RUM JUNGLE REHABILITATION PROJECT

A TECHNICAL OVERVIEW

by P. F. Loveday
PROJECT MANAGER
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A TECHNICAL OVERVIEW

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RUM JUNGLE REHABILITATION PROJECT

A TECHNICAL OVERVIEW

1. INTRODUCTION

The Rum Jungle mine, 80 km south of Darwin, Northern Territory, was Australia's first major uranium mine, with mining operations spanning the period from 1953 to the closure of the treatment plant in 1971. Besides uranium, mining included extraction of copper and lead.

The Federal Government negotiated with the mining group Consolidated Zinc Pty Ltd (now known as C.R.A.Pty Ltd) to undertake the mining and processing of the uranium on a management basis for the Australian Atomic Energy Commission.


Since the mining days, the attitudes, expectations and requirements of society with respect to environmental issues together with legal requirements have changed, and both the Federal and Northern Territory Governments were anxious to improve the environmental damage resulting from the mining and treatment operations at Rum Jungle.

In March 1981 the Prime Minister accepted in principle that the Northern Territory should take responsibility for investigating and conducting a rehabilitation programme at Rum Jungle. The Northern Territory developed detailed proposals which formed the basis of an Agreement between the Commonwealth of Australia and the Northern Territory of Australia signed on 4 March 1983. Under that Agreement the Northern Territory undertook to carry out the rehabilitation works over 4 years at an estimated cost of $16.2 million at June 1982 prices, with funding provided by the Commonwealth. The general location and layout of the mine site is shown on Figure 1 attached.

The overview set out below is based upon the works intended to be carried out. It makes no attempt to deal with options previously considered or to justify the scope or extent of works. It is aimed to provide a limited amount of technical detail to those who seek a little more than a general overview.
Figure 1
LOCALITY & SITE PLANS
2. **THE ENVIRONMENTAL PROBLEMS RESULTING FROM MINING**

By far the most significant source of chemical pollution on the site and adjacent water courses in terms of quantity of pollutants released and their toxicity are the overburden heaps and the Copper Heap Leach Pile. Principally through the action of water and oxygen infiltrating the overburden heaps sulphidic (pyritic) ores are chemically and bacteriologically oxidised releasing heavy metals (Iron, Copper, Zinc, Cobalt, Manganese, Nickel) and sulphates. The pollution has entered the East Finniss River, plus ground water and surrounding ground. The figures in Table 1 gives an indication of annual pollution loads carried by the East Finniss River.

**TABLE 1**

**ANNUAL POLLUTION LOAD CARRIED BY THE EAST FINNISS RIVER**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall</td>
<td>896</td>
<td>1611</td>
<td>1542</td>
<td>1545</td>
<td>2000</td>
<td>1512</td>
</tr>
<tr>
<td>Period of flow in East Finniss River</td>
<td>Dec</td>
<td>Nov</td>
<td>Nov</td>
<td>Dec</td>
<td>Nov</td>
<td></td>
</tr>
<tr>
<td>Flow (10^6 m^3)</td>
<td>7.0</td>
<td>33.2</td>
<td>30.9</td>
<td>26</td>
<td>97</td>
<td>39</td>
</tr>
<tr>
<td>Pollution load (tonne)</td>
<td>Cu : 44</td>
<td>77</td>
<td>51</td>
<td>45</td>
<td>130</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Mn : 46</td>
<td>110</td>
<td>64</td>
<td>49</td>
<td>100</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Zn : n.a.</td>
<td>24</td>
<td>19</td>
<td>16</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>SO₄ : 3300</td>
<td>12000</td>
<td>6600</td>
<td>5500</td>
<td>13000</td>
<td>8080</td>
</tr>
</tbody>
</table>

The Tailings Dam is aesthetically the worst affected area. It is a low level source of radiation, it is acidic and contains heavy metals, and as a result of erosion, contributes significantly to the contaminated sediment within Tailings Creek and the East Branch of the Finniss River.

The two open cuts known as Whites and Intermediate have, since mining was completed, filled with ground and surface water and via various mechanisms have become highly polluted and contain significant concentrations
of heavy metals and dissolved acids. These escape to the environment by way of ground water movement. The remaining open cut, Dysons, does not contribute significantly to the pollution of the area, but was used towards the end of the mining operations as a tailings disposal site.

