site contaminated sites assessment. The assessment will then trigger the development of remediation plans, if required, and update the contaminated site register.  

Other contamination related studies conducted to date include potential contamination in the LAAs and effective radiation does estimates (for the LAAs). These works indicate the dose contribution from the all LAAs to be very low and, with the exception of Magela A and B, are below the exemption levels. These results indicate that no remediation for radiological contamination will be required in the LAAs. Work to assess contamination from metals in the LAA is ongoing.  

Works to assess acid sulfate sediments (ASS) is currently in progress. Observed acidification events in Coonimba Billabong during the early-wet season indicates that sediments in this onsite billabong may pose a risk to the site environment post-closure. ASS can occur naturally in the Magela Creek catchment and the region. In general, activities at the Ranger Mine are thought to have influenced the formation of ASS in some areas such as the Coonimba Billabong and Retention Pond 1 (RP1) by affecting sulfide, sulfate and water balance dynamics. As part of agreed further studies, work is progressing on developing a preliminary side-wide ASS conceptual model. The outcomes of this assessment (expected in late 2019), will inform the prioritisation of targeted fieldworks to address data gaps, |
### Area of study | Summary of studies
---|---
**Water Quality** | Development of location specific ASS conceptual models and consideration of closure planning decisions for these location specific conceptual models.

**Background and operational water quality**

Surface water and sediment quality monitoring at the Ranger Mine and surrounding environment has occurred for several decades providing significant information on surface water and sediment quality within the creeks and billabongs. Several studies describe the background conditions in billabongs and creeks in the Magela Creek catchment. Surface water monitoring over 30 years indicates that at the end of the wet season, upstream of Ranger Mine, waters have elevated magnesium and EC levels which are not related to mining. Downstream of the Ranger Mine there is a general trend of relatively constant magnesium concentration and salinity.

The Supervising Scientists integrated monitoring programs have been developed over nearly 30 years and are leading practice. The 30 years of multiple lines of evidence show that during the operational phase, the mine derived constituents of potential concern (including magnesium, uranium, manganese and radium-226) have not adversely affected the abundance or diversity and quality of aquatic organisms downstream of Ranger Mine.

**Surface water**

A surface water model was developed to evaluate contaminants of potential concern (COPCs) migration downstream of the Magela Creek and Gulungul Creek confluence after mine closure. The model considered manganese, total ammonium nitrogen (TAN), magnesium and uranium.

The surface water model indicated that stream flow within Magela Creek will be sufficient to dilute the post-closure mine inputs of COPC to low background concentrations downstream of the Gulungul Creek confluence. The model indicated that there would be no exceedances of proposed criteria downstream of the Gulungul confluence.

Based on the predicted downstream solute concentrations, and the magnesium-calcium ratios, the post-closure final landform therefore does not pose a risk to the downstream environment.

ERA is in the process of repeating this work using an independently developed surface water model and a more detailed scope. Once these results are available (late 2019), multiple projects including assessments of sediment accumulation, human diet and health, ecosystem vulnerability, release water pathways and cumulative aquatic risks will be conducted to assess if water quality closure criteria/objectives will be met under the current closure strategy. This will include additional studies such as assessing the traditional diet, eutrophication risks associated with the predicted water quality, and predictions of accumulation of uranium into sediments. This will also inform decisions on what is as low as reasonably achievable (ALARA) on the RPA.

**Groundwater**

The 2016 Ranger Mine conceptual and numerical models for groundwater were updated in 2018 for use in assessment of potential impacts from post-closure conditions. The updated conceptual model describes the most important hydrogeologic elements governing groundwater flow and transport at the Ranger Mine. The calibrated groundwater flow model incorporates the major stresses applied to the Ranger groundwater flow system at Pit 1, Pit 3 and the TSF.

All available spatial and temporal data was used to build and calibrate the flow model constrains the values of the model parameters and provides confidence gained through the calibration process.

Development of the post-closure groundwater flow model consisted of modifying the calibrated groundwater flow model to represent backfill, landform conditions and the...
time scale of post-closure hydrogeologic conditions. The groundwater calibrated model will meet all indicators for a high confidence level after the planned peer review by an independent hydrogeologist with modelling experience is completed. The Ranger Mine conceptual modelling has been undertaken in part to support Key Knowledge Needs projects for groundwater and surface water. Further hydrogeological studies include updates to groundwater flow models at the local scale for groundwater and surface water interaction, closure related groundwater elevation recovery, solute modelling and uncertainty analysis. Updates to the post-closure solute transport modelling are scheduled to commence in early 2020 following a number of supporting studies. Updates to predictions of post-closure solute transport modelling will be provided to in subsequent submissions of the MCP.

**The Ranger Mine conceptual model and solute transport areas of interest/concern**

The Ranger Mine conceptual model is an important tool for understanding groundwater and surface water flow and solute migration within and out from the Ranger Mine. Conceptual models were developed for the regional scale, sitewide scale, and the scale of individual areas of interest where the COPC sources are located. The Ranger Mine conceptual model provides an evidence based framework by which ERA can measure and implement decommissioning and closure activities to meet its environmental rehabilitation obligations.

There are specific areas that are of interest/concern for COPC sources and migration within and from the Ranger Mine site, and smaller-scale conceptual models have been developed for each of these areas (Section 7.7.3):

- Pit 3
- Pit 1
- TSF
- Processing plant area
- LAAs
- Ranger 3 Deeps
- Landform waste rock.

**Pit 1 Solute Egress Modelling**

The Pit 1 solute egress model, updated in 2014, demonstrates that no detrimental impact to the surrounding environment will occur for at least 10,000 years due to tailings storage within the pit, as required under the Ranger Authorisation.

