POWER AND WATER AUTHORITY
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JULY 1988

REHABILITATION MONITORING AND
ASSESSMENT AT RUM JUNGLE
NORTHERN TERRITORY

AUSTRALIAN GROUNDWATER
CONSULTANTS PTY LIMITED
1 July, 1988

The Manager
Rum Jungle Project
GPO Box 1096
DARWIN NT 5794

ATTENTION: MR JOHN VERHOEVEN

Dear John.

RE: RUM JUNGLE REHABILITATION
MONITORING STUDIES

Please find enclosed fifteen (15) copies of our report on rehabilitation assessment and maintenance works at Rum Jungle.

We thank you for the opportunity of being involved in the Project, which has been both enjoyable and technically rewarding. Please feel free to contact Peter Ryan or the undersigned with any queries.

Yours faithfully,

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

J. A. GROUNDS
Principal
# POWER AND WATER AUTHORITY

## REHABILITATION MONITORING AND ASSESSMENT AT RUM JUNGLE

### NORTHERN TERRITORY

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1.0 INTRODUCTION

Assessments of several aspects of minesite rehabilitation at the Rum Jungle minesite were conducted by Australian Groundwater Consultants Pty Limited (AGC) in August 1987 and May 1988 on behalf of the Power and Water Authority (PAWA). An interim report was presented in September 1987. This report presents more complete findings and conclusions of the monitoring and assessment works as a result of site inspections conducted on all rehabilitated surfaces in May 1988 (Figure 1). Aspects addressed include drainage works stability, pasture status, slope stability, tree growth, maintenance works, and land use recommendations.

2.0 RESULTS AND RECOMMENDATIONS

2.1 SURFACE DRAINAGE STRUCTURES

2.1.1 Whites Heap

Since construction in September 1984, the rip rapped section (Drain B) of the main runoff drain on Whites Heap has experienced instability. The probable causes of instability of rip rap used in the main drain on Whites Heap were addressed in the interim report (AGC, 1987) and can be summarised as being:

(i) short, over-steep sections of channel,
(ii) rip rap particle sizing and wide tolerance in the <100 mm range,
(iii) possible less than optimum layer thickness.
The interim report (AGC, 1987) recommended the mattressing of damaged sections of rip rap, in addition to extensions to the mattressed outfalls from erosion control drains which discharge surface runoff into the main drain. These works and, in particular, the outfall mattressing, were substantially successful in stabilising active sections of rip rap. However, two significant zones of instability developed during the 1987/1988 wet season (Plates 1 and 2). These zones appear to relate to the location of mitigation works carried out in 1987, whereby mattressing or low gabion structures were to be constructed on previously active zones of rip rap. These works were carried out, with the addition of the construction of gabion weirs across the drain (Plate 1). Movement of rip rap and damage to the drain occurred downstream (and in one case upstream) of the gabion weirs.

Inspection of the damaged sections of drain was conducted with the assistance of Conservation Commission soil conservation specialists in May 1988. There was general agreement that at least one of the gabion weirs had been constructed too high and the downstream mattressed section too short, leading to significant flood damage downstream (Plate 2). In the remaining zones of damage, the precise cause of failure was more difficult to define and the separation of damage attributable to mitigation works from historical (i.e. construction and design works) causes was not possible.

As a result of the site inspections, it is recommended that the damaged sections of rip rap be repaired with mattressing, and the two gabion weirs be substantially lowered. Loose pieces of geotextile fabric should be removed from the drain to minimise the potential for blockage to flow in the drain (Plate 1).

Elsewhere on Whites Heap, surface runoff drains appeared stable and future problem areas were not evident.

2.1.2 Dysons Opencut

Corrective earthworks conducted in 1987 have resulted in shedding of runoff to the main drain. Previously, the low area had accumulated water. The main drain continues to pond water along a 20 m section of subsidence. Remedial measures are not considered economically feasible, or warranted in terms of the potential (low) impact of allowing seasonal ponding to occur.

PLATE 2  Damaged section of rip rap downstream of gabion weir. May 1988.
A small amount of leachate or "groundwater" was observed emanating from the base of the drop structure beneath the main drain (Plate 4). Details of this leachate are discussed in the report by Menkel and Alcock (1988).

2.1.3 Dysons Heap

The rip rapped and mattressed sections of drains on Dysons Heap remain stable. The soil conservation works conducted on the approach track to Dysons in 1987 have been successful in preventing further gullying of the soil covers.

