Energy Resources of Australia Ltd

2. Project overview

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GLOSSARY

Below are key terms that are used in this section.

Key term	Definition
Annual Plan of Rehabilitation	High level plan used to determine the securities amount to be held by the Commonwealth Government for Ranger Mine rehabilitation obligations.
Environmental Requirements	The Ranger Environmental Requirements are attached to the s.41 Authority and set out Primary and Secondary Environmental Objectives, which establish the principles by which the Ranger operation is to be conducted, closed and rehabilitated and the standards that are to be achieved.
Ranger Mine water management technology	Refer Appendix 2.1 for the definitions for common terms used in water management.
Reference Level	Reference Level abbreviated to RL. Denotes a specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the TSF or depth of Pit 3
Release Plan Calculator	Basic mass balance equation model used to assist with the prediction of changes in water quality between upstream (MCUS) and downstream (MG009) monitoring points. The RPC is used to determine when it is appropriate to actively release water from the minesite
WA mine closure guidelines	Guidance documentation provided by the Western Australia Department of Mines, Industry Regulation and Safety for the development of mine closure plans.
Water Management System	The infrastructure, operations and procedures required to manage water at Ranger which includes capturing, storing, transferring, treating and disposing volumes of water.

ABBREVIATIONS & ACRONYMS

Below are abbreviations and acronyms that are used in this section.

Abbreviation/ Acronym	Description
ARRAC	Alligator Rivers Region Advisory Committee
ARRTC	Alligator Rivers Region Technical Committee
BC	Brine Concentrator
CCWLF	Corridor Creek Wetland Filter
EIS	Environmental Impact Statement
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPIP Act	*Environmental Protection (Impact of Proposal) Act 1974*
ER	Environmental Requirements
ERA	Energy Resources of Australia Ltd
HDS	High Density Sludge

Abbreviation/ Acronym	Description
LAA	Land Application Area
MTC	Minesite Technical Committee
NLC	Northern Land Council
NT	Northern Territory
NP	National Park
OBS	Osmoflow Brine Squeezer
R3D	Ranger 3 Deeps
RL	Reference Level
RP1	Retention Pond 1 - also denotes other retention ponds used on site – e.g. RP2, RP3, RP6
RPA	Ranger Project Area
RPC	Release Plan Calculator
SSB	Supervising Scientist Branch
TSF	Tailings Storage Facility
WTP	Water Treatment Plant

2 PROJECT OVERVIEW

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

2.1 History

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. Further drilling confirmed the feasibility of mining two ore bodies, 'Ranger 1' and 'Ranger 3'. In June 1971, Peko and EZ established Ranger Uranium Mines Pty Ltd to manage and develop the deposits.

The grant of a mining lease to allow development of the project was deferred whilst the new Commonwealth Government, elected in December 1972, defined and implemented a policy of public ownership of certain energy resources, including uranium. To comply with the energy resources policy of the Government, Peko, EZ and the Australian Atomic Energy Commission (AAEC), as an agent for the Government, signed the ‘Lodge Agreement’ in October 1975. Under this agreement: (i) the AAEC retained ownership of the uranium and financed 72.5 percent of the project; (ii) Peko and EZ were to fund the balance in equal shares; and (iii) the AAEC would sell the uranium for the Commonwealth Government, with Peko and EZ entitled to share in 50 percent of the net sales proceeds.

A new Commonwealth Government announced approval of the project under the 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. The Commonwealth Government made the decision to approve the project following the recommendations of the First and Second Reports of the Ranger Uranium Environmental Inquiry, which had been established under the *EPIP Act* (termed 'the Fox Inquiry') into the potential impacts of uranium mining in the Alligator Rivers Region (Fox *et al.* 1976, Hart & Jones 1984a).

At the same time, 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).[2] In 1978, title to the Ranger Project Area (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

[2] The functions of these committees and research bodies are described further in Section 4.

Commonwealth Government entered an agreement with the Northern Land Council (NLC) to permit mining to proceed.

Construction of the Ranger Mine began in January 1979 and the mine came into full production in October 1981. During the early stages of construction, the Commonwealth Government announced its intention to divest its interest in the project. Peko subsequently established a new company, Energy Resources of Australia Ltd (ERA), to purchase the existing partners' interests.

Mining of the Ranger 1 orebody (Pit 1) was completed in December 1994 and development of the adjacent Ranger 3 orebody (Pit 3) commenced in 1996. Mining in this pit continued through to the end of 2012, after which time ERA has been producing uranium from stockpiled ore.

Uranium product from the Ranger mine is sold to power utilities in Asia, Europe and North America under strict international and Australian Government safeguards[3].

In 2008, ERA announced a significant mineral exploration target, 'Ranger 3 Deeps', of 15 to 20 million tonnes with a potential for 30,000 to 40,000 tonnes of uranium oxide. In 2011, ERA approved the construction of an exploration decline to conduct close spaced underground exploration drilling of Ranger 3 Deeps and works began on constructing the exploration decline in May 2012. On 16 January 2013, ERA submitted a referral and notice of intent under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) and *Northern Territory Environmental Assessment Act*, for the Ranger 3 Deeps underground mine (EPBC 2013/6722). Although an Environmental Impact Study (EIS) was lodged for the proposed mine in 2014 (ERA 2014b), in 2015 ERA announced that the Ranger 3 Deeps Project would not proceed to final feasibility study due to a depressed uranium market and project economics.

2.1.1 Ranger Mine EIS assessment

In February 1974, an EIS was submitted for the Ranger Mine under the repealed *EPIP Act*. Supplements 1 and 2 to the EIS were submitted in May 1975. As outlined above, in August 1977 a new Commonwealth Government announced approval of the project, following the assessment of the proposal via the Ranger Uranium Environmental Inquiry, or Fox Inquiry (Fox *et al.* 1976, 1977).

The draft EIS and supplements described all components of the proposed Ranger Mine, including but not limited to:

- geographic location of the proposed Ranger Mine, uranium ore deposits and estimated U_3O_8 content
- conformance with standard open cut mining practices proposed for ore extraction
- intended milling and processing method

[3] The Nuclear Non-Proliferation Treaty, the Convention on the Physical Protection of Nuclear Material and Australia's other various bilateral cooperation agreements.

- water treatment and management, including descriptions of, for example, Retention Ponds 1 & 2 and water release strategies during operations
- the proposed tailings dam, known as the Tailings Storage Facility (TSF), construction and operation, including future wall lifts, intended to ensure there was always an adequate height of embankment above the water surface in the TSF
- management of potential radiation, air and water pollutants, and
- proposed rehabilitation and the continuing protection of the surrounding region.