**Pit 3 Solute Transport Modelling**

Pit 3 solute transport modelling, both conceptual and numerical, was developed to assess the ability of the proposed Pit 3 backfill options to meet the ERs outlined in the Ranger Authorisation. Much of the data has been incorporated into the Ranger Mine conceptual model.

The overall objective was to quantify the amounts and rates of groundwater COPCs transported from Pit 3 to Magela Creek over a 10,000-year period for closure scenarios, with and without mitigation features. The mitigation features evaluated include a low-permeability cap at the top of the shallow waste rock backfill, a low-permeability cap over the tailings, and a cut-off wall between Pit 3 and Magela Creek.
The modelling identified that mitigation through the use of low-permeability caps was preferred over a cut-off wall. When reviewing the effectiveness of these caps in reducing solute loads to Magela Creek in the context of the overall site, the modelling predicted the caps only have a marginal impact on loads. The conceptual model demonstrates that these low-permeability caps will not be required.

Other closure related groundwater studies that have informed the Ranger Mine conceptual model include:

- magnesium loading to Magela Creek from Pit 3 tailings – post-closure
- extent and hydraulic properties of the MBL hydrolithological zone near Pit 1
- effect of tailings deposition on flow from Pit 3
- hydrological conditions after halt of pumping in the Ranger 3 Deeps decline
- predicting post-closure groundwater solute loading to creeks using uncertainty analysis
- assessment of groundwater levels and quality in Sed2B bores
- groundwater assessment in waste rock stockpiles, and
- aquatic ecosystem assessment & framework development.

The shape of the current final landform is largely determined by the requirement to maintain pre-mining drainage and catchment areas and to ensure stability in either current or the predicted climate/rainfall regime that will result from climate change. Initial landform development was based on landform design criteria developed by ERA through studies of a nearby natural analogue area.

Topography of the final landform is similar to the pre-mining landform; maximum elevation after consolidation increases from 38 m pre-mining to a final landform maximum of 44 m Australian height datum (AHD).

Slopes of the landform range in grade from approximately 2 percent to 5 percent. Analysis showed slopes vary from about 1 in 30 (3 %) to 1 in 200 (0.5 %), with the larger catchments tending to have lower slopes, although this is not always the case.

The current version of the final landform version 6 (FLv6). Each version of the landform has been subjected to landform evolution modelling by the Supervising Scientist to assess the performance of the landform. SSB uses a modified version of the CAESAR-Lisflood landform evaluation model to assess the stability of the final RPA landform over time frames ranging from decades to millennia.

The model predicts both the locations of gully formation and the broad scale erosion and deposition across the landform with long-term denudation rates being calculated. The results show most of the deposition occurs in the first 100 years with erosion ongoing throughout the model. Denudation rates decrease over time and are found to approach the published background denudation rate for the region.

Modelling of FLv6 is ongoing, to date the SSB landform model simulations for extreme wet and extreme dry rainfall scenarios over the Corridor Creek catchment predict that gullies, which could potentially expose tailings, will not form across the surface of Pit 1 within a simulated period of up to 1,000 years.
### Area of study

<table>
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<th>Summary of studies</th>
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<tbody>
<tr>
<td><strong>Ecosystem rehabilitation</strong></td>
<td><strong>Long-term flora and fauna baseline monitoring</strong></td>
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</table>

In 2011, ERA implemented a long-term fauna and flora monitoring program on the RPA and in adjacent areas of Kakadu NP (in agreement with Mirarr Traditional Owners and Kakadu NP Management). The primary objective of the program is to study the natural woodland ecosystem for the development of fit for purpose closure criteria, and to inform the development of the rehabilitation strategy. Historical flora and fauna surveys, including targeted studies, and extensive ecological research on the Ranger Mine site and surrounds, have also contributed to development of closure criteria and measurement, and rehabilitation approaches. The program development, site selection and monitoring has been undertaken in collaboration with SSB/ERISS.

Soil, vegetation and ecohydrological studies undertaken have included:

- plant responses to water stress in the wet-dry tropics
- whole-tree sap flow
- stand transpiration
- stand evapotranspiration
- canopy cover dynamics
- seed provenance
- total water requirements of the vegetation, and
- shallow groundwater table and soil water dynamics.

Flora species composition and community structure studies include:

- species selection
- species establishment via seeding vs tubestock, and
- emergent vegetative features in constructed waterbodies.

Annual monitoring of both the final landform and the analogue sites will continue to provide data to determine trends in the composition and abundance of flora and fauna, and any natural variability resulting from seasonal changes and potentially fire.

### Trial landform (TLF)

The eight hectare (ha) TLF, constructed in 2008/2009, was designed based on ERA and the Environmental Research institute of the Supervising Scientist (ERISS) studies of analogue sites and previous revegetation work conducted at the Ranger Mine. The TLF is four to seven metres above the original natural ground surface and is comprised of 800 k tonnes of primary and weathered waste rock. The design allowed for the performance testing of different types of substrates, different depths of mixed materials over the waste rock only layer, different planting methods and different irrigation regimes.

Runoff and catchment management features and monitoring systems provides water quality data to inform decision-making on future water management strategies and landform design. The monitoring includes 66 soil moisture probes, a weather station and four erosion plots.

The TLF was first planted with tubestock in 2009 and monitoring of revegetation performance and ecosystem development has been ongoing. Flora monitoring includes the growth, performance and survival of plants and vegetation communities under different conditions.
Area of study | Summary of studies
--- | ---
 | Ten years of studies have assessed aspects critical to the successful closure and revegetation of the landform, including:
 | • infiltration, runoff, soil erosion and solute loss
 | • radon exhalation
 | • plant available water
 | • revegetation trials
 | o establishment
 | o performance
 | o root distribution.

