Management of Ranger Uranium Mine Waters, Kakadu Region, Northern Territory, Australia

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ABSTRACT

The Ranger uranium mine has operated in the Kakadu region of the Northern Territory since 1979. The mine's water management system was designed to cater for the wet-dry monsoonal climate and to satisfy the recommendations of the Ranger Uranium Environmental Inquiry - Second Report, 1977 (The Fox Report) with respect to environment protection. The Fox Report advised that the aquatic ecosystem of the region must be protected and that the mine should collect all runoff from disturbed areas. Furthermore, the mine was to operate as a no-release system until release standards, based on the experience of several years of operation and on the results obtained from monitoring and scientific investigations, could be established.

Monitoring and research data have now been collected for a decade. It is evident that lower-than-expected concentrations of chemical constituents are present in the runoff waters which are retained on site. Standards have been established for the release of these waters to the streams when in flood during the wet season. Mine water quality data and release standards are presented. It can be confidently concluded that controlled release will not cause detriment to the aquatic ecosystems of the Kakadu region.

The Ranger operation has demonstrated that environmentally responsible management of mine waters is feasible for future mining ventures in the Kakadu region.

INTRODUCTION

The Ranger uranium mine is located about 230 km east of Darwin in undulating lowlands of the Alligator Rivers region. The mine site occupies 6.7 km^2 within a total project area (mining lease) of 78.6 km^2. The vegetation of the area is dominated by open eucalypt woodland. The climate is monsoonal, with over 90% of the annual rainfall, which averages about 1500 mm, falling in the five wet-season months of November to March.

The uranium deposits were discovered in 1969. After considerable nation-wide debate and a major environmental inquiry, the Commonwealth Government, in 1977, announced its decision to allow uranium mining to proceed. Operations at Ranger commenced in 1979. In the same year, the first stage of Kakadu National Park, which surrounds the project area, was proclaimed. The Park now has been expanded to cover about 19,500 km^2.

The principal water course adjacent to the mine site is Magela Creek, which flows into the East Alligator River and eventually into the Van Diemen Gulf. Magela Creek ceases to flow in the last months of the dry season.

The Aboriginal people of the region have been granted title to the land on which Ranger lies. Royalty-type payments are made to both regional and Territory-wide Aboriginal organisations.

At present, about 5 million tonnes of rock are mined by open cut each year, and about 3000 tonnes of uranium oxide concentrate (yellowcake) are produced. Nearly 1.3 million m^3 of tailings are pumped to the tailings dam each year.

DEVELOPMENT OF THE WATER MANAGEMENT SYSTEM

The twin objectives of the Ranger water management system are to ensure that an adequate supply of water is available for mine and mill purposes and that impacts on the surrounding environment as a result of operations are minimised.

The base for minimisation of environmental impacts was laid in the Ranger Uranium Environmental Inquiry - Second Report, (the Fox Report) (1), published in 1977. The Report recommended the establishment of a water management system which minimises the release of contaminants from the mine site, whether by runoff or by deliberate releases both during and after mining. The report also recommended that no intentional release to the environment be made until it is shown that release is necessary.

These recommendations have led to development of two concepts: the restricted release zone (RRZ), and best practicable technology (BPT). Both concepts are fundamental to the Ranger water management system.

The RRZ includes all areas in which material containing more than 0.02% uranium is mined, stockpiled, stored or handled, and the catchment draining rainfall from such areas. All waters in the RRZ must be kept within the RRZ, unless release is approved. Waters which come into contact with disturbed areas with a uranium oxide content

of less than 0.02%, such as the waste-rock dumps, do not need to be retained, but do pass through sediment control ponds.

BPT is that technology which produces the minimum environmental degradation that can reasonably be achieved, having regard to a number of factors, including practice in uranium mining elsewhere in the world, cost, evidence of detriment or lack of it, project location, the age and effectiveness of equipment and facilities, and social factors.