The proposed Ranger Mine, as defined in the draft EIS, was fully assessed as part of the Fox Inquiry. The Fox Inquiry made several recommendations including conditions specific to rehabilitation and closure. Further detail is presented in Section 3.

2.2 Overview of operations

Sections 2.2.1 to 2.2.8 provide an overview of the components of the mining and processing operations at the Ranger Mine (Figure 2-1), including the associated key activities and infrastructure. Section 2.2.9 summarises the site wide water management system. Discussion on the closure of Jabiru East area is not included within the Mine Closure Plan.

Conventional open cut mining of uranium ore ceased in November 2012. The processing of stockpiled ore continues 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 are shown in Figure 2-1 and Figure 2-2 and include:

- processing plant area, including a power station (which also provides power to the town of Jabiru), administration and maintenance facilities
- one tailings dam (referred to as the TSF)
- two mined-out pits – Pit 1 and Pit 3
- ore and waste rock stockpiles
- several water retention ponds, water storage structures and constructed wetland filters
- water treatment plants
- irrigation areas for the disposal of managed release water
- an access road and service tracks
- Ranger 3 Deeps exploration decline with associated vent shaft and portal, and
- Jabiru Airport, Jabiru East and associated infrastructure.

These components are described in the following sections.

Site layout for the Ranger Mine	
Authored: G Landwehr	Date: 24/02/2020
Prepared by: C Newland	Print Size: A3
Map Name: Ranger Mine Site Layout .mxd	
Spatial Data: "A5988_Ranger_50mm_RGB_MGA94z53_14-May-2019.ecw", ERA "Ranger_Mine_Features_V2.shp"	

Ranger Mine

0 500 1,000 1,500 2,000
Metres
GDA 1994 MGA Zone 53
Scale 1:20,000

Figure 2-1: Ranger Mine site (aerial 2019)

Ranger Mine	Site layout for the processing plant at the Ranger Mine				0 100 200 300 400 Metres GDA 1994 MGA Zone 53 Scale 1:3,500
	Authored: G Landwehr	Prepared by: C Newland	Date: 24/02/2020	Print Size: A3	
	Map Name: Ranger Mine Site Layout Processing Area.mxd				
	Spatial Data: "A5988_Ranger_50mm_RGB_MGA94z53_14-May-2019.ecw", ERA "Ranger_Mine_Features_V2.shp"				

Figure 2-2: Ranger Mine plant layout

Site Layout

01, Car Park	40, HDS Plant
02, Security	41, Brine Squeezer
03, Bulk Fuel	42, Lime Mill & Silos
04, Shellsol	43, Mine Wash Down
05, Simon Carves Yard	44, Retention Pond 2
06, Water Management Yard	45, Retention Pond 3
07, Ammonia Handling	46, Mines Office
08, Emergency Dump Tank	47, Old Orica Yard
09, Calciner & Product Packing	48, Trial Evaporation Channels
10, Solvent Extraction	49, Pit 1
11, Sand Filters	50, Georgetown Creek Medium Bund Level - GCMBL
12, Administration	51, Corridor Creek Land Application Area
13, Water Management & Environmental Services	52, Retention Pond 5
14, Engineering & Supply	53, Corridor Creek Wetland Filter
15, Ranger 3 Deeps Portal	54, Tailings Dam
16, Decline Laydown Area	55, Retention Pond 6
17, Ranger Closure Office	56, Trial Landform
18, Sub Station	57, Magazine
19, Demineralisation Plant	58, Retention Pond 1 Land Application Area
20, Power Station	59, Retention Pond 1
21, Plant Services	60, Retention Pond 1 Wetland Filter
22, Grinding	61, Retention Pond 1 Land Area Extension
23, Counter-Current Decantation	62, Accommodation Camp
24, Tailings Neutralisation & Process Water Header Tank	63, Workshop - Gagadju
25, Corridor Road	64, Jabiru East Land Application Area
26A, A - WTP 1	65, Office of the Supervising Scientist
26B, B - WTP 2	66, Telstra
27, Septic Transpiration Area	67, Airport
28, Acid Leach	68, Exploration Storage Yard
29, Laterite Treatment Plant	69, Jabiru East Potable Water Supply
30, Coarse Ore Stockpile	70, Exploration Core Yard
31, Fine Crushing	71, Djalkmarra Land Application Area
32, Secondary Crushing	72, Djalkmarra Land Application Area Extension
33, BC Power Station & Control Room	73, Pit 3
34, Acid Storage	74, Levee
35, Brine Concentrator	75, Magela Land Application Area
36, Water Treatment Plant 3	76, Borrow Pit
37, Radiometric Sorting	77, Djalkmarra Pumping Sump 12 - DJKPS12
38, Primary Crushing	78, Exploration decline vent shaft
39, Pond Water Tank	79, ROM

Ranger Mine	**Index for Site Layout Figures - Ranger Mine**			
	Authored: G Landwehr	Prepared by: C Newland	Date: 24/02/2020	Print Size: A3
	Map Name: Ranger Mine Site Layout Index.mxd		Spatial data: ERA "Ranger_Mine_Features_V2.shp"	

Figure 2-3: Index for site layout figures (2-1 & 2-2)

2.2.1 Mining

Mining activity at the Ranger Mine involved a conventional open cut process, which commences with drilling and blasting. Pit 1 was mined out in 1994 and mining in Pit 3 ceased in November 2012. Prior to the completion of mining in the pits, mined material was categorised by a discriminator, which measured the uranium grade for either stockpiling or immediate processing (Table 2-1). Low-grade ore and non-mineralised rock was stockpiled and will be returned as backfill to the mined-out pits and contoured to create the final landform.

Table 2-1: Indicative ore grades and mineral type

Grade	Grade (% U_3O_8)			Material type
	1980-1997	**1998-2009**	**2010-Current**	
1	<0.02	<0.02	<0.02	Non-mineralised rock
2	0.02-0.05	0.02-0.08	Low 2 0.02-0.06	Very low-grade ore
			High 2 0.06-0.08	Low-grade ore
3	0.05-0.10	0.08-0.12	0.08-0.12	ore
4	0.10-0.20	0.12-0.20	0.12-0.20	ore
5	0.20-0.35	0.20-0.35	0.20-0.35	ore
6	0.35-0.50	0.35-0.50	0.35-0.50	ore
7	>0.50	>0.50	>0.50	ore

2.2.2 Processing

The major ore processing stages are described below.

- Uranium ore is crushed and ground, then the fine ore is mixed with water to produce a slurry
- The ore slurry is pumped to leaching vessels where, over a period of 24 hours, more than 90 percent of the uranium in the ore is dissolved using sulfuric acid and pyrulosite (an oxidant).
- The uranium in solution is then separated from the depleted ore in a seven-stage washing circuit.
- After separation, the acidity of the depleted ore (tailings) is partially neutralised with lime before being pumped to the TSF, whilst the leach solution is clarified and filtered.
- The uranium is extracted from the leach solution and concentrated, and then pumped to precipitation tanks.