Future studies | Key studies that are either underway or planned to commence in 2019/2020 to inform the closure strategy include:
--- | ---
 | • radiation dose assessment (uranium)
 | • source characterisation: actinium
 | • dose assessment: actinium
 | • gamma and radon flux surveys Pit 1
 | • rock particle size distribution on Pit 1
 | • monitoring of Pit 1 landform shape, stability and consolidation
 | • Pit 1 monitoring of sediment discharge
 | • waste rock particle size distribution
 | • contaminated sites
 | • conceptual site water modelling, and
 | • surface water modelling and pathway risk assessments.

8 CLOSURE COMPLETION CRITERIA

A key component of closure planning for the Ranger Mine is the development of closure criteria. The closure criteria represent performance metrics which will be used to measure the achievement of the rehabilitation closure objectives. These criteria represent direct measurable and quantifiable values, or tiered assessment processes based on industry best practice frameworks. Close-out certificates will be issued by the relevant authority upon the successful fulfilment of these closure criteria.

The closure criteria have been developed to align with the requirements of the ERs and Ranger Authorisation to achieve the overarching closure objectives. Development of the criteria has involved continuous consultation with stakeholders and input by the Closure Criteria Working Group (CCWG) with the support of various studies and reports. Section 8 provides justification for criteria development; identifies measurable parameters; and provides a formal description for the individual closure criteria that have been assigned to each of the relevant closure themes. The closure criteria will be subject to further refinement, improvement and validation to ensure finalised criteria reflect acceptable standards and achieve desired outcomes.

In consultation with key stakeholders ERA developed a set of closure themes, which are: landform; radiation; water and sediment; flora and fauna; soils; and cultural (Figure 8-1,
Stage 2). These are the themes around which the closure criteria and monitoring program have been structured.

For each theme the following have been identified, against the relevant ERs:

- Objectives
- Outcomes
- Parameters
- Draft or Final criteria, and
- Corrective Action (when relevant).

Section 8 also provides justification for the outcomes, parameters and closure criteria for each of the key elements of the theme. Closure criteria are also given an identification number (ID), which is used to reference the criteria in subsequent sections of the MCP.

Section 8.8 includes an update on the status of closure criteria, providing a breakdown of the agreement status by closure theme based on the 2016 and the 2018 MCP. This section also discusses progress on additional studies to support the development of the criteria and how the criteria has been adapted to respond to the feedback from the Supervising Scientist on the MCP 2018 criteria or other stakeholder consultation work.

The Supervising Scientist has developed a series of rehabilitation standards for Ranger Mine (Section 8.8, Table 8-10). ERA has considered aspects of the rehabilitation standards when refining the closure criteria and will continue to do so as the remaining criteria are finalised.

9 BEST PRACTICABLE TECHNOLOGY

The identification and use of Best Practicable Technologies (BPTs) are a key component of the ERs (described above).

The ERs within Section 3 specify that:

12.1 All aspects of the Ranger Environmental Requirements must be implemented in accordance with BPT

12.2 Where there is … agreement … that the primary environmental objectives can be best achieved by … (an) action which is contrary to the Environmental Requirements … and which has been determined in accordance with BPT, that proposed action should be adopted

12.3 All environmental matters not covered by these Environmental Requirements must be dealt with by the application of BPT.

BPT is defined in the ERs (Annex A – 12.4) as that technology from time to time relevant to the Ranger Project Area which produces the maximum environmental benefit that can be reasonably achieved having regard to all relevant matters, with further details of the definition provided in Table 9-1. The definition of BPT in the ERs establishes a framework for assessment of currently available technology at any point during the operational and
rehabilitation phases of mine life, rather than the ERs specifying particular technologies which may become obsolete.

A summary of each closure related BPT submitted to regulators to date is provided in Section 9.2. Further BPT assessments will accompany each future closure application submitted to the MTC for assessment, as per the provisions outlined in the Ranger Authorisation. Future BPT assessments are outlined in Section 9.3.

10 RISK ASSESSMENT AND MANAGEMENT

Section 10 presents a summary of the ERA approach to closure related risk assessment and the outcomes of the most recent closure risk assessment.

The approach ERA has taken to risk assessment has been developed to identify hazards, aspects and opportunities in advance of project or activity implementation. The resulting risks and impacts to the business, people, property, assets and the environment are recorded and evaluated, and strategies are developed to manage them. The framework is consistent with recognised Australian standards and corporate management standards and practices including AS ISO 31000:2018 Risk Management – Principles and guidelines, AS/NZS ISO 14001 Environmental Management Systems and internal Rio Tinto and ERA standards and commitments.

During the Ranger Mine closure feasibility study, a series of risk assessment workshops were completed to further develop the Ranger closure risk register. These were conducted in accordance with the ERA hazard identification and risk management standard (ERA 2018) and the Rio Tinto HSEC-C-01 HSEC Risk Assessment Group Procedure.

In June 2019 the environmental risk assessment published in the 2018 MCP was updated with the outcomes of the feasibility study risk assessment and to consider the comments received from the Supervising Scientist on the 2018 MCP risk section.

Forty-seven risks were identified across the themes of project schedule (19), radiation (four), health and safety (five), environment (19), legal and regulatory compliance (20), licence to operate (27) and communities and social performance (20).

One risk, insufficient volume or quality of viable seed stock available for whole of site revegetation, was found to be class IV (critical). Identified potential causes include seasonal impacts to source seed, including fire, labour challenges, biological impacts, ineffective storage, access to seed stock and variability in seed stock quality. This risk has the potential to impact the timing of rehabilitation. Identified controls to address include seed collection scheduling, permitting, labour planning, relationship and tubestock preference. This risk is being actively managed to reduce either its consequence or likelihood.