3. REHABILITATION OBJECTIVES

The rehabilitation work is aimed at achieving the following objectives:

(a) major reduction in pollution in water courses feeding the East Branch of the Finniss River and in particular the reduction of the average annual releases of copper, zinc, and manganese in that river by 70%, 70% and 56% respectively as measured at the junction of that river with the Finniss River;

(b) reduction in public health hazards and in particular reduction of radiation levels at the site at least to the standards set out in the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores published by the Australian Government Publishing Service in 1980;

(c) reduction of pollution in the water contained in the open cuts known as Whites and Intermediate; and

(d) aesthetic improvements including revegetation.

4. PRINCIPLE FEATURES OF THE REHABILITATION WORKS

The principle features of the rehabilitation programme being implemented are:-

(a) reshape, construct impervious covers, construct drainage and revegetate three overburden heaps known as Whites, Intermediate and Dysons Overburden Heaps. Whites North Overburden Heap to be moved to the toe of Whites Overburden Heap prior to the latter heap being rehabilitated; lime, apply topsoil and revegetate the area originally occupied by Whites North Overburden Heap;

(b) place tailings from the Tailings Dam and the low grade copper ore from the Copper Heap Leach Pile into the open cut known as Dysons Open Cut then cover, drain and vegetate all three areas;

(c) treat the water in Whites and Intermediate Open Cuts using a water treatment plant based on a hydroxide precipitation process and then divert the East Branch of the Finniss River through those two open cuts; the resultant precipitate to be buried on the site;
(d) clean up stream beds and generally clean up and revegetate the area;

(e) monitoring activities to allow adequate project management; to verify the validity of design parameters and provide a basis for evaluating the extent to which project objectives have been achieved.

The minimum design life adopted for the rehabilitation works is 100 years, and the intention is that the treated water in Whites and Intermediate Open Cuts is suitable for recreational use.

Further aspects associated with some of the above works are now further addressed.

5. REHABILITATION OF THREE OVERBURDEN HEAPS

By preventing, or minimising infiltration of water and oxygen into the overburden heaps, the chemical and bacteriological actions producing pollutants will be reduced and the mechanism of transportation of pollutants is removed or minimised.

The characteristics listed below were regarded as objectives when arriving at a cover design meeting the design life:-

1. Support a vegetation cover to maximise the interception store capacity - to reduce the erosive effects of low intensity storms.

2. Be resistant to erosion, including on the batters.

3. Possess low permeability to minimise infiltration to the ground water.

4. Be well drained and free from depressions and hollows which could contribute to the retention of water within the depression store.

5. Provide a soil moisture store, to support vegetation.

6. Be of minimum thickness compatible with objectives 1 to 4, to reduce costs.

7. Be of maximum thickness to render more effective the objectives 1 to 4.

8. Be of simple construction optimising the use of locally available materials without waste or processing wherever possible.
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(e) monitoring activities to allow adequate project management; to verify the validity of design parameters and provide a basis for evaluating the extent to which project objectives have been achieved.

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This led to two basic cover designs being developed—one for the top surface of the heap; the other for the heap batters, using three different layers of materials. Typical cross sections used on Whites Overburden Heap are shown on Figure 2, and the position with each zone is as follows.

. **Zone 1A:** Compacted clay: this constitutes the primary "sealing" layer by means of which infiltration into the heap is reduced. Compacted at a moisture content below optimum to reduce the risk of desiccation cracking.

. **Zone 1B:** Clayey Sand/Sandy Clay: this constitutes the primary layer for the maintenance of soil moisture and maintenance of vegetation with minimal wilting during the dry season and assists in the prevention of dessication of the Zone 1A layer.

. **Zone 2A:** Gravelly Silty Clayey Sand: this constitutes the erosion resistant layer which provides retention for the initial 20mm of rainfall by virtue of its granular porous nature, whilst at the same time being unsaturated constitutes a pore breaking horizon to limit moisture loss by clearing of vegetation.