- A bright yellow uranium compound (ammonium diuranate), commonly referred to as 'yellowcake' is precipitated using ammonia.
- In the final stage of the process, the yellowcake is heated to 800 °C to produce the final product – uranium oxide, which is a dark green powder.
- The product is packed into 200 litre steel drums. These are sealed and transported by road, using an accredited transport company, to a secure holding facility and then exported by ship.

2.2.3 Ranger 3 deeps exploration decline

ERA constructed an exploration decline at the Ranger Mine adjacent to the south-eastern rim of Pit 3, from early May 2012 to December 2014 (Figure 2-4). This enabled an underground exploration and infill drilling program to increase orebody knowledge and provide geological, hydrogeological, geotechnical and radiological data.

The decline extends 2,700 m in length and 450 m below the ground surface, above and parallel to the target mineralised zone. The decline was intended to provide access to the mineral resource and subsequent underground mine known as 'Ranger 3 Deeps' (or R3 Deeps).

The decline was extended, and the ventilation shaft was constructed between October 2013 and October 2014. Exploration diamond drilling began in May 2013. Preliminary drilling results were announced in August, and the third drill rig was mobilised in November 2013. Drilling ceased in September 2014. In 2015 the decision was made to not progress and the project was placed into care and maintenance.

ERA received approval from both the Commonwealth and Northern Territory Ministers in April 2019 to commence rehabilitation and closure of Ranger 3 Deeps. Works to commence rehabilitation commenced immediately after approval of the plan. The 2019 rehabilitation works program included the removal of infrastructure and subsequent backfilling of the vent shaft access. The decline was then allowed to flood naturally flood to -25 mRL. This was undertaken by the end of June 2019. Since this time Ranger 3 Deeps has been in reduced care and maintenance. Further information is provided in Section 9.3.9.2.

2.2.4 Tailings storage

The Tailings Dam (TSF), Pit 1 and Pit 3 have been approved for the storage of tailings and process water in accordance with relevant conditions prescribed in the Ranger Authorisation (Section 3). Tailings are deposited to achieve the maximum practicable density, and both subaqueous (below water surface) and subaerial (in air) deposition methods have been used.

Figure 2-4: Spatial extent of the Ranger 3 Deeps exploration decline

2.2.5 Tailings Dam (TSF)

The Ranger Tailings Dam was commissioned in 1980. The dam is classified as a “ring dyke” tailings dam and is in the form of an approximate square with sides of about 1 km in length. The initial dam design was based on a proposed crest level of 51.0 mRL[4]. Designed structural additions have allowed the crest level to attain 60.5 mRL. The eastern, southern and western walls run along ridges approximating catchment divides which separate Coonjimba Creek from adjacent surface water catchments, including Gulungul Creek to the west and the Djalkmarra and Georgetown catchments to the east.

Neutralized mill tailings were deposited within the tailings dam from 1980 to 1996, after which time mill tailings were sent to the mined out Pit 1 in accordance with regulatory approvals. Once Pit 1 reached its maximum tailings level, mill tailings were again directed to the Ranger Tailings Dam from 2008 through to February 2015, when the mined out Pit 3 became available for tailings storage. At this time, the tailings within the Ranger Tailings Dam were estimated at 27 Mt.

Tailings management was initially subaqueous due to concerns with radon gas emissions. In 1987 tailings deposition within the dam was changed to sub-aerial due to (a) studies which showed that radon gas emission was not an issue and (b) concerns with low water levels causing the floating tailings pipelines to become stranded on tailings “islands”.

The free process water inventory held in the tailings dam is progressively reduced through passive evaporation and water treatment via the brine concentrator (BC).

Performance of the dam is monitored and inspected annually by independent engineers, in accordance with the Ranger Authorisation. It is operated in accordance with the requirements of the Australian National Committee on Large Dams and International Commission of Large Dams guidelines for tailings dams design, construction, operation and closure (ANCOLD 2019). The data is reported to the regulators to confirm that the structure continues to perform according to its design and operational criteria. All ERAs tailings storage facilities are operated in accordance with the Rio Tinto Standard D5: *Management of Tailings and Water Facilities* (Rio Tinto 2015), which covers all development phases from planning, design through construction, operation, closure and post-closure where applicable.

2.2.6 Pit 1

Approximately 18 million tonnes of ore were mined from Pit 1 between May 1980 and December 1994. Tailings deposition into the pit commenced in 1996, to an average height of +12 mRL, until deposition ceased in November 2008.

The proposed method and level of unconsolidated tailings deposition in Pit 1 was described in two applications to the MTC submitted in 1995 and 2005, respectively (ERA 2014a). The first

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[4] Reference Level abbreviated to RL. Denotes a specific elevation relative to mean sea level and is regularly used to identify the height or depth of plan or mine infrastructure – e.g. the height of the TSF or depth of Pit 3.

application proposed the deposition of neutralised tailings to 0 mRL; the second application proposed tailings deposition to +12 mRL. Both applications received ministerial approval and were the precursor to the bulk backfill activities currently underway.

Between 1996 and November 2008, ERA deposited approximately 25 million tonnes of tailings into the pit. Pit 1 then functioned as a process water storage facility until 2012. Since then, various works have been undertaken to expedite pit tailings consolidation and facilitate bulk backfilling and landform development. The two latter activities commenced after ERA received Northern Territory (NT) and Commonwealth regulatory approval (via the MTC) for a predicted final average tailings consolidation level in the pit of approximately +7 mRL in March and April 2017, respectively.

For information on Pit 1 tailings consolidation and solute egress modelling, refer to Section 5.

2.2.7 Pit 3

Open-cut mining in Pit 3 commenced in July 1997 and ended in November 2012 with a base (floor) elevation of -265 mRL. In order to use the pit for tailings storage to achieve a good rate of rise and consolidation of the tailings, the pit was backfilled with 33.7 million low-grade ore and non-mineralised rock (known as underfill) to an approximate elevation of -100 mRL. The void within the underfill is being used for storage of residue from the Brine Concentrator. An underdrain system comprising a 2 m layer of waste rock and a sump was constructed over the underfill to facilitate tailings consolidation and allow for the injection of brine.

An application to backfill Pit 3 was submitted in November 2006 and approved in June 2007 by the NT Minister. The application sought approval to backfill Pit 3 *"… to an average interim fill level of ~RL-20m during the period from 2009 until 2014 …"* Following a pit expansion in 2007, and further advice to the MTC (e.g. Shell 50), it was indicated that the pit tailings would likely be significantly lower than the original predicted height.