Fourteen risks were identified as class III (high) with the majority of these related to impacts to project schedule and licence to operate. In each case, controls to mitigate the risks have been identified and these have been, or will be, implemented ahead of closure (Section 10.6). All Class III (High) risks require ongoing management.
11 CLOSURE IMPLEMENTATION

Section 11 presents a summary of closure implementation strategies and key closure activities for the Ranger Mine, and a description of the closure work programs for each key closure domain/activity.

The primary goal of closure at the Ranger Mine is to rehabilitate the disturbed areas of the RPA, establishing an environment similar to the adjacent areas of Kakadu NP. The total area of disturbance in the RPA to be rehabilitated (including Land Application Areas (LAAs)) is approximately 1190ha. The major closure rehabilitation aims are to:

- revegetate using local provenance plant species
- ensure radiation doses to members of the public are below limits and ALARA
- ensure erosion characteristics do not vary significantly from those of comparable landforms in surrounding undisturbed areas
- ensure all tailings are placed in mined-out pits by the end of operations
- ensure the tailings are physically isolated from the environment for at least 10,000 years
- ensure any contaminants arising from the tailings will not result in any detrimental environmental impacts for at least 10,000 years.

The most appropriate closure strategy for the Ranger Mine has been developed through the combination of the application of Best Practicable Technology, business requirements and the outcomes of engineering, solute modelling and consolidation modelling.

The closure strategy includes the completion of the following key activities before January 2026:

- place all tailings into mined out pits (transfer tailings in the TSF to Pit 3)
- following tailings deposition, backfill Pit1 and Pit3 with low-grade mineralised and waste rock
- eliminate the process water inventory
- manage salt and store brine in mined-out Pit 3
- demolish plant and associated infrastructure and dispose of within Pit 3
- deconstruct and rehabilitate the TSF and surrounds
- create a final landform that blends in with the surrounding environment
- revegetate disturbed areas to develop a self-sustaining ecosystem similar to the Kakadu NP, and
- demonstrate, with appropriate modelling, no detrimental impact from tailings for 10,000 years.
Table ES- 3 provides a description of the terminology used within the MCP for the phases of closure and rehabilitation activities.

Table ES- 3: Timelines of the operations and closure phases of the Ranger Mine

<table>
<thead>
<tr>
<th>Operations &amp; Closure Phase</th>
<th>Timeline</th>
<th>Closure Related Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operations</td>
<td>Period prior to 8 January 2021</td>
<td>Progressive rehabilitation occurring, and operational, closure &amp; research monitoring</td>
</tr>
<tr>
<td>Closure</td>
<td>Period between 8 January 2021 &amp; 8 January 2026</td>
<td>Decommissioning, completion of rehabilitation &amp; transition of monitoring requirements</td>
</tr>
<tr>
<td>Post-closure</td>
<td>Period after 8 January 2026</td>
<td>Completion criteria monitoring (and maintenance rehabilitation works if required) [note – access to site still under negotiation]</td>
</tr>
<tr>
<td>Relinquishment</td>
<td>Issue of close out-certificate (s)</td>
<td>May occur for entire RPA at single point in time or for separate areas at differing times.</td>
</tr>
</tbody>
</table>

The proposed closure strategy is subject to ongoing review based on the outcomes of closure studies and assessment of implementation activities to ensure feasibility and a best practice approach.

The closure domains and corresponding disturbance areas determined for the Ranger Mine are provided within Table ES- 4(Figure ES- 2).

A schedule for all activities that will be occurring in the next 2 years is provided in Table ES- 5. The schedule is indicative, and subject to ongoing revision to reflect the status of closure activities. The Ranger Mine closure strategy includes contingency options should the preferred option later prove undesirable. These contingencies options have generally been identified during best practical technology assessments (Section 9).

ERA is committed to completing rehabilitation and the achievement of the environmental requirements. The current closure strategy and schedule indicates that this can be completed by the closure date of January 2026.
Table ES-4: Land Disturbance Domains

<table>
<thead>
<tr>
<th>Reference No.</th>
<th>Domain</th>
<th>Areas (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Pit 1</td>
<td>41.40</td>
</tr>
<tr>
<td>2</td>
<td>Pit 3</td>
<td>107.12</td>
</tr>
<tr>
<td>3</td>
<td>TSF</td>
<td>185.18</td>
</tr>
<tr>
<td>4</td>
<td>Land Application Areas</td>
<td>324.65</td>
</tr>
<tr>
<td>5</td>
<td>Processing Plant, administration buildings and water treatment plant</td>
<td>39.86</td>
</tr>
<tr>
<td>6</td>
<td>Stockpiles</td>
<td>268.65</td>
</tr>
<tr>
<td>7</td>
<td>Water management areas</td>
<td>125.61</td>
</tr>
<tr>
<td>8</td>
<td>Linear infrastructure</td>
<td>40.79</td>
</tr>
<tr>
<td>9</td>
<td>Miscellaneous</td>
<td>55.02</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>1188.28</strong></td>
</tr>
</tbody>
</table>

The mining area (pits, TSF, processing plant and stockpile areas) will comprise the ‘final landform’. All site disturbance will be addressed through closure works, with implemented topography and vegetation strategies aimed to achieve rehabilitation that is similar to the surrounding landscape, 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.