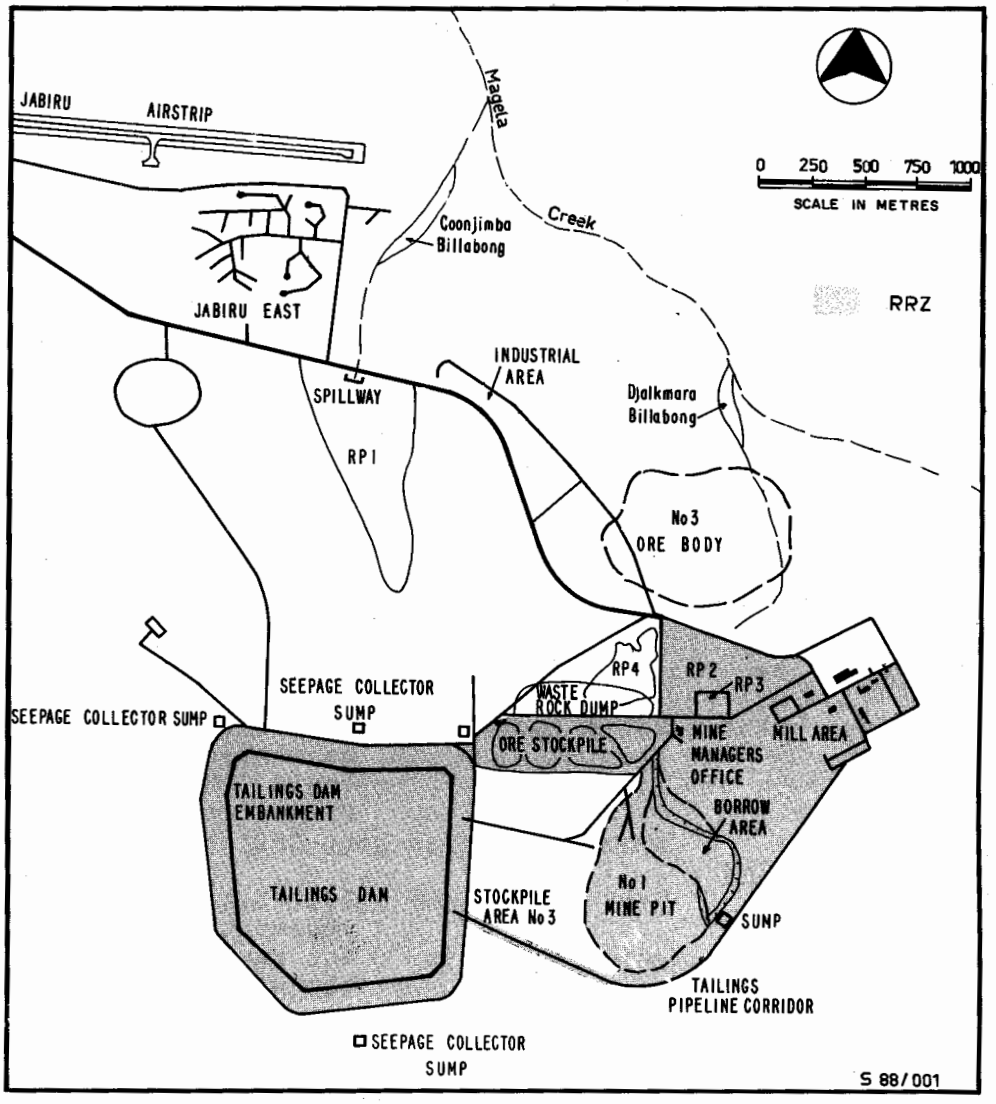

Figure 1: Site Plan, Ranger Uranium Mine

DESCRIPTION OF THE WATER MANAGEMENT SYSTEM

The principal components of the Ranger water management system are illustrated on Figure 1.

Within the RRZ, the main water-retaining structures are the tailings dam, retention ponds 2 and 3 (RP2 and RP3), and the mine pit. The sediment control ponds outside the RRZ are retention ponds 1 and 4 (RP1 and RP4). A summary of catchment and utilisation of all ponds is given in Table 1.