The 2006 application was followed up with a "notification" submitted in August 2014, on the *"Assessment of Potential Environmental Impacts from an 'Interim' Final Tailings Level of RL-20 m in Pit 3" (ERA 2014a)*. The predicted modelling was based on *"… the designated maximum tailings (RL-20 m) and maximum brine (RL-118 m) levels within Pit 3 as a constant level over the full 10,000 year assessment period. In the case of the Pit 3 tailings level this is a very conservative assumption as the expected average tailings level in 2026, after consolidation, is expected to be RL-30.2 m."*

The transfer of tailings from the mill to Pit 3 began in early 2015 and will cease when mill processing stops. Dredging and tailings transfer from the TSF commenced in December 2015. All TSF tailings transfer resulting from routine dredging or the final TSF floor and wall clean will be completed in 2021.

In April 2019, ERA submitted an MTC application to seek approval to modify the dredged tailings deposition method from subaerial to subaqueous, and consequently to modify the final maximum tailings level from -20 mRL to -15 mRL at the end of deposition. Approval was received in August 2019 to increase maximum tailings level to -15 mRL, applying specifically to the discharges from the fixed mill deposition spigots situated along the south and eastern pit perimeter. A tailings deposition level of -20 mRL was instated as the final average level of deposited tailings. This approved final deposition level was further increased in August 2020 to maximum height of -10mRL across the pit. This increase acknowledges the limitations on ERA that all remaining tailings must be deposited in Pit 3 and recognises that the risk to the offsite environmental during deposition is low provided process water levels in Pit 3 remain below 3.5 mRL.

The most recent modelling (August 2020) indicates that the combined tailings from the mill and TSF will fill the Pit 3 void from a starting elevation of approximately - 100 mRL to a maximum of approximately -13 mRL and an approximate level across the majority of the pit of -15.8 mRL at the end of deposition. Approximately 37 million tonnes of tailings have been deposited into Pit 3 since the beginning of tailings deposition in 2015.

2.2.8 Stockpiles

Several stockpiles comprising of ore grade material and waste are situated within the vicinity of the mine pits and the TSF. Approximately 21 million tonnes of ore will be processed from these stockpiles, whilst about 252 million tonnes of waste exist within the stockpiles, which will be used for backfilling of pits and shaping of the final landform for closure.

Throughout the mine life, the stockpiles have been segregated according to both grade and material type. Details of grade segregation is provided in Section 2.2.1.

Three main material types are used: primary, weathered and laterite. Primary material consists of unweathered host rock, which consists mainly of altered quartz-feldspar schists and to a lesser extent, cherts and carbonaceous materials. Weathered material consists of friable rock (usually quartz-feldspar schist) with altered mineral assemblages but generally still low in clay content. Laterite is a near-surface, highly weathered and sometimes reconsolidated material that is generally high in iron and aluminium clays and other gangue minerals that have made it difficult to process conventionally. Early in the mine life, improved processing performance led to the combination of the weathered with the primary material being fed to the processing plant. In more recent years, a separate laterite processing circuit was developed that allowed this material to also have uranium recovered.

2.2.9 Water management

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. Water is managed according to the Ranger Water Management Plan, which describes the method used to control water on site (ERA 2019). The management plan, which fulfils the requirements of the Ranger Authorisation (0108-18) and is approved annually by regulators, outlines the approach ERA takes to:

- protect both the wider environment and Magela Creek from the impacts of mining and processing operations

- meet all current statutory requirements
- manage water inventories and discharge mechanisms based on water quality according to the whole of mine approach rather than the source of the water
- strategically manage process and pond water inventories in accordance with current closure planning and strategies.

Water at the Ranger Mine is categorised into different classes according to its source and composition (Appendix 2-1). Each class of water is managed in a specific way, in accordance with the Ranger Water Management System (Table 2-2).

The Ranger Mine footprint is divided into catchment areas (Figure 2-8) which generate surface runoff and/or seepage as a result of incident rainfall. Each catchment may comprise of several elements such as retention ponds, sumps, collection basins and groundwater interception ponds. The water circuit for the Ranger Mine, including the five water classes, the different treatments and water management features, are shown in Figure 2-10. A description of the individual water management elements is provided in the following sections.

Figure 2-5: Corridor Creek wetland filter (CCWLF)

2.2.9.1 Retention ponds

Four retention ponds are used at the Ranger Mine to provide sediment control, and dilution and storage of pond and managed release waters:

- Retention Pond 1 (RP1) (capacity = 390 ML) comprises an earthen embankment that dams Coonjimba Creek, and receives release quality water for discharge into Coonjimba Billabong (both passively and actively) or for active discharge into Magela Creek (Figure 2-1, 59).
- Retention Pond 2 (RP2) (capacity = 1,150 ML) comprises an earthen wall impoundment in the former Djalkmarra Creek catchment (now subsumed by Pit 3). RP2 is the primary storage of pond water with distribution networks to the water treatment elements (Figure 2-1, 42).
- Retention Pond 3 (RP3) (capacity = 61 ML) is an earthen impoundment within RP2. Water from RP3 is transferred to RP2 via a spillway and pumped for use on site (Figure 2-1, 43).
- Retention Pond 6 (RP6) (capacity = 976 ML) is a turkey-nested, double-lined pond that receives water from RP2 transfers and rainfall (Figure 2-1, 56).

Table 2-2: Water classes and their management

Water class	Description and treatment
Process water	The most impacted water class on site. Currently stored in the TSF and Pit 3. The process water inventory is derived predominantly from water that has passed through or encountered the uranium extraction circuit, and rainfall from designated process water catchments.
Pond water	Water of a quality that requires active management. Derived from rainfall that falls on the active Minesite catchments. The main storage facilities for pond water include Retention Pond 2 (RP2), RP3 and RP6.
Release water	Release water is derived from incident rainfall that falls on catchments within the mine footprint and is of a high enough quality that it is possible to leave on the site as storm water runoff. Specific streams are routed through passive treatment systems or staging points for management and release (Figure 2-8).
Potable water	Potable water is sourced from the Brockman Borefield located in the south-east of the RPA. A second production borefield (Magela Borefield) was established to the north of Jabiru East, primarily as a source of supply for Jabiru East and the Ranger Mine village. Grey water (e.g. from showers and toilets) is treated on site and pumped into septic tanks and then to leach drains.