Table ES-6 presents a summary of the closure implementation work programs presented in Section 11.
Figure ES-2: Ranger Mine closure domain map
### Table ES-5: Closure schedule

<table>
<thead>
<tr>
<th>Aspect/Activity</th>
<th>Task</th>
<th>Stage</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit 1 closure</td>
<td>Installation of prefabricated vertical drains (wicks) within previously transferred tailings.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Installation of geotextile and preload activities commence. Finished January 2016.</td>
<td>Complete</td>
<td></td>
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<tr>
<td></td>
<td>Pit 1 bulk backfill, completion due by Jan 2020.</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td></td>
<td>Revegetation activity commences on the perimeter of the Pit 1 landform.</td>
<td>Scheduled</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Final landform shaping and revegetation.</td>
<td>Scheduled</td>
<td></td>
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<tr>
<td></td>
<td>Open cut mining ceases in November 2012.</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Initial backfill of Pit 3 with waste rock completed to form underfill.</td>
<td>Complete</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Underfill drainage layer and extraction pumping system installed.</td>
<td>Complete</td>
<td></td>
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<tr>
<td></td>
<td>Processing plant to Pit 3 tailings delivery piping and infrastructure installed.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Processing plant tailings and Dredged tailings from tailings dam delivered to Pit 3. Completion 2020.</td>
<td>Ongoing</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Installation of prefabricated vertical drains (wicks) within pit.</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Installation geofabric and initial preload over pit.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Bulk backfilling of Pit 3 and placement of waste material including deconstructed mill and other infrastructure.</td>
<td>Complete</td>
<td></td>
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<tr>
<td></td>
<td>Backfilling of Pit 3 completed, surface contoured to final landform shape, and revegetation commences.</td>
<td>Scheduled</td>
<td></td>
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<tr>
<td>Tailings</td>
<td>Construction of dregde to deliver tailings from the tailings dam to Pit 3 and installation of tailings transfer piping and infrastructure.</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>management</td>
<td>Commission the tailings dam dregde and tailings transfer infrastructure.</td>
<td>Complete</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Dredging increased to full operational capacity, completion scheduled for 2020.</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Decommissioning of dregde, tailings transfer infrastructure and removal of remnant tailings/contaminated material from TSF.</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Tailings dam converted to process water storage.</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Process water storage in the tailings dam ends, and decommissioning commences.</td>
<td>Scheduled</td>
<td></td>
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<tr>
<td></td>
<td>Removal of tailings dam walls complete. Final landform contouring complete and revegetation.</td>
<td>Scheduled</td>
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<tr>
<td>Brine</td>
<td>Brine injection bores installed into Pit 3 underfill.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td>management</td>
<td>Brine injection system - piping and infrastructure installed and commissioned.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Brines from the brine concentrator are injected into Pit 3 underfill (ongoing until 2025).</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td></td>
<td>Additional brine injection wells installed into Pt 3 underfill if required.</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Brine injection infrastructure is decommissioned.</td>
<td>Scheduled</td>
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<tr>
<td>Contaminated</td>
<td>Assessment of radiation contamination in LAA soils indicates doses are below exemption level.</td>
<td>Complete</td>
<td></td>
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<tr>
<td>sites management</td>
<td>Determine need for remediation and/or revegetation strategy for contaminated sites (including LAAs and processing plant area).</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Staged removal of infrastructure in LAAs and remediation and/or infill revegetation of LAA areas as required (ongoing to 2025).</td>
<td>Scheduled</td>
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<tr>
<td>Processing</td>
<td>Ongoing processing plant operations until end 2020.</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>plant closure</td>
<td>Commence decommissioning of the processing plant infrastructure and stockpile for later disposal in Pt 3.</td>
<td>Scheduled</td>
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<tr>
<td>Water</td>
<td>RPB constructed and commissioned.</td>
<td>Complete</td>
<td></td>
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<tr>
<td>storage</td>
<td>RPB converted to process water storage if required.</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>RPB decommissioned.</td>
<td>Scheduled</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Water</td>
<td>Pond water treatment MF/RO continues. Clean water discharged to wetland filter/RP1 (ongoing until 2025).</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>treatment</td>
<td>Brine concentrator constructed and commissioned in September 2013.</td>
<td>Complete</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Clean water discharge from the brine concentrator to wetland filter/RP1. Brines are recirculated to the process water inventory.</td>
<td>Complete</td>
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<tr>
<td></td>
<td>Recirculation of brines from brine concentrator to process water inventory ceases; brine injection commences.</td>
<td>Complete</td>
<td></td>
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<tr>
<td></td>
<td>Brine concentrator capacity increased. Additional process water treatment capacity installed</td>
<td>Scheduled</td>
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<tr>
<td></td>
<td>Decommission &amp; demolition of brine concentrator, water treatment plants and other water treatment infrastructure.</td>
<td>Scheduled</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>All of site</td>
<td>Cessation of closure activities.</td>
<td>Scheduled</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Table ES- 6: Closure implementation work program summaries

