RUM JUNGLE
REHABILITATION PROJECT

IMPLEMENTATION REPORT

VOLUME 1 REPORT

OCTOBER 1981

PREPARED BY

DEPARTMENT OF TRANSPORT AND WORKS

- WATER DIVISION

INDEX

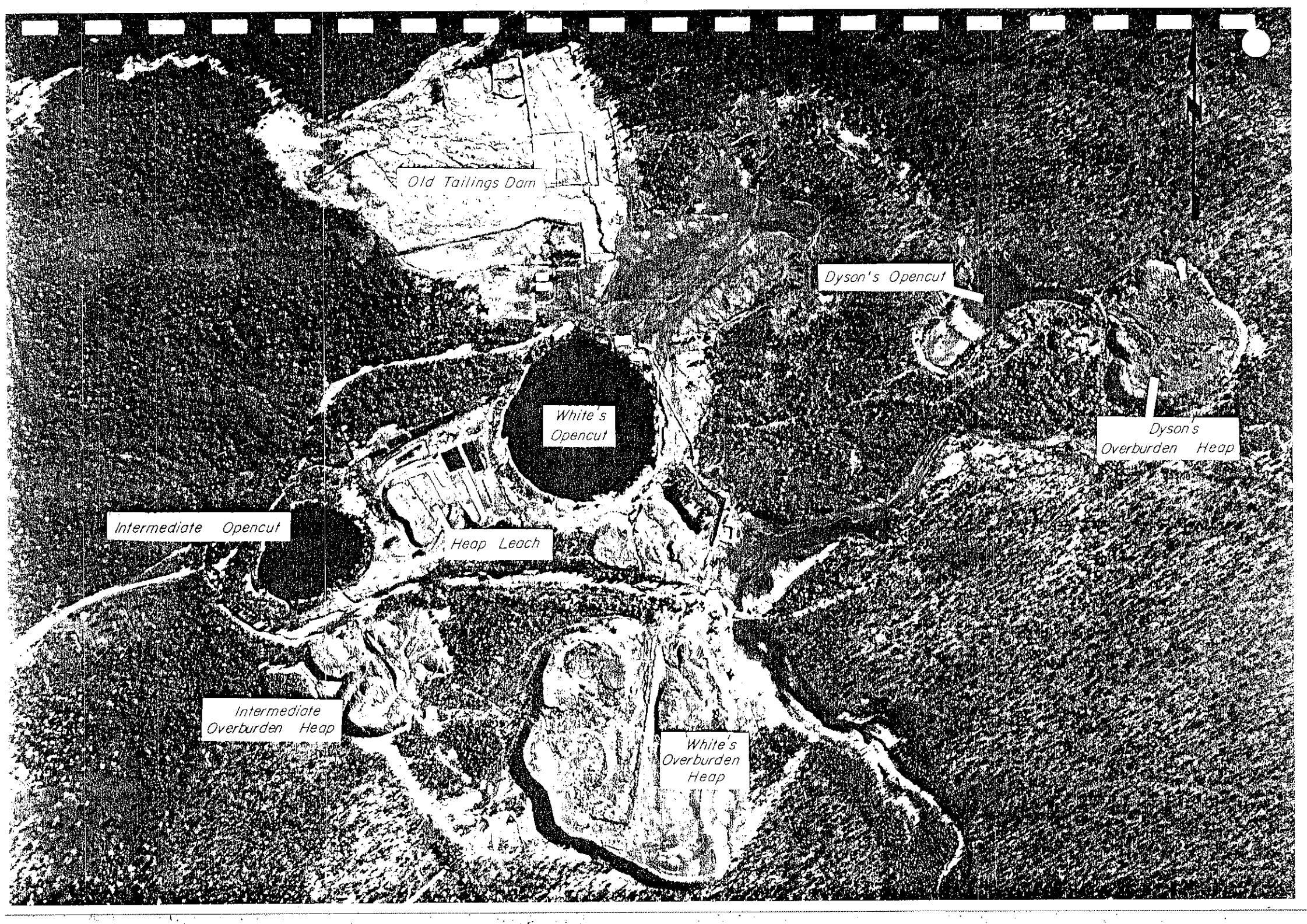
INTRODUCTION

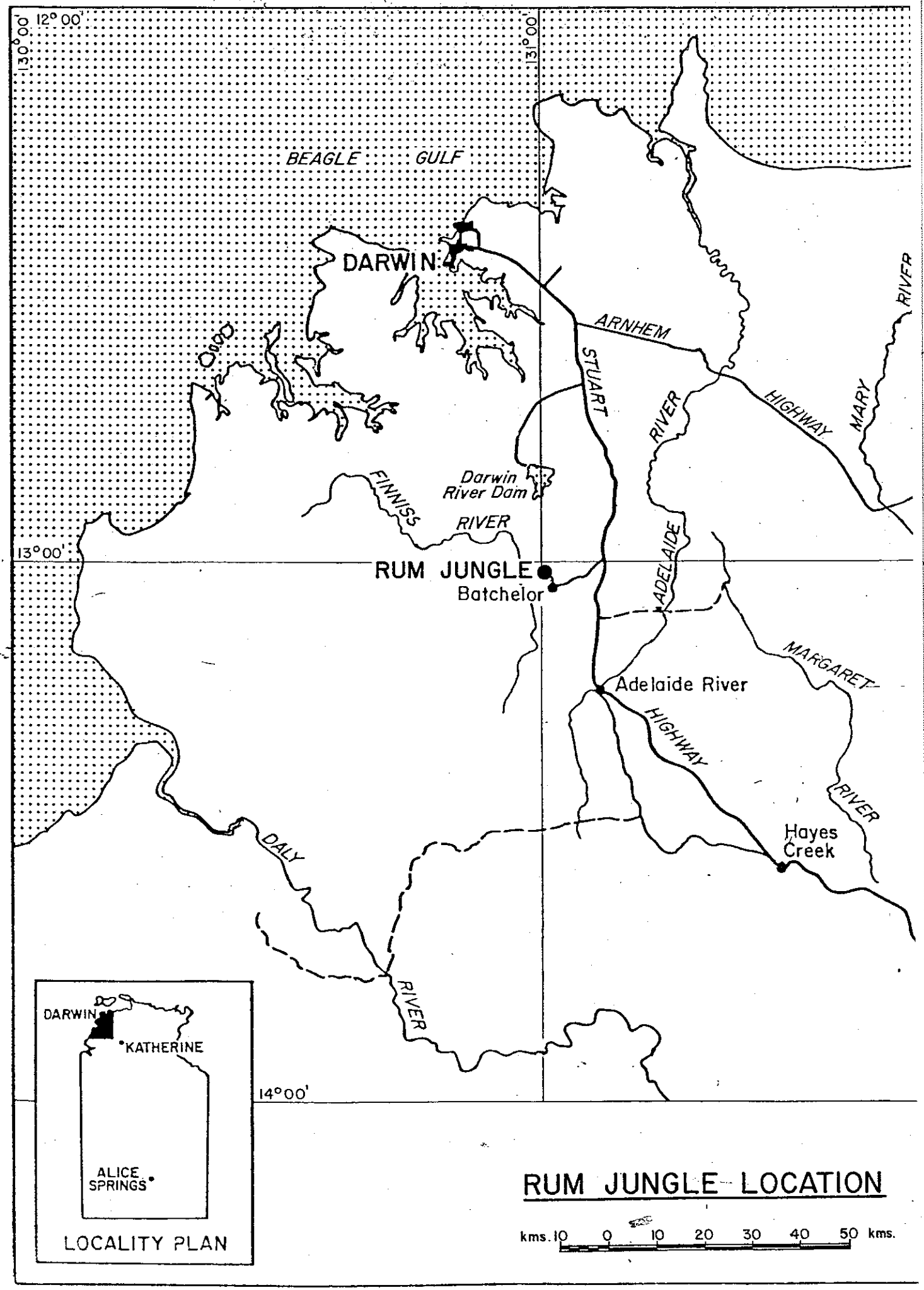
On behalf of the Northern Territory Government, the Department of Transport and Works has prepared a detailed implementation report to be used as a guide for the Rum Jungle rehabilitation works.

The general scope of the work considered in this report was described in the Working Group's 'Summary' presented to the Commonwealth Department of National Development and Energy in 1978. The Commonwealth Government subsequently accepted 'Option D' proposals to achieve an annual average reduction in heavy metal releases to the East Branch of the Finniss River in the order of 70 % for copper, 55 % for manganese and 70 % for zinc as a suitable level of pollution reduction and agreed in principle with the Chief Minister for the Northern Territory to have the restoration works carried out utilising available resources within the Northern Territory Government agencies.

This report has described the activities required to implement all phases of the programme and identified the problems that have still to be resolved before 'Option D' proposals can be confirmed to provide the degree of pollution reduction anticipated by the Commonwealth Government. This report has not attempted to solve any of the problems raised in the 'Summary', but it has considered the services needed to assist in reaching a final solution, and provided the necessary activities in the overall implementation programme.

The costs of the project have been reviewed and the expected levels of estimate confidence has been included for the various stages of the project. Some estimates have been presented in this report for the first time, others have been taken from previous documents.

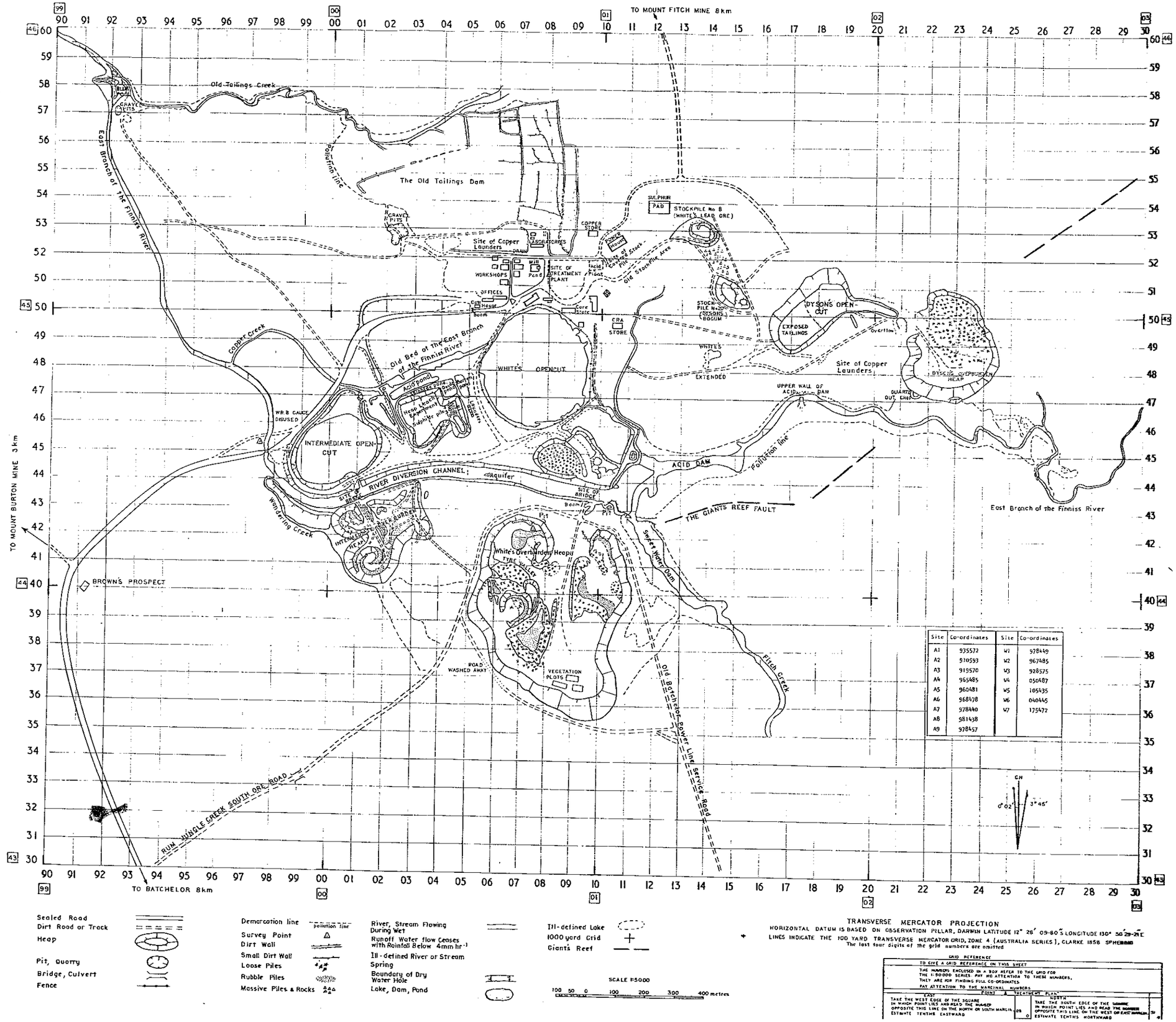

Old Tailings Dam
Dyson's Opencut
White's Opencut
Dyson's Overburden Heap
Intermediate Opencut
Heap Leach
Intermediate Overburden Heap
White's Overburden Heap


12° 00'
130° 00'
131° 00'
BEAGLE GULF
DARWIN
ARNHEM
STUART
RIVER
HIGHWAY
MARY
RIVER
Darwin
River Dam
FINNISS
RIVER
13° 00'
RUM JUNGLE
Batchelor
ADELAIDE
MARGARET
Adelaide River
HIGHWAY
RIVER
Hayes
Creek
DALY
RIVER
14° 00'
DARWIN
KATHERINE
ALICE
SPRINGS
LOCALITY PLAN
RUM JUNGLE LOCATION
kms. 10 0 10 20 30 40 50 kms.

MAP 2·4
THE RUM JUNGLE MINE

1:5000

DRAWN. R.T. LOWSON. APRIL 1974



Site	Co-ordinates	Site	Co-ordinates
A1	935572	W1	978449
A2	970593	W2	967485
A3	919570	W3	928575
A4	965485	W4	050487
A5	960481	W5	105435
A6	968478	W6	040445
A7	978440	W7	175472
A8	981438		
A9	978457		

GN
0° 02'
3° 45'

Sealed Road
Dirt Road or Track
Heap
Pit, Quarry
Bridge, Culvert
Fence

Demarcation line
Survey Point
Dirt Wall
Small Dirt Wall
Loose Piles
Rubble Piles
Massive Piles & Rocks

River, Stream Flowing During Wet
Runoff Water flow Ceases with Rainfall Below 4mm hr⁻¹
Ill-defined River or Stream
Spring
Boundary of Dry Water Hole
Lake, Dam, Pond

Ill-defined Lake
1000 yard Grid
Giants Reef

SCALE 1:5000
100 50 0 100 200 300 400 metres

TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM IS BASED ON OBSERVATION PILLAR, DARWIN LATITUDE 12° 28' 09·80"S LONGITUDE 130° 50' 29·21"E
LINES INDICATE THE 100 YARD TRANSVERSE MERCATOR GRID, ZONE 4 (AUSTRALIA SERIES), CLARKE 1858 SPHEROID
The last four digits of the grid numbers are omitted

GRID REFERENCE
TO GIVE A GRID REFERENCE ON THIS SHEET
THE NUMBERS ENCLOSED IN A BOX REFER TO THE GRID FOR THE 1:50000 SERIES. PAY NO ATTENTION TO THESE NUMBERS, THEY ARE FOR FINDING FULL CO-ORDINATES
PAY ATTENTION TO THE MARGINAL NUMBERS

POINT	EASTWARD	NORTHWARD
A	TAKE THE WEST EDGE OF THE SQUARE IN WHICH POINT LIES AND READ THE NUMBER OPPOSITE THIS LINE ON THE NORTH OR SOUTH MARGIN. ESTIMATE TENTHS EASTWARD	TAKE THE SOUTH EDGE OF THE SQUARE IN WHICH POINT LIES AND READ THE NUMBER OPPOSITE THIS LINE ON THE WEST OR EAST MARGIN. ESTIMATE TENTHS NORTHWARD

LIST OF ABBREVIATIONS

Northern Territory Government departments, divisions, sections and agencies	:	N.T. Govt. Depts.
Commonwealth Department of National Development and Energy	:	NATDEV
Commonwealth Department of Housing and Construction	:	D.H.C.
Australian Atomic Energy Commission	:	A.A.E.C.
Plasticity Index	:	P.I.

SECTION 1

TERMS OF REFERENCE

1.1 The Commission of the Project Group

On 25 September, 1981 the Dept. of Transport and Works established a project group to prepare a detailed implementation report for the rehabilitation of Rum Jungle.