Water class	Description and treatment
Treated water	Treated water is water that has passed though one of the three water treatment plants, the Osmoflow Brine Squeezer (OBS) or through the BC. Treated water is divided into the following categories: Water treatment plant permeate: Water that has been treated to remove a significant amount of its dissolved solids to allow it to be released. BC distillate: Purified water that is produced by the BC. Treated distillate is subject to release criteria. Osmoflow Brine Squeezer (OBS) permeate: water derived from further reverse osmosis treatment of water treatment plant brines by the Brine Squeezer. Water quality is equivalent to water treatment plant permeate.
Reject streams	Water treatment plant brines: Water that contains the remaining dissolved solids removed from the pond water. Brines are typically discharged to the process water inventory. However, brines may be discharged to the pond water inventory based on operational requirements. BC brines: Residue water after the distillate has been extracted. OBS brines: residue water that contain the remaining dissolved solids removed from the treatment of pond water brines. Typically, discharged to the process water inventory or alternatively to pond water inventory based on operational requirements. High Density Sludge product water: water arising for the lime treatment process of the HDS plant to remove most salts present in process water. HDS product water may be either recycled to the process water inventory, or subject to further approvals, sent directly to the water treatment plants or discharged into the pond water inventory

2.2.9.2 Water treatment plants

Ranger Mine operates three water treatment plants to treat excess pond water to a level suitable for release to the environment. All water treatment plants are currently configured to treat only pond water to a required standard for release or disposal via land application. The treatment process of pre-filtration followed by reverse osmosis results in four distinct streams that may be directed to specific destinations: permeate, backwash from pre-filtration, chemical clean water and water treatment plant brine.

Figure 2-6: Water treatment area at Ranger Mine

2.2.9.3 Brine Concentrator

The BC was commissioned in September 2013 with the capacity to produce 1.83 GL per annum of clean distilled water (distillate) by using mechanical vapour recompression technology to evaporate water sourced from the process water inventory (Figure 2-7). Distillate from the BC is discharged through the Corridor Creek Wetland Filter prior to release to Magela Creek, with brine currently transferred direct to the TSF. In 2015, ERA completed the installation of five injection bores from the surface of Pit 3 to the underfill. The purpose of the injection system is to pump brine from the BC directly into the underfill layer at the base of the pit for final storage.

2.2.9.4 Brine Squeezer

Commissioning of the Brine Squeezer began in June 2019 and is expected to be fully operational by the 2020/2021 wet season. The Brine Squeezer has been approved to treat both pond and process water. The Brine Squeezer provides an additional stage of treatment for the treatment of pond water through the water treatment plants (WTP) generates brines that are added to the process water inventory. This results in 200 to 1,000 ML/year of additional process water to be treated by the BC. However, the WTP brines are less concentrated than process water (less than 25 percent brine of process water concentration), and treatment via the Brine Squeezer is more cost effective than treating WTP brines alone. More detail on the Brine Squeezer is included in Section 9.4.3.3.

2.2.9.5 High Density Sludge plant

The High Density Sludge plant was built in 2005, overhauled in 2009 and recently recommissioned following a period of inactivity, due to the installation of the BC. ERA has obtained approval to operate the recommissioned plant with discharge of the product water to the pond water inventory. Provisional approval has also been obtained to direct the product water on to the pond water treatment plant 1 (WTP1) to complete additional test work on the product water quality. It is expected that the confirmation of this water quality will occur in the second half of 2020, with the permeate then being approved for release.

The HDS plant treats process water, through to a water quality similar to pond water, through two stages of softening. The process creates a sludge which is discharged from the HDS plant into the processing plant neutralisation tank and then pumped to Pit 3 via existing mill tailings pipeline. Within Pit 3, the sludge will be co-disposed with mill and dredge tailings, until the cessation of mill operations. After this, the sludge must be disposed of in an alternative manner. Approval will be sought for the alternative disposal option following a BPT assessment.

Treated water is discharged from the HDS plant to either the pond water inventory (via RP2) or directly to water treatment plant (WTP) 1 depending on water treatment plant requirements and the condition of the pond water inventory. HDS product discharged to the pond water inventory may be then treated by any of the pond water treatment plants.

Further detail on the HDS plant in included in Section 9.4.3.2.

Figure 2-7: Brine Concentrator

2.2.9.6 Release of treated water

Releasing in the wet:

Discharge of treated pond water can be to Retention Pond 1 (RP1), Collection Basin 2 (CB2), Corridor Creek Wetland Filter (CCWLF) and Georgetown Creek Mine Bore L pond (GCMBL) in accordance with regulatory approvals, where applicable. Water can be released from the RPA from the following locations:

- Collection Basic 7 (CB7);

- Djalkmarra Pump Station 12 (DJKPS12);
- Djalkmarra Release Point (DJKRP) (treated pond water (WTP permeate) and distillate only);
- Georgetown Creek 2 (GC2); and
- RP1.

To assist in managing potential impacts to the Magela Creek all of these locations are incorporated in the Release Plan Calculator (RPC) to assist with determining water quality at MG009 during releases.

Releasing in the dry (irrigation):

ERA defines land application as the process by which water (release water, permeate, wetland polished water) is irrigated to the Land Application Areas (LAAs) (Section 2.2.9.8). Land application follows the general principles of maximising evapo-transpiration loss, minimising surface pooling and seepage as well as preventing surface run-off during operations.

2.2.9.7 Wetland filters

RP1 wetland filter comprised a series of earthen embankments forming an impoundment with discrete cells arranged in series. The wetland filter has an ecosystem dominated by water lilies and native reeds (Eleocharis sp.). Upon entering the wetland, water flows through each of the cells under gravity over a path length of approximately 1,000 m. The last cell of the wetland filter can be equipped with a pumping station and a controlled overflow channel that spills to RP1.

The primary role of the wetland filter is to attenuate uranium from the water using biogeochemical processes before the water is discharged (passive flow) to RP1, used in land application, used in operations for dust suppression or used as construction water.

RP1 wetland filter is currently removed from operational use and its operation will be assessed at a future date.

The Corridor Creek wetland filter is the only wetland filter currently in operation at the Ranger Mine (Figure 2-1, 50). This wetland filter is a combination of natural and constructed wetlands (or cells) with a surface of approximately 17 ha and a total water volume (at full capacity) of approximately 38 ML. Constructed in 2001 and situated at the head of the Corridor Creek Catchment, the Corridor Creek wetland filter was designed primarily to passively treat (i.e. polish) ammonia from treated pond water permeate and uranium from surface water runoff. The Corridor Creek wetland filter is now used to re-mineralise and remove heat from brine concentrator distillate (clean water from process water treatment, Section 9.4.3). The wetland filter continues to polish ammonia from distillate.