. **Zone 3A:** Rock Mulch: this constitutes the layer which provides both erosion protection on the outer slopes and a rock mulch to encourage the development of pockets of moist topsoil as void infilling and a seed bed for revegetation.

The designers estimated that the cover design would achieve a minimum of 85% reduction in stormwater infiltration to ground water via Whites Overburden Heap.

An integral part of the design which helped reduce erosion was the reshaping and drainage of the overburden heaps, with a variety of different drainage controls used. Some typical details are included on Figure 2.

The design of revegetation took in many facets such as field conditions; maintaining the integrity of the covers; fertiliser and mulching needs, long term propagation, watering, mowing needs, seed purity and availability, removal of noxious weeds and trees, fire protection and effects of fire, fencing. Various types of seed species were identified for use on Whites Overburden Heap as per Table 2, and a similar approach is expected to be adopted for the other two heaps.
**Table 1**

<table>
<thead>
<tr>
<th>Drain</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>'A'</td>
<td>3000</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>1000</td>
</tr>
<tr>
<td>'E'</td>
<td>4000</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>1000</td>
<td>1500</td>
<td>2000</td>
<td>2500</td>
<td>1000</td>
</tr>
</tbody>
</table>

**TYPICAL CROSS SECTION**

**TYPICAL CROSS SECTION DRAIN D**

**TYPICAL CROSS SECTION DRAIN A, B, C**

**SUBSOIL DRAIN OUTLET**

**Figure 2**

**WHITES OVERBURDEN HEAP**

**TYPICAL CROSS SECTIONS**
<table>
<thead>
<tr>
<th>Species Name</th>
<th>Common Name</th>
<th>Sowing Rate kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Top Surface:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum bicolor</td>
<td>Hybrid dwarf sorghum</td>
<td>4</td>
</tr>
<tr>
<td>Chloris hayana</td>
<td>Rhodes grass</td>
<td>3</td>
</tr>
<tr>
<td>Brachiaria decumbens</td>
<td>Signal grass</td>
<td>4</td>
</tr>
<tr>
<td>Cyonodon dactylon</td>
<td>Green couch</td>
<td>1</td>
</tr>
<tr>
<td>Paspalum notatum</td>
<td>Pensecola Bahia grass</td>
<td>4</td>
</tr>
<tr>
<td>Stylosanthes guianensis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. Graham</td>
<td>Graham stylo</td>
<td>6</td>
</tr>
<tr>
<td>Stylosanthes hamata</td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. Verano</td>
<td>Verano stylo</td>
<td>4</td>
</tr>
<tr>
<td>Digitaria decumbens</td>
<td>Pangola grass</td>
<td>Runners at 1 metre centres</td>
</tr>
<tr>
<td><strong>Batters:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorus gayana</td>
<td>Rhodes grass</td>
<td>6</td>
</tr>
<tr>
<td>Brachiaria decumbens</td>
<td>Signal grass</td>
<td>6</td>
</tr>
<tr>
<td>Cyonodon dactylon</td>
<td>Green couch</td>
<td>2</td>
</tr>
<tr>
<td>Stylosanthes scabra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>var. Seca</td>
<td>Seca stylo</td>
<td>4</td>
</tr>
<tr>
<td>Macroptilium atropurpureum</td>
<td>Siratro</td>
<td>2</td>
</tr>
<tr>
<td>Calopogonium mucunoides</td>
<td>Calopo</td>
<td>4</td>
</tr>
<tr>
<td>Digitaria decumbens</td>
<td>Pangola grass</td>
<td>Runners at 1 metre centres</td>
</tr>
<tr>
<td><strong>Surrounds:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sorghum bicolor</td>
<td>Hybrid dwarf sorghum</td>
<td>4</td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>Rhodes grass</td>
<td>5</td>
</tr>
<tr>
<td>Paspalum notatum</td>
<td>Pensecola Bahia grass</td>
<td>4</td>
</tr>
<tr>
<td>Stylosanthes hamata</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.v. Verano</td>
<td>Verano stylo</td>
<td>5</td>
</tr>
<tr>
<td><strong>Channels:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloris gayana</td>
<td>Rhodes grass</td>
<td>5</td>
</tr>
<tr>
<td>Brachiaria mutica</td>
<td>Para grass</td>
<td>5</td>
</tr>
<tr>
<td>Paspalum plicatulum c.v. Bryan</td>
<td>Bryan Plicatulum</td>
<td>10</td>
</tr>
</tbody>
</table>
6. BURYING OF TAILINGS AND COPPER HEAP LEACH PILE