2.1.4 Intermediate Heap

The rip-rap drains of Intermediate Heap are stable and have been colonised in patches by stands of pasture grass. The mattressed sections of drain appear quite stable, with no further slumping evident at the drop structure above the outfall of the main drain.

Minor sheeting of the 2A soil covers either side of the drop structure has occurred. Elsewhere, vegetation and the rock mulch are providing adequate protection of soil covers from surface drainage, and significant zones of erosion are not evident.

2.1.5 Whites North and Copper Heap Leach Area

The contour drainage and outfall systems established on Whites North appear to have been operating effectively. Minor sheeting on the flank of Whites North at the East Finniss channel to Whites Opencut has occurred. Drainage banks on the old Copper Heap Leach area are stable and performing to expectations.

2.1.6 Tailings Dam Area

The main rip rap channel draining the Tailings Dam area is essentially stable. Fine gravels and sands are gradually infilling voids between the rip rap particles, providing a form of cementing matrix (Plate 8). A single point of scour has developed at the confluence of the rip rap drain and the western channel. No remedial action is recommended at this stage. Contour drain outfalls to the drain are stable and performing effectively.

The developing tree belts lining the main rip rap drain are also providing additional stability to the drain surrounds and batters (Plate 8). Relatively minor sheet erosion of the soil cover is occurring in the western sector of the tailings dam, at the break in slope between the pasture covered surface and the western channel batters.

2.1.7 Treatment Plant and Stockpile Area

Drainage structures on these areas consist of a main rip rap channel, contour drain outfalls and contour drains. All structures remain essentially stable and grass cover in the drains is increasing.

The remedial soil conservation works conducted on the old Treatment Plant site have repaired the runoff backfall problems that previously existed. However, some runoff along the vehicular track will inevitably continue to occur. Runoff will probably continue to channel at one side of the track, maintaining the small gully that exists on the track.

2.1.8 Filter Cake Disposal Area

Remedial erosion control works conducted on the Filter Cake Disposal area have been largely successful. The previously existing scour channel in the centre of the site has been successfully stabilised with rip rap and a low mattress outfall.

Minor sheeting is taking place on the northern boundary, however remedial action is not considered necessary at this stage.
2.1.9 Borrow Pits

Attention by the Conservation Commission to ensure effective drainage and recontouring of borrow pits during the operational phases between 1984 and 1986 has resulted in a high standard of borrow pit rehabilitation.

Two borrow pits to the south west of Whites Heap continue to display some batter erosion. These particular pits were sources of IB material and were located in highly erodible weathered granitic material. However, there are signs that vegetation and slope lowering will gradually reduce the degree of erosion.

2.2 PASTURE STATUS

2.2.1 Whites Heap

A high standard of vegetation cover has developed on the surface of Whites Heap (Plate 5). Pastures are dominated by Urochloa mozambicensis (Sabi grass), Stylosanthes hamata (Verano stylo) and Chloris gayana (Rhodes grass). The previously dormant Paspalum notatum (Bahia grass) has made some advances in the past 12 months. The creeping legume Macroptilium atropurpureum (Siratro) is advancing from the batters into the top surface pasture sward.

Overall, the appearance of the pasture is good and an effective erosion cover has been established due primarily to the provision of a soil medium and follow-up maintenance fertilization and slashing.

The naturalised grass Pennisetum pedicellatum (Pennisetum) is a common species on sections of Whites Heap, particularly in the main drain (Drain B). Cynodon dactylon (Couch grass) continues to dominate barren areas, and is often present beneath the taller, more visible grasses. Acacia holosericea shrubs are slowly colonising the top surface and are mostly confined to contour drainage banks and alongside drains. Some 50 specimens were counted.

Vegetation cover over the rock-mulched batters continues to increase. Siratro is the dominant species, in association with annual Sorghum and Heteropogon species. Numerous shrubs of Acacia holosericea have established.
PLATE 5  Whites Heap; view to the north-west, showing good quality pasture cover and colonisation by *Acacia holosericea*. May 1988.

PLATE 6  Intermediate Heap; view to the west showing a dense pasture sward dominated by *Brachiaria decumbens* (Signal grass). May 1988.
2.2.2 Dysons Opencut

Pastures are dominated by Sabi grass, Verano stylo and Rhodes grass. The wet season annuals, *Alysicarpus vaginalis* (Alyce clover) and *Digitaria ciliaris* (Summer grass) are also common. Couch grass appears to dominate minor low-lying areas. Significant amounts of Pennisetum grass have established in the main runoff drain.