Figure 2-8: Surface water monitoring points on the RPA

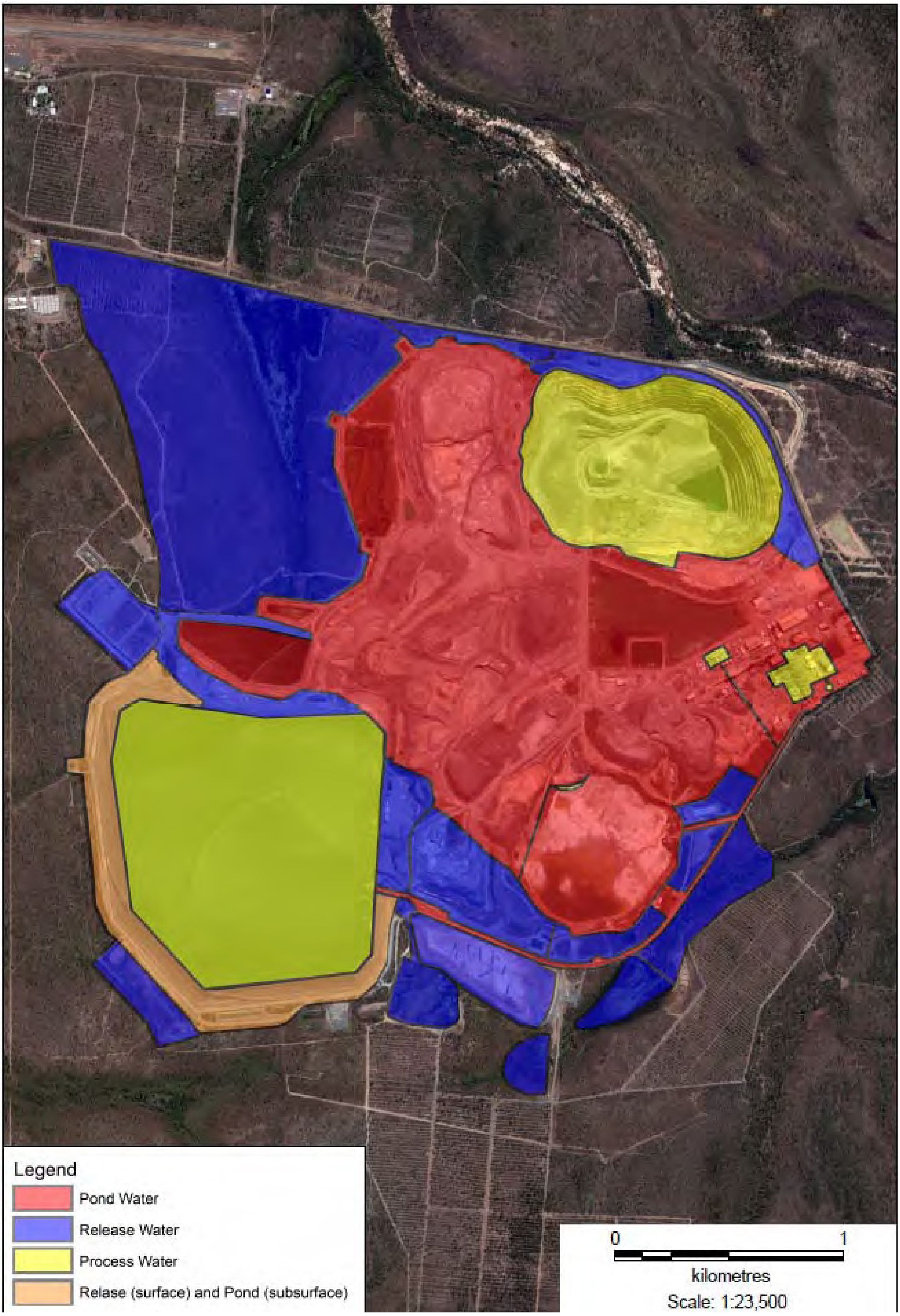

Figure 2-9: General arrangement of water class catchments on the RPA (Deacon 2017)