<table>
<thead>
<tr>
<th>Area</th>
<th>Summary of closure implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit 1</td>
<td>ERA commenced deposition of neutralised tailings into Pit 1 in 1996 following an application to the MTC, approved by the NT Minister in 1995. Following the installation of pre-fabricated vertical drains (wicks) to promote consolidation in 2012, Pit 1 backfill activities commenced. Placement of waste rock to cap the tailings continues with the final landform contouring and ripping scheduled to be completed by mid-2020. Revegetation activities will commence, with initial planting to occur during the 2020/2021 wet season. Water is removed from Pit 1 via the decant wells. The consolidation model currently predicts that consolidation will be 100% complete by April 2021.</td>
</tr>
<tr>
<td>Pit 3</td>
<td>Open-cut mining in Pit 3 commenced in July 1997 and ended in November 2012. Tailings deposition into Pit 3 commenced in 2015 and is estimated to end by December 2020, this will be followed by activities to facilitate tailings consolidation, as in Pit 1. Tailings deposition methods have been trialled and modified to improve consolidation and increase likelihood of achieving the target closure date. Levels are managed so as to maintain the pit as a hydraulic sink and prevent outflows of solutes to groundwater. Decant wells will be installed during backfill options for tailings dewatering/consolidation. Prior to placement of tailings in Pit 3, 33Mt of waste rock was backfilled into the base of the pit to provide a flat surface for tailings deposition. This waste rock underfill was also designed to be a reservoir for long term brine disposal. Brine is produced during process water treatment in the Brine Concentrator. Brine injection well are installed to allow for placement of the brine into Pit 3 underfill. Brine injection is expected to commence early 2020 and is scheduled to occur until 2025. Should brine injection cease to be a viable option, an alternative such as solidification will need to be progressed. Following completion of backfilling, surface contouring to final landform shape, and revegetation of Pit 3 is planned for 2025.</td>
</tr>
<tr>
<td>TSF</td>
<td>To enable ERA to complete closure as planned, the TSF dredged tailings transfer to Pit 3 started in 2015 and will continue through 2020. After completion of tailings reclamation and transfer, the TSF will be cleaned of all visible tailings, infrastructure and foreign objects prior to use as a process water storage. On completion of process water storage, the TSF will be deconstructed. The TSF will serve as an important storage facility for water, during Pit 3 closure works and then for disposed infrastructure (dredges) following appropriate decontamination and decommissioning processes. During closure, the TSF will act as a catchment to prevent the outflow of impacted rain water. The TSF will then be deconstructed and converted to a release catchment. Final landform contouring and revegetation for the TSF site is planned for 2025.</td>
</tr>
<tr>
<td>Water management</td>
<td>Process water, contained within the Tailings Storage Facility (TSF), is fed to the Brine Concentrator (BC) plant for treatment via induced thermal evaporation. Distillate from the BC is released to the wetland filter system and brine is injected into the Pit 3 for disposal or recirculated to the TSF as required. A High Density Sludge (HDS) plant is available to support the BC and treat additional process water using a two-step process involving the application of lime and soda ash to promote precipitation. HDS permeate is suitable for further treatment within the pond water circuit and sludge disposal within Pit 3. Pond water is currently treated with a series of pond water treatment plants (WTPs), which involve ultrafiltration and reverse osmosis. Pond water treatment plant permeate is distributed to either the wetland systems or to retention pond storage (RP1) for release onto the Land Application Areas (LAAs). Pond water treatment brine is fed to the Brine Squeezer (BS) for further treatment (reverse osmosis) with waste brine being directed to the TSF and permeate being</td>
</tr>
<tr>
<td>Area</td>
<td>Summary of closure implementation</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>released to the wetland systems. Modifications to the current water treatment system are being considered to increase the treatment capacity and capability in order to minimise the site water inventory post-closure.</td>
<td>The water inventories relevant to closure are those associated with pond water and process water. To enable the successful closure of the Ranger Mine, both the pond and process water inventory on site must reduce to a zero balance, in time to allow for deconstruction of the water storage facilities prior to the closure of the RPA.</td>
</tr>
<tr>
<td>The process water inventory is actively tracked, and additional water treatment facilities may need to be installed if expected water treatment and inventory targets are not met. The capacity of existing site infrastructure for treating process water is critical to meeting closure target dates and is being reviewed for suitability as closure processes and material volumes become clearer. Rainfall is a variable with the potential to impact closure water management and schedules. Should a number of higher than predicted wet seasons occur, in particular late in the closure project, additional water treatment capacity may be required in order to meet the final closure date in January 2026.</td>
<td>Throughout closure, site water flows and facilities will be required for use and need to be managed. However, by January 2026 all water management areas will need to have been rehabilitated and require no active management. These areas include pond water storage, release water storage, wetland filters, water management sumps, land application areas and onsite billabongs that receive release discharge water. The exact timing and methods for rehabilitation of the various water management areas will depend largely on rainfall and the need for their continued use. Currently it is assumed within the closure schedule that all are to undergo rehabilitation toward the end of the closure period, commencing from 2023.</td>
</tr>
</tbody>
</table>

**Plant and administration buildings**

A decommissioning sequence has been determined for the areas of the plant, based on the interaction of the plant decommissioning with other activities in the overall RPA closure project. Decontamination of assets in the demolition area will be undertaken to allow safe and efficient demolition and disposal.

Plant, equipment, buildings and other structures will be removed unless approval of the Traditional Owners and Commonwealth Minister is given for infrastructure to remain on the RPA. Demolished materials will need to be disposed of onsite at 8 m level deep below final landform if disposed amidst waste rock.

The ERISS offices, Jabiru Airport and external services (Telstra) facilities are excluded from the Ranger Mine Closure Plan, but discussions on each are currently underway.

**Ranger 3 Deeps exploration decline**

The proposed R3D underground mine project was not progressed and the decline was in care and maintenance since June 2015. ERA has now commenced transition to final closure. The ventilation shaft, portal and decline will be decommissioned in a staged closure approach with consideration given to geological and hydrological conditions. The first stages of closure of the decline commenced in 2019 with the removal of all infrastructure, the plugging of the base of the vent shaft and the flooding of the underground workings. Final decommissioning is planned for 2021.

**Stockpiles**

The bulk material movement of all waste rock to final destination and the construction of the final landform has been considered within the Ranger Mine closure feasibility study. A dynamic mine model, including haulage simulations, has been created to assist in producing the closure strategy. This confirmed a complex sequence of material movements to ensure all mineralised material ended up in the right part of Pit 3 and that access is not constrained.