The batters of Dysons Opencut exhibit gradually increasing cover by Siratro and an assortment of naturalised and native annual grass species.

2.2.3 Dysons Heap

Pasture development on Dysons Heap has progressed satisfactorily, and, in general, a good protective cover exists. The sward is dominated by Sabi, Rhodes and Bahia grasses, with amounts of *Brachiaria decumbens* (Signal grass). Sections of the drains and outfalls continue to support a cover of *Paspalum plicatulum* (Bryan plicatum) and *Brachiaria mutica* (Para grass).

Patches of native spear grasses are evident in the pastures and on contour bank surfaces. Some colonisation by Siratro, presumably from Dysons Opencut batters, has also occurred.

2.2.4 Intermediate Heap

The pasture sward on Intermediate Heap is noticeably different to other surfaces, being dominated almost exclusively by a dense cover of Signal grass (Plate 6). Verano stylo is present in lesser amounts, and Rhodes grass occurs consistently but in low densities. Trees have not colonised the surface or batters. Batter vegetation is dominated by Siratro, and the naturalised species *Eriachne glauca* (Pan Wanderrie Grass).
2.2.5 Whites North and Copper Heap Leach Area

Pasture cover on both these areas is of a good standard and primarily dominated by Sabi and Rhodes grasses and Verano stylo. Significant amounts of Signal grass occur in the south eastern sector of Whites North. Colonisation by other species has been minimal.

The native shrub and tree species sown as seed along the northern flank of the Copper Heap Leach area have established well. They should continue to provide stability to the discharge channel from Whites Opencut.

2.2.6 Tailings Dam Area

A healthy cover of pasture generally dominated by Sabi, Bahia and Rhodes grasses and Verano stylo, has established on the Tailings Dam site (Plate 7). Noticeable advances by Bahia grass have been made in the past 12 months, particularly in the southern sector.

The tree belts and clumps continue to develop and a dense line of trees, dominated by Acacia holosericea, has established on both sides of the main runoff drain (Plate 8).

Isolated specimens of Mimosa pigra continue to appear in the drainage bank outfalls on the Tailings Dam site (Plate 8 and Section 2.3).

2.2.7 Treatment Plant and Stockpile Areas

Pasture cover on these areas remains somewhat retarded in comparison to the surfaces discussed above. The degree of soil compaction and consequent moisture infiltration rates are the likely reasons. However, the lighter cover does not appear to be detrimental to the erosion status of the surfaces and may be expected to increase with time and favourable seasons.

Sabi and Rhodes grasses dominate, with lesser amounts of Verano stylo. Couch grass occurs in isolated patches and as a common ground cover beneath the taller grasses.
PLATE 7  Tailings Dam area viewed from the old plant site, showing pasture cover and developing tree belts.  Slashing in progress.  May 1984.
PLATE 8  Close up view of main drain on the Tailings Dam area, showing developing tree belts and infilling of rip rap voids with fine material. May 1988.

2.2.8 Filter Cake Disposal Area

Vegetation cover on the disposal area has improved considerably over the 1987/1988 wet season. The site was sown in December 1986 with an extensive mixture of remaining available pasture grass and legume species, and the resultant cover reflects this mixture. The dominant species include Rhodes, Sahi and Couch grasses, and the legumes Verano stylo and Stylosanthes scabra (Seca stylo). Significant numbers of invader species have colonised including, Pennisetum grass, native couch, spear grasses, Wanderrie grass and the common weeds Hyptis suaveolens (Hyptis) and lesser amounts of Sida acuta (Sida). Trees and shrubs have not yet colonised the site.

2.2.9 Borrow Pits

Attention to drainage, recontouring and topsoil respreading aspects during borrow pit operations has resulted in high standard of revegetation (Plate 10). Minor exceptions are generally confined to sections of batter, particularly on the pits located in granitic soil profiles south-west of Whites Heap.

2.3 WEEDS

The commonly occurring weeds, Hyptis and Sida are present to varying degrees on all rehabilitated surfaces. Competition from the pasture grasses has been strong to date, resulting in a general restriction of weed species to the contour drainage banks, and the edges of the rehabilitated heaps. This situation can be expected to continue whilst the vigour of the pasture species (both sown and colonising species) is maintained. This is related to a variety of factors, including soil nutrient levels, seasonal climatic variables, fire, and vegetation density.