The tailings dam covers some 33 ha of gently sloping land and contains finely ground acid leached waste from the processed ore which was treated for uranium and copper. They were discharged unneutralised and contain high levels of heavy metals and sulphates as well as the radioactive daughter products of the uranium decay series.

The relocation of the tailings will be the key phase with regard to radiological hazards associated with the mine site.

It is considered that the emplacement of tailings ore and contaminated subsoil into Dysons Open Cut will constitute a geomorphologically stable environment and that this emplacement will address the long term management requirements for the uranium mill tailings. The proposed cover will be sufficient to reduce radon exhalation to an acceptable level.

During removal and burial of the tailings a comprehensive Radiological Safety Regime is to be established, under day to day control of the Department of Health. The main radiological objectives during the operating phase will be:

- to meet or exceed clearly defined rehabilitation design criteria;
- to comply at all times with the Code of Practice on Radiation Protection in the Mining and Milling of Radioactive Ores 1980 and any legislation that may be relevant at the time;
- to protect employees and the general public from any abnormal risk of injury to health from the rehabilitation operations and to keep their radiological exposures to the lowest practical level;
- to adhere to the philosophy of radiation protection expounded by the International Commission on Radiological Protection and its associated dose limitation system;
- to minimise the impact of rehabilitation measures on the local environment.

To comply with the above objectives, many measures are taken such as medical checks of workers; briefing of all workers by Department of Health; special washing facilities for workers and equipment are provided; all earthmoving equipment are fitted with positive pressure air conditioned cabs; dust suppression measures are adopted; establishment of Restricted Zones on site with
relevant restrictions and supervision.

Sufficient soil underlying the tailings will also be removed and buried to ensure satisfactory clean up of all migrated radio-nuclides. The area will then be reshaped; lime added and mixed; cover materials and drainage control structures installed and the total area revegetated.

The soil adjacent to the pyritic copper ore overburden in the Copper Heap Leach Pile clearly shows the effects of acidification with very high levels of soluble Copper, total Copper, soluble Aluminium and pH values less than 4.0. High levels of salts, primarily sulphates contribute to a salinity hazard.

Once the tailings, Copper Heap Leach material and underlying subsoils are placed in Dysons Open Cut the resultant area in the vicinity of Dysons Open Cut will be shaped, covered, drained and revegetated. Like the other cover designs, the final design represents an optimisation of the requirements for

. infiltration minimisation

. erosion resistance

. revegetation supportability

within the overall cost constraints for the project.

The general arrangement in Dysons Open Cut is shown in Figure 3, showing typical cross-sections.

7. TREATMENT OF WATER IN WHITES AND INTERMEDIATE OPEN CUTS

The two open cuts contain a total of approximately 4 million cubic metres of water that has been polluted by previous treatment operations and acidic seepage containing heavy metal salts from the slowly oxidising overburden heaps.

The composition differs widely between Whites and Intermediate insofar as heavy metals are concerned, the difference being largely due to the past mining and treatment history, plus the nature of the material in the mine vicinity.

The aim is to treat the water such that it is suitable for limited recreational use. Table 3 shows some typical water compositions in the open cuts, and the water quality Design Targets for the Treated Open Cut Water.
Figure 3
DYSONS OPEN CUT
TYPICAL CROSS SECTIONS
After examining various possible means of treatment it was decided to construct a treatment plant based upon an hydroxide precipitation process. It is a process in which hydrated lime (approximately 12,000 tonnes) is used as a source of hydroxyl ions in an aqueous solution (called slurry) to react with the pit water which contains heavy metals. As the concentration of lime and hence the pH of the slurry is increased the heavy metals combine to form hydroxides which precipitate out of the
solution in the order ferric iron, aluminium, cupric copper, zinc, manganese. Manganese, is the most difficult to precipitate and dictates the pH of the outflow from the treatment plant. In addition to the addition of lime, a flocculant is added which causes the fine particles to cling together and form "flocs" which settle out more readily. The treatment plant includes a filter press which accepts the settled pulp which is pumped into its chamber; the pulp is compressed and the filter opened to allow a material termed "filter cake" to fall on to a conveyor which stacks the cake ready for removal. Figure 4 shows the schematic arrangement for the treatment plant.