In 2008 an extensive stockpile block model was developed. The block model has been maintained, tracking locations of sources and destinations of materials since...
**Area** | **Summary of closure implementation**
---|---
| that time. Mineralised material stockpiled for processing will be processed prior to commencement of closure. All mineralised material not processed at the completion of milling in January 2021 will be placed well below final landform surfaces. Low 1s (non-mineralised material) has been scheduled to be used for final landform surface.
| Other areas | Other areas subject to closure implementation and addressed in this MCP include:
| |  - waste material management  
| |  - linear infrastructure  
| |  - non-plant buildings  
| |  - nursery and core-yard.
| Contaminated sites | Soil remediation across the RPA will occur prior to decommissioning and will be based on the *Plume and Contaminated Site Management Plan CDM.03-0000-EG-REP-00024* (Appendix 12-2), developed during the feasibility study, and the Ranger Mine contaminated site register and identified sites where contamination could occur as a result of the storage of inorganic and organic chemicals, and solute migration from mine-related activities.
| | Works have been undertaken to identify and risk rank potential contaminated sites, as outlined in Section 7. Remediation strategies have been broadly developed, including identification of further works to further define requirements.
| | Remediation activities will be considered in relation to other closure activities for efficiencies and to avoid double handling of potentially contaminated sites. A schedule of rehabilitation of contaminated sites will be prepared at a later date based on the outcomes of ongoing work and further refinement of the closure schedule.
| Final landform | A number of landform studies have been undertaken to address key closure issues and risks to inform the design parameters of the final landform. to validate design attributes such as landform stability, erosion, topography and visual amenity; and inform the current landform model predictions (Sections 7.5). The outcomes of these studies have resulted in a final landform topography that incorporates low elevation and slopes to enhance landform stability and visual aesthetics to blend with the surrounding landscape.
| | The digital model of the final landform continues to be updated on the basis of closure activities and outcomes of studies. The final landform design (Figure 11-68) continues to mirror the original topography as much as possible. The model addresses:
| |  - total material available for closure works  
| |  - flood modelling for erosion  
| |  - control of infiltration  
| |  - control of sediment movement, and  
| |  - outcomes from land evolution modelling conducted by the SSB.
| | The surface layer to form the final landform will be constructed as 1s waste rock (non-mineralised) to ensure that radiation doses from the final landform are as low as reasonably achievable (ALARA) and to facilitate successful rehabilitation.
| | To achieve the revegetation objectives, plant available water, depth and heterogeneity of the waste rock surface layer, material chemical characteristics, and surface treatments to optimise nutrient cycling have been considered when developing the design and construction of the surface layer. The studies outlined in Section 7 have informed the process.
| | The final landform construction of Pit 1 has commenced and is scheduled for completion mid-2020. The remainder of the final landform construction will not be
Area Summary of closure implementation

**Revegetation strategy**

commence until March 2023 and will be ongoing to enable areas to be released progressively for revegetation. This will enable revegetation works to be completed by the completion of closure milestone (8 January 2026).

There is approximately 1190 ha of land to rehabilitate and revegetate for the successful closure of Ranger Mine, including 759 ha of waste rock covered area. Revegetation will be guided by the ERA revegetation strategy (Appendix 11.4) that was developed utilising knowledge from over 30 years of revegetation trials, analogue vegetation studies and particularly the findings from the trial landform (Sections 7.3 and 7.6). Ongoing monitoring of the trial landform will continue to inform the final approach to revegetation of the RPA.

A key consideration of the closure strategy was to provide progressive handover of final landforms to facilitate achievable revegetation production rates for contractors. A maximum rate of 1.5 ha/day revegetation day was set as a target, with the schedule commencing in April 2023.

### 12 CLOSURE MONITORING AND MAINTENANCE

The monitoring section describes the monitoring programs developed for the Ranger Mine to assess performance against the closure criteria (Section 8) and to address the requirements of the Ranger Authorisation.

Some aspects of post-closure monitoring require finalisation of the closure criteria to develop further. This adaptive management approach is designed to remove uncertainty from the monitoring program and undertake the monitoring needed to determine progress towards achieving the closure objectives.

The monitoring programs outlined in Section 12 align with the six closure themes, within each closure theme is a description of the proposed monitoring as it will occur during the closure and post-closure phases. The closure monitoring programs proposed build upon the existing, extensive monitoring regimes established during mining operations at the Ranger Mine. The closure monitoring program is required to assess rehabilitation success, including determination of the protection of potentially impacted ecosystems and environmental values.

The focus of landform monitoring and maintenance program will be erosion control, and design of the program will utilise information derived from the TLF studies. Surface water monitoring in the post-closure period is required to assess rehabilitation success including identifying any unexpected events or COPC concentrations (compared to model predicted results), and assessing the protection of ecosystems, human health and environmental values by comparison of water quality against closure criteria (when agreed).

The aims of the post-closure surface water monitoring program can be described as:

- assess whether closure criteria are met, or if water quality is transitioning toward meeting criteria
- provide assurance that the environment is being protected, and
- validate and assess confidence in, the solute transport predictive models.
The proposed surface water monitoring program details include the location, parameters, relevant closure criteria and frequency of sampling, which are summarised in Table 12-4 and is applicable to both the closure and post-closure phases. Monitoring during the closure phase will identify the potential opportunity to decrease the monitoring scope during post-closure.

The primary objective of the closure groundwater monitoring program will be to confirm that measured time series changes to water quality are consistent with the hydrogeological model predictions and the regional groundwater environment remains protected. Monitoring 'envelopes' in the four sub-catchments; Gulungul, Coonjimba, Djalkmara and Corridor creeks, will be progressively refined during decommissioning. The 'envelopes' will comprise new and/or existing monitoring bores.

The proposed groundwater monitoring will comprise monthly measurements of standing water level and quarterly sampling and chemical analysis (Table 12-8). The aim of post-closure groundwater monitoring is to demonstrate that solute transport velocities and concentrations are consistent with modelling predictions and that the receiving environment will remain protected from defined COPCs. A representative sample of bores will remain for the groundwater monitoring program post-closure. As the post-closure groundwater environment stabilises, it is proposed that monitoring frequency requirements will decrease over time if no risks are identified.