Scope: The report was to include;

(a) the problem

(b) a review of acceptable standards and define what end result the N.T. and Commonwealth were aiming to achieve

(c) how it is proposed to tackle the problem including the resources envisaged and cost estimates of those resources (with qualifications as appropriate)

(d) the capacity of the N.T. Govt. to undertake the task.

Time: The report to be completed by 27 October, 1981 ready for presentation and subsequent discussions with representatives from Depts. of the Commonwealth Govt.

Controlling Dept: The project study to be under the direct control of the Director of Water Division, Dept. of Transport and Works reporting to the Chief Executive Officer, or Secretary and inter-Government Review Committee.

1.2 Objectives of the Report

Since 1969 a number of studies and proposed solutions have been put forward for discussion with the objective of finding satisfactory means of reducing the level of pollutants presently identified at Rum Jungle.

In 1978 the Working Group formed by the N.T. Govt. reviewed the previous studies and presented a number of qualified recommendations for solutions to identified problems.

From the various alternatives put forward in the 'Summary' the Commonwealth Govt. selected 'Option D' proposals as the most appropriate solution giving regard to the potential reduction in pollution sources and the cost of implementing such rehabilitation works.

It is the intention of the project group preparing this report to present a detailed implementation plan that will identify all unresolved problems put forward in the 'Option D' proposal, and explain the services required to complete technical investigations that will in turn assist the detailed design and site works phase to proceed with confidence.

It is important that the completed works has a quantitative means to measure any degree of success achieved. For this reason the report has considered it necessary to develop a set of acceptable standards to provide the necessary base for measurement prior to, during and after rehabilitation.

The requirement to reduce pollution levels of heavy metals cannot be easily measured, but the establishment of a sensible set of standards covering water quality, radiation emission, radon emanation, flora revegetation and fauna rehabilitation which will take into account all aspects of the previous mining operations, current pollution levels, present day environmental standards and future use of the land is an objective of this report.

The methods to be employed for correction of the existing problems have to be decided using 'best practicable technology' with regard to the cost and the overall benefit. The implementation programme recognises the requirement to provide solutions that will endure a period of time. This report has recommended the collection of further information which will permit design decisions to be taken with a higher level of confidence than can be presently achieved, to ensure that the stated life of the rehabilitation work is achieved.

The resources to carry out the tasks necessary for a timely completion of the works have been critically examined. The proposed method of execution and make up of the project task force team has considered the expertise needed to resolve the technical problems that lie ahead, management of expenditure to provide the maximum cost benefit results, and retainment, by the N.T. Govt., of expertise gained on the project. The proposed management team will be structured with the aim of resolving the necessary problems, completing the works on time, within budget and achieving the anticipated results in pollution control.

1.3 Relevant Documents for Background Information

The relevant background information required for this report has been primarily drawn from three reports:

1. The 'Summary' - prepared by the N.T. Govt. Working Group and presented to the Commonwealth Dept. of National Development and Energy in April 1978.

It is assumed that the 'Summary' correctly interpreted all other previous technical papers and reports summarized within it and there has been no objections raised to the accuracy of the information contained therein.

2. 'Document A' - 'Capital Cost for 'Option D' Strategy' - prepared by the Commonwealth Dept. of Housing and Construction, Canberra region, September 1979.

3. 'Document B' - 'Preliminary Construction Strategy for 'Option D' - prepared by the Commonwealth Dept. of Housing and Construction, S.A./N.T. region, August 1980.

For reference, these three reports have been included under separate cover as Appendicies 1, 2 and 3 respectively, thus preventing the need to include lengthy transcripts of various sections in this report. Where necessary a brief summary of these documents will be included together with the appropriate reference to the Appendicies.

SECTION 2

PROJECT TASK FORCE

2.1 General Structure of Task Force

To effectively manage a project of this magnitude and complexity, resources from a number of areas will be necessary to form a project task force that has the ability to solve technically complex problems which relate to sensitive environmental issues, provide proper documentation and directions to site contractors, establish an environmental monitoring programme that is reliable and effectively co-ordinate all activities to ensure planned progress is maintained with proper budgetary control.

It is proposed that the task force shall comprise the following :

Project Management

A conventional project management task force is recommended for the proper co-ordination and supervision of all assigned staff and activities.

The positions indicated on the task force organisation chart (see Section 2.4) will be drawn from Dept. of Transport and Works other N.T. Govt. Depts. and contracted services where necessary.

Each N.T. Govt. Dept. with an interest in the project will be requested to appoint a representative who will co-ordinate the activities of his Dept.

The representative shall be responsible for his Depts. performance, for the collection of base line data to establish a reference bank for future monitoring works and provision of necessary services to carry out initial investigations for use during the detailed design phase when resolving the rehabilitation methods to be employed in each specific area. In some cases short term contract staff will be employed by the Depts. to maintain the present objectives of permanent staff level projection by the N.T. Govt.

The services that will be the responsibility of each N.T. Govt. Dept. have been detailed in Section 2.3 of this report.

Once investigation data has been collected and reported to the project task force, the N.T. Depts. will maintain an ongoing monitoring programme during and after the rehabilitation works.

The appointed Departmental representatives will assist the project task force in assessment of engineering decisions. They will be asked to advise on all aspects of the project including the likelihood of achieving the standards set for the project, as more data becomes available.

During the detailed design phase the project task force will require the Departmental representatives to co-ordinate ongoing N.T. Govt. Dept. activities and review the methods to be employed, any problems the designs may create and implementation of any new techniques or restrictions considered necessary by the Committee.

Once the principle of engineering design has been agreed, the preparation of detailed design and documentation will be carried out by using the Department of Transport and Works and contracted engineering services.

Tender preparation and contract administration of all site works shall be the responsibility of the project task force and the expert staff who will be assigned to the project as the need arises.

It should be noted that the project must proceed with a strong interaction between investigation works, engineering studies and final detailed design. Once final recommendations have been accepted, the detailed design can be completed. Some problems will take longer to resolve than others due mainly to the collection of seasonal base line data. The N.T. departmental representatives will have a necessary function for the duration of the project for continuity of expert opinion at all stages.

Project Administration

The project task force will have the responsibility to recommend payment for services rendered to the project. The services from N.T. Govt. Depts. will be treated in a similar manner for cost approval as the private sector services, where all hours expended by full or part time staff should be allocated on weekly time sheets for approval by the Departmental representatives assigned to the project task force. Incidental expenses such as airfares, freight charges, printing services etc. will be dispursed to the project by each Department. Any Departmental equipment used on the project will be charged at a rate to be recommended by the project administration section after consultation with the respective departments, agencies and Treasury.

The project administration section will have the responsibility for all certification of expenditure.

2.2 Project Resource Requirements

This section has examined the sources of potential resources for a project of this nature. A somewhat unique make up of the project task force has been proposed with the necessity to draw on resources from various sectors.

The complexity of the problems involved and the alternatives to be employed, require a great deal of expert opinion to be made available to the project task force. The standards of Govt. and public acceptability to environmental problems are becoming more stringent each year which require the project task force to be aware of changing parameters during the course of the rehabilitation works. It is considered appropriate for this reason to have all N.T. Govt. Depts. regulatory services represented in the project task force to advise on any changes of standards and review them against those which have been outlined in this report.

The N.T. Govt. facilities were independently assessed and were found to have the capacity to perform most investigatory and monitoring functions required for this project without any premium cost over comparable consultant services.

The expertise within the N.T. Govt. in radioactive material handling and monitoring, water quality standards, surveying services, soil investigation services, revegetation techniques and knowledge of the Rum Jungle problems is of great benefit which must be utilised on the project.

The resources of the N.T. Govt. Depts. have been described in further detail in Section 2.3.

The use of consultants is considered necessary so that expert opinion is available to assist in achieving better resolution of technical problems. One specific example is the design of an impervious cap for the stockpiles. It is one of the complex problems that has not been resolved by past studies.

Opinions put forward for this project when compared to future methods in the Alligator Rivers region, reflect a divergence of design parameters. The proposed depth of cover varies considerably which relates to the factors used for its life expectancy.

The variance of opinion has a marked effect on the final cost of the project hence it may be necessary to seek other expert opinions that can be reviewed by the project task force before reaching a final conclusion.

Assistance to the Dept. of Transport and Works materials section may be necessary for detailed soils investigations of the area to ascertain quantities available, suitability and design parameters. This work is extremely important to the selection of methods to seal the stockpiles.

It may be necessary to embark on joint studies to achieve the best results. The studies will have a finite time scale, which will place a sense of urgency on them and only permit positive proposals to be persued.

These studies may include:

- Water treatment methods and a satisfactory release of treated water from the open cut pits.

- Groundwater use to assist with treated water flushing during the dry season.

- Soil models to determine expected life of the clay cap concept.

- Soil loss equation model in conjunction with the Conservation Commission.

- Metallurgical evaluation of existing overburden heaps to establish the amount and condition of pyrites and sulphates.

- Investigations to inhibit the bacterial action producing acidic conditions in the overburden stockpiles.

- pH-oxygen effects on metal stability in ore stockpiles.

In most cases the N.T. Govt. will provide the necessary field staff and equipment to collect the necessary data. The role of the consultant will be to evaluate results and provide opinions for discussion by the project task force. If not considered necessary to draw on large manpower requirements from this sector, only individual expert opinions when considered appropriate.

Detailed Design and Documentation Resources

The detailed design and documentation of major earthworks specifications, treatment plant, protection fences, temporary diversion works and permanent on site monitoring stations, should be carried out by the joint efforts of the project task force, and contracted engineering services. The interaction between the investigations, seasonal periods when certain works must be completed and the necessity for N.T./Commonwealth Govt. review, may place limitations on the division of potential packages and demand that the detailed engineering remain under close control of the project task force.

Specialist Advisory Resources

The Australian Atomic Energy Commission and the Dept. of Housing and Construction have offered their services to the project which has been accepted by the N.T. Govt. The project group preparing this report consider the project would be best served by both Depts. in the following manner.

Australian Atomic Energy Commission: (A.A.E.C.)

The vast knowledge of the Rum Jungle problems and the experience gained in the area would provide valuable assistance to the project task force throughout the project. It would be considered appropriate to have one member of the A.A.E.C. assigned to the project for its duration who will be called upon to review the results gained from N.T. Govt. Depts. or be requested to engage other A.A.E.C. staff to carry out specific studies or detailed reviews as the case may be. In this way the experience of the A.A.E.C. can be drawn on to provide guidance on technical problems that require detailed understanding of local conditions or previous investigations and provide comment on any new technology that may be appropriate to the subject.

The use of the A.A.E.C. should be confined to provide opinions and guidance rather than a large commitment of manpower to carry out detailed investigation programmes that may well prevent the appropriate time being available to review all problems requested by the project task force.

Department of Housing and Construction:

In the same context as the A.A.E.C. consulting role, the project group consider the D.H.C. would provide valuable assistance in the review of regular reports, provided by the project task force, on the methods to be employed and in particular the detailed estimates associated with the selected methods. The order of accuracy of the previous estimates has been discussed in Section 7.1 of this report. Briefly, the estimates put forward in the 'Summary' and 'Document A' have been heavily qualified. The final value can be affected dramatically by the selected solutions to the method of water treatment and the impervious stockpile cover. Therefore the use of the D.H.C. as a review group who can confirm and critically review the proposed methods and comment on the accuracy of the estimates put forward would be beneficial to the project. It is considered vitally important that the project task force be able to communicate directly with the D.H.C. on technical matters. It should be clearly understood at this stage that the final cost of the works cannot be accurately predicted due to the

problems yet to be resolved and because of this, the use of the D.H.C. in the role described is considered necessary for progressive review of budgets as estimates become realistic.

The technical expertise of the D.H.C. will obviously be of benefit to the project task force during the course of the project. The experiences gained from rehabilitation works at Captain's Flat may provide valuable assistance, but as with most projects the decisions to be made are closely related to local conditions, investigation results and in this case, standards set up by the 'Committee'.

It is not considered necessary to have the D.H.C. carry out major design and documentation but rather give opinions and guidance at various stages of the project.

It is not considered necessary to have a full time representative of the D.H.C. assigned to the project but one point of contact for the duration of the works would be desirable.

Resources for Site Works

The site works have five (5) major classifications for resource considerations.

1. Permanent structures and preparatory site works for the initial investigation works and equipment for long term monitoring programmes.

2. Bulk earthworks.

3. Water treatment plant and supply of associated chemicals.

4. Protective fencing.

5. Revegetation works.

Permanent Structures - the permanent structures such as stream monitoring stations, an on site laboratory, meteorological towers for wind, temperature and humidity monitoring can all be contracted on a job by job basis to the Dept. of Transport and Works. The use of N.T. Govt. day labour gangs or local contractors for this work can only be decided when the scope of the work is fully specified and the availability of N.T. Govt. 'day labour' or contractor resources have been identified in a specific time frame.

Specialised monitoring equipment required for initial investigations and long term monitoring programmes will be purchased from project funds by the N.T. Govt. Depts. but shall remain under the control of the project task force to ensure it remains at the project's disposal until completion of all necessary works for which that equipment is required.

Bulk earthworks - the magnitude of the work in this section is extensive and will require careful consideration of local and interstate contractor's capacity to perform the works. For contract works greater than $1 ; million, it is proposed to request pre-tender registration and categorise interested companies, then provide contract packages that can be effectively managed by the different sized contractors.

The requirement for a site construction camp has been briefly reviewed. The project schedule and estimates has provided for a staff caravan park at Batchelor and would not propose a major construction camp until the contractors requirements had been investigated. A detailed manpower analysis is required before any decisions on camps can be taken.

Water treatment plant - lime supply - when design is completed the specifications will be fully detailed to allow construction by local contractors. The overall responsibility for the plant's operation would remain the responsibility of the project task force to allow participation by local contractors. The overall benefit of a 'performance' plant would probably limit the number of organisations that would be prepared to offer their services.

The supply of lime will be a major decision as it may require the purchase of approximately 15,000 tonnes of quick lime (CaO) from a local or interstate source. A detailed investigation will be required before the engagement of a supplier, to ascertain reliability of supply and a competetive price.

Protective fencing - to be fully specified by project consultants and contracted on a competitive tender basis to local contractors.

Revegetation works - the Conservation Commission would provide the required direction for this work. The revegetation programme will be a progressive operation that would be best carried out with contracted labour, equipment and materials from local sources. The Conservation Commission would be required to provide a suitably trained officer to assist with initial design criteria, investigations and the site activities.

In summary the review of resources available to properly manage and implement the rehabilitation programme has not found any major problem provided the project task force uses N.T. Govt. expertise and some consultant assistance to augment existing technical skills and provide a wide spectrum of opinions. The assessment of contractor resources cannot be stated with any high degree of confidence at this stage but it should not cause any major difficulties. Interstate contractors must be considered along with locally based companies.

2.3 N.T. Govt. Resources - support to project task force

The N.T. Govt. Depts. have the key role to play in the successful implementation of the rehabilitation works.

The programmes outlined in this section are essential to the success of the project and will be supervised by the respective Depts., in some cases using contracted staff to supplement staff levels.

2.3.1 Surface Hydrology and Water Quality Programme

The Water Division of the Dept. of Transport and Works will provide a full time representative to the project task force. He will be responsible for implementing all programmes and reporting all results to the project task force. The programmes to be undertaken by the Dept. are described in detail under Section 4.0. They will generally include:

- Intensive stream flow monitoring during the wet seasons from 1981/82 for two (2) successive years then after that for eight (8) years on a reduced level of intensity.

- Surface and groundwater quality testing to complement stream flow monitoring.

- Progressive review of results against project standards and provision of design criteria for major rehabilitation works.

- Review consultant's reports for proposed methods to adequately treat acidic water and release systems to the Finniss River.

. Laboratory studies to provide data for:

(a) alternative chemical treatment methods that may provide a lower level of dissolved solids.

(b) further tests using quick lime suspensions to improve sedimentation characteristics.

The Water Division would require an additional three (3) field assistants and one (1) laboratory assistant to effectively carry out the programme. The current laboratory facilities and level of supervision is adequate to take on an assignment of this magnitude.

2.3.2 Groundwater Monitoring Stations

The Water Division has the necessary expertise to provide the required facilities, however the long term commitment of senior staff to provide analysis of results and design of remedial systems is not possible with other Division works.

It is proposed that a competent consultant be engaged to supervise the groundwater drilling and monitoring programme plus co-ordination of results being taken from surface hydrological stations.

The Water Division will carry out all drilling of production and observation bores, installation of monitoring equipment, pump tests and other related activities. The results from both groundwater and surface tests will be used to provide an integrated interpretation of the area, water balances, level of pollution present, total available water and recommended design parameters in the general terms of 'Option D' proposals.