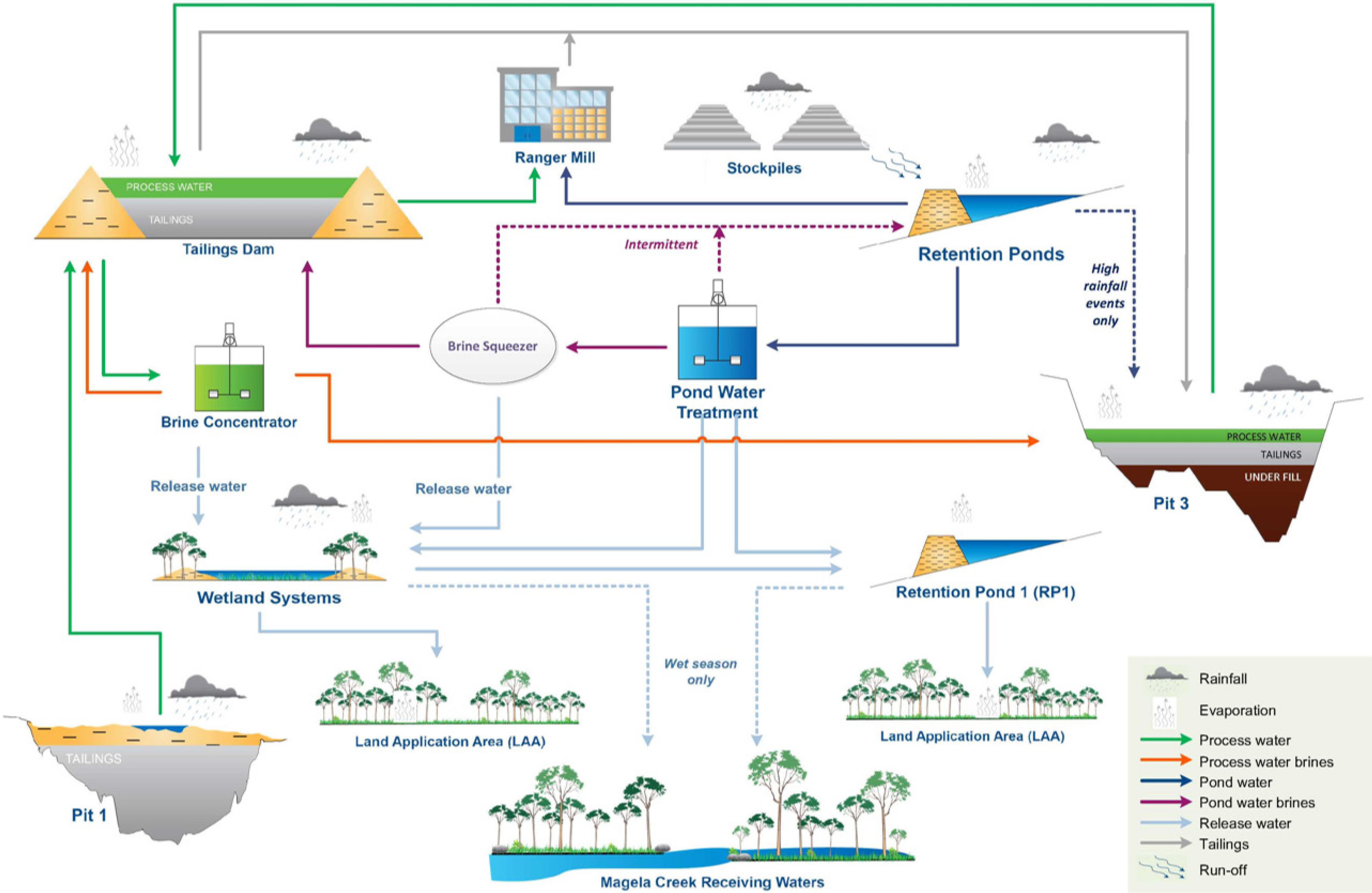

Figure 2-10: Current Ranger Mine water circuit

2.2.9.8 Land Application Areas

The Land Application Areas (LAAs) have been used at the Ranger Mine since 1985 and have a total area of approximately 350 ha. ERA defines land application as the process by which water (release water, permeate, wetland polished water) is applied to the LAAs through a network of distribution pipes and sprinkler heads, thereby maximising evapotranspiration loss whilst minimising surface pooling and seepage, and preventing surface runoff during operations. Table 2-3 provides a generalised description of each operational LAA. Figure 2-11 shows all LAAs on the RPA, noting that Magela LAA was decommissioned in 2007.

Further information on the studies undertaken in the LAAs is provided in Section 5.

Table 2-3: LAA description of generalised water management

Land Application area	**Description**
4A Corridor Creek Land Application Area (CCLAA)	The CCLAA is comprised of a network of pipes and sprinkler heads located to the south of Pit 1. The area is approximately 135 hectares. This area receives waters from Georgetown Creek median bund leveline (GCMBL) and Georgetown Creek Brockman Road (GCBR) and is operated during daylight hours only (Figure 2-8). There are no bunding requirements during active operation of CCLAA.
4C & D Djalkmarra Land Application Area (DLAA)	The DLAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of sparse native woodland north of the Pit 3 access road. The area is approximately 38 hectares. This area receives permeate (via Coonjimba Billabong 2 catchment) only and is operated during daylight hours only. There are no bunding requirements during active operation of DLAA.
4E RP1 Land Application Area (RP1LAA)	The RP1LAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of disturbed sparse woodland to the west of RP1. The area is approximately 43 ha. This area receives release waters from RP1 and can be operated 24 hours a day and is suitable for flood irrigation. There are no bunding requirements during active operation of RP1LAA.
4F RP1 Extension Land Application Area (RP1Ext LAA)	The RP1Ext LAA is comprised of a network of distribution pipes and sprinkler heads set out across a tract of native woodland to the west of RP1. The area is approximately 8 ha. This area receives release waters from RP1 and is operated during daylight hours only. There are no bunding requirements during active operation of RP1 Ext LAA.
4G Jabiru East Land Application Area (JELAA)	The JELAA is comprised of a network of pipes and sprinkler heads that covers an area on the old Jabiru East town site. The area is approximately 52 ha. This area receives release waters from RP1 and is operated during daylight hours only. Whilst release quality water is used for irrigation on the JELAA there is no requirement for bunding.

Figure 2-11: Land Application Areas

2.2.9.9 Site water model

Water management and closure planning at the Ranger Mine has been supported since 2006 by a dynamic water and solute balance model. The model is implemented using OPSIM, an operational simulation package for the modelling of water resource systems (OPSIM Pty Ltd 2017).

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 9. Elements included are the process and pond water catchments and storages, the water treatment plants, the mill, the BC and planned additional water treatment facilities. The model also contains approximations for the release water catchments and storages, and the facilities and rules for managed release to the environment.

The understanding of the site's water systems, as captured in the model, is routinely tested by an annual validation and calibration process that has been conducted since the model was first introduced. This validation and calibration process take advantage of the extensive array of water related measurements at the RPA to reconcile model predictions against actual observations and provides updates to the model which addresses any identified variations. The most recent validation and calibration was completed in June 2019 by an external contractor, and no major changes that pertain to water management were found.

The forecasting approach used applies multiple sequential periods of historical daily rainfall data to the model, using the multiple periods of historical rainfall as an estimate of the possible variation in future rainfall. Model results are collected for each period, simulated, and statistically analysed to provide confidence traces for each variable of interest.

The historical rainfall data for the forecast has been sourced from a point interrogation ('data drill') at a geographic point corresponding to Jabiru Airport, of a climate database prepared by the Science Delivery Division of the Queensland Government Department of Science, Information, Technology and Innovation (Jeffrey *et al.* 2001). The current rainfall data set in use commences on 1 January 1889 and runs through to 30 June 2016.

Typically, median forecasts are used for planning over closure timeframes, with higher confidence forecasts (generally corresponding to higher rainfall) used for contingency and capacity planning.

The model's forecasts for the inventory of free process water in the TSF and Pit 3 over time, are presented in Figure 2-12.

Revisions continue to be made to the water model in response to updated measurements of site process water inventory, changes in closure plan tactics and recommendations arising from the annual model validation and calibration process.

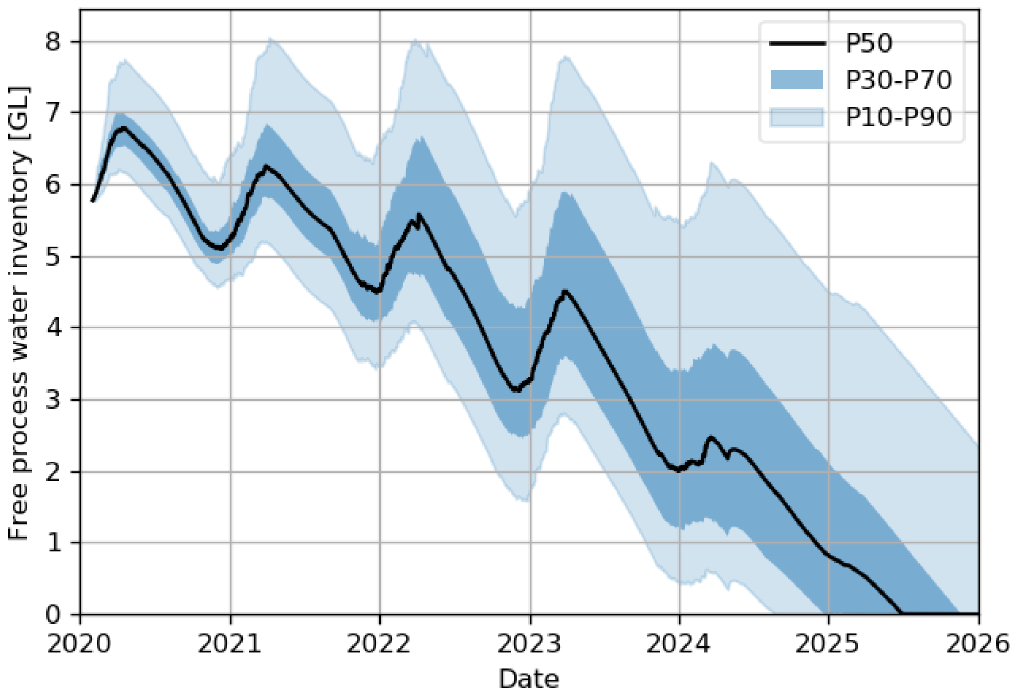

Figure 2-12: Site water model free process water inventory forecast (June 2020)