Radiation monitoring, undertaken for the purposes of assessment of closure criteria, will be limited during the closure phase. The proposed post-closure monitoring (Table 12-9) for radiological performance has been structured around the exposure pathways for radiation due to the potential access to and final land use of the area. These pathways are:

- inhalation of Long Lived Alpha Activity (e.g. radioactive dust)
- inhalation of radon progeny (Potential Alpha Energy Concentration)
- ingestion of radioactive material in (or with) food or water, and
- external irradiation from gamma rays (and beta particles).

Given the possible post-closure uses of the landform, the critical group will be Traditional Owners using the site for traditional activities including transient camping and the gathering of traditional bush foods for consumption. Further detail will be provided in future MCPs following the outcomes of the Monitoring Evaluation and Research Review Group.

Soil remediation at contaminated sites within the RPA will be monitored to confirm successful achievement of closure criteria.

Flora and fauna monitoring and maintenance for post-closure will begin following initial planting. The majority of the infill planting and understorey planting activities will occur during this phase. The flora and fauna monitoring will utilise the information provided by the monitoring of established reference sites and will comprise vegetation plots and fauna-trapping transects to address terrestrial flora and fauna closure criteria. The flora and fauna monitoring program presented in Table 12-10 details the routine tasks anticipated for the overall revegetation program.
The flora and fauna monitoring program to be implemented will be developed to capture relevant information as the revegetation progresses. For example, the early fauna monitoring (e.g. years one to three), is likely to focus on incidental observations of vertebrates and invertebrates. As the vegetation establishes, there will be an increase in monitoring to include trapping and systematic observation-based surveys to determine the presence of major functional groups. In the initial stages of revegetation (e.g. years one to five), the flora monitoring will focus on species survival rates, which will inform remediation works. As saplings develop, a more comprehensive suite of parameters addressing ecosystem development and closure criteria will be introduced.

Alongside the development of the cultural closure criteria (Section 8.7), consultant linguist Murray Garde proposed a number of indicators that could be used to reflect the Traditional Owner attitudes towards rehabilitation progress and by extension the satisfaction of the cultural closure criteria during the closure and post-closure phases (Table 12-11). A number of these indicators are largely based on visual and aesthetic values, as viewed through the lens of Mirarr culture. These indicators represent the overall cultural health of the ecosystem, which needs to be assessed by Mirarr Traditional Owners.

The GAC and the NLC have provided feedback that the MCP is to include a compliance and monitoring process for meeting the cultural closure criteria and that they would propose a process for ERA consideration that included direct involvement of Traditional Owners with technical support. The GAC and the NLC have been working with Traditional Owners and Murray Garde to build on previous work completed. Once GAC and NLC have finalised the proposed process, it will be reviewed by ERA and incorporated into future revisions of the MCP.

13 FINANCIAL PROVISION FOR CLOSURE

The ERA rehabilitation provision as at 30 June 2019 was $799 million. The calculation of the rehabilitation provision relies on estimates of costs and their timing to rehabilitate and restore disturbed land to original condition.

The costs are estimated on the basis of this MCP and the closure model, taking into account considerations of the technical closure options available to meet the obligations of ERA. The provision for rehabilitation represents the net present cost at 30 June 2019 of the preferred plan within the requirements of the Ranger Authority.

The closure model is based on the closure feasibility study, completed in February 2019, which expanded on the previous prefeasibility study (PFS) completed in 2011. Key packages of work completed since 2012 include preliminary Pit 3 backfill, Pit 1 capping and design, construction

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4 Infill planting requirements will be informed by frequent site inspections over the course of the first 1 – 2 years until vegetation establishment.

5 The 30 June 2019 provision discounted at 2 per cent and presented in real terms ($857 million undiscounted in real terms).
and commissioning of the tailings dredging system. The feasibility study has increased the level of certainty regarding forecast rehabilitation expenditure.

Major activities for the execution of the rehabilitation plan include: material movements, water treatment, tailings transfer, demolition and revegetation. Major cost sensitivities include material movements, water treatment and tailings transfer costs.

The ultimate cost of rehabilitation is uncertain and can vary in response to many factors such as technological change, weather events and market conditions. It is reasonably possible that outcomes from within the next financial year that are different from the current cost estimate could require material adjustment to the rehabilitation provision for the RPA. Selected downside sensitivities on the Ranger rehabilitation provision are detailed in Section 13.1.

Separate to this MCP, each year ERA prepares and submits an Annual Plan of Rehabilitation (APR) to the responsible Commonwealth Minister for assessment and approval in accordance with the Ranger Uranium Project Agreement between ERA and the Commonwealth Government (Government Agreement). The specific purpose of the APR is to determine the securities amount to be held by the Commonwealth Government for rehabilitation obligations; these funds are held in the Ranger Rehabilitation Trust Fund. Once the APR is accepted by the Commonwealth Government, the APR is independently assessed and costed and the amount to be provided by ERA into the Ranger Rehabilitation Trust Fund is determined.

14 MANAGEMENT OF INFORMATION AND DATA

This section provides an overview of the information management systems used by ERA to manage closure related data.

To support closure activities and provide confidence in the strategy, ERA has identified three key components for closure knowledge to be retained:

- validation of site conceptual/numerical models
- landform design and construction, and
- progressive rehabilitation.

The retention and management of this information is important to demonstrate the appropriateness of and adherence to the closure strategy, drive change where required and provide a history with which to inform any future issues.

Table 14-11 is indicative of the types of data collection at ERA, and the internal/external departments and groups responsible for the maintenance and reporting of this data. New/expanded data sets will continue to inform and/or validate the various conceptual and numerical models on which the closure strategy and design criteria are developed, as well as other aspects of the overall design and construction of the final landform. ERA maintains these datasets within its various document management systems.