The filter cake will be buried within the Rum Jungle rehabilitation area. The pit location and method of burial and subsequent revegetation of the burial area will take into account the need to impound the material and prevent future pollution as a result of water infiltration and leaching.

An issue critical to the final treatment process, and the effectiveness and cost of treatment will be the development of stratification in the open cuts resulting from the different densities of the untreated water and the treated water once it is returned to the pits. In the case of Whites Open Cut, it is intended to use compressed air to mix the upper levels (approx 20 metres) of water to ensure that the treated water remains above the untreated water, during the early stages of the water treatment process. During treatment numerous parameters will be monitored to evaluate the effectiveness and stability of the stratification and water treatment.

The treatment plant is due to be commissioned in August 1984, and treat water at 10,000 cubic metres per day. It is intended to operate the plant on a 6 day per week, 24 hour per day basis, using 2 operators per shift under the direction of a day shift supervisor.

Subject to the outcome of treatment it is intended to redive the East Finniss River through the two open cuts to ensure flushing of the upper levels of the pit water during each wet season. Flushing will be promoted by the use of various control structures.

8. MONITORING

A monitoring programme has been developed and is being progressively implemented to allow adequate project management; to verify the validity of design parameters and to provide a basis for evaluating the extent to which project objectives have been achieved, as well as
Figure 4

SCHEMATIC ARRANGEMENT WITH THE WATER TREATMENT PLANT
to assess the long term effects of the programme.

As a guide only, set out below are some general indicators of the types of areas where monitoring is being carried out, excluding monitoring associated with day to day project controls.

Overburden Heap(s) : Water quality profiles; water temperature profiles; water balance within heap; ground water in and around heap; chemical activity; meteorology, erosion of covers and drains, vegetation, radon emanation

Tailings Dam : Radiation including in subsoil, atmospheric dust, revegetation, erosion

Dysons Open Cut : Ground water regime; radon emanation; settlement of fill and associated drainage issues; vegetation

Whites/Intermediate Open Cuts : Water Quality profiles; water temperature profiles; pH; specific conductance; embankment revegetation.

Water Treatment Plant : Water quality and temperature at in flow and out flow; filter cake quantities and properties; filter cake disposal covers and containment

Miscellaneous : Ground water; surface water quality and quantities; sediment load in East Branch of Finniss River; Radiological tests; Biological Status of Finniss River.

One further by-product of the monitoring program should be a better understanding of the issues, and performance of techniques and materials which should be of value to others when considering rehabilitation of other mine sites.

9. REHABILITATION IMPLEMENTATION

The Commonwealth Department of Resources and Energy is the sponsoring Department for the project and are assisted on technical matters by the Commonwealth Department of Housing and Construction plus the
The Northern Territory Department of Transport and Works has the responsibility for managing and implementing the rehabilitation works and liaison with the Commonwealth and is supported with project team representatives provided through the Department of Health and the Northern Territory Conservation Commission.

The majority of the detailed designs are being carried out by Northern Territory based consultants, and where the nature of the work is of a multi-discipline nature, various consultant companies are working together to produce the design and documents necessary to invite public tenders. Assistance has also been provided by the University of New South Wales and University of Western Australia.

Virtually all manufacture, supply and construction works are being undertaken by private enterprise after inviting public tenders.

The consultant engineering firm who designed the water treatment plant is also providing the labour and expertise to manage and operate the water treatment process and to supervise and arrange for the maintenance of the water treatment plant.

The first site-works contract was awarded in April 1983 for the removal of Whites North Overburden Heap and it is intended that, with the exception of ongoing monitoring, the rehabilitation programme at Rum Jungle will be complete by June 1986.