2.3.3. Radiation and Radon Emanation Investigations

The Dept. of Health will be required to appoint a representative to the project task force to implement a detailed survey of the tailings dam area and other areas of interest around the site.

Once a report is completed the project task force will require assistance in interpretation for design parameters.

It may be necessary to carry out site pilot tests on impermeable clay cap layers to ascertain optimum thickness for cover design which will require assistance from the Dept. of Health.

In the event that the tailings dam may be shifted, regulatory procedures for men and equipment will be required during the site works phase and an overall safety programme with an appropriately trained officer on site will be the responsibility of this Dept.

An additional two (2) suitably trained personnel will be required. New equipment will be required and should be purchased and controlled in the manner previously described.

2.3.4 Topographical and Control Survey

Detailed contour maps have been recently completed for the region that should permit accurate take off of earthworks, quantities and detailed engineering design of new works.

It will be necessary to carry out some check survey work to confirm the accuracy of major features on the maps, provide a control survey for location of water monitoring stations and the co-ordinates for radiation surveys.

The Water Division have survey teams available and will carry out the initial control survey but contracted services will be required for survey committments during the site works stage. The current number of Water Division survey parties and planned work load in the first quarter of 1982 will permit the use of this service without any additional labour or equipment.

2.3.5 Soils Investigations and Classification

The extent of investigations required to fully design a suitable long life impervious layer using local Rum Jungle materials and the identification of a possible 800,000 m^3 of clays and soils is a major assignment with a major influence on the final project costs. Experienced opinions are considered necessary together with the laboratory facilities to carry out permeability tests. It is recommended that this work be carried by a joint N.T. Roads division/consultant effort to provide detailed design parameters. The Roads Division will carry out all site investigations, laboratory analysis and recommended blend for a high P.I., low permeable material from selected local materials.

2.3.6 Revegetation Programmes

The Conservation Commission has been closely involved with the Rum Jungle problems and have already conducted a number of local trials to determine suitable revegetation methods.

The requirement of the Commission will be on a part time advisory capacity during the first two (2) years of the project but when revegetation work commences, a full time field officer will be required to plan and implement the works in co-operation with the project task force site supervisory team. This report recommends the use of the Commission with one (1) additional officer during the initial 6 month investigation stage and one (1) additional assistant for the duration of the site works.

2.3.7 Mining Tenements and Studies

The mining companies that hold current licences in the area will require co-ordination to prevent any disruptions to both the rehabilitation activities and the exploration works. The Dept. of Mines & Energy will be used to negotiate with the mining companies and provide the necessary guidance to the project task force.

The metallurgical assay studies and geochemical investigations will require the services of the same department.

The geological history of the area will be required for groundwater evaluation and the records contained in the 'Mines & Energy' archives should be sufficient for these purposes. The need to carry out geological drilling in the area has not been considered necessary with this information available. Information has not been examined in detail during the time of this reports preparation so the programme and estimates may have to be reviewed at a later date.

2.4 Project Task Force - Organisation Chart

Drawing NT-DTW-001 outlines the proposed task force structure and the resources to be used during the project. The services of the Govt. Depts. may be full time during parts of the project on an 'as required' basis.

The engineering studies undertaken by the project task force to provide final design criteria will be largely completed by the N.T. Govt. departments. The use of consultants may not be necessary if the project task force is satisfied with the results and in turn are prepared to recommend the methods chosen, to the Project Director. In the event that the project task force consider it appropriate to call on a consultant for a second opinion, it will only require the engagement of an experienced person with the required expertise.

It is not envisaged to use consultants for large manpower requirements, only individual experts when considered appropriate.

64,000

DEPT. OF TRANSPORT & WORKS.
PROJECT DIRECTOR.

APPROPRIATE N.T. GOVT./ COMMONWEALTH AUTHORITY

PROJECT MANAGER.

PROJECT ADMIN.

A.A.E.C. & D.H.C. ADVISORS.

CO-ORD. GEN.

LANDS DEPT.

TREASURY DEPT.

N. T. GOVT. DEPT. REPRESENTATIVES.

core

SENIOR DESIGN INVESTIGAT'S. PROJECT ENGINEER. FOR CONSULTANTS, SERVICES & STUDIES.

SENIOR CONSTRUCTION PROJECT ENG. RESPONSIBLE FOR SITE WORKS

CONTRACTS ENG. DOCUMENTS/TENDERS

CONTRACTS OFFICERS

DEPT. HEALTH.

ROADS DIVISION.

MINES & ENERGY.

WATER DIVISION.

CONSERV. COMM.

GROUND WATER CONSULTANTS

SOILS CONSULTANTS

METALLURGICAL CONSULTANTS

WATER TREAT. PROCESS CONSUL.

SITE CONSTR. ENGINEER.

HYDROLOGY / GROUND WATER SITE WORKS

DESIGN OF COVERS SELECTION SURVEY FOR MATERIALS.

GEOCHEMICAL & GEOPHYISICAL ANALYSES FOR METAL STABILITY.

DESIGN OF BEST WATER TREATMENT METHODS.

SITE SUPERINTENDENT

SITE ENGINEER.

SUPERVISORS FOR EARTHWORKS, INVESTIGATIONS, WATER TREATMENT, SAFETY.

LAND QUANTITY SURVEYOR FOR TECHNICAL ASSISTANCE

DEPARTMENTAL STUDIES/SERVICES
REQUESTED BY PROJECT MANAGER.
INITIAL BASE LINE DATA COLLECTION, INVESTIGATIONS & LONG TERM MONITORING.

DETAIL DESIGN.

SITE CONTRACTORS & INVESTIGATION LABOUR

Prepared By:

MINING & PROCESS ENGINEERING SERVICES (W.A.) PTY. LTD.

316 LORD STREET, HIGHGATE, WESTERN AUSTRALIA

	BY	DATE
PROJECT APPR.		
DESIGN APPR.		
DESIGNED	R. WILDE.	16-10-81.
CHECKED		
DRAWN	L. IRELAND.	16-10-81.

CLIENT: DEPT. OF TRANSPORT & WORKS.

JOB: RUM JUNGLE REHABILITATION PROJECT.

TITLE: PROJECT TASK FORCE ORGANISATION CHART.

SIZE: A3

SCALE:

REV. No.:

DRAWING No.: N.T. - D.T.W. - 001.

SECTION 3

PROJECT REHABILITATION CRITERIA

3.1 Purpose of Criteria

It has been stated in previous reports that the solutions to some of the problems facing this rehabilitation project are without precedent. It will therefore be necessary to approach these problems with a degree of emperical analysis combined with known engineering solutions of similar problems. Consideration has to be given to a cost benefit solution which adds to the constraints imposed, however to be able to select the final methodology and materials necessary to carry out each phase of the rehabilitation programme, a set of adequate standards is considered an essential requirement to provide the foundation for the selection of options previously put forward in the 'Summary'. The standards will make it possible to interpret the problems and the extent of the remedial work involved.

Anticipated reductions in heavy metal pollution levels required by the Commonwealth Govt. in its selection of 'Option D' may not be achieved with any degree of confidence because of the limited information available to the Working Group from previous site investigations.

Discussions held with various personnel involved with the investigations over the years have confirmed that sampling and data collection was carried out on a restricted basis for economic reasons. The results published on metal releases from individual sources are indicative only because of the tests carried out and the difficulties in measuring a total catchment of all streams emanating from stockpiles.

The characteristics of rainfall intensity in the area may have affected the results used. Stockpile leaching has been observed to be more prominent when rainfall occurs over a long period rather than peak intensity falls which tend to run off the stockpiles without soaking in. The results being used extensively in the 'Summary' for pollution levels were taken in a year of abnormally high rainfall. It is not known whether the intensity of rainfall in the same period was high or only extended over a long period. Predictions on long term weather patterns cannot be made confidently as a long term rainfall pattern has not been established for this area.

Table II of the 'Summary' p.89 states that a variation of ±15% to ±10% in the potential reduction percentages may be applicable. The only source of information for the release of metals from individual sources was taken in one wet season, 1973-74 (reference Table 5 p.32 of the 'Summary') where rainfall was 30% above average and the results for copper discharge varied on sampling from 95 to 142 tonnes. For the above reasons, the combined effect of these variable factors may give a possible variation greater than ±40% but even this estimate of deviation from the mean, cannot be put forward with any degree of confidence using the results taken to date.

The level of confidence in the reduction of percentages proposed by the 'Summary' was too high and it may not be possible to achieve the mean expected results using the techniques put forward.

Rather than base a whole rehabilitation project on information that does not have a high order of confidence it is considered necessary to devise criteria that can be justified using sensible practical judgements, taking into account the objective to achieving 'Option D' improvements, but prescribed in a form that can be quantitatively measured by known methods during the rehabilitation project.

The criteria contained in this section has been put forward using the current knowledge of future use of the Finniss River water system, current day public acceptability of pollution release, the potential 'no release' methods to be employed by new uranium mines in the Alligator Rivers region and a realistic future land use of the Rum Jungle area. When compared to current day regulatory standards for new projects, these recommendations in some cases will be less stringent but will permit the reuse of the land, revegetation and rehabilitation of waterways.

The recommended criteria for water quality, radiation emmission and radon emanation, flora and fauna regeneration in this report should be considered as basic engineering parameters rather than 'Standards'.

The implication of 'Standards' demands a more stringent application and may confuse the intended use of the recommendations in this section.

It is intended to consider the Rum Jungle Standards as design targets to aid the ultimate resolution of the problems but will not be considered as any official Govt. standard to be adopted for regulatory purposes.

3.2 Expected Life of the Rehabilitation Works

To permit selection of practical engineering solutions to problems at Rum Jungle it is necessary to establish the estimated life that the selected method must remain impervious to deterioration by the elements such as wind, water erosion, natural decay, flora and fauna influences.

'Option D' proposes the use of impervious clay and soil caps to prevent water ingress into reshaped overburden heaps and the Old Tailings Dam. The use of clay presents an expected life problem which is influenced by swelling and drying each season, wind and water erosion, root intrusion from large trees and other deleterious factors.

Taking into account the expected rate of metal release stated in 'Option D' and the requirements to achieve a practical, safe solution, this report recommends a 100 year life be adopted for all protection works undertaken.

If all design parameters prove correct the protective works may break down after that period, however, the amount of metals left in the stockpiles should be small and no significant rise in release should occur. In the case of the tailings dam it may be necessary to reconstruct the protective cap to prevent a rise in radiation and radon emanation.

3.3 Rum Jungle Rehabilitation Standards

The following criteria shall be applied to this project and will be used to develop engineering solutions to all problems yet unresolved.

3.3.1 Water Quality Standards

This report has considered the expected reduction of heavy metals expected from 'Option D' proposals and it is the recommendation of the N.T. Water Division and Dept. of Health to use of the criteria set out in p.2 of the 1980 publication prepared by the -

> National Health & Medical Research Council/Australian Water Resources Council for the "Desirable Quality for Drinking Water in Australia"

Calcium and sulphates are two exceptions from the table of values but only during the rehabilitation programme. It is discussed later in this section.

The radiation criteria has been independently assessed by the N.T. Dept. of Health for this project and the values stated in the publications for radioactive material are not applicable.

Table 1: Three columns of figures for metals and chemicals have been tabled for comparison between:

- the anticipated release using the percentage reduction technique
- the recommended Rum Jungle criteria using the 1980 N.H.M.R.C. publication
- the Canadian Mine effluent standard

Column 1 - the theoretical level of release from the Rum Jungle area after 'Option D' percentage reductions have been calculated using the total pollution levels as described in Table 5 p.32 of the 'Summary' for the 1973/74 wet season. They are included for comparison against the standards recommended for use by this report. It refers only to the heavy metals that are presently identified as the major pollution sources and the expected levels of calcium and sulphates that will be released using one possible method of open cut water treatment.

By using the recommended criteria in this report, a higher level of copper release is permissible rather than the Option 'D' 70% reduction criteria. The level of manganese must be lower than the 55% reduction criteria.

Column 2 - the proposed Rum Jungle release standard adopted directly from the N.H.M.R.C 1980 publication referred to previously, with the exception of calcium and sulphate levels during the four year rehabilitation programme.

Column 3 - the Canadian Standard for Metal Mining Liquid Effluent Regulations - taken from the Canadian Gazette Part II Vol. III No. 5 February 1977. This standard has been generally considered as an international guide to acceptable standards in other countries. It is included to allow comparison of expected Rum Jungle releases with a recognised mine effluent standard.

The criteria to be applied to the Rum Jungle project should be achievable in all categories when the total works programme has been completed plus a three year 'settling down' period.

It is intended to measure the water quality in the Finniss River below the confluence of the East Branch as the arbitrary station for all quantitative monitoring of before, during and after effects.

TABLE 1

		COLUMN 1	COLUMN 2	COLUMN 3
		THEORETICAL RELEASE FROM RUM JUNGLE AFTER REHABILITATION BASED ON 'OPTION D' PERCENTAGES	AUST. PUBLIC HEALTH RECOMMENDED STD. FOR DRINKING WATER (AUST.) 'RUM JUNGLE STANDARD'	CANADIAN MINE WASTE STD. (INFO. ONLY)
		mg/l		
	Physical			
	Colour units		50	
	Turbidity		25	
	Odour		Unobjectionable	
	Taste		Unobjectionable	
	pH range		6.5 to 9.2	5.0
	Chemical		mg/l	mg/l
	Total solids		1500	50.0
**	Calcium	200	200	
	Chloride		600	
	Copper	0.53	1.5	0.6
	Total Iron		1.0	
	Magnesium		150	
	Manganese	0.83	0.5	
**	Sulphate	400	400	
	Sodium (a)			
	Zinc	0.19	15	1.0
	Nitrate (as N)		10	
	Fluoride		1.5 (b)	
	Total hardness (as $CaCO_3$)		600	
	Phenolics (as Phenol)		0.002	
	MBAS (c)		1.0	
	Chromium (hexavalent)		0.05	
	Cadmiun		0.01	
	Cyanide		0.05	
	Arsenic		0.05	1.0
	Barium		1.0	
	Lead		0.05	0.4
	Silver		0.05	
	Mercury		0.001	
	Selenium		0.01	
	Nickel			1.0

** *Standards to be exceeded during rehabilitation works - effects of open cut water treatment methods.*

(a) *Due to insufficient data, criteria for this characteristic cannot be recommended at this time.*

(b) *Subject to any restrictions in accordance with 1.6 p.1 & WHO International Standards for Drinking Water, 1981 (3rd edn) p.36 Table 2 (see Annexure B).*

(c) *Methylene Blue Active Substances.*

The wet season dilution effects have been considered in both sections of the river. The first flush release of all heavy metals, which accounts for a substantial amount of the total metal release each year, should not raise the amount of heavy metals above the limits prescribed if the works are successful.

The existing background level of metals, calcium and sulphates in the Finniss River upstream from the East Branch have been considered when arriving at the selection of the appropriate standard. The margin between the expected release from Rum Jungle and the recommended criteria is sufficient to account for the existing levels.

Two standards are expected to be exceeded during the rehabilitation programme which may affect the Finniss River to a greater extent than is presently experienced.

It is expected to have an excess of dissolved calcium and sulphates if the open cut water is treated with calcium oxide (CaO) to raise the pH level to a neutral condition. This method is one of the 'Option D' alternatives which proposes to remove water from White's and the Intermediate Open Cuts after treatment. The quantity of water to be released during each wet season will be determined after more accurate stream flow data has been collected, however the results available at present indicate that to maintain a water release programme, which is related to open cut filling operations, may require the release of treated water with a calcium level of 400 mg/l and the sulphate level to 600 mg/l. The appropriate criteria is 200 mg/l and 400 mg/l respectively which can only be achieved by prolonging the water release programme or supplementing the surface water with ground water. The former option may increase the duration of the project and it is not considered necessary when the potential short term effects of the increased levels are considered.

The quantity of water measured in the East Branch see Table 1 p.7 of the 'Summary' would indicate sufficient volume to achieve the desired 10:1 dilution that appears necessary for calcium and sulphates when treating the open cut water. The added effect of the Finniss River dilution should ensure a high factor of safety in achieving the required standards in the Finniss River.

Calcium - A level of 400 mg/l of calcium may have the following effects:

1. Human Health - no effects to human health .

2. Aquatic Life - evidence available indicates that fish and other marine life can exist in higher calcium conditions. if necessary it would be possible to carry out satisfactory tests before actual releases occur. These tests are adequately described in a publication 'Compilation of Aust. Water Quality' by B.T. Hart - technical paper no. 7 - 1974. In the aforementioned paper certain brown trout have survived in water of 1800 mg/l concentrations.