Isolated outbreaks of Mimosa pigra continue to occur in consistent locations. These are the drainage outfalls on the Tailings Dam site, the ripped area in front of the sheds/workshops, Borrow Area 3 (immediately east of workshops), and Drain B on Whites Heap. Inspection and eradication of outbreaks at 6 monthly intervals is strongly recommended.

PLATE 11  Original sward of pasture, Tailings Dam area, May 1988. The plot has remained un-mown since planting in December 1984.
2.4 ROCK MULCH STABILITY

Detailed monitoring of the stability transects established in 1985 on Whites Heap was not conducted, since gross movement or failure of the mulch has not occurred on any of the Heaps.

Movement, however, continues to occur in discrete particles. Conversely, vegetation cover across the batters continues to increase, adding stability to the mulch.

Future potential avenues of gross failure of rock mulch, such as failure of sections of 1A clay, or widespread windthrow of colonising trees were not investigated because their occurrence is considered remote.

2.5 SOIL FAUNA

Several species of ants and one species of termite continue to be active on the rehabilitated surfaces. The surface of Whites Heap displays the most diverse array of species and activity, with an active soil fauna in the surface litter layer.

The grass-eating termite Nausitermes triodeae occupies at least 20 mounds, mostly in the north-western sector of Whites Heap surface. The mounds are generally less than 350 mm high and appear to be increasing more in number than individual size. Observation (by eye) of the particle size and quartz particle content of the mounds, and their colour, would indicate that the 1A clay material is not being targeted as a construction material.

2.6 OPENCUT SURROUND

A small proportion of the hand-sown native shrub and tree seed spread around Whites and Dysons Opencuts has established. Acacia holosericea dominates the successful species. A gradual increase over time in the development and diversity of cover is predicted.
2.7 TREE COLONISATION

An extensive search of literature pertaining to the effects of tree roots upon the integrity of compacted clay layers has revealed surprisingly little data. Reference is often made in the literature to potential effects, however, quantification or case studies are absent (Section 4 - References).

On the basis of the trials conducted on site for 18 months between 1985 and 1986, regional observations, and an analysis of tree removal costs/benefits versus stability/aesthetic benefits, some comments are presented:

(i) Endemic trees have the ability to penetrate the IA clay seal. Whilst the Eucalypts on trial maintained their habit to deep root, they confined many major roots to a lateral habit, following the planes of weakness created by compacted lift layers. Acacia species on trial maintained their habit to confine the great bulk of roots in the less compacted, surface layers. However, rootlets were able to penetrate the IA clay.

(ii) Competition from pasture species and Acacia shrubs will delay the colonisation of surfaces by Eucalypt species for an unknown period of time, perhaps several years.

(iii) Colonising trees will need to expend considerable energy penetrating compacted layers, severely retarding their physical development.

(iv) Volumetrically, the pore spaces (and therefore potential pathways) created by tree roots in the IA clay can only constitute a small percentage of the total amount of seal afforded by the IA clay layer.

(v) Windthrow of colonising trees is not considered to be a significant factor on the rehabilitated top surfaces. Windthrow on the batters could potentially lead to local erosion.

(vi) The annual removal of trees entails an annual, permanent maintenance cost estimated to be of the order of $5,000 to $10,000, and increasing with increased tree numbers.
I

Gradually, trees and shrubs will take on some of the erosion protection role currently undertaken by the pastures. Removal of trees will place a greater requirement for pasture maintenance works, and therefore costs.

In terms of floral and faunal population dynamics, the available literature on rehabilitated landforms suggests the attainment of a vegetation community incorporating grasses, shrubs and trees is a more desirable goal.

Consequently, it is recommended that trees not be removed. The characteristics of colonisation and the effects of trees upon the integrity of the covers at Rum Jungle should be specifically addressed, again, within the next two years.

2.8 PASTURE MAINTENANCE

2.8.1 Soil Chemistry and Implications

From an agronomic point of view, the soils at Rum Jungle in which pastures are establishing have a low nutrient status (Table 1).
### TABLE 1
TAILINGS DAM AREA SOIL COVER – SELECTED ANALYSES

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<th>SOIL DEPTH (mm)</th>
<th>0 - 100</th>
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#### GENERAL PARAMETERS

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<td>EC mS/cm (May 1988)</td>
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#### NUTRIENTS (ppm)

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<td>N/R</td>
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<tr>
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#### SPECIFIC ELEMENTS (ppm)

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<tr>
<td>S</td>
<td>30</td>
<td></td>
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1. Located adjacent to the southern grazing/mowing enclosure (TD1).
4. N/R Not recorded.
The analytical results for the common nutrients required for plant growth (nitrogen, phosphorus, potassium and sulphur) for May 1988 (Table 1) show the available nutrient levels for a soil profile through the Tailings Dam soil cover system. Levels of N, P and K are low whilst S is adequate. Comparison of these levels, however, with those recorded from the same site in November, 1986 show the benefits of maintenance fertilizing between 1986 and 1988 whereby the more stable nutrients, P and K, have built up from extremely low to low levels.