2.2.10 Jabiru Airport & Jabiru East

Jabiru Airport is located within the RPA at the location know as Jabiru East. The airport caters for light aircraft such as those providing tourist flights, location community charters, medical services and fly in/fly out services from Darwin.

Other infrastructure located with the Jabiru East vicinity include:

- Nursery
- Core storage facilities
- Ranger Mine Village
- Gagadju Yard.

These areas are discussed in Section 9.3.10.

Infrastructure located within the Jabiru East area not to be considered within the Mine Closure Plan consists of:

- Commonwealth Government buildings occupied by the Supervising Scientist Branch (SSB)
- external services (Telstra).

The Commonwealth Government is responsible for the removal and remediation of the Jabiru field station (ERISS buildings) occupied by the SSB . The core yard is included within the closure implementations strategy (Section 9).

2.3 References

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APPENDIX 2-1 WATER MANAGEMENT TERMINOLOGY

TERMS OF REFERENCE (WATER)

TERM	DEFINITION
Water Class	A grouping of a source or inventory of water, based on its properties and management requirements. There are four water classes at Ranger – process water, pond water, release water and potable water.
Process water	All water that either has passed through the uranium extraction circuit; has come into contact with the processing circuit (i.e. milling, leaching, extraction, tailings, washing processes); or has come into contact with a process water storage facility (i.e. TSF, Pit 1 decant and Pit 3 underdrain). The quality of process water is characterised by high dissolved solids. Process water must be contained within a closed system, unless it is treated via an approved process.
Pond water	Water derived from rainfall that falls on active mine-site catchments or disturbed surfaces, that is of a quality which requires active management or treatment prior to release.
Release water	Water derived from rainfall runoff, or the various treatment product streams, which can be released off site without further treatment while complying with regulatory water quality criteria.
Potable Water	Water that can be used for drinking and ablution purposes. Potable water is also used in safety showers, and in parts of the plant where high quality water is required.
Inventory	The volume of a water class that exists on site at a single point in time. Inventories are inferred from water level measurements or measured by survey across various storages.
Water Management System	The infrastructure, operations and procedures required to manage water at Ranger which includes capturing, storing, transferring, treating and disposing volumes of water.
Storage Facility	A designated area or structure where a particular water class will be contained prior to future transfers, treatment or disposal pathways. For example, process water storage facilities include the Tailings Storage Facility (TSF) and Pit 3.
Retention Pond	A large constructed storage facility that collects runoff and stores pond water for treatment (RP2 & RP6) or release water post-treatment (RP1).
Collection basin	Smaller constructed storage facility built to capture runoff along the western stockpile (Collection Basin 1, CB3, CB4, CB5, and CB6) which requires pond water treatment. Note that CB2 collects clean runoff and WTP permeate which passively drains into RP1.
Wetland filter	A constructed biological filter system that is designed for final treatment of release water and is monitored to ensure water quality meets regulatory criteria for disposal.
Land Application Area	A designated area where irrigation of release water may occur during the dry season.
Treatment Facility	Infrastructure that has been installed to undertake water treatment to achieve desired water quality outputs that is suitable for disposal. The main treatment facilities on site include: Brine Concentrator (BC), Water

TERM	DEFINITION
	Treatment Plants (WTPs), Brine Squeezer (BS) and High Density Sludge (HDS) plant.
Brine Concentrator (BC)	A treatment facility that treats process water by distillation to produce a clean product stream (distillate) and a waste stream (brine).
Water Treatment Plants (WTPs)	A series of ultrafiltration/reverse osmosis treatment plants that treat pond water to create a clean product stream (permeate) suitable for disposal and a waste stream (brine).
Brine Squeezer (BS)	A treatment plant that uses reverse osmosis to further process brine generated from the WTPs to recover additional permeate.
High Density Sludge (HDS) Plant	A treatment plant that treats process water (in parallel to the BC) with lime and soda ash to produce a moderately clean product stream (HDS product) and a waste stream (HDS sludge).
Treatment product	Water that has undergone treatment to remove excess solutes and improve water quality. The product stream from primary treatment may be suitable for disposal (i.e. BC distillate, BS permeate and WTP permeate) or may require secondary treatment prior to disposal (i.e. HDS product).
BC distillate	The product stream produced by BC plant treatment that has very low dissolved solids. Subject to water quality criteria this product may be discharged to the environment.
WTP permeate	The WTP product stream which has significantly reduced dissolved solids to achieve water quality objectives and regulatory criteria for disposal.
HDS product	The HDS product stream which is of a quality similar to that of pond water. HDS product requires further treatment by the WTPs before it can be considered for disposal.
Treatment waste	The waste stream produced by the treatment facilities which contains a higher concentration of solutes due to removal from the original feed water. This also includes water that is used during backwashing and cleaning processes. Treatment waste must be retained on site and returned to source storage for further processing.
Brine	A generic term for the waste stream from the BC, BS or WTP. For each plant, the brine stream contains most of the salt removed from the feed stream to the plant in a concentrated liquid form. The handling of a brine stream depends on the characteristics of that stream.
High density sludge	The waste stream generated from the HDS plant which is a mixture of solids such as gypsum and various metal hydroxides, and water. This is directed to Pit 3 or another approved location for final disposal.
Transfer	The process of physically distributing water across the water management system using pumps, pipes, valves and other supporting infrastructure to meet operational requirements.
Disposal	The final transfer of release water into the environment. Disposal requires compliance with regulatory water quality criteria and must only be transferred from an approved location.
Direct discharge	The disposal of release water from a control point into an authorised water course location when flowing (i.e. MG001) or enables passive transfer to the environment (i.e. RP1 and GC2).

TERM	DEFINITION
Irrigation	A form of disposal which allows release water to be dispersed via a sprinkler system over an approved land application area (LAA) at an approved rate.
Evaporation	A form of disposal where water is lost as water vapour into the atmosphere.