3. Vegetation & Aesthetic Effects - during the dry season it is expected that surface encrustations will occur along the East Branch of the Finniss (a current problem caused by magnesium sulphates) and the Finniss River (not currently observed). The calcium deposits are expected to be flushed down the river with the early wet season stream flow. It is not expected to commence the treated water release programme until the peak of the wet season thus allowing early flow in both river arms to remove the previous years' deposits. This method should control any annual increase in concentrations.

It is expected that the calcium deposits will improve the soil conditions particularly in the East Finniss River where the discharge of acidic liquors have contributed heavily to the removal of vegetation. The deposits are expected for possibly 3 years after the completion of the water treatment programme.

At that stage it is expected to return to Aust. Drinking Water Quality of 200 mg/l, hence an acceptable long term objective is possible for all elements transported in the water.

Sulphate - A level of 600 mg/l of sulphates may have the following effects:

1. Human Health - no harmful effects.

2. Aquatic Life - no information on the subject could be found during the preparation of this report. The marginal increase in the drinking water standards should not present a problem, but before any water release programme was finalised, this report recommends that the studies being carried out by the Supervising Scientist on the Alligator Rivers region be reviewed to gain any aquatic life information relevant to the programme.

   There is a standard LC_{50}^{96} test described in B. Hart's paper that could determine the acceptable levels to be used, however the tests take approximately 18 months to 24 months at a cost of approximately $180,000. It is not considered necessary to include for the tests or the costs as studies referred to should provide sufficient data.

3. Vegetation & Aesthetic Effects - there should be no harmful effects to vegetation in the Finniss River But some precipitation during the dry season may occur.

It should be stressed that the East Branch of the Finniss River will have higher levels of calcium and sulphate solids and heavy metals than the standards referred to, during the rehabilitation period, but it is of no consequence until the acidic soil surrounding the river course is treated and new vegetation is introduced during the final stages of the programme. It is necessary to use the East Finniss arm as a 'drain' for the release of the treated open cut water, but every consideration has been given to the Finniss River water course to ensure no detrimental effects to its present condition occur during the rehabilitation works.

3.3.2 Radiation Emission and Radon Emanation Criteria

This report has considered the radiological conditions that prevail in the Rum Jungle area and recommend the use of the criteria described herein. The recommendations were put forward by the N.T. Dept. of Health to provide a level of safety in the area comparable to other uranium mining operations in the N.T. region. The recommended cover to achieve the levels of emission required do not cause any major (change to the Option D) design parameters. The criteria for a 100 year life of the cover is expected to exceed any radiation requirements so acceptance of the radiation recommendations will not have any significant effect on the final project design criteria or cost.

The radiation and radon criteria proposed in this report place a restriction on the final use of the land, which is considered practical under present ownership circumstances. The land use is described in Section 3.3.5 of this report.

The following should be considered arbitrary rehabilitation standards for the relevant radiological parameters.

External Radiation

Suggested Limit	. 80 μRem.h^{-1} (0.8 Sv.h^{-1})
Method	. at 1 metre from surface . combination γ and β
Location	. applicable to entire site and . 0.1 km around site . applicable to 1 km downstream
Impact on Project	. should be readily achievable . typical values on OTD $\cong$ 1000μRem.h^{-1} (10 Sv.h^{-}) . reduction factor required $\cong$12.5 . typical HVL 10 cm compact soil . required soil depth > 50 cm

Impact on Public

- for full time occupation 700 mRem per annum (7 mSv per annum)
- ICRP/NH&MRC limit for general public 500 mRem.y^{-1} (5 mSv.y^{-1})

Radon/Radon Daughter Concentration

Suggested Limit

- 1 pCi.l^{-1} radon
- 0.01 WL radon daughters
- 4 pCi.$m^{-2}s^{-1}$

Method

- at 1 metre from surface
- Rolle method

Location

- applicable to entire site and 0.1 km around site

Impact on Project

- should be readily achievable
- typical maximum values on OTD ≅ 0.1-0.3 WL
- required reduction factor average = 10
- approximate HVL clay ≅ 10 cm
  compact soil ≅ 30 cm
  soil ≅ 50 cm
- required thicknesses (single
- layer) ≅40 cm clay
  OR ≅120cm compact soil
  OR ≅200cm soil
- required thicknesses (2 layers)

(30 cm clay
(
(30 cm compact soil

OR

(30 cm clay
(
(50 cm soil

OR

(60 cm compact soil
(
(100cm soil

Impact on Public	. for full time exposure (crude estimate) 0.12 WLM . code of practice limit - annual member of public 0.4 WLM . normal conditions will mean levels are significantly below 0.12 WLM

Radionuclide Contamination - Water

Suggested Limits	. ^{226}Ra 10 $pCi.l^{-1}$ (.37 $Bq.l^{-1}$) . ^{230}Th 2000 $pCi.l^{-1}$(74 $Bq.l^{-1}$) . ^{210}Pb 100 $pCi.l^{-1}$(3.7 $Bq.l^{-1}$)
Method	. consultation Water Division . surface and groundwater . yearly average

This section on Radionuclide Contamination does not apply to the remanent water in the open cuts after the rahabilitation programme has been completed.

Location	. applicable at monitoring sites to 0.1 km downstream of agreed site boundary . applicable at junction of East Finniss and Finniss Rivers
Impact on Project	. consultation with Water Division . little impact on project maximum concentration in Old Tailings Creek 12 $pCi.l^{-1}$
Impact on Public	. standards equivalent to NH&MRC AWRC standards for drinking water . standards approximately 2.5 times discharge limits set down by Radiation (Safety Control) Act (^{226}Ra) . application of this standard should adequately limit impact on public

Radionuclide Contamination - Soil

Suggested Limits	. ^{226}Ra 10 $pCi.g^{-1}$ (0.37 $Bq.l^{-1}$) . ^{230}Th 10 $pCi.g^{-1}$ (0.37 $Bq.l^{-1}$) . ^{210}Pb 10 $pCi.g^{-1}$ (0.37 $Bq.l^{-1}$)
Method	. in consultation with Land Conservation Unit . average for 30 cm from surface
Location	. applicable to entire site and extending beyond site boundary to 0.1 km . applicable to creek banks to 1 km from site boundary and downstream of OTD
Impact on Project	. average concentration in present top layer of tailings 330 $pCi.g^{-1}$. average reduction factor 33 . final concentration unrelated to tailings material if safely capped and covered with topsoil . little impact on project anticipated unless uncontaminated soil is not readily available
Impact on Public	. no comparable standard . should allow unlimited use of land . should leave land in quasi-virginal condition
Longevity Standard	. period - 100 years or more . requirement - all above limits to apply for period
Land Use Restrictions	. single limitation erection of permanent dwelling for long term occupation . all other activities unrestricted

No standards have been established for other radionuclides, e.g. uranium, polonium-210 either in air, water and soil. If it is considered after further study that such standards are necessary the limits derived are unlikely to be more restrictive than that set for soluble ^{226}Ra.

The suggested limits have been arbitrarily set and further study and analysis is required to link the standards with risk to critical groups of people and to assess their comparability with present background levels or concentrations expected at the site.

The limits do not relate to those to be applied during the rehabilitation phase. During the operational phase it is intended that the 1980 "Health" Code will be applied. The limits listed are design targets and an indicator of acceptable conditions after the rehabilitation is completed.

3.3.3 Flora Revegetation

The N.T. Conservation Commission consider the following standards to be an acceptable level of rehabilitation and this report recommends a programme to achieve the standards described herein.

Surface Stabilisation - all rehabilitated areas should achieve a long term surface stability to prevent wind and water erosion for the expected life of the works.

The design parameters for surface stability shall be consistent with those required to satisfy the 'Universal soil loss equation for an effective life of 100 years'. The emperical factors in the equation will be developed by the N.T. Conservation Commission during the initial investigation phase.

Ground Cover - establishment of self sustaining plant population over all rehabilitated areas. It is expected to achieve a 100% ground cover over the rehabilitation area after the first wet season after seeding has been completed in each area. Some contingency for replanting will be necessary and can only be assessed on an 'as required' basis.

Plant Population - to achieve an aesthetically satisfactory revegetation programme it is desirable to achieve a plant population similar in structure and composition with surrounding nature flora. The aesthetic requirements shall be a secondary consideration to stability requirements, hence the use of ground cover that is not consistent with surrounding flora, shall be a necessary compromise in some situations.

The use of deep rooted species will be restricted over any areas where an impermeable clay cap is necessary to prevent water ingress into reshaped overburden stockpiles and the tailings dam. Aesthetics will again become of secondary consideration when considered against the confinement of metal pollution into water courses.

Natural revegetation along river courses - the use of fertilizers such as phosphates to assist with soil enrichment will prevent some natural species returning to the area. It is not anticipated that the same level of vegetation present in the Finniss River will return to the East Branch.

Weeds - the introduction of any new weed species into the rehabilitation area must be avoided by the use of seeds certified to be free of weeds and ensuring that topsoil introduced to the area is free of weeds not presently in the Rum Jungle area. Monitoring of ground cover composition is essential to ensure any unexpected weed growth is eliminated using suitable treatment.

Borrow pit revegetation - wherever large quantities of clay are removed for use in impermeable clay and top soil layers, the borrow pits shall be graded to re-establish natural contours and revegetated by seeding for rapid ground cover to ensure surface stability in the minimum time possible. Where stability is not a problem, then natural revegetation is an acceptable standard over a longer period. The selection of borrow pit sites must not only consider the material required but the location of the pit site to ensure that erosion and aesthetic destruction is not a legacy after removal of engineering materials to satisfy the rehabilitation of overburden stockpiles in the Rum Jungle area.

3.3.4 Fauna/Fisheries Rehabilitation

It is recommended that the current fauna population in the surrounding areas outside the Rum Jungle affected area, be the required standard, once all works are completed. The change in vegetation species may have an effect on bird life due to a restriction on deep rooted trees and shrubs but the increased ground cover may encourage more grazing animals to return to the area. The type of fauna expected in the area should be restricted to those which will not damage the rehabilitation works.

During the rehabilitation works it will be necessary to fence off the site and temporarily remove all larger animals that may interfere with the revegetation programme. The removal of some animals will allow early regeneration of flora species and may be required for at least 3 years after all major works have been completed. The temporary reduction is not considered to be a long term ecological problem. When fences are removed a rapid migration of local fauna is considered likely due to superior grazing conditions expected in the rehabilitated areas, however proper management of the area is recommended to prevent possible damage.

Aquatic biotica is not expected to change over the rehabilitation period and it is expected to see the aquatic life in the East Finniss River achieve a similar level to that present in the Finniss River below the confluence. The expectations of regenerated aquatic life may take many years due to the influence of revegetation in the same area. The return of fish life in the East Finniss should be considered one of the last quantitative measures of the overall success of the project.

The lack of any base line studies at the time of this report prevents an aquatic standard being set, however with the results of the Supervising Scientist's studies it may be possible to draw some conclusions for this area.

3.3.5 Land Use

The future use of the Rum Jungle land area has been considered and it is important in its relation to other standards previously set.

The land is currently held under Crown Land status with mining and exploration rights held by the companies listed in Appendix 4 of the Appendicies.

It is recommended that the long term objectives for the selected methods of rehabilitation should return the Rum Jungle area to a recreational reserve standard with some restrictions on habitation. The radiation standards recommended in this report require that no permanent inhabitants be permitted on the tailings dam area and other isolated areas within the 200 hectare site where there is evidence of radioactive material under impermeable covers. Some form of control will be necessary over the total 200 hectare site to prevent damage of impermeable overburden heaps and revegetated areas.

In the unlikely event that a mining operation became viable in the rehabilitation area within the next four years, the N.T. Dept. of Mines and Energy would ensure that the operations would not contravene any current N.T. Govt. mining regulation and that any further rehabilitation works required would be carried out at no additional cost to the Commonwealth Govt.

The rehabilitation project task force may be required to modify some of the proposed works programmes. It would be done in a manner that would cause minimum disruption and still permit the reduction of pollution sought by the Commonwealth Govt.

The current exploration lease holders works programme would be organised by the same Dept. to prevent any major disruptions to the rehabilitation programme.

The treatment of White's Open Cut may take some time after the four year rehabilitation works programme is completed. The use of the open cuts for swimming and fishing should be restricted until the high level of calcium and sulphate solids have been removed by successive annual wet seasons. As part of the long term monitoring programme it is recommended that a regular check be kept on the pH level and radionuclide concentrations. It may be necessary to continue with intermittant water treatment until a stable condition is achieved.

The management of fauna movement will be required for some time while ground cover is being established. It is recommended that the protective fence around the site remain for 3 to 5 years after completion. When natural movement of fauna is permitted, long term management of grazing is recommended to protect the area against possible reduction of vegetation. The revegetated area will substantially consist of ground cover rather than trees thus providing a more attractive food source.

The long term use of the land should be the main consideration and any activities within, say, the next 20 years should be controlled to meet the recommended recreational use but the alternative use of the area for future mining and exploration, restrictions on inhabitants and fauna management should not be viewed as a change to these recommended standards.

SECTION 4

DETAILED SITE INVESTIGATION PROGRAMMES

4.1 Reasons for further Investigations

The implementation report strongly recommends the first stage of the rehabilitation programme considers the need for sufficient site investigations to provide data as a sound basis for problem solving of engineering matters left unresolved in the 'Summary', and a a 1981 record of current conditions for future comparison with results to be taken during and after rehabilitation.

The results published in the 'Summary' were sufficient to provide some guidance to the Working Group in identifying the magnitude of the pollution sources present and assist in selecting some alternatives.

It is not recommended to use the same conclusions without further investigations as there are more considerations to be taken into account before a final decision is possible. The lack of results in some areas may well lead to a design criteria being adopted that will not provide any improvement to the existing problem.

An example of this problem can be adequately illustrated using the data on surface hydrology and its relation to groundwater conditions. The results of rainfall and runoff conditions have previously been taken over a continuous three week period during one wet season then weekly readings during the remaining part of that same wet season. The hydrological data was extrapolated rather than calculated from actual results over say hourly periods during rainfall periods. It is generally known that the weather pattern is variable in this region and continuous monitoring over a wet season to gain meaningful results is necessary for at least one complete wet season.

There has never been any investigation of groundwater movement during the same period hence a total understanding of water movement, under or out of open cut pits cannot be accurately predicted. Any loss of surface water and its re-emergence as groundwater has never been investigated. This information has an affect on two 'Option D' proposals, the treatment of open cut acidic water and the dumping of copper ore in White's Open Cut.

The lack of hydrological data prevents an accurate dilution factor to be established hence the rate of water release of lime neutralised water cannot be accurately predicted. This may result in the construction of a large holding dam to cope with the extra water or a reduction in the annual release period of treated water to the rivers which may extend the length of the rehabilitation programme by one year for every additional wet season that is needed. If sufficient groundwater is available it may be practical to pump water out of production bores to extend the release period by supplementing surface dilution water after the wet season has finsihed. The possibility of this alternative to assist an already identified water treatment method may substantially reduce the time required to release water which would allow an accelerated earthworks programme.

The other proposal to dump copper ore into White's Open Cut and cover it with Dyson's overburden material may do no more than transfer the problem to the groundwater.

There is sufficient evidence that the surrounding geology is highly fractured, comprising transmissive dolomites among other rock formations. The water movement may be extensive which would allow continued oxidation of the ore and bacterial change to the sulphides thus releasing metals to underground aquifers that may resurface in downstream rivers.

If proper investigations of all water movements have been properly implemented, the decision to place material in the open cut may still be the solution but a number of adjacent bores may be required to return contaminated water to the pit for further stabilisation until a balanced pH-oxygen condition is reached before allowing groundwater release.

Another major problem that affects the project costs dramatically, will be the selection of material to provide for the impermeable clay seals. A clay that is impervious to weathering, filtration and has a low permeability has a conflict of engineering parameters within that specification. It will be necessary to adequately research local materials, carry out laboratory tests to provide a suitable material with the desired characteristics, then return to the area to find the quantities required, before any final decisions can be taken. It would be unwise to use the present recommended cover specifications and find that the material was not available nor would provide an impermeable barrier. Using the current data both of the above results are possible. The cost of changing the earthworks on site, once it had shown signs of failure, would be far more than all the investigations works proposed in this report.

These examples have been raised to emphasise the requirement of a detailed investigation programme. The previous studies were quite explicit in the assumptions made in respect to site resources. The assumptions permitted a 'rough' order of cost estimate to be put forward for discussion.