Soil pH and conductivity remain at stable and desirable levels, whilst the levels of specific elements in Table 1 do not indicate abnormal migration of elements from the old tailings subsoil into the overlying soil covers. The recorded level of 150 ppm Cu at depth is, however, an indication of the presence of metals in the old subsoil and probably reflects some mixing of soil cover with subsoil.

The higher pH of the lower-most layer of soil covers (400 mm depth) is a reflection of the residual lime that is still visible in soil samples from depth.

In terms of the natural soil systems surrounding the rehabilitated surfaces at Rum Jungle, the levels of soil nutrients are not abnormal. Thus, discussion of the nutrient status of Rum Jungle soil covers should be made only in conjunction with discussion of the intended land use of the site.

2.8.2 Land Use Options and Recommendations for Pasture Maintenance

With regular maintenance fertilization, the rehabilitated surfaces at Rum Jungle are currently capable of supporting light forms of primary production, such as grazing or annual hay cutting. Without maintenance, soil nutrient levels are insufficient to support such land use.

Additional land use options fall in the more passive category, and include light visitor use, research and rehabilitation monitoring, and simply leaving the site alone.

Primary production is not a recommended form of land use at Rum Jungle, unless a commitment to maintenance fertilization is guaranteed. Given the decreasing financial commitment to the site, this would appear to be an unlikely development. Activities such as hay cutting and grazing without fertilization will remove large amounts of available nutrient, to the detriment of vegetation cover. Commonly, about 180 kg of nitrogen per hectare is removed in clippings from maintained pastures.
If funds permit, fertilization of pastures with a compound (NPK) fertilizer in the 1988/1989 or 1989/1990 wet season is recommended. A similar recommendation for an annual slashing towards the end of the wet is also made.

Without maintenance, and in particular, slashing, pastures will gradually develop a thicker, taller habit with increasing colonisation by native and neutralised species (Plate 11). Species used in the rehabilitation of batters such as Siratro, will also tend to colonise for the first few years. Fires will burn "hotter" due to the increased amount of combustible matter, and native Acacia shrubs *Acacia holosericea*, in particular, will probably tend to be replaced over time with the fire-favourable species such as the eucalypts.

Thus, a balance between the currently maintained pastures and a no-maintenance policy is recommended. Slashing and fertilizing on an ever-reducing frequency should allow the phasing in of a no-maintenance policy.

It is strongly recommended that the pasture status and maintenance issues be reviewed in 12 months time. Fire breaks should be re-instated around the site. This will not exclude fires, but should reduce their frequency and extent.

### 3.0 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

#### 3.1 LAND USE/MAINTENANCE

Primary production without a guaranteed commitment to fertilization and activities supervision is not recommended.

A decreasing level of current maintenance practices is recommended. Review in 12 months is recommended.

Controlled visitor use of the site, with the provision to visitors of an accurate summary of the project's history (i.e. an official handout sheet), is recommended.

Unrestricted vehicular use of the site is not recommended.

Regular eradication of *Mimosa pigra* outbreaks is recommended. The Department of Industry and Development may be able to provide assistance with control.
Tree eradication programmes are currently not considered necessary. However, a review of the situation within the next 12 months is recommended.

A low level of monitoring of the issues investigated in this report is strongly recommended. This could be simply achieved, and take the form of inspections at 12 monthly intervals.

3.2 PROVISION OF MONITORING RESULTS

The rehabilitation of Rum Jungle will continue to provide both government legislators and the mining industry with valuable data with respect to more effective mine regulation and decommissioning.

Assessment of the success of the project in the form of revegetation, and surface stability monitoring is therefore recommended at an appropriate and economically practical level. Also, as part of Project assessment, it is understood that the appropriate agencies will be seeking a continuance to water quality monitoring programmes. The dissemination of the results of monitoring programmes to the appropriate authorities and industry personnel is an important adjunct to monitoring programmes.

4.0 SELECTED REFERENCES


Redrawn from P.A.W.A. figures