TABLE 1: Water management ponds, Ranger

	Catchment area (ha)	Catchment description	Comments
RRZ Ponds			
Tailings Dam	115	Dam & walls	About 8 x 10^6 m^3 filled to date. Dam wall raised as required. Primary source of mill process water.
RP3	12	Primary crusher area and adjacent stock-piles	50 ML Storage of more-contaminated runoff. Used in mill process circuit.
RP2	100	Mill site and ore stockpiles	1100 ML capacity. Storage of less-contaminated runoff used in mill circuit if necessary.
Mine Pit	51	Pit & surrounds	Excess water could be stored in pit but would inhibit mining. Pit water is pumped to RP2 or RP3.
Ponds outside RRZ			
RP4	35	Waste rock dump	200 ML capacity sediment control pond for runoff water from the waste rock dump
RP1	285	Surrounds of tailings dam; mostly undisturbed	380 ML sediment control pond

OPERATION OF THE WATER MANAGEMENT SYSTEM

The first of the twin requirements of the water management system is to ensure an adequate supply of water for mine and mill usage throughout the year. The system is managed to allow maximum flexibility within the system and to maintain segregation of waters with differing degrees of contamination. The poorest-quality water is in the tailings dam. Supernatant tailings-dam water is recycled as process water in the mill. Process water is kept separate from rain runoff water in the retention ponds. Considerable volumes of water are entrapped within the tailings and it is necessary to use additional water in the mill circuit. Additional water is supplied from RP3 and as well as from RP2 and pit water. Borefields in the project vicinity are available as a contingency source in times of drought. Ranger Mines has indicated (2) a nominal annual requirement of nearly 950 ML water in addition to that available from recycled supernatant tailings water, for the mine and mill.

In particularly heavy wet seasons, water in excess to needs may accumulate in the water management system. The report of a Technical Working Group "Application of Best Practicable Technology to Water Management at Ranger Uranium Mine" (3) evaluated volume increments for wetter than average years as a function of their probability of occurrence using rainfall data collected on the project area during the past 16 years. The results for the RRZ, excluding the tailings dam, are:

Probability %	50	20	10	4
Annual Rainfall (mm)	1560	1810	1960	2090
Estimated volume increment (ML)	1200	1800	2200	2500

More recent work by the Department of Mines and Energy suggests that the actual volume increments are considerably lower than those estimated in the Working Group report. It is still clear, however, that accrued RRZ water volumes will exceed the capacity of RP2 in very wet years.

DISPOSAL OF EXCESS WATER

Land application of RRZ water

Land Application is a method of disposing of waste water through infiltration into soil and evapotranspiration by plants. At Ranger, the technology has been progressively introduced since 1985, and a spray irrigation system on a 35 ha site is available for disposal of up to 900 ML of RRZ water during the dry season. Current legal requirements preclude the use of the site during the wet season.

Monitoring of groundwater and vegetation at and surrounding the site continues to confirm the feasibility of land application for disposal of excess water (4) without detriment to the environment.

Direct release to Magela Creek

If the volume of runoff water collected in the RRZ during the wet season exceeds the storage capacity of RP2, the excess water must either be stored in the mine pit or the tailings dam, or else be released from the RRZ. Storage in the pit is environmentally possible, but would disrupt mining. Tailings-dam storage is environmentally unsound, since relatively good quality water would be significantly degraded. Release from the RRZ to Magela Creek during the wet season is the remaining option. Discharge standards have been authorized in order to ensure the protection of the environment and human health (Table 2). To date, RRZ waters have not needed to be released to the waterways, but the principal conclusion of the Best Practicable Technology Working Group (3) was that BPT for Ranger water management is disposal of excess RRZ water by controlled release, as necessary, to Magela Creek during the wet season, supplemented by land irrigation during the dry season.

TABLE 2: Discharge standards, Magela Creek

CONSTITUENT	MAXIMUM ALLOWABLE ADDITION		ADDITIONAL ANNUAL LOAD LIMIT	
Turbidity	1.5	NTU		
Calcium	1.3	mg/L		
Magnesium	1.0	mg/L		
Sulphate	19	mg/L		
Nitrate/nitrite (as N)	0.6	mg/L	4.4	t/a
Phosphate (as PO_4)	0.01	mg/L	8.6	t/a
Copper, total	0.6	ug/L	90	t/a
Lead, total	0.7	ug/L	8	t/a
Zinc, total	5	ug/L	200	t/a
Manganese, total	24	ug/L	6	t/a
Uranium, total	3.8	ug/L		
Cadmium			1.3	t/a
Uranium - (238+234)			88	GBq/a
Thorium - 230			170	GBq/a
Radium - 226			13	GBq/a
Lead - 210			8	GBq/a
Polonium - 210			7	GBq/a

Note: Additional Annual Load Limits for radionuclides are subject to summation of fractions in individual limits with sum to be less than unity.