This report has identified the engineering problems that will cause a major effect on the final cost of the project and has described them in Section 5.2 of this report. The investigation programmes described in the following sections 4.2.1 to 4.2.8 are considered the minimum requirement to establish the necessary data for final resolution and selection of current alternatives.

The other secondary reason for an initial detailed investigation programme is to establish up to date records of the 1981 pollution levels from which the project's success can be measured over future years.

The results of the rehabilitation works may be of major significance to other rehabilitation projects by providing valuable data on the ability of the selected solutions to achieve an environmental reversal. The time period taken to reverse the present conditions, the predicted versus actual life of impermeable, natural materials and the effects on fauna/fish populations may be watched with some interest.

The method of quantitative measurement is considered important not only to justify the project expenditure but to provide a sound basis for future scientific evaluation. The Rum Jungle rehabilitation procedures and results will no doubt be of public interest and interested groups may critically examine the methods of reporting. It is considered important to provide a 'before' and 'after' position where all data has a common base date. The data collected to date cannot be used in this manner because of varying time scales from 1971 to 1975 when different investigations were carried out on different years.

4.2 Detailed Programmes

The following detailed programmes set out all activities considered necessary to confirm previous data and collect further information not previously undertaken. All investigation programmes have been critically reviewed to ensure the end use for the results has been identified. Studies and investigations that do not directly relate to solving 'Option D' alternatives have been discarded and investigations that would provide 'nice to have' data have not been considered.

The investigation programmes have been structured so that maximum use of N.T. Govt. Depts. is possible. In some cases the use of specialist consultants and contract staff has been necessary to supplement sections of the programmes. The results from the investigations cannot be superficial or lacking in technical expertise.

The N.T. Govt. resources were previously discussed and the use of each Dept. has been identified in the following sections. The detailed estimates provided in Section 7.2 of this report reflect the use of N.T. Govt. resources and private industry.

The following programmes will generally extend until June 1982, when all reports on the results must be consolidated for use in further engineering studies. The ground water and water quality programme will continue until October 1982 before completion of Stage 1. A preliminary hydrological report by June 30th 1982 will be necessary to institute some of the engineering studies.

It may be necessary to extend hydrological investigations if the data from the 1981/1982 wet season is considered inconclusive.

The ongoing investigation and engineering study work after June 1982 has been carefully identified but the extent of the work cannot be as accurately defined because the scope of the work is dependent on the results.

The programme of works presented in Section 9.0 accurately represents the investigation and study phase, but cannot provide any more than a general guide for detailed design and site works under the assumption that the scope of work in 'Option D' strategies described in 'Document A' will not substantially change.

4.2.1 Soils Classification and Quantity Investigations

Reasons for investigation:

To determine the source and availability of suitable quantities of soil material, vegetation required for the rehabilitation recontouring and revegetation of the Rum Jungle mine area.

Detailed description of programme.

1. Field sampling to locate and identify the types of materials available.
2. Laboratory tests to determine which materials will be suitable for the impermeable covers.
3. Field investigations to determine the quantities and availability of clay materials found necessary from laboratory studies for overburden covers.

Programme duration:

Phase 1 Four weeks (items 1 and 2)

Phase 2 Six weeks (item 3)

4.2.2 Surface/Groundwater Hydrology and Quantity

Reason for investigation:

The water management data monitoring and collection programme is aimed at obtaining base line quantitative hydrological information over the whole site area to determine the water treatment and rehabilitation options available and to use as a standard against which to measure the progress and/or success of the rehabilitation programme on a whole.

Detailed description of programme:

. 1. Evaluate water qualities and volumes in all open cuts and storage areas.

. 2. Undertake sampling and analysis programmes for base line data at sufficient stations throughout the site to determine major pollution sources and movements of pollutants throughout the entire surface water system.

. 3. Establish long term monitoring stations throughout the surface water system to measure and analyse the effects of the rehabilitation programme in general.

. 4. Drilling and pump testing of a network of bores (5 test bores and 20 observation bores) around the site to determine groundwater movement and the extent of pollutant transportation. Groundwater testing will be carried out to determine rate of water movement, the level of contaminants and the effects of the Option D rehabilitation programme on the groundwater system.

. 5. Carry out an adequate study of the topography, climate, geology and hydrology to formulate a geohydrologic model of the immediate area.

Programme duration: Fifty weeks (the last quarter of the 1982 dry season will consist of office evaluation only)

4.2.3 Radiation and Radon Emanation Investigation

Reason for investigation:
To provide suitable information to allow the safe and effective rehabilitation of key sites in the area and provide sufficient base line data against which post-rehabilitation data may be compared.

- purchase of equipment

Detailed description of programme:

To survey key sites within the rehabilitation area -

(a) Old Tailings Dam
(b) Dyson's Open Cut
(c) White's Open Cut
(d) Selected sites in the Finniss River system

Programme duration: Dependent on wet/dry season.
Part time: 26 weeks.

50 m grid
2 people part-time
9 man-weeks
= $12,000

4.2.4 Metallurgical, Geochemical, Geology Investigations

Reason for investigation:

To study and evaluate the physical properties of the over burden heaps and waste products of the mine site area to confirm the present level of metal oxides and other potential contaminants in the area for evaluation with geohydrological model.

Detailed description of programme:

1. To carry out a detailed geological survey of the mine site and all adjacent contaminated areas. The N.T. Govt. mining records may be sufficient to gain the required information.

2. Carry out detailed auger tests, and percussion drilling of overburden heaps to properly establish the metallurgical composition of the overburden heaps. Previous results have been drawn from limited sampling that cannot be considered representative of the heaps.

3. A detailed micro-geology study of the mine site to investigate geological features and discontinuities and the depth and variety of weathering patterns to evaluate seepage losses and flow patterns beneath the tailings dam, open cut mines and river channels.

- Drawn sample taken & chemical analysis made
- to bottom of holes
- Dawson Study first
- repeat project work position
- In principle OK 1982/3

. 4. Take samples of the bottom of White's Open Cut for assessment of physical properties in relation to its ability to take additional fill.

. 5. To carry out analyses of material in heap leach and overburden heaps to establish their geochemical and metallurgical make up.

. 6. Investigate chemical properties and rate of acidification of overburden heaps.

Programme duration: Twelve weeks

4.2.5 Flora/Fauna Base Data Investigation

Reason for investigation:

To investigate the requirements to successfully revegetate disturbed areas and to survey all fauna which normally inhabit the area to evaluate the effects of the rehabilitation programme.

Detailed description of programme:

. 1. Evaluate quantities and attributes of earth resources required for rehabilitation.

. 2. Determine the effect and extent of borrow areas on the environment and rehabilitation of these area.

. 3. Determine potential limitations on plant growth.

. 4. Investigate past regeneration trials to determine types and quantities of fertilizers required.

. 5. Determine grass species, seeding rates and tree species needed for revegetation.

. 6. Investigate availability of irrigation water for rehabilitation programme.

. 7. Determine timing for revegetation operations.

. 8. Determine strategies necessary to regulate humans and animals against interference with the implementation and success of the rehabilitation programme.

. 9. Carry out a fauna survey to determine the extent of local animals and the appropriate location for a boundary fence around the rehabilitation project.

Duration of programme: Twelve weeks

4.2.6 Meteorological Data Collection

in with 4.2.2 (stream gauging)

Reason for investigation:
To provide accurate information on rainfall patterns at different stations around the site that will be used to complete the hydrological model of the area.

To provide wet and dry bulb humidity readings for humidity condition monitoring when working near tailings.

To provide differential temperature recorders for inversion condition monitoring.

To provide wind speed and direction readings for use when working near tailings.

Detailed description of programme:

. 1. Install one standard N.T. climate station with anemometers, dust sampling station, rain gauge, evaporation pans, wet/dry bulb thermometers and differential temperature recorders. This station will remain a fixed structure and will not be affected by the rehabilitation works.

. 2. Install four other rain gauge stations at strategic positions around the site.

Duration of programme:

Construction and supply of equipment	Twelve weeks
Collection of data	Forty weeks

4.2.7 Land Survey

Reason for investigation:
To provide control stations for future locations of all features with reference to the A.G.M. datum.

To provide proper datum for stream gauge stations, check existing topographical contour maps to ensure stockpile features have been correctly interpreted and provide detailed grid for radiation survey.

Detailed description of programme:

. 1. Provide control stations around the site that will establish bearings and heights in relation to A.G.M. datum.

2. Check existing photogrammetry survey to ensure stockpiles and heaps have correct contour features required for quantity check on all overburden heaps.

3. Provide stream cross section data and gauge board reference for hydrological investigations.

4. Provide 20 metre grid over tailings dam area and other specific areas around the open cuts for radiological surveys.

Programme duration: Six weeks

4.2.8 Bathymetric Survey

Reason for investigation:
To establish the volume of water in White's open cut for base line data. The results will be required for final design criteria of the proposed water treatment method and maximum volume available for backfilling purposes.

Detailed description of programme:

1. Take readings at close intervals over the entire area.

2. Calculate total volume from plotted cross sections of each open cut.

Programme duration: Fourteen days.

SECTION 5

DESIGN AND SITE WORKS CRITERIA

5.1 Use of Investigations Results

The results of the field investigations will play a paramount role in the final adoption of design criteria for the detailed methods to be used.

The results will be evaluated by the project task force then summarised into a design criteria brief for use by the detailed design team.

The design criteria will contain the required methods to be used by the design team. It will not be left to the detailed design team to find answers from investigation results. The engineering studies undertaken by the project task force with possible assistance from expert consultants will be specifically structured to give detailed guidance for all criteria.

The ultimate responsibility for the selection of rehabilitation methods will remain with the project task force who as agent for the N.T. Govt. must assess the technical recommendations using the departmental representatives and other resources then choose the desired method. The chosen method must account for the project criteria and standards set together with a satisfactory cost-benefit result.

Once the decisions of the project task force have been agreed to by the Dept. of Transport and Works Project Director and other appropriate authorising agencies a detailed report will be prepared for the Commonwealth Dept. of National Development and Energy (hereafter referred to as NATDEV) outlining the problems, reasons for a particular solution and the expected capital cost.

The selection of any design investigation consultants must be carried out with considerable care so that specialist assistance is given using the results of 'in house' investigations.

The project task force require the specialist investigation/study consultants to act as an extension to the main N.T. Govt. investigation and monitoring services rather than a means to subcontract responsibilities.

5.2 Design Criteria and Unresolved Problems

After investigations and specialist studies have been completed the project task force will use resources of the N.T. Govt. Depts. and contracted services to prepare detailed design criteria for each of the unresolved problems so that the detailed design effort is closely supervised to prevent further opinions or options being introduced. The design criteria should be in sufficient detail to eliminate any misunderstanding of the scope and provide the technical solutions required. Further investigations cannot be tolerated at this stage unless the detailed design cannot proceed because of an unexpected problem that may arise during detailing of the work.

The unresolved design options have been listed in this section for each defined area at Rum Jungle. A comment on the likely effects of each option is provided, not as the ultimate solution but to highlight the requirement for the initial detailed investigation programme before commencing detailed design.

References to proceeding notes of estimates have been taken from 'Document A' (see Appendicies) which reflects 'Option D' proposals.

Reference p.10 - Assumptions and limits of information available for estimate preparation:

Item 2. A land unit map was the only information available when selecting a borrow area for the works and hence a haul distance. No site investigations were carried out to confirm the land unit map which is normally used for order of magnitude studies. The assumptions must be verified.

Items 3. & 4. The depth of the borrow pit was assumed at 2 metres and it was acknowledged that the material will probably have a low P.I. An impervious clay cap will require a high P.I. material. The assumed borrow pits suitable for winning 400,000 m^3 to 800,000 m^3 of clay material may have no useable material for the impermeable clay covers until site investigations have been completed. The location of a suitable clay and the eventual designed depth will influence the final cost of the project more than any other single problem to be resolved.

Item 6. Conditioning soils to $\pm$1% in a borrow pit, then transporting the material to the designated sites is particularly difficult in a warm climate. If the success of the impermeable cover requires such a strict tolerance then it will probably lead to either more expensive earthworks under tight supervision or, more likely, a lower standard of moisture control at various times hence a potential failure of the impervious cover within the 100 year life objective.

A more practical design should be considered before reaching such a conclusion where large quantities are involved.

Items 7. to 9. Assumptions on soils for vegetation and the accuracy of estimates.

'Document A' has qualified the scope and highlighted assumptions made in arriving at the estimates. It suggested the need for further investigations before the required confidence could be gained for both design and cost estimates.

'Document A' has considered a 25% contingency, however the scope of work has assumptions that may well change the base scope by 50% to 100% hence it may be assumed that the order of accuracy related only the cost per unit item, not the total project cost.

Reference p.11 - Copper Heap Leach Stockpile and Oxidation Ponds.

Item 1. Removal of the stockpile to White's open cut may not resolve the release of copper. The oxidied nature of the ore and the presence of bacteria that causes pyritic changes may continue to cause substantial releases to the groundwater system and continue to counteract the water treatment efforts in the open cut. A stable pH-oxygen condition is required and until groundwater movement is understood the problem should not be transferred to White's open cut even with a suitable soil cover. Clay type materials can transmit oxygen freely given the correct differential conditions hence no guarantee can be drawn from a clay cover in respect to the inhibition of oxygen.

Item 4. The release of water from White's open cut depends heavily on the amount of water available during the wet seaon. This information is not confidently known hence the backfilling operation into White's is dependent on the amount of displaced water.

The water treatment method must be known, together with local hydrological conditions before a programme of works can be implemented hence the need for investigation and study results.

Item 9. The volume of the heap leach pile in the 'Summary' has a variation of $\pm$20% hence the order of accuracy of the final project cost will be influenced by this variance as well as others mentioned.

Reference p.13 - White's Overburden Heap

Item 2. The impermeable clay seal over the overburden has been taken as 200mm. The thickness may have been an arbitrary choice or gained from Captain's Flat (Canberra) rehabilitation works.

The ultimate selection of the type of clays available in the area will determine the cover thickness, however other design criteria being used for new tailings dams in the East Alligator River suggests that the first layer should be a minimum of one metre thick with a high moisture content to provide an initial cover that will remain in a flexible state for a long term. The design theory will permit stockpile movement and be less prone to swelling during the wet season as its air voids will not take in as much water.

It will not be possible to design a totally impermeable cover using a clay material. A thin cover will be more likely to crack after a lesser number of years because of the higher surface area to depth ratio.

If the clay layers have to be increased to 500mm, the estimates provided for this section may change by up to say 150%. The design criteria for the impermeable cover is critical to the overall solutions for expected reduction in Rum Jungle pollution sources and the final project costs.

Reference p.17 - White's (North) Overburden Heap

The same problem of impermeable covers applies to this heap. Once an overall design criteria has been developed it will be applied to all overburden heaps.

The differential compaction layer between the sealing layer and the vegetation layer may raise a problem with water movement through the top layer then creating a shear path between layers. Some literature has suggested an intermediate layer of sand/gravel which is bound into the upper layer of the clay seal, but it must be thicker to accommodate this technique. It is still a problem to be resolved during the first 12 months of the project.

Reference p.19 - Intermediate overburden heap

Same comments for White's Overburden Heap

Reference p.22 - Dyson's Overburden Heap

It is proposed to use Dyson's overburden to cover the copper heap leach ore once dumped into White's open cut. The reason to use Dyson's material is beacuse of its low sulphide content. The number of samples taken to assay the overburden heap is unknown and if the results were not representative, the effects of placing the heap into White's open cut with the copper ore may give problems. It would accelerate the release of copper which is the main source of pollution in the area. Before a conclusion is reached on the use of Dyson's material the design criteria will have to assess the previous assays. In the event that the results are inconclusive the assays will have to be done again with the correct sampling procedures to ensure a high level confidence in the results.

The question of production rates has been raised previously in this report in respect to filling White's open cut. The 'Summary' did not compare the rate of water release to the rate of backfilling operations. The design criteria for the water treatment plant which requires detailed knowledge of surface hydrology will determine the rate of backfilling operations. The decision to place any material into the open cut has a number of unanswered questions which will reflect on the final project costs.

Reference p. 24 - White's Open Cut - Water Treatment

The 'Summary' proposed the use of lime (CaO) as a method of treating the water. 'Document A' reviewed the type of treatment plant and proposed compressed air infusion as a solution to increase the rate of treatment.

'Document A' suggested a backfilling rate of 1000 m^3/hour. Considering the amount of material proposed to be dumped in the open cut -

Dyson's	1.2	million	cubic	metres
Heap Leach pile	0.2	"	"	"
Total	1.4	"	"	"

Note: 'Option F' suggested both Dyson's and Intermediate heaps be used, 'Option D' proposal used only Dyson's. 'Document A' incorrectly considered Intermediate heaps as part of 'Option D' proposal.

Considering an effective 8 hour day of actual water displacement:

$$\frac{1{,}400{,}000 \text{ m3}}{8 \text{ hr} \times 1000 \text{ m}^3/\text{hr}} = 175 \text{ days of water displaced to the Intermediate Open Cut}$$

The release of water to the East Branch is critical because of total dissolved solids levels of calcium and sulphates. It will be necessary to store the total volume of displaced water until the next wet season. Consideration is required for possible extra storage in the Intermediate open cut if the proposal to connect the open cuts is adopted.

In the event that all treated water in both White's and Intermediate were to be released to the East Finniss River, the total volume involved would be 3.450,000 m^3. The rate of water release may delay the completion of all works within 4 years if the annual wet season rainfall is not sufficient.

Clearly the complexity of using White's open cut has some major problems to be resolved. The interrelationship between groundwater, pH-oxygen stability of metal oxides under water, bacterial action on sulphides and the design of a suitable water treatment plant presents some difficult decisions that must be resolved before any final costs can be sensibly put forward.

Reference p.26 - Intermediate Open Cut - Water Treatment

The same comments apply re treatment of water. The proposed method of treatment put forward in 'Document A' would be the basis of any design studies undertaken to fully develop a design criteria.

The major unknown factor in the use of the Intermediate Open Cut for a water treatment plant is the possible groundwater connection between the two open cuts. The geology indicates a strong possibility of a large aquifer system connecting the two pits along a major shear fault. The proposed groundwater studies will provide the necessary information before completing the water treatment design criteria. If water movement is excessive it would be difficult to achieve a steady rate of treatment as the East Finniss River connection to White's Open Cut would provide a differential head that may be discharged by way of underground aquifers rather than a controlled surface diversion channel as proposed.

Reference p.28 - Dyson's Open Cut

Item 1. The water volume in this pit is relatively small however the use of Dyson's Overburden as a cover material should not be assumed to be feasible until detailed sampling and assays have been either proved past investigations or redone during the proposed investigation programme.

During a site visit to the area in September 1981 the author of this report and a qualified metallurgist observed large quantities of surface pyrite exposed over the total overburden heap.

The visit raised some doubts to the accuracy of previous results that indicate a low sulphide content. It should be examined during the investigation period.

If the heap cannot be used, additional costs will result as more cover material will be required for both the copper heap in White's open cut (if this option is taken) and additional protection to Dyson's heap. It has been excluded from 'Document A' costs.

Reference p.29 - Rehabilitation of the Old Tailings Dam

Item 2. The tailings dam strategy has been based on the recommendation by the A.A.E.C. not to move the tailings because of increased health hazards.

This report recognises the validity of the statement and the approach to minimise any unnecessary exposure of personnel to radiation hazards. If the objectives of this report are accepted in terms of the expected life for all rehabilitation works, the tailings dam in its present position may require an expensive cost solution to satisfy the design criteria and possibly no solution at all that can guarantee a 100 year life.

The N.T. Dept. of Health's recommends a cover of compacted clay - approximately 400mm thick to adequately reduce the radiation emmission and radon emanation to a satisfactory level.

The health hazard requirement does not present a problem but the major problem will be in achieving an impermeable cover to an area that is situated in a relatively high water shed area leading to a well defined river stream course, where one end of the area is subject to an all year high water table. During the wet season it is subject to local flooding of the same area occurs.

The present tailings dam has an uncontrolled perimeter by local topography. The principles to be adopted by new uranium mines is the exact reverse to this situation where the dams are properly defined on all sides and located in areas of low water shed.

The area covered by the old tailings dam is approximately 31 Ha (refer the 'Summary' Table 4 p.29). The large uncontrolled area of material approximately one metre deep will require approximately 426,000 m^3 of soil to provide a three layer cover system of 600mm to 900mm, of which only 400mm is tightly compacted. Other design criteria being used for tailings, not having the high water table problem and being located in a low water shed area, have recommended a system of -

Layer 1. High moisture clay layer loosely compacted 1 to 2 metres thick to allow for tailings movement and prevent layer cracking due to shrinking/expanding nature of the material when air voids are present.

Layer 2. To act as a vapour barrier 0.5m thick laterite gravel and support an upper rock layer.

Layers 3 & 4. Sandy-gravel mix 0.5m layer for vegetation layers and surface erosion protection.

(reference McMahon Burgess Report May 1981 - see Appendix 5 for relevant extract for Koongarra tailing dam rehabilitation).

This report recommends the proposals put forward for covering the tailings dam in the existing location be reviewed. The N.T. Dept. of Health consider the tailings dam can be shifted without undue risk to equipment operators provided the current code of practice for mining and milling of radioactive ores (Health Code) is strictly observed.

It is considered necessary to examine two other alternatives as well as the 'Option D' proposal.

1. Move the tailings and subsoil to a confined area with side walls to hold the relatively dry material in a much reduced area then provide an adequate clay-rock cover to provide a 100 year impermeable cover.

The potentially high cost to cover the tailings with a protective surface to last the expected life, may be 100% higher than the 'Document A' proposal if the Koongarra methods were adopted. The cost of moving the tailings may prove cost-effective.

2. Remove the tailings back into White's Open Cut and use the water as a protective blanket. The removal may be with machines or a reslurry pumping system.

It is recognised that the tailings are highly acidic and it may affect the water treatment programme for White's open cut. The design criteria and final methods would require all aspects to be evaluated.

Reference p. 31 - 'Document A'

Item 7. 'Document A' recognises the unresolved problems in the tailings dam area and states the need for further investigations.

This report recommends the study of only three proposals to determine a cost effective method that satisfies the criteria in Section 3.0 of this report.

Reference p.34 - Acid and Sweetwater Dam

The problem in this area is largely one of acidic soil that requires removal or treatment to permit revegetation. The aesthetics of the area are the major concern (reference the 'Summary' Table 10 p.89).

The location of the dams will require the design criteria to take into account the effects of White's overburden heap rehabilitation methods as it appears the Sweetwater Dam is the water course for some of the metal pollution being leached out of the heap.

The eventual shape of the White's overburden batters will affect rehabilitation of the dams in one area. In terms of degree of difficulty this area can be easily rehabilitated without extensive investigations.

Borrow Pits

There has been no discussion on borrow pits in 'Document A' other than the assumed haul distance from the site and depth. Given the possibility of stockpile clay covers being 500mm thick, the total volume of clay and topsoil required for the project may be as high as 800,000 m^3

Using 'Document A' assumed depth of 2 metres the total area stripped out around the Rum Jungle site may be in the order of 40 Ha. The revegetation and general reshaping of the borrow areas will also require careful consideration to ensure one problem is not being rectified at the expense of creating others. The costs for borrow pit rehabilitation and revegetation does not appear to be in the 'Document A' estimate.

In summary, considering the number of major decisions to be taken there seems little value in providing estimates for major site work activities until they have been resolved. The possible magnitude of scope variations as each design criteria is established is considerable, and final project cost estimates may be more misleading than beneficial.

5.3 Detailed Design and Documentation

Once design criteria has been established for all problems the project manager will authorise the engagement of design engineers and draftsmen to complete the necessary drawings, specifications and bills of quantities to provide the required documentation for competitive tendering to local and interstate contractors.

The detailed designers will be adequately directed by the N.T. Govt. representatives and other senior members of the project task force. The technical selections of options will not be the responsibility of the detail designers. This will allow the work to proceed on a local basis without the requirement of technical specialists within the design groups other than a sound knowledge of civil engineering practices, drawing techniques and specifications. The project task force may carry out this phase almost entirely using contracted engineering and drafting services. In the event that some resources may not be available at a specific time, there are a number of competent consultants in the Darwin area who may be invited to carry out some of the work.

Some parts of the design work such as the water treatment plant may require more technical input at the detailing stage. The project task force will have all study data and should be the best group to directly control the detailed design phase of the work.

The documentation will be organised to maximise the use of a lump sum tender system based on bills of quantities.

The measurement of quantities will be an essential part of the detailed design to ensure all contractor progress claims can be accurately assessed during the course of the site works. There will be some requirement for schedule of rates work to tidy up difficult areas in the early preparatory stages but the use of day labour should be kept to a minimum for better cost control.

Some of the individual works to be identified for discrete design packages may be:

1. Fencing works

2. Upgrading of site roads and creek crossings

3. East Finniss river diversion and open cut connection channel.

4. Ameliorative treatment of existing acidic soils in river courses

5. Backfilling White's open cut

6. Rehsaping stockpiles and clay covers

7. Water treatment plant

8. Construction camp -

9. Site offices and laboratory (temporary only)

10. Security and animal proof fence

11. Seed planting and design of erosion control structures on stockpiles.

The detailed design will rely heavily on the results of site investigations and engineering studies. It will be the responsibility of a senior design project engineer to co-ordinate all design works including the co-ordination of departmental services through the nominated representatives who will play an active part in providing design criteria for the various problems.

The documentation and tender analysis will be provided by the project task force' assigned staff. After receipt of detailed design and specifications, the commercial requirements will be provided generally in accordance with normal N.T. Dept. of Transport and Works procedures. Prior to any contract award the project task force will agree on the proposed contractor then seek the approval of the Project Director.

The project task force will then assume responsibility for the administration of the contracts.

The supply of lime will be a major contract to be negotiated. The total tonnage will be known once the water treatment method is finalised. The quantities, rate of supply and storage methods on site will be documented during the detailed design and procurement phase.

All contracts awarded for any service will be between the Dept. of Transport and Works and the contractor with the project task force acting as agent.

5.4 Site Works

The responsibility of the operational phase on site will be delegated to a senior construction engineer assigned to the task force. He will have been involved in the tender preparation, evaluation and recommendation of awards for the project. Once the contractor has been selected, the site engineer and site superintendent will be briefed by him on the scope and project timing.

The site works contractor will have day to day contact with the superintendent who will maintain overall supervision of contractor's activities, site movement, particularly in relation to any work around potential radiation areas. The site engineers will be responsible for providing technical assistance to ensure all detailed design is implemented and keep a close watch on standards to ensure control is maintained on certain sections of the earthworks where moisture and compaction control is required.

The personnel used to collect base line data and samples will report to the site engineer for day to day matters. The various N.T. Govt. Dept. representatives will provide the technical assistance to the specific staff engaged on site projects but the overall priorities will remain the responsibility of the senior construction engineer to avoid conflicts of site use during major earthworks activities.

The site staff will be assigned by the project manager to adequately supervise the site programme. The build up of staff will coincide with the increasing activities during years 1982 to 1984. The first year of site investigations would require minimum supervisory staff. The need to maintain site order and safety procedures including radiological aspects will make it necessary to establish a site project office during the early stages of the first year.

The site works will be scheduled to optimise the use of the dry season period for bulk earthworks. Recontouring of existing stockpiles can proceed throughout the wet season to ensure general site activities continue all year round avoiding remobilisation costs each year.

SECTION 6

MONITORING PROGRAMME

6.1 Collection of Base Line Data and Monitoring Programme

The site investigations results used in the 'Summary' have been collected over a number of years. The number of samples taken in some instances were limited particularly in respect to hydrological monitoring of stream flows during the wet season. The water quality sampling programme did not always relate to the same period when hydrological data was collected so there is some doubt regarding the dilution effects on heavy metal releases from the area.

The proposed investigation programme should provide the required correlation between each programme.

It is considered necessary to arrange the investigation programme in such a manner to provide a 1981 base line for any data tests considered to be essential indicators of the projects success.

The investigation programme has been proposed with this requirement in mind and has considered the type of data required, the number of samples and tests needed to adequately prove the current levels of pollution and the location of sampling stations.

The major sampling stations for water quality monitoring will be installed in the following locations.

Station 1 - Upstream of the Rum Jungle rehabilitation site on the East Finniss River.

Station 2 - Upstream of the Finniss/East Finniss River confluence, probably under the existing railway bridge.

Station 3 - Upstream of the same confluence on the Finniss River.

Station 4 - Downstream of the same confluence on the Finniss River.

The standards set out in Section 3 for water quality are expected to be consistent with data collected at station 4.

These stations will be used for the collection of base line data and will have stream gauges, weirs, automatic samplers, local rain gauges, sediment collecting samplers and other necessary equipment. The stations will be constructed for a long term endurance of the local conditions.

A meteorological station previously described will be set up so that site works will not require it to be shifted.

Some local rain gauge and hydrological stations set up to monitor seepage and runoff from overburden heaps may be lost during site works but these stations are required only for investigation works to build up a total model of the area rather than a point of critical base line data collection for future monitoring work.

The groundwater programme has considered a number of test and observation bores in a similar manner. The location of the observation bores will allow long term monitoring from the same points after the intial investigations have been completed.

The radiation survey has been designed to confirm data received from the A.A.E.C. and provide accurate base line information for the design criteria of the proposed impermeable cover to the area.

It is intended to locate all positions where readings are taken on the tailings dam and around the site by means of a land survey grid, set out during the land survey programme.

If the design criteria proposes that the tailings be covered in its existing location, then further readings will be possible in the same positions as previous but on top of the proposed cover. The comparison of results should confirm the success of the cover for emission reduction.

The soil in the river courses will be subject to examination at arbitrary points, probably adjacent to the stream monitoring stations. The base line data will confirm statements re migration of radioactive material out of the tailings area and it can be used for long term monitoring. Radionuclide particles in the water will be confirmed during the normal water quality sample analysis.

The investigations and base line data collection is programmed to commence by mid January 1982 when all major monitoring stations will be installed and ready for use. Groundwater stations will commence installation in November 1981 and it is expected to have two test bores and eight observation bores ready by January 1, 1982.

Four trained field assistants will be assigned to collect samples from the designated stations on a minimum of 8 hourly intervals, 7 days per week.

The automatic samplers will allow data collection during the night periods and each unit will be regularly serviced to ensure reliability. The groundwater quality sampling will be supervised by a competent hydrogeologist on a full time basis and pump tests will be carried out each month to coincide with the wet season rainfall activities.

The stream gauges will be checked hourly if required during intense rainfall periods in the same wet season and rain gauges, dust collectors, evaporation pans etc. will also be regularly checked over the January 1982 period.

It is expected to take some 2000 samples over this period that will be analysed and evaluated in the Water Division's Darwin laboratory as well as the on site facility.

The intense campaign for 6 months will provide the necessary results to use in engineering design studies - to commence in the June to December 1982 period.

The hydrological model of the total water movement on site will probably take until October 1982 to complete and because of the initial January commencement of the intense data collection it may be necessary to carry out the same level of data collection for the complete 1982/83 wet season, for confirmation of design criteria. The results from the second wet season should only slightly modify the design decisions. It is not planned to hold up detailed design and documentation for the confirmation results.

It is intended to monitor surface water movement each wet season to a level where the hydrologic unit maps can be updated for more accurate predictions of total water volumes available each year for dilution purposes is expected.

The water quality monitoring programme will continue through each wet period but at a lower level of intensity. The monitoring programme will be properly designed to maintain compatibility between stream gauging, groundwater movement and rainfall patterns so that the model of the area can be confirmed.

Random testing at various stations is not considered to be of any value, so it will be necessary to maintain at least 2 field assistants on site during the dry season and at least 4 assistants during the wet season for the four years of rehabilitation. Other activities on the site during the dry season should fully utilize the assistants when not engaged on sampling and other monitoring duties.

The radiation survey will require 2 full time technical officers on site for 6 months for base data collection in wet and dry climatic conditions. These investigations will not be full time and again, the assistants will be used elsewhere on other monitoring works. The costs included in the estimates have accounted for the personnel utilisation described.

The White's open cut water treatment investigations has been deliberately timed to allow for utilization of staff in the dry season. Groundwater pumping tests and metallurgical assay sample collection will also keep a constant work load for the technical assistants for at least 6 months.

A long term monitoring programme can be easily established using the equipment already installed at all major sampling stations for the investigation and base line data phase. It is important for the comparison of results to have the same sampling station and techniques continue during the long term monitoring programme. It is recommended that long term monitoring be confined to the following general areas -

- All four major stream gauging/sampling stations previously described.
- Meteorological station for rain gauge readings.
- White's/Intermediate open cuts - Water quality and radionuclide concentrations.
- Nominated groundwater observation bores to check on any contaminants; probably located close to White's and Intermediate open cuts to monitor any changes in pH, metals, calcium and sulphates.
- Nominated protection bores that may be returning water to White's open cut during stabilization period.
- Spot checks on radiation survey grid previously identified in the investigation programme.