Disposal of non-RRZ water

Excess water in RP1 and RP4 has been disposed of during past wet seasons by natural overflow of the ponds' spillways, or, for RP4 in recent years, by pumping down the pipeline to Magela Creek. The water quality in both ponds (Table 3) is such that all release standards have been satisfied. Monitoring of water quality downstream of the release point indicates that release of water from both ponds has not caused any detectable detriment to the environment (4).

TABLE 3: Typical water quality, retention ponds
(RP4 and RP2 figures are averages for the period Jan 1981 - Feb 1988)

Parameter	Units	RP1	RP4	RP2
Conductivity	uS/cm	42	270	540
pH		7.6	7.8	8.0
Turbidity	NTU	5	14	36
Sodium	mg/L	2.5	4.5	22
Potassium	mg/L	1	1.7	2.9
Magnesium	mg/L	2.6	25	33
Calcium	mg/L	0.7	2.6	17
Bicarbonate	mg/L	10	60	27
Chloride	mg/L	1.5	4.9	3.6
Phosphate	mg/L	<0.02	0.06	0.09
Nitrate	mg/L	<0.05	0.94	2.2
Sulphate	mg/L	5.3	59	200
Lead	ug/L	<1	<1	5
Copper	ug/L	1	2	19
Managanese	ug/L	14	53	1100
Zinc	ug/L	2	3	23
Uranium	ug/L	2	190	670
Radium	Bq/L	<0.02	0.17	1.7

Discharge standards

Discharge standards for release of water to Magela Creek have been determined so that any additions will result in only very small departures from the natural range of concentrations in the creek. The standards ensure that impacts of the water management system on the surrounding environment are minimised. The standards were established on the basis of existing scientific and technical information, together with the baseline water-quality data for the creek. They are expressed as maximum allowable

additions (Table 2), which, for each chemical constituent, are the maximum amount of constituent which may be added per volume of mixed creek water, and a discharge formula

$$D < \frac{A \times F}{C}$$

which must be satisfied.
C is the concentration of a constituent in the water to be released;
F is the flow rate in Magela Creek in cumecs;
D is the discharge rate in cumecs; and
A is the maximum allowable addition for the constituent.

The cumulative additional loads released to the creek must also not exceed the annual load limits listed in Table 2.

For release of RRZ water, legislation requires the Magela flow to be greater than 20 cumecs. This minimum, combined with the maximum discharge rate for the current pump/pipeline outlet from RP2 of 0.25 cumecs, dictates that the minimum dilution for a release is 1 to 80. At this dilution, and at average chemical constituent values for RP2 (Table 3), the elements manganese, uranium and magnesium are those which are most likely to limit the discharge rate, and are therefore those which need to be most closely monitored in a release situation.

Biological testing

The Research Institute of the Commonwealth Government's Office of the Supervising Scientist, in conjunction with the mining company, has developed laboratory protocols for toxicity testing of a range of sensitive aquatic species in various concentrations of mine waters. Biological testing aims to determine the concentrations of mine water in which the lowest observable response and no observable response occur. After the tests have been validated in the field, they will be considered as a possible adjunct to the current discharge standards.

CONCLUSIONS

The water management system at Ranger Uranium Mines is being operated in accordance with BPT, satisfies the water needs of mining and milling and ensures protection of the environment. To date it has not been necessary to release water from the RRZ, and land application of excess water during the dry season has enabled the mine to keep the water management system in balance. Regulatory standards have been emplaced for release of excess mine water to Magela Creek during the wet seasons. The standards are

designed to ensure a high level of protection for the aquatic ecosystem and the public.

Monitoring of surface waters, groundwaters and the biota for the 9 years of operation of the mine's water management system has not revealed any detriment to the environment surrounding the mine site. The Ranger operation demonstrates that environmentally responsible management of mine waters is feasible for future mining ventures in the Kakadu region.

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