- Flora check on the whole area to assess ground cover establishment and any possible erosion areas.

The river courses should have established reference observation area set up prior to commencement of rehabilitation works where photographic records of plant regeneration is taken, say every six months. The East Finniss river and the Finniss river should both have reference observation areas for monitoring.

Fauna/Fisheries - The barrier created by the fence will prevent any meaningful monitoring of fauna movement in the area. The long term management of the area to prevent over grazing may also influence any natural habitation in the area.

The monitoring of fish and other aquatic life has not been examined in this report. The work being carried out by the Supervising Scientist may give some guidance to a long term monitoring programme. In general terms the Finniss river aquatic life should be monitored to watch for any changes that may occur during the high calcium/sulphate water release programme from the Intermediate Open Cut.

The question of frequency for long term monitoring should be resolved during the intensive investigation stage and before major site works commence in 1983. The rehabilitation works should physically be completed within 4 years but the potential stabilization of water, possible use of groundwater protection bores, assessment of revegetation programme and likely remedial works, will demand some regular attention for say an additional 3 years.

The long term monitoring programme may take three changes in the level of sampling activity:

1. During rehabilitation; the site works activities will permit personnel to be on site each day and the level of monitoring should continue on a medium to high level but not as intense as the first 6 months during investigations and base line data collections.

2. After all works have been completed it is expected that the site will go through a 'settling down' period where water releases from the Intermediate Open Cut should return to normal, the effects of the recontouring works may require some changes, so monitoring should be kept at a medium to low level of activity. Because of the requirement to check the completed works, this period may extend for 3 years after completion of site works.

3. The final long term monitoring of results is a matter for discussion between the N.T. Govt. and the Commonwealth Govt. It would seem reasonable to maintain a monitoring programme for the period of the site works then a minimum of six years there after thus providing a total record of results and achievements from January 1982 until the year 1992.

This report has considered a 100 year life of the protective works to be incorporated. The necessity to monitor the life of the works may be of interest for research purposes but the success of the project should be known within the ten year period described.

SECTION 7

PROJECT COST ESTIMATES

7.1 Previous Estimates and the Degree of Confidence

The estimates presented in the 'Summary' and in 'Document A' were heavily qualified in respect to the scope of work considered appropriate for each rehabilitation activily. 'Document A' was quite specific on the assumptions made and they have been well documented throughout the notes.

After discussions held with one member of the 1978 Working Group who assisted in providing the estimates for the 'Summary', it was confirmed that the accuracy of those estimates should not be considered to be any more than a rough 'order of magnitude', to be used only as a rule of thumb guide. The Commonwealth Govt. considers the estimates put forward in 'Document A' to be the more appropriate value for 'Option D' proposals; this report has confined the review of project costs to 'Document A'.

A letter from the Prime Minister to the Chief Minister of the Northern Territory, in August 1980 (reference Appendix 6) indicated an estimated project cost of $12.14M (February 1980 prices).

It appears that 'Document A' estimates have been taken out of context as the scope was so heavily qualified with many technical decisions still unanswered, any reference to the final project cost seems inappropriate. The total value of the project estimate should be considered in a similar category as the 'Summary'; being no more than an 'order of cost' magnitude.

The level of confidence in the rates used for each section of the work is not being questioned. 'Document A' allowed a +25% contingency loading for unknowns, but the scope was assumed and it is in that premise where the end project cost may vary by possibly 100% depending on final decisions.

The following comments on 'Document A' and the possibility of estimate variance have been tabled to highlight the potential changes to the estimate. It is not intended to be a criticism of the previous work as it was necessary to arrive at a cost, with insufficient field investigations, before any economic analysis was possible. The end project cost at this stage should be understood to be no more than an order of magnitude with a real chance of substantial variations.

7.1.1 'Document A' made the assumption that suitable clay could be found within 1.5 km radius of the site. It put forward some order of cost variations if material had to be hauled from 10 km away. This amounted to $1,948,000 alone.

The N.T. Road Division have doubts as to the suitability of local clays in the area to form a high P.I. low permeable cover. They consider that blending may be necessary with other distant kaolinitic clays. Assuming the cover thickness used in 'Document A', the quantities of loose materials required will be in the order of 450,000 m^3. To blend and haul special materials for those quantities may cost in the order of $\$6/m^3$, adding an additional 450,000 x $\$6/m^3$ = $2,700,000 to the project cost.

The thickness of the clay cap is probably the item that will influence the costs more than any other factor.

If the design theory put forward for the Koongarra is considered more appropriate clay cover would increase from 200mm to say one metre, and a vapour layer of gravelly sand would be added between the clay cap and the vegetation top soil.

The clay quantities would increase from 450,000 m^3 to 2,250,000 m^3 causing an order of cost change of:-

1,800,000 m^3 x $\$10/m^3$ = $18,000,000

(assuming a 20 km haul and blending)

The vapour layer may change the estimate by:-

450,000 m^3 x $\$4/m^3$ = $1,800,000.

Revegetation of the borrow pits would increase dramatically and it may cost an additional $315,000 to rehabilitate 90 Ha of additional borrow pits. A potential cost variance using the Koongarra design parameters may be in the order of -

Extra clay	$18,000,000
Extra vapour layer	$ 1,800,000
Extra rehabilitation of borrow pits	$ 315,000
Potential variation from 'Document A' estimate	$20,115,000

It is not suggested that the final design of Rum Jungle will follow Koongarra techniques but it must be recognised that professional opinions put forward indicate that 200mm is extremely thin for a 100 year life expectancy.

In the time that this report was being compiled, the author received technical opinions from two recognised soils consultants who considered a 500mm layer of high moisture clay followed by a 200mm gravel/sand vapour layer to bond the top soil layer into the clay layer and prevent subsurface drainage paths at the interface, was a more realistic design criteria.

If this criteria is extended to the Rum Jungle case, the 'Document A" estimate may increase by an order of:

675,000 m^3 x $6/$m^3$ = $4,050,000
(assuming clay within 10 km little or no blending)

Vapour layer
450,000 x $4/$m^3$ = $ 1,800,000

Revegetation of additional borrow pits area
50 Ha x $3500/Ha = $ 175,000

Total $ 6,025,000

If the original estimate is upgraded to December 1981 costs, a two year inflation factor is required.

'Document A' estimate	$12,140,000
Escalation (25% for 2 years)	$ 3,035,000
Extra earthworks	$ 6,025,000
Borrow pit rehabilitation	$ 175,000
Detailed investigations & engineering studies (see Section 7.2)	$ 1,630,000
	$23,005,000

The detailed estimate sheets for 'Document A' were not available at the time of this report's preparation. 'Document A' recommended further investigation before final design was completed. Our detailed estimate for the required site investiagations and final engineering studies is in the order of $1,630,000. The amount may not have been allowed in the $12 million estimate.

Other items that may affect the 'Document A' estimate:

1. Supply of lime - approximately 15,000 tonnes of lime may be required, it is not know what allowance for lime was made.

2. Detailed design, project co-ordination and contract supervision - there is not an itemised amount for this activity but for a project of this type, 10% of the actual direct costs may be appropriate. It should be noted that this project has a heavy bias to technical evaluation and data collection that may weight the engineering costs higher than normal.

3. Stockpile Quantities - the 'Summary' indicated a 20% variance in quantities. This may affect the surface area calculations used in 'Document A'.

4. Groundwater Movement - no consideration was given to groundwater contamination. This may affect the methods to be used and the prevention of groundwater movement away from White's open cut when treatment is in progress.

   If the copper heap leach cannot be dumped into White's open cut a sealing layer will be required thus adding more quantities of clay and top soil previously allowed for.

5. Use of Dyson's Overburden - the low sulphide content reported in Dyson's Overburden may not be the case. If this material cannot be used then additional impermeable cover material will be required for overburden heap.

Only significant cost variance factors have been raised, many other minor problems will influence the final costs but have not been included. The variance in the final cost cannot be reduced until all design criteria is fully established by December and new estimates have been completed for each activity.

The 'Document A' estimates should be used as a guide only. It is recommended that all project control estimates should be developed from first principles rather than using factors applied to Document A figures.

It is proposed to prepare a report by March 1983 with more accurate estimates once the scope was defined and the engineering design of all rehabilitation methods was selected. The contingency requirements would be substantially reduced giving the estimate a better level of confidence for budgetry purposes.

It is recommended by this report to consider the project costs in two parts:

1. Detailed Investigations and Engineering Studies

   The order of accuracy defined in costs presented in this section is -5% to +15%.

The substantial portion of costs relate to activities between November 1981 and June 1982.

2. Engineering Studies/Design Criteria/Stage 1 Site Works.

In March 1982 it is proposed to send a report to the Commonwealth Govt. outlining the work for the 12 months from June 1982 to June 1983. The engineering design criteria will not be known at that time but an order of cost estimate for the first stage of the site works and a more precise estimate for the remaining engineering studies, design and documentation could be established. The order of accuracy may only be ± 25% for this phase.

It is not considered realistic to produce any 'end of project' until March 1983 when the aforementioned is completed.

It is the objective of this implementation report to follow the 'Option D' proposals and only implement investigations and engineering design to solve the stated alternatives and unresolved problems within it. If the final costs of 'Option D' become prohibitive once design parameters are established, then it may be necessary to review the total rehabilitation project and its economic benefit.

The objectives to reach the expected reduction in pollution levels as stated in 'Option D' should be the primary target at this stage. The end costs to achieve those objectives cannot be meaningfully stated until further work is completed.

7.2 Summary of Estimates - Parts 1 and 2

7.2.1 Part 1

Detailed Investigations/Base Line Data Collection and Engineering Studies - November 1981 to June 1982

The activities for this work have been identified in detail and the costs accurately calculated. All resources have been identified and their costs have been included in the estimates.

The work programme and cost estimates reflect an immediate start on Nobember 15, 1981 to allow important data collection in the 1981/82 wet season.

A contingency of 15% has been added to this estimate to cover unknown occurrences, such as delays due to rain, hole failure when drilling, change in investigation requirements etc. It does not cover any allowance for escalation.

7.2.2 Part 2

Costs from June 1982 to June 1983

The costs for the engineering studies, project co-ordination, N.T. Departmental costs and further groundwater evaluation have been calculated from first principles. The costs of the site works have been assessed using 'Document A' estimates and engineering design parameters. They are included to indicate an order of magnitude only for future project budget allocations.

Part 1

Detailed Investigation Costs To October 31, 1981

The costs in preparation of the implementation report including professional fees, travel, accommodation, N.T. Govt. miscellaneous charges (airfares, accommodation). Salaries of N.T Departmental representatives assisting the project group have not been charged for the time spent to date.

Estimate: $ 25,000

Site Establishment

project office/laboratory/ablution blocks/services: power/water/telephone/office stationary/furniture/equipment/ vehicles/transport/travelling allowance.

Estimate: $121,000

Site Accommodation (at Batchelor)

Caravan park at Batchelor for 10 vans including site preparation, power/water/ablutions and rental of 6 vans for 10 project staff.

Estimate: $ 40,000

Preparatory Site Works

Provide access for groundwater drilling, upgrade culverts, roads and drains to allow movement during the 1981/82 wet season, prepare area for site office.

Estimate: $105,000

Topographical and Land Survey

As per detailed programme Section 4.2.7.

Estimate: $ 22,000

Radiation and Radon Emanation Survey

As per detailed programme Section 4.2.3.

Estimate: $ 86,000

Soils Classification and Quantity Survey

As per detailed programme Section 4.2.1.

Estimate: $ 65,000

Surface/Groundwater Hydrology and Water Quality

Analysis of existing data, supervision of site sampling programme, evaluation of results, pump test supervision, development of hydrological model - recommendations for design criteria.

Part A $202,000

Site drilling of test and observation bores, installation of equipment, stream gauge station installation and monitoring, field data collection from all stations, laboratory analyses of all water samples (undertaken by Water Division).

Part B $322,000

Part A & Part B Estimate: $524,000

Bathymetric Survey

As per detailed programme Section 4.2.8.

Estimate: $ 5,000

C4 Metallurgical Geochemical and Geology Investigation (para 4.2.4)

? Re check sampling techniques for overburden assays, carry out further assays on stockpiles to determine 1981 conditions, check sulphide contents of all overburden heaps, geochemical analysis of all stockpile samples and the tailings dam. Study on bacterial presence and possible inhibition of action on sulphides.

Estimate: $ 30,000 ? 1982/3

B5 Flora/Fauna Base Line Data (para 4.2.5)

? Check all existing fauna in the area before erection of protection fence, establish design criteria for vegetation programme, establish a soil loss equation model for detailed design of erosion protection structures. Field work to identify all soil types in the area and the potential quantities - establish some field trials for species selection.

Estimate: $ 22,000 ? 1982/3

E N.T. Govt. Representations in the Project Task Force para 2.4.

E Salaries and incidental costs of N.T. Dept. representatives assigned to the project. Some reps. required full time (Water Division) other on a part basis. The A.A.E.C. representation costs have been included.

Weekly rental

Estimate: $ 64,000 ✓

Project management/co-ordination/supervison

For the services of all senior staff including project manager, senior project engineers, site superintendent, supervisors, project office in Darwin with drafting, stationary, telephone/telex services for all consultants and advisors engaged to assist the project without a local office. Provision of all technical/progress and funding reports to N.T. Govt. & Commonwealth Govt.

Part A professional services: $232,000

Part B miscellaneous costs: $ 87,000

Part A & B Estimate: $319,000

Total Estimate for all works between November 1981 and June 1982.

Part 1	TOTAL ESTIMATE:	$1,428,000
	Contingency (approx.) 15%	$ 204,000
	Part 1 Grand Total	$1,632,000

Part 2

Engineering studies/design/documentation/site works - Stage 1
July 1982 to June 1983

For this phase of the project the investigation and design programme cannot be estimated with the same degree of accuracy because the engineering studies to be undertaken and recommendation of final design criteria will be determined by the reports produced in June 1982. For indicative, order of magnitude budget projections and cash flow predictions the following estimates have been prepared. The major site works for overburden shaping and covering have a lower order of confidence than the engineering studies, remaining investigation work and project co-ordination costs but have been included to provide indicative costs for all activities between June 1982 and June 1983.

1. Engineering Studies

- Soil and clay cap cover
- Water Treatment Plant
- Method of Disposal of heap leach
- Use of Dyson's Overburden in White's Open Cut
- Tailing Dam alternatives
- Lime supply and requirements
- N.T. Govt. Lab. studies

Estimate: $ 88,000

2. Detailed Design Documentation and Engineering Studies

For engineering studies, detailed design of river diversion, water treatment plant, White's/Intermediate overburden recontouring and cover - sufficient to allow Stage I of the site works to proceed.

$ 287,000

Site Works

River diversion connection of acid pond, White's Open Cut into Intermediate Open Cut.	$ 500,000
White's Overburden Heap recontour/cover.	$2,700,000
Water Treatment Plant.	$ 300,000
Acid/Sweetwater Dam rehabilitation.	$ 200,000
Protection Fence.	$ 300,000
Project Co-ordination & Supervison. Key personnel costs plus Darwin project office and associated costs.	$ 485,000
N.T. Govt./A.A.E.C./D.H.C. reps. assistance	$ 86,000
Part 2 Total	$4,946,000
Contingency approx. +25%	$1,254,000
Part 2 GRAND TOTAL ESTIMATE	$6,200,000

The order of cost for the remaining part of the project cannot be stated at this time for reasons previously given.

Qualifications to the Estimates

The estimates have been developed using the following general parameters. Major qualifications have been noted.

1. N.T. Govt. Salary, Equipment and Material Costs.

The salaries for all N.T. Govt. staff assignees has been calculated on a $\frac{\text{Nett Annual Salary}}{\text{52 weeks/annum}} \times 100\% = \text{weekly rate.}$

The loading covers all leave entitlements, sick pay, workers compensation, pay roll tax and other burdens and allows for the administration services of the Treasury Dept. and the Water Division to assist the project task force without being charged directly.

There will be a requirement for one full time accounts officer who will be charged to the project using the above formula, but no others.

2. N.T. Govt. equipment used for a finite short duration on the project, such as water drilling rigs, will be charged at a fixed daily rate.

Any long term equipment such as site offices, sleeper units, caravans, monitoring equipment and vehicles etc that will be required for most of the project duration will be purchased directly from project funds and sold to the N.T. Govt. or other at the end of its use. The salvage value will be credited to the project's funds.

Consultants costs have been included where it has been considered necessary to supplement the N.T. Govt. resources.

The project co-ordination and supervision costs have assumed contracted staff from a suitable management company including the costs of a project office to be established in Darwin and on stie.

The additional technical assistants required by the Water Division and the Dept. of Health have been allowed for at Public Service temporary staff rates.

The groundwater drilling works has been allowed for at Water Division rates and assumes the use of its drilling rigs. The depths of holes is assumed to average 100M but may change if the water table and rock formations alter.

The site works have not been estimated from new quantities or new contractors.

Part 2 site works estimate have been taken from 'Document A' and do not include any escalation from 1980 costs.

The site preparation for the project office/laboratory and general upgrade of the site has been allowed on day works basis for 8 weeks - scope and extent assumed to be covered in that time.

The project office consists of 3 second hand 40' x 10' transportable office units purchased ex. Nabarlek. Only 30% of new price has been allowed which should be the nett residual after purchase and resale at the end of the project. Water for the office is assumed to be available from bore water sources previously used near Brown's shaft.

Power to the site - allowance included to reinstall the power line, recently removed, back to Batchelor. It is understood that all poles and insulators still remain and only the transmission line requires replacement.

The existing buildings on site were not considered for use because of location. The movement of equipment and proximity to the tailings dam may cause problems in its use over the four year duration.

The accommodation for project supervision staff and sampling technicians has been allowed for in a caravan park to be constructed at the project's expense. The park will permit 10 caravans. Once construction works commence there will be a requirement for a camp to house approximately 60 men. The major contractors may wish to bring in a separate camp and locate it at Rum Jungle hence no allowance has been made to extend the caravan park for such temporary accommodation.

. The estimates have no allowance for escalation.

SECTION 8

CASH FLOW REQUIREMENTS

8.1 General

The cash flow table in this section has been extended to include the detailed activities from November 1981 to June 1982 and an 'order of magnitude' cash projection for July 1982 to June 1983.

8.2 Project Cash Flow

Refer to cash flow chart included in this section.

RUM JUNGLE REHABILITATION WORKS

VALUES IN THOUSANDS OF AUST. $ AS AT OCT. 1981.

DESCRIPTION OF WORK	OCT	NOV	DEC	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.–JUNE	TOTAL
	1981								1982							1983				
SITE PROJECT OFFICE/WATER LAB.	116 ✓	5	6	45	40	5	5	5	5	5										121
CONSTRUCTION CAMP.	38 ✓	2	6	10	10	3	3	2	2	2										40
PREPARATORY SITE WORKS.	105 ✓	5	10	50	40															105
STREAM GAUGE STATIONS/WATER SAMPL'S	110 ×	2	20	40	40	6	2													110
GROUND WATER DRILLING & SUPERVISION.	240 ×	4	40	60	60	28	28	10	10											240
TOPOGRAPHICAL & LAND SURVEYS.	22 ✓	4	12	4	2	+ Geochemical (30) ?														22
RADIATION SURVEY-EQUIP. & FIELD WORK.	78 ✓	2	12	20	10	10	8	8	8	2	2	2	2							86
SOILS INVESTIGATION - CLASS/QUANTITY.	65 ✓	5	20	16	16	8	+ Flora/Fauna Baseline (22) ?													65
BATHYMETRIC SURVEY OF OPEN CUTS.	5 ✓	1	3	1																5
WATER MONITORING	23 ×		3	5	5	5	5	5	5	2	2	2	2	2	5	5	5	5	11	74
ENGINEERING STUDIES ~~Balance of Groundwork~~	10		Institute of metallurgy/mining						10	19	18	18	18	17	17					117
PROJECT TASK FORCE COSTS																				
N.T./AAEC/D.H.C. REPRESENTATIVES	64 ✓			11	11	11	10	10	11	10	10	10	10	8	8	8	8	6	18	160
PROJECT SUPERVISION & CO-ORDINATION	24+25 ✓	28	6	40	55	55	40	40	40	40	40	40	45	45	45	45	45	45	135	829
DETAIL DESIGN & DOCUMENTATION	20				5	5			10		10	26	26	26	26	26	26	26	48	260
HYDROLOGY & GROUNDWATER EVALUATION	× (+model)									40	30	30	15	15	10					140
SITE WORKS DIVERSION WORKS																		50	450	500
STOCKPILE RESHAPING																		80	2620	2700
WATER TREATMENT PLANT																		50	250	300
ACID/SWEETWATER DAM REHABILITATION																		40	160	200
FENCE											60	60	60	60	60					300
TOTAL		58	138	302	294	136	101	80	101	120	172	188	178	173	171	84	84	302	3692	6374
CUMULATIVE TOTAL		58	196	498	792	928	1029	1109	1210	1330	1502	1690	1868	2041	2212	2296	2380	2682	6374	
CONTINGENCIES		5	21	45	44	21	15	12	15	18	43	47	45	43	43	21	21	76	923	1458

Prepared By

MINING & PROCESS ENGINEERING SERVICES (W.A.) PTY. LTD.

316 LORD STREET, HIGHGATE, WESTERN AUSTRALIA

	BY	DATE
PROJECT APPR.		
DESIGN APPR.		
DESIGNED	M. RODDA.	19-10-81.
CHECKED	R. WILDE.	19-10-81.
DRAWN	L. IRELAND.	17-10-81.

CLIENT: DEPT. OF TRANSPORT & WORKS.

JOB: RUM JUNGLE REHABILITATION PROJECT.

TITLE: INVESTIGATION WORKS / CASH FLOW.

SIZE: A3 | SCALE: —

REV. No.:

DRAWING No.: N.T. - D.T.W. - 003.

SECTION 9

PROJECT SCHEDULES

9.1 General: Key Activities and Constraints

The project schedules included in this section have two orders of accuracy.

1. Detailed Investigations Programme

All activities and resources considered necessary for the execution of this phase have been identified.

The detailed investigation schedule has allowed for work during the wet season after advice from local residents but has built in some contingency for a small amount of lost time each week and approximately 2 to 3 weeks in February. The monitoring station installation has been specifically scheduled to gain maximum results from the late January to March wet season.

2. Preliminary Project Schedule

An overall project schedule has been drawn up to provide a total project concept. The site works have been based on design assumptions and general earthworks quantities described in 'Document A'.

The schedule has indicated a rather intense site works programme in 1983 and 1984 to have sufficient impermeable stockpile covers completed each year so that vegetation programmes can be started before each wet season.

The overall project duration of four years has been taken from the exchange of letters between the Prime Minister and the Chief Minister of the Northern Territory.

The project can be completed within the desired time scale provided investigation programmes commence on November 15, 1981.

RUM JUNGLE REHABILITATION PROGRAMME

DESCRIPTION OF WORK	1981 OCT.	NOV.	DEC.	1982 JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	1983 JAN.	FEB.	MAR.	APR	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.
SITE PROJECT OFFICE / WATER LABORATORY		EARTHWORKS																								
			BUILDINGS & SERVICES																							
CONSTRUCTION CAMP — (CARAVAN PARK)		EARTHWORKS																								
			BUILDINGS & SERVICES																							
PREPARATORY SITE WORKS.		ROADS / CULVERTS / DRAINS FOR WET SEASON																								
TOPOGRAPHICAL & LAND SURVEY.																										
— CONTROL STATIONS.																										
— BORE HOLES																										
— GRID & PEG OLD TAILINGS DAM.																										
— LEVEL COMPARISON — OPEN CUTS & STOCKPILES																										
SOILS INVESTIGATION. — CLASSIFICATION		PHASE 1																								
— QUANTIFICATION			PHASE 2	REPORT																						
RADIATION SURVEY. — EQUIPMENT																										
— FIELD WORK			WET SEASON TESTING								DRY SEASON	SURVEY	REPORT													
GROUND WATER DRILLING.																										
— TEST BORES			SITE WORKS					DATA EVALUATION & DESIGN OF HYDROLOGICAL MODEL					REPORT													
— OBSERVATION BORES			SITE WORKS						INTERIM REPORT																	
STREAM GAUGE STATIONS & WATER SAMPLERS			INSTALLATION																							
BATHYMETRIC SURVEY OF OPEN CUTS																										
WATER MONITORING.																										
— SAMPLE COLLECTION																										
— GROUND / SURFACE WATER STAT'S																										
— LABORATORY ANALYSIS																										
ENGINEERING STUDIES.																										
— METALLURGICAL ASSESSMENT.						REPORT																				
— WATER TREATMENT METHODS													REPORT													
— TAILINGS DISPOSAL													REPORT													
— IMPERVIOUS STOCKPILE COVER.													REPORT													
— SOIL LOSS MODEL													REPORT													
— HYDROLOGIC + WATER MODEL													REPORT													
— BACTERIA / SULPHIDE INVEST'S													REPORT													
N.T. DEPARTMENTAL STUDIES																										
DETAIL DESIGN & DOCUMENTATION																										
PROGRESS REPORTS TO GOVT					COMM. FUND REPORT		COMM / N.T. PROGRESS REPORT			COMM / N.T. PROGRESS REPORT			COMM / N.T. PROGRESS REPORT			COMM FUND REPORT			COMM. N.T. PROGRESS REPORT			COMM. N.T. PROGRESS REPORT		
SITE WORKS																										
— PROTECTION FENCE																										
— DIVERSION WORKS																										
— STAGE 1 SITE WORKS																										
WATER TREATMENT PLANT																										
LONG TERM MONITORING.																										
DATA COLLECTION.																										

COMMENCEMENT PROJECT

"PROGRAMME BASED ON OPTION D STRATEGY - TO BE CONFIRMED BY INVESTIGATIONS & ENGINEERING STUDIES"

DRAWING No | REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (W.A.) PTY. LTD.

316 LORD STREET HIGHGATE WESTERN AUSTRALIA

No	By	Date	Revision	Checked	Approv

	By	Date
PROJECT APPR		
DESIGN APPR		
DESIGNED		
CHECKED		
DRAWN	L. IRELAND	16-10-81

PLANT GRID NORTH

CLIENT: DEPARTMENT OF TRANSPORT & WORKS.

SIZE: A1 | SCALE: —

TITLE: RUM JUNGLE REHABILITATION PROJECT. DETAILED INVESTIGATION PROGRAMME.

REV No

DRAWING No: N.T. - D.T.W. - 002.

RUM JUNGLE REHABILITATION PROGRAMME

DESCRIPTION OF WORK.	1981 O N D	1982 J F M A M J J A S O N D	1983 J F M A M J J A S O N D	1984 J F M A M J J A S O N D	1985 J F M A M J J A S O N D	1986 J F M A M J J A S O N D	1987 J F M A M J
SITE OFFICE / ESTABLISHMENT & ACCOMMODATION							
PREPARATORY SITE WORKS							
TOPOGRAPHICAL & LAND SURVEY							
RADIATION SURVEY.							
GROUND WATER-DRILL TEST BORES/INSTALL SAMPLERS							
-COLLECTION OF DATA.							
-DATA EVALUATION & REPORT.							
SURFACE HYDROLOGY - STREAM GAUGE STATIONS & WATER SAMPLERS.							
-COLLECTION OF DATA.							
-DATA EVALUATION & REPORT.						LONG TERM MONITORING PROGRAMME. 5 YEARS. WATER SAMPLING & RADIATION CHECKS FROM REFERENCE MONITORING STATIONS.	
CLIMATE STATION - TOWER & EQUIPMENT.							
SOILS INVESTIGATION-FIELD WORK/CLASSIFICATION & LABORATORY DESIGN.							
WATER QUALITY-BATHYMETRIC SURVEY/SAMPLING							
ENGINEERING STUDIES-DESIGN CRITERIA/REPORTS.							
DETAIL DESIGN & DOCUMENTATION.		REPORT TO COMM.					
SITE WORKS:							
-INSTALL PROTECTION FENCE.							
-ACID/SWEETWATER DAM.							
WHITES HEAP-RE-CONTOUR/COVER/VEGITATE							
-RIVER DIVERSION.							
LIME SUPPLY-DELIVER/STORE ON SITE							
WATER TREATMENT-TREAT INTERMEDIATE OPEN CUT.							
-CONNECT WHITES TO INTERMEDIATE.							
-TREAT WHITES OPEN CUT WATER							
FILL WHITES OPEN CUT: -DUMP HEAP LEACH.							
-DUMP DYSONS OVERBURDEN.							
DYSONS OPEN CUT: -TREAT WATER.							
-REVEGITATE OVERBURDEN HEAP							
INTER MEDIATE OVERBURDEN HEAP-RECONTOUR/COVER/VEGITATE.							
OLD TAILINGS DAM-RECONTOUR/COVER/VEGITATE.							
EAST FINNIS RIVER - TREAT SOIL/REVEGITATE							
REVEGITATION-TREAT SOIL / REVEGITATE OTHER AREAS.							

RELEASE RELEASE RELEASE

TREAT REMAINING WHITES WATER

TREAT & PUMP TO WHITES.

VEGITATE.

REGULAR INVESTIGATIONS OF SITE REPAIRS TO NEW VEGITATION PROGRAMME

PROGRAMME BASED ON OPTION 'D' PROPOSALS - TO BE CONFIRMED BY INVESTIGATIONS AND ENGINEERING STUDIES.

DRAWING No | REFERENCE DRAWINGS

MINING & PROCESS ENGINEERING SERVICES (W.A.) PTY. LTD.
316 LORD STREET HIGHGATE. WESTERN AUSTRALIA

No	BY	DATE	REVISION	CHECKED	APPROV

	BY	DATE
PROJECT APPR		
DESIGN APPR		
DESIGNED		
CHECKED		
DRAWN	L. IRELAND.	17-10-81.

PLANT GRID NORTH

CLIENT: DEPARTMENT OF TRANSPORT & WORKS.

SIZE: A1 SCALE: —

TITLE: RUM JUNGLE REHABILITATION PROJECT. PRELIMINARY PROJECT SCHEDULE

REV No

DRAWING No: N. T. - D.T.W.- 004.

SECTION 10

PROJECT REPORTS

10.1 PROJECT REPORTS

The project task force will be required to produce a series of reports during the course of the works. The reports will be necessary for:-

- Technical recommendation for each method to be used and associated cost estimates.
- Project fund requirements.
- A review of project progress.

It is proposed that the reports will be prepared on the following time scale:-

Technical Report

By March 1982 some of the recommendations should be completed for less critical activities that do not require the results from the initial site investigations. A report is proposed to explain the selected option, the information used to reach the decisions and a detailed estimate of the expected final cost.

A second report would be prepared in March 1983 when all design criteria had been resolved and detailed recommendations and cost estimates could be put forward for the remaining activities.

The reports would be suitably prepared for evaluation by the Commonwealth Dept. of Housing and Construction or any other agency appointed by the Commonwealth Dept. of National Development and Energy.

Fund Report

A proposed project fund report would be prepared in March 1982 outlining the expected project expenditure for the proceeding twelve months.

This report would be financially oriented, with brief references to technical recommendations and methods previously agreed to. All detailed estimates of known activities together with order of magnitude costs for planned works that had not been engineered would be presented. The required monthly cash flow from July 1982 to June 1983 would be included for general budgetary purposes. The first March 1982 fund report could only be considered as an interim report. The site works planned for January 1983 to June 1983 period would not be accurately defined until March 1983.

The 'funding' report will be sufficiently qualified to establish an order of accuracy and potential cost variations from the mean estimates presented.

Project Status Report

It is considered necessary to provide the Dept. of Transport and Works with a detailed progress report every three months that outlines all key activities and expenditure on the project.
It should cover:-

1. Description of works completed.

2. Key date achievements for activities such as investigation reports, design engineering, documentation and all site contracts.

3. Expenditure summary covering original estimates, costs to date against forecast expenditure, variations to original budgets, contingency items that may affect the budgets and a revised estimate for any activities where scope changes have occurred.

4. Comments on performance of all contractors, consultants and N.T. Govt. Depts. identifying areas of concern together with recommended changes where applicable. The contents will be comprehensive and serve as a complete record for job history purposes.

It should provide the necessary project control reports together with summaries of technical information received and its benefits, any pending changes from the original objectives and any early confirmation of the expected success of each phase of the Works in terms of pollution reductions and achievement of the standards set as well as physical site works.

The three monthly report will be published in an acceptable form for use by the Commonwealth Dept. of National Development and Energy.

Monthly Cost Report

For control of the project it is proposed to have a monthly budget and cost analysis report available to the Project Director (Dept. of Transport and Works). It will be a detailed account of costs, progress and expected variations from original budget and project schedule. It will not contain the same amount of technical information as the three monthly report. The monthly cost reports will be summarised and consolidated into the three